भारत सरकार

GOVERNMENT OF INDIA

रेल मंत्रालय (रेलवे बोर्ड)

MINISTRY OF RAILWAYS (RAILWAY BOARD)

भारतीय रेल

INDIAN RAILWAYS

दूरसंचार नियमावली

TELECOM MANUAL

2021

सत्यमेव जयते

INDIAN RAILWAYS TELECOM MANUAL

2021

सुनीत शर्मा
SUNEET SHARMA

अध्यक्ष एवं मुख्य कार्यकारी अधिकारी,
रेलवे बोर्ड
पदेन प्रमुख सचिव, भारत सरकार
रेल मंत्रालय
CHAIRMAN & CHIEF EXECUTIVE OFFICER,
RAILWAY BOARD
EX OFFICIO PRINCIPAL SECRETARY
GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS

सत्यमेव जयते

24th February, 2021

Message

Indian Railways (IR) is playing a key role in the development of the country by providing a safe, financially viable and environmentally sustainable transport for both goods and passengers. IR is steadily working towards modernizing its network and assets, increasing capacities and improving safety of train operations.

Trains operations and assets of Indian Railways are spread over its vast network of around 68,000 rout km. Dedicated railwaymen are involved 24x7 in train operation and asset maintenance. It is imperative that clarity and standardization of processes and technical specifications exist uniformly across all the units. Also equally important is the regular updation of knowledge, instructions and directives in our codes and manuals.

Telecom is playing a vital role in Train Operations, Voice & Data Requirement and moving IR towards IoT based maintenance regime, and at the same time, Telecom technology is changing at rapid pace. Thus, the task of standardization and knowledge updation of our Telecom Engineers is must for overall system improvement.

In the difficult times of Covid-19 pandemic, Indian Railway Employees worked 24X7 and ensured uninterrupted supply chains across the country. Utilizing this time and using the latest Communication Systems, the task of revision of Telecom Manual was taken up.

I am happy to note that Signaling & Telecommunication Department has successfully completed revision of Telecom Manual with dedicated team efforts and now, same is being issued for guidance of all Telecom Engineers.

I am sure that this will standardize the processes in telecom field and enable Telecom Engineers to easily grasp new Telecom technologies and implement them, leading to rapid modernization of Indian Railways.

With best wishes

(Suneet Sharma)

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PRADEEP KUMAR

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एवं पदेन सचिव, भारत सरकार
रेल मंत्रालय, रेल भवन
नई दिल्ली–110001

MEMBER INFRASTRUCTURE, RAILWAY BOARD
&
EX-OFFICIO SECRETARY
GOVERNMENT OF INDIA
MINISTRY OF RAILWAYS
RAIL BHAWAN, NEW DELHI-110001

FOREWORD

Role of Telecommunication has increased over the years including on Indian Railways. Its role is vital in train operations, providing Internet of Things (IOT) and to perform administrative functions. At the same time, this field is rapidly changing and improving over the years.

Telecom Manual lays down the key technical specifications across different zones and divisions for Telecom engineers. It needs to be dynamically updated as per the technological advancement and to suit the present requirements.

Telecom Manual was last revised in 2007 and since then a number of new & modern telecommunication technologies have been introduced on Indian Railways. The role of Telecommunication has increased immensely not only in managing voice data & video communication but also in providing safe communication for signaling & other systems verticals in recent time which necessitate its revision.

The current revision of Telecom Manual is the culmination of dedicated, painstaking efforts by the Convener and Committee members comprising members from RDSO, IRISET & Zonal Railways. The draft submitted by the committee was further deliberated in the special TCSC meeting comprising of PCSTEs & CCEs of all Zonal Railways.

It is praise worthy that the committee members and the special TCSC meeting utilized the online collaborative VC tools for deliberation& discussions during the COVID-19 pandemic. I am happy that chapters on new technologies such as IP-MPLS, Ethernet Radio, Mobile Train Radio Communication- LTE-R, Wi-Fi, IP Addressing –IPv4/IPv6, Tunnel Communication etc have been incorporated in the revised Telecom Manual.

PCSTEs of Zonal Railways may supplement, complement them in respective Zonal Railways through Technical Circulars, duly keeping in mind industry's best practices, Reliability, Availability, Maintainability& Safety(RAMS) & Operational flexibility.

I sincerely hope that this revised manual will enable officers & staff to adopt new technology in a cost effective, efficient and seamless manner and will be the driving force behind the modernization of Indian Railways.

With Best Wishes

(Pradeep Kumar)

New Delhi
February,2021

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CHAPTER I

ORGANISATION OF THE SIGNAL AND TELECOMMUNICATION DEPARTMENT

SECTION 'A'- GENERAL

1.1 TELECOM ORGANISATION IN THE HEADQUARTER

(a) **The Principal Chief Signal & Telecommunication Engineer**- The Principal Chief Signal & Telecommunication Engineer is the administrative and professional head of the Signal & Telecommunication Department and is responsible to the General Manager for its *professional,* efficient and economical working.

b) **The Chief Communication Engineer** - The Chief Communication Engineer is responsible for systematic and professional working of the telecommunication system. He assists the Principal Chief Signal & Telecommunication Engineer in the administrative and professional work for all telecommunication matters.

c) The **Deputy Chief Signal & Telecommunication Engineer (Tele)** - The Deputy Chief Signal & Telecommunication Engineer (Tele) assist~~s~~ the Principal Chief Signal & Telecommunication Engineer and Chief Communication Engineer in the administrative and professional work as per assigned job/work/power (authority) distribution.

d) **Senior Scale Officer (Tele)** - Senior Scale Officers designated as **Senior Signal & Telecommunication Engineer** (Tele) are employed in the Headquarters Office of the Zonal Railway assists the Principal Chief Signal & Telecommunication Engineer and Chief Communication Engineer or the Deputy Chief Signal & Telecommunication Engineer (Tele) as per assigned job/work/power (authority) distribution.

e) **Assistant Signal & Telecommunication Engineer (Tele)** - They assist higher level officers as per assigned job/work/power (authority) distribution.

f) The Telecom organization is professionally managed with the assistance of SSE/JE/Telecom(s) and Ministerial staff employed at the Zonal Head Quarter for the purpose.

Note: For the signal organization, please refer to Signal Engineering Manual, Part I.

1.2 ORGANISATION ON A DIVISION

(a) Sr. DSTE is incharge of all the signal and telecommunication systems in the division. He works under the administrative control of the Divisional Railway Manager and Technical control of PCSTE. If there is more than one SG/JAG officer, the senior one among them is normally designated as Sr. DSTE/Co-ordination and is overall incharge of the S&T organisation of the Division. He is assisted by other S&T officers in SG/JAG/SS/JS and all officers discharge their duties as per preassigned job/work/power (authority) distribution.

1.2.1 TELECOMMUNICATION:

(a) The telecommunication system on each division shall be divided into sections and each section is maintained by Sr. Section Engineer(Telecom)/Junior Engineer(Telecom).

(b) On a division, each SSE/JE shall be responsible to the Sr. Divisional Signal & Telecom Engineer through DSTE/ADSTE, for efficient maintenance and correct installation of all telecommunication equipment under his charge.

1.2.2 DUTIES OF Sr. SECTION ENGINEER/JE (Tele):

The essential duties of SSE/JE (Tele) are:-

(a) Regular Inspection and efficient maintenance of all telecommunication equipments and systems such as, IP/MPLS networks , Telephone Exchanges including its line plants, Optical Fibre & systems , all telecom Quad cables & systems, wireless communication systems, Various Passenger amenities such as Train/Coach Indicator Boards, other Passenger Information Systems, Public address System, data communication system, Train Radio Communication, Wi-Fi, Video Surveillance Systems, Video Conferencing , any latest telecom system commissioned in their jurisdiction, power supply system and earthing of all telecom equipment etc.

(b) Execution of all works involving alterations to the existing installations, and installations of new equipment, its adjustment and connections.

(c) Carrying out periodical tests/measurements of Telecom systems independently and/or jointly with the officials of the BSNL/RailTel/Other Telecom Service Providers as the case may be.

(d) Efficient maintenance of stores and establishment matters by SSE(Tele)

1.2.3 STAFF UNDER SSE(Tele):

(a) Each SSE shall be assisted by one or more JE, Technicians and Helpers/Tele for maintenance. JE/Tele may work as sub-sectional in charge. The strength of JE, Technicians and Helpers/Tele shall be fixed in accordance to the yardstick and local conditions/work load.

(b) Where railway's underground telecommunication cables including Optical Fibre exist, a cable break-down transport such as a pick up van shall be provided. An emergency gang with full complement of cable jointing materials, tools and testing equipment should be available with the break-down vehicle.

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CHAPTER II

ROLE OF PTCC AND PTCC CLEARANCES

2.1 Power and Telecommunication Co-ordination Committee (PTCC) is a central standing committee for co-ordination of Power and Telecommunication system. The committee was formed by the Government of India in the year 1949.The objective of the PTCC is to ensure the safety of telecommunication equipment and precious human lives of personnel working in the concerned organizations as also those working in the close vicinity of power transmission line. The role of the committee is to deal with route approval for all new power lines . The PTCC have issued guidelines and manuals from time to time for preparation of proposals for clearance. The norms are reviewed by PTCC to affect changes in line with the technological advancements and bringing safety standards. The clearance of this committee is required before energization of new power lines of 11KV and above, which is given after obtaining clearances from the Railway/Telecom having lines in the area.

2.2 **Various committees connected with Power and Telecommunication Co-ordination:**

i. **Central Standing Committee:** This consists of two representatives from DOT and two from Central Electricity Authority (CEA).This was set up by the high level committee to look into estimates, which have resulted in delay in settling re-engineering cases.

ii. **High Level Committee**: This is a committee at the level of secretaries or Chairman/Members of the Board from Power and Telecommunication sectors. The committee is assisted by officers from the two sides. Cases where no consensus could be arrived at the level of the central PTCC are referred to this committee. Officers from the Railways are invited when there are issues involving them.

iii. **Central PTCC:** This consists of members from the CEA, DOT, Railways and the Army. The composition of the committee is given in Annexure ‘A’. The basic functions of this committee are:

a) To consider all matters relating to adverse effect of power lines on telecom lines.
b) To consider specific cases of route approval of power lines exceeding 33 KV and telecom lines.
c) To consider and adopt new protective measures to minimize the cost of protection.

iv. **State Level PTCC:** The present membership of the State Level PTCC consists of officers of Junior Administrative Grade from the concerned SEB, Telecom Circle, Railways and Defence. The composition of the committee is given in Annexure ‘B. The main function of this committee are:

a) To review the progress of route approval cases of 11 KV lines dealt with by Telecom District Engineers.

b) To consider route approval cases up to service voltages of 33 KV.
c) To consider re-engineering schemes for cases where induction exceeds the protection limit for GD tubes.
d) To co-ordinate and watch the progress of installation of protective measures and re-engineering works and issue of energization certificates on completion of protective works.
e) To consider violation of PTCC regulations and take suitable corrective measures.
f) To discuss cases of power lines of 66KV and above held up for PTCC clearance

Various Level of PTCC meeting:

S. No.	PTCC meeting	Frequency/Periodicity
1	Central level	Once in six months
2	State level	Once in three months
3	SSA/Telecom District	Once in three months
4	Divisional Level	Once in two months
5	Sub divisional level	Once in a month

2.3 (i). Central PTCC deals with cases of energization of power lines of 220KV and above.
(ii). Cases of energization of power lines up to 132KV DC are processed at the state level. However, for cases of 33KV DC and above up to 132 KV DC, final PTCC clearance is to be given by DET(PTCC).

For cases of above 11KV up to 33KV S/C clearance is given by State Level PTCC.

For power lines of 11KV, clearance is given by DET of the Telecom Department.

2.4 Copies of route map drawn to a scale of 1 cm=0.5 km of the proposed electrical lines are to be submitted to the GM(S&T) of the concerned Railways in 4 copies. The Route Map should depict all topographical details including Railway lines, Railway stations, Rivers, Canals and important roads and other land marks like towns, villages with names etc.at a radius of 8 Km around the proposed power line.

Topographical maps of the Survey of India are used for this purpose.

The distances over which the details are to be marked, are as under:

Capacity of Power Line	Telecom assets to be marked
HT (High Tension power line)	
11 KV	3 Kms on either side of proposed power line
22 KV	5 Kms on either side of proposed power line
33 KV SC (Single Circuit)	5 Kms on either side of proposed power line
EHT (Extra High Tension power line)	
33 KV DC (Double Circuit	8 Kms on either side of proposed power line
66 KV SC and above	8 Kms on either side of proposed power line

2.5 On receipt of the power line route maps, Railways shall check whether the proposed power line falls within the jurisdiction of the Zonal Railway. If it does not fall within the Zonal Railways jurisdiction, the proposal shall be returned back to the PTCC without any delay and the Railway to which it should be sent shall also be advised. The Railway concerned on receipt the proposal shall mark their telecom lines on the maps and submit one copy to the PTCC. The details in full of all the circuits working on the telecom alignments giving the discontinuity points and route length should be furnished.

2.6 Induced voltage calculations are calculated by the following:

Proposed Power Line	11 KV	Above 11 KV and up to 33KV Single Circuit(SC)	33KV Double Circuit (DC) and up to 132 KV	Above 132 KV
Calculation of I.V done by	DET Concerned	SLPTCC	SEB	Central Electricity Authority, New Delhi (CEA, New Delhi)

Method to calculate Induced Voltage :

The induced voltage on a telecommunication line during an earth fault on the power line is given by the expression:

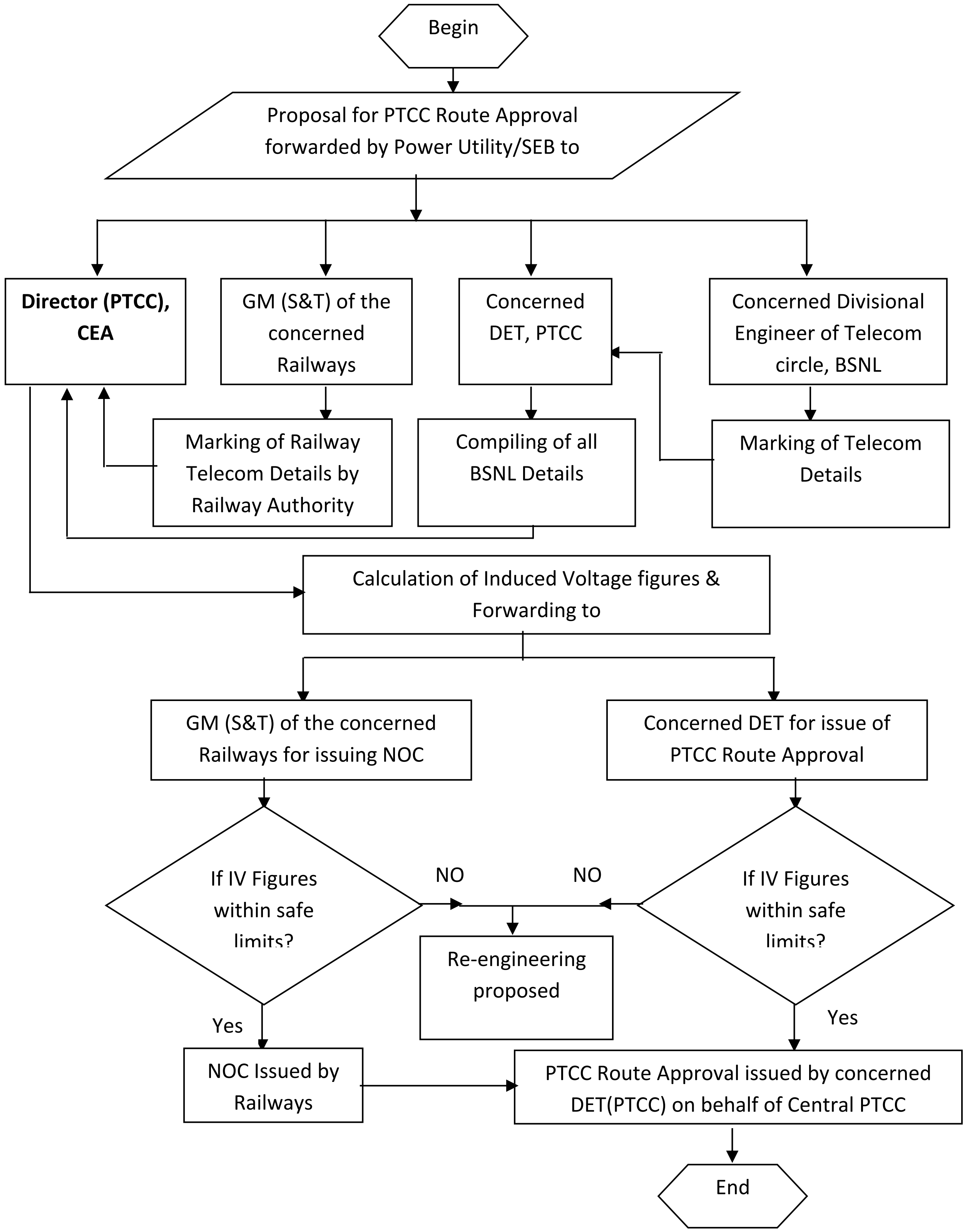
$$V = M \times I$$

Where **V** is induced voltage in Volts,
I is Earth Fault Current in Amps and
M is Mutual Coupling in Ohms between Power line and telecom line

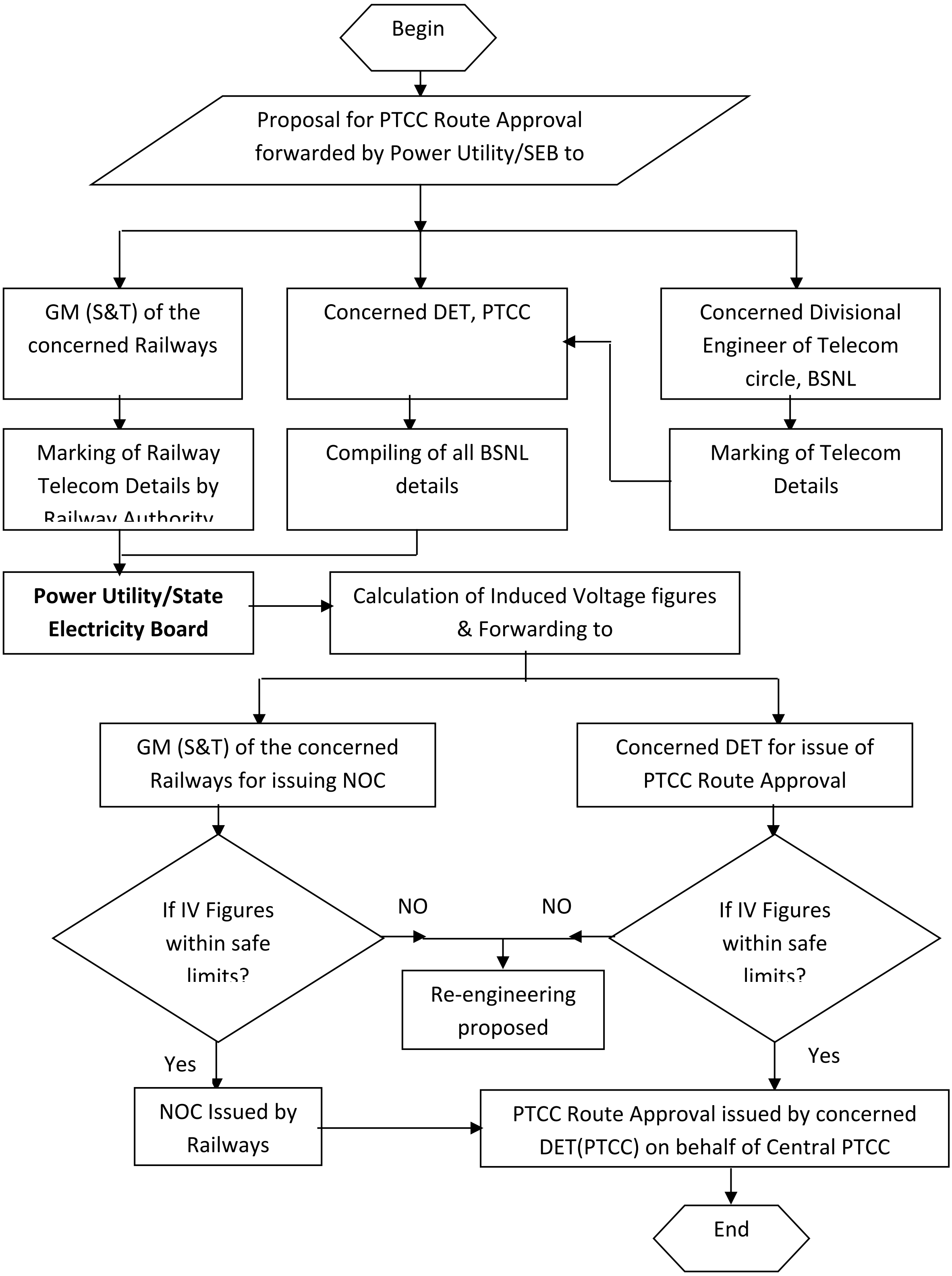
The value of Mutual Coupling (M) depends upon the distance between the power and telecom lines, the length of parallelism, the fundamental frequency of the power supply and the soil resistivity of that area.

Flow Flowchart for the processing of PTCC Route approval of Power Lines

A. Power Lines above 132KV



B. Power Lines up to 132 KV



2.7 Safe limit for induction due to Low Frequency Induction due to short circuit fault is 430V and is generally the ruling factor. In specific cases, longitudinal induced voltages under normal conditions are to be examined. In case, where the induced voltages due to short circuit fault on the telecom circuits, exceeds prescribed safe limit of 430V, it is necessary to consider various protection measures so that the equipment installed and the personnel working on these circuits are not subjected to the influence of hazardous potentials.

One of the measures commonly adopted for protection is the use of three electrode Gas Discharge (GD) tubes. Two electrodes of the tube are connected to the wires of a telephone pair and the third electrode to the earth, through the earth cap. Under normal conditions, the telecom line is kept insulated. The gap breaks-down and the telecom line is virtually earthed, when induced voltage excess the pre-determined value (250V). Through the discharge path, the earth connection to the tube should be of very low resistance so that the voltage across the tube is restricted to safer values.

Numbers of GD Tubes are required for protection:
Nos of GD tubes = Induced Voltage/Constant,   Value of constant is 300.
If value comes in fraction then it is rounding off to next integer value.
If Nos of GD tubes are 3 then two GD tubes should be installed at the ends of telecom lines in the paralleling section and one in the middle of these two.

In case the number of GD tubes worked out are more than three, two of these should be fitted at each end of the paralleling section of the telecom lines and the rest of the GD tubes be fitted in between space at equal intervals.

GD tubes worked out by the above method should be fitted on all the telecom wires in the paralleling section.

2.8 Protective measures against induced voltages in excess of the safe limits on different types of block instruments in use in Indian Railways is given in Appendix XVII to Chapter I of PTCC manual – edition 2010. The limits for the block instruments presently in use on IR are given below:

(i) SINGLE LINE BALL TOKEN/ TABLET TOKEN BLOCK INSTRUMENT

(a) For induced voltage not exceeding 430 V no special precaution is necessary.

(b) For induced voltages exceeding 430 V metallic return and appropriate Gas Discharge tubes are to be provided.

(ii) Double Line Block Instrument

As in Sl. No. (i).

(iii) Kyosan Tokenless Push Button

650 V AC with modification similar to Podanur’s Tokenless Single line block instrument as mentioned below in Item no (ix)

(iv) Diado Single Line Tokenless Block Instruments

Without modification this instrument can safely stand induction up to 74V 50 cycles AC induced voltages. For induced voltages up to 650V AC the following modification is to be made:

A-3 position polarized relay of the type used in Neale's token or SGE double line block instrument is to be interposed in the line circuit and the existing line relay (NR Relay) fed from local battery through the contacts of polarized relay. Also the line condensers C1 & C2 each of the microfarad capacity with a voltage rating of 160V are to be replaced by condensers of equal capacitance but with a voltage rating of 1000V Standard gas dischargers will also have to be provided for the lines.

(v) Push Button Type Single Line Tokenless Block Instrument

This instrument is only suitable for use in non-AC electrified sections. This instrument is safe for use in block circuits subjected to maximum induction 650V r.m.s. 50 cycles AC from neighboring power line provided the existing DC blocking condenser in the telephone circuits is replaced by a one rated for 1000V DC for non AC section only (non AC electrified).

(vi) Sectional Axle Counter for BPAC/IBS/ABS

Please refer to OEM manual for voltage limit for safe working.

(vii) UFSBI

Please refer to OEM manual for voltage limit for safe working.

(viii) Electronics Interlocking

Please refer to OEM manual for voltage limit for safe working.

2.9 Maximum acceptable limit of induced voltage due to power parallelism is up to 2000V on railway block and communication circuits subject to the specific limitations mentioned above.

The cases of induced voltages above these limits should be treated as re-engineering cases and each such case should be treated separately in consultation with the Railway Board.

2.10 Railway control/block and all other Circuits are now normally working on OFC/Quad however Railway control and other overhead circuits to be invariably provided with GD tubes on par with the protective arrangements required for protection of block circuits.

2.11 Interference to signaling circuits shall be checked up with reference to the A.C. immunity of the signaling equipment viz., track circuit relays, line relays, point machines etc. Interference voltages to signaling circuits are not provided by PTCC and will have to be done by the Railways in specific cases where interference is suspected.

2.12. After calculation of induced voltages, divisions shall be advised of the protective measures to be taken and final clearances for energization of power lines shall be given only after provision of protective measures is completed wherever necessary.

2.13 Divisions shall ensure that protective measures are maintained properly. During inspections, the availability of the protective measures at the stations shall be checked.

2.14. The expenditure for provision of the protective measures shall be deposited by the agency which carries out erection of the new power lines.

2.15. Method for carrying out low frequency induction test if required, and code of practice for protection from earth potential rise (EPR) are described in the PTCC manual. It should be ensured that the EPR at locations of telephone exchanges, cable joints, terminals, pillars, cabinets etc., is within safe limits. The EPR counters which define hazard zone for telephone plants are given below:

S.No.	Type of Telecom Plant	Type of Power System	
		High Reliability Lines	Other Lines
1.	Terminal, apparatus, joints, cabinets, Pillars, Manholes, Pins, Poles.	650 V	430 V
2.	Telephone Exchanges	430 V	430 V
3.	Cables:		
	a) Metal Sheathed	650 V	430 V
	b) Plastic insulated and plastic sheathed.	7 KV	7 KV

2.16. PTCC Monitoring cell headed by CCE/Dy.CSTE(Tele)/any nominated official by PCSTE of the railway shall monitor the timely disposal of pending and new cases. The cell shall maintain the concerned data on PC with the help of nominated official/supervisor and shall share all relevant information, calculation sheets with divisions.

Time limits for obtaining PTCC Route Approval:

(i) For Approval of 11 KV Lines – Approval by the respective DEs (Telecom)

(a) 8 weeks if the power line proposal pertains to single case.

(b) 12 weeks if the cases are referred in-group.

(ii) For 22 KV/33 KV Power Lines – Approval by the State Level

(a)	Furnishing the telecom details by BSNL/ Railway/Army etc.	10 weeks
(b)	Examining cases and computing the Induced Voltage (IV) calculations and forwarding the same to Railways, if required.	3 weeks
(c)	Forwarding recommendations by Railways	4 weeks
(d)	Final examination and issue of certificate	3 weeks

(iii) For 33 KV D/C and above up to 132 KV Power Lines (Central Cases)

(a)	Furnishing telecom details by BSNL/ Railway/Army	12 weeks
(b)	Scrutinizing the details, preparing copies & forwarding to concerned Electricity Board by DET PTCC.	2 weeks
(c)	Furnishing I.V. calculations by Electricity Board and endorsing copies to all concerned	10 weeks
(d)	Furnishing recommendations by Railway /Army	4 weeks
(e)	Final examination & Issue of certificate	4 weeks

(iv) For Approval of Power Lines above 132 KV (Central Cases)

(a)	For furnishing telecom details by BSNL/Railway/Army.	12 weeks
(b)	Scrutinizing the details, preparing additional copies and forwarding to Joint Secretary Power.	2 weeks
(c)	Furnishing Induced Voltage calculation by Joint Secretary Power & endorsing copies to all concerned.	10 weeks
(d)	Furnishing recommendations by Railway/ Army.	4 weeks
(e)	Final examination and issue of certificate	4 weeks

For protective works after the PTCC approval

(a)	For quoting the charges and furnishing Estimate	8 weeks
(b)	Arrangement for payment	8 weeks
(c)	Execution of protective works by BSNL	10 weeks
(d)	Execution of protective works by Railways	10 weeks

Notes:

1. In general, the time schedule recommended for the various functions shall not apply to cases where re-engineering is involved. Even for

such cases the appropriate authorities may quote the reasonable time required for the re-engineering.

2. The period for implementing the protective works has been recommended assuming the essential materials for those works would be available in reasonable time.

3. If the protective works are to be undertaken by the Department or Agencies other than the Unit submitting the proposal, every attempt should be made for speedy completion of the protective works. However, energization shall not take place if the protections are not completed.

4. The time prescribed may be taken as maximum.

For watch and monitoring

- Cases below 33 KV: - Necessary monitoring and watching would be done by the respective State Level PTCC Committees.

- The Standing Sub-committee will examine badly delayed cases of 33 KV D/C and above.

- Information pertaining to such cases would be called for in the prescribed form from the various DETs (PTCC) for review by the Sub-committee

Annexure-'A'

COMPOSITION OF THE CENTRAL PTCC:

<table>
<tr><td>1.</td><td>Chief Engineer (LD & T),
Central Electricity Authority,New Delhi</td><td rowspan="2">Chairman
In Alternate
Years</td></tr>
<tr><td>2.</td><td>Chief General Manager, T&D Circle
Bharat Sanchar Nigam Ltd (BSNL)
Jabalpur</td></tr>
<tr><td>3.</td><td>Director (PTCC),
Central Electricity Authority,New Delhi</td><td>Secretary (Power)</td></tr>
<tr><td>4.</td><td>Deputy General Manger, T&D Circle
BSNL, Jabalpur</td><td>Secretary (Telecom)</td></tr>
<tr><td>5.</td><td>Director (Telecom), Railway Board
New Delhi</td><td>Member</td></tr>
<tr><td>6.</td><td>Jt. DDG (ML), Ministry of Communication</td><td>Member</td></tr>
<tr><td>7.</td><td>Chairman/ Co-Chairman of SLPTCC</td><td>Member</td></tr>
<tr><td>8.</td><td>Director (GP), Ministry of Communication</td><td>Member</td></tr>
<tr><td>9.</td><td>Representative of Dept. of Power</td><td>Member</td></tr>
<tr><td>10.</td><td>A representative from the Army Headquarters</td><td>Member</td></tr>
<tr><td>11.</td><td>DDG(NE), TEC, BSNL, Hyderabad</td><td>Member</td></tr>
<tr><td>12.</td><td>DET (PTCC), T&D Circle, BSNL</td><td>Member</td></tr>
</table>

***Annexure-*'B'**

COMPOSITION OF THE COMMITTEE AT STATE LEVEL:

<table>
<tr><td>1.</td><td>GM (Telecom) of concerned Telecom Circle, BSNL</td><td rowspan="2">Chairman
In Alternate
Years</td></tr>
<tr><td>2.</td><td>Chief Engineer (Transmission) of the concerned SEBs/ State Power Transmission Corporations</td></tr>
<tr><td>3.</td><td>DGM (Telecom) who deals with PTCC matters of the Telecom Circle</td><td>Secretary (SLPTCC)
Telecom Sector</td></tr>
<tr><td>4.</td><td>SE/DGM, who deals with PTCC matters of the State Power Utility.</td><td>Secretary (SLPTCC)
Power Sector</td></tr>
<tr><td>5.</td><td>EE of Power Utility / SDE (PTCC), T & D Circle BSNL</td><td>Co-ordination Secretary</td></tr>
<tr><td rowspan="4">6.</td><td colspan="2">Other members from Power Sector</td></tr>
<tr><td>Zonal SE/ EE in-charge of PTCC</td><td>Member</td></tr>
<tr><td>Representative from any other Central/ State Power Trans. Corporation</td><td>Member</td></tr>
<tr><td>Chief Electrical Inspector or his authorized representative from state</td><td>Member</td></tr>
<tr><td rowspan="4">7.</td><td colspan="2">Other Members from BSNL</td></tr>
<tr><td>AGM (Plg) in charge of PTCC, BSNL</td><td>Member</td></tr>
<tr><td>DET (PTCC), BSNL of the concerned region</td><td>Member</td></tr>
<tr><td>Any other representative of BSNL as special invitee, as required</td><td>Member</td></tr>
<tr><td>8.</td><td>DSTE of Zonal Railway</td><td>Member</td></tr>
<tr><td>9.</td><td>Army representative of the Area</td><td>Member</td></tr>
</table>

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CHAPTER III

ROLE OF WPC AND SACFA CLEARANCES

3.1. INTRODUCTION:

3.1.1 WIRELESS PLANNING & COORDINATION WING.

The WIRELESS PLANNING & COORDINATION (WPC) Wing of the Ministry of Communications, created in 1952, is the national radio regulatory authority responsible for frequency spectrum management, including licensing and caters for the needs of all wireless users (government and private) in the country. It exercises the statutory functions of the Central Government and issues licenses to establish, maintain and operate wireless stations. WPC is divided into major sections like Licensing and Receival (LR), New Technology Group (NTG) and Standing Advisory Committee on Radio Frequency Allocation (SACFA). SACFA makes the recommendations on major frequency allocation issues, formulation of the frequency allocation plan, making recommendations on the various issues related to International Telecom Union (ITU), to sort out problems referred to the committee by various wireless users, Siting clearance of all wireless installations in the country etc.

3.1.2 The Standing Advisory Committee on Radio Frequency Allocations (SACFA) is a high level committee chaired by Secretary (DOT)/Chairman, Telecom Commission. Heads of major wireless users/administrative ministries of the Govt. of India, Member (Technology), Telecom Commission, and Wireless Adviser to the Govt. of India, Joint Secretary, DoT are its members. WPC wing of the Ministry of Communications provides secretarial help to the committee. Joint Wireless Adviser, WPC wing is the member-secretary of the Committee. Executive Director-Telecom Development (ED-TD) Railway Board is member of SACFA representing Ministry of Railways.

3.1.3 The main functions of the committee are to make recommendations on:-

- Major frequency allocation issues,
- Formulation of National Frequency Allocation Plan,
- Making recommendations on various issues related to International Telecommunications Union (ITU),
- Asia Pacific Telecommunity (APT),
- To sort out the problems referred to the committee by various wireless users, siting clearance of all wireless installations in the country, etc.

3.1.4 SACFA clearances are issued after getting 'no objection' from various SACFA members who have to carry out detailed technical evaluation including field surveys, etc. At times they have to obtain evaluations from their field units. The technical evaluation is done primarily for-

a) Aviation hazards.

b) Obstruction to line of sight of existing/planned networks
c) Interference (Electro Magnetic Interference (EMI)/Electro Magnetic Compatibility (EMC)) to existing and proposed networks.

3.1.5. SACFA Monitoring cell headed by CCE of the railway shall monitor the timely disposal of pending and new cases. The cell shall maintain the concern data on PC with the help of nominated official/supervisor.

3.2. CATEGORIES OF SITES FOR WIRELESS STATIONS:

3.2.1 Mast Height Category:

3.2.1.1 Sites for VHF/UHF:

Those fixed wireless stations whose mast/tower height do not exceed 30 meters above ground level and are operating in certain frequency bands with limited output power as given below are covered under this category:

a) (i) All VHF stations below 174 MHz with power output of 50 watts or less except broadcast stations.
(ii) All VHF stations in the frequency range 174-230 MHz with output power up to 25 watts except broadcast stations.
b) All VHF/ UHF stations with a power output of 10 watts or less.

Siting Applications of the above wireless stations are to be forwarded to the members of SACFA listed in **Annexure-I** in the application form **(WPC S-1).**

3.2.1.2 Sites for V-SAT/ Micro-Earth Stations (C-, Extended C and KU bands) with power output up to 5 watts:

(A) Antenna size- up to 4.0 Meters:

In case the total height of antenna including support structure is 30mteres or less from the ground level, the siting application need to be processed under **Mast Height Category** and Siting applications need to be circulated to members of SACFA as per **Annexure -IV** using the proforma **(WPC S-4).**

(B) Antenna size- More than 4.0 Meters:

If the antenna height is more than 4 metres but less than 20 metres AGL and the distance from airport reference point is less than 7 kms, clearance need to be obtained from Army Hqs., Air Hqs., Naval Hqs., JCES and AAI under **Mast Height Category**. If the distance of the site is more than 7 km from airport reference point and antenna height is less than 20 metres 'no objection' is to be obtained from AAI only. The siting applications of the above stations may be forwarded to SACFA members as per list at **Annexure-IV** in application form **(WPC S-4).**

3.2.2 Exemption from Mast Height Clearance:

3.2.2.1 Sites for VHF/UHF:

Those mast height cases which satisfy the following conditions are exempted from mast height clearance:-

(i) Antenna mast should be installed on the **rooftop** of the building.

(ii) The height of mast including antenna to be installed on the rooftop should not be more than **3 meters.**

(iii) The site should be at least **3 KM** away from the nearest airport.

3.2.2.2 Sites for V-SAT, Micro-Earth Stations (C, EXTENDED C & KU bands with power output upto 5 watts:

(A) Antenna size- 1.8/ 2.4 Meters:

If the antenna is to be installed on the rooftop of an existing building with mast height not exceeding 3 metres from rooftop and which is at least 3 kms away from the nearest airport 'no objection' from Department / Organization may not be necessary. These cases will be processed under **Mast Height Exemption Category**. The site details are to be furnished to Secretary SACFA in the Mast Height (VSAT) application proforma **(WPC S-4).**

(B) Antenna size- More than 2.4 Meters and up to 3.8 meters:

If the antenna diameter of VSAT is more than 2.4metres and upto 3.8 metres and antenna height up to 4 metres above ground level beyond the distance of 7 km from airport reference point (ARP) 'no objection' from any of the Departments may not be necessary. These cases will be processed under **Mast Height Exemption (VSAT).**

3.2.2.3 The procedure for fast-track clearances of applications for mast height exemption is given in Annexure IX

3.3 Full Siting Category:

The following fixed stations are covered under the full siting category:

3.3.1 (i) All VHF stations below 174 MHz with power output more than 50 watts.
(ii) All VHF stations in the frequency range 174-230 MHz with power output more than 25 watts. All UHF stations with power output more than 10 watts

3.3.2 Station in microwave, line of sight, radio-relay systems.

3.3.3 All radar stations, Satellite Communication System (including Earth stations), radio navigation and radio location system.

3.3.4 All VSATs / micro-earth stations with transmitter power more than 5 watts

3.3.5 Receiving stations in services like Space Research, Radio astronomy and other sensitive receiving systems operating above 1 Ghz.

3.3.6 Any other change in existing parameters other than reduction in power and mast height of the approved parameters.

The siting applications for the above stations are to apply to members as per list at **Annexure-II** in application form **(WPC S-2).**

3.4 <u>Additional Antenna Category</u>:

3.4.1 <u>Sites for VHF, UHF and Microwave</u>:

All those antennas which are to be installed on the existing mast, already cleared under full siting category, fall under this category. The application is to be circulated to all SACFA members as per **Annexure -III** in the application form **(WPC S-3)** but the site is cleared by SACFA Sectt after ensuring receipt of applications by all members of SACFA except cases falling under DIZ area for which clearance from JCES is necessary.

Wherever tower space is being leased to private operators, it has to be through RCIL, the application shall be processed by the private operator quoting the full siting clearance approval that was obtained by railways.

3.4.2 <u>Sites for Earth Station</u>:

The Earth Station dishes within 50 mts. from an already cleared site may be treated under this category provided the height of proposed installation, including, building height does not exceed the height of already cleared site/mast.

3.5 The procedure for fast-track clearances of applications under additional antenna category is given in Annexure-X.

3.6 <u>GUIDELINES FOR FILLING UP SITING APPLICATIONS</u>:

3.6.1. Application forms for all categories of siting may be obtained from SACFA secretariat and necessary information may be furnished keeping in view the following:-

(i) Six digit coordinates of the site are necessary. These six figure coordinates may be taken with the help of GPS system or any other method for accuracy.

(ii) The height of the site above mean sea level (AMSL) should be obtained from Survey of India or any other agency except in the case of additional antenna category for which a copy of the earlier SACFA clearance and AAIs clearance for that site is mandatory.

(iii) Name of the nearest airport and its distance from the site should be mentioned in the application for categories of siting. This information is also supplied by survey of India on demand.

(iv) If the site is within 5 kms from the airport then the site map should be authenticated by either the nearest airport authority or any other government organization such as municipal corporation/local town planning committee, etc distance of the site from airport may also be authenticated.

(v) (a) The map should be of scale of 1 cm = 1 km or nearest and should cover an area of 12 kms radius around the site.

(b) The following should be marked clearly on the map:

(i) scale of the map

(ii) location of the site

(iii) name and geo-coordinates of the site

(c) Map should contain at least two parallel lines of latitude and longitude.

(vi) Geo-coordinates of the site on the map should be authenticated by the applicant himself.

3.6.2 Applications hard copy along with soft copy be submitted for examination, verification and issue of ID Nos. to SACFA secretariat. Software is available from SACFA Secretariate.

3.6.3 Not more than 5 applications should be submitted in one bunch.

3.6.4 Separate application forms are to be filled for different frequency band and different site.

3.6.5 After issue of ID Nos., siting application is to be circulated as per list applicable to each category of siting clearance. A forwarding letter issued by SACFA is also to be attached with the siting application.

3.6.6 The applications for additional antenna category need to be circulated to all members of SACFA but no NOC from any member is necessary for approval of site except sites which fall in DIZ area for which NOC from JCES is necessary.

3.6.7 A copy of the agreement letter assigning the frequencies from WPC should be attached with application.

3.6.8 A copy of DOT’s license agreement may also be endorsed in case of value added service.

3.7 CLEARANCE OF SACFA CASES FROM RAILWAYS

On receipt of the proposal for site clearance the following aspects have to be checked from railways activity point of view:

3.7.1 **FREQUENCY**: The frequency of the proposal and the band at which it is proposed is to be cross checked with the allotted frequencies and frequency bands of Railways and clearance can be given if it is not interfering with Railway frequency.

In case if the proposal frequency and band are adjacent to the railway working frequency a condition has to be imposed in the no objection certification that permission is given provided the transmission won't interfere with the railway frequency.

3.7.2 **SITE**: The Longitude and Latitude of the proposed site has to be cross checked with the existing Longitude and Latitude of the railway communication site. If the Longitude and Latitude are very near to the railway site, the locations have to be physically checked on the topography map for clearance of signal.

3.7.3 **TOWER HEIGHT**: When the proposal is near to Longitude and Latitude for the railway site then the tower height proposed has to be cross checked for any interference in the path of the railway communication.

3.7.4. **TRANSMITTER POWER**: The transmitter power of the proposal has to be cross checked whenever the proposal is nearer to the railway site and a conditional certificate should be given for avoiding spurious signal from the transmitter.

3.8 Further information on the role of WPC and SACFA and the procedures to be followed can be obtained from https://dot.gov.in/spectrum-management/2457.

ANNEXURE-I

List of SACFA members to whom the application for
<u>Mast Height (general)</u> Category needs to be circulated

Name & Designation	Deptt.	Address for communications	No. of copies to be sent
Addl. Director General (TT)	Army Hqrs.	Room No. 634, A-Wing, Sena Bhavan, New Delhi – 110011.	2
Director (Signals)	Naval Hqrs.	Room No.33, Sena Bhavan, C-Wing, New Delhi 110011.	2
Principal Director (Sigs)	Air Hqrs.	Room No. 514, Vayu Bhavan, New Delhi – 110011.	2
General Manager (ATM)	AAI	Room No. 128, Rajiv Gandhi Bhavan, Safdarjung Airport,New Delhi – 110003	2
Joint Wireless Adviser, Secretary, SACFA	WPC Wing	Room No 607, Sanchar Bhavan,New Delhi - 110 001	2
Director	JCES	Cabinet Secretariat, Military Wing,Room No. 5, Plot No.108, Church Road, New Delhi.	1
Director General	IMD	Room No. 606, Mausam Bhavan, Lodhi Road, New Delhi-110003	1

ANNEXURE –II

List of SACFA members to whom the siting application under full siting category need to be circulated

Name & Designation	Deptt.	Address for communications	No. of copies to be sent
Engineer in Chief	All India Radio	Room No.141 Akashvani Bhavan, Parliament Street, New Delhi -110001.	1
Engineer in Chief	Doordarshan	Room No.502 Mandi House, Copernics Marg, New Delhi-110001	1
Director	JCES	Cabinet Secretariat, Military Wing, Room No. 34, Plot No.108, Church road, New Delhi.	1
VSM, Addl. Director General (TT)	Army Hqrs.	Room No.634, A-Wing ,Sena Bhavan, New Delhi – 110011.	4
Director (Signals)	Naval Hqrs.	Room No. 33, Sena Bhavan, C-Wing, New Delhi-110011	1
Principal Director(Sigs)	Air Hqrs.	Room No.514, Vayu Bhavan, New Delhi-110011.	1
Sr. DDG (TX)	BSNL	Room No.601, Statesman House, Barakhamba Road, New Delhi - 110001.	2
Director	DCPW	Room No.300, Block No. 09, CGO Complex, Lodhi Road, New Delhi-110003.	4
Executive Director (Telecom)	Ministry of Railways	Room No. 152, Railway Board, Rail Bhavan, New Delhi- 110 001.	A list of sites circulated to the concerned Rly. Zones
General Manager (ATM)	AAI	No.128, Rajiv Gandhi Bhavan, Safdarjung Airport, New Delhi-110003.	1
Director (Electronic)	Light house and light ships, Ministry of Transport	A-13, Sector 24, NOIDA, Gautam Buddha Nagar. UP- 201301.	1
Dy. General Manager (TP)	VSNL	Room No.400, 4th Floor, Videsh Sanchar Bhavan, M.G. Road, Fort, Bombay-400001.	1
Director General	IMD	Room No.606, Mausam Bhavan, Lodhi Road, New Delhi 110003	1

Director	DOS	Room No.304, Antariksh Bhavan, ISRO Hqrs., Frequency Management, New Bel Road, Bangalore – 560094.	1
Chief Engineer (E&T)	ONGC	12th Floor, Scope Minar, Laxmi Nagar, Vikas Marg, New Delhi 110092.	3
Sr. Director	Deptt. Of Information Technology	Room No.4003, Electronics Niketan, 6, CGO Complex, Lodhi Road, New Delhi – 110003.	1
DDG	NIC	Room No.227, NIC Building, CGO Complex, Block-A, Lodhi Road, New Delhi – 110003.	1
Director (WM)	Wireless Monitoring Organisation (DOT)	Room No 321, Wireless Monitoring organization, E-Wing, Pushpa Bhavan, New Delhi – 110062.	1
Joint Wireless Adviser Secretary, SACFA	WPC WING	Room No 607, Sanchar Bhavan, New Delhi - 110 001.	2

ANNEXURE -III

List of SACFA members to whom the siting application for additional antenna category needs to be circulated

Name & Designation	Deptt.	Address for communications	No. of copies to be sent
Engineer-in-Chief	All India Radio	Room No.141, Akashvani, Bhavan Parliament Street, New Delhi - 110001.	1
Engineer-in-Chief	Doordarshan	Room No. 502, Mandi House, Copernics Marg, New Delhi –11.	1
Director	JCES	Cabinet Secretariat, Military Wing, Room No. 5, Plot No.108, Church Road, New Delhi.	1
Addl. Director General (TT)	Army Hqrs.	Room No. 634, A-Wing ,Sena Bhavan, New Delhi – 110011.	1
Director (Signals)	Naval Hqrs.	Room No.33, Sena Bhavan, C- Wing, New Delhi 110011.	1
Principal Director(Sigs)	Air Hqrs.	Room No. 514, Vayu Bhavan, New Delhi – 110011.	1
DDG(TX)	BSNL	Room No. 601, Sanchar Bhavan, 20, Ashoka Road, New Delhi - 110 001.	2
Director	DCPW	Room No.300, Block No. 09, CGO Complex, Lodhi Road, New Delhi – 110003.	1
Executive Director (Telecom)	Ministry of Railways	Room No.152, Railway Board, Rail Bhavan, New Delhi - 110 001.	1
General Manager (ATM)	AAI	Room No. 128, Rajiv Gandhi Bhavan, Safdarjung Airport, New Delhi – 110003.	1
Director (Electronics)	Light house and light ships, Ministry of Transport	A-13, Sector 24, NOIDA, Gautam Buddha Nagar, UP – 201301	1
Director General	IMD	Room No. 606, Mausam Bhavan, Lodhi Road, New Delhi-110003	1
Director	DOS	Room No. 304 , Antariksh Bhavan, ISRO Hqrs., Frequency Management, New Bel Road, Bangalore - 560094	1
Chief Engineer (E&T)	ONGC	12th Floor, Scope Minar, Vikas Marg, Laxmi Nagar, New Delhi-110092.	1

Sr. Director	Ministry of Information Technology	Room No4003, Electronics Niketan, 6, CGO Complex, Lodhi Road, New Delhi – 110003.	1
DDG	NIC	Room No.227, NIC Building, CGO Complex, Block-A, Lodhi Road, New Delhi –110003.	1
Director (WM)	Wireless Monitoring Organisation (DOT)	Room No 321, Wireless Monitoring organization, E-Wing, Pushpa Bhavan, New Delhi-110062	1
Joint Wireless Adviser Secretary, SACFA	WPC WING	Room No 607, Sanchar Bhavan, New Delhi - 110 001.	2

Annexure-IV

List of SACFA members to whom the application for mast height clearance (V-Sat) needs to be circulated

Name & Designation	Deptt.	Address for communications	No. of copies to be sent
Addl. Director General (TT)	Army Hqrs.	Room No. 634, A-Wing, Sena Bhavan, New Delhi – 110011.	2
Director (Signals)	Naval Hqrs.	Room No.33, Sena Bhavan, C- Wing, New Delhi 110011.	2
Principal Director(Sigs)	Air Hqrs.	Room No. 514, Vayu Bhavan, New Delhi – 110011.	2
General Manager (ATM)	AAI	Room No. 128, Rajiv Gandhi Bhavan, Safdarjung Airport, New Delhi – 110003.	2
Joint Wireless Adviser Secretary, SACFA	WPC WING	Room No 607, Sanchar Bhavan, New Delhi - 110 001.	2
Director	JCES	Cabinet Secretariat, Military Wing,Room No. 5, Plot No.108, Church Road, New Delhi.	1
Director General	IMD	Room No. 606, Mausam Bhavan, Lodhi Road, New Delhi-110003	1

ANNEXURE-V
WPC S-1

Application form for Mast Height (General)

1 ID Number & Date

2 Name of Applicant

3 Address of applicant

4 Transmitter power (in watts)

5 Frequency/Frequency band of operation

6 Antenna location

7 Lattitude/longitude (six digit)

8 Height of site above mean sea level

9 Height of antenna mast above ground (building height to be included if it is to be installed on the roof top)

10 Height of building

11 Name of the nearest Airport

12 Distance of the site from the nearest airport

13 Location map with boundary reference

14 Ministry’s reference with date vide which frequencies earmarked (A copy of agreement to be attached)

15 Remarks

Signature of Applicant

ANNEXURE-VI

WPC S2

Application form for Full Siting Category

1 Service

2 ID number and date

3 Name of Applicant

4 Address of Applicant

5 Transmitter power (in watt)

6 Frequency/Freq. band of operation

7 Antenna location

8 Latitude and longitude (six digit)

9 Height of site above mean sea level

10 Height of antenna mast above ground level

11 Height of building if antenna is to be installed on the roof top

12 Type of antenna and its size

13 Azimuth of maximum radiation

14 Gain of Tx. Antenna (db)

15 Gain of Rx antenna (db)

16 Beam width (in degree)

17 Name of the nearest airport

18 Distance of the site from the nearest airport

19 Receiver location

20 Nature of service

21 Circuit/hop length

22 Approx. area covered by antenna location

23 Service area

24 Location map

25 Ministry's reference and date

26 DOT agreement number and date, if required

27 Remarks

(Signature of Applicant)

ANNEXURE-VII
WPC S-3

Application form for Additional Antenna Category

1	Service
2	ID number and date
3	Name of Applicant
4	Address of Applicant
5	Transmitter power (in watt)
6	Frequency/Freq.band of operation
7	Antenna location
8	latitude and longitude(six digit)
9	Height of site above mean sea level
10	Height of antenna mast above ground level
11	Height of building if antenna is to be installed on the roof top
12	Type of antenna and its size
13	Azimuth of maximum radiation
14	Gain of Tx. Antenna (db)
15	Gain of Rx antenna (db)
16	Beam width (in degree)
17	Name of the nearest airport
18	Distance from the site
19	Receiver location
20	Nature of service
21	Circuit/hop length

22 Approx .area covered by antenna location

23 Service area

24 Ministry's reference and date

25 DOT agreement number and date

26 Earlier SACFAreference vide which site cleared

27 Remarks

(Signature of Applicant)

ANNEXURE-VIII
WPC S-4

Application form for Mast Height (VSAT)

1	ID number and date
2	Name of Applicant
3	Address of applicant
4	Transmitter power (in watts)
5	Frequency/Frequency band of operation
6	Antenna location
7	Latitude/longitude (six digit)
8	Height of site above mean sea level
9	Height of antenna mast above ground (building height to be included if it is to be installed on the roof top)
10	Height of building
11	Type of antenna and its size
12	Azimuth of maximum radiation
13	Gain of Tx antenna (db)
14	Gain of Rx antenna (db)
15	Name of the nearest Airport
16	Distance of the site from the nearest airport
17	Location map with boundary reference
18	Ministry’s reference with date vide which frequencies earmarked (A copy of agreement to be attached)

19 D o T agreement number and date

20 Remarks

<u>Signature of Applicant</u>

ANNEXURE-IX

F.No. K-19012/Misc./2005-CFA
Government of India
Ministry of Communications & IT
Department of Telecommunication
WPC Wing

Sanchar Bhavan
New Delhi-110001
Dated: 27th July, 2005.

OFFICE MEMORANDUM

Sub: Simplified procedure for sites falling under "Mast Height Exemption Category".

In case of sites for VSATs and other masts/antennae for various applications falling under "Mast Height Exemption Category", the following procedure comes into force with immediate effect.

2. For the sites falling under "Exemption from Mast Height Clearance", the applications are to be filed online like other SACFA siting applications. Signed hard copies along with the details of ID numbers and the required amount of Bank Draft be submitted to SACFA Secretariat.

3. In addition, a consolidated list of such sites along with the details as per the prescribed format **(Annex-1)** are to be submitted in duplicate.

4. An earnest money of Rs. 1000/- (Rupees One thousand only) per site in the form of State Bank of India Demand Draft, drawn in favour of The Pay & Accounts Officer (HQrs), Department of Telecommunications, payable at New Delhi, is required to be submitted.

5. An undertaking as per **Annex-2** shall also be submitted by the applicant.

This procedure supersedes all earlier OMs in this regard.

---s/d---
(D.SINGARAVELU)
Deputy Wireless Adviser
to the Government of India

Annex-1

Details of VSATs and other masts/antennae sites under 'SACFA Mast Height Exemption Category"

1. Name, address of the Organisation /VSAT Service Provider :
   Tele & Fax No. :
   E-mail address :

2. Name of the Hub Station for the network:
   Reference of WPC Licence No./ :
   Decision letter for the network :
   (for masts/antennae of other applications this is not applicable)

SACFA ID	Location /address of VSAT/ mast	Location Longitude	Location Latitude	Frequency band of operation	Size of Antenna / VSAT	AMSL (meters)	Height of Building above ground (meters)	Name of the nearest airport	Distance of the airport from the site (KMs)

Annex-2

UNDERTAKING

Whereas M/s.___________________________________, a company incorporated under the Companies Act, 1956, having its registered office situated at _______________________ is a provider of VSAT Service.

AND for the purpose of VSAT Service, M/s. _______________________________ as aforesaid applied for Licence / permission from Government of India on its own volition and has agreed to abide by terms and conditions relating to the VSAT licence etc.

AND the M/s._________________________________ has installed VSAT stations some of which fall under " SACFA Exemption Category", full details and Particulars of which are given above (in Annex-I appended hereto).

I, _________________________, Son/Daughter of Shri__________________, resident of __________________________________ and Owner/Managing Director/Director/Partner/Authorised Signatory; for and on behalf of the above said company do hereby undertake that all the VSATs as detailed above (in Annex-I) have antenna size up to 2.4 meter diameter and use RF Power up to 5 watts.

I further undertake that all the terms and conditions framed regarding VSATs will be fully observed, and in the event of any violation of such terms and conditions or furnishing of wrong information above (in Annexure I) or otherwise, I and M/s. _______________________________________shall indemnify jointly and severally the WPC Wing, Department of Telecommunications (DOT) against all third party claims and shall accept full responsibility and liability for the same, including any penalty or, dismantling of the VSAT (at our cost) and / or cancellation of the wireless licence, as decided by the WPC Wing, Department of Telecommunications.

Signed on _________day of __________________Two thousand Five by Shri _______________________ holder of General Power of Attorney executed pursuant to the Board resolution dated ______________________.

Date: (Signature)
Place: (Name & Designation of the Authorised Signatory)

(Name & Address of the Service Provider Company)

In the present of Witnesses:

1.

2.

(Note: For masts/antennae for other applications, the Undertaking may be modified accordingly)

ANNEXURE-X

Fast track site clearances for additional antennae

K-16011/05/2002-CFA
Government of India
Ministry of Communications & Information Technology
Department of Telecommunications
Wireless Planning and Coordination Wing

223-B, Sardar Patel Bhavan,
Parliament Street, New Delhi 110001
Date: 03.07.2002

OFFICE-MEMORANDUM

Subject:Fast track site clearances for additional antennae

Kindly refer to agenda item no. 5 of Summary Record of 137th meeting of SACFA held on 28.05.2002 where BSNL representative informed pendency of their cases for additional antennae despite involvement of less number of SACFA members. After detailed discussion, it was decided that no NOC (s) from SACFA members will be required for siting cases falling under additional antenna category. However, siting applications are to be circulated to all members of SACFA and their receipt is to be ensured. After ensuring receipt of such cases, SACFA Sectt. will issue necessary clearances for sites falling under additional antenna category.

The following modified procedure for additional antennae cases will be followed in future-

- Applicant will apply to SACFA Sectt in a prescribed proforma available with SACFA Sectt for which softcopy may be obtained from SACFA Sectt for obtaining ID numbers.
- Applicant will enclose a copy of earlier SACFA clearance, NOC received from AAI with regard to site under consideration if site was cleared after 1995 and appropriate map indicating the site.
- Applicant will be issued ID numbers after scrutinizing applications for correctness.
- When applicant informs SACFA about likely date of circulation of siting applications, he will be issued circulation letter meant for all members of SACFA, which he will attach with applications and circulate within a week's time.
- Applicant will obtain acknowledgement slip in token of receipt of his applications by SACFA members.
- Applicant has to submit a copy of frequency agreement letter issued by WPC at the time of obtaining SACFA clearance.
- Applicant will be issued SACFA clearance within a short time after confirming receipt of applications through receipts

---s/d---
(Deepa Aggarwal),
Assistant Wireless Adviser
For, Secretary, SACFA

-x-x-x-

CHAPTER IV

COMMUNICATION REQUIREMENTS FOR NEW STATIONS/SECTIONS

4.1 Opening of new stations whether in an already existing line or as part of a new section shall be governed by “Rules for opening of a Railway”.

4.2 Communication systems for new sections shall be planned on underground OFC & Quad cable and/or on modern cellular communication duly suited for Train Traffic Control such as GSM-R/LTE. Suitable system to meet the future communication requirement of the section shall be planned. Adequate capacity shall be built in to meet the safety requirements of block working, TAWD, BPAC, TCAS, emergency requirements for accident communication etc. and Data communication requirements of UTS,PRS,FOIS,COIS, Datalogger, SCADA, Control, VSS, WiFi etc.

4.3 Communication arrangements at a new station shall be governed by:

a) Controlled / Uncontrolled section.
b) Electrified/Non-electrified section.
c) Importance in terms of the various departmental staff to be posted at the station.
d) classification of station on commercial ground as per latest guidelines

4.4 The following communication arrangements shall be provided at new stations:

a) Control telephone (2-wire/4-wire/VoIP based) in controlled sections.
b) Phone communication to all manned level crossing gates controlled from the station preferably with voice logging facility.
c) 25W VHF sets with proper standby power supply.
d) Communication arrangements with sidings. Mode of communication shall be decided by the Railway administration, depending on the importance of the siding.
e) BSNL phone wherever feasible with Caller ID. In the absence of feasibility for land line BSNL phone, FCT of CUG or any other service provider shall be provided.
f) At new stations, if feasibility exists, Railway auto phone facility may be provided with the help of IP exchanges installed at another location. At important stations, telephone exchanges shall be provided where there is a sizable establishment for railway working. Wherever feasible, such exchanges shall be connected by suitable means to the divisional exchange with path redundancy as in ring/mesh/star network.
g) At all new stations, communication arrangements may be provided to Officer/SSE/JE/Technician and ASM office through CUG/Railway auto phone/control phone if required.
h) In a new section, communication arrangements for block working to suit the system of working to be followed shall be provided.
i) In electrified territory, TPC phones shall be provided.

j) Provision for telecom circuits/network for Railnet with IP DSLAM & LAN extender/FOIS/UTS & PRS and other important telecom facilities.

k) OFC and QUAD cable to be laid for SSP/SP/TSS for SCADA working.

l) Gate phone for communication Gateman and Station Master to be provided as per requirement.

4.5 Additional communication facilities to be provided in new electrified sections, shall be governed by the provisions in Chapter - IV of the 25KV AC traction manual.

4.6 All the communication equipment shall be provided with suitable power supply, power backup and proper protective arrangements.

4.7 All the communication equipment and power supply units shall be properly earthed and suitable lightning and surge protection arrangements shall be provided.

4.8 Besides telecommunication facilities, one or more of the following facilities are to be provided depending on the requirement of the station as per the latest Railway Board's guidelines.

a) GPS /Precision Platform clocks.
b) PA systems for announcements on the platforms.
c) IPIS/Train/Coach Indication Boards
d) VSS/CCTV and WiFi
e) Other facilities such as Fare display board, face to face counter communication etc. required by division

4.9 Telecom power supply should be monitored through data-logger/NMS (Network Monitoring System). It is desirable to get it monitored by generating SMS alerts from suitable gateway to the concerned section in-charges.

4.10 S&T DG supply should be extended to OFC/Telecom Room. In electrified sections, in addition to normal supply, AT supply, both UP and DOWN, to be extended to telecom equipment also, through separate fuse/MCB of suitable capacity (minimum 10 Amp).

4.11 All telecom equipment should preferably work on -48 V DC supply to avoid multiplicity of power supplies. Otherwise, wherever feasible, separate IPS type of power supply arrangement to be provided for all the telecom equipment together.

4.12 Cables used for Telecom Equipment should be properly dressed up and covered in station areas and buildings to maintain the reliability and aesthetic. Separate duct arrangement for all Telecom cables should be provided on all platforms of stations.

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CHAPTER V

TRAIN TRAFFIC CONTROL

5.1 GENERAL

5.1.1 RAILWAY CONTROL CIRCUITS: Railway Control Circuits are omnibus telephone circuits which provide communication with each train working point, thus facilitating efficient train operation. They should provide satisfactory and reliable communication between the controller and the various way-side stations, important signal cabins, loco sheds, yard offices etc. There should be provision of Voice Data Logger/ Monitor for Control Circuits

5.1.2. TYPE OF CONTROL SYSTEM: According to traffic requirements and to cater to the needs of Electric Traction area, a section may be provided with one or more Railway Control Circuits as detailed below:

a) SECTION CONTROL / TRAIN CONTROL: This is provided for communication between the Section/Train Controller in the control office and way-side stations, junction station, block cabins, loco sheds and yards in a division for the control of train movements and effective utilization of section capacity.

b) DEPUTY CONTROL: If required by division, this is provided for communication between the Deputy Controller in the control office and important stations, junctions & terminal stations, yard master's offices, loco sheds and important signal cabins in a division for supervisory control of traffic operation in general.

c) TRACTION POWER CONTROL: Provided between traction power controller and SM's Office, FPs/SPs/SSPs for maintenance of OHE system.

d) Remote Control for Supervisory Control and Data Acquisition System: SCADA is provided between traction power controller and FPs/SPs/SSPs for various data acquisition and remote control of OHE energisation/de-energisation etc. purpose.

e) EMERGENCY CONTROL: Provided from selected points along the track route for establishing communication between train crew (in case of emergency), traction and permanent way staff with traction power controller and with section controller in non-RE area if control office does not have traction power controller. The emergency sockets are provided at an interval of 1 Km (Max.) along the route. They are also provided at FP/SP/SSPs, isolators in yards, LC gates and both sides of major bridges. Emergency control can be dispensed with specific approval of the Railway Board wherever any other form of emergency communication (MTRC etc.) is commissioned and put into use.

f) EMERGENCY WIRELESS CONTROL COMMUNICATION: The following equipments can also be utilized for emergency wireless communication where such system exists:-

a. Handsets for Mobile Train Radio Communication (MTRC) in sections.
b. Handsets (Official or Private) for Cellular Mobile Communication in sections.
c. Walkie-Talkie sets in sections where VHF communication from train to control office has been provided in lieu of any physical medium or MTRC.

Any other form of emergency wireless communication shall have the specific approval of the Railway Board.

5.1.3 REQUIREMENTS FOR TRAIN TRAFFIC CONTROL SYSTEM :
Train Control systems shall fulfill the following requirements :-

a) Facilities should be provided to section controllers for selectively calling one or a group of stations or all stations.

b) Push buttons of non-locking type or soft keys/tabs/buttons in case of touch screen based dialing equipment shall be provided for selective calling of any station by the controller.

c) The station masters shall lift their control phone and it should be possible to directly talk to the section controller with no dialing or minimum dialing. The control phone shall have a non-lockable type press-to-talk switch for enabling the speech transmission of the station master so as to minimize background noise while in listening-only mode. However in CCEO/VOIP control communication system, PTT switch is not mandatory.

d) Means shall be provided to automatically inform the section controller whenever the bell/buzzer at the station rings in response to the call initiated by him.

e) The signalling used for selective calling shall not hamper normal telephone conversation on the line.

f) Feature of prolonged ringing of any way-station shall be provided.

g) The equipment should be rugged and capable of intensive use.

h) The equipment should work satisfactorily within allowable margins of line characteristics without frequent critical adjustments.

i) The system should be capable of progressive expansion without any replacement.

j) Earth return circuits shall not be retained on AC traction and all Telecom circuits shall work on metallic return or OFC.

k) Facility shall be provided in the control office for transferring/conferencing Emergency Control (wherever exists) to the Section Control circuit.

l) No overhead Railway telecom alignment is permitted over Indian Railway. However in unavoidable cases local Railway administration can give permission for temporary overhead telecom alignment for a temporary period not exceeding 3 months which may be extendable by further 3 months period.

m) Provisions must be made to record the control communication with time stamps.

n) Multiple protection paths with route & service provider diversities shall be provided to ensure high reliability of control communication circuits,

5.1.4 INTERCOMMUNICATION BETWEEN LOCAL TELEPHONE AND CONTROL CIRCUIT

a) It is also desirable to make provision of an approved type to interconnect the local telephone exchange with important control circuits to enable important officials served by the local telephone exchange to gain access to such control circuits with or without the assistance of an operator.

b) Such a provision shall not affect the performance of the control circuits from the point of view of signalling or speech.

c) Whenever interconnection is made through an operator, the manual board shall be provided with necessary supervisory facilities so that the telephone connected to the exchange is disconnected from the control circuit as soon as the conversation is over.

d) It should be ensured that only important officials have access to control circuits in this manner.

5.1.5 TYPES: In one control section, only one type of equipment should be provided to ensure ease of maintenance and inventory management. Traffic Control Equipment shall be of the following or any other approved type.

a) DUAL TONE MULTIFREQUENCY SYSTEM: In this system two frequencies are being transmitted simultaneously as per the standard DTMF Frequencies plan given in Annexure-I with 2 digit code to call either one station at a time or a nominated group at a time or all at the same time.

b) CCEO: Control Communication Equipment for OFC System (CCEO) is being used for Control Communication between Control office and way stations. This system permits working of voice communication and signaling through an Optical Fibre Communication System and also works through quad cable with some changes of input and output impedances.

c) VoIP Based Train Control Communication System: Voice over internet protocol based train control communication is to make use of the standard, modern and widely proven Internet Protocol technology as a platform. This enables use of common infrastructure for voice and data services. This system provides many additional features such as caller ID, call logs, different ringtones etc.

5.1.6 INTERCOMMUNICATION EQUIPMENT: All controllers in a control office shall be provided with an intercommunication system covering local requirements with facilities for each controller to call any other controller, including Deputy Controller, Chief Controller and the Technician/JE/SSE(Tele) on duty.

5.2 DUAL TONE MULTI FREQUENCY CALLING SYSTEM.

5.2.1 (a) This system for train traffic control equipment with voice frequency signaling using Dual Tone Multi Frequency(DTMF) signals for 4 Wire and 2 Wire operation is known as DTMF Calling System.

(b) The control office equipment is normally designed for 4 Wire operation which can be converted into 2 Wire operation by provision of hybrid attachment. The way station equipment shall be different for 4 Wire and 2 Wire working.

5.2.2 CONTROLLERS EQUIPMENT: The control office equipment consists of an operating console with DTMF code generator and voice communication equipment.

(i) The operating console with code generator has following facilities :

a. Standard 16 key DTMF Key Pad for calling 99 stations with two push button operation.

b. Station group code buttons A, B, C, D. and some additional buttons (4). Some buttons are used for Special Functions such as –

c. Push button (marked ‘G’) for general call for calling stations simultaneously.

d. Push button LR for extending long ring at way stations.

e. Special push button 'RT' - for repeating last transmitted station code. 'RS' - to reset the system 'RC' - for row/column frequency check. 'DL' - for cancellation of code.

f. Visual indications for “System O.K”., “Display of station code” and “power ON” indication.

(ii) The communication equipment consists of loudspeaker/microphone with amplifiers and hand micro telephone and controllers headset.

5.2.3 WAY STATION EQUIPMENT: The way station equipment shall consist of DTMF decoder which can be assigned any DTMF station code/group code selectable with DIP switches, voice communication equipment and 2-Wire/4-Wire desk type control telephone.

5.3 **CCEO System:**

5.3.1 The CCEO (Control Communication Equipment for OFC) is an advanced equipment connected to traditional control communication system on OFC as per RDSO Specification No. RDSO/SPN/TC/66/2007 or latest. The main equipment is kept in OFC hut itself and it works only on standard telecom supply (-48 V DC). No other DC power supply is required for normal PSTN analog handset.

5.3.2 Components of the CCEO system

S.No.	Name of the Segment or Unit	Part of
1.	Control Room Equipment (CRE)	Headquarters Equipment
2.	Test Room Equipment (TRE)	
3.	Local Telephone Equipment (LTE)	
4.	Multi Telephone Way station Equipment (MTWE)	Way station Equipment at OFC hut.
5.	Three Way Amplifier (TWA)	
6.	Remote Patching Equipment (RPE)	
7.	Two-Wire Dialing Control Telephone (TDCT)	Way station equipment with the ASM.

5.3.3 Control Room Equipment (CRE): This equipment is provided on the controller’s desk. Using this equipment the controller can selectively call any way station or any local telephone, TDCT (Two wire Dialing Control Telephone), of any way station and can speak to it.

5.3.4 Test Room Equipment (TRE): This unit is provided in the test room for carrying out maintenance and testing functions on way station equipment.

5.3.5 Local Telephone Equipment (LTE): The LTE is used to provide 20 local telephones at Head Quarter.

5.3.6 Multi Telephone Way station Equipment (MTWE): This unit is provided at every way station and it is connected to the VF channel from the PD Mux on

OFC system by a 4-wire cable. It gives a facility to connect maximum 4 control telephones at a way station.

5.3.7 Three Way Amplifier (TWA): The TWA unit is used when the number of telephones required at a way station is more than four which is the maximum capacity of a MTWE unit. By using TWA one more MTWE can be provided at a way station.

5.3.8 Two-Wire Dialing Control Telephone (TDCT): The Two-wire Dialing Control Telephone (TDCT) is the standard telephone instrument with a handset and a numeric dial. Each TDCT is connected to MTWE with a twisted pair having a loop resistance of less than 1200 Ohm.

5.3.9 Remote Patching Equipment (RPE): The function of RPE is to provide patching between the two 4-wire VF control circuits available on the OFC system. The patching can be effected locally from the way station where the RPE is provided, or remotely from the test room.

5.4 VoIP based Train Control Communication System

5.4.1 VoIP Based TCCS is the latest among the various control communication systems being used in Indian Railways as per RDSO specification. It leverages open standard IP technology to provide control communication thereby reducing dependence on railway specific equipment/ technology which limits market driven innovation. It provides the benefit of economy of scale and open market competition using common network infrastructure for voice, video and data

5.4.2 The VoIP based TCCS has three major components:

1. Control Communication network (CCN).
2. HQ equipment/servers for control communication
3. Waystation equipment including control phones.

5.4.3 It is desirable that the Control Communication Network be kept logically separate from other networks for performance and security. It may be devised using traditional IP components or can be designed as a L3 VPN on Railways MPLS/SDH infrastructure.

5.4.4 CCN should be designed in such a way that it has sufficient OFC paths available either in the Railways OFC or through other service providers network. This shall provide very high redundancy.

5.4.5 OSPF shall be used as the routing protocol.

5.4.6 All Equipment of VoIP based TCCS shall be monitored through an NMS and it is desirable to monitor through mobile dash-boards also.

5.4.7 It is important that the system is secure, easy to configure and maintain. Hence, it is desirable that all the VoIP equipment used in this system are remotely manageable and capable of picking their configuration from a central location.

5.4.8 One communication server shall be used for all the control Boards of the division along with redundant server. It is desirable to keep them at separate networks/locations in the division.

5.4.9 The communication server shall be connected to the Railway exchange using a suitable interface. It must be possible for the controller to dial a railway number and make the subscriber a part of the control conference.

5.4.10 CCN may be used to provide railway auto phones at stations.

5.4.11 Divisions may use either IP control phones or PSTN analog phones at way stations with suitable interface. However, the controller should have a suitable robust dialing arrangement for ease of operation.

5.4.12 Time in all the IP equipment in the CCN shall be synchronized with the communication server. The control communication server may also work as NTP server and shall provide timing information to all the VoIP/IP equipment in the CCN.

5.5 INSTRUCTIONS FOR INSTALLATION

5.5.1 LAYOUT OF CONTROL OFFICE:

a) Control offices and the attached test rooms shall be air-conditioned with provision of emergency exit.

b) The layout of the control office shall, as far as possible, conform to the layout shown in Annexure II. They should be located, as far as possible, in the ground floor.

c) Control offices, especially the controller's booths, shall be acoustically treated to eliminate disturbing noises, echoes, etc., to enable use of microphones and loudspeakers. The reverberation constant of the booth shall not be more than 0.4 seconds.

d) All equipment except those required for operation by the controllers, especially equipment producing noise during operation, shall be located in a different room outside the control office.

e) Batteries, especially secondary cells, shall be located in a separate room outside the control office.

f) The test room shall be located as close to the control office as possible to enable the test room staff to attend to any fault promptly.

g) The test room shall have enough floor area to accommodate the test panel and maintenance spares required for the various equipment. It shall also accommodate tables and chairs for the maintenance staff to carry out overhauling, repairs and maintenance.

h) While planning a control office, space required for future additions and alterations should be kept in view.

i) Adequate space should also be earmarked for stationery and filing cases.

5.5.2 INSIDE WIRING IN CONTROL OFFICE:

a) Wire runs to the controller's table shall be terminated on a terminal strip of approved type, fixed at a suitable place in the rear. The terminal strip shall be protected by a suitable cover.

b) Separate conduits or runways shall be provided for communication and high voltage electric wires.

c) Before constructing a building for a control office, distributing systems for communication wires shall be included in the building specifications.

d) Facilities for provision of communication wire should be made during construction of the building to enable concealment of cables and wires, thereby improving the general appearance of the control office.

e) Mechanical protection should, as far as possible, be provided for cables and wires to achieve trouble-free service.

f) Terminal and junction boxes should be located suitable to enable maximum flexibility while carrying out additions or alterations.

g) All incoming line wires underground cables shall be terminated in the test room before extending them to the control office.

h) Where direct termination in the test room is not possible, they should be terminated on a termination box of approved type and extended to the test room in a duct or a conduit through the wall.

i) It should be ensured that the entrance cable is not susceptible to damage due to proximity of water pipes, steam pipes, engine exhausts, electric light or power circuits, elevator shafts, storage dumps or inflammable materials, etc.

j) The entry should be planned so that it is not objectionable from the standpoint of appearance.

k) All line wires/communication cables entering the building from outside and all inside wiring shall be terminated in the test room with facilities for cross-connection and distribution.

l) Test rooms shall be free from overhead piping and the walls should be fire-proof.

m) Provision of outlets for soldering iron and portable lights shall be made in test rooms.

n) The area surrounding the test room shall be dry and clear and shall be constructed so that there is no possibility of the basement getting flooded.

o) Provision of fire detection and suppression should be ensured to protect vital telecom equipment of the test room and control office. Adequate number of suitable fire extinguishers should be made available in the Test room as well as in the Control office.

p) Where loudspeakers and microphones are provided for the controller, the loudspeaker shall be provided with the volume control easily accessible to the controller. The microphone shall be fitted on an adjustable bracket on the arm.

q) Cable tray/rack(s), if any, shall be made of longitudinal strips iron or angle iron with horizontal cross pieces of light material. The size of the material shall be decided on the basis of the ultimate weight that the rack is expected to carry.

r) Cable tray/rack(s) shall be located so as to be accessible and laid out for the shortest practicable runs between the various units.

5.6 INSTRUCTIONS FOR MAINTENANCE:

5.6.1 DUAL TONE MULTI FREQUENCY CALLING SYSTEM

CONTROL OFFICE EQUIPMENT

a) For equipment with DTMF signalling proper functioning of the following keys shall be checked.
   - i) Group codes A, B, C and D
   - ii) Long ring - LR
   - iii) General call
   - iv) Special purpose keys
     - Reset - RS
     - Delete - DL
     - Repeat - RT

b) All visual indications provided on equipment shall be checked.

c) Quarterly Maintenance:
   The following shall be checked:
   1. Proper functioning of all station codes including special codes shall be checked.

2. DTMF signalling code level shall be between 0 dBm to - 7dBm across a load of 600 ohms.
3. Row/column DTMF frequency shall be checked by pressing the 'RC' button and shall be within the specified limits.

WAY STATION EQUIPMENT

Monthly Maintenance:
The following shall be covered:

1. Proper decoding of the set code of the equipment and actuation of buzzer/ loudspeaker Ring back and LED on the control telephone.
2. LED indication on the telephone shall clear after the handset is lifted of the cradle.
3. Correct fitting of fuses and their rating.
4. Cleaning and proper termination of wires on the terminals on the rosette and CT box.
5. Telephone cord is in good condition and connected properly.
6. Cleaning of battery terminals and vent plugs.

5.7 TESTING OF CONTROL CIRCUITS FROM CONTROL OFFICE

5.7.1 For ease of operation, testing and management, NMS along with associated equipment (STM, PDMUX, IP/MPLS router, switch etc.) should be provided in telecom control room in control office

5.7.2 TEST PANEL: A test panel of approved type should be installed in all control offices for the use of the maintenance staff to facilitate the following:

a) Disconnection of control office equipment to enable independent testing of control circuits with either the way station equipment or the control office equipment.

b) Patching facilities for substitution by radio patch, of deputy control or spare lines to restore communication on interrupted circuits.

c) Monitoring of all circuits without interruption to the normal working of circuits.

d) Provision for a universal calling device to call any station on any circuit.

e) Provision for calling attention of the maintenance staff by the controllers.

5.7.3 TEST OSCILLATOR: A standard line test oscillator with a dB meter should be provided to carry out measurement of line transmission loss and equipment insertion loss.

5.7.4 MEGGER: A 100 volt megger should be provided to carry out insulation tests on internal wiring and external lines.

5.7.5 PERIODIC TESTS:

a) All control circuits should be periodically tested by the inspector incharge to check the condition of inside wiring in control offices and way-stations, external line and cables, and control office and wayside station equipment. Voice logger has to be checked periodically for working of channels and recording.

b) Circuits transmission loss should be measured once every year.

c) Line loop resistance should also be measured once every year. The loop resistance and disparity between each limb shall not exceed 5% of normal calculated value.

d) Result of such tests should be entered in a register maintained separately at each sectional inspector's headquarters and in the office of DSTE/Sr.DSTE.

e) Any defects noticed during such tests should be rectified on the spot and the circuit retested before proceeding with further tests. Defects and their rectification should be recorded in periodic test.

f) All loss measurements should be carried out by means of a test set provided with an audio oscillator giving a variable output from -10 dB to +10 dB with reference to 1 milliwatt across 600 ohms, between 300 and 3000 Hz. The dB meter should have a sensitivity of -30 dB with reference to 1 milliwatt across 600 ohms.

g) All tests should preferably be carried out for the smallest subsections.

h) All Protection path for Control Circuits of BSNL/RAILTEL to be Checked daily and its parameters should be tested monthly. Joint testing of Long Haul network protection path with NOC (Railtel) once in three months.

5.8 CONTROL INTERRUPTIONS

5.8.1 PROCEDURE

a) As soon as interruption such as complete ringing failure, very low speech, hum, noise or heavy induction on a control circuit, the Section controller on duty shall localise the faulty section with the help of the way station operating staff.

b) Telecom technical staff in the test room/control office and way-station may be called upon to assist in the localisation whenever any technical difficulty arises.

c) As soon as the faulty section is localised, the matter should be brought to the notice of the Technician/JE/SSE(Tele) on duty, who will confirm the faulty section.

d) After confirming the faulty section, Technician/JE/SSE(tele) on duty will restore it by utilizing the alternate path/circuits available for protection purpose. They shall inform to field telecom staff/Railtel staff/Railtel NOC if there are equipment failures/ 6 quad cable or OFC cut /damage in the section. Once the working path is restored, the circuit functioning must be put back to the working path from the protection path. It is desirable to get configured such switching arrangement in automatic mode.

e) An additional facility of single touch multi key phone (Railway/BSNL/ FCT) should be provided to avoid discontinuity in control communication in case of failure of section controller HQ equipment.

5.9 INSPECTION RECORDS AND REPORTS

5.9.1 RECORD AND REPORTS BY INSPECTORS: The SSE/JE incharge of the control office shall:

a) Keep a record of all interruptions on the control line as well as failure of way station and control office equipment.

b) Prepare a monthly line interruption and failure report with Circuit and Operating Efficiencies along with MTTR and MTBF and submit it to the Sr. Divisional Signal & Telecommunication Engineer in duplicate.

5.9.2 RECORD AND REPORTS BY DSTE/Sr.DSTE.

The Sr. Divisional Signal & Telecommunication Engineer/DSTE shall

a) Forward one copy of the report to the PCSTE for his information after scrutiny of the line interruption and failure reports and reports of periodical test.

b) Maintain record of control interruptions, preferably graphically, showing

i) The total number of interruptions and their duration, and

ii) The efficiency of line operation.

The efficiency is calculated as under:

$$\text{Efficiency} = \frac{A-B}{A} \times 100$$

Where A = Total working hours in a month
B = Total working hours lost on account of line interruptions.

ANNEXURE – I

STANDARD DTMF FREQUENCY

RS	DL	RT	RC	
1	2	3	A	697
4	5	6	B	770
7	8	9	C	852
G	0	LR	D	941
1209	1336	1447	1633	

LOW GROUP FREQUENCY (Hz)

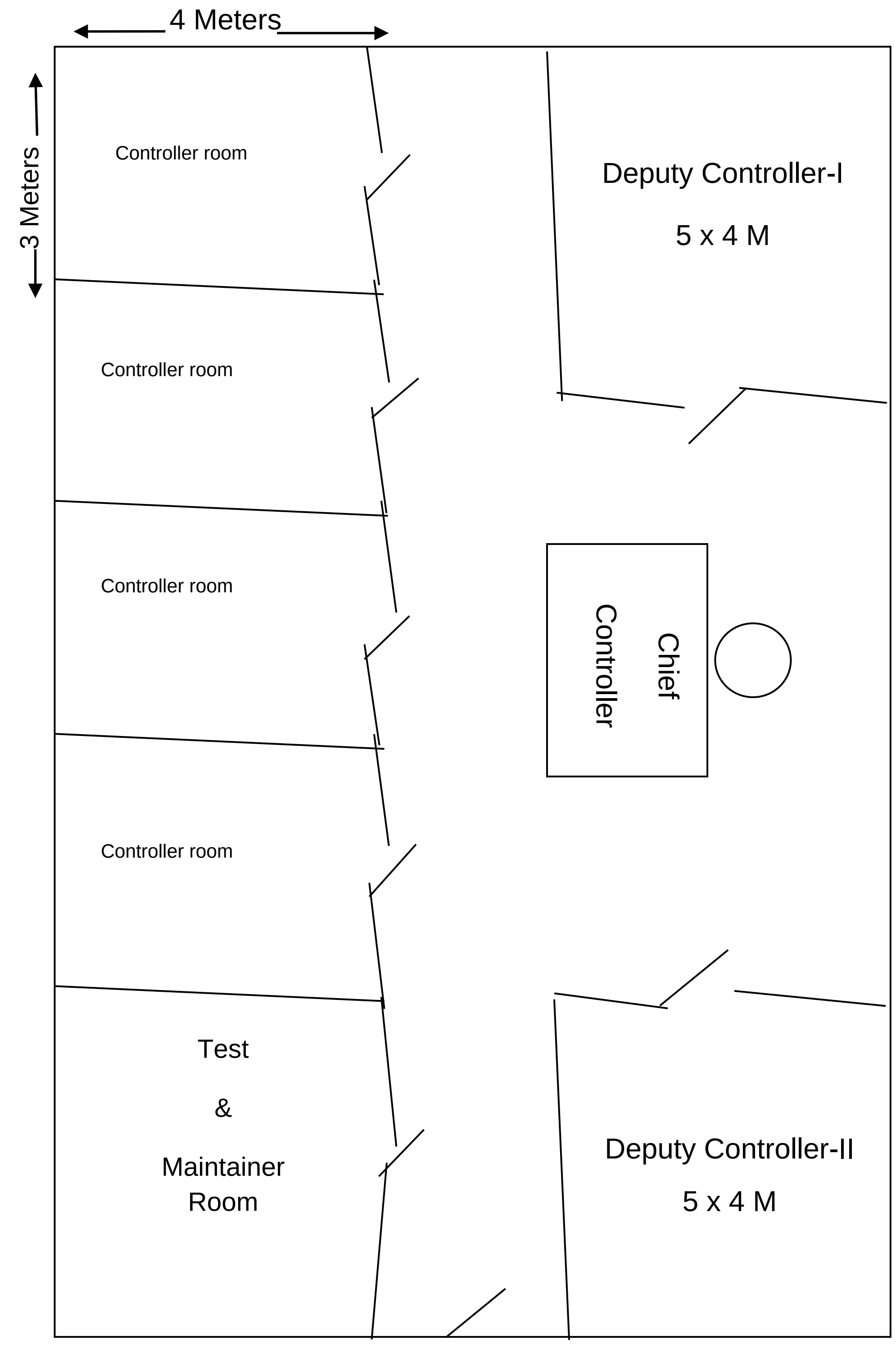
HIGH GROUP FREQUENCY (Hz)

Note : 1. The frequency tolerance is ± 1.5%

2. ABCD — For Group Calling
3. LR — For Long Ring
4. G — For General Call
5. RS — Reset
6. DL — Cancel
7. RT — Last Code Repeat
8. RC — Row/Column Frequency

ANNEXURE II

Typical layout of a control office



Note: Power plant room shall be located outside

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CHAPTER VI

VIDEO SURVEILLANCE SYSTEM

6.1 Introduction:

6.1.1 Video Surveillance System is an important security requirement in Indian Railways.

6.1.2 Video Surveillance System in Indian Railways is provided at the following locations:

i. IP based Video Surveillance System (Stations & Railway Establishments).
ii. IP based Closed Circuit Television (CCTV) Surveillance System in Coaches of Indian Railways.

6.1.3 Day to day operation of CCTV system shall be under control of RPF. CCTV System should be regularly checked and monitored by the concerned RPF staff. In case of any failure, they must notify it to SSE/JE/Tele- in-charge of that station.

6.2 IP based Video Surveillance System (Stations & Railway Establishments):

6.2.1 IP based Video Surveillance System may be provided at all entrance/exit, Platforms, Waiting hall, Reservation counter, Parking area, Railway yards, Foot over bridges etc. of Railway stations and other Railway establishments to capture images of commuters & public and to carry out analysis.

6.2.2 It shall be suitable for provision at stations (25 KV AC Railway Electrified & Non-Railway Electrified Section) and other Railway establishments. For Stations, IP cameras complying to RDSO specs to be used. For other non critical locations in Railway premises, Railway may install CCTV cameras after taking approval of competent authority either as per Railways own specification or as per RDSO specification.

6.3 System Description:

6.3.1 Video Surveillance System shall be end to end IP based with IP Cameras as per site requirement.

6.3.2 In IP based Video Surveillance System, the Cameras shall be provided at different locations so that the output is available as Ethernet and connected to the Servers/NVRs

6.3.3 It shall be possible to integrate the surveillance system using the existing LAN/WAN infrastructure on Optical Fibre network of Railways.

6.3.4 The system shall be able to work on both wired as well as wireless networks. The wireless network is envisaged for extreme areas like, yards, foot over bridges and any other area in the station where cable is difficult to lay and maintain.

6.3.5 The system shall have a diagnostic facility through NMS for Video & Network interfaces. System logging shall be possible either through system software, remote client or console port on the system. It should be possible for authorized users to view the video through a mobile platform as well.

6.3.6 There shall be provision of Panic Button/Buttons at various locations at Stations. Pressing the Panic Button, the alarm shall be sent to the central location through an available network. Panic Button System shall utilize the same network system provided for CCTV system at Stations. Number of Panic Buttons and location of Panic Buttons shall be decided by the purchaser as per site conditions.

6.4 General Requirements:

6.4.1 The system shall be based on non-proprietary open architecture where the Video Management Software, Video Recording Software, Video Analytics Software and Face Recognition Software can work and integrate with any make of IT hardware like Server, Storage, Workstation, Network Video Recorder and Switches etc.

6.4.2 The System i.e. IP Cameras, Network Video Recorders and Software (Video Management and Video Recording) shall be compliant to global standards ONVIF (Open Network Video Interface Forum) profile 'S' & 'G' for the interface of network video products. The quoted models should appear on the ONVIF website and a confirmation certificate for the offered models should be available at the time of supply. Profile 'S' defines interoperability between Video Management Software/ NVR and Camera. Profile 'G' defines interoperability between Video Management Software/NVR and SD (memory) Card in the Camera.

6.4.3 Required licenses for Video Management, Video Recording, Video Analytics and Face Recognition Software shall be ensured.

6.4.4 The Video Recording and Management System shall provide secured recording for evidence purposes and user authentication to protect data integrity.

6.4.5 Redundant Servers / NVRs may be provided. The Redundancy System shall support a number of Servers / NVRs in N+1 configuration so that the recording and playback availability is not affected in case of failure of any Server / NVR. The continuous recording of the last 30 days at any given point of time should be available through redundant Server / NVR in case of a Server / NVR failure.

6.4.6 The equipment shall be able to work in the typical temperature range and humidity. Railway may specify any other temperature requirement and humidity as per site requirement with provision of Air conditioner in CCTV control room and Server room.

6.4.7 It shall be possible to view any camera from the Divisional, Zonal Headquarters and from the Railway Board at the time of emergency or whenever desired.

6.4.8 Every control room of surveillance system shall be capable of getting connected to the optical or other communication backbone of Railways and shall be preferably air conditioned to ensure proper reliability of video surveillance system.

6.4.9 The power supply available at the stations for the system shall be 230 V / 50 Hz AC nominal with adequate backup / AT supply. In case of fluctuation in the power supply, suitable stabilization shall be provided by Railways.

6.4.10 The Recording shall be stored for at least 30 days at 25 FPS Full HD resolution for Full HD Cameras and 25 FPS Ultra HD resolution for 4K UHD Cameras with H.265 or higher Video Compression.

6.4.11 All cameras used shall have Edge Storage feature. In case of any failure or interruption of network, the Camera shall automatically start recording on Edge Storage Memory Card at resolution and frames per second as required and when the network recovers, the Video data shall automatically be transferred to the External Storage Device/Server/NVR installed at respective Stations under RPF control without any impact on the system operations. The concerned RPF-in-charge shall extract and issue video footage to GRP and other investigating agencies as per instruction of competent authority.

6.4.12 The GUI Software and camera shall support text superimposing the title and date & time on the video. If continuous data is not transferred instantaneously to main storage due to network outage, it is required that timestamps are maintained in order to avoid duplication in transmission of data.

6.4.13 Racks to house field switches in the platform area should desirely be IP55 compliant.

6.4.14 Network and storage equipment rooms should have access control entry so that only authorized personnel are given access.

6.5 Typical Components of VSS

6.5.1 IP based Video surveillance System for all type of stations should mainly consist of the following:

- (i) Full HD Fixed Box Type IP Colour Camera with Varifocal Lens and Housing & Mount
- (ii) 4K UHD Fixed Box Type IP Colour Camera with Varifocal Lens and Housing & Mount
- (iii) Full HD Bullet type IP Colour Camera
- (iv) 4K UHD Bullet type IP Colour Camera
- (v) Full HD Fixed Dome Type IP Colour Camera
- (vi) Full HD PTZ (Pan, Tilt, Zoom) IP Colour Camera
- (vii) Digital Keyboard

(viii) Large Format Display Monitor
(ix) Server Hardware
(x) Network Video Recorder (NVR)
(xi) PC Workstation
(xii) External Storage Device
(xiii) Core Switches
(xiv) Aggregation Switches
(xv) Layer 2 Switches (24Port)
(xvi) Field Switches (8 port)
(xvii) Wireless Transmitter/Receiver Unit
(xviii) Copper to Fiber Media Convertor
(xix) Various types of cables:
   a. STP CAT-6 Cable
   b. Underground Optic Fiber Cable
   c. Arial Optic Fiber Cable
   d. Power Cable
(xx) Video Management Software
(xxi) Graphical User Interface Client Software
(xxii) Video Recording Software
(xxiii) Video Analytics Software
(xxiv) Remote viewing on Web and Mobile App
(xxv) Face Recognition Software
(xxvi) Software License

6.5.2 Fixed Box type IP Colour Camera / Bullet type IP Colour Cameras shall be provided in the parking area, entrance/exit points, platforms, yards etc.

6.5.3 Fixed Dome type IP colour Cameras shall preferably be provided in indoor locations such as waiting halls, ticket counters, offices etc.

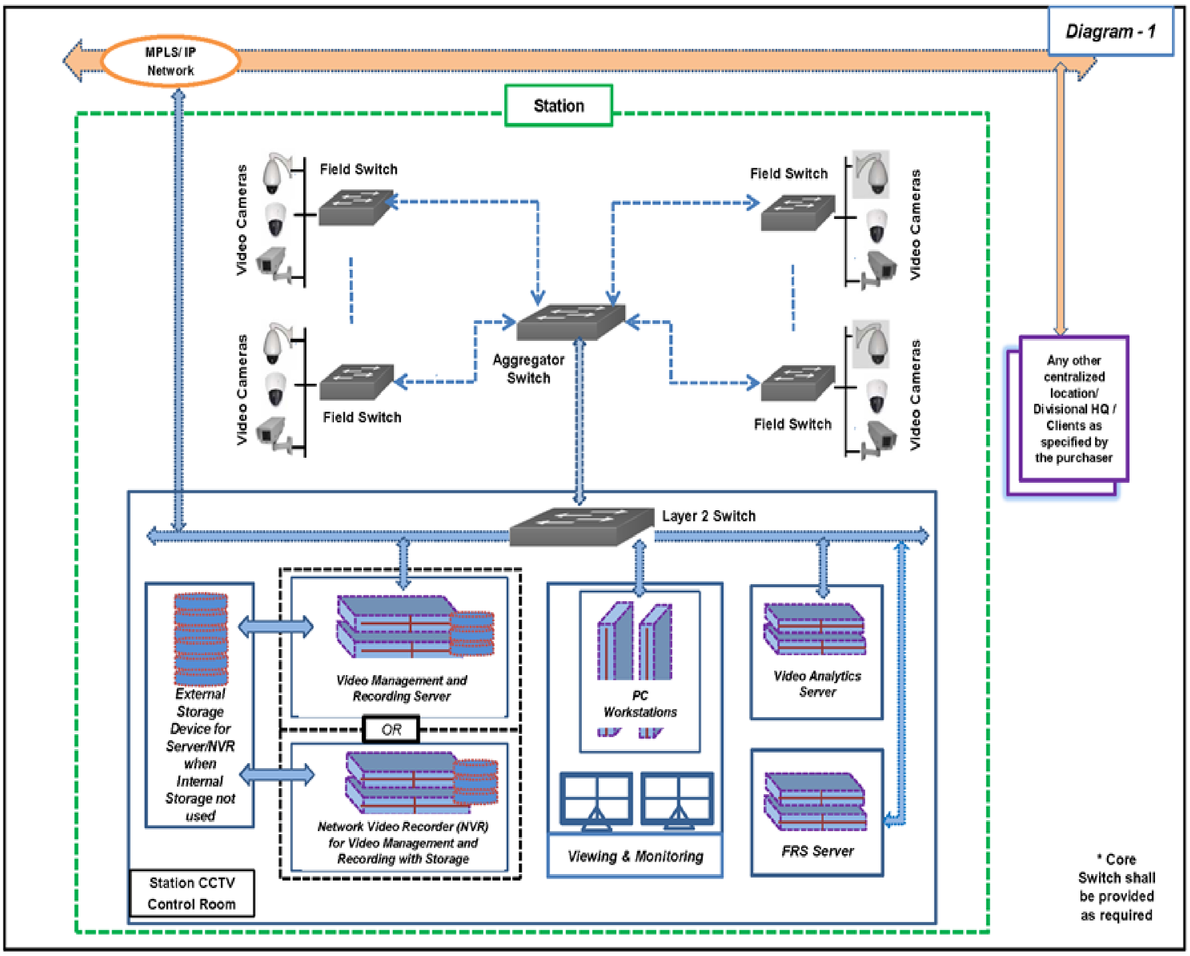
6.5.4 In addition to Fixed Cameras, PTZ (Pan, Tilt, Zoom) IP colour Cameras shall also be provided in parking areas, circulating area, platforms, foot over bridges etc. and for general perimeter surveillance where special attention or tracking is required.

6.5.5 Wireless systems shall normally be used for far away locations, where cabling is difficult to be installed & maintained like yards, extreme corners of stations etc. Camera with Solar Powered Battery and Long Range Wi-Fi Antenna may be used for such locations.

6.5.6 Tentative Implementation Schemes of IP based Video Surveillance System

6.5.6.1 Station only / Standalone architecture:

6.5.6.1.1 This implementation scheme of Video Surveillance System is meant for such Stations where Video Management, Video Recording, Video Analytics and Face Recognition Software for the Cameras of a Station are provided in the Station.

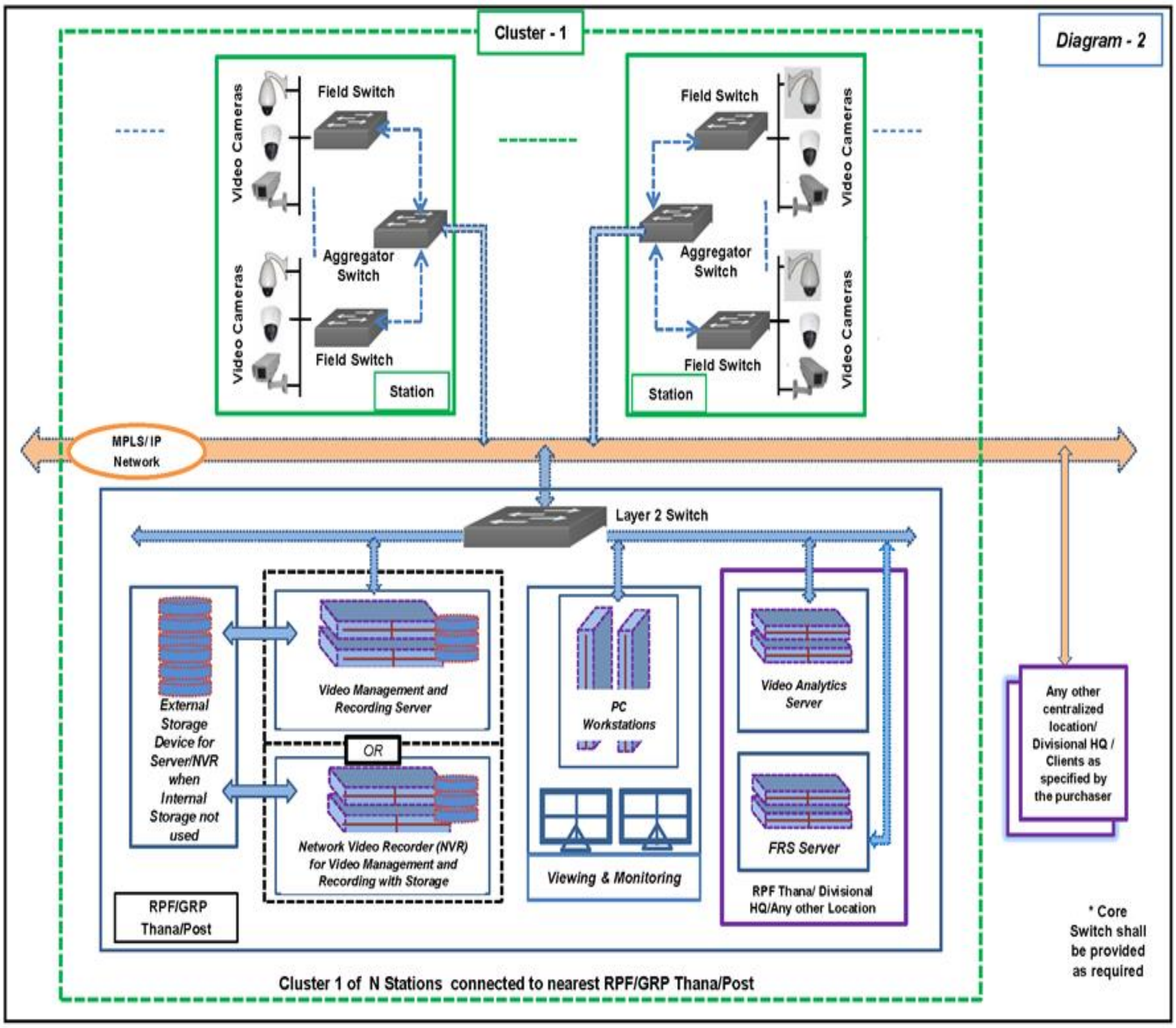


6.5.6.1.2 The Cameras of Station Platforms are connected to Field Ethernet Switch with STP cable. The screen of STP cable should be properly grounded. The Field Ethernet Switch streams Video data to a suitable location at stations such as CCTV Control Room through Aggregation Switch connected with OFC.

6.5.6.1.3 CCTV Control Room may be connected to MPLS/ IP network through the Core Switch. Video Management and Video Recording are deployed on Servers/Network Video Recorders. For Viewing and Monitoring of Cameras, requisite numbers of PC Workstations and Large format display monitors provided at Station CCTV Control Room. Required Storage is provided on External Storage Devices/Servers/Network Video Recorders. Video Analytics and Face Recognition Software are deployed on Servers at the Station CCTV Control Room or at any other location. There shall be provision for Viewing and Monitoring of Camera streams at Divisional HQ/ any other centralized location or other Clients connected to MPLS/ IP network as per requirement. VMS system shall also be provided with a mobile app for Android, Windows as well as Apple iOS based smartphones to allow secure access of VMS Server live and recorded video streams using smartphone or a tablet from Divisional HQ/any other centralized location or other clients connected to MPLS/IP network. Mobile App should be easy to use application allowing simultaneous multiple camera monitoring.

6.5.6.2 RPF/GRP Thana/Post Clustered based architecture:

6.5.6.2.1 This implementation scheme of Video Surveillance System is meant for Cluster of Stations where Video Streams of Cameras of Stations are aggregated to a nearest suitable location such as RPF/GRP Thana/Posts for Video Management (Viewing and Monitoring)Video Recording, and video analytics including automatic face recognition .

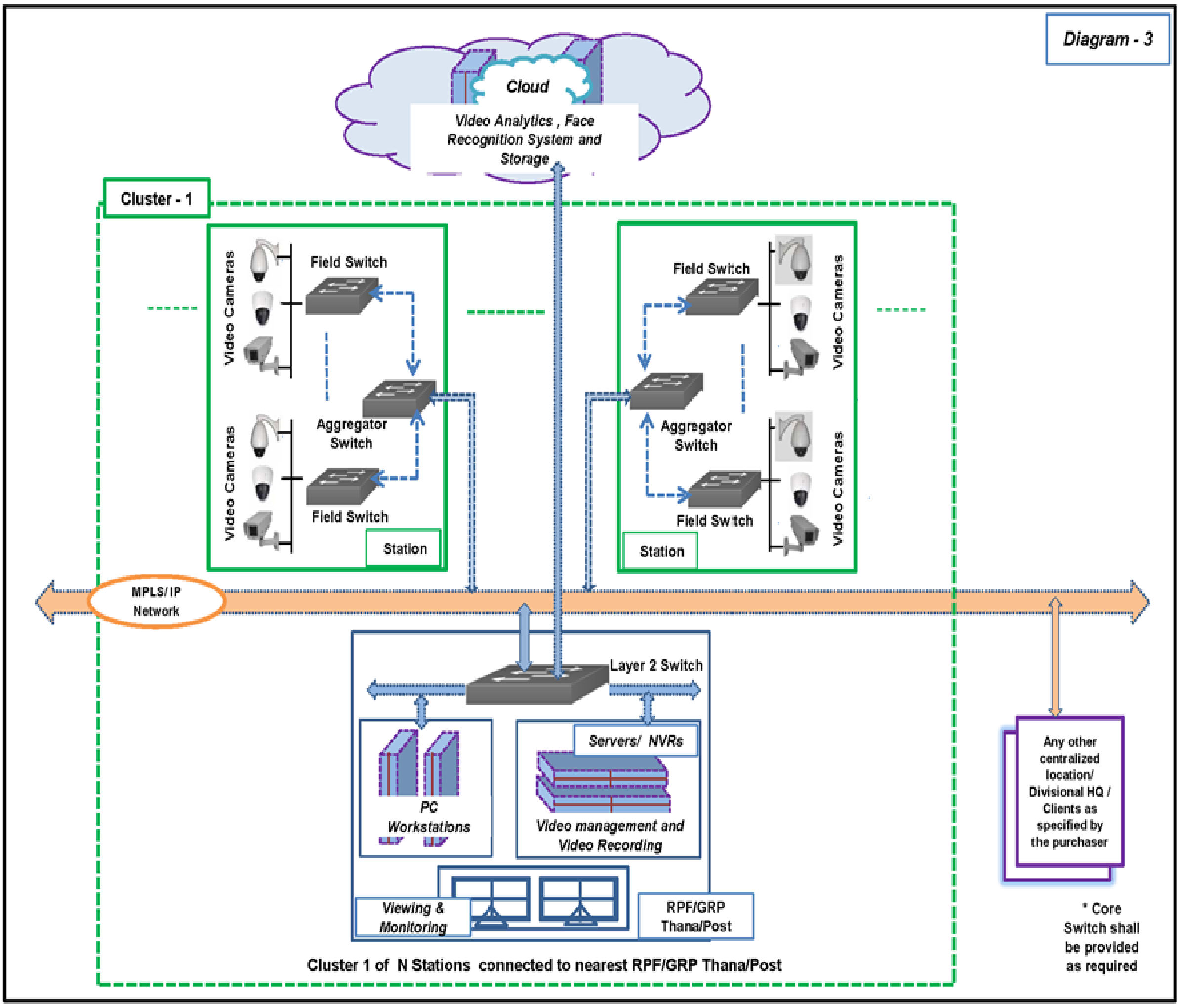


6.5.6.2.2 Video Analytics and Automatic Face Recognition Software are deployed at Divisional HQ or RPF/GRP Thana/Posts or any other location. The Cameras of Station Platforms are connected to Field Ethernet Switch. Field Ethernet Switch streams Video data to RPF/GRP Thana/Posts through Aggregation Switch. RPF/GRP Thana/Posts are connected to MPLS/ IP networks through the Core Switch. Video Management and Video Recording are deployed on Servers/Network Video Recorders at RPF/GRP Thana/Posts, where the Video streams are aggregated. For Viewing and Monitoring of Cameras, requisite numbers of PC Workstations and Large format display monitors be provided at RPF / GRP Thana/Posts. Required Storage is to be provided at RPF / GRP Thana / Posts on External Storage Devices/Servers/Network Video Recorders. Video Analytics and Face Recognition Software are deployed on respective Servers. There's a provision for Viewing and Monitoring of Camera streams at Divisional HQ/ any other centralized location or other Clients connected to MPLS/ IP network.

6.5.6.2.3 For centralized management of such multiple Clusters, Video Management Server and Server for Face Image database may be deployed with N:1 redundancy at Data-Centers i.e. Divisional/Zonal HQ or any other centralized location. Face Image Database Server at Datacenter shall be in sync with each individual RPF/GRP Thana/Posts local FRS Servers as and when any subject or alarm is generated / updated. Synchronization to be done at least once daily. The System shall have a storage solution at Data-Centers for keeping flagged/marked video data by RPF/GRP personnel for longer retention, FRS and Video Analytic alerts across all stations for 30 days, Audit trail logs, application data etc. as per solution requirement.

6.5.6.3 Cloud based architecture:

6.5.6.3.1 This implementation scheme of Video Surveillance System is meant for Cluster of Stations where Video Streams of Cameras of Stations are aggregated to a nearest suitable location such as RPF/GRP Thana/Posts for Video Management (Viewing and Monitoring) and Video Recording. Video Analytics and Face Recognition Software shall be deployed at the Cloud. Video/data shall be stored at RPF/GRP Thana/Post on External Storage Devices /Servers/NVRs and at Cloud as per requirement.



6.5.6.3.2 Video Analytics and Face Recognition Software is deployed in the Cloud. Video Data is to be stored at RPF/GRP Thana/Posts on External Storage Devices/ Servers/ Network Video Recorders and at Cloud. The Cameras of Station Platforms are connected to Field Ethernet Switch. Field Ethernet Switch streams Video data to RPF/GRP Thana/Posts through Aggregation Switch. The RPF/GRP Thana/Posts are connected to the MPLS/ IP network and the Cloud through the Core Switch. The Video Management and Video Recording are deployed on Servers/Network Video Recorders at RPF/GRP Thana/Posts, where the Video streams are aggregated. For Viewing and Monitoring of Cameras, requisite numbers of PC Workstations and Large format display monitors are to be provided at RPF/GRP Thana/Post.

6.5.6.3.3 In case Video Management and Video Recording Software is required for operation of Video Analytics and Face Recognition Software at Cloud, same is to be provided at Cloud. There shall be provision for Viewing and Monitoring of Camera streams at Divisional HQ/ any other centralized location or other Clients connected to MPLS/ IP network. All Video data and alarms generated by Video Analytics and Face Recognition Software at the Cloud are to be available at RPF/GRP

Thana/Posts and Divisional HQ/ any other centralized location or any other clients through Cloud.

6.5.6.3.4 Continuous Video Monitoring/ Live Viewing for all the Cameras through PC Workstations and Large Format Display Monitors with Full HD and 4K UHD resolution display support. One such Monitor displays 16 Cameras on a single unit. For simultaneous viewing of more cameras, more monitors can be provided. One 32/64/128 Channel Server/NVR shall support Playback of recorded video for minimum 16 Channels simultaneously at Full HD or higher. During playback, continuous recording should not be interrupted.

6.6 IP based Closed Circuit Television (CCTV) Surveillance System in Coaches of Indian Railways:

6.6.1 IP based CCTV Surveillance Systems is to be provided for Surveillance in Coaches of passenger trains of Indian Railway.

6.7 System Description:

6.7.1 Each Coach shall be installed with tentatively 8 nos. of Cameras. 4 nos. of Cameras shall be installed in doorways, 1 no. of camera facing each Vestibule portion and 2 nos. of Cameras shall be installed in the aisle area.

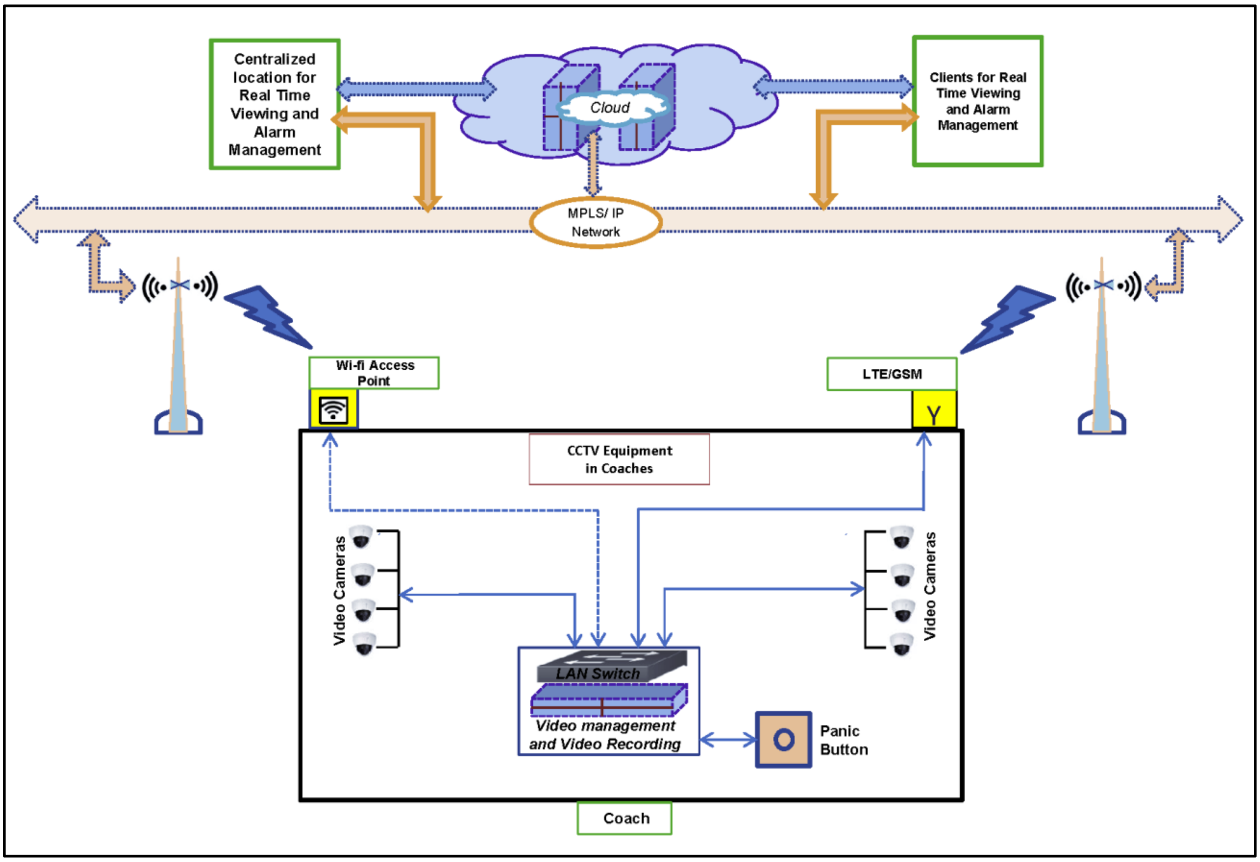
6.7.2 Each Coach shall be provided with a Video Recorder Unit or Mobile Network Video Recorder (Mobile NVR) along with System Software.

6.7.3 Each Coach shall be provided with Wi-Fi Access Point and LTE/GSM for connecting the Video Recorder Unit / Mobile NVR to the Data Centre / Centralized location / Cloud. Video Recorder Unit / Mobile NVR should be provided with a GPS module for GPS applications within the housing.

6.7.4 The Cameras and Video Recorder Unit / Mobile NVR of running trains shall be accessible on a real time basis through available Wi-Fi and LTE/GSM network as and when required from Data Centre / Centralized locations / Clients for Viewing and Monitoring and Alarms.

6.7.5 There shall be provision of Panic Button / Buttons in each Coach. Pressing Panic Button shall provide local buzzer as well as alarm to the Data Centre / Centralized location through available network for CCTV application.

The connectivity diagram of this system is as below:



6.8 General Requirements:

6.8.1 The Closed-Circuit Television (CCTV) Surveillance System shall be end to end IP (Internet Protocol) based.

6.8.2 The Video Surveillance system shall be based on non-proprietary open architecture where the System Software can work and integrate with any make of IT hardware.

6.8.3 The System i.e. Mobile NVR, IP cameras and System Software shall be compliant to global standards ONVIF Profile 'S' for the interface of network video product (ONVIF – Open Network Video Interface Forum). The quoted models should appear on the ONVIF website and a confirmation certificate for the offered models should be available at the time of supply.

6.8.4 The Video Recorder Unit / Mobile NVR shall provide secured recording for evidence purposes and user authentication to protect data integrity.

6.8.5 A suitable power supply unit for VSS in coaches shall be provided matching with the power supply available in the coaches.

6.8.6 The Cameras shall be installed and fixed on Coach Ceiling with vibration-proof fixing and connection arrangements. The other equipment and other accessories shall be housed in concealed, powder coated metal enclosure with suitable Ingress Protection for dust and water by providing gasket & sealing of cable entry / exit along with suitable lock and key.

6.9 Typical Components

6.9.1 IP based CCTV Surveillance Systems is to be provided for Surveillance in Coaches should mainly consist of the following:

(i) Fixed Dome Type IP Colour Camera
(ii) Video Recorder Unit
(iii) Managed PoE Ethernet Switch
(iv) Wi-fi Access Point
(v) Mobile NVR
(vi) System Software
(vii) Face Recognition Software
(viii) Server Hardware (Data Centre)
(ix) Various types of Cables
    a. STP CAT-6 Cable
    b. Electrical Power Cable
(x) Software License

6.9.2 The Railway Track / Stations / EMU Shed / Stabling Line / Washing Line / Coaching depot may be provided with the high-speed Wi-fi or LTE(4G), 3G network. The Video Recorder Unit / Mobile NVR shall have capability to automatically transmit the required data (video / face images / alarms etc.) from the Coaches to the Data Centre / Divisional Control / Cloud on getting connected automatically to available Wi-fi or LTE (4G) / 3G network.

6.9.3 If Required Data is not offloaded instantaneously through available Wi-fi network and/or 4G/3G network completely at first Station due to short stoppage time or network outage, it is required that timestamps are maintained in order to avoid duplication in transmission of data at next station(s).

6.9.4 Video Recorder Unit/ Mobile NVR installed in individual Coaches shall be provided with a unique digital identification number. It shall be possible to change identification number of Video Recorder Unit / Mobile NVR as per requirement while adding or deleting the coaches in train set.

6.9.5 Central Management System (CMS) including Video Management Software (VMS) shall be deployed in Datacenter / Centralized Location / Cloud or any other location as specified by the purchaser.

6.9.6 The Video data at Data Centre / Cloud shall be accessible to any other centralized location or other clients through MPLS / IP network as per requirement of purchaser for Viewing and Monitoring.

6.9.7 The Video and Alarm data of Cameras shall be stored in the Video Recorder Unit / Mobile NVR for at least 30 days at 25 FPS with Full HD resolution with H.265 or higher Video Compression.

6.9.8 The equipment enclosures shall be positioned in such a way that maintenance can be done without any difficulty. The enclosures should be such that it is able to effectively dissipate heat generated by the equipment without allowing dust ingress.

6.9.9 Required number of Software licenses , if required, for Video Surveillance System in Coaches shall be as specified by purchaser.

6.10 Maintenance:

6.10.1 The equipment shall be kept clean and tidy without dust.

6.10.2 The connectivity to Switches, Cameras, Servers, PC Workstation, Storage, etc. shall be checked and ensured that the network is complete till the end mile.

6.10.3 Condition of various cables to be checked by carrying out routine checks done for various cables.

6.10.4 OFC cables and connectors to be checked as per routine checks done on OFC.

6.10.5 The Antivirus patches to be updated in the system time to time.

6.10.6 Staff has to be trained for maintenance of video surveillance system.

6.10.7 Necessary action is to be taken to ensure uptime better than 99.5% in consultation with the manufacturer of video surveillance system & system integrator.

6.10.8 In addition to the above, any other checks suggested by manufacturers.

6.10.9 LAPTOP alongwith other required accessories and tools should be provided to the supervisor maintaining VSS system.

6.10.10 The complete VSS system of a station should be inspected, checked and maintained by concerned SSE/JE on a monthly basis.

6.11 Do’s & Don’ts

6.11.1 Do’s

- Do write the configuration changes if any done in a register.
- Do proper lacing of the internal wiring.
- Protect the cables from rodents where cabling is done through false flooring.
- Train the staff and update the knowledge to maintain the VSS network more efficiently.
- Use ESD wrist bands while handling VSS equipment.
- Use a good quality earth and maintain the earth resistance below 1 Ohms
- Change the password of PC workstation/servers once in a month and record it securely and confidentially.

- Take back-up of the various configurations every time the configuration is changed. This will help in faster restoration in the event of software error/Flash failure.
- Follow the procedure of clearing the event and performance logs of the PC workstation / server at specified intervals.
- Plan replacement of UPS batteries as per the specified lifecycle.
- Keep the operation and maintenance manual provided by OEM / System Integrator handy.
- Check the backup at least once a week.

6.11.2 Don’ts

- Do not change the hardware of the system when power supply is ON unless it is clearly mentioned that it supports hot swapping.
- Do not change the IP addressing scheme and IP address of the working network without the written permission of the in-charge.
- Do not change any configuration without the permission of the in-charge.
- Do not run down the batteries of the UPS below specified level.
- Never switch off the equipment without following the proper shut down procedure.
- Do not share the passwords of PC workstation, wireless system, switches and servers with your colleagues.
- Never use water to clean the equipment room.
- Don’t use water based fire extinguishers for any installations.

-x-x-x-

CHAPTER VII

LINE PLANT SYSTEMS – UNDERGROUND COPPER CABLE

7.1 SYSTEM

7.1.1 Railway departmental telecommunication lines are usually laid underground between railway offices in railway colonies, large workshops, station yards and in the block sections alongside the track.

7.1.2 SPARE CAPACITY

All telecom lines shall, as far as possible, be laid in a manner that due provisions are kept for any future extensions or extra connection which can be catered for without considerable alteration to the existing circuits or reconstruction of the entire alignment.

7.2 LINE PLANT (UNDERGROUND COPPER CABLES)

7.2.1 TYPES & PERFORMANCE PARAMETERS

7.2.1.1 TYPES OF CABLES USED UNDER VARIOUS SCENARIOS

The following types of underground cables are generally used for various telecommunication circuits as indicated.

a) Quad Cable 0.9 or 1.4 mm conductor dia as per IRS specification No. IRS:TC 30/05. These are 6 quad polythene insulated jelly filled cable suitable for underground laying and are used for control circuits and block interfaces. 1.4 mm conductor dia cable is used for longer block sections. It is desirable to provide 1.4 mm Quad cable in block sections longer than 12 kms.
b) Multi pair (from 10 pairs to 200) Multi Dia (0.5mm/0.63mm/0.9mm) PIJF (Polythene insulated Jelly Filled) Cable as per IRS specification No. IRS:TC 41/97. This is suitable for underground laying and is generally used for exchange subscriber lines or branch cables branching off from the main Quad cable.
c) Twisted Pair Switch Board Cable of sizes 0.5 mm / 0.6 mm copper conductor dia as per IRS/TEC specification. These are not designed for underground laying and are generally used for indoor applications such as distribution to various telephone subscribers in a building, MDF to exchange wiring etc.
d) If RE cable containing paper as well as polythene insulated copper quads is still available, it should be planned to replace the same at the earliest.

7.2.1.2 SIZES OF CABLES

The different sizes of cables to be used for various telecommunication circuits are detailed in the following table:

a) OUTDOOR UNDER GROUND

Sizes of conductor	Circuit for use
0.5 mm cond Dia twisted Pair PIJF or 1.83 kg/km (6.5 lb/mile)	Subscriber's connection up to 5 kms.
0.63 mm cond. Dia. twisted Pair PIJF or 2.81 kg/km (10 lb/mile)	Subscriber's connections up to 10 km.

b) INDOOR

Sizes of conductor	Circuit for use
0.5 mm Annealed Tinned Copper (ATC) Switch Board cable1.76 kg/km	subscriber's connection in a building, exchange to MDF wiring etc.
0.6 mm ATC Switch Board cable 2.52 kg/km	Trunk connections etc.

c) The size of the telephone exchange cables, shall be specified in a manner indicating the number of pairs, dia. of conductor, type of insulation/sheath, jelly filled, armoured or unarmoured as illustrated below:

   (i) 50 pair, 0.63 mm cond. dia armoured polythene insulated polythene sheathed jelly filled armoured telephone cable as per IRS : TC-41/1997.
   (ii) In underground laying, only Jelly filled armoured cables to be used.

7.2.2 TESTING CABLE BEFORE LAYING

a) Before the cable is laid, it shall be tested for insulation and continuity of the cores. Continuity of armour and screen of the cable need to be checked before laying.

b) Bedding and armouring of the cable shall also be inspected to see that there has been no damage during transit or in storage.

7.2.3 LAYING OUT THE CABLE

a) For laying out cables, the cable drums shall be mounted on cable-wheels
b) The drum on the wheel shall be brought to one end of the trench and the end of the cable freed and put into the trench.
c) The cable-wheels shall then be drawn along the road or track.
d) A party of labours shall follow the drum and guide the cable from the road into the trench carefully so that the cable is not damaged or bent unduly.
e) In case where the wheels are not available, the drum shall be mounted on an axle at one end of the trench and cable laid out and carried by labourers.
f) In no case, shall the drum be rolled off on to the road for laying the cable and the cable dragged on the ground for laying purposes.

7.2.4 GENERAL

a) While excavating earth for trenches or making other pits necessary for installation of cable junction boxes in between the tracks or in close vicinity of the track the Permanent Way Inspector or his representative shall be present. In 'Quad' type of cables, conductors diagonally opposite shall form one circuit.
b) In telephone cables, electro-static and electro-magnetic induction between different pairs of conductors shall be minimized by a lead or aluminium sheath and by the provision of twisted pairs.
c) Whenever a road-crossing or rail-crossing is encountered in busy areas, HDD (Horizontal Directional Drilling) method should be used to lay all types of cables in DWC pipes or any other approved protection arrangement.
d) Where concrete large size duct is provided in the station section for laying signalling cables, the same may be utilized for telecom cables also following due precautions.

7.2.5 CABLE TERMINATION

a) Cables can be terminated in any of the following methods:
    (i) DP Box of approved type.
    (ii) Direct termination.

b) PIJF cable of various sizes shall be terminated through DP Box of approved type.

7.2.6 JOINTING OF PIJF CABLE:

(i) Jointing should be done by a skilled and experienced person using the correct RDSO specified jointing kit to ensure quality.
(ii) The entire cable laying and jointing to be done under close supervision of telecom staff. To expedite work, use of video recording may be resorted to ensure quality of laying and jointing of cables and the same may be submitted in the form of DVD or other suitable form to the concerned Railway officials by the agency carrying out the cable laying work to ensure proper depth of trench and quality of joints.
(iii) Thermo shrinkable jointing material shall be used for jointing armoured PIJF cable with thermo shrinkable jointing technique using RDSO's code of practice.
(iv) The jointing material is readily available in the form of a jointing kit. For different sizes of cable (No. of pairs and cond. dia.) the kits are different e.g. TSF-1, TSF-2 etc as per latest RDSO specification. For quad cable, only Reinforced Thermo Shrink Jelly Filled kit (RTSF) type jointing kit to be used as per latest RDSO specification.
(v) Quad cable joint may normally be kept underground or it may be housed inside a location box of proper size avoiding sharp bends as per local requirement of Railways. Wherever joint is kept inside the Location Box,

EC Socket also should be fixed on that location box itself and that location box should be painted with black & yellow stripes

(vi) The screen and armour of copper cables to be jointed shall be made through with suitable wires. This is essential to get the specified screening factor in association with its earthing at stations. This should be done first to avoid any electric shock due to induction.

(vii) The copper cable screen and armour shall be earthed with a low value earth (<1Ω) at stations to achieve the specified screening factor.

7.2.7 SYSTEM REQUIREMENTS

7.2.7.1 PLANNING

a) While planning for cabling on a route, the number of conductors and sizes and type of cable (quad/PIJF) required should be first determined depending upon the type of circuits desired. Zonal Railway may issue allocation of quad on the 6Q including BPAC/IBS etc.

b) It will be generally desirable to leave 25% or more conductors spare for all cables carrying 5 or more pairs of conductors for future expansions as codal life of these cables are very high.

c) Then actual route for taking the cables should be decided upon. This should be done by travelling/walking along the track and deciding upon the best alignment for the cable route.

d) The desired route should be shown clearly on a route plan showing the actual alignment of track giving offsets from permanent way or permanent structures. The diagram should indicate the various road and track crossings, crossing with power cable, water and sewage mains and other points of importance. It is preferable to chart the route on a route plan on which the existing routes of power cables etc. are shown.

e) After the route has been decided upon, the convenient points for distribution (main cable to smaller distribution cables in case of subscriber cabling for exchange, emergency socket locations in case of emergency communication etc.) should be chosen.

f) The telecom cables should normally be laid within 1 meter inside the Railway boundary. For this the reference should be taken from boundary pillars. Where such pillars do not exist, the concerned P.Way/works officials to be advised to provide the same. Further it should be laid at least 2 m away from the nearest track and beyond embankment. Trenches in/nearer to the formation area of track shall be made only after consultation with P.Way staff and it shall be filled up and rammed properly after laying the cables on the same day before sunset. Special care, in this regard, shall be ensured during the monsoon season and in alluvial soil. It shall also be ensured that it is separated by at least 1 m from the nearest electrical power cable.

g) Cable markers shall be provided all along the route at a nominal interval of 50 m. Additional markers shall be provided to indicate important points like cable joints, water and sewage mains, power cable, crossings, alignment bends/curves, etc. The Quad cable RCC route marker shall be as per Drawing no. RDSO/TCDO/COP-22(a) available at chapter XIII. It should be painted with red colour as specified in above drawing. For easy identification of Quad joint, yellow enameled painting to be provided on all sides of RCC cable marker above ground.

h) The cable shall be at least 1 m below the surface of the ground. The trench shall be sufficiently wide to ensure smooth cleaning of trenches and laying of cables.
i) In exceptional cases, such as in yards and when the depth of the cable trench is limited to 0.5 m. due to local conditions a minimum distance of one meter shall be maintained between the cable and the OHE mast supporting the catenary or any other structure likely to come in contact with the high tension conductors. When the observance of this rule creates difficulty, the cable shall be laid in concrete pipes and in that case the distance to be maintained as specified above can be brought down to 0.5m.
j) When the depth of the cable trench exceeds 0.5 m. near the OHE masts, it shall be ensured that the nearest edge of the cable trench is at least 3m away from the OHE mast.
k) Position of cable joints shall be marked on the nearest OHE mast by painting of an approved legend.
l) Laying of cables in the vicinity of traction sub-stations, OHE switching stations and their associated earthing system shall be governed by the following principles:
    i. In the vicinity of traction sub-stations, the cable shall be laid at least one meter away from any metallic body of the sub-stations, which is fixed in the ground, and at least one meter away from the sub-station earthing. The cables shall, further, be laid in concrete pipes or enclosed brick channels for a length of 300 m. on either side of the sub-station. As far as possible, the cable should be laid on the side of the track opposite the sub-station side.
    ii. In the vicinity of the OHE switching stations (feeding posts, sectioning and sub-stationing posts), the cable shall be laid at least one meter away from any metallic body of the station which is fixed in the ground and at least 5 m. Away from station earthing. The distance of 5 meter from station earthing can be reduced to one meter, provided the cables are laid in concrete piles
    iii. Where an independent earth is provided for an OHE structure, the cables shall be laid at least one meter away from such earthing.
m) Outside station limits, the cable shall generally be laid at a standard distance from 10m. from the centre of the nearest track.
n) When signalling and telecommunication cables are laid in the same trench, a distance of about 100 mm. is to be maintained between them by placing bricks between them, at intervals of two metres.
o) HT and LT power cables and telecommunication cables shall not be laid in the same trench.
p) The cable laid parallel to the track shall normally be buried at the depth of 1.0 m. While those laid across the track must be one metre below the rail flanges.
q) The trench for the telecommunication cable shall be kept as far away as possible from the trench for the power cables.

r) When cables are to be laid along the girder bridges, over the culverts, through the bed of culverts, over the rocky terrain and the like, they shall be laid as per the approved methods for each such location.
s) While laying, the cables shall not be subjected to sharp bends. The bending radius for the cable shall in no case be less than 40 times the diameter of the cable in case of aluminium sheathed armoured cables.
t) Normally OFC and quad cables are laid in the same trenches. Drawings to lay OFC/quad cable are provided in chapter-XIII.

7.2.7.2 METHODS OF LAYING CABLE

Cables should invariably be unwound from the cable drum by mounting the cable drum on jack with the axle parallel to the base. It should never be unwound by keeping the drum on its sides.

7.2.7.2.1 TYPES

Cables shall be laid using one of the following methods, viz., laying direct in the trench, drawing through ducts and laying solid. The choice of the method depends upon the type of the cable to be laid, the nature of the cable route, initial outlay, and future expansions, and economy in maintenance charges

7.2.7.2.2 DIRECT - IN - THE - TRENCH METHOD

a) For direct laying, the bottom surface of the trench is made free of corrosive elements and the cable is laid on the bedding of the soft earth of the trench
b) Where the bottom surface is rough, a 10 cm layer of fine sieved earth/sand shall be used as bedding.

7.2.7.2.3 DRAWING THE CABLES THROUGH RCC DUCTS / PIPES

a) RCC ducts / GI Pipes or DWC / HDPE pipes may be used for laying the cable.
b) Whenever the cable is laid in the duct, there shall be sufficient holes at the bottom of the duct for draining away of any water that may collect.

7.2.7.2.4 LAYING SOLID

a) For laying solid, a trough is made in an excavated trench and the cable is laid in the trough.
b) Molten bituminous compound or asphalt or similar materials of approved type is poured in to fill the trough completely.
c) It is then lined with bricks on the top after the compound is set.
d) Care is taken to hold the cable in the trough on wooden pieces, so that the cable is entirely surrounded by the molten material.
e) This type of laying is can be justified only in cases where the soil is chemically detrimental due to electrolytic corrosion, or at critical bridges and theft prone areas.

7.2.8 MAINTENANCE SCHEDULE

7.2.8.1 TESTING CABLES

7.2.8.1.1 TESTING

a) During cable laying work Cables section shall be tested after each joint is made to facilitate tracing of a fault during the course of jointing.
b) On discovery of a fault during the cable laying, the last joint must be opened out and defect rectified.
c) The wires in the cable must be tested just before laying and after laying and jointing and also regularly on the laid cable for the following:

    (i) Continuity
    (ii) Absence of crossed pair/quad
    (iii) Absence of conductor cores contacts
    (iv) Insulation resistance
    (v) Absence of contacts between wires forming a pair (short circuit)
    (vi) Transmission loss & cross-talk
    (vii) Continuity of armour and screen of the cable need to be checked before laying

d) Quad pairs used for signalling purposes are required to be tested carefully and taking assistance of signalling staff who will arrange for disconnection of signalling gears.

7.2.8.1.2 PROCEDURE FOR PREPARATION OF CABLE

a) To facilitate testing, every wire at the starting end shall be twisted with its mate to form a loop in each pair, each twist being insulated from other pairs by means of PVC sleeves.
b) The tests shall be conducted from the other end of the cable.
c) In case of multi-layer cable, the layers of the cable shall be separated with cotton thread or twine to keep the wires in their proper places, so that the position of faulty wire or pair may be easily ascertained.
d) After the test is over, the end shall be cut and sealed or terminated as per the requirements at site.
e) In case it is desired to maintain the end for further tests, it may be suitably protected.

7.2.8.1.3 TESTING FOR CONTINUITY, ABSENCE OF CROSSED PAIR AND ABSENCE OF CONTACTS

a) The following procedure may be adopted:
    (i) At one end the cable should be made ready as described in para 7.2.8.1.2 a) to facilitate testing from the other end.
    (ii) At the testing end, a Multimeter shall be used for the tests.
    (iii) All conductors are to be bunched together and then earthed through the armour and screen of the cable with a soft bare copper wire and

connected to one probe of the Multimeter. Multimeter to be kept in Continuity Test mode.

(iv) Now any of the wires from the bunch may be separated and when touched to the other probe of the Multimeter, it should give continuity buzzer sound and loop resistance value. If the loop resistance value is substantially less than the calculated value as per the loop length, it indicates shorting within the pair.

(v) Disconnect the mate of the wire under test from the bunch and this buzzer sound should disappear proving the absence of crosses and wrong contacts.

(vi) If any of the wire shows the cross or contact, they should be earthed again to trace wires with which they are crossed or are in contact. Each pair of conductors should be tested in the above manner before jointing the next length.

b) Where the test proves that wires have been cross jointed, the joints shall be opened and the fault rectified to avoid crosstalk. Re-crossing in the next jointing does not clear the fault.

7.2.8.1.4 TESTING FOR INSULATION

a) The insulation test shall be taken on half of the pairs of the cable bunched together, the other half being earthed to the armour and screen. The second half shall then be tested in a similar manner with the first half earthed.

b) The test shall be carried out with a megger before connecting it to the terminal equipment.

c) The insulation resistance per km is calculated by applying the following formula:

$$\text{M}\Omega/\text{Km} = \frac{\text{No. of wires tested } \mathbf{x} \text{ Insulation Resistance (M}\Omega) \ \mathbf{x} \text{ Length in metres}}{1000}$$

The proper working of telecom circuits, insulation resistance per Km shall not be less than 625 MΩ at 16º C. Insulation at 16 degree C may be found out by the formula:

$$\text{Insulation at } 16^{o}\text{ C} = \text{Insulation at T}^{o}\text{ C} * 1.04^{(T-16) * 9/5}$$

d) If a contact between the wires forming a pair exists, it will be shown by the megger registering a dead earth. In this case, each pair shall be tested individually until the faulty pair is found.

e) Insulation test of newly laid U/G cable shall be done with a megger of 500V and afterwards it shall be done with a megger of 100V/500V depending upon the overall condition of cable and spares available.

7.2.8.1.5 ROUTINE TESTS SCHEDULE

Underground cables shall be tested once every year for continuity, transmission loss, cross-talk, loop resistance, armour continuity, insulation resistance and tracing & updation of cable route diagram and the results of tests shall be submitted to DSTE/ADSTE. In routine test schedule, the Insulation test should be carried out limb to earth and Limb to limb.

7.2.9 MAINTENANCE AND INSPECTION - CABLES

7.2.9.1 MAINTENANCE

a) Underground cable installations when laid strictly in accordance with the recommended practice will hardly need any maintenance throughout their anticipated span of life. As far as the buried portion of the cable is concerned, no repairs are generally possible except in cases where moisture or water has entered the cable and is detected before it has damaged the insulation.

b) No digging operations by other departments shall be carried out close to the cable route without prior notice to the Telecommunication Sectional Engineer who shall supervise or arrange supervision to ensure necessary precautions to protect the cable from damage has been taken or being taken during the work. The latest Joint Procedure Order (JPO) from Railway Board/Zonal Railways regarding undertaking digging work in the vicinity of railway track and S&T cables alignments shall be followed.

c) Each Emergency socket provided through quad cable shall be inspected once in 15 days by the sectional technician/JE/tele for its performance and good shape and the emergency socket markings on OHE masts shall be well painted.

d) Quad and PIJF cables in each section should be maintained by a cable gang. The staff strength should be as per the latest yardstick issued by Railway Board. The maintenance gang should have provision for a vehicle where the men and material can be loaded and comfortably reach the site.

7.2.9.2 CABLE FAULTS

7.2.9.2.1 TYPE

a) Low insulation in one limb or both
b) Open/break in one limb or both
c) Short/Earth
d) Multiple faults
e) Foreign potential

7.2.9.2.2 LOCALISATION OF FAULTS

Various types of cable fault locators available generally work on the following principle:

(i) Potential distribution method
(ii) Pulse reflection (ECHO) method

7.2.9.2.3 RECTIFICATION OF FAULTS

After localisation of faults, the defective portion of cable may be replaced by healthy piece of cable with proper joints.

7.2.9.2.4 Psophometric voltage and crosstalk value of telecom cable shall be maintained as per OEM's equipment requirement.

ANNEXURE - A
TOOLS AND EQUIPMENT FOR JE/SSEs

1.	Multimeter	-	1 No.
2.	Megger 100V/500V	-	1 No.
3.	Transmission and measuring set	-	1 No.
4.	Pshophometer	-	1 No.
5.	Digital Earthing Tester	-	1 No.
6.	LED torch	-	1 No.
7.	Cable jointing tools- (i) LPG blow torch (ii) Iron soldering tip	-	1 Set
8.	Hammer 1 Kg	-	2 Nos.
9.	Knife clasp 20 cm	-	2 Nos.
10.	Files flat 30 cm	-	2 Nos.
11.	Files round 30 cm	-	2 Nos.
12.	File half round 30 cm	-	2 Nos.
13.	File triangular 30 cm	-	1 No.
14.	Tape steel 30 cm	-	1 No.
15.	Tent small	-	1 No.
16.	Wire stripping tool	-	1 No.
17.	Crimping tool	-	2 Nos.
18.	Cable Fault Locator	-	1 No.
19.	Cable Route Tracer	-	1 No.
20.	Soldering Iron set	-	2 Nos.
21.	Cross Talk- -measurement Set	-	1 No.
22.	Wire cutter	-	1 No.
23.	Nose plier	-	1 No.
24.	Plier	-	1 No.
25.	Measuring Tape 30 mtr	-	1 No.
26.	Hacksaw Blades	-	1 Set
27.	Tool van vehicle	-	1 No.

TOOLS AND EQUIPMENT FOR TELECOM TECHNICIAN

1.	Multimeter	-	1 No.
2.	LED torch	-	1 No.
3.	Wire stripping tool	-	1 No.
4.	Crimping tool	-	1 No.
5.	Nose plier	-	1 No.
6.	Wire Cutter	-	1 No.
7.	Plier	-	1 No.
8.	Measuring Tape 30 mtr	-	1 No.
9.	Insulating Tape	-	1 No.
10.	small hacksaw blade	-	1 No.

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CHAPTER VIII

IP-MPLS

8.0 Introduction:

8.1 Multiprotocol label switching (MPLS) also known as IP-MPLS (IP-MPLS is one type of MPLS which primarily uses IP-routers) is a routing mechanism within a telecommunications network. The routers direct data from one node to another based on the short path labels instead of the relatively longer network addresses. It avoids the need for complex lookups in the routing table, so communications tend to be faster. Since it also encapsulates the protocols of the individual streams which are diverse, into the packets with its own protocol, it is called the “multiprotocol” routing technique.

8.2 MPLS is an “Internet Engineering Task Force” (IETF) specified framework that provides efficient forwarding, routing and switching of traffic flow through the network.

8.3 MPLS belongs to the family of packet switching networks and was designed to overcome the limitations of IP based forwarding for VPN. In a traditional IP network each router performs an IP lookup, determines the next hop based on its routing table and forwards the packet to the next hop thereby creating a lot of overhead at each routers interface. However, MPLS on the other hand makes packet forwarding decisions which are based entirely on the label of the packet without the need to examine the packet itself.

8.4 MPLS works in between OSI data link layer and network layer and is summarised as Layer 2.5 networking protocol. MPLS is an innovative approach that uses a label based forwarding model.

8.5 Out of the three major technologies viz. IP-MPLS, MPLS-TP and Carrier Ethernet, IP-MPLS has been chosen as the choice of future transport technology for Indian Railways. The basic advantage of IP-MPLS is its support for L2 and L3 services that is essential for Railways. Besides this, it also services the requirement of core, aggregation and access network and can work on a common NMS for OAM(Operations, Administration and Management/Maintenance) of all the three parts of a Network. The advantage of IP-MPLS is that it supports IP routing as well as network oriented connections. The forwarding is done through hardware with the introduction of MPLS and hence is much faster than normal routing. The paths are unidirectional and the forward and return paths are usually different. For serving the requirement of Transport, congruent bidirectional paths can be defined. SD-WAN (software-defined networking in a wide area network) with IP-MPLS simplifies the management and operation of a WAN by decoupling the networking hardware from its control mechanism.

8.6 Technology & Terminology:

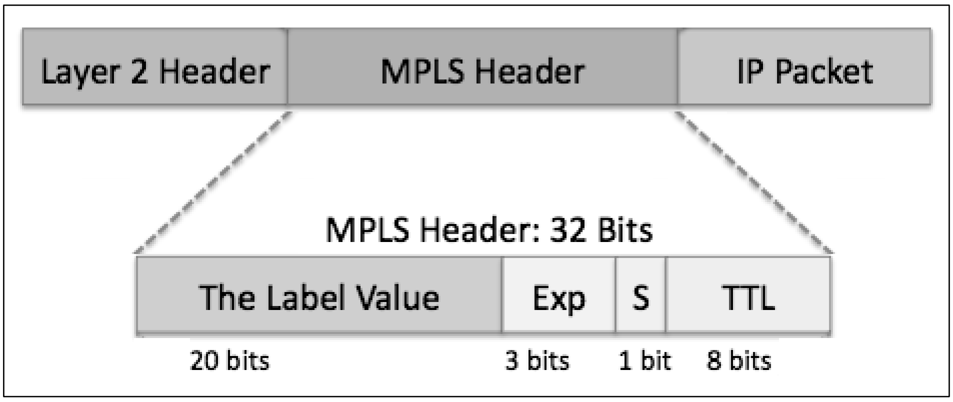
8.6.1 MPLS is not associated with any specific technology, rather it is an overlay technique that aims to improve performance and efficiency.

8.6.2 When a packet enters the MPLS network, a forwarding equivalence class (FEC) value is assigned to it by adding a small label to the packet. Every router within the network knows how to handle different FEC labels, so there is no need to do a header analysis each time. Instead, every router uses the label as an index to identify a new FEC for that packet.

8.6.3 MPLS creates a predetermined path to route traffic in the most efficient way possible based on the FEC label.

8.6.4 This mechanism gives routers the option to choose low-latency routes for certain applications like live video streaming so it is delivered faster to the destination when compared to the traditional routing mechanism.

8.6.5 **Label:** The label is a part of MPLS header. It is placed between the data-link and IP headers. It identifies the path a packet should traverse. The MPLS header is composed of 32 bits out of which 20 bits are allocated to the label also called label stack, 3-bits are experimental bits often used for specifying class of service. One bit is reserved for the bottom of the stack bit and is set if no label follows. 8-bits are used for time-to-live (TTL) used in the same way like IP headers.



8.6.6 **Label Forwarding Information Base:** A table is created by a label switch-capable device that indicates where and how to forward frames with specific label values.

8.6.7 **Label Switched Path (LSP):** It is a unidirectional tunnel between a pair of routers routed across MPLS network.

8.6.8 **Label Edge Router/Ingress router (LER):** It is a router that first encapsulates the packet inside an MPLS LSP and also makes initial path selection.

8.6.9 **Label Switched Router (LSR):** A router which only does MPLS switching in the middle of an LSP.

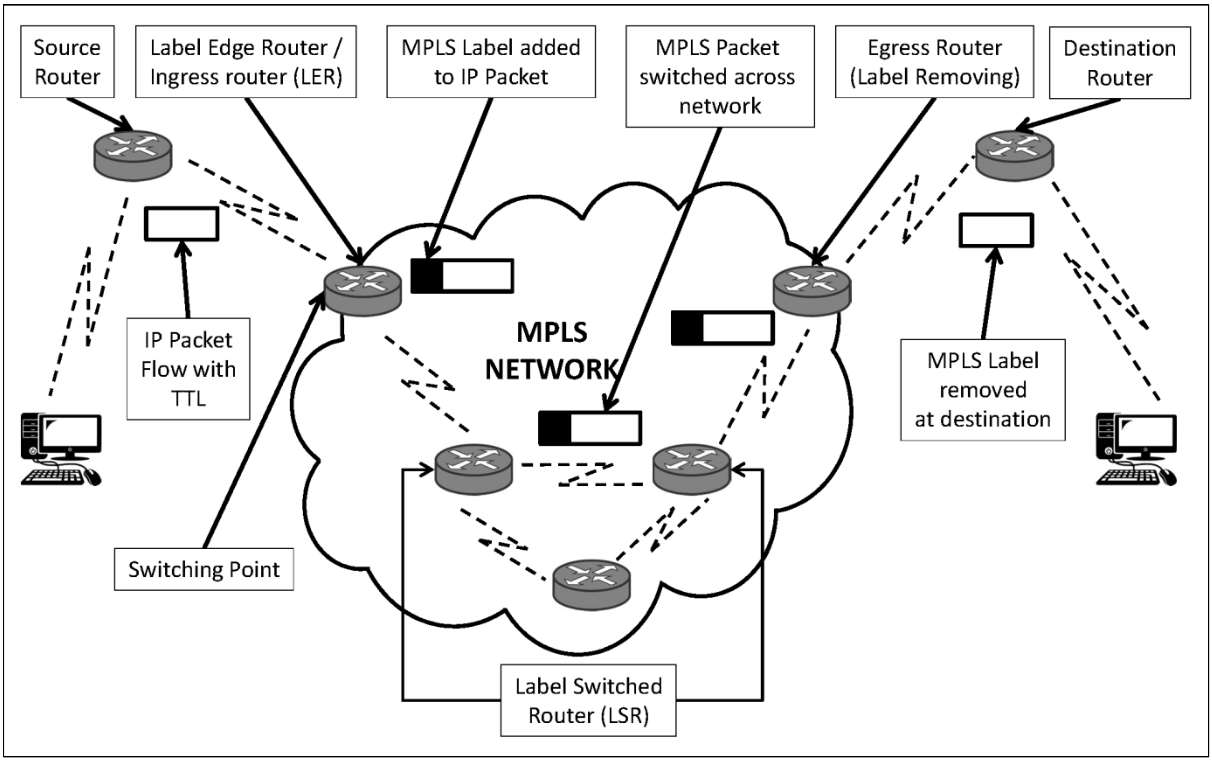
8.6.10 **Egress Router:** The final router at the end of LSP which removes the label.

8.6.11 **Label switched:** When an LSR makes forwarding decisions based upon the presence of a label in the frame.

8.6.12 **Label Switch Controller (LSC):** An LSR that communicates with an ATM switch to provide and provision label information within the switch.

8.6.13 **Label Distribution Protocol (LDP):** It is one of the primary signalling protocols for distributing labels in MPLS network. It is a set of procedures and messages by which Label Switched Routers (LSR) establish Label Switched Path (LSP) through a network by mapping network layer routing information directly to data link layer switched paths. By Label Distribution Protocol, LSR can collect, distribute and release label binding information to other LSRs in the MPLS network thus enabling hop-by-hop delivery of packets in the network along routed paths.

8.6.14 **Forwarding Equivalence Class (FEC):** It is a group of IP packets that are forwarded. Packets within an FEC are equivalent in terms of forwarding, such as same destination, same path and same class of service. A LSP is assigned to each FEC that is defined using IP interior routing protocols.



8.7 MPLS Operation:

8.7.1 MPLS relies on two principal components i.e. Control Plane and Data Plane.

8.7.1.1 **Control Plane:** Essential to MPLS is the notion of binding between a label and network layer routes. The control plane is responsible for the routing information exchange and label distribution between adjacent devices. It uses standard dynamic routing protocols, such OSPF routing, IS-IS and BGP, to exchange information with other routers to build IP forwarding table or label forwarding information base. The control component creates label bindings and then distributes the label-binding information among LSRs using a Label Distribution Protocol (LDP).

8.7.1.2 **Data Plane:** The data plane is responsible for forwarding packets according to the destination IP address or label using Label Forward Information Base (LFIB) managed by the control plane. The Data plane is a simple label based forwarding engine i.e independent of the type of routing protocol or label distribution protocol running on the control plane.

8.7.2 The network automatically builds routing tables as MPLS capable routers participate in interior gateway protocols (OSPF, IS-IS) throughout the network.

8.7.3 Label distribution protocol (LDP) establishes label to destination network mappings. Label distribution protocol (LDP) uses the routing topology in the tables to establish label values between the adjacent devices. This operation creates Label Switching Paths (LSP) pre-configured maps between destination end points.

8.7.4 A packet enters the ingress edge label switching router (LSR) where it is processed to determine which layer-3 service it requires, such as quality of service (QoS) and bandwidth management. The edge LSR selects and applies a label to the packet header and forwards it.

8.7.5 The LSR reads the label on each packet, replaces it with a new one as listed in the table and forwards the packet.

8.7.6 The Egress Edge Router strips the label, reads the packet header and forwards it to its final destination.

8.8 MPLS Services:

8.8.1 **MPLS Traffic Engineering (MPLS-TE):** Traffic Engineering is the process of routing data traffic in order to balance the traffic load on various links, routers and switches in the network.

8.8.1.1 It has the ability to control specific routes across a network to reduce congestion and improves the cost of efficiency of carrying IP Traffic. MPLS is capable of full traffic engineering.

8.8.1.2 In MPLS TE, a Label Switched Path (LSP) is established for carrying traffic along an explicit traffic-engineered path, which can be different from the normal destination-based routing path. IP networks typically have multiple pathways that traffic can take to reach its destination. Relying solely on routing protocols such as Open Shortest Path First (OSPF) some of the paths may become congested while others are under-utilized.

8.8.1.3 MPLS can specify an explicit route for certain traffic flows such as Voice over IP (VoIP) to take less optimal but less congested routes and avoid packet loss while maintaining very high link utilization.

8.8.2 **MPLS and Quality of Service (QoS):** Some types of traffic, such as video, place specific demands on a network for successful transmission. QoS in an IP network gives devices the intelligence to preferentially handle traffic as dictated by each subscriber's network policy.

8.8.2.1 QoS is defined as those mechanisms that give network managers the ability to control the mix of bandwidth, delay, jitter and packet loss in the network.

8.8.2.2 At the ingress of the MPLS network, Internet Protocol (IP) precedence information can be copied as Class of Service (CoS) bits or can be mapped to set the appropriate MPLS CoS value in the MPLS label.

8.8.2.3 This is the distinction between IP QoS that is based on IP precedence field in the IP header and MPLS QoS that is based on the CoS bits in the MPLS label.

8.8.2.4 MPLS CoS information is used to provide differentiated services and MPLS CoS enables end-to-end IP QoS across the network.

8.8.3 **MPLS VPNs:** Virtual Private Networks (VPNs) are a method of interconnecting multiple sites belonging to a customer using a Service Provider (SP) backbone network in place of dedicated leased lines.

8.8.3.1 Each customer site is directly connected to the SP backbone. The SP can offer a VPN service more economically than dedicated private WANs built by each individual customer because the SP can share the same backbone network resources (bandwidth, redundant links) between many customers.

8.8.3.2 The customer also gains by outsourcing the complex task of planning; provisioning and managing a geographically distributed network to the SP.

8.8.3.3 MPLS-enabled IP VPNs are connectionless IP networks with the same privacy as frame relay and multiple IP service classes to enforce business-based policies.

8.8.3.4 MPLS-based VPNs make operations much more efficientthan the traditional overlay VPN solutions which requires tunnelling or encryption deployed over a frame relay, ATM or IP network. This mesh solution is built point-to-point, requiring separate configuration of each tunnel or Virtual Circuit (VC). Moreover, since traffic is tunnelled or overlaid, the circuit does not know which kind of traffic it carries. By contrast if the customer traffic can be classified by application type, such as voice, mission-critical applications or e-mail, the network can easily assign traffic to the appropriate VPN, without configuring complex, point-to-point meshes.

8.8.3.5 Compared to a VPN overlay solution, an MPLS-enabled VPN network can separate traffic and provide privacy without tunnelling or encryption. Using labels, MPLS enabled networks provide privacy on a network-by-network basis much as frame relay provides it on a connection-by-connection basis.

8.8.3.6 The frame relay VPN offers transport while MPLS-enabled network supports services. MPLS is the technology that brings - VPN awareness to switched or routed networks.

8.8.3.7 It enables quick and cost-effective deployment of VPNs of all sizes - over the same infrastructure. MPLS provides a flexible and elegant VPN solution based on the use of LSP tunnels to encapsulate VPN data.

8.9 Advantages and disadvantages:

8.9.1 **Advantages:**

In order to upgrade the existing telecom infrastructure, MPLS can be an excellent option. It can help with enhanced flexibility, more bandwidth, and better performance.

8.9.1.1 **Scalable:** MPLS provides a highly scalable mechanism. It ensures high-performance telecommunication networks. Networks can easily be engineered and maintained for bandwidth optimization.

8.9.1.2 **Inter-Connectivity Growth:** MPLS allows growth of the inter-connectivity of the network by using the minimal addition of hardware.

8.9.1.3 **Common applications:** MPLS can be used for interconnecting data centers with branch offices and branches at other locations.

8.9.1.4 **Remote connections:** MPLS allows adding new remote connections without using any additional hardware system at the primary site. Being fully cloud-based, it doesn't require the point to point connectivity.

8.9.1.5 **WAN routing:** With the MPLS link, WAN routing is left to the service provider and employs fewer staff for WAN.

8.9.1.6 **Quality of service:** MPLS comes with the quality of service (QoS) options, which empowers to treat latency-sensitive traffic like VoIP etc.

8.9.1.7 **WAN protocol:** MPLS is the perfect mode to manage any-to-any connectivity, including video and voice.

8.9.1.8 **Service level agreements:** MPLS services are deliverable SLAs (service-level agreements). These SLAs include delivery guarantees unlike consumer broadband, etc.

8.9.1.9 **Enhanced bandwidth:** The technology allows accessing multiple traffic types.

8.9.1.10 **Improved up-time:** MPLS allows having an alternative network, thus improves up-time.

8.9.1.11 **Lower congestion:** With MPLS, there is an option to use alternative paths and avoid high traffic congestion, thus reduced network congestion.

8.9.2 **Disadvantages:**

8.9.2.1 **Lack of Total Control:** The service provider has to configure the overall networks. And we will need to work along with service provider in routing MPLS traffic while using dynamic routing. MPLS does not allow having total control of the network.

8.9.2.2 **Expensive:** Since MPLS is an advanced way of networking, it can cost more than the Ethernet. However, the cost is less than T1 lines.

8.10 Implementation considerations:

8.10.1 From the various communications in use on the Indian Railways, a Division is the basic operational unit of the Railways and all the activities of all departments are initiated, implemented, coordinated and monitored and hence is the basic aggregation layer for the communication bandwidth.

8.10.2 Most circuits originate from Divisional HQ and terminate at one/many/all of the stations within the Division, adjacent divisional HQ, Zonal HQ and the internet gateway. In the event of any emergency or unusual, all activities are controlled and monitored from the Divisional HQ.

8.10.3 Some of the existing data communication circuits are centralized across the zone such as UTS/FOIS. Some of the services/applications like IP exchanges, section control/TPC/TLC, applications on VOIP, File services for storage of critical data/drawings of departments, application software such as MS Office/AutoCAD/Primavera/Anti-Virus, VMS and Video Analytics for Surveillance etc.are controlled within the Division.

8.10.4 Considering the various services and applications used by the division, it is desirable that servers for running the various services and applications relevant to the Division are located in the Divisional HQs in suitable Data Centers. This will also serve to address latency and response time issues besides optimizing bandwidth utilization.

8.10.5 The specific implementation steps:

8.10.5.1 All future replacement of SDH shall only be with MPLS equipment.

8.10.5.2 Equipment with modular and hybrid interfaces should be used so that interfaces with legacy TDM equipment are replaced as and when needed.

8.10.5.3 As this is a new technology area, intensive training on these technologies should be imparted to officers and supervisors. Railways may also try to have dedicated staff and officers in the division for smooth adoption of these technologies.

8.10.5.4 Divisional and Zonal NOC for OAM of the unified network should be created.

8.10.5.5 NMS & NOC Architecture

8.10.5.5.1 **NMS:**
Network monitoring and provisioning systems will be deployed at Divisional and Zone HQ locations.

8.10.5.5.2 **NOC:**
Zonal and Divisional HQ NOC to be manned round the clock on 24X7 basis.

8.10.5.5.2.1 Zone HQ NOC capabilities:

- Single point of contact for the interdivisional and inter-zonal issues.
- Node installations, troubleshooting and updating for zonal nodes.
- Service provisioning for zonal nodes.
- Internet Policy Control.
- Overall Performance reporting and improvement recommendations.

- Patch management and whitelisting.
- Backup management.

8.10.5.5.2.2 DIV HQ NOC capabilities:

- Troubleshooting and updating.
- Field support.
- Node installations, troubleshooting and updating.
- Service provisioning.
- Performance reporting and improvement recommendations.
- Patch management and whitelisting.
- Backup management.

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CHAPTER IX

TELEPHONE EXCHANGE

9.1 RAILWAY EXCHANGES

9.1.1 Telephone Exchanges being used on IR are of Automatic, Electronic, Digital, Stored Programme Controlled (SPC) type with conventional digital technology [(Pulse Code Modulation (PCM), Time Division Multiplexing (TDM)] or with IP technology. All new exchanges shall be with IP technology.

9.1.2 For IP telephony Session Initiation Protocol (SIP) shall be used. The exchange software shall work on any common off-the-shelf server.

9.1.3 Normally, open source software for VoIP shall be used for ease in integration and cost optimization.

9.1.4 IP exchanges with "open standards" only shall be used in the Railway Telecommunication Network for the sake of interoperability. These exchanges shall support third party phones. Licenses if any required for this purpose shall be provisioned. The system shall also support Video telephony.

9.1.5 IP telephony shall be integrated with existing LAN infrastructure. For this purpose, Railnet switches may be configured to carry voice traffic on a separate voice VLAN. This voice VLAN frames shall have priority over the general data frames. The SRTP/RTP/SIP data packets shall be provided priority using QoS in the whole network.

9.1.6 Intercom facilities shall be provided either through independent exclusive exchange of suitable capacity or may be built through such features of main exchanges using common telephony infrastructure. Railways should endeavour to optimise their requirements of multiple Intercom systems.

9.1.7 FXS gateways shall be used for interfacing FAX, analog telephones and other analog telephony equipment if any. FXS gateways can be used in a centralized or a distributed architecture.

9.1.8 IP phones used in the network shall be PoE enabled and shall draw power from the PoE switches and ensuring UPS backup for the PoE switches. Local adaptors for the phones may be avoided. IP phone should have two Gigabit Ethernet ports one port for connecting the IP phone with LAN on PoE, and other port to connect PC through IP phone to avoid separate LAN wiring in room from distribution switch.

9.1.9 SIP Trunk/ PRI gateway shall be used to connect to NGN or PSTN. In cases where availability of PRI from PSTN is a challenge, FXO can be used.

9.1.10 Telephones used in the VoIP exchanges shall also be open standard. Thus, these phones shall work with third party exchanges/ SIP servers as well. It must also be possible to use third party SIP clients loaded on mobile phones using Wi-Fi.

9.1.11 Separate trunk Exchanges are normally not required as trunk exchange function is handled by NGN (Next Generation Network) network. NGN uses MPLS network of RCIL to provide a distributed trunk exchange with which all zonal and divisional exchanges are connected using E1 links and all trunk calls are routed through this network. A back up for trunk connectivity at Zonal and divisional level may be done using direct E1/ SIP/ PRI connectivity.

9.1.12 Provision for remote maintenance of the exchange from a remotely located operation & maintenance center shall be available in the system. Remote maintenance devices / Interface should be built within the system. All access should be through a secure method like SSH, HTTPS etc.

9.1.13 The system shall be capable of use as a local, tandem, transit exchange or combination of these.

9.1.14 The system shall also support Video telephony. Hence, IP video phones can also be used for telephony.

9.1.15 Subscriber Telephone Set

a. The subscriber telephone set can be analog or IP including softphones and video phones. The IP telephone shall support SIP
b. Analog phones shall preferably be provided with CLI facility.

9.1.16 All the divisional exchange and the headquarter exchange shall be connected with NGN using either PRI or SIP Trunk. Subdivisional exchanges may also be connected with NGN if feasible. As far as possible, the railway exchanges shall be connected through different routes to multiple media gateways of NGN to ensure better reliability.

9.1.17 Other sub divisional exchanges shall be connected to the divisional exchange using PRI or SIP Trunk in mesh/ring configuration if feasible. Wherever feasible, Division IP exchange may be used for whole division.

9.1.18 NGN network shall carry STD traffic. Every HQ exchange and divisional exchange shall have a railway STD code allotted by the Railway Board. All the exchanges in the division shall have the same STD code. Number planning for the sub-divisional exchanges may be done by the Railways. All exchanges shall be available on the IR STD network.

9.1.19 SIP/ PRI/ E1 connectivity shall be provided to link between the sub-divisional exchange and the divisional exchange. SIP/ PRI/ E1 connectivity may also be provided between the Zonal HQ exchange and the divisional exchange.

9.1.20 Railways may define a closed numbering scheme whereby each of their divisions are available through a uniform 5 digit number across the zonal Railway telephone network. However, it must be ensured that the divisional exchanges are connected to NGN and are accessible to other zones through the STD code allotted to the division.

9.1.21 Wherever possible interconnection to PSTN exchange shall be provided through Direct Inward Dialing (DID) and Direct Outward Dialing (DOD) facility. SIP/PRI/E1 connectivity may be provided between the Railway exchange and the PSTN exchange. The traffic for such trunk lines shall be taken as 0.8 Erlang/Trunk line and calculation of trunk lines shall be done accordingly.

9.1.22 All India Intercom

i. An All India Intercom (IP phone) may be provided to SAG and above officers in HQ and JAG and above officers in divisions.
ii. This can be integrated with the Railway exchange.
iii. No Boss-secretary configuration shall be done in this intercom.

9.1.23 IP exchange server should be provided on a common off-the-shelf hardware so as to work on generic hardware platform . It should support both IP and analog telephones. The IP exchange software shall be installed on this hardware. Telephone Exchange equipment room should be air-conditioned.

9.1.24 IP exchange servers with redundant power supply shall always be provided in 1+1, active-passive or active-active configuration i.e. if one Server fails the second server should be able to take the complete load of the calls automatically (without any manual intervention) without dropping any existing calls. It shall be possible to keep redundant/standby server in the same location (of primary Server) or may be kept at a geographically different location in order to protect against common catastrophe damage.

9.1.25 The IP Exchange should log important events that may help in analysis of failures.

9.1.26 The end-to-end security may be planned if so required using secure protocols like SRTP, SIPS etc. However, it is preferred to secure the network instead.

9.2 PARAMETERS OF EXISTING TDM EXCHANGE

9.2.1 The exchange has ports to connect subscribers with

- DTMF phones
- Key telephones
- Hot line
- Long distance
- Trunk through all media of communication (Copper Cable, Radio link, OF link)
- Attendant consoles

9.2.2 2 Mbps/higher speed trunk ports have been provided in the exchange for high speed connectivity between exchanges.

9.2.3 The capacity of the exchange is defined with the following details :-

- Wired Capacity
- Equipped Capacity with
  - No. of subscriber ports.
  - No. of long distance subscriber ports, trunk ports with various type of signaling.
  - 2 MB or higher speed trunk ports.
  - Ports for attendant console.

9.2.4 The Architecture of the Exchange is with the following protection arrangement.

a) Up to 128 ports

CPU and control cards	-1 + 0 Configuration
Memory	-1 + 0 Configurations
Power supply unit	-1 + 1 hot Standby (S/B)

b) Exchange with capacity higher than 128 ports

CPU & control card	-1+1 hot Standby configuration & hot swappable
Memory	-1+1 hot Standby configuration & hot swappable
Power supply card	-1+1 hot Standby configuration & hot swappable

9.2.5 The TDM exchange is non-blocking type and all the port cards have equal access to any free available time slot and have equal access to TDM bus.

9.2.6 The Signalling used:

i)	User line signalling	*	Decadic dc loop/disconnect signalling
		*	DTMF signalling
		*	D-Channel protocol (ISDN)
ii)	Inter Exchange Signalling	*	4W E&M
		*	4W digital (64 kbps)
		*	DC - loop/disconnect signalling
		*	R2 MFC (Indian version)
		*****	**CCITT Signalling system No.7** (Common Channel Signalling)
		*	Q-Sig for feature transparency

9.3 SYSTEM REQUIREMENTS

9.3.1 The railway telephone number is a 5 digit long number. Every HQ and divisional exchange is allotted an STD code by the Railway Board. The STD code is 3 digit long including the preceding zero (‘0’). Thus, the full railway number is 8 digit long including STD code.

9.3.2 In HQ, GM intercom shall be provided on a separate telephone set. Similarly, in the division, the DRM intercom shall be provided on a separate telephone set. Departmental intercoms, if provided, shall be integrated with the 5-digit Railway telephone itself. These Intercoms shall be of 2 or 3 digit number .

9.3.3 No Boss-secretary configuration shall be done in the GM/DRM/departmental intercom.

9.3.4 Boss-secretary configuration can be of two types. One is that the secretary's phone rings and if it is unanswered, the call gets transferred to the boss. In the other method, the call to the boss is not made through unless screened by the secretary.

9.3.5 Audio conferencing features shall be available in divisional/zonal IP exchanges. In case Railways use a video conferencing solution, then the video conferencing system shall have a SIP interface to integrate with Railway exchange so that railway exchange subscribers can join the video conference meeting using only audio if required. The Video conferencing solution can be part of the IP exchange or can be a separate system.

9.4 Exchange General Components and Cabling

9.4.1 The various components of the exchange system shall be

a) Exchange hardware
b) Exchange software
c) FXS/FXO/PRI gateway
d) Man Machine Interaction Terminal PC with Printer
e) Test and measuring instruments
f) Power supply Arrangement consisting of Batteries, Charger, Changeover panel and stand-by system.
g) Intermediate Distribution Frame
h) Main Distribution Frame
i) Protection arrangement
j) Attendant consoles
k) Cable (underground and switch board)
l) Subscriber telephone sets - Analog, digital and VoIP based
m) Maintenance tools
n) Documentation
o) Lightning protection and Earthing arrangement

9.4.2 The man machine language must be in English and user friendly. A VDU, keyboard and a printer along with a PC must be available for interaction with the Exchange.

9.4.3 IP exchanges shall be worked on 230V AC/-48V DC. In case of provision of 230V AC, 2 sets of UPS along with 2 sets of batteries of adequate capacity shall be provided at each location. In case of provision -48V DC, 2 sets of Telecom chargers along with 2 sets of batteries shall be provided to ensure minimum 12 hours of back up at each location. The charger shall be of SMPS (Switch Mode Power Supply) type.

9.4.4 The IDF (Intermediate Distribution Frame) shall have disconnecting type connectors with facility for isolating exchange indoor and outdoor side. The cable terminals shall be installed on a rack. Protection arrangement shall be available on the IDF. The IDF frame shall be connected to proper earth for effective use of protection devices. No testing for the line side shall be done from IDF. All testing for the line side shall be done from the MDF. The IDF may be accommodated in the exchange equipment room.

9.4.5 All outdoor cable shall be terminated on a rack forming the Main Distribution Frame (MDF). This shall provide connectivity between outdoor cable and indoor switch board cable. The Main Distribution Frame shall be installed in a separate room but not in the exchange room. An earth is connected across the frame for its entire length and preferably this shall be a copper strip clamped to the frame.

9.4.6 Cables:

The outdoor cables shall be jelly filled underground type. The indoor cables shall be twisted pair switch board cables.

The outdoor cable shall have outdoor Termination Box/Location Box with terminals for proper termination of the cable. The indoor cable shall be terminated on CT boxes of appropriate size. The cables, cable Terminals in CT Boxes shall be planned with 30% spare capacity. All outdoor cable sheath shall be earthed while entering the exchange at MDF.

9.4.7 Lightning and surge protection and Earthing arrangement

This shall in general be provided as per chapter on “Protection of Telecom Equipments against Lightning”.

The telecom earthing arrangement shall consist of

- Two earth wires connecting Earth Electrodes to Earth Distribution Frame
- Earth wires from each equipment to Earth Distribution Frame (Exchange rack, IDF, MDF, Charger, Battery, Cables)

9.4.8 Civil Infrastructure:

The exchange room shall be dustproof, with false ceiling, mosaic/tile flooring, windows with double doors, underground duct or overhead trough for running of indoor cables. Separate Operator Console room, Power supply room, Battery room, DG set room and MDF room shall be provided. Floor should be strictly level and high enough to avoid flooding.

9.4.9 Electrical Supply:

Standard 230V AC single phase supply with voltage level display continuously shall be available with power lines suitable for taking the load. Alternate supply shall be provided - either traction supply or DG supply. The power supply shall enter the room through MCB and changeover switch (preferably auto change-over) with proper earthing arrangement.

9.4.10 The exchange equipment room shall be air conditioned. 22-25 degree C. shall be maintained inside the room. 50% standby air conditioners shall be provided. Lighting shall be adequate for maintenance.

9.4.11 All equipment shall be provided on racks. Mounting on the walls shall be avoided. The equipment rack shall be minimum 1 meter away from the wall. The racks shall be fixed on the floor with proper arrangement. Underground ducts shall be provided for entry of UG cables. Duct/overhead troughs shall be provided to run the indoor cables. In case of UG cable entry the duct shall be filled with sand and plastered on the top.

9.5 Man Machine Communication

9.5.1 The man machine language (MML) should be in common English, not in Mnemonics or Crypts, easy to learn & use, easy to input commands & interpret outputs.

9.5.2 The MML shall contain commands, output, control actions for operation, maintenance, testing of switching system. The MML structure shall be such that addition of any new function will have no influence on the existing ones, also MML shall provide facilities for editing, cancelling.

9.5.3 Execution of any command shall not result in malfunctioning and / or overloading of the system. The system shall also ensure that operator is not locked out.

9.5.4 The errors in commands or control action shall not stop the system or unduly alter the system configuration.

9.5.5 Command errors detected by the system shall be indicated by the output of error messages

9.6 Supervision

9.6.1 Provision shall be made for continuous testing of the system to allow system quality check & fault indication as and when fault arises.

9.6.2 The following types of supervision shall be provided in the system:

a) Continuous supervision of its own power supply system
b) Automatic detection of abnormalities in processing

9.6.4 The system shall have the capacity to monitor its own performance and to detect, locate and report faults.

9.6.5 No single hardware failure in the core system shall result in complete system break down. The backup of system software and configuration to be maintained in cloud / CD / External Hard disk/Pen drive/any other media so as to restore the system quickly in a new hardware.

9.7 PROTECTIVE DEVICES ON IDF

9.7.1 The basic requirements of the protective device provided on IDF are as under:

- i) The device shall not operate on speech or signaling currents/voltages.
- ii) It shall not decrease the efficiency of speech or signaling circuit.
- iii) The device shall promptly operate in cases of the specified voltages or currents being reached. For this requirement its voltage rating must be only slightly above the exchange fed voltage levels in the subscriber circuits. If the voltage rating of the protective device is very high, it won't protect until surge or other extraneous voltage level reaches to that high level and in the meantime the damage might have already taken place.
- iv) The device shall promptly isolate the equipment and prevent further damage in cases of overload due to artificial or natural causes.
- v) The current/voltage rating of the device shall be such that they do not produce noticeable heat in the components of the main equipment.
- vii) The device shall be as far as possible self restoring type.
- viii) The prospective devices shall consist of normal fuse or self restoring type fuse & lightning discharger. The fuse shall be connected in series with each external line.
- ix) The Integrated Protection Modules shall be provided in case of Krone type connectors.
- x) The rating of the fuse shall be as per the requirement of exchange equipment.
- xi) The Protection arrangement shall be installed on IDF or MDF if there is no IDF.
- xii) The subscriber's protective device assembly shall consist of a single compact dust proof unit containing fuse and lightning arrester.

9.8 MAINTENANCE

9.8.1 PREVENTIVE MAINTENANCE

In case of non-availability of continuous automatic logging features for taking measurements in the system, the following measurements are to be taken manually;

A) Daily:

- i) Battery set voltage and UPS/charger output/input voltage.
- ii) Failure list of the subscribers.
- iii) Working of Lights, Air conditioners.
- iv) System status listing.
- v) Failure history list.
- vi) Alarm checking
- viii) Room temperature recording

B) Fortnightly:
   i) Individual cell Voltage and load test of the batteries, sulphation of terminals.
   ii) Testing of all the trunk circuits.

C) Monthly:
   i) Specific gravity in case of non-VRLA batteries
   ii) The different modes of operation of FCBC,
   iii) Earthing connections of all equipment with earth electrodes.
   iv) All cabinets of equipment, Man machine interaction, terminal printer, attendant consoles if available to be cleaned.
   v) Cable termination MDF and IDF to be cleaned and checked.
   vi) Cable runs-inter rack, rack to IDF, MDF and Attendant consoles to be checked.
   vii) BER test of all trunk circuits
   viii) Checking of lightning and surge protection devices
   ix) Functional Testing of Attendant console if available
   x) Wiring and connecting terminals of power supply arrangement
   xi) Data Back up to be updated.

D) Quarterly:
   i) Testing of All Service features from the Test Telephones.
   ii) Cleaning of terminations in CT boxes, Location boxes.
   iii) Complete testing of power supply system

E) Six monthly:
   i) Earth resistance value measurement
   ii) Line loop resistance and insulation testing

F) Yearly:
   i) Checking of wiring of subscribers premises, CT boxes and location boxes.
   ii) Testing of spare cards

9.8.2 Inspection:

The following are the details to be checked during routine Inspection.

a) Subscriber's office
   i) CT boxes
   ii) Wiring
   iii) Lightning/surge arrester
   iv) Batteries/power supply arrangement

b) Cables
   i) Type of cable and length
   ii) Cable route conditions with special attention at culverts, bridges, road crossings, track crossing, building entry points.
   iii) All registers pertaining to cable laying, testing

c) Exchange

i) MDF/IDF wiring, connectors, terminals, fuses, Protection devices.

ii) Earth connections, Earth readings.

iii) Power supply arrangement, battery registers, battery terminals, wiring, charger and power panel.

iv) Internal cabling, cabinets, visual inspection of wiring.

v) Fault register (Electronic/Paper)

d) Periodical Inspection

i) All exchanges and related installations shall be inspected by ADSTE/DSTE/Sr. DSTE at least once in a year.
Maintenance records and fault registers shall be checked for their proper upkeep.

ii) Sr. Section Engineer/Telecom should carry out detailed and effective inspection and testing once in a quarter year and Junior Engineer/Tele once in a month.

9.8.3 Testing and Commissioning:

i) Cable testing shall be conducted for each subscriber. Insulation, loop resistance for cable is to be tested and recorded.

ii) Provision of fuses, IPMs are to be checked for all lines.

iii) The earth resistance for each earth electrode is to be measured. The connectivity of earth wires to each equipment is to be checked.

iv) Hardware testing shall be conducted as per instructions of manufacturer.

v) Software testing shall be done as per guidelines given by supplier.

9.8.4 Documentation :

The exchange shall have the following documentation:

a) Indoor Equipment

- Exchange layout plan
- Rack layout plan for each rack with connection details
- MDF and IDF termination plan
- Installation manual for equipment
- Software documentation
- Operation and maintenance manual
- Wiring diagram for power panel
- Manual for chargers/UPS and all other equipment
- Troubleshooting flowchart
- Pin Configuration chart of LAN cable and Type D connectors and euro connectors and other connectors
- LAN/ IP implementation scheme

b) Outdoor Equipment:

- Telephone No. wise subscriber's details
- Subscriber wise Telephone Directory
- Cable layout plan
- Subscriber premises wiring plan typical.

9.8.5 The tools available in exchange shall consist of

- Screw drivers assorted
- Nose Plier
- Spanner
- Normal plier
- Crimping tool
- Krone Extractor
- Cutter
- Soldering kit
- Wrapping and unwrapping Tool
- Torch

9.8.6 The following test and measuring instruments shall be available in exchange for testing and maintenance

* Line tester to test line conditions
* Megger for testing of insulation of line.
* Digital multimeter
* BER Tester
* Earth Tester
* Cable Route Tracer
* Cable Fault Locator
* Clamp Meter
* Throughput Tester
* LAN Tester

-x-x-x-

CHAPTER X

QUAD CABLE BASED CONTROL COMMUNICATION SYSTEM

10.1 SYSTEM:

In electrified as well as non-electrified sections of Indian Railways, on important routes, OFC cable as well as six quad jelly filled cables are being laid, but on non-important non-electrified routes, only quad cables are being laid.

Wherever OFC and quad cables are laid, control communication is provided on OFC by providing STM-1/IP-MPLS router and P.D.MUX equipment at every station. Block circuits, emergency sockets and level crossing gate communication are provided on quad cable.

Wherever OFC cable work is not completed yet and only quad cable is laid, control as well as block communication are provided on the quad cable itself.

10.2 SYSTEM OF WORKING OF CONTROL CIRCUITS USING AMPLIFIER-EQUALISER SYSTEM:

10.2.1 Wherever Amplifier-Equaliser system is used, quad cable is not required to be loaded. Every station shall be provided with Amplifier-Equaliser equipment to provide communication at that station and to equalize the losses in the VF band.

10.2.3 The equipment shall be provided with the facility for end/mid station patching working in case of cable or equipment failure without reversing the direction of amplifiers.

10.2.4 The complete system shall comprise of the following assemblies and shall be suitable for mounting on a 19 inch rack**;**

a) Cable termination, distribution and monitoring panel.
b) `U' Link Panel.
c) Equaliser Amplifier and VF Transformer panel.
d) Decoder and other PCBs.

10.2.5 ELECTRICAL PARAMETERS:

a) Input impendence of VF Amplifier shall be 470 Ohm ±10%.
b) The nominal gain of the amplifier shall be 20 dB ±1 dB when measured at a frequency of 1 KHz.
c) The frequency response of the amplifier shall be flat within ±3 dB in the frequency range of 300 Hz to 3.4 KHz.
d) The signal at input may be at (-)20 dBm (minimum) and the output in this case shall be 0 dBm with amplifier gain at

maximum. The upper limit of input signal is determined by overload point, so that the output does not exceed +4 dBmwithout need arising for adjusting the gain of the amplifier.

e) The amplifier shall not be overloaded beyond an output of +4 dBm

f) Cross talk level of the equipment when measured after termination point shall be better than –60 dB, across the amplifiers meant for same quad and adjacent quad. Frequency for the measurement for cross talk shall be 1 KHz.

g) The Equaliser response shall have variable slope from 0 dB to 12 dB at least in the frequency range of 300 Hz to 3.4 KHz.

h) Harmonic distortion at 1 KHz shall not exceed 3% when the gain of the amplifier is set to its maximum and output is properly loaded.

10.2.6 POWER SUPPLY REQUIREMENT:

10.2.6.1 The power supply unit of Amplifier-Equaliser equipment shall normally operate at 230V AC nominal with variation from 160 V to 270 V. It should also have facility for Solar Power operation with arrangement of automatic change over from 230V AC to Solar Supply and vice versa. The charge controller for use with Solar Panel shall be provided as part of the power supply unit.

10.2.6.2 The power supply unit shall be fully duplicated including batteries with suitable over voltage protection (above 270 V).

10.2.6.3 The power supply unit shall be provided with short-circuit protection of self restoring type.

10.2.6.4 It shall be possible to by-pass automatically the way station equipment in case the battery voltage drops to threshold voltage of the amplifier to be defined by the manufacturer as per requirement of design.

10.2.6.5 A set of two low maintenance batteries of 12V each, capable of operating the equipment for 72 hours at least, shall be kept in a separate housing made of unbreakable material. The capacity of the each of the battery shall be minimum 40AH.

10.2.7 INTERCOM FACILITY:

10.2.7.1 In addition to Omnibus circuits to be provided at each station, 8-way intercom shall be provided with facility for dialing any of the subscribers by the controller.

10.2.7.2 Separate Cards shall be provided for 8-way intercom in the way station equipment. It shall be possible to extend these telephones up to loop resistance of 300 Ohms.

10.2.7.3 Intercom circuit shall be so designed that all the subscribers can talk to each other without disturbing the controller.

10.2.7.4 It shall be possible to call any subscriber within the group using suitable access codes.

10.2.7.5 The controller shall be able to call any of the subscribers using DTMF code and whenever the controller calls it, it gets disconnected from other telephones. Even when a subscriber's telephone is off-hook, it shall be possible for controller to call the subscriber and talk.

10.2.7.6 The subscriber shall also be in a position to call controller by dialing suitable access code.

10.2.7.7 There shall be facility to bar any telephone from calling the controller.

10.2.7.8 Facility of conference among the subscribers shall be provided.

10.2.8 REMOTE MONITORING FACILITY:

10.2.8.1 Remote Monitoring facility shall be provided for remote monitoring and fault localization from test room. Remote Monitoring facility for Sectional Control, Deputy Control and S&T Control Circuits shall be separately provided.

10.2.8.2 It shall be possible to execute the following functions using remote monitoring facility;

i) Disconnect one side of the Card of that Circuit at a particular station.
ii) Disconnect another side of the Card of that Circuit at a particular station.
iii) Buffer 1 cut for the Card of that Circuit at a particular station.
iv) Buffer 2 cut for the Card of that circuit at a particular station.
v) Battery change over.
vi) Connect Cards of that Circuit at a particular station.
vii) Monitor Power Supply Voltage.
viii) Monitor AC fuse, battery charging status.

These commands with relevant access codes shall be displayed on the equipment in addition to being displayed at Control Desk in test room.

10.2.8.3 On failure of AC fuse, remote Card automatically sends fuse fail signal to Test Room Equipment along with its identity code.

10.2.8.4 Disabling and enabling of Command Codes through suitable authorization Code/Password or Key shall be desirable to prevent any unauthorized initiation.

10.3 EARTHING:

10.3.1. All non-current carrying metal parts of amplifier/equaliser equipment including armour and sheath of quad cable shall be bonded together and earthed.

10.4. MAINTENANCE SCHEDULE FOR REPEATER AND AMPLIFIER-EQUALISER SYSTEM

EQUIPMENT	ITEM	TELECOM TECHNICIAN	JUNIOR ENGINEER	SR.SECTION ENGINEER
Repeater/ Amplifier-Equaliser Equipment		Weekly	Monthly (Every installation)	Quarterly (Every installation)
	i) Checking Power Supply voltage at the input point.	-do-	-do-	-do-
	ii) Checking of various cards in proper position.	-do-	-do-	-do-
	iii) Checking the functioning of all the circuits.	-do-	-do-	-do-
	iv) Section wise and end to end line up of all circuits.	----	-do-	-do-
Batteries		Weekly	Monthly (Every installation - checking only to ensure)	Quarterly (Every installation - checking only to ensure)
	i) Cleaning & tightening of all connections	-do-	-do-	----
	ii) Measurement of voltages and gravity	-do-	-do-	-do-

Earthing		3 Monthly (Every installation)	6 monthly (Every installation)	Yearly (Every installation)
	i) Cleaning & tightening of all connections	-do-	-do-	----
	ii) Measurement of earth resistance	---	-do-	-do-

-x-x-x-

CHAPTER XI

RADIO COMMUNICATION (Analog/Digital VHF)

11.1 RADIO COMMUNICATION

11.1.1 "Communication by Radio" means the transfer of intelligence from one point to another through space using radiated electromagnetic energy (Radio Waves) (in the FREQ spectrum of from about 10KHz to about 30,000 KHz.)

Radio Frequency Spectrum

Class	Freq. Range	Wave length
VLF	10-30 kHz	30,000-10,000 m
LF	30-300 kHz	10,000 - 1,000 m
MF	300-3000 kHz	1,000-100m
HF	3-30 MHz	100-10m
VHF	30-300 MHz	10-1m
UHF	300-3000MHz	100-10cm
MW	3 to 30 GHZ	10-1 cm

11.1.2 The objective of any communication is to pass information from one place to another. Radio Communication consists of generation, propagation and reception of electromagnetic waves. Modes used in Indian Railways are-

- VHF Communication
- UHF Communication
- M/W Communication

11.1.3 VERY HIGH FREQUENCY (VHF) COMMUNICATION

The frequency band of VHF Communication is 30 MHz to 300 MHz. The frequency allotted by WPC (Wireless Planning and Coordination wing of ministry of communication) in VHF for Indian Railways are in the band 146.2 MHz to 167.95 MHz. Communication in this range of frequencies is mainly due to line of sight, reflection and scattering of waves.

11.1.4 Uses of VHF

VHF Communication is used (now a days) for many applications such as:-

- Traffic Control
- Police Duties
- Mobile Communication
- Point to Point Communication
- Point to MultiPoint (Group) Communication
- Disaster Management

Possible uses of VHF Communication on IR are

- Communication during Maintenance and Construction Blocks
- Yard communication
- Communication in the train between Guard & Driver.
- Mobile Communication in between moving train/vehicle with fixed location (Station) or another moving train/ vehicle.
- Emergency Communication:
    - ART equipped with hand held and base station VHF sets
- Duplex VHF Sets are utilised for
    - Extension of exchange number to distant place.
    - Control working.(Train Traffic Control)/Patching.

11.2 SPECIFICATION & PERFORMANCE PARAMETERS

11.2.1 VHF PARAMETERS

1. Frequency Range

   - 30 MHz to 300 MHz
   - Frequency Band used in Railways is 146.2 MHz to 167.95 MHz.
   - One spot frequency is used for each channel

2. Mode of Propagation:

   -Line of sight waves
   -Reflection & scattering of waves

3. Type of operation: Simplex
   Duplex

4. Channel capacity: - 1/16/128/256 channel
   - Voice or Low speed Data or both.

5. Type of Equipment:

   i) Walkie-Talkie (Hand Held) Set-
   1W/2W to 5W switchable output power operated on in-built NiMH / Li-ion batteries. (For communication in the train in between Guard & Driver, in between moving train/vehicle with fixed location (Station) or another moving train/ vehicle, 5W sets are to be used)

   ii) Portable 25W VHF Sets –
   Portable 25W VHF Sets are normally used in Loco and vehicles operated on 12V battery set.

   iii) Fixed 25W VHF sets (Base Stations) – Installed at desired locations , mainly at ASM rooms.
   - Operating on AC Mains or by 12V battery.
   - External antenna with feeder cable connector mounted on a mast by itself or on Roof top as needed. (For digital 25W

VHFset : RDSO specification no. RDSO/SPN/TC/107/2018 or latest ,
for analog 25W VHF set with secured station to station communication : RDSO Specification no. RDSO/SPN/TC/73/2008 or latest)

6. Antennas used

- Whip Antenna
- Ground Plane (GP) Antenna
- Dipole
- Low Profile
- Yagi Antenna

7. Feeder cable:

- 50 Ohms Unbalanced Coaxial cable.

8. Expected Communication Range in open area:
- Walkie -Talkie to Walkie - Talkie - 1 to 2 Km.
- Portable Set can transmit - 12 Km to 15 Km.
- Fixed 25W VHF Set to Fixed 25W VHF Set - upto 25 Kms when antenna used are directional & fixed at the height of 15 to 20 metres.

The range may get reduced due to the number of parameters like terrain, ghat section, tunnels and obstructions etc.

9. License:

- Mandatory

As per the latest guidelines WPC license is required to be taken for each VHF set.

10. Frequencies allotment:

Following frequencies has been decided by the Railway Board for different use:

Standardisation of VHF- Frequencies on Indian Railway

Chl#	Frequency in MHz	SM at All Stations	Station to LC Gate	Driver & Guard	Shunting/Operating	Engineering Deptt.	Electrical Deptt.	S&T Deptt.	Commercial Deptt.	RPF	Mechanical Deptt.	To be Used for	
1	146.400									X		Security department	
2	147.975	ART Frequency										Accident site communication	
3	148.100										X	Mechanical Department	
4	149.750					X						Engg. Department	
5	150.100	XC										F1 for PLC, 1st Section of Straight sec.	
6	150.150	XC										F2 for PLC, 2nd Section of Straight sec.	
7	159.600	XC										F3 for PLC, 3rd Section of Straight sec.	
8	159.650							X				S&T department	
9	159.700		XC									Communication with LC Gate	
10	160.400	X			X	X	X	X	X	X	X	Common Frequency	
11	160.550								XE	XE		Train Escorting purpose	
12	161.150	X		X								Driver & Guard Communication	
13	161.425						X					Electrical Department	
14	162.100	X			X							Shunting & Yard Communication	
15	146.200	XC										F4 for PLC, 1st Section	For Junction Station (Direction 1)
16	148.050	XC										F5 for PLC, 2nd Section	
17	149.800	XC										F6 for PLC, 3rd Section	
18	149.850	XC										F7 for PLC, 1st Section	For Junction Station (Direction 2)
19	151.400	XC										F8 for PLC, 2nd Section	
20	151.450	XC										F9 for PLC, 3rd Section	
	160.450	VHF based Approaching Train Warning System for Track Maintainers											

Note:

- X Channel Programmed
- XC Channel Programmed with CTSS/MF Coding.
- XE For Train Escorting only
- # Frequencies allocated against channels can be interchanged if railways are using some other frequencies except Driver Guard. Use of un-allocated frequency is prohibited.

11.2.2 LIMITATIONS OF VHF COMMUNICATION

- Range limited up to 25 Km maximum due to requirement of line of sight.
- Dark Zones occur due to terrain, high rise buildings & other structures.
- VHF sets consume more power, hence the set may require more than one battery set for long duration usage.
- Interference due to other users operating at the same frequency.
- Effect of prevailing noise in the surrounding.

11.2.3 Digital radio VHF sets

Digital Mobile Radio (DMR) is an open standard which is not proprietary to any single manufacturer. The DMR standard specifies that DMR equipment must be compatible, so a radio will work on any base station or network, which improves availability of options and pricing. These are having several advantages in terms of Voice Quality, Coverage, Battery Life, Channel Capacity and Data Capabilities etc. In view of these additional features/advantages, Digital Walkie-Talkie sets should be preferred over Analog sets and Analog sets to be phased out gradually. Use of Licence exempted Digital VHF set allowed by WPC may be considered for maintenance purpose (non- crew usage).

11.3 INSTALLATION OF VHF

- For point-to-point communication availability of line of sight is essential.
- Antenna height must be decided at both locations by measuring minimum field strength needed for satisfactory communication. This can be measured by putting one trans-receiver at one end and mounting antenna at a suitable height of 15m to 20 m and measuring the field strength by field strength meter at receiving locations. VHF sets of the same power and frequency can also be installed to check the quality of communication. Antenna height and orientation can be adjusted to get a maximum signal strength or voice.
- Antenna can be mounted on a tower/Mast of approved design or on a pipe on the roof of a building. Feeder cable must be of 50 Ohm. impedance unbalanced of approved design. Antenna and its feeder cable must be earthed as per earthing arrangement defined in chapter XXIII.
- Connectors used must also be of good quality and supplied by an approved supplier.
- 230V AC mains operated power supply of rated voltage & current is supplied by the supplier along with VHF set. A 12V/80-120 AH battery must be connected on float to the set to prevent communication failure during mains failure.

11.4 VHF Walkie/Talkie Sets

11.4.1 VHF Walkie/Talkie sets are used in several departments of the Railways. PCSTE with approval of GM and Sr. DSTE with approval of DRM shall distribute these sets among various departments and units under their jurisdiction in view of safety, train operation, security and maintenance.

Distribution of these sets using a pool system through crew lobby etc. should be followed to optimize the requirements of sets.

11.4.2 Procurement of VHF sets and their condemnation shall be done by the S&T department.as per RDSO procedures and Railway Board guidelines.

11.4.3 The S&T department of the divisions shall be responsible for obtaining frequency authorization and obtaining license from Wireless Planning Commission. It shall also be responsible for payment of spectrum charges and license renewal of the entire population of the VHF sets being used in the division. Funds for the procurement, initial license fee and its subsequent annual renewals of license shall be provided by the respective user department.

11.4.4 Maintenance of VHF sets

a. Maintenance of the VHF sets for the entire population of the division is the responsibility of the S&T department.

b. Nodal supervisors of the user department shall inform or handover defective sets to the concerned SSE/Tele.

c. SSE/Tele concerned shall then arrange for repair/replacement of these sets for minor defects departmentally and for major defects through authorized agencies/OEM.

d. The unserviceable handsets should be expeditiously condemned and payment of license fee for those sets to be stopped.

e. VHF set’s transmitting power at different frequencies/channels are to be measured once in a year.

f. Spurious emission squelch operation current drain frequency stability, frequency deviation, sensitivity of receiver & adjacent channel selectivity are to be checked once in a year in the centralized repair center or during repair through authorized agencies/OEM.

g. List of Standard Testing Tools for VHF sets in the centralized repair center include Digital Multimeter, Communication radio test set, Dummy Load, Variable power supply, 0-30V, 0-30 A, Battery analyzer, Digital load for battery test, Channel programming kit etc.

11.5 INSPECTION

Fixed VHF installation must be inspected every month by JE, by SSE once in six months and by ADSTE/DSTE once in a year.

11.6 FAILURE REPORT

- VHF system's failure must be reported to the controlling officer daily in the morning.

- Monthly statements of a failure must be reported in the PCDO to Headquarter.

- Spare sets must be kept at site or at a suitable location to replace the faulty sets.

-x-x-x-

CHAPTER XII

ETHERNET RADIO

12.1 Point-to-point wireless digital links should be used between two locations when it is difficult to use OFC/CAT cable between the locations or the sites are to be connected in an expeditious manner or other administrative reasons like backup purpose, solving the miscreant activities etc. To maximize the performance of the wireless link, line of sight is required between the two locations and hence the antennas may have to be provided at a certain height. At 2.4 GHz, line of sight (LOS) operations provide a much more reliable wireless link. Point to point wireless link at frequencies around 900 MHz or in the UHF band (400 MHz) can work reliably in near line of sight (NLOS) or in non-line of sight conditions (NLOS point to point wireless links).

12.2 Point to Point Ethernet radio equipment normally operates in 2.4 or 5.8 GHz License Free Frequency Band. They must comply with standards and regulations issued by WPC (Wireless Planning & Coordination Wing of Ministry of Communication & Information Technology). The transmitted power of the system should not exceed the maximum permitted power level specified by WPC at the frequency on which the system works. These radios typically deliver a throughput from 25 Mbps to 750 Mbps. They can work as short range as well as long range links which can go up to 50 Kms or even more in some cases.

12.3 The payload can be voice, data or video signals and can carry any type of signaling as per the requirements. The output signal can be framed or unframed, synchronous or asynchronous.

12.4 Each side of the link comprises an Indoor Unit (IDU), an Outdoor Unit (ODU), an External Antenna, a CAT-5e (or better) UV Protected Outdoor Cable from Indoor Unit to Outdoor Unit (which provides both Data and Power). In some models, the outdoor unit and antenna are integrated. Besides, an Application Software for configuring and managing the link is also a key component.

12.5 The Ethernet Radios can meet a variety of communication needs of Indian Railways including Building-to-building and campus connectivity, High-speed Internet access, T1/E1 leased-line replacement, traffic backhaul, Video surveillance connectivity, Voice-over-IP and multimedia communications as required.

12.6 The Ethernet Radio (Wireless Tx and Rx Unit) can be Point to Point (PtP) or Point to Multi Point (PtMP) type.

12.7 When Ethernet links are provided, some of the security measures that may be taken are as under:

12.7.1 If possible, Link Lock a pair of Outdoor Units of Point to Point Wireless Link to each other so that these Outdoor Units will get synchronized / connected to each other only. This shall prevent the situation where an Outdoor Unit is stolen and used as a pirate link to steal services or information.

12.7.2 It is preferred that the link lock is based on MAC Authentication and is activated on site.

12.7.3 It is preferable to use two way locking. For example, if you lock the Outdoor Unit A to the Outdoor Unit B, you must still lock the Outdoor Unit B to the Outdoor Unit A unit to ensure complete two way locking.

12.7.4 Point to Point Wireless Link may be encrypted using suitable encryption to ensure Data Security and shall comply with IEEE 802.11i / FIPS-197 security recommendations.

12.7.5 Uninterupted Power Supply shall be used for Ethernet Radio system.

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CHAPTER XIII

OPTICAL FIBRE COMMUNICATION SYSTEM

SECTION – I

PLANNING AND SYSTEM DESIGN

13.1.1. Optical Fibre Communication System is the backbone system for all types of communication needs of Indian railways such as;

(a) Control Communication with emergency communication
(b) Administrative voice and data communication.
(c) Mobile Train Radio Communication.
(d) Various IP networks carrying IT applications and internet/intranet services
(e) Modern signalling applications

13.1.2. Guidelines for use of Optical Fibre System.

Following Optical Fibre system configuration should be used.

- 24/48 Fibres Optical Fibre Cable as per latest RDSO specification with 6 Quad Jelly Filled Quad cable as per latest RDSO specification. All Optical Fibre Cable should be laid in HDPE pipe using blowing method. one pair of fibres shall be used for communication. For back up, a second pair of Fibre shall be kept reserved to be used in case any of the working fibre gets defective/faulty. Rest of the fibres have been transferred to M/s Railtel for commercial revenue realisation. If required some of the transferred fibres may be taken back from Railtel.
- In all future works, IP-MPLS network shall be installed for both short haul and long haul communication requirements keeping provisions of redundant equipment and routes.
- Short Haul Communication is presently on STM-1 System with Primary Digital Multiplexers (PDMUX). For Control Communication application, VOIP system shall be used which shall work on existing STM network and in future it will be shifted to IP MPLS network. Long haul communication requirements are being met through Railtel's network on mutually agreed terms.

13.1.3. System design for the above types of communication are as under:-

(a) Location of optic fibre stations/nodes
(b) Optical loss budget between adjacent nodes
(c) Requirement of system capacity to meet present and future needs.
(d) Availability/Reliability of the system.
(e) Design of power supply system for each station/node.
(f) Preparation of an estimate.

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SECTION – II

LOCATION OF OPTIC FIBRE EQUIPMENT ROOMS

13.2.1. GENERAL :

13.2.1.1. The system design and the planning covered under section I lists out the requirements of optic fibre equipment locations along the route such as station, level crossing, etc.

13.2.1.2. For fixing the exact location of the optic fibre equipment room at such arrived locations, the following considerations at para 13.2.2 need to be kept in view.

13.2.2. SURVEY OF EXISTING BUILDING :

13.2.2.1. In order to optimize the existing infrastructure facilities and to ensure cost effective project execution, it is necessary to scan the building at the station where optic fibre equipment room could be provided as per system design. However, the recourse to utilize existing building should be made subject to the following :-

(a) Expenditure on addition/alteration necessary to make the room suitable for housing the optic fibre equipment shall be much less than cost of construction of new rooms at the appropriate site for Optic fibre equipment.
(b) The total area is sufficient to accommodate the layout as per Section-III.
(c) The location of the building is close to the cable route to avoid extra cable length.
(d) Power supply is available and preferably standby power is also there.
(e) The site shall be higher than the highest flood level of that place.
(f) It shall not involve many track crossings.
(g) It should be preferably in same station building/ close to the station building

13.2.2.2. In case the existing building for wayside location is not available, a new optic fibre equipment building for wayside location shall be decided with the following considerations;

New OFC building site should be close to the station building:

(a) Restaurants, tea stalls should not be close by.
(b) Site should be at an even level.
(c) Site in between track to be avoided.
(d) Preferably the site should be on the same side of the track as the route of optic fibre cable.
(e) There is road access to the site.
(f) Sufficient open space is available for –
- Storage of the equipment

- Construction of tower for train radio communication.

(g) The distance of copper cable required to join the OFC room for local services should be minimum.

(h) For reasons of security of equipment, it should be close to the ASM's Office.

13.2.3. FOR CONTROL ROOM LOCATION

13.2.3.1 All the above requirements are to be met except that of the location OFC room shall be a part of the control office complex.

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SECTION – III

BUILDING LAYOUT

13.3.1 The wayside OFC room shall be as per drawing No. RDSO/TCDO/COP-1(a).

13.3.2 The building for the main control station and Critical Nodes shall be as per Drawing No. RDSO/TCDO/ COP-2(a).

13.3.3 Following is to be ensured for the building:

13.3.3.1 It should be made preferably of bricks and concrete. The front door shall be sturdy to prevent the intrusion by antisocial elements and sealing shall be such that it prevents ingress of dust also.

13.3.3.2 Cable pit near OFC room shall have depth of 1.25 m. Two RCC pipes of 100 mm dia each will be provided separately for OFC and quad cable. The pipes shall be laid up to 2 m length away from the cable pit outside with suitable slope in such a way that smoother entry of cable inside the cable pit is obtained. One end of the RCC pipe will open at the bottom of the cable pit in one of the side walls and the other end will extend to 2m inside the trench with suitable slope. The cable trench will be made deeper at the entry. End of RCC pipes should be sealed with Plaster of Paris.

13.3.3.3 AT Power supply and standby arrangement with remote monitoring of supply should be provided. Preferably the wiring for electrical fittings, plug points, etc. should be concealed type.

13.3.3.4 To avoid frequent distempering, Oil distemper which may last for 10 to 12 years to be provided.

13.3.3.5 Floor shall be provided with PVC tiles or any other suitable synthetic covering in the equipment room.

13.3.3.6 In the battery room, the exhaust fan shall have a rain protection shed and hole covered with wire mesh to avoid entry of birds, insects, etc. Acid proof tiles should be used for the battery room.

13.3.3.7 Air Conditioning should be provided in all critical OFC backbone locations where ambient temperature is normally on the higher side. In other locations, Ventilation arrangements should be provided as shown in Drawing No. RDSO/TCDO/COP-1(a) & 2(a).

13.3.3.8 Windows and Ventilators shall be provided with suitable wire mesh and grill arrangement to prevent theft and entry of rodents etc.

13.3.3.9 Earthing arrangements should be provided near the OFC room.

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SECTION IV

LAYOUT OF EQUIPMENT

13.4.1 The layout of equipment in the OFC room at wayside stations and control office shall be as per Drawing Nos. RDSO/TCDO/COP-03(a) and RDSO/TCDO/COP-04(a) respectively.

13.4.2 The equipments shall be accommodated in standard 19” size racks

13.4.3 The wiring from battery to the location of equipment shall be inside PVC channels suitable size and suitably supported all along length.

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SECTION V

PRELIMINARY SURVEY OF OPTIC FIBRE CABLE ROUTE

Preliminary survey shall be carried out for finalizing the drawing for the route of optical fibre cable as a part of project planning and execution.

Following main items of work shall constitute the survey.

13.5.1 Selecting the route in general.

13.5.2 Deciding the number of drop and insert locations.

13.5.3 Deciding the size and assessing the length of cable required.

13.5.4 Working out the requirement of circuits which are to be provided in the cable.

13.5.5 Working out the requirements of heavy tools and plants depending upon the nature of the territory, availability of roads along the tracks, etc.

13.5.6 Assessing the special problems of the section such as type of soil, long cuttings, new embankments, water logged areas, types of major bridges, major yards.

13.5.7 Collecting details of the existing telecommunication facilities and the additional requirements due to electrification and preparing tentative tapping diagrams.

13.5.8 Assessing the number of track crossings and other protective works required to be done.

13.5.9 Avoiding laying of cable too close to a newly laid track, as far as possible.

13.5.10 Avoiding the toe of the embankment adjacent to the cultivated fields.

13.5.11 Avoiding burrow pits and areas prone to waterlogging.

13.5.12 Avoiding soil made up of cinders, coal ashes, etc.

13.5.13 Avoiding heavily fertilized soils containing acids, electrolytes and decomposable organic materials promoting bacterial activity.

13.5.14 Avoiding proximity to chemical, paper and such other industries which discharge chemically active affluent.

13.5.15 Avoiding large rock cuttings, thick jungles, routes of existing cables and areas difficult to approach.

13.5.16 Deciding carefully the cable route approaches to cable huts to avoid built up areas including those areas where building, etc. are likely to come up in future.

13.5.17 Determining composition of the soil which may affect corrosion, etc. on the cable and special protection required for cable.

13.5.18 Working out the requirement of the various circuits to be provided in the cables along with the cable circuit chart and tapping diagrams.

13.5.19 Working out requirement of transport vehicles. for the execution of the work.

13.5.20 Avoiding on the side of the alignment which is likely to be affected due to addition/alteration of earth work/supply structures (such as construction of double lane, shifting of alignment of the existing track etc.)

13.5.21 **Preparation of cable route plan and tapping diagrams**.

The cable route plan should indicate the route with respect to the main line centre of track, that is, whether the route along the DN main line or UP main line in case of double line sections and whether it is on both side or right side of the main line when facing a particular direction in case of single line section. A tentative tapping diagram should be prepared for the section indicating the tappings of various circuits. In addition to above, the cable route plan should also indicate the route with respect to other available permanent structures for easy identification of route.

13.5.22 **Selection of the Cable Route**.

Generally the terrain conditions on the two sides of the track vary to such an extent as the cable route on one side of the track has a distinct advantage over that on the other side. While operating on the principle, it should be borne in mind that frequent track crossings are not desirable.

In addition to the above, the following also need consideration:-

13.5.22.1 Avoiding underground structures, signalling cables, power cables, pipe lines, etc.

13.5.22.2 Avoiding the laying of cable on the side of the drains in built up areas which is generally difficult.

13.5.22.3 Selecting the cable route as far as possible on the opposite side where Railway signalling cables already exist in station yards, etc.

13.5.22.4 Taking the cable route preferably through the bed of small culverts preferably through HDD method where water does not accumulate instead of taking it over the culverts.

13.5.22.5 Avoiding termites/rodents infected areas.

13.5.22.6 Preference at the side of the main line away from the coastal side.

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SECTION – VI

DETAILED SURVEY AND FINALISATION OF THE ROUTE PLAN OF OPTIC FIBRE CABLE

Detailed Cable Route Survey:

13.6.1 Purpose:

The purpose of the detailed survey is to undertake closer study of various existing telecommunication facilities to work out exact requirement of materials required for different items of work to finalize all the drawings and site plans required for the execution of work as also to examine the details collected during preliminary survey and to offer necessary changes/modifications, if any.

13.6.2 Main items of work:

The following are the main items of work which should constitute the detailed survey:

i) Closely examining the proposed cable route and prepared cable route plans.
ii) Siting of cable hut buildings and preparation of site plans.
iii) Siting and preparation of site plans for buildings required for the execution of the work, as offices at different stations, store godowns, etc.
iv) Siting of areas for loading/unloading of cable drums and siding facilities for the EMTs (Engineering Materials Trains) for the project.
v) Estimating of requirement of special cable lengths for long girder bridges.
vi) Preparation of the material schedule required for different protective works.
vii) Arranging isolated telephone circuits to be provided in the cable.
viii) Investigation on special problems, if any, of the section and finding out proposed solutions thereof.

13.6.3 Procedure:

For the preparation of the main cable route plan, "5 Km charts" should be prepared which covers a length of 5 Km of the route. The horizontal scale is 10 cm = 1 Km.

Based on the OHE location survey plan, the locations of ASM's office, cabins, OHE switching posts, etc. should be marked on the charts. The name of the location should be put in the 'LOC' column and the chainage in the 'CH' column. At every 10cm the km post number should be written and its exact equivalent chainage as per OHE survey plan entered in the 'CH' column. The equivalent chainage is required for working out the length of the cable required. The name of the station should be shown against the location of the Station Master's office.

Based on the OHE survey, the serial number and the length of culverts, bridges and level crossing shall be marked on the 'Track Line' of the cable route plan. The survey party should be supplied with prints of '5 km charts' with the above details entered for enabling them to mark the route, and other details after surveying.

The following are the guidelines for finalizing the route and preparation of the cable route plan:-

i) Prepare the '5 km charts' as explained above and collect the latest copy of approved OHE survey plan to enter the relevant chainages and details in the '5 km charts'.

ii) Actual measurement by 30m steel tape or chain along the route is necessary only in case of important locations to be termed as 'special terrains' for example, approach to long bridges, big yard, sharp diversions in the cable route from its parallel course along the main Railway tracks due to obstruction, cuttings, etc.

iii) Inspect and decide the portions of route falling in the category of 'special terrains' stated in para (ii) above, i.e. where actual longitudinal measurement is necessary.

iv) The remaining portions of the route, i.e. other than the portion decided as 'special terrain' as per para (ii) above are to be termed as 'straight runs'. Actual chaining along the route is not necessary for such 'straight runs' and these can be marked on the '5 km charts' by taking chainages from the OHE plan.

v) The cable route shall be started from the control office. At that measurement along the route should be done by means of a 30m steel tape for a few drum lengths up to a convenient point along the main line where from the distances along the route may be reckoned from the OHE plan.

vi) Actual measurements of the separation distance from the centre line of the reference track (a reference track shall always be the main line) is essential in case of 'special terrains' on 'straight runs' this measurement shall be made where necessary. In case of 'special terrains' the separation distance at some points on the route may also have to be reckoned from some other permanent structures depending upon the site conditions.

vii) As a rule, a minimum distance of 5.75 m should be maintained between the OHE masts and the cable. In yards, etc. where observance of this rule may be difficult, a minimum distance of 1 m shall be maintained ensuring that OFC is laid in HDPE pipe.

viii) The route shall be decided by walking along the track on long stretches of ‘straight runs’ a push trolley moving slowly may be used. The trolley shall be on the track close to the proposed route.

ix) Actual measurement shall be made for the protective works required for the cable passing over the culverts under tracks, over long girder bridges, arch bridges, level crossings, rocky areas, under the bed of culverts and near OHE switching posts, etc.

x) The survey party shall visit each location such as cabins, SM’s offices, loco sheds, pump houses, gate lodge, etc. and verify the details collected during the preliminary survey of all the existing telecommunication facilities to be provided due to RE such as tappings on traction power control, traction loco control, remote control and emergency control circuits. For emergency control circuits in addition to the general tappings to be provided at every 1 to 1.2 km. The details of tappings specifically required by the Electrical Engineering Department for their switching posts such as sub-sectioning posts, sectioning posts, traction sub-stations and isolated locations, etc. shall be collected well in time. The exact location of the various tappings on the emergency control shall then be worked out taking into consideration the tappings to be essentially provided at specific locations for the Electrical Engineering Department so as to ensure that the distance between the consecutive emergency socket posts does not exceed 1 to 1.2 km.

The position of each tapping shall thus be finalized and a final tapping diagram prepared.

13.6.4 CABLE LENGTH :

13.6.4.1 Cable entry in the cabin and other buildings shall be as per Drawing Number RDSO/TCDO/COP-18.

13.6.4.2 The cable length shall be worked out on the following basis :

(a) Route length as per actual measurement plus contour allowance of 2.5%.
(b) Extra length for track crossing including 2.5 meters loop on each side.
(c) 10 meters extra length on approach/crossing of the bridges and culverts on each side as per measurement in the detailed survey.
(d) 5 meters of cable to be kept on either side of major steel bridges and 2.5 meters of cable on short bridges.
(e) At every joint a loop of 10 meters on either side shall be kept.
(f) In cable huts a loop of 10 meters in the cable pit shall be kept.

13.6.4.3 **Special lengths for long girder bridges**.

For long girder bridges, special length of cable may be required. This is to avoid the location of a joint on such bridges, on slopes leading to bridge abutments and on top of deep cuttings, etc. These details regarding the approaches to the bridges shall be worked out.

13.6.5 Materials required for protective works.

13.6.5.1 For crossing masonry platform, and at culverts, level crossings and road crossings etc. special protection for cable is required.

13.6.5.2 Actual measurement should be made for the length at which special protection is necessary and requirement of materials for the protection should be worked out. The requirement of material based on the actual measurement should be shown in cable route plan at the appropriate place.

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SECTION – VII

CABLE HANDLING TECHNIQUE FOR STOCKING & TRANSPORTATION OF OPTIC FIBRE CABLE

13.7.1 GENERAL:

The following practices are to be followed to prevent damages or deterioration of the cable during handling and storage.

13.7.2 The cable drums stored in open shall be kept on a strong surface such as released sleepers to prevent sinking.

The drums shall not be stacked on its flat side and also suitable stoppers shall be placed properly for its stability.

13.7.3 The cable drums shall be stored in a manner allowing easy access for lifting and moving and the drums shall be stored away from other construction activities.

13.7.4 When rolling the cable drum either for unloading or transportation to cable laying site, the drum shall always be 'ROTATED IN THE DIRECTION OF AN ARROW WHICH IS MARKED ON THE SIDE BOARDS OF THE DRUMS' SOMETIMES 'ROLL THIS WAY' ARROW IS INDICATED ON THE DRUM FLANGE.

13.7.5 The drums shall not be rolled over objects that could cause damage to the protective battens or the cable.

13.7.6 After transit, the drums shall be inspected for damage such as broken battens and where possible, the outer layers of the cable should be inspected.

13.7.7 The cable drums shall always be kept upright with the cable ends securely tied to prevent unwrapping. All battens or coverings shall be left in a place until the cable is unrolled from the drums during installation.

13.7.8 UNLOADING OF CABLE DRUMS AT PLACE OF STORAGE OR AT CABLE LAYOUT LOCATION :

13.7.9 UNLOADING OF CABLE DRUMS

(a) When unloading of a drum is carried out from a vehicle, the drums SHALL NOT BE DROPPED ON THE GROUND directly to avoid irreparable damages to the cable due to impact.

(b) Steps for unloading :

i) Unload the drums with fork lift truck with forks enough to take full width of the drum so that the weight is born by both the flanges.

OR

ii) The cable drum may be lifted by a suitable crane. For this purpose, a suitable size spindle shall be placed through a central hole and double ended shall be attached to the spindle. The spindle shall be equipped with a stopper of such a length that will not cause damage.

13.7.10 LOADING OF CABLE DRUMS

Same precautions as for unloading are to be followed.

13.7.11 SEALING OF CABLE and HDPE PIPE END

During all stages of storage/use, it is essential that the end of the cable and HDPE pipe are effectively sealed end cap. Failure to effectively seal may result in water entry in the cable and making it unfit for the use.

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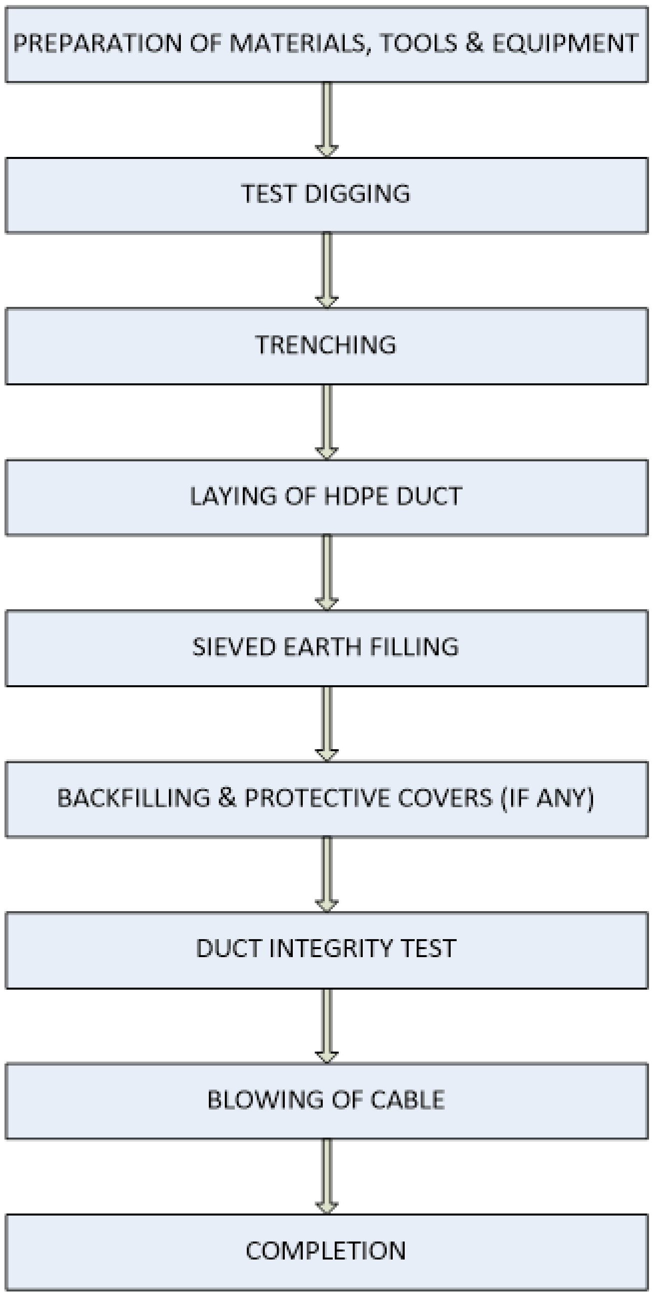
SECTION – VIII

LAYING OF DUCT IN TRENCHES AND BLOWING/PULLING OF CABLES IN DUCT

13.8.1 WORK FLOW DIAGRAM :

The major steps for cable laying in trenches are shown below. Before commencing each step, be sure to check how far the work of preceding step has been completed and how well the preparations for the work of subsequent step have been made.



13.8.2 CABLE INSTALLATION AND TRENCHES – GENERAL

Armoured fibre optic cable shall be blown into duct laid and suitably aligned in the trench. Only in unavoidable conditions due to terrain/approach, pulling of cable in duct may be permitted in small subsections. The trenching and laying method is dependent on both ground configuration and nature of the soil at site. The duct shall conform to the latest Specification of TEC/RDSO.

From specifications and drawings, ascertain the route of the cable, requirement of the materials, labour and work period, etc.

13.8.3 PREPARATION OF MATERIALS , TOOLS AND EQUIPMENTS

(a) Check that all tools and equipment for installation detailed in Section XI are ready at site.
(b) Check that the required quantity and type of material for laying of cable in trenches are ready at site.
(c) Take care to keep the tools metal fittings equipment in a warehouse to prevent being stolen/lost.
(d) In case, materials have to be kept on the road care must be taken to ensure that traffic is not hampered and no inconvenience is caused to the public.
(e) Special attention must be paid to avoid keeping material on or around the fire plug or hydrants sewage duct. In case, it becomes unavoidable, use across such locations.

13.8.4 TEST DIGGING

Before cable installation, inspect the route with reference to the approved plans and the specification and ensure that there are no obstacles in the route.

Conduct test digging to ascertain the existing facilities and record the position and depth of cable to be installed as well as any existing underground cable or water pipes etc.

13.8.5 INSPECTION

(a) Check the cable installation position shown in the cable route plan vis-à-vis the actual condition site.
(b) Determine the cable jointing points and curving points from the offset shown on the cable route plan and measure the distance between them and the surplus lengths.

13.8.6 TRENCHING

13.8.6.1 Traffic Safety :

The telecom cables should normally be laid within 1 metre inside the Railway boundary and far away from traffic movement. At the site of cable installation, take the following measures for traffic safety if trenching is unavoidable near places where traffic movement is involved;

(a) Provide ‘WORK IN PROGRESS” plate wherever necessary at both ends of the site and provide signages and sufficient lighting during night.

(b) Wherever necessary, provide suitable fences at the end and side of the trenches to keep vehicles and pedestrians away. At night, use warning lamps or equivalent at adequate distances.

13.8.6.2 Burying depth of duct

(a) The standard depth of duct should be such as to ensure the standard depth of cable which are defined in drawings for various types of locations/civil structures.

(b) The depth of the duct shall be enough to prevent natural, artificial obstacles and damages. The standard depth must not be less than the specified. Sharp depth variations to be avoided to prevent macro bending of the OFC affecting performance.

(c) In case it is a rocky area, the depth may be reduced by using the concrete protection.

13.8.6.3 The standard trench :

(a) The standard trenches are as follows for different conditions:

- Trench for laying duct for optic fibre cable (typical RDSO/ TCDO/COP-6(a)).
- Trench for laying duct for optic fibre cable with 6 quad cable and PIJF cable in the same trench (typical RDSO/TCDO/COP-8(a)).
- Trench on embankment for duct for optic fibre cable (RDSO/TCDO/COP-9(a)).
- The trenching in the rocky area for duct for optic fibre cable (typically RDSO/TCDO/COP-10).

13.8.6.4 Excavation :

The excavation for trenching may be made either manually or by mechanical means.

(a) **Manual excavation** :

- The depth of the trench may be measured by a rule made of pipes as per RDSO/TCDO/COP-11(a)
- When the surface of the ground where the trench is dug is slanting or uneven, the depth is measured with respect to lower edge.

(b) **Machine excavation** :

Excavation of trench can also be done mechanically by:-

- Loading backhoe equipped with excavating bucket, cleaning bucket, back filling blade and lifting tackle. This backhoe may be suitably used for lifting cable drum equipped suitably.
- Other mechanical excavation with mechanical fittings to trench and excavate.
- CATERPILLAR TRACTOR can be used for laying cable along cable route using adjustable ripper having typical preparation of 1.20 meter depth to install cable at 1.2 meter depth.

13.8.6.5 After digging is done to specified depth, the bottom of trench should be levelled by removing the exposed stones or obstacles, etc.

13.8.6.6 A day's trenching is to be such a length that cable laying and back filling can be finished during the day. This however, would not apply to cases where operation does not hamper the traffic and where cable trenches are not exposed to likely interference/damages.

13.8.7 HANDLING AND LAYING OF DUCT :

13.8.7.1 The coil of duct shall be unloaded by the side of the Railway track from either a crane or by any other suitable means very carefully so as not to cause any damage to the duct. The coils at site shall be protected until they are laid. The duct shall be given the same care in handling as that given to the cable. The coils shall be kept as per the guidelines issued by the manufacturer. The coil shall not be set by jerks but shall be handled slowly and carefully. The walls of the ducts shall not be damaged while moving the coils, if required for unloading.

13.8.7.2 The coil shall normally be unrolled at the same place and the duct carried by workmen near the trench. The coils shall not be dragged in any case. But where the drums/coils of duct have to be moved should always be rolled in the direction of the arrow, otherwise the coils tend to unwind and the same may get battered. In case no such direction of arrow is given see the direction of winding of the coil and the coil should be rolled pointing in the opposite direction in which the upper end is coiled.

13.8.7.3 All care should be taken in handling the coils with a view to ensure safety of the coils but also of the working party handling them. The coil should not be broken by standing in front of the coil but only from side.

13.8.7.4 DUCT LAYING :

It is advisable to employ the same people at the same place or job while duct is being laid.

Before commencement of the laying, inspection of the trench and inspection of protection works should be carried out so as to ensure their conformity with the specification. The trench bottom should be clean, smooth and free of small stones. When the soil contains stone or pieces or rock and therefore cannot be raddled, sieved earth about 10 cm. thick should be used for the bedding on which the duct is being laid.

The duct coil should be brought as close to the trench as possible. It should be lifted carefully with the aid of jacks

13.8.7.5 (i) It is customary for the mate to stand in a commanding position where he can view the entire road and shout evenly and call his men to pull. If there is proper synchronization between the mates call in the pulling by the men the duct will leave the coil without difficulty. It is important that the duct shall be pulled with steady and even pulls and there should not be unnecessary twists. Care should be taken to avoid twist as this is likely to damage the duct. When pulling around bends one or two men should be stationed to give the duct the correct bent when it passes.

(ii) While laying the duct, we should employ an adequate number of men so that the duct can be conveniently carried by them in both hands without stretched arms. The distance between any two persons carrying the duct shall be two to ten meters depending upon the weight such that the maximum sag of the duct between any two persons is not more than 0.5 meters.

(iii) While laying work is in progress one man has to continuously observe the duct along its line in order to determine indentations poles or other damaged parts are apparent. Such damaged parts have to be protected immediately.

(iv) The conditions of the duct shall be visually inspected throughout its line and in case damage or defect is noticed, the trench shall be filled up only after ensuring that the damage is not likely to affect the cable.

(v) The end of the duct should be sealed with flex to prevent entry of soil before filling back. Adjoining ducts shall be joined by couplers. Duct integrity testing (as per annexure-I) shall be carried out when laying is completed in a block section (8-10 kms). In case the continuity is not achieved the fault shall be localized and rectified by providing HDPE couplers/Compression couplers.

13.8.7.6 Tools necessary for laying Duct is detailed in Section XI to be checked as physically available before starting the Duct laying.

For efficient and safe Duct laying, communication may be provided between following points using portable VHF Walkie talkie sets :

a. Duct Coil end

b. Any intermediate manhole/diversion/track crossing through which the Duct will be passed.
c. The Supervisor Incharge of the Duct laying.

Whenever duct is to be laid in the duct (GI pipe or RCC pipe), suitable lubricant on duct may be used to reduce friction and consequently the tension on the cable.

During duct laying care must be taken not to twist duct in any direction. For this purpose, the swivel (rotating hook) shall be attached between pulling line and pulling eye at the end of duct so as to avoid any possible twist during pulling and laying of the cable.

In case it is planned to lay the cable in duct by pulling the cable by using a winch; the duct should be provided with a nylon rope for pulling the cable.

13.8.8 PREPARATION FOR PAYING OUT CABLE

(a) Check the drum number and length of the cable, etc.

(b) Entrust cable drum to the contractor after testing the fibres with OTDR for attenuation and to ensure that no mechanical damage of the fibre exists while handing over the cable to the contractor.

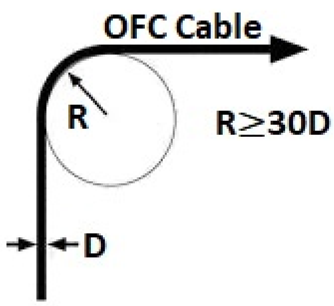
(c) Place the cable jack (to support cable drum) on a flat surface.

(d) Put cable spindle through drum and adjust cable jacks so that the drum may be 3-5 cm clear from the ground and that the spindle may become horizontal. Remove carefully lags of drum with bar or other means by taking care that no damage to the cable takes place.

(e) Pull out nails from lags or bend them so that operation can be done safely.

(f) Normally both ends of the cable is provided with cable grip and pulling eye. In case, it is not already provided, fit the cable grip/pulling eye to the swivel and pull the wires by means of shackle.

(g) Bending of a fiber optic cable can damage the cable if the radius of the bend is too small. The normal recommendation for fiber optic cable bend radius is the minimum bend radius under tension during pulling is 20 times the diameter of the cable. For armoured OFC used by IR, keeping sufficient safety margin, bending radius under tension during pulling should always be greater than 30 times the diameter of the OFC.



13.8.9 LAYING OF CABLE BY WINCH

This method should be used for smaller lengths only

(a) Stretch pulling rope on rollers and fix its end on winch.

(b) Use 2-3 tonnes winch and put it near the dug trench. The winch shall be fastened at the back wire to a pile driven into the ground to prevent from moving out of place due to pulling tension.

(c) After everything is ready, post workman at winch, cable and using communication, pull slowly into the duct by means of winch. Cable shall be laid under a specified pulling tension bending radius and pulling speed as shown below :

(d)

DURING INSTALLATION	ITEM	VALUE
	PULLING TENSION	(1.1 times W)Kg.
	BENDING RADIUS	>30 times D
	PULLING SPEED	Max.15 m/min

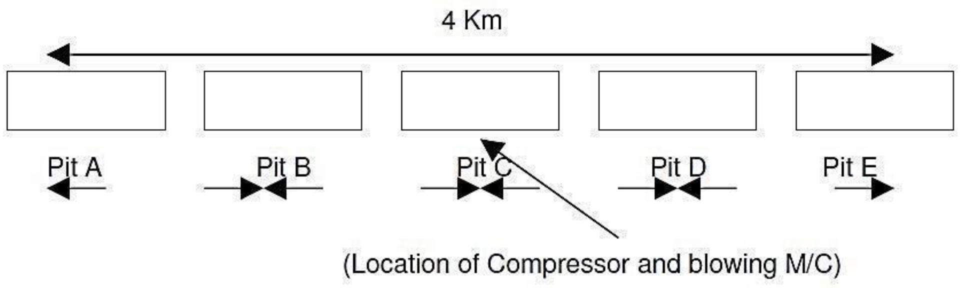
D – Cable outer dia
W – Weight of Cable per Km. in Kg

13.8.10 BLOWING OF OFC CABLE

Optical fibre cable will be blown into pre-lubricated HDPE duct laid with the help of a compressor and blowing equipment. Before blowing of OFC, duct integrity testing (as per annexure-I) on laid HDPE duct should be carried out. The blowing method involves feeding of optical fibre cable into the duct with the help of consistent high pressure airflow, equally distributed along the entire cable throughout the duct.

The following steps may be adopted for safe blowing of OFC :

i) Position the compressor and blowing machine at blowing pit C for location A & E shown below.



ii) Put the cable drum on cable wheel and blow the OFC towards pit A. A pusher equipment may be placed at B if required.

iii) When the cable reaches pit A and coil of 10 - 15m of OFC should be kept in pit A. Then seal the duct end at A with the sealing plug.

iv) Uncoil the cable on the drum in a figure of eight configuration and blow towards blowing pit E and coil of 10 - 15m of OFC should be kept in pit E.

v) Since the cable will be available in length of 3 km and above, so the contractor has to plan the location of blowing pits before laying of HDPE duct. The contractor has to ensure that excess OFC is not coiled in the blowing pit and also optical fibre cable does not fall short of the location of blowing pit. The contractor has to match the cable drum length with the location of blowing pits, to ensure minimum cut length and wastage of OFC. To achieve the blowing of above shown strength, blowing can be carried out downhill, wherever possible.

vi) HDPE ducts will be sealed with the help of cable sealing plugs after blowing of OFC into the duct at jointing pit locations.

13.8.11 TREATMENT OF CABLE AFTER IT IS LAID

a. After completion of cable laying check the following items:
    - Confirm extra jointing length as required at end.
    - In case cable is damaged, take necessary prevention and remedial steps for removal of defects.
    - If there is any snaking or rise in cable put right.
    - Examine the interior of the trench and remove any pebbles, etc.
    - Take protective steps for such objects projecting the trench such as sewer pipe etc.

b. While laying one piece of cable, when part of the work is to be put off till the following day, keep the remaining portion of cable wound on the drum, reduce as much as possible the distance of the drum from already laid cable considering cable bending radius and general traffic safety and also ensure that drum is prevented from tumbling down or rolling away. Already laid cable shall be fully covered to avoid outside interference.

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SECTION – IX

PROTECTION OF OPTIC FIBRE CABLE ROUTE AND BACK FILLING OF TRENCHES

13.9.1 GENERAL :

13.9.2 This chapter covers the various protection arrangements, which are required to be provided along the cable route for the purpose of preventing damage to the cable and protection to staff.

13.9.3 The chapter also covers the arrangement for back filling of cable trenches to provide protection to the cable.

13.9.4 PROTECTION OF CABLE ROUTE :

13.9.5 PROTECTION OF CABLE CROSSING BRIDGES/CULVERTS.

The typical arrangements for protection for the following types of bridges/ culverts are as under.

i) Arrangement of cable troughs and channel for girder bridges and major culverts (Typical Drawing RDSO/TCDO/COP-12) and RDSO/TCDO/ COP-13). Separate troughs should be provided for laying 6 quad cable & OFC. For smaller culverts/bridges, if feasible, trenchless horizontal directional drilling (HDD) should be adopted with DWC pipe protection and ensuring that cable is minimum 2 m below the bed of culverts/ bridges.

ii) Drawing of crossing major culverts (high flood level and normally blocked by water) and major bridges by steel troughs at rail level (Typical drawing RDSO/TCDO/COP-14(a)).

iii) Drawing of crossing of Railway bridges by perforated GI pipe (Typical drawing RDSO/TCDO/COP-17(a)).

iv) Drawing for crossing culverts pipe/box with high flood level (Typical Drawing RDSO/TCDO/COP-16(a)).

13.9.6 MEASURE AGAINST THEFT OF STEEL TROUGHS :

(a) In the drawing for major culverts and bridges steel troughs are to be provided on the channels as indicated in the drawing RDSO/TCDO/COP-12 and RDSO/TCDO/COP-13.

(b) In order to prevent theft of optic fibre cable steel troughs with optic fibre cable should be filled up by bitumen compound conforming to IS specification. The cover of the trough to be effectively secured as per the drawing.

(c) Bitumen filling job should be supervised at a responsible level not below the rank of Sr. Supervisor.

(d) In order that the temperature of the cable does not increase beyond 55°C, bitumen compound should be poured in the early hours/late hours of day when ambient temperature is around 18°C or less.

(e) While pouring the heated bitumen compound, steel trough covers should be removed all through the bridges in order to permit fast cooling.

(f) Before pouring bitumen compound, its temperature should be accurately measured to ensure that the pouring temperature is not more than 140°C.

(g) The bitumen compound should be filled upto a height of approximate 60mm.

(h) Both End of steel troughs should be concreted at the end of bridge/culvert

13.9.7 ARRANGEMENT ACROSS CULVERTS :

(a) Most of the culverts are generally dry and as such the arrangement as indicated in RDSO/TCDO/COP-17(a) can be adopted.

(b) For culverts which are normally filled with water or which are having high flood level, the protection arrangement can be done as per the arrangement shown in drawing RDSO/PCDO/COP-16(a).

13.9.8 ARRANGEMENT FOR LAYING OF FIBRE OPTIC CABLE ACROSS GIRDER BRIDGES :

(a) Girder bridges up to span length of 12 meter :

i) Girder bridges of up to 6 meter span can be crossed with perforated GI pipe as per the arrangement shown in drawing No. RDSO/TCDO/COP-17(a).

ii) The same arrangement can be followed for girder bridges of span length between 6 and 12 meter where an intermediate support to GI pipe can be provided.

(b) Girder bridges of span length more than 12 meters.

i) The crossing of girder bridges of more than12 length can be done as per the drawing No. RDSO/TCDO/COP-14(a). The arrangement for fixing of steel trough indicated in drawing RDSO/TCDO/COP-12 and RDSO/TCDO/COP-13.

ii) The procedure for filling bitumen compound is indicated in Clause 13.9.6 above.

iii) Separate trough for laying 6 quad cable should be used.

13.9.9 PROTECTION ARRANGEMENT ON THE CABLE ROUTE :

The typical drawings of cable trenches under various situations are given in Section-VIII. These drawings include the protection arrangement of brick provided along the cable route. These protection arrangements are summarized below:

(a) The cable laid in the station yard (Home Signal to Home signal) and on the embankment, after covering the duct with riddled earth, B-class brick to be placed transversely through out to over the cable laid in station yard/embankment.

(b) The cable marker shall normally be provided at distance of every 50 meters on the cable route and at places wherever the route changes. A joint indicator shall be provided at all joints. The cable marker and joint marker provision shall be as per Drawing No. RDSO/TCDO/COP-22(a) for normal and rocky area.

(c) The cable marker and joint markers provided shall be of standard stone RCC type.

13.9.10 CABLE CROSSING TRACKS AND LEVEL CROSSING GATE :

To the extent possible, track crossings within the station yard requiring crossing of number of tracks to be avoided. Wherever it crosses the track or LC gate:

(a) The cable shall be laid in RCC/DWC ducts keeping the depth same as in normal routes.

(b) In case of cable crossing the LC gates, RCC/DWC ducts to be laid on the road and for a distance of at least two meters from either side of the road.

(c) Minimum depth at any track crossing shall not be less than 1.2 meters with RCC/DWC duct. In case cable crossing the track, it may be ensured that it should not be bent less than 600mm radius. Suitable fixture with RCC/DWC duct should be provided to ensure proper bending radius to be used at each end.

(d) The drawing for track crossing, road crossing platform shall be as per Drawing No. RDSO/TCDO/COP-19(a).

(e) Arrangement of RCC/DWC duct under metalled road shall be as per RDSO/TCDO/COP-20(a)

(f) In case of Road/Platforms/Railway track etc. trenchless horizontal directional drilling should be adopted. A minimum depth of 1.2 meters to be ensured.

(g) Cable should be taken in GI pipe in rocky areas, culverts, girder bridges and PSC girder bridges (without duct). At the end of these structures where the pipe enters the trench the pipe should extend right into the trench and then should be protected with a concrete/brick masonry work, 5 meter cable should be kept at the ends.

(h) Wherever new PSC girders are being constructed, provision of ducts should be catered, OFC cable shall be taken through class B GI pipes of 80 mm diameter.

(i) Inside the tunnels, the cable should be laid by excavating a suitable depth in the drainage area levelling the bottom surface in B class GI pipe of 80 mm diameter, the entire length of GI pipe will be concreted and substantially protected. Another method may be clamping of DWC ducts to side walls of tunnels at safe height.

(j) Wherever new track is constructed inside tunnels, provision for DWC duct should be catered which can be embedded in the concrete base to be ensured by Engineering unit constructing tunnels.

(k) The joints should be avoided inside tunnels. If the tunnel length is more than 3 kms suitable area with proper finishing inside tunnel refuge to be earmarked for housing OFC joints and telecom equipment.

13.9.11 BACK FILLING OF TRENCHES:

For back filling of cable trenches following precautions shall be taken:

(a) At least 120 mm from the surface of the last cable, cable should be covered with riddled earth. This portion of the earth is not loose. This will also prevent entry of rodents and other insects.

(b) At 500 mm depth a PVC warning tape shall be provided continuously running in the trench.

(c) For the remaining portion of the trench, the released earth may be used. However, after filling up the trench, the earth shall be consolidated by ramming.

(d) Back filling of trench and ramming shall be supervised by a responsible Supervisor and also at officer’s level for the specified percentage of the section. In case of shortage of manpower, video recording of cable laying, depth of trench, protection arrangement and back filling of trenches should be included in scope of contract. All these recordings should be handed over to concerned SSE/Tele/Maintenance along with handing over of section.

(e) It shall be ensured that before the start of monsoon session, all open trenches are properly back filled to avoid water logging of the trench.

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SECTION – X

JOINTING AND TERMINATION OF OPTIC FIBRE CABLE

13.10.1 Techniques for jointing of optic fibre cable.

13.10.2 Following types of techniques shall be used for splicing of fibres :-

(a) Mechanical Splice

This aligns the axis of the two fibres to be joined and physically hold them together.

(b) Fusion Splicing

This is done by applying localized heating (i.e. by electric arc or flame) at the interface between the butted, pre-aligned fibre end, causing them to soften and fuse together.

13.10.3 Mechanical splicing may be used only for temporary splicing of fibres.

13.10.4 At all other locations and during initial installation of optic fibre cable, fusion splicing shall be adopted.

13.10.5 STRAIGHT JOINT FOR OPTIC FIBRE CABLE

There are various types of joint enclosures available in the market. The procedure for assembly of joint closure is described in the installation manual supplied with straight joint closure. This includes the following :

(a) Material inside joint closure kit.
(b) Installation tools required.
(c) Detailed procedure for cable jointing
(d) Procedure for reopening the closure.

13.10.6 Generally, the following steps are involved for jointing of the cable :

- Preparation of cable for jointing
- Stripping/cutting the cable
- Preparation of cable and joint closure for splicing
- Stripping and cleaving of fibres
- Organising fibres and finishing joints
- Sealing of joint closure and
- Placing joint in pit

13.10.7 PREPARATION OF CABLE FOR JOINTING

(a) During the installation, a minimum of 10 meter of cable at each end is coiled in the jointing pit to provide for jointing to be carried out at convenient location as well as spare length to be available for future use in case of failures.

(b) The pit size shall be so as to ensure the length of the wall on which joint is mounted is greater than closure length plus twice the minimum bending radius of the cable. A pit length of 1 meter is sufficient for most of the cable and joint closures. Bracket to support the cable coil are also fixed on the wall of the pit. Details of cable pit are given in Drawing No.RDSO/TCDO/COP-21(a).

(c) The cable is then coiled on to the pit wall in the same position as required after the joint is complete. The marking is done on all the loops so that it will be easier to install it later.

13.10.8 STRIPPING/CUTTING OF THE CABLE

(a) The cable is stripped of outer and inner sheath with each sheath staggered approximately 10mm from the one above it.

(b) Proper care must be taken when removing the inner sheath to ensure that the fibres are not scratched or cut with the stripping knife or tool. To prevent this, it is better to score the inner sheath twice on opposite sides of the cable, rather than cutting completely through it. The two scores marking on either side of the cable can be easily stripped of the inner sheath by hand.

(c) The fibres shall be then removed from cable one by one and each fibre is cleaned individually using kerosene/suitable liquid to remove the jelly.

(d) Armouring shall remain outside the gland and will not be connected through.

13.10.9 PREPARATION OF CABLE JOINT CLOSURE FOR SPLICING

The type of preparation work performed on the cable prior to splicing differs on the type of joint closure and fibre organizer used. However, the following steps shall be usually common for different types of joint closure.

(a) The strength member of each cable shall be joined to each other and/or the central frame of the joint closure.

(b) The joint closure shall be assembled around the cable.

(c) The sealing compound or heat shrink sleeve shall be applied to the cables and closure, or prepared for application after splicing is complete.

(d) Tags which identify the fibres number shall be attached at suitable location on the fibres.

(e) Splice protectors shall be slipped over each fibre in readiness for placing over the bare fibre after splicing.

13.10.10 STRIPPING AND CLEAVING OF FIBRE

(a) Prior to splicing, primary protective coating of each fibre shall be stripped off up to length of 50 mm. by using fibre stripper. Fibre strippers shall be manufactured to fine tolerances and only score the coating without contacting the glass fibre.

(b) The bare fibre shall be then wiped with a lint tissue paper rinsed with ethyl alcohol.

(c) Cleaving of the fibre shall then be performed to obtain as close as possible to a perfect 90 degree face on the fibre.

13.10.11 SPLICING OF THE FIBRE

13.10.12.1 FUSION SPLICING OF FIBRE

Some of the general steps with full automatic microprocessor control splicing machines shall be as under:

i. Hands shall be thoroughly washed prior to commencing this procedure.

ii. The clean bare fibre shall be dipped in the beaker of ethyl alcohol of the ultrasonic cleaver and ultrasonic clever switched on for 5-10 seconds.

iii. The bare fibre shall then be placed inside 'V' groove of the splicing machine by opening clamp handle, in such a way so that 1 mm gap is available between the electrodes and the end of fibre being spliced and heat shrink protector inserted.

iv. The same procedure shall be repeated for other fibre.

v. The start button on the splice controller shall be pressed.

vi. The machine shall pre-fuse set align both in 'X' and 'Y' directions and then finally fuse the fibre.

vii. The splice shall be inspected on monitor provided on the fusion splicing machine, there shall be no nicking, bulging and cores are adequately aligned. The above procedure shall be repeated if the splice is not visually good looking.

viii. The heat shrink protector shall be slid over the splice and tube shall be placed in tube heater. Heating shall be considered complete when soft inner layer is seen to be 'oozing' out of the outer layer of the protector.

ix. The steps 9a) to (h) above shall be repeated for other fibres.

13.10.12.2 MECHANICAL SPLICING OF THE FIBRE

There are two types of mechanical splicing system. In case, one with precision alignment of fibre in 'V' groove and fibre ends are sealed with some index matching fluid and adhesive. The other system uses ultrasonic light source for curing optical adhesive in addition to alignment etc.

The general steps involved above are as under:

(a) Stripping and cleaving of fibres shall be done as per Clause 13.10.10.
(b) Protective end cap shall be removed from mechanical splice and vent tube pulled up.
(c) Adhesive shall be injected into splice as specified by supplier into splice.
(d) Fibre shall be inserted till it butts against fibre end already bonded in place.
(e) Adhesive shall be cured with UV light following exposure times as specified by the supplier.
(f) The steps (a) to (e) above shall be repeated for all fibres.

13.10.12 ORGANISING FIBRE AND FINISHING JOINTS

(a) After each fibre has been spliced, the heat shrink protection sleeve shall be slipped over the bare fibre before any handling of fibre takes place as uncoated fibres are very brittle and cannot withstand small radius bends without breaking
(b) The fibre shall then be organized into its tray by coiling the fibres on east side of the protection sleeve using the full tray side to ensure the maximum radius possible for fibre coils.
(c) The tray then shall be placed in the position
(d) OTDR reading shall be taken for all splices in this organized state and recorded on the test sheet to confirm that all fibres attenuation is within specified limits. The OTDR test confirms that fibres were not subjected to excessive stress during the organizing process. Care should be taken that the fibres are not interchanged while jointing.
(e) The joint shall then be closed with necessary sealing etc. and considered ready for placement in the pit.

13.10.13 PLACING OF COMPLETED JOINT IN PIT

(a) Joint shall be taken out from the vehicle and placed on the tarpaulin provided near the pit.
(b) The cable is laid on the ground and looped according to the marking done in the beginning. These loops shall then be tied together with the tape.
(c) The joint shall be permanently closed and sealed by heating heat shrinkable sleeve, etc.
(d) The joint closure shall be fixed to the bracket on the pit wall and pit closed.

13.10.14 REOPENING OF THE JOINT

For attending faults, etc. special kits shall be used for opening of the joint and the instructions shall be followed. The general steps are as under:-

(a) Suitable knife shall be used to cut heat shrink sleeve longitudinally along its entire length.
(b) It shall be ensured that there is no damage to the smaller heat shrink sleeve on the ends of the joint.
(c) Heat shall then be applied to the cut sleeve until it begins to separate.
(d) The cut sleeve shall be removed gently from the joint so that joint can be opened.
(e) Protective sleeve/cover shall be removed for attending to faults, etc.

13.10.15 TERMINATION JOINT FOR OPTIC FIBRE CABLE

This joint is provided in the cable hut for terminating the outdoor optic fibre cable of both the sides, splicing through fibres, connecting fibres to pigtails for connection to optical line terminal equipment, etc.

The procedure for installation of termination joint box shall depend on the type of joint enclosure. The installation manual shall contain the step by step procedure for installation. The general steps shall be as under:

- Marking the cable
- Stripping/cutting the cable
- Gripping cable in sheath/clamp
- Treatment of tension member
- Fibre splicing
- Enclosing fibre
- Fixing strength member
- Closing the cover
- Fixing termination box
- Fixing the cable

13.10.16 MARKING THE CABLE

(a) The cable length shall be determined up to the proposed location of termination box. It shall also be ensured that at least 10 meters of cable is coiled in the cable pit.
(b) The cutting point shall be determined and the cable marked.
(c) The length sheath peeling point shall be determined and cable marked.

13.10.17 CUTTING/STRIPPING THE CABLE

(a) The cable shall be cut as per the marking.
(b) The sheath shall be removed from cable end. During sheath stripping care shall be taken that the fibres are not damaged.
(c) The length and the steps for various sheath cutting shall be as per the instructions given in the manual.

13.10.18 GRIPPING THE CABLE

(a) PVC tape shall be wound around the cable core just beside edge of the sheath.
(b) The bushing inside sheath shall be inserted by cutting the cable sheath for about 25mm.
(c) The sheath grip (lower half and upper half) shall be placed and tightened it with the help of torque wrench.

13.10.19 FIXING OF TENSION MEMBER

(a) The tension member shall be marked for the specified length and cut.
(b) The tension member shall be thoroughly cleaned by alcohol and cotton cloth.
(c) Tension member holder shall be fixed at the end of tension member with the help of instant adhesive.

13.10.20 FIBRE SPLICING

The procedure for fibre splicing shall be same as described for straight joint closure in Clause 13.10.12.

13.10.21 ENCLOSING FIBRES

(a) The fibre cassette shall be set on the base of the joint closure.
(b) Excess length of fibre shall be arranged to make double figure of eight.
(c) The spliced fibre and its excess length shall be enclosed carefully.
(d) The steps (a) to (c) above shall be repeated for other fibres.

13.10.22 MOUNTING OF TERMINATION BOX/FDMS

Termination box/FDMS is fixed either on wall or on equipment rack.

(a) The fixing holes are marked on the walls/bracket/frame.
(b) The termination box is placed and the nuts inside the base box shall be tightened.
(c) Sufficient silica gel in bags are kept inside and the covers shall then be put on termination box and closed.
(d) Fibre Distribution Management System (FDMS).
In all future installations, OF cable should be installed in the suitable Fibre Distribution and Management System (FDMS). The FDMS shall conform to latest TEC/RDSO specification.
(e) Patch Cords/Pigtails.
Patch cords and pigtails shall be procured as per RDSO/TEC's latest specification.
(f) Jointing/Splicing: The optic fibre placed in the joint should be safely protected in a RCC concrete chamber as per RDSO drawings. The chamber should be filled with fine sieved sand. The upper surface of the chamber should be kept 50 cm below the surface; a suitable joint

marker should be placed on all joint locations. 10 m of extra cable should be coiled in the pit for future use. Armouring must not be put through. The armouring of OFC should be earthed at all locations with new/existing available telecom/signalling earthing arrangements. In absence of earthing, it must be properly wrapped with insulator tape in order to prevent electric shock to the working staff.

13.10.23 FIXING THE CABLE

The cable on the wall/frame shall be secured at two places within 1 m from the termination box keeping in view the straight entry of cable into termination box.

After the cable is laid and splicing has been completed, measurements in the enclosed proforma has to be prepared.

Section		Distance	Cable length	Fibre No	Loss in dB		Remarks
From	To				1310nm	1550nm	

The end to end loss should not exceed 0.25db/Km at 1550 nm and 0.40 db/Km at 1310 nm.

****

SECTION – XI

TOOLS AND EQUIPMENTS FOR INSTALLATION AND TESTING OF OPTIC FIBRE CABLE

GROUP – I TOOLS REQUIRED FOR TRENCHING, CABLE LAYING AND BACK FILLING.

SNo.	Tool's Name
1.	Cable Jack
2.	Cable Grip
3.	Reopening device
4.	Free Hood Hook
5.	Shackle free head hook
6.	Growling hook
7.	Pulling bolt
8.	Tension meter
9.	Pulley
10.	Anti twist device (swivel)
11.	Roller
12.	Flexible cable
13.	Pulling rope
14.	Brush
15.	Mandrel
16.	Chain
17.	Measuring cord for strain gauge
18.	Slip winch
19.	Wire rope
20.	Portable VHF set
21.	Measuring tape
22.	Phawarah
23.	Iron Plate
24.	Loader Backhoe for drilling
25.	Warning Tape
26.	Caterpillar tractor
27.	Fork lifter
28.	Tool Van vehicle
29.	Tachometer
30.	Portable Generator
31.	tent type Umbrella
32.	Blank dark coloured cloth for splicing machine

GROUP – II TOOLS AND EQUIPMENTS REQUIRED FOR JOINTING AND TERMINATION OF OPTIC FIBRE CABLE.

SNo.	Tool's Name
1.	Branch Joint Closure
2.	Termination Box
3.	Rubber and Block
4.	Sheath Clamp
5.	Bushing
6.	Strength Member holder
7.	Heat Shrinkage tube
8.	Arc fusion splicer machine
9.	Power cord AC/DC
10.	Walkie-Talkie with spare battery
11.	Tube heater
12.	Precision cleaver
13.	Cable sheath stripper
14.	Fibre stripper
15.	Knife for HDPE cutting
16.	Hacksaw for strength membrane
17.	Isopropyl alcohol or methanol of high specific gravity
18.	Johnson Buds
19.	Tweezers
20.	Gun heater blower type
21.	Sleeve for splice protection
22.	OTDR
23.	Stabilized optical power source and power meter
24.	Stickers for numbering of splicers

****

SECTION – XII

13.12.1 List of items to be handed over to the Maintenance Organization before handing over the section for maintenance.

The following items should be handed over to the maintenance in charge before handing over the section for maintenance.

1. The Cable Route Plan in electronic form (CD) preferably using AUTOCAD. Distances from fixed reference structures like centre of track, OHE mast, bridges, culverts, etc. should be indicated in the route plan for easy reference in future.
2. The Fibre Distribution Plan
3. Measurements of Optical Parameters which includes sectional losses, splice wise losses, set of measuring equipment, programing/maintenance terminal and tools & plants should be handed over to the maintenance organization.
4. Joint test report of important parameters for all fibres Jointly done by Construction/Railtel with Maintenance organisation.
5. OEM Manuals, warranty certificates of all Telecom equipment with pre commissioning check list if any**.**
6. Spare materials

13.12.2 Staff Requirement.

OFC in each section should be maintained by a cable gang. The staff strength should be as per the latest yardstick issued by Railway Board. The maintenance gang should have provision for a vehicle where the men and material can be loaded and comfortably reach the site.

****

APPENDIX – I

MAINTENANCE SCHEDULE FOR FIBRE OPTIC SYSTEM

EQUIPMENT	ITEM	TELECOM TECHNICIAN	SECTIONAL SUPERVISOR	SUPERVISOR INCHARGE
POWER SUPPLY EQUIPMENT	Maintenance of Batteries	monthly	Quarterly	Half yearly
	Meas. of Battery voltages	fortnightly	monthly	Quarterly
	Meas, of Charger In/Out voltages and currents	fortnightly	monthly	Quarterly
	Checking of fuses and terminations	fortnightly	monthly	Quarterly
	Checking of Earthing connections	fortnightly	monthly	Quarterly
GENERAL	Removal of dust from the equipment and cards. Ensuring cleaning of the flooring	weekly		
	Measurement of room temperature	weekly		
	Measurement of earth resistance		Quarterly	Yearly
	Check of electrical services (lights, fans, ACs etc.).	weekly	monthly	Yearly
	Maintenance of pigtails, fibre distribution frame etc.		Quarterly	Yearly
OPTICAL FIBRE CABLE	OTDR Measurement of spare fibres		Quarterly	Yearly
CABLE ROUTE	Integrity of cable route	monthly		
	Protective works on bridges & culverts	monthly	Quarterly	Yearly
	Cable route markers	monthly	Quarterly	Yearly
	Earthing of sheath of cable	monthly	Quarterly	Yearly
Periodical line up	OTDR measurement on			Yearly

	all Fibres, Tx/Rx optical power loss, Error performance measurement			

Note :

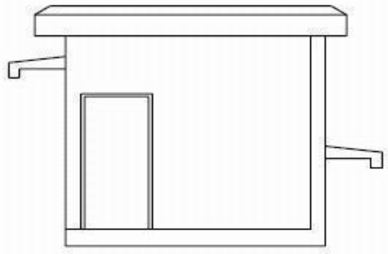
1. Items related to cable gang shall be done by cable maintenance Gang.
2. Items related to equipment shall be done by the equipment maintenance gang.

APPENDIX - II

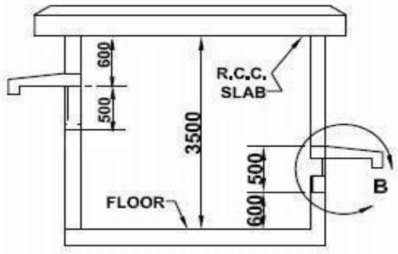
T&P ITEMS AND MEASURING EQUIPMENTS FOR MAINTENANCE STAFF

S.No.	GANG	RECOMMENDED T&P ITEMS & EQUIPMENTS
1.	**Equipment Maintenance**	● Soldering Iron ● Vacuum Cleaner ● Standard Tool Kit containing Screw Drivers, etc. ● Digital Multi-meter ● Optical Fibre connector Cleaning kit
2.	**Sectional Supervisor Equipment**	● All equipments as prescribed for equipment maintenance gang. ● Portable BER & PCM Test Set (For STM) ● Meager ● Optical Attenuation Measurement set consisting of optical power meter, optical source and optical attenuator
3.	**Supervisory Incharge for equipments**	● Test and Repair Van ● PCM Transmission Analyzer (For STM) ● PCM Channel Analyzer along (For STM) ● Fibre Optic tool kit ● Mini portable Generator
4.	**Sectional Engineer Cable Maintenance**	● Digital Multi-meter ● Mini ODTR ● Mechanical splicing kit ● Optical Fibre cable 200 Mts ● Splicing machine with battery ● Fibre Optic Tool Kit ● All types of Adopters & Connectors ● Insulation Tester ● TMS kit
5.	**HQ gang for cable**	● Test & Repair van ● Portable generator ● Automatic Fusion Splicing machine ● OTDR ● Fibre Optic Tool Kit ● Cable route tracer ● Mechanical Splicing kit ● All types of Adopters & Connectors. ● Lighting arrangements and emergency lamps (2 Nos) ● PCP sets (4 Nos) ● Walkie-Talkie sets (4 Nos) ● Torches with batteries (6 sets)

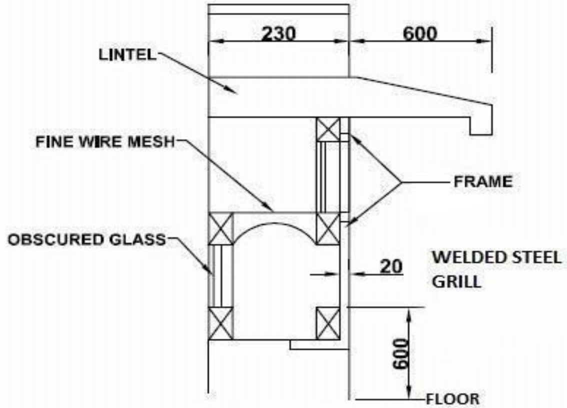
		● Spare batteries for splicing machines (1 No) ● Puncha (to remove ballast) (2 Nos) ● Pickaxe (4 Nos) ● Motar pan & showel (4 Nos) ● Spade (4 Nos) ● Portable tent (1 No) ● Crow bar (2 Nos) ● OFC spare cables (cables of adequate length) ● HDPE pipe pieces (10 Nos) ● Drinking water can (20 litres) (1 No) ● Glasses (2 Nos) ● Folding table and chair (1 each) ● Stool light weight (2 Nos) ● First aid box (1 No)



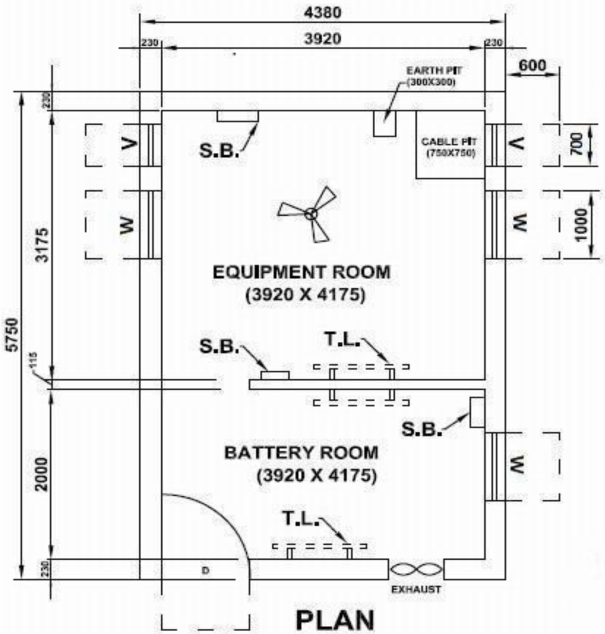
FRONT ELEVATION



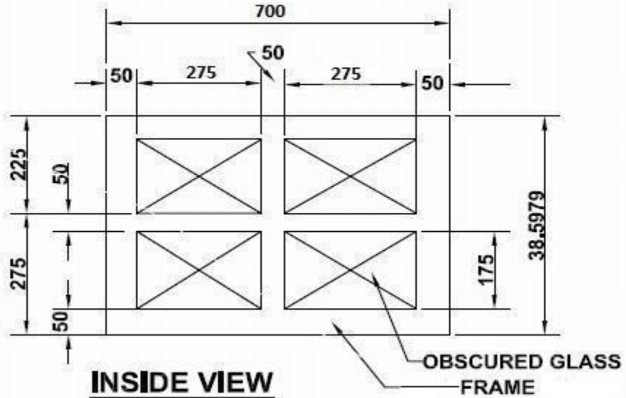
SECTION AT 'AA'



DETAIL AT 'B'



PLAN



INSIDE VIEW

DETAIL OF VENTILATOR 'V'

1. ALL DIMENSIONS ARE IN mm.
2. PROPER SLOPE TO BE PROVIDED ON THE ROOF FOR THE RAIN WATER DRAINAGE.
3. WELDED STEEL GRILL SHOULD BE PROVIDED IN THE OUTSIDE OF WINDOW GRILL.
4. TWO VENTILATORS SHALL BE PROVIDED IN OPPOSITE WALLS. ONE AT 600mm ABOVE FLOOR LEVEL & OTHER AT 600mm BELOW ROOF SLAB.

SCHEDULE OF DOOR, WINDOW & VENT		
	WIDTH	HEIGHT
DOOR 'D'	1000	2135
WINDOW 'W'	1000	1535
VENTILATOR 'V'	700	500

EQUIPMENT ROOM

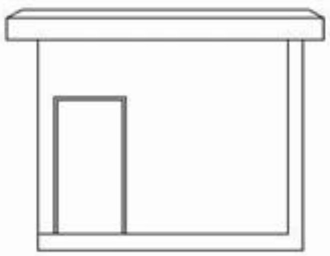
1. EQUIPMENT ROOM SHOULD HAVE DOOR CLOSURE.
2. 2 NOS OF LED TUBELIGHTS.
3. 2 NOS OF 5 AMP SOCKETS WITH PIANO TYPE SWITCH ON SWITH BOARD (SB).
4. 1 NO OF CEILING FAN.
5. MARBLE TILE FLOORING.

BATTERY ROOM

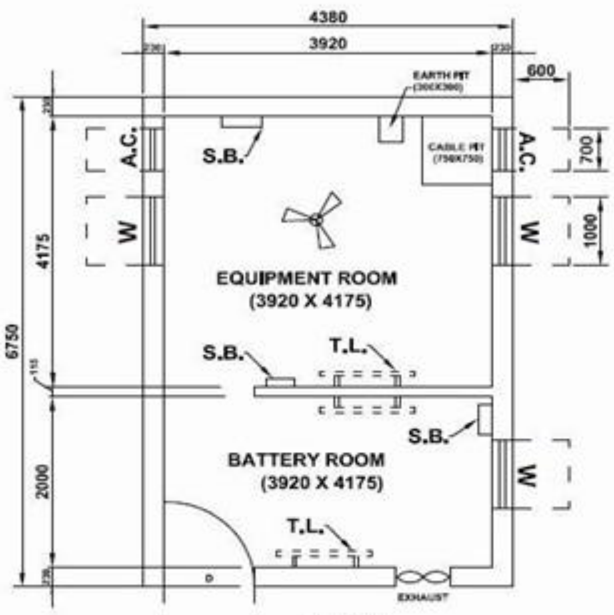
1. 2 NOS OF THIN LED TUBELIGHTS.
2. ONE EXHAST FAN.
3. ONE 5 AMP SOCKET WITH PIANO TYPE SWITCH ON SWITH BOARD (SB).
4. ACID PROOF TILE FLOORING IN BATTERY ROOM.

BUILDING LAYOUT FOR FIBRE OPTIC HUT FOR NON CRITICAL STATIONS

DRG.NO.RDSO/TCDO/COP-1(a)



FRONT ELEVATION



PLAN

EQUIPMENT ROOM

1. EQUIPMENT ROOM SHOULD HAVE DOOR CLOSURE.
2. 2 NOS OF LED TUBELIGHTS.
3. 2 NOS OF 5 AMP SOCKETS WITH PIANO TYPE SWITCH ON SWITH BOARD (SB).
4. 1 NO OF CEILING FAN.
5. MARBLE TILE FLOORING.

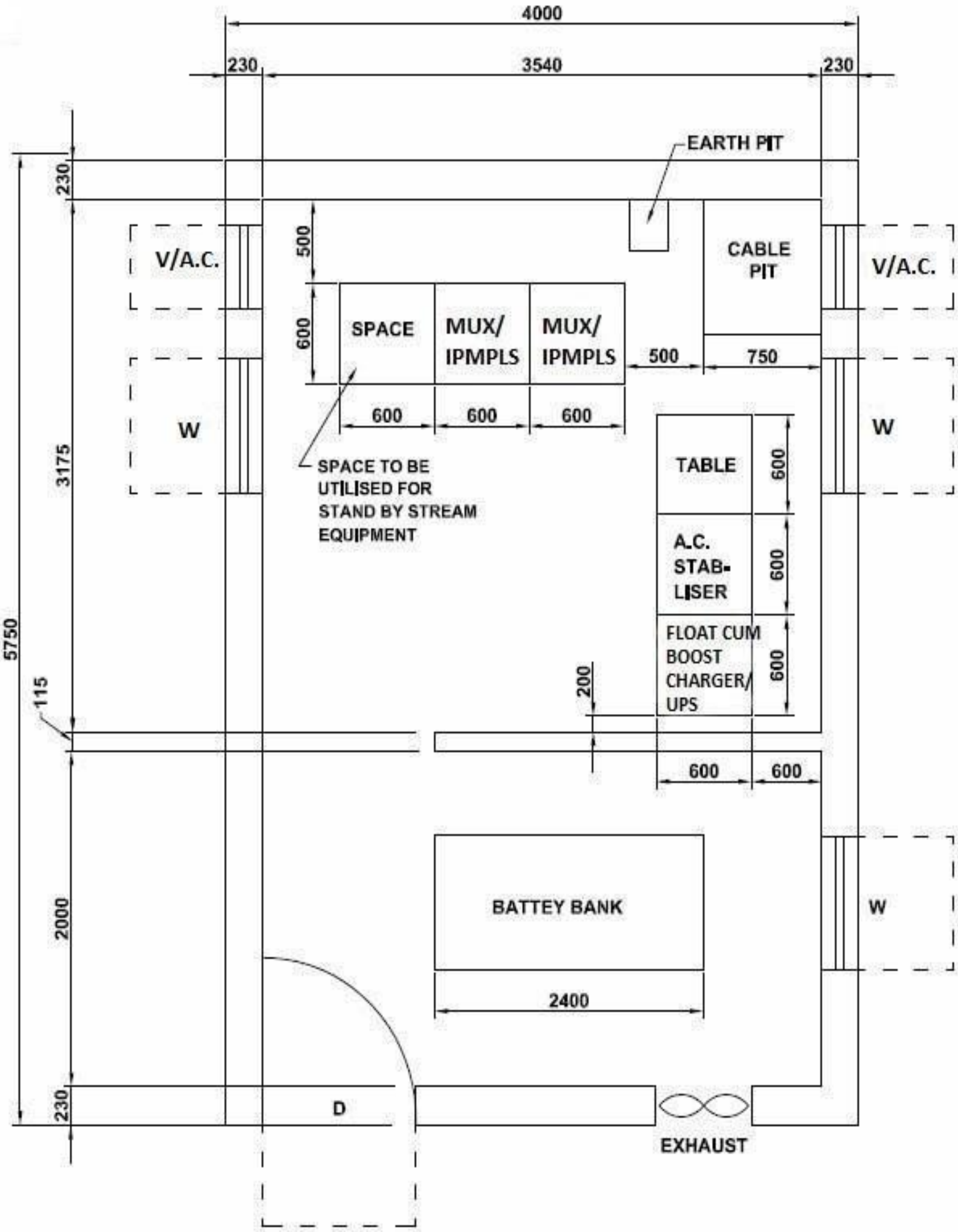
BATTERY ROOM

1. 2 NOS OF THIN LED TUBELIGHTS.
2. ONE EXHAST FAN.
3. ONE 5 AMP SOCKET WITH PIANO TYPE SWITCH ON SWITH BOARD (SB).
4. ACID PROOF TILE FLOORING IN BATTERY ROOM.

SCHEDULE OF DOOR, WINDOW & VENT		
	WIDTH	HEIGHT
DOOR 'D'	1000	2135
WINDOW 'W'	1000	1535
A.C.	700	500

BUILDING LAYOUT FOR FIBRE OPTIC HUT FOR CRITICAL STATIONS

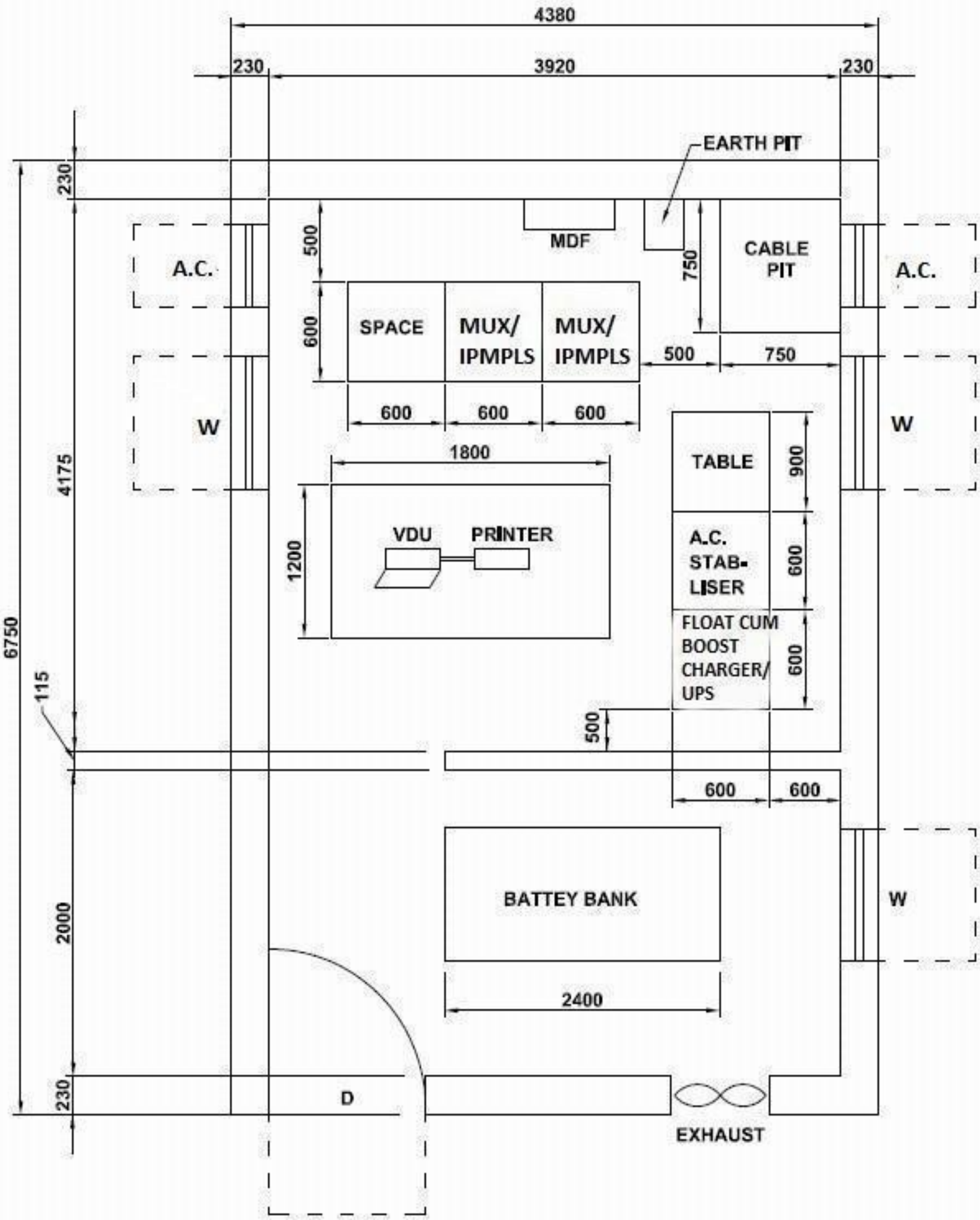
DRG.NO.RDSO/TCDO/COP-2(a)



1. ALL DIMENSIONS ARE IN mm.

ARRANGEMENT OF EQUIPMENTS IN OPTIC FIBRE HUT

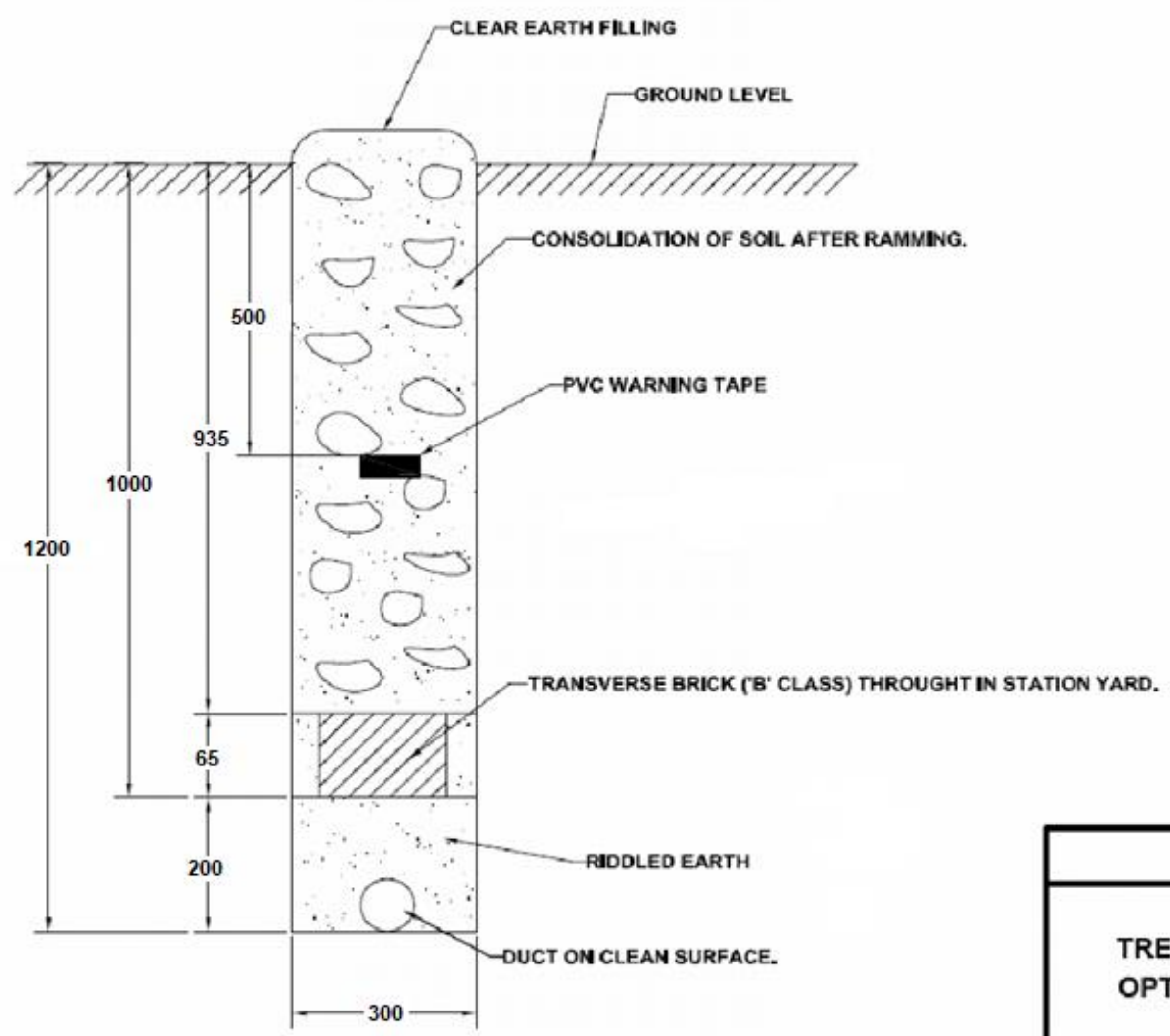
DRG.NO.RDSO/TCDO/COP-03 (a)



ARRANGEMENT OF EQUIPMENTS IN OPTIC FIBRE HUT FOR CRITICAL STATIONS

1. ALL DIMENSIONS ARE IN mm.

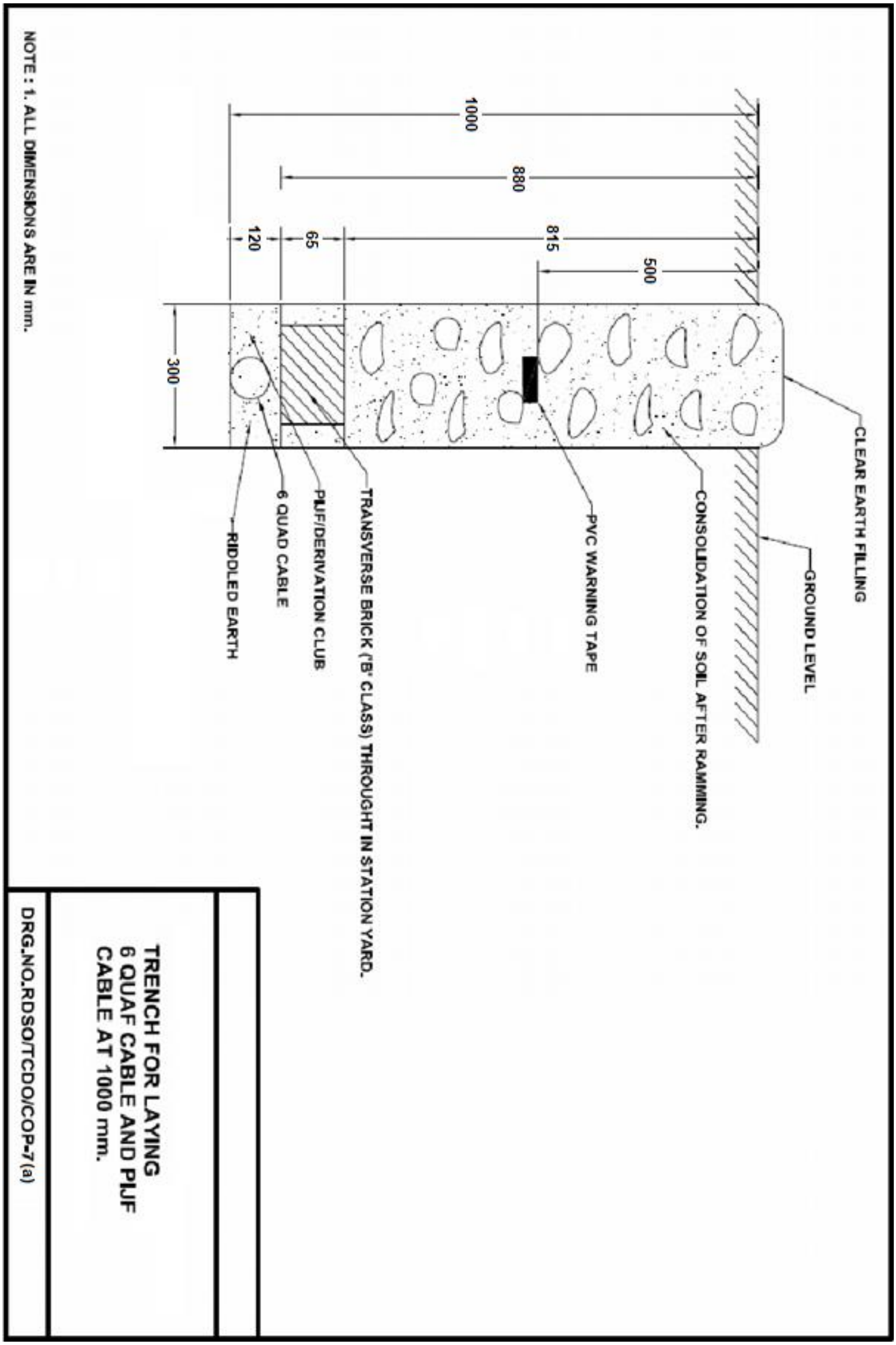
DRG.NO.RDSO\TCDO\COP-04 (a)

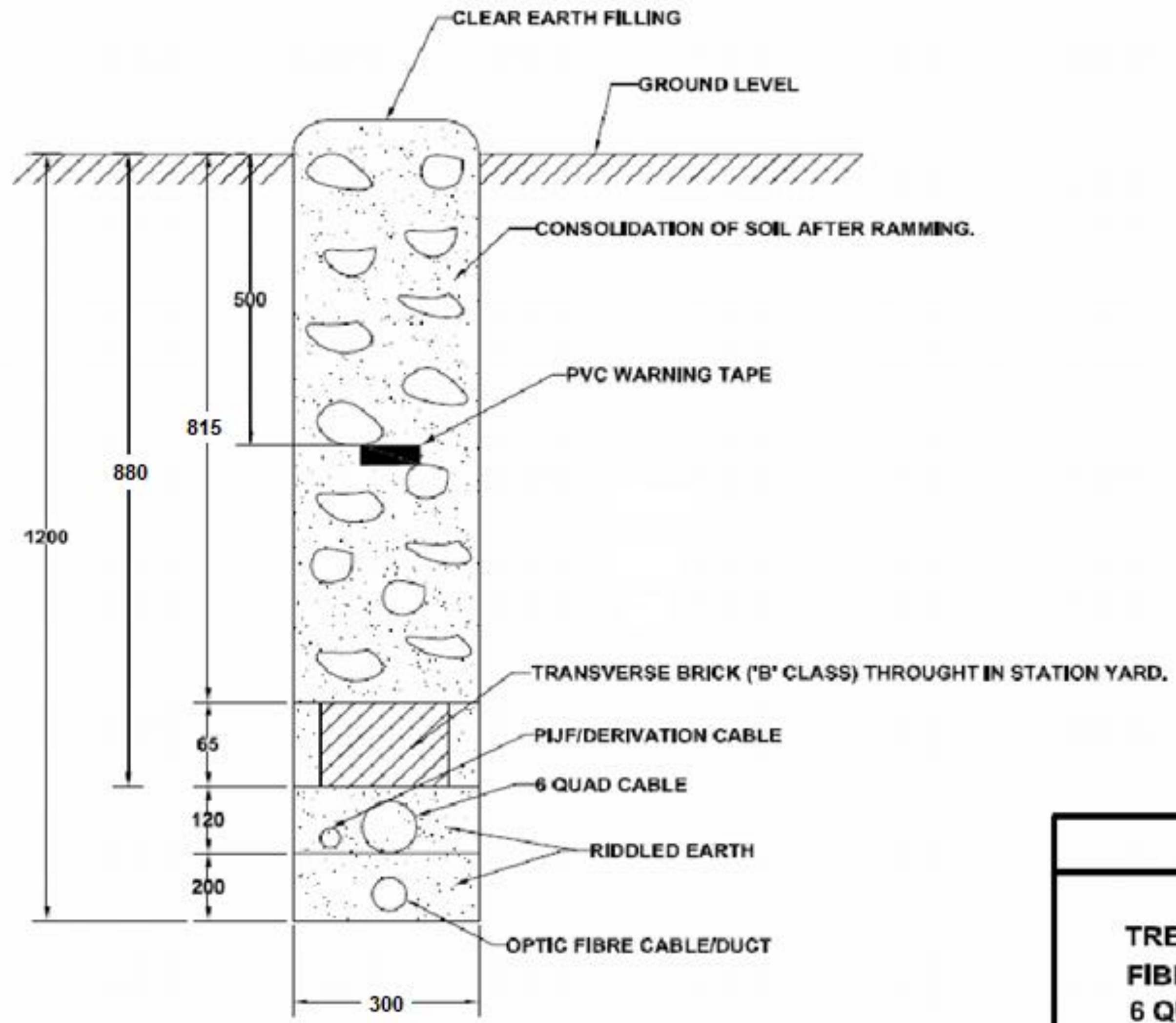


NOTE : 1. ALL DIMENSIONS ARE IN mm.

TRENCH FOR LAYING ARMOURED OPTIC FIBRE CABLE.

DRG.NO.RDSO/TCDO/COP-6(a)

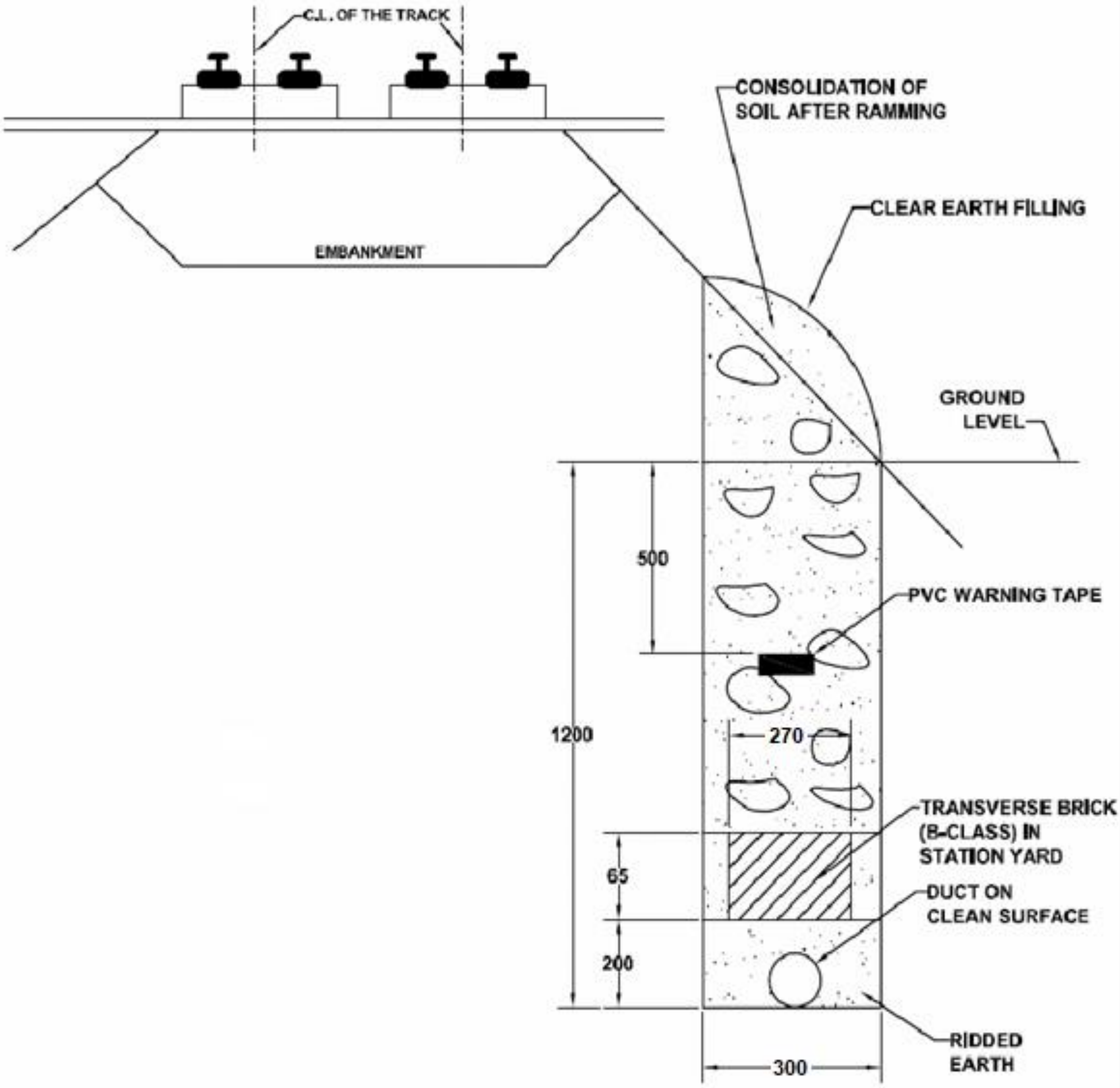

CLEAR EARTH FILLING
GROUND LEVEL
CONSOLIDATION OF SOIL AFTER RAMMING.
PVC WARNING TAPE
TRANSVERSE BRICK ('B' CLASS) THROUGHT IN STATION YARD.
PIJF/DERIVATION CLUB
6 QUAD CABLE
RIDDLED EARTH
1000
880
815
500
120
65
300
NOTE : 1. ALL DIMENSIONS ARE IN mm.
TRENCH FOR LAYING
6 QUAF CABLE AND PIJF
CABLE AT 1000 mm.
DRG.NO.RDSO/TCDO/COP-7(a)



NOTE : 1. ALL DIMENSIONS ARE IN mm.

TRENCH FOR LAYING ARMOURED FIBRE OPTIC CABLE WITH 6 QUAF CABLE AND PIJF CABLE AT 1200 mm.

DRG.NO.RDSO/TCDO/COP-8 (a)



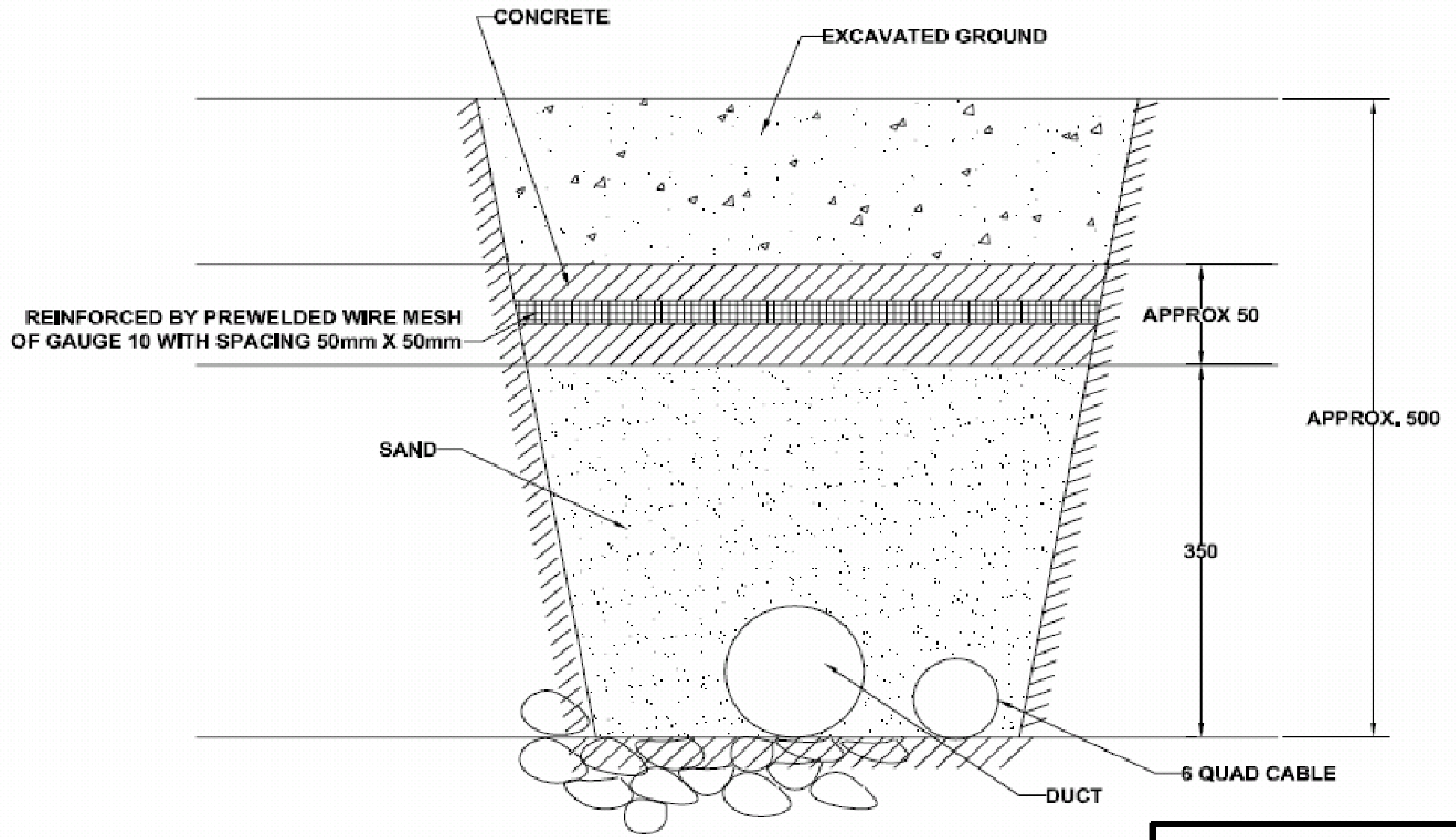
EXCAVATION OF EARTH AND REFILLING

3. APPROVAL OF P-WAY ENGINEERS TO BE OBTAINED AS PER SITE CONDITION.
2. THIS ARRANGEMENT TO BE FOLLOWED IN RARE CASES WHEN CABLE TRENCHING AT END BEYOND TOE OF EMBANKMENT NOT POSSIBLE.
1. ALL DIMENSIONS ARE IN mm.

NOTES :

TRENCH ON ENBANKMENT FOR ARMOURED OPTIC FIBRE CABLE .

DRG.NO.RDSO/TCDO/COP-9 (a)

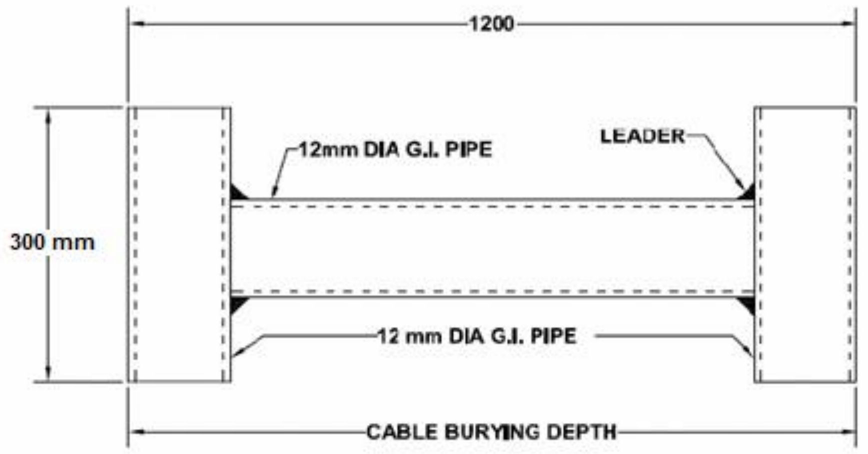


2. NOT TO SCALE.

NOTE : 1. ALL DIMENSIONS ARE IN mm.

LAYING OF OPTIC FIBRE CABLE IN ROCKY AREA

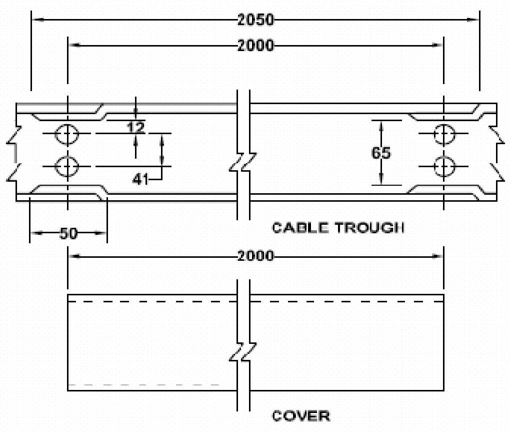
DRG.NO.RDSO\TCDO\COP-10

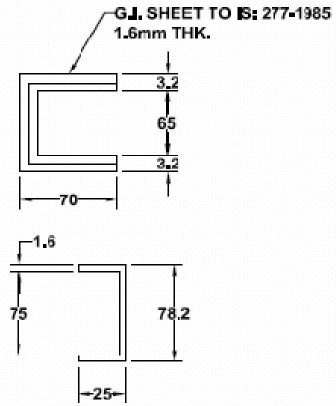


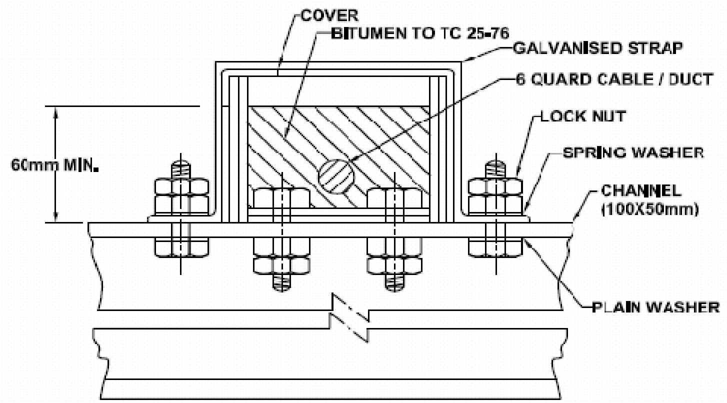
RULE MADE OF PIPE FOR
MEASURING TRENCH DEPTH

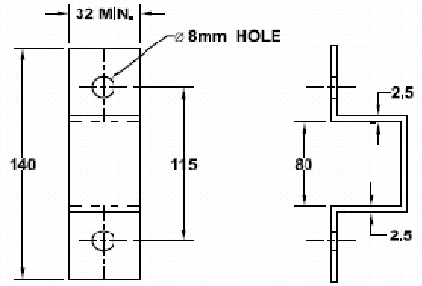
DRG.NO.RDSO\TCDO\COP-11(a)

NOTE : 1. ALL DIMENSIONS ARE IN mm.







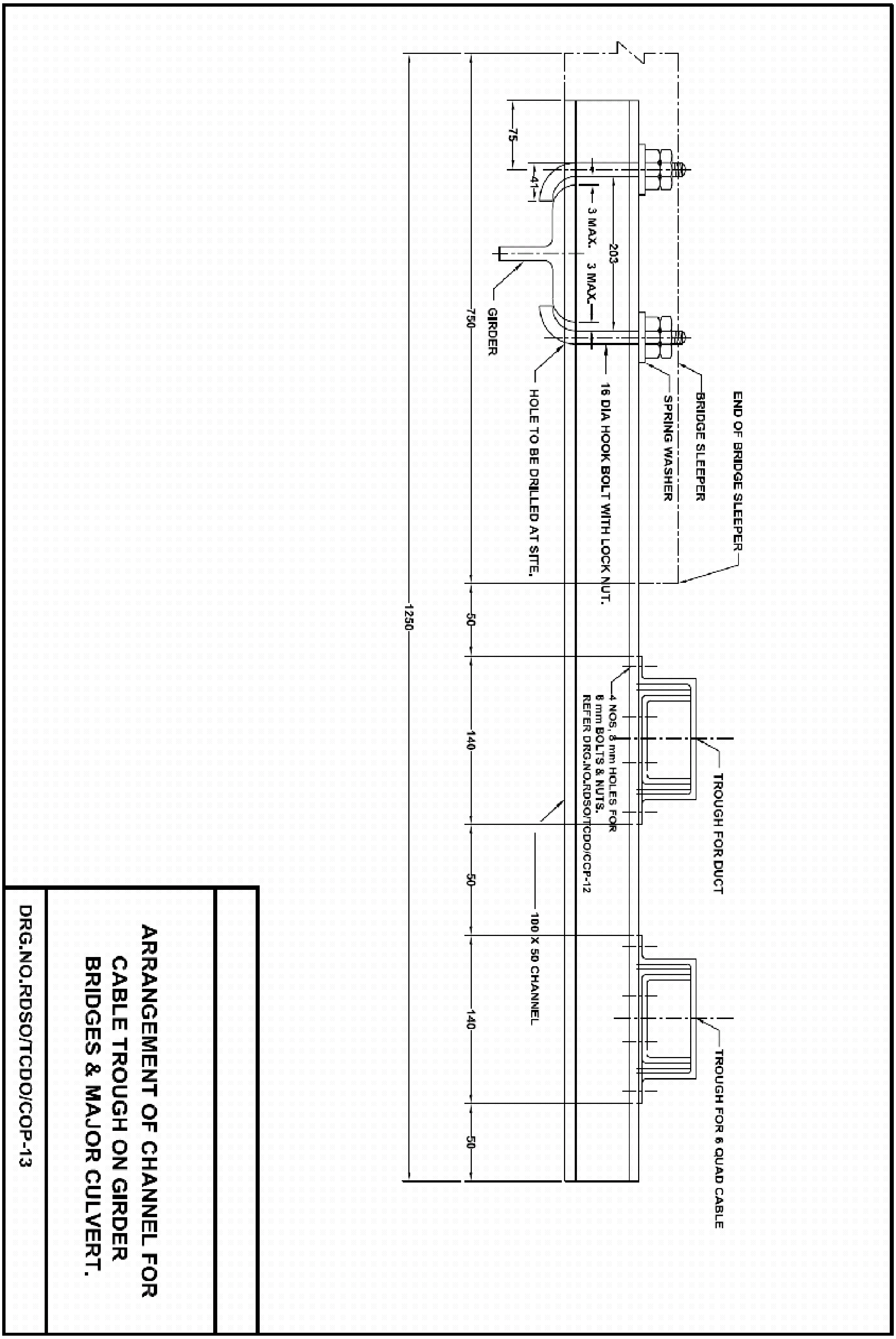


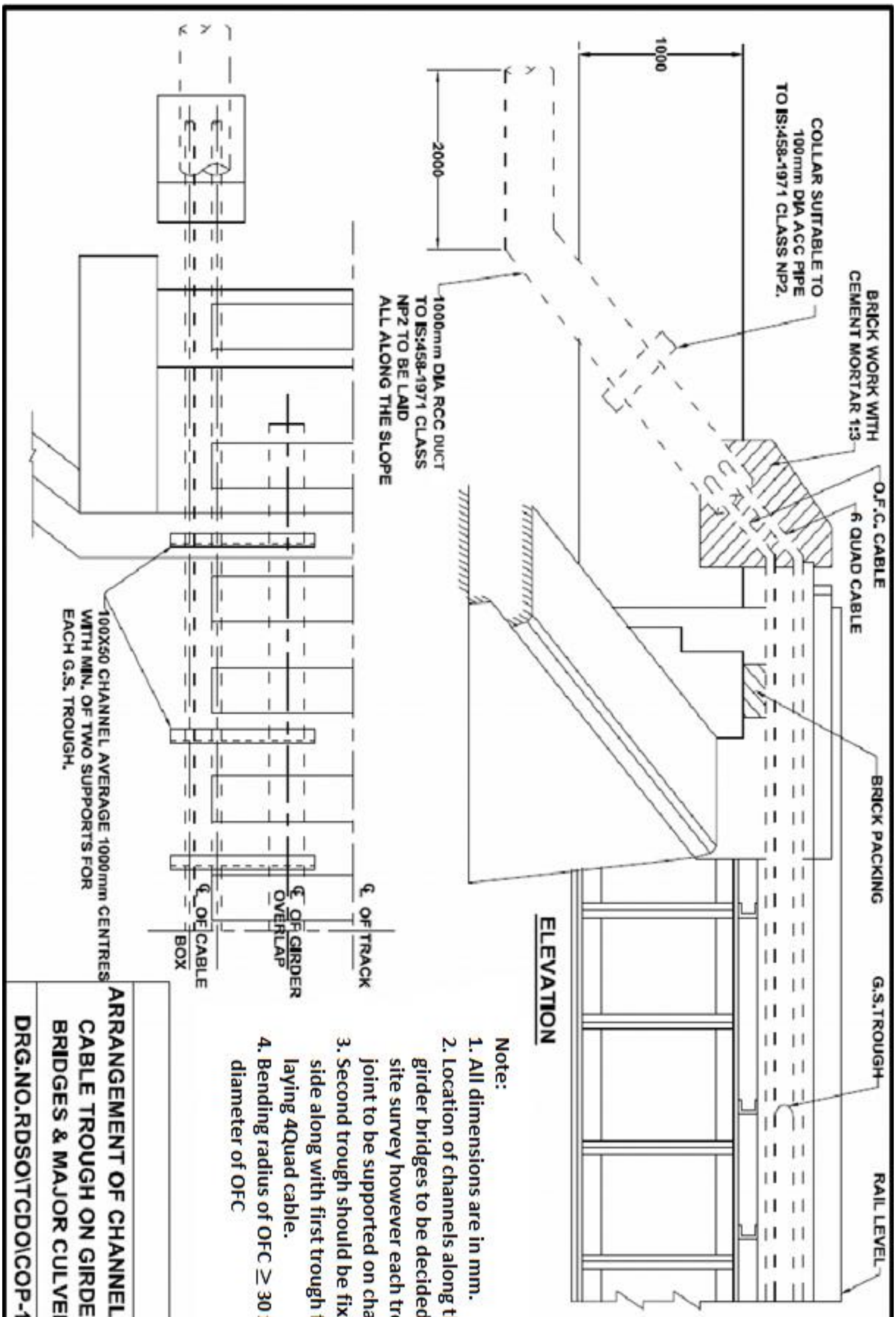
SHEDULE OF MATERIALS		
S.NO.	DESCRIPTION	NO.REQD.
1.	TROUGH 2.05 M LONG	1
2.	COVER 2.0 M LONG	1
3.	STRAP	2
4.	BOLT HEX. HEAD 6 mm Ø X 32 mm	4
5.	NUT FOR ABOVE	4
6.	LOCK NUT FOR SL-4	4
7.	DISH WASHER FOR SL-5	4
8.	PLAIN WASHER FOR SL-5	4

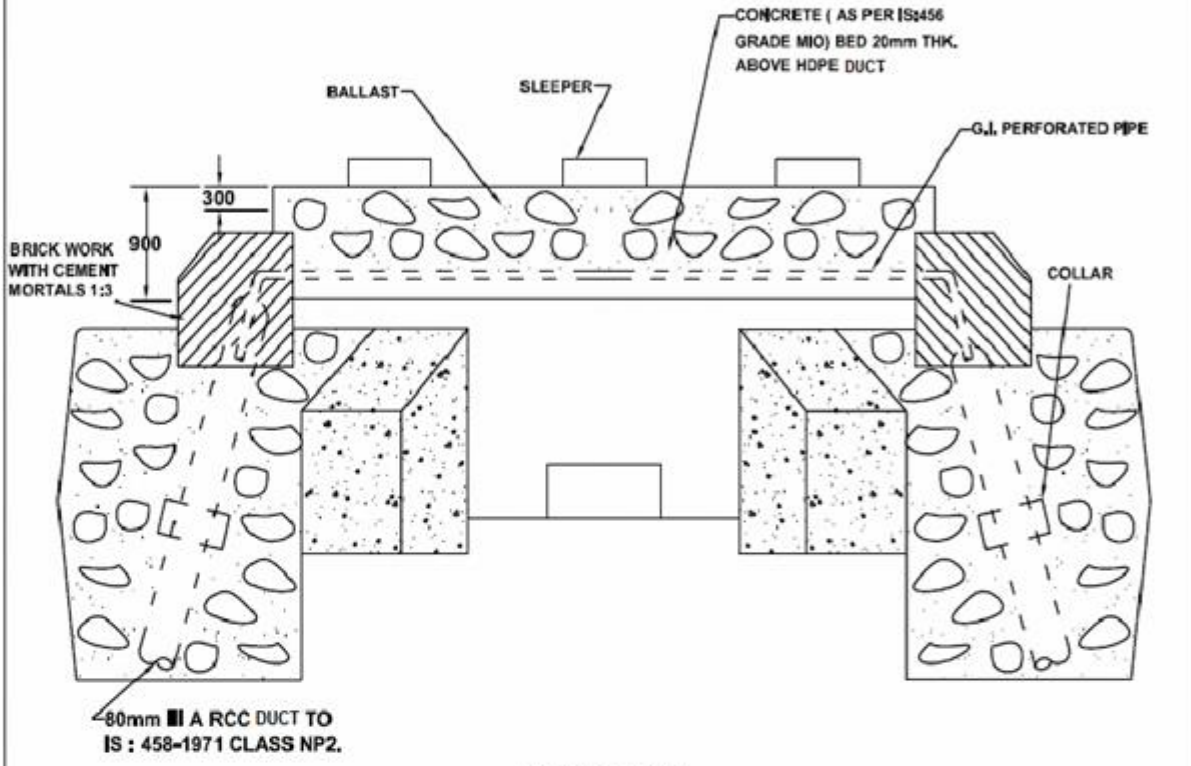
5. AFTER TIGHTENING NUTS FOR FIXING STRAP, THE THREAD OF THE BOLT MAY BE BURRED TO PREVENT THEFT.
4. CABLE TROUGH TO BE FITTED TELESCOPICALLY.
3. NO WELDING SHALL BE DONE ON ANY COMPONENT FOR FABRICATION.
2. TROUGH TO BE FABRICATED OUT OF GALVINISED STEEL SHEET TO I.S.277-1983 WITH FOLLOWING STIPULATIONS.
   THICKNESS : MINIMUM 1.6 mm.
   GRADE OF ZINC COATING : 200.
1. ALL DIMENSIONS ARE IN mm.

ARRANGEMENT OF CABLE TROUGH (G.S.) FOR GIRDER BRIDGE.

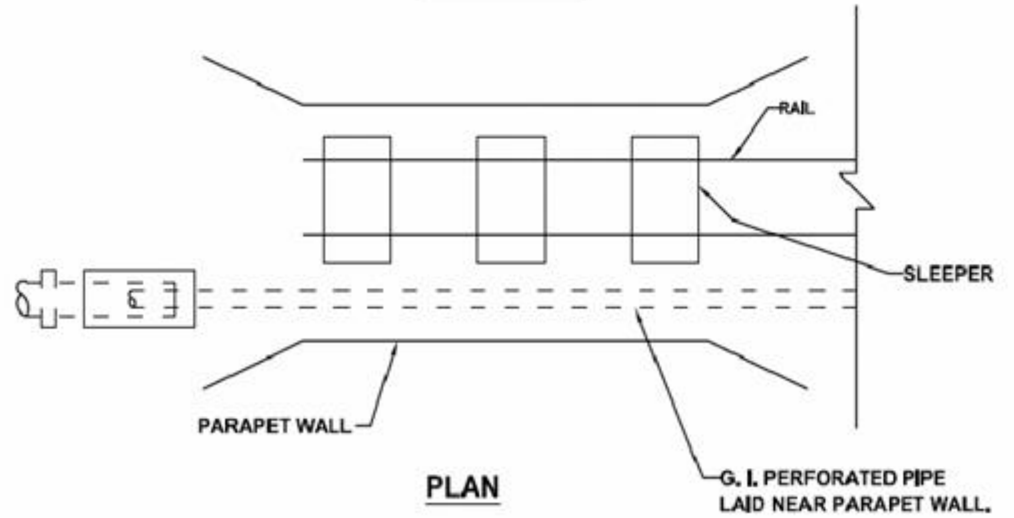
DRG.NO.RDSO\TCDO\COP-12


END OF BRIDGE SLEEPER
BRIDGE SLEEPER
SPRING WASHER
16 DIA HOOK BOLT WITH LOCK NUT.
HOLE TO BE DRILLED AT SITE.
GIRDER
3 MAX.
3 MAX.
203
75
41
750
1250
50
140
50
140
50
4 NOS. 8 mm HOLES FOR 8 mm BOLTS & NUTS. REFER DRG.NO.RDSO/TCDO/CCP-12
TROUGH FOR DUCT
100 X 50 CHANNEL
TROUGH FOR 6 QUAD CABLE
ARRANGEMENT OF CHANNEL FOR CABLE TROUGH ON GIRDER BRIDGES & MAJOR CULVERT.
DRG.NO.RDSO/TCDO/COP-13


1000
COLLAR SUITABLE TO 100mm DIA ACC PIPE TO IS:458-1971 CLASS NP2.
BRICK WORK WITH CEMENT MORTAR 1:3
O.F.C. CABLE & QUAD CABLE
2000
1000mm DIA RCC DUCT TO IS:458-1971 CLASS NP2 TO BE LAID ALL ALONG THE SLOPE
BRICK PACKING
G.S.TROUGH
RAIL LEVEL
ELEVATION
Note:
1. All dimensions are in mm.
2. Location of channels along the girder bridges to be decided after site survey however each trough joint to be supported on channel.
3. Second trough should be fixed by side along with first trough for laying 4Quad cable.
4. Bending radius of OFC ≥ 30 x diameter of OFC
100X50 CHANNEL AVERAGE 1000mm CENTRES WITH MIN. OF TWO SUPPORTS FOR EACH G.S. TROUGH.
℄ OF TRACK
℄ OF GIRDER OVERLAP
℄ OF CABLE BOX
ARRANGEMENT OF CHANNEL FOR CABLE TROUGH ON GIRDER BRIDGES & MAJOR CULVERT.
DRG.NO.RDSO\TCDO\COP-14(a)



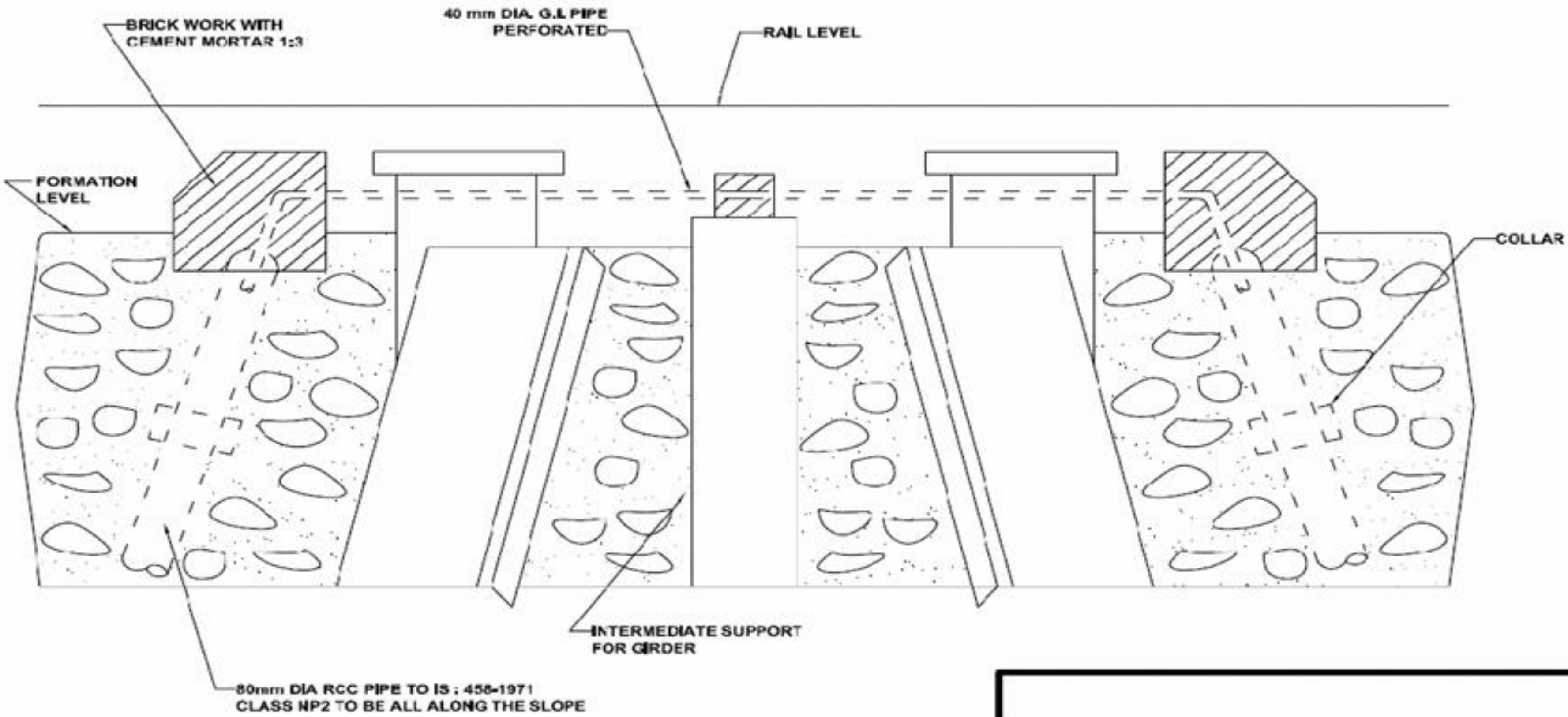
ELEVATION



PLAN

Note:
Bending radius of OFC $\geq$ 30 x diameter of OFC

FIBRE OPTIC CABLE CROSSING CULVERT (PIPE/BOX) WITH HIGH FLOOD LEVEL.
DRG.NO.RDSO/TCDO/COP-16(a)

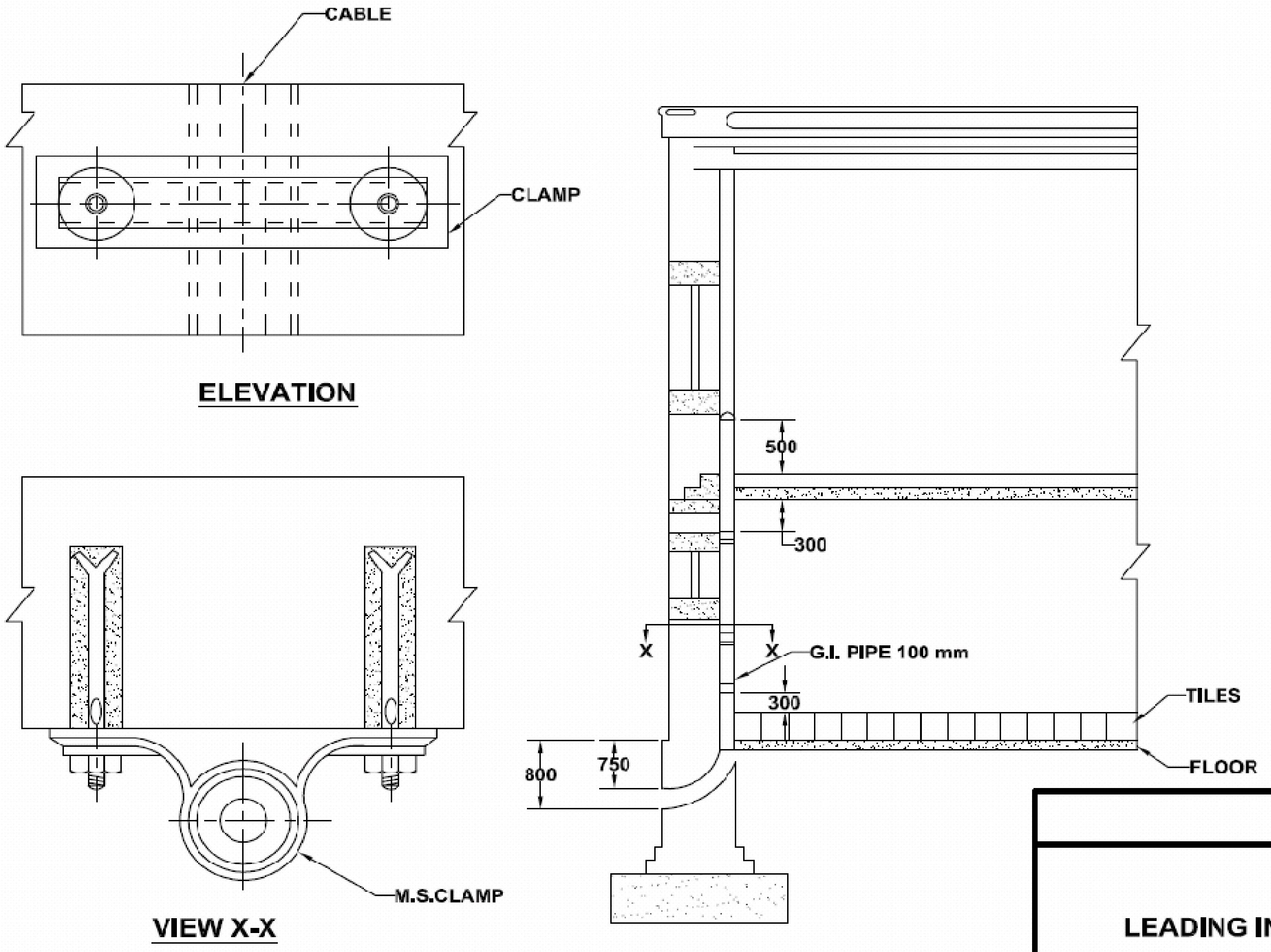


ELEVATION

Note:
1. The height at which G.I. Pipes is to be laid shall depend on stie condition.
2. This arrangement is applicable for girder bridge having span upto 6 mtrs without any intermediate support and upto 12 meters with an intermediate support.
3. Bending radius of OFC $\geq$ 30 x diameter of OFC.

ARRANGEMENT OF FIBRE OPTIC CABLE LAYING IN G.I. PIPE ON GIRDER BRIDGE.

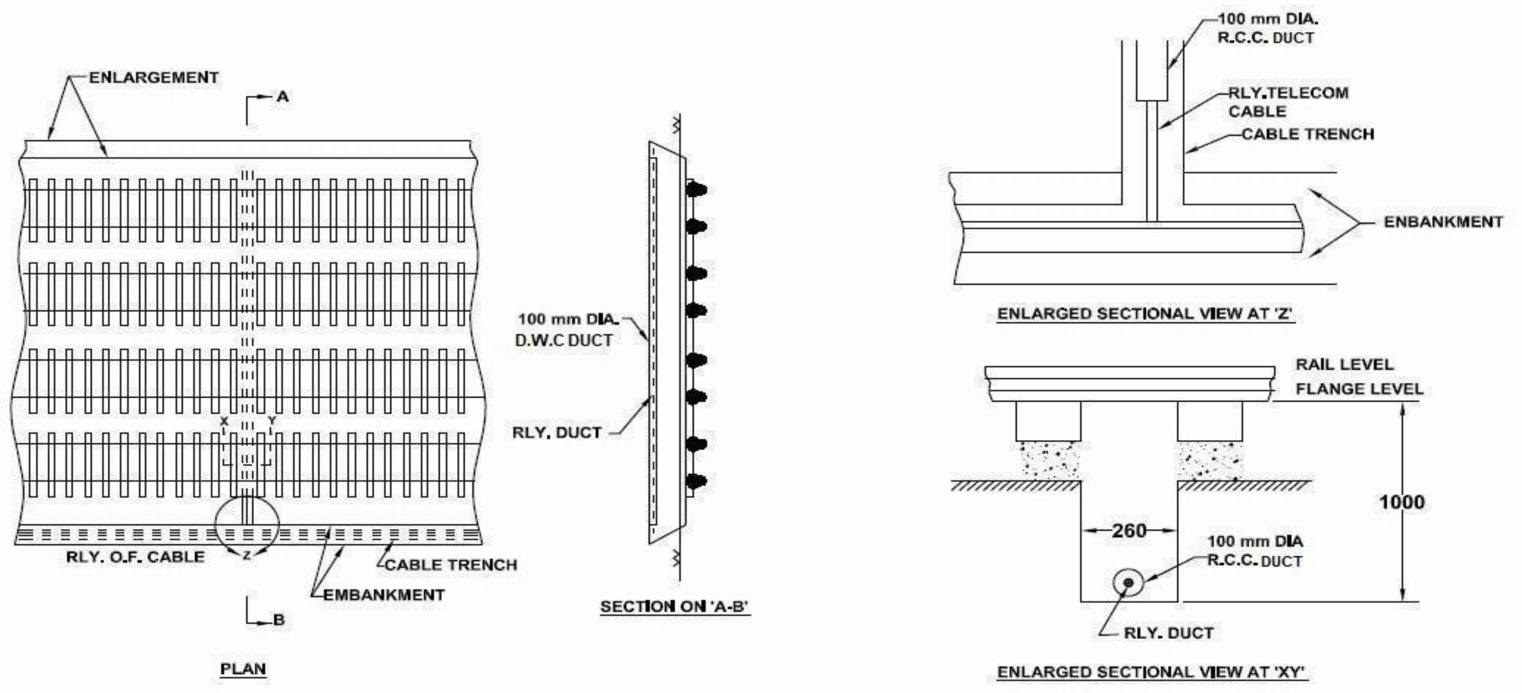
DRG.NO.RDSO\TCDO\COP-17(a)



ALL DIMENSIONS ARE IN mm.
FOR ASM's OFFICE AND SIMILAR BUILDING PORTION ONLY OF LEADING IN PIPE TO BE PROVIDED
8" TO BE INSERTED OVER THE CABLE.

LEADING IN ARRANGEMENT OF OPTIC FIBRE CABLE FOR CABINS & OTHER BUILDINGS.

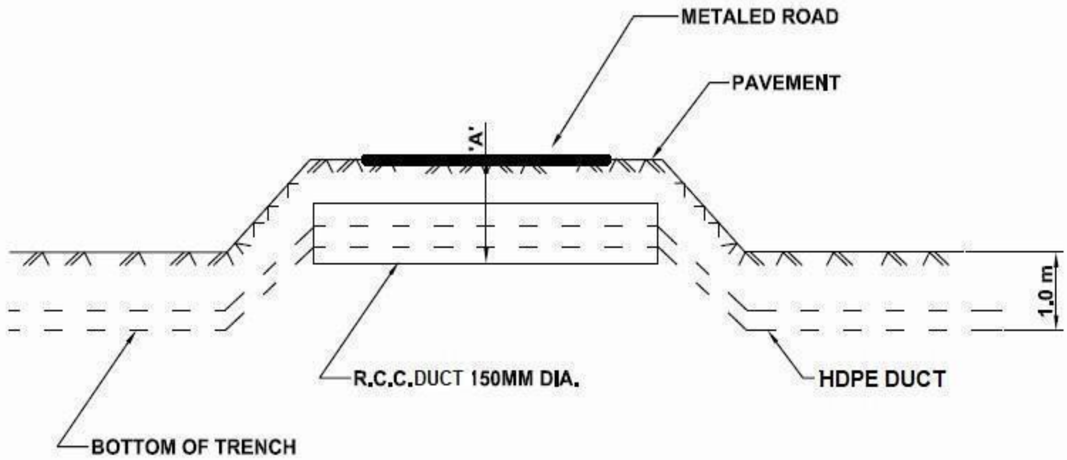
DRG.NO.RDSO/TCDO/COP-18



ALL DIMENSIONS ARE IN mm.

ARRANGEMENT OF O.F. CABLE R.C.C. / D.W.C. DUCT UNDER TRACK CROSSING.

DRG.NO.RDSO/TCDO/COP/19 (a)

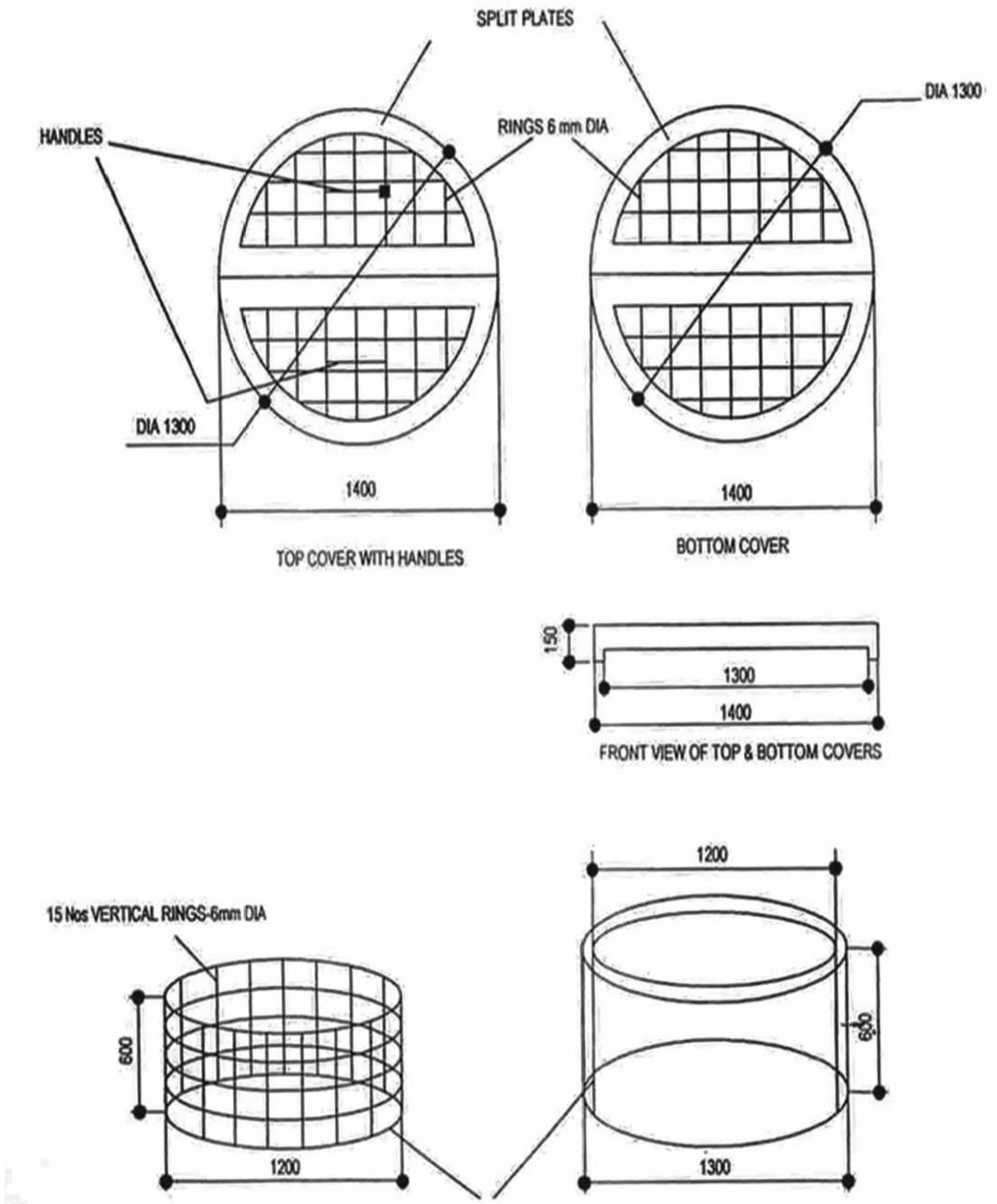


ARRANGEMENT OF R.C.C. DUCT
UNDER METALED ROAD

DRG.NO.RDSO/TCDO/COP-20 (a)

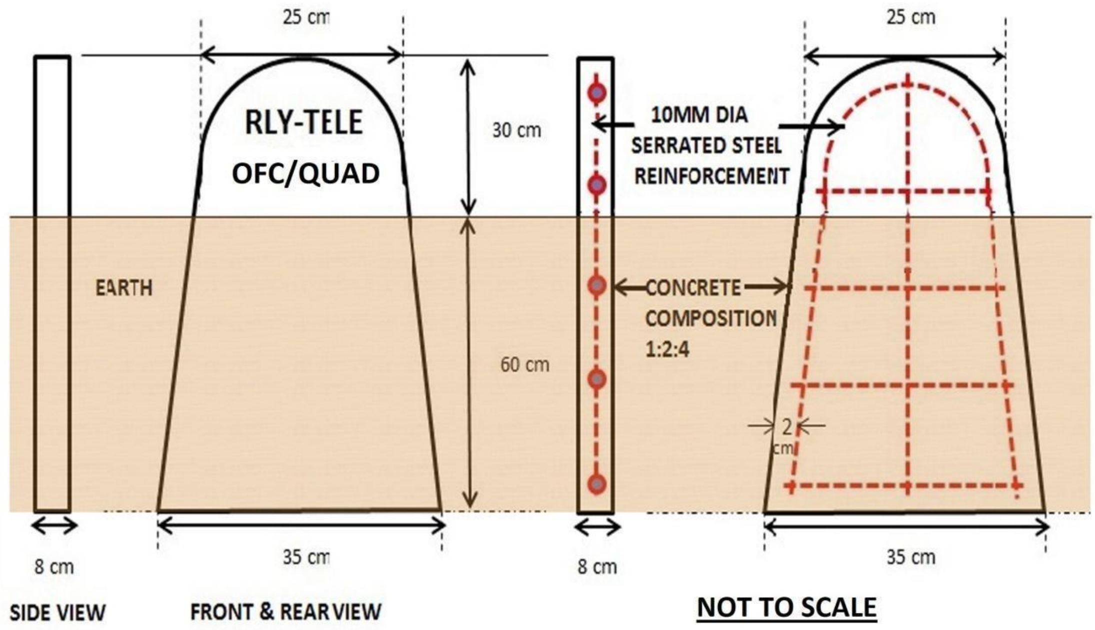
NOTE:
'A' DEPTH WILL BE 1.0 m.
OR OTHERWISE WILL BE
DECIDED BY THE ENGINEERS
AT SITE.

RCC CIRCULAR OFC JOINT ENCLOSURE



RCC CIRCULAR OFC JOINT ENCLOSURE	
DRG. NO. RDSO/TCDO/COP-21(a)	

RCC CABLE ROUTE MARKER



NOT TO SCALE

For OFC and/or QUAD cable route :-

1. All sides above ground to be painted with RED enameled paint to IS specifications with 2 coats.
2. The concrete composition to be added as 1:2:4.
3. Engraved portion to be painted with WHITE enameled paint to IS specifications with 2 coats.

For OFC Joints :-

1. All sides above ground to be painted with GREEN enameled paint to IS specifications with 2 coats at OFC Joints.
2. RLY TELE OFC to be engraved on both sides.

For QUAD Joints :-

1. All sides above ground to be painted with YELLOW enameled paint to IS specifications with 2 coats at Quad Joints.
2. RLY TELE QUAD to be engraved on both sides.

RCC CABLE ROUTE MARKER
DRG.NO. RDSO/TCDO/COP-22(a)

Annexure-I

DUCT INTEGRITY TEST (DIT)

1.1 Duct Integrity Test (DIT) is to be carried before OFC cable blowing. The Purpose of duct integrity Test is to ascertain and ensure the suitability of the duct for cable installation through jetting. It is first necessary to ensure that the duct into which cable is to be installed is continuous over the length of the duct. Some reasons for lack of continuity are:

- Missing Sections of Duct.
- Couplers not connected.
- Over lapping of Ducts.

1.2 The Air Test establishes the duct continuity. Air is introduced from one end of the duct. If air comes out from the other end of the duct, then it is established that the duct is continuous. If no air emerges, then the fault is to be identified and corrected before proceeding further. Duct overlap can lead to potentially very dangerous situation and should be corrected promptly.

1.3 Second step in the DIT Test is to establish that there is a clear passage for the cable to go through the duct. Possible reasons for lack of clear passageway are:

- Kink in the Duct.
- Blockage in the Duct.

1.4 These deficiencies are to be corrected before proceeding further. Kink in the duct may be caused at the duct laying stage when back filling may have been done without taking care to keep boulders out of the way and out of the trench. A fallen boulder on top of a laid duct can cause the problem. The kink may also have been caused at the de-coiling stage, when this is attempted without use of a de-coiler.

1.5 The kink in the buried duct is located through the shuttle Test. A suitable shuttle is first passed through the duct. The shuttle will get stuck at the point where the duct is either kinked or blocked. Next a transmitter is passed through the duct. It gets stuck behind the shuttle. The path of the duct is then tracked with a receiver. As the receiver passes over the transmitter, the signal from the transmitter is heard loud and clear. In this way the transmitter, and just a head the shuttle, and just ahead the kink are located. The spot is marked and the trench has to be dug up again. The boulder responsible for the kink is removed. The portion of the damaged pipe is cut and replaced with good duct of equal length. Joint with laid duct is made with push-fit coupler.

1.6 Cable installation through jetting can be carried out successfully only under a pressure of 10 bar. Before cable installation is attempted it is necessary to verify that the duct can hold this pressure. This is the major purpose of the pressure Test.

1.7 Possible reasons for failure of DIT pressure test are:

- Leakage at Couplers.
- Puncture in Duct.

1.8 Coupler leakage is caused by improper installation of coupler. A puncture in the duct can result from improper handling of the duct. A sharp-edged boulder if it should come to rest on top of the buried duct can also puncture the duct. Air leakage from the leaking coupler or the punctured duct is the tale sign of the problem which can then be rectified.

1.9 Thus, in summary, the DIT Test is conducted prior to cable blowing/pulling with a view to check and if necessary rectify so it is made suitable for cable blowing/pulling. The possible duct faults that may show up during the DIT Test process are:

- Missing sections of duct.
- Couplers not connected.
- Overlapping of Ducts.
- Kink in the Duct.
- Blockage in the Duct.
- Leaking at Couplers.
- Puncture in Duct.

1.10 These faults are to be corrected before proceeding further. The DIT Test consists of the following 4 important steps:

1) Air blowing purpose is to ensure that there are no discontinuities (or missing sections) in the duct.
2) Shuttle of a diameter 80% of the duct inside diameter and of 150 mm length is passed through the duct. Purpose is to check for bends, kinks, crush and deformity in the duct.
3) Sponge of a diameter two times the duct inside diameter, and length of 100 mm is blown through the duct. Purpose of passing, the sponge through the duct is to clean the duct.
4) Pressure test is conducted at 5 bar pressure for 30 Minutes with maximum permissible drop of 0.5 bar.

1.11 **Air blowing:**
Air is introduced into the duct and a check is made at the end of the 2 Km section of duct. Possibilities are:

- Normal flow of air is perceived at the other end. So far, so good, proceed further with the DIT Test.
- No flow of air at the other end of the duct. Trouble is indicated, Leakage at couplers, puncture in duct, missing duct, duct overlap, blockage in the duct.
- Less than normal flow of air. Leakage at couplers, puncture in duct.

If there is no flow of air at the other end, check the pressure at the point where air is introduced into the duct. If the pressure is less than normal this would rule out blockage in the duct. It would indicate leakage from the duct or at a coupler location. Higher than normal pressure, would indicate blockage in the duct.

The problem can be localized by opening the coupler at the 1 Km point and introducing air once again through the duct. This will help identify whether the problem exists in the first kilometer of the duct under check or in the second kilometer.

1.12 **Shuttle Test:**

Once the air test has been successfully concluded, a shuttle of a diameter 80% of duct inside diameter and of 150 mm length is passed through the duct. Purpose is to check for bends, kinks, crush and deformity in the duct. If the shuttle passes through successfully this confirms that the bends in the duct are gradual and there are no kinks or deformity that would hinder the progress of the cable during the installation process. The shuttle should pass through the 2 Km of duct length in a space of three minutes.

In case there is a problem and the shuttle does not emerge from the other end of the duct even after 5 to 6 minutes, then a transmitter is to be blown through the duct to identify where the shuttle is stuck. A receiver at the 1 km point will pick up the signal from the transmitter as it goes by, and in this way it will be known that the shuttle is stuck in the second kilometer of duct. If no signal is picked up then the problem would have been localized as existing in the first kilometer, shuttle, and the kink in the duct would be identified, and the duct can be suitably rectified.

Often times the shuttle gets stuck due to a minor kink, and when the transmitter is blown the shuttle and transmitter both come out the same time.

1.13 **Sponge Blowing:**

Purpose of blowing sponge through the duct is to clean it. A sponge of a diameter twice the inside diameter of the duct, and 100 mm in length, is blown through the duct. The time required for the sponge to pass through the 2 Km duct length is three minutes.

1.14 **Pressure Test:**

The pressure test is conducted at 5 bar pressure. Over a 30 minutes period the pressure loss should not exceed 0.5 bar. Once this pressure test passed, the duct is pronounced ready and fit for cable blowing/pulling.

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CHAPTER XIV

DIGITAL MULTIPLEXING EQUIPMENT

14.1 PRINCIPLE OF DIGITAL MULTIPLEXER

14.1.1 The existing digital multiplexing equipment are based on 2048 Kbps SDH – (STM -1, STM -4, STM – 16 or higher) 10 Mbps, 100 Mbps, 1 Gbps (Ethernet) based hierarchy. In future, it has been decided that all new work shall be based on IP-MPLS technology.

14.2 MEDIA OF TRANSMISSION

- Symmetric cable pairs / HDSL modems
- Star quad cable in 25 KV AC electrified areas
- Optical fibre
- Radio based communication

14.3 Primary multiplexing equipment

(a) This equipment shall multiplex 30 analogue and/or data channel to 2048 Kbps ITU compatible digital stream on transmit side and on receive side, it shall demultiplex ITU compatible 2048 Kbps digital stream to 30 analogue voice /data channels.

(b) Following type of primary multiplexers are in use:

(i) **TERMINAL MUX**

It shall have one 2048 Kbps port each for trans and receive side and shall be used as end multiplexer.

(ii) **PRIMARY DROP/INSERT MUX**

This shall have at least two 2048 Kbps ports (P1 and P2 port) each for send and receive side. It shall be possible in drop/insert any channel to P1/P2 port or make a time slot through P1 port to P2 port and vice versa.

(iii) **DROP/INSERT MUX WITH CONFERENCE FACILITY**

Its function is similar to drop insert MUX described above with additional facility of at least 3 party conferences between any combination of time slots of either P1 port or P2 port and voice interface.

(c) **TYPE OF INTERFACE CARDS FOR THE PRIMARY MULTIPLEXER**

Following types of interface cards are provided in primary digital multiplexer –

- 2W speech card with E&M Signalling
- 4W speech card with E&M signalling
- Exchange end interface cards
- Subscriber side interface cards
- Hotline interface cards
- Digital Subscriber Line Interface Card
- Network Termination Unit/ Remote Data Unit
- E1 Branching Interface
- Data interface cards of various types like
  - (i) G703 (64 Kbps Data Interface)
  - (ii) NX64 Kbps data interface cards etc.

14.3.1 All digital multiplexing equipment shall be as per approved specification of RDSO.

14.3.2 **CHARACTERISTICS OF INTERFACE**

Bit rate, Code, Characteristics of output and input ports for various interfaces are as under:

ITEM		2048 Kbit/s PORT
(a)	BIT RATE	2048 Kbit/s ± 50 PPM
(b)	Code	HDB3

OUTPUT PORT:

(a)	Pulse shape	Rectangular as per ITU-T G.703
(b)	Pulse peak voltage /impedance	2.37V/75 ohm or 3.0v/120 ohm
(c)	Normal pulse width	244 ns

INPUT PORT:

(a)	Permissible attenuation	F law 0-6 db at 1024 Khz
(b)	RETURN LOSS	
	Frequency corresponding to normal bit rate	
	2.5% to 5%	12
	5% to 100%	18
	100% to 150%	14

14.3.3 **REQUIREMENT OF SYSTEM PERFORMANCE**

(i) The overall system performance with the proposed transmission media shall be so designed and ensured that it meets ITU-T parameters. The system availability shall be at least 99.5%.

(ii) The characteristic of complete circuit shall be measured on the basis of audio frequency 4W/2W interface in respect of characteristics and parameters defined in ITU-T G.712.

(iii) The measurement of performance parameters made during the life cycle of the equipment shall be within acceptable limits.

14.3.4 SYNCHRONIZATION

The equipment shall have provision of deriving timing signals on internal, external and incoming digital signal tributaries. The equipment shall have automatically switched over from one timing signal source to another in case of failure of primary source. Synchronization as per approved scheme shall be ensured.

14.3.5 FRAME STRUCTURE

2048 Kbps TRIBUTARY

The frame structure shall conform to ITU-T Rec.G.704/G.732. The frame shall consist of 32 time slots numbering from time slot 0 to time slot 31. Time slot 0 shall be used for transmission of frame synchronization word and alarms, etc. Times slot 16 shall be used for transmission of signalling of channels 1 to 15 and 16 to 31. Remaining slots shall be used for speech data/channels.

The allocation of bits 1 to 8 of time slot 0 of the frame 0 shall be as under: c0011011

A multi frame shall comprise of 16 consecutive frames and shall be numbered from 0 to 15. A multi frame alignment signal 0000 shall occupy bit 1 to 4 of channel time slot 16 in frame 0.

14.3.6 FAULT CONDITION AND CONSEQUENT ACTION

Where signalling gears also run on common telecom equipment such as Primary MUX and STM1 etc., S&T control should be advised before taking up any maintenance work on such telecom equipment.

(i) **Primary PCM Multiplexer Equipment**

Generally, following minimum alarms are provided :

(a) Power supply failed.
(b) Loss of incoming signal at 64 Kbps input port
(c) Loss of incoming signals at 2048 kbps
(d) Loss of frame alignment
(e) Loss of multiframe alignment
(f) Excessive error ratio alarm in framing pattern for 1 in 10E-3
(g) Remote failure
(h) AIS alarm
(i) Loss of transmit clock

14.3.7 Digital Cross Connect

Provision of Digital Cross Connect should be made as per ITU-T G.796 at all junctions, to facilitate channel level cross connect features for better operational flexibility. The capacity of the cross connect may be chosen depending on the traffic requirement generally a cross connect of 4 ports to 32 ports capacity may be used.

14.3.8 INSTALLATION

(i) **SIZES OF ROOM**

The layout requirement of the equipment room shall, apart from housing equipment, should cater for enough movement space for doors and routine measurement of equipment.

(ii) **SPACING**

(a) The spacing between ceiling and cable carrier from the rack may be (min) 30 CM. The cable carrier itself may be mounted 30 CM minimum above the rack.
(b) There must be a space of 2 meters (min) between two rows of double sided rack.
(c) The space between the equipment rack and wall/other racks should be minimum 2 meters.

(iii) It should be ensured that the room where the equipment is installed is well ventilated and illuminated and is at least 3 meters away from major sources of electromagnetic radiation such as photocopiers and facsimile machines.

(iv) The rack on which the equipment is to be mounted shall be on standards 19” rack. Minimum 2u spacing should be provided in between two equipment. The racks shall be provided with suitable covers on all sides to protect entry of rodents, etc.

(v) All connections from the equipment to be terminated on the suitable MDF mounted on the rack. All cables may be carried above the wayside on cable carriers separated from the ceiling. The cable carrier may be of 15 cm to 30 cm in width.

(vi) **EARTHING**

All equipment, sheath of underground cable and the screen indoor cable etc. should be connected to the main station earth as per approved standards. The earth resistance shall be maintained less than 1 ohms.

(vii) **POWER SUPPLY**

The equipment shall operate on - 48 Volt DC with positive earth. It should be connected with common power supply arrangement provided for OFC equipment/Radio equipment. Preferably power supply shall be installed in a separate room adjacent to the equipment room with sufficient power back up.

14.3.9 MAINTENANCE

(i) **General Precaution and Instructions**

Each equipment is supplied with the detailed precaution to be followed for maintenance and testing. These should be strictly followed:

(ii) Electronic circuits on the multiplexer are easily damaged by electrostatic discharge. Hence, the following precautions are to be followed:

- Always wear a proper anti static strap/ wristband.
- Before handling any electronic components, touch the grounded metal surface to discharge static from your body. It is recommended to use antistatic flooring along the equipment on all the sides.
- Avoid touching the components on the PCB.
- Follow any other safety instructions provided by the manufacturer.

(iii) Some of the cards cannot be inserted with power supply ON. Proper precaution may be followed for removing or inserting such cards.

(iv) The PCBs should be transported to the repair center after electro statically sealing the card and as per the procedure specified by the supplier.

(v) Maintenance schedule for multiplexing equipment. The measurements may be carried out in line with relevant ITU-T standards being updated from time to time (for e.g., ITU-T G.823, 824, 825, etc.)

Following schedule shall be followed for maintenance of multiplexing system:

-	Alarm check	….	3 monthly
-	Voltage check	….	3 monthly
-	Audio level check at 1020 Hz on all 2W/4W channels of primary MUX	….	6 monthly
-	Idle channel noise on all channels on 2W/4W circuits of primary MUX	….	6 monthly
-	Signalling operation for E&M and Exch.ckt.of primary MUX	….	6 monthly
-	Total distortion for 2W/4W circuits of primary MUX	….	Yearly

-	Variation of gain with input level for 2W/4W circuits of primary MUX	….	Yearly
-	Clock frequency	….	Yearly
-	Bit error test on spare time slot/ tributary for a period of at least one week	….	Yearly

(vi) **FAILURES**

The alarm system will help to localize the faults to a particular card or sub-system. The step by step procedure for the localization of fault is given in troubleshooting manual supplied along with the equipment.

A systematic record of faults must be maintained indicating the details of the card, time of failure, duration of failure, action taken to rectify the faults.

(vii) **TEST INSTRUMENT**

The testing instruments are to be provided at a centralized place or with the maintenance gang and need not to be provided separately at each of the stations.

(a) Equipment to be provided at centralized location
- PCM test set with facility for A to A and A to D, D to A, D to D testing.
- BER test set with jitter measurement
- Data tester
- The insulation resistance measuring set
- Cable fault locator
- Earth resistance measuring set

(b) Equipment to be provided with each of the maintenance gang –
- PCM MUX tester with facility to test at least up to 8 Mbps with framed and unframed signal
- Digital multi-meter
- Portable PCM test set
- Signalling test set

(viii) **INSPECTION, RECORD AND REPORT**

(a) Three monthly and six monthly test shall be carried out by the JE/SSE of the section and he shall maintain all the records.

(b) Yearly schedule of maintenance shall be carried out by the JE/SSE In charge. The critical yearly schedule/tests/adjustments shall be carried out under the supervision of ADSTE/DSTE. The records of the tests and maintenance schedule shall be maintained in the relevant pro-forma.

(c) ADSTE/DSTE/Sr.DSTE during their annual inspection shall check the record of tests and failures and availability of proper instruments and details of testing.

14.4 SDH EQUIPMENTS

The synchronous Digital Hierarchy (SDH) has evolved as a result of standardization by ITU. The format allows different types of signal formats to be transmitted over OFC. The STM-N signals are generated using a standard multiplexing pattern. Generally, STM-1 & STM-4 are used in Indian Railways STM-1 can accommodate E1 streams/10/100 Ethernet with maximum 63 E1s.

In Railways, SDH only upto level 16 are used. The various SDH signal levels along with the bit rates are shown below.

SDH LEVEL	BIT RATE Mbps
STM-1	155.520
STM-4	622.080
STM-16	2488.320

14.4.1 SYSTEMS CHARACTERISTICS & PERFORMANCE

(a) The TEC Generic specification as per requirement is adopted. The system shall be capable of interfacing with optic fibre cable as per latest RDSO specification with latest amendments.

(b) **Configuration**

The system should support various application configurations required by Indian Railways like –

- Point to point topology
- Bus topology
- Mesh topology
- Ring topology

Note: Railways should take advantage of its geographical ring available in their Railway network to configure all their E1s with best possible next shortest path protection. Where necessary they may provide smaller E1 rings by taking channels from other established telecom service providers for control circuits.

(c) **Multiplexing**

The system should be compatible with MUX as per latest RDSO specification

(d) **Tributaries**

The SDH system should facilitate transport of the various tributaries like –

- E1 (2Mbps)
- Tributary STMs
- 10/100/1000 Mbps Ethernet systems

(e) **Alarms & Indications**

The SDH system should have adequate failure alarms indication for easy maintenance. This should be brought out on the Network Management Systems (NMS). The system in general should have the management capabilities as per ITU-T G.831. It is desirable that NMS should have management capabilities to check current status of AC/ DC input voltage of each SDH system within the network for easy maintenance**.**

(f) **Installations**

The guidelines described as per para 14.3.8 shall be adopted for the installations of SDH equipments also. The system shall be commissioned after carrying out all pre--commissioning checks specified by the manufacturer or the laid down policies.

(g) **Protection switching**

The communication systems provided should preferably have Automatic protection switching. Generally, the switching should take place within 60 m sec. Revertive (systems reverts automatically to the original circuits after restoration of defect) systems shall be adopted, normally.

(i) **SYNCHRONIZATION**

The equipment shall have provision of deriving timing signal on internal, external and incoming digital signal tributaries. The equipment shall have automatically switching over facility from one timing signal source to another in case of failure of primary source. The system should also have facility for manual selection of clock. Synchronization as per approved scheme shall be ensured.

14.4.2 MAINTENANCE

(i) The SSE/JE of the section should maintain close liaison with the Engineers/Managers of RailTel Corporation of India (RCIL) in ensuring proper maintenance of the SDH equipment wherever the maintenance is being carried out by RCIL.Joint testing of protection channels should be jointly carried out by Railtel and field staff once in three months. A proper log/record of incidences of interruptions occurring in the sections should be maintained. SSE/JE of the section should also maintain the history of all the equipment failures and keep track of defective and working spare modules.

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(ii) **PROCEDURE FOR FAULT RECTIFICATION:**

(a) When the fault is conveyed by NCC/Control Office, SSE/JE must consult NCC/Control Office to ascertain the exact nature of fault and plan the rectification in coordination with the NCC, mobilize the maintenance team and proceed to the site of interruption by fastest means.

(b) After reaching the site, OTDR testing may be done on short haul fibers from either side of the cable hut on both sides from the nearest OFC POP for localization of the fault as close as possible.

(c) Fault rectification shall be taken up in such a manner that working fibers are made through from both ends and link restored first and then proceed ahead to restore the remaining fibers. Splicing of fibers should be done in the prescribed order. It should not happen that only a few fibers are restored while others are not attended. Testing shall be done and SSE/JE should personally satisfy himself that the work has been done properly.

(d) During an OFC outage, the prime goal of the SSE/JE shall be to restore the link. In case fault localization becomes difficult due to site conditions, the link should be made through by temporarily patching the OFC/mechanical splice or by laying OFC on the ground or by use of aerial OFC, so as to minimize the outage.

14.4.3 **SCHEDULE OF INSPECTION AND MAINTENANCE**

(i) Inspection of each equipment will have to be done thoroughly keeping time for it. A normal or casual visit for any other reason will not be treated as inspection. An inspection register will be kept at each location wherein inventory shall also be recorded with date of inspection. The brief inspection note shall be recorded by visiting officers. Compliance of the inspection notes should also be recorded by SSE/JE. Indoor equipment for long haul and short haul links shall be inspected and recorded. Following minimum schedule shall be followed.

(ii) **Every indoor location – (ADSTE/DSTE/Sr.DSTE)**

-	Electronics	:	Yearly
-	Power supply equipment	:	Yearly
-	Checking of proper functioning of external alarms	:	Yearly
-	DG sets (if provided)	:	Yearly
-	Air conditioning	:	Yearly
-	Earth	:	Yearly

-	Fire alarm system	:	Yearly
-	Link status/loss auditing	:	Yearly
-	Testing of alarms and its appearance on NMS	:	Yearly

(iii) **Section Incharge – (JE/SSE)**

-	Electronics	:	Monthly
-	Power supply equipment	:	Monthly
-	DG set	:	Quarterly
-	Air-conditioning	:	Quarterly
-	Earth	:	Half yearly
-	Fire alarm system	:	Quarterly
-	General upkeep of equipment room	:	Quarterly
-	Checking of proper functioning of external alarms	:	Quarterly

The officer in-charge should verify the above details during his/her annual inspections.

(iv) **Periodical Checks and Preventive Maintenance**

Preventive maintenance of all indoor and outdoor equipment is to be done for their proper upkeep and availability of network. The same will cover the following, however, additional items may have to be done based on manufacturer's guidelines or the condition of the equipment.
The various checks (measurements performed should be suitably recorded (ref. Annexure A – D).

(a) **Electronics**

As prescribed by the manufacturer.

(b) **Battery charger**

- Testing of auto changeover of SMRs
- Current setting as per load
- Checking of input and output voltages
- Reporting of alarms to NMS
- Proper connection of input and load cables
  Testing of Class B & C surge arrestor by suitable means
- Other checks as prescribed in the manual

(c) **Battery set**

- Checking of electrolyte level/gravities in case of low maintenance battery sets.
- Checking of cell voltages and battery voltage at equipment end.

- Cell whose voltage is found to be below prescribed value by the manufacturer should be noted and immediate corrective action taken for their replacement.
- Checking of sulfation/physical damage
- Testing of AH capacity (During installation and periodically as decided by the Railway)
- Proper connection of load cables.

(d) **Diesel Generator Set, wherever provided**

- Testing on load
- Testing of auto-start in case of AC failure
- Checking of hour meter readings
- Checking of diesel oil/engine oil level
- Checking of oil/air filters
- Battery voltage (self start)
- Cleanliness
- Water level (in radiator) if applicable
- Any other check prescribed in the manual

(e) **Air Conditioning**

- Working of the air conditioners
- Working of changeover arrangement, if provided

Any defect noticed may be reported to the Electrical staff/ Maintenance in charge.

(f) **Earthing**

- Watering of the pits
- Checking integrity /continuity of the physical connections including at equipment ends.
- Tightening of nuts/bolts
- Checking of earth resistance (value should be less than 1 ohm preferably)

(g) **Fire Alarm System**

- Cleaning of fire sensors
- Simulate the fire situation by applying smoke near to sensors.
- See the fire panels for reports and analysis

(h) **General Upkeep of co-located equipment**

- Ensure cleanliness
- Ensure the tower maintenance is done as per schedule by the nominated agency.

Annexure A

POWER SUPPLY CHECK DATA LIST

SN	Item	Frequency	Unit	D1	D2	D3
A.	**Battery Charger**			{date1}	{date2}	{date3}
1	Current		Amp			
2	Voltage		V			
3	Alarms					
4	Fuse/Grip					
5	Connections					
6	Checking of protection (X,Y & Z)					
7	Proper working of AC/DC alarms from NMS					
B.	**Battery Set**					
1	Electrolyte Level					
2	Total Voltage at Battery		V			
3	Total Voltage at equipment		V			
4	Sulfation/Physical condition					
5	Cell voltage		V			
6	AH capacity		AH			
7	Connections					
8	Room temperature		°C			
C.	**Diesel Generator Set**					
1	Diesel oil level		Litre			
2	Engine oil level					
3	Water level					
4	Testing on load					
5	Output voltage		V			
6	Output current		A			
7	Battery voltage (self-start)		V			
8	Hour meter reading		Hrs			
9	Checking of AMF panel					
10	Condition of oil filter					
11	Condition of air filter					
12	Overhauling					

ANNEXURE – B

AIR CONDITIONER CHECK DATA LIST

(To be ensured theough Electrical staff / AMC by Maintenance in charge)

SN	Item	Frequency	Unit	D1	D2	D3
				{date1}	{date2}	{date3}
1	Cleaning air filter					
2	Cooling					
3	Load current					
4	Cable connections					
5	Auto changeover					
6	Overhauling					

ANNEXURE – C

FIRE ALARM CHECK DATA LIST

SN	Item	Frequency	Unit	D1	D2	D3
				{date1}	{date2}	{date3}
1	Cleaning of sensors					
2	Simulation of fire by applying smoke					
3	Checking of alarm system					

ANNEXURE – D

EARTHING CHECK DATA LIST

SN	Item	Frequency	Unit	D1	D2	D3
				{date1}	{date2}	{date3}
1	Watering of pits wherever necessary					
2	Verification of connections					
3	Measurement of earth resistance					
3.1	Earth pit					
3.2	Overall value outside					
3.3	Overall at equipment end					

ANNEXURE – E

MAINTENANCE FORMAT FOR FIBRE OPTIC SYSTEM

EQUIPMENT	ITEM	MAINTAINER	SECTIONAL SUPERVISOR	SUPERVISOR INCHARGE
Network Management System	Daily routine monitoring of system			
	Analysis & Recording of statistics of Optical and Digital equipments			
	Monitoring of alarms			
	Periodical check and verification of configuration			
	Checking and verification of control functions			
OPTICAL TERMINAL EQUIPMENT	TX/RX optical power			
	Meas. of voltages			
	Cleaning of connectors			
	Earthing			
	Cleaning of dust			
	Alarms			

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CHAPTER XV

DATA NETWORK

15.1 The interconnection of a large number of data processing devices through suitable communication links enabling data transfer between the data processing devices constitutes a DATA NETWORK. Indian Railways has three major data networks viz. Railnet, Unified Ticketing network (UTN) and FOIS network. Special purpose data networks are also being established by the Railways like the network for monitoring the CCTV network, VoIP control communication network, etc. Several applications are already operating over the networks and many new applications are contemplated .The various applications are as under:

- Passenger Reservation System (PRS) & Unreserved Ticketing System (UTS)
- Freight Operations Information System (FOIS), Coaching operations Information System (COIS), Control Office Automation (COA) & Crew Management System (CMS)
- Material Management Information System (MMIS)
- Integrated Coaching Management System (ICMS)
- Parcel management system (PMS)
- Software for Electric Locomotive Asset Management (SLAM)
- Time Table Management System (Satsang)
- E-procurement System
- Integrated Material Management System (iMMS)
- Locomotive Management System (LMS)
- Health Management Information System (HMIS)
- e-Office
- Track Management System (TMS)
- Works Program Management System
- Railway Land Management System
- RPF Security Management System (RSMS)
- e-Drishti – A Dashboard for Indian Railways
- TDMS – Traction Distribution Management System (Pilot project)
- EEMS – Electrical Energy Management System
- Signaling Maintenance Management System (SMMS)
- Real-time Train Information System (RTIS)
- Integrated Payroll and Accounting System (IPAS) and Web enabled Railway Budget System
- Computerization of Train Signal Registers (TSR)
- Human Resource Management System (HRMS)

The data networks can also be used for other applications like Video Conferencing, Data Conferencing, VOIP, IVRS, Disaster Management, Office Automation etc.

15.2 Railway Networks:

15.2.1 Railway applications primarily run over Railways' Private Network, i.e. Railway applications are normally transported by Railway network, The general purpose wide area intranet of IR is known as Railnet. Railnet is also being used for accessing the Internet.

15.2.2 Railnet is built up by Railways own transport network, utilising bandwidth from RailTel Corporation of India (RCIL) or leasing bandwidth from BSNL or other service providers. In special cases, Railnet may be extended through the public networks like the Internet using Virtual Private Network (VPN) solutions taking sufficient security measures. A virtual private network (VPN) extends a private network across a public network and enables users to send and receive data across shared or public networks as if their computing devices were directly connected to the private network. Applications running across a VPN may therefore benefit from the functionality, security, and management of the private network. Encryption is a common, although not an inherent, part of a VPN connection. For Internet access, Railnet is connected to Internet at specific locations duly ensuring network security by means of suitable firewalls along with other devices to circumvent cyber threats.

15.3 Communication Media:

The communication links making up the data network are a combination of media like OFC, GSM-R/LTE, IP Radio links, VSAT, Twisted pair copper for last mile connectivity. For Local Area Network (LAN) in the same building Optic Fibre Cable/Cat 6 cables are used.

15.4 Network Speeds:

15.4.1 The earlier networks were non-IP based and worked at speeds of 9.6 Kbps. Gradually some of the non-IP based network speeds were upgraded to 64 Kbps. Generally higher speeds were not adopted in non-IP networks.

15.4.2 Presently networks are mostly IP based and operate at speeds of 2 Mbps at the core and access levels. Some of the access level links are also working at 64kbps speed. In future, all IP networks should be planned with minimum 2 Mbps connectivity at distribution level and nX2 Mbps in the core. Preferably, Ethernet links may be used for all data networks with fibre connectivity.

15.5 Network Topology & Architecture

15.5.1 Railnet

15.5.1.1 Railnet is currently built as an L3 VPN over MPLS infrastructure of RCIL.

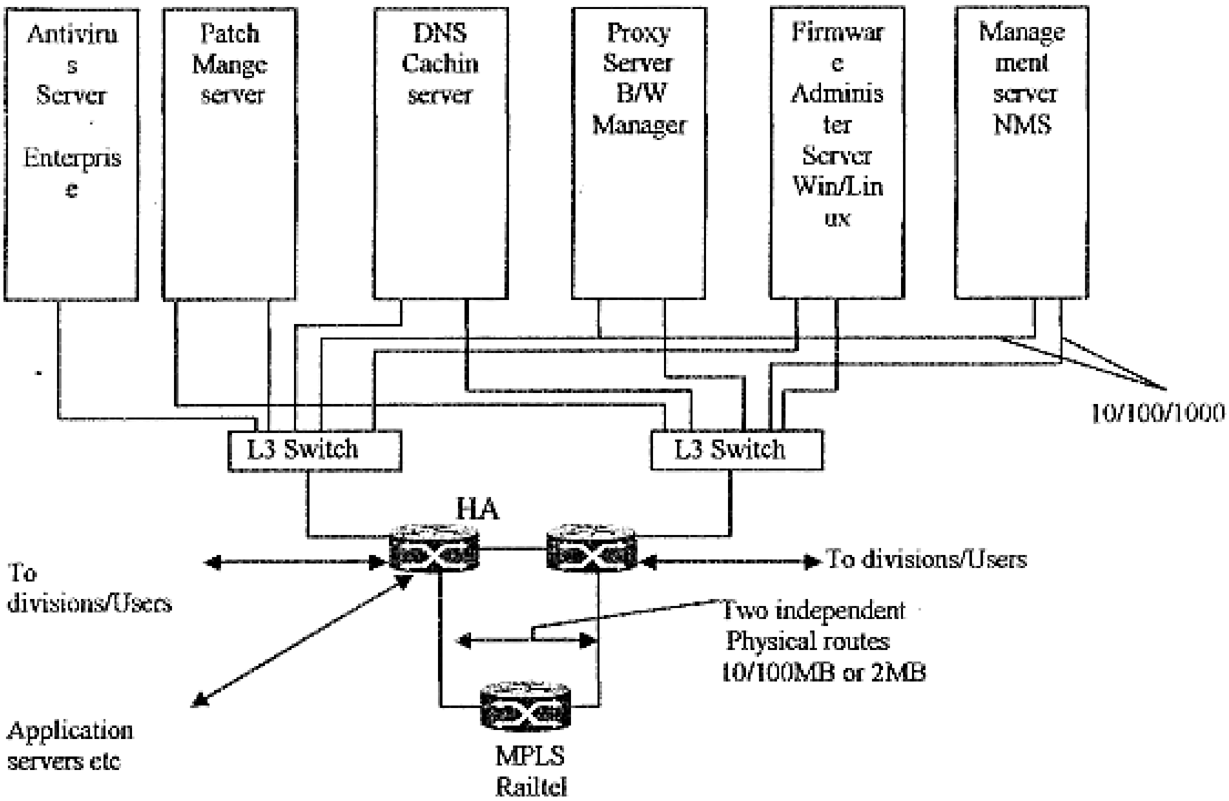
15.5.1.2 Each zone and division is connected to an MPLS router of RCIL with appropriate bandwidth ranging from 20Mbps to 300Mbps. Zonal Railways can increase/decrease this bandwidth based on the demand themselves.

15.5.1.3 Railnet setup at the zonal and divisional HQs may have the following setup:

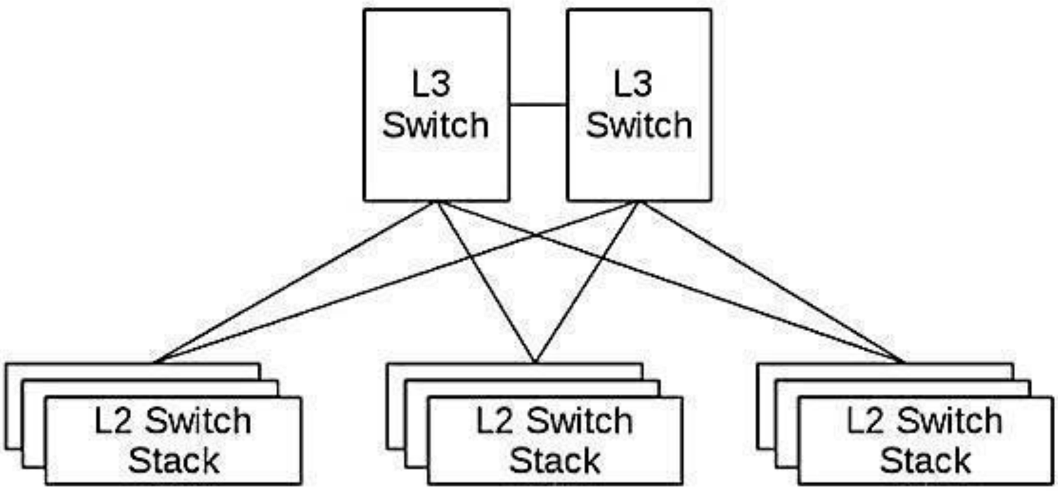
a. Railnet routers in high availability.
b. UTM /Firewall
c. L3 switches working in 1+1 redundancy.

d. DNS cache server
e. Network Management server
f. Other servers like DHCP, Web server, Antivirus server, Patch Management server, Proxy server etc.

The same is shown in the figure below:



15.5.1.4 Railnet LAN Architecture:



i. The Railet LAN Architecture shall be as shown in the figure above. This should be followed at Railway Board, RDSO, zonal HQ, divisional HQ and other units.
ii. The core switch should be a Layer 3 switch and the distribution/access switches shall be Layer 2. The L2 switches should be with PoE support to power the IP phones & security cameras.
iii. Layer 2 switches should be used in the LAN for the purpose of interconnecting user nodes. These switches should support the following minimum features
    a. VLANs
    b. RSTP and MSTP
    c. DHCP relay
    d. DHCP snooping and trusted DHCP server support.
    e. MAC address authentication through a radius server.
    f. Non-blocking Gigabit PoE access ports

iv. The connectivity of Layer 2 switch and the Layer 3 switch shall be on OFC. This shall be 1G or 10G multiple links with path protection.
v. The distribution switch should have Gigabit access Copper ports. For connec-tivity to the Layer 3 switch, SFP based optical ports shall be supported.
vi. The connectivity between the user (clients) and the distribution/access switch shall be through Cat-6 UTP cable/OFC.
vii. The connectivity to the user nodes shall be upgraded to 1Gbps.
viii. VLANs shall be used to limit the Ethernet broadcast domain in such a way that one VLAN should normally not have more than 70-100 computers. For simplicity, one VLAN should normally not cover more than one switch stack. One may configure multiple VLANs in one switch stack.
ix. RSTP/MSTP may be configured in the switches with the Layer 3 core switch as the root bridge.
x. Switches must be configured to recognize a trusted DHCP server and should not allow access to rough DHCP servers that may get enabled in the network.
xi. Use of a DHCP server should be mandatory for a network node. Any node that does not obtain its IP address from the DHCP server should not be allowed network access. One way to achieve this may be to disable ARP based MAC learning and use DHCP snooping for building MAC address tables in the switch.
xii. DHCP server shall be provided in redundancy. Two DHCP servers shall be provided in the network. Both these DHCP servers shall provide IP addresses from disjoint sets so as to avoid IP clash.
xiii. All the local servers providing network services like DNS etc. shall be con-nected to the Layer 3 switch in a different VLAN either directly or through a distribu-tion/access switch. In this case, manual configuration of IP addresses can be done.
xiv. When there are more than one Layer 2 switch at one location, they must be stacked. Stacking is better than connecting the switches using 1/10G port as it provides better speed and better forwarding rates.

xv. Layer 3 switches shall be used as the gateway for the nodes in each of the VLAN. Load balancing should be configured in such a way that one Layer 3 switch is the gateway for half the total VLAN and the other Layer 3 switch is the gateway for the balance VLANs. This will ensure that both the switches are in service and are handing half of the traffic of the LAN.

xvi. VRRP(Virtual Router Redundancy Protocol) should be configured between the switches for the gateway IP for each VLAN. Thus, when one switch goes down the other takes over the role of traffic forwarding/routing. With this arrangement manual load balancing is achieved.

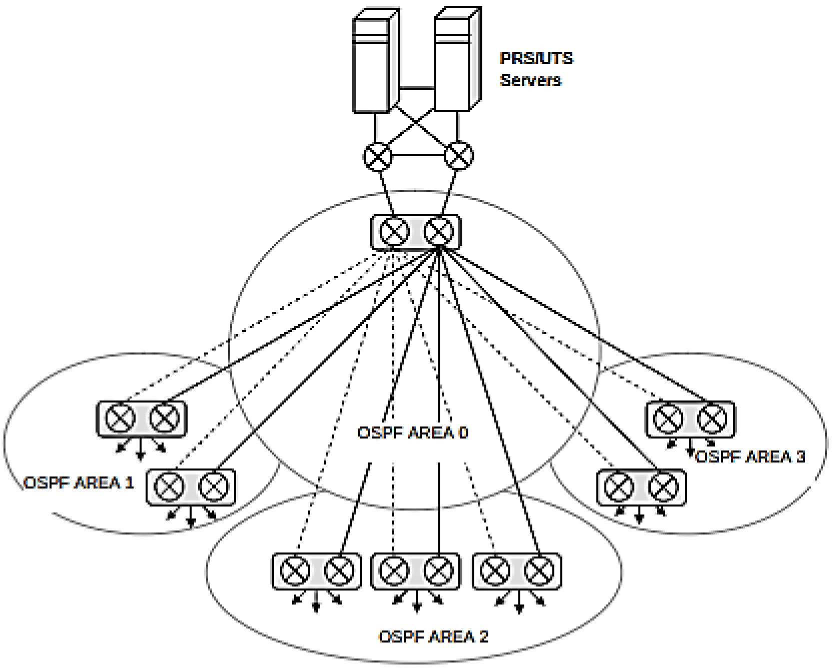
xvii. The L3 switches shall be connected to the routers/switches on the WAN side and route the traffic out of the network towards MPLS network of RCIL.

15.5.2 Unified Ticketing Network

15.5.2.1 Unified Ticketing network in the unified PRS and UTS network.

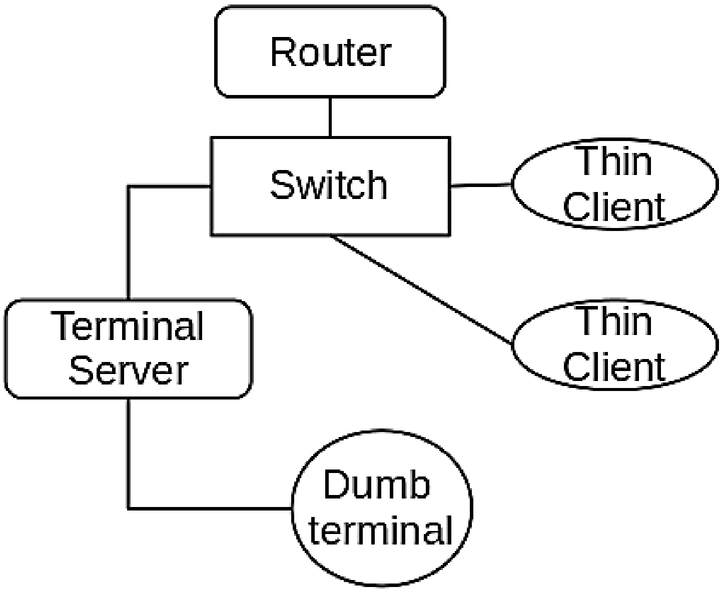
15.5.2.2 The PRS network is used to issue reserved tickets to railway passengers. The UTS network is used to unreserved tickets to railway passengers.

15.5.2.3 The network is an IP network that spans all the stations with ticketing activity. The network is a tiered network. The general architecture is as shown below.



The UTN uses OSPF as the routing protocol. Every division has been divided into one or more OSPF areas that are connected to area zero connecting the main UTS/PRS servers.

15.5.2.4 The following diagram shows the arrangements at the station:

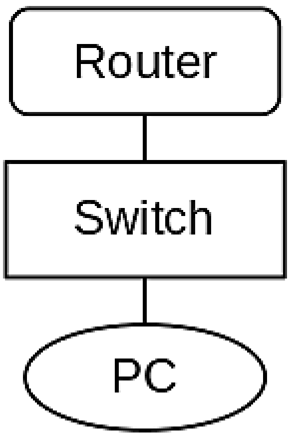


15.5.3 FOIS network

15.5.3.1 FOIS network is used for operation of Freight Operation Information System. It also hosts almost all the operational intelligence software that helps in train operation. A few systems that are hosted on this network are Integrated Coach Management System, Crew Management System, Parcel management System, Control Office Application etc.

15.5.3.2 FOIS network is also an IP network spanning the whole of Indian Railways. It uses OSPF as the routing protocol and its architecture is similar to that of UTN.

15.5.3.3 The typical arrangement of FOIS at a station is shown in the diagram below.



15.5.3.3 At some of the stations only one FOIS PC is required and at such stations, the switch is not used and the PC is connected directly with the router.

15.5.3.4 The network topology of any new network is to be decided according to the type, size and requirement of the application. Mesh architecture is recommended at the core and distribution levels. At the access level, point-to-point or point-to-multipoint architecture is followed.

15.6 Network path protection: Data networks are critical applications for Railway operation and the data devices at various locations are required to remain connected to the network all the time. At the core levels, the availability of 100% is required and this is achieved by adopting mesh architecture. It should be ensured that a single failure in the network will not cause interruption of services. At the access level, availability of better than 99.9% is desired for each location. This can be achieved through provision of proven equipment along with path diversity, equipment redundancy, multiple service providers connectivity etc . Wherever feasible channels utilized from Railways shall be protected by provision of alternative path by protection switching. Channels utilized from RCIL/other service providers shall always be protected by provision of alternative path by protection switching. In the event of any of the communication links being provided by the operators through public networks, adequate protection in the form of VPN and using encryption is to be taken.

15.7 Network Devices: The various devices used in the data network other than the nodes on which the applications reside, along with their interface specifications are given below:

1. Modems
    a. G.703/V.35
    b. G.703/G.703
2. Switches
    a. L2 PoE switch
    b. L2 non-PoE switch
    c. L3 switches
3. Routers
4. UTM/Firewalls
5. LAN extenders
6. WiFi Access Points and Controllers
7. Interface Converters
8. Media converters
9. DSLAM, ADSL,
10. GPON/, EPON

15.8 Network extension: It should be possible to add new network devices either at existing locations or at new locations by extending the WAN. The network components should be so selected to permit scalability without having to replace existing network components. At least 25% spare equipment should be planned for equipment like modems, UPSs, switches, LAN Extenders etc. Spares are recommended in N+1 configuration in each critical location for core level network equipment like High end routers, manageable switches, Servers, Firewall etc., for efficient maintenance of the Networks. If any department has its own dedicated network installed by them, scope of S&T department will be limited to provision of railway telecom connectivity if it is feasible.

15.9 **Access from public network:** Wherever it is necessary to allow access to Railway Data networks from public networks like the Internet, such access may be permitted only at protected points where network must be adequately protected through provision of firewalls/Intrusion Prevention System (IPS)/ Intrusion Detection System (IDS) etc.

15.10 **Network Security:** The main aspects of security is:

15.10.1 **Network Access Control:** The access control protocols perform three functions:

(a) **Authentication**: Authentication is the process of identifying and verifying a user. Only authorized personnel should be permitted access the network resources. This is important for Network and also wireless access. Network security starts with authentication, commonly with a username and a password (termed as one-factor authentication). With two-factor authentication, something the user 'has' is also used (e.g., a security token or 'dongle', digital certificate dongle, an ATM card, or a mobile phone); and with three-factor authentication, something the user 'is' is also used (e.g., a fingerprint or retinal scan).

(b) **Authorization:** It provides capabilities to enforce policies on network resources after the user has gained access to the network resources through authentication. After the authentication is successful, authorisation can be used to determine what resources the user is allowed to access and the operations that can be performed.

(c) **Accounting:** It provides the means of monitoring and capturing the events done by the user while accessing the network resources. It even monitors how long the user has an access to the network. The administrator can create an accounting method list to specify what should be accounted and to whom the accounting records should be sent.

15.10.2 **Network Protection**, **Intrusion Detection and Intrusion Prevention**:

All computers on the network should be protected against viruses by installing suitable antivirus software. This is necessary as viruses can also slow down the network speeds apart from affecting the computers. Enterprise level antivirus software with control of the network administrator should be installed. Another important aspect of security is to prevent outsiders from monitoring the network or disrupting the network. Periodical Network Auditing should be done. Policies issued by Railway Board from time to time regarding network security should be complied during periodical network auditing. Network security is achieved through deployment of:

(a) **Firewall**: First level of defence at the network perimeter. State full inspection of packets based on protocols.

(b) **Intrusion detection and Protection system**: Signature identification, Protocol identification etc. Detects and Drop the suspected packets.

(c) **UTM (Unified Threat Management)** is just another name for an all in one security appliance. A UTM appliance will consist of a firewall as well as other key security features such as spam filtering, web filtering, anti-virus, anti-spyware, anti-phishing, IPS/IDS, DOS and DDOS protection, Application filtering, Network Access and Bandwidth Management Control , VPN's and so on.

15.11 Network Management system and Traffic Monitoring:

15.11.1 Network Management System (NMS) is an essential part of any data network to monitor the health of the network. It is an essential tool for managing the complete data networks using SNMP protocol based on open standards. The Network Management System can do various tasks like configuration, diagnostic, provisioning, security and originating various MIS reports to be utilized by the Network Manager. NMS also has the facility of performance monitoring through resource utilization graphs. As far as possible traffic logs from various network devices may be recorded at a central server for analysis purposes.

15.11.2 Indian Railway Data Network being very large in size there may be several NAMes at different locations controlling different segments of the network. Each division and zone should have integrated NMS at their Network Operation Center (NOC) in standby mode. Network administrators will exercise total control over the network through the NMS.

15.11.3 The policy for network access control shall be Approved by PCSTE and should be reviewed periodically.

15.11.4 The password for router, switches, servers, modems, UTM, CCTV and all other IT equipment in the division to be available with Test Room. It is to be ensured by all JE/SSE/Tele/Incharge to get it noted down to Test Room during commissioning of any system.

15.12 List of the Test and Measuring Equipments:

- Communication Analyzer
- Ethernet Analyzer
- Protocol Analyzer
- The measuring instruments generally used are
- BER meter
- LAN cable meter
- Other latest measuring instruments if any.

15.13 Measurements:

The various measurements which are required to be done on Data network for trouble- shooting and for performance monitoring of the network are listed below:

BERT: Simple bit error ratio test.

G. 821,G.826 and M.2100 performance analysis : The G.821 is an out of service measurement whereas G.826 and M.2100 are in-service measurements. The tests are normally conducted for 48hrs. These tests are required for the WAN segment for different bandwidth. For the LAN segment Ethernet analyzer is used for testing and monitoring the performance.
Jitter and Wander:
Intrinsic Jitter
Maximum Tolerable Jitter
Jitter Transfer Function
Wander.
LAN cable: By using LAN cable meters.
Any other measurements or tests suggested by manufacturers.

15.14 Fault Diagnosis:

The fault diagnosis is categorized into three

- Hardware
- Software
- Media/Channel
  - The datacom equipment is provided with visual indications by which the status of the equipment can be known. The next option is by login into the equipment and test the equipment with standard commands given by the manufacturer.
  - The software part like IOS of Routers and other intelligent/managed equipment can be checked or upgraded to higher versions depending on the type of the fault encountered.
  - The media which actually connects two locations through interface device can be checked with testing facility given on the interface device or through measuring instruments. The BER of the media/channel is generally measured to know the percentage of errors and other related information.

15.15 Environment, Rack and Flooring:

All Core and critical network datacom equipment should be housed in air-conditioned rooms. Other datacom equipment should be housed in a dust free environment, preferably air-conditioned. The equipment should be housed in a standard 19” rack with front and back openings to facilitate ease of maintenance. The Datacom equipment rack should be provided with power supply distribution panel for AC/DC distribution. Good quality earth with value less than one Ohm should be provided. The rack should be placed in such a way that sufficient space is available in the rear and sides of the rack from the walls, typically 1.2 mtrs for ease of maintenance and proper air circulation. Cabinet/equipment cooling fans should be provided especially for the routers. False flooring is recommended for the **Data Centre** so that various cabling systems can be accommodated within the flooring. The flooring should be anti-static. Data Centre floor strength shall be designed to carry loads up to 600 Kg/sq.meter. Illuminated & usable clear space of at least 7.5 feet to 8.5 feet shall be provided between the false floor & false ceiling for housing the

Data Centre equipment. The raised floor height should be 24” and in any case not less than 18”. On-line UPS should be provided preferably with two UPS systems, one for the main system and the other as backup supply.

The datacom equipment shall be installed in n x U size racks of required size. The equipment room shall be free from dust and temperature within the room shall be maintained as per the equipment manufacturer data sheet. In addition to equipment room, maintenance supervisor room cum store room shall be provided to store spares and other important equipment. At Zonal Headquarters where Network management System is proposed, the room size can be decided as per requirement.

15.16 Earthing:

Earthing is extremely important for reliable working of Datacom equipment and for protection from lightning and surges. Earthing arrangement has to be done as per chapter on earthing and surge protection for telecom installation (chapter XXIII)

15.17 Power Supply:

The power supply whether it is AC or DC is the heart of any equipment. Standard values at the input to be made available to the equipment. The type as well as capacity of power supply required for the equipment to be decided at the time of designing of new networks and for existing networks enhancement of power supply has to be done whenever necessary. Uninterrupted Power supply has to be provided to increase the life of the equipment as well as to keep up the availability of the location/node. The capacity and redundancy of the UPS is to be decided taking into consideration availability of local power supply, standby supply , importance of the location. UPS in N+1 redundancy mode with sync control option shall be provided for all core network equipment. Wherever feasible –48V DC supply shall be used for Data Communication Equipments.

15.18 Maintenance Schedule:

i The datacom equipment shall be kept clean and tidy without dust and shall be cleaned regularly and to be inspected once in a year by SSE/JE incharge.

ii The diversity channels shall be checked at least once a month by switching off main channels and ensure that automatic switch over/routing is taking place.

iii Condition of underground cables to be checked by carrying out routine checks done for U/G cables.

iv OFC cables and connectors to be checked as per routine checks done on OFC.

v The Antivirus patches to be updated in NMS system time to time.

vi In addition to the above, any other checks suggested by manufacturers

15.19 Do’s and Don'ts:

Do's:

i. Do write the configurations changes if any done in a register so that proper documentation is done for performance analysis and recode purpose.
ii. Take the print outs of the configuration of the routers and document them.
iii. Store the configuration files of the routers in softcopy so that they will be useful at emergency whereby with one command entire configuration can be copied thereby reducing the down time. Take backup of the router configuration every time the configuration is changed.
iv. Do proper lacing of the internal wiring,
v. Protect the cables from rodents where cabling is done through false flooring.
vi. Train the staff and update the knowledge to maintain the network more efficiently.
vii. Use ESD wrist bands while handling datacom equipments
viii. Use a good quality earth and maintain the earth resistance below 1 Ohms
ix. Change the password of router/servers once in a month
x. Follow the housekeeping procedure of clearing the event and performance logs of the NMS at specified intervals.
xi. Plan replacement of UPS batteries as per the specified lifecycle.
xii. Keep the operation and maintenance manual handy.
xiii. The bills and Guarantee/warranty cards of the datacom equipment should be kept handy to use it when required.
xiv. Check the backup links at least once a month.

<u>Don’t's:</u>

i. Do not change the hardware of the routers like data cards when the router power supply is ON unless it is clearly mentioned that it supports hot swapping.
ii. Do not change the V.35 Data cable when the router and modems are ON.
iii. Do not change the IP addressing scheme and IP address of the working network without the written permission of the Network Administrator.
iv. Do not change the configuration of the router without the permission of the Network administrator.
v. Do not run down the batteries of the UPS below specified level.
vi. Never switch off the datacom equipment without following the proper shut down procedure
vii. Do not share the passwords of routers’ and servers with your colleagues.
viii. Never use water to clean the equipment room.
ix. Don’t use water based fire extinguishers for datacom installations.

-x-x-x-

CHAPTER XVI

POWER PLANT SYSTEMS FOR TELECOM INSTALLATIONS

16.1. GENERAL

16.1.1 This chapter discusses the power supply requirements for following Telecommunication Equipments:

Train Radio System	Public Address System
Network Server Centre	Passenger Information Display System
Optic Fibre Equipment	Video Surveillance System (Close Circuit TeleVision)
Multiplexing Equipment	Centralised Clock System
Telephone Exchanges	Datacom Equipment of PRS, FOIS, UTS, SCADA etc.
Train Traffic Control Equipment	Voice Logging Equipment
WiFi equipment	Railnet, Video conference equipment

16.1.2 All Telecom Equipments shall be provided with a reliable Power Supply.

16.1.3 Telecom System/Equipments like Public Address System, Passenger Information Display System, Wifi equipment, Video Surveillance System (Close Circuit TeleVision), Centralised Clock System, Voice Logging Equipments, Railnet, Video conference equipment, Datacom Equipment of PRS, FOIS, UTS etc operates on 230 V AC Power Supply.

16.1.4 Telecom System/Equipments like Train Radio System, Optic Fibre Equipment, Multiplexing Equipments, Telephone Exchanges etc operates on 48 V DC Power Supply.

16.1.5 Train Traffic Control Equipment operates on 12/24/48 V DC. VOIP based TTC may work on standard AC power supply (230 V AC) too. Datacom Equipment of SCADA operates on 48/110 V DC or 230V AC.

16.1.6 If more than one type of system such as Radio Equipment, OFC system and Train Radio are housed in the same room or adjacent rooms of the same building, only a common power plant shall be used for all such systems.

16.1.7 Power supply in the network server centers are important as they are supposed to be working under all conditions. Network server centers normally host servers and few Telecom equipment. Hence, most reliable 230V AC shall be provisioned in the network server center. Here, the UPS system shall be provided with N+1 redundancy. For telecom equipment inside the network server center, the telecom charger may be connected with the output of UPS without its own 48 V battery backup arrangement. DG supply is also to be extended to the network server center.

16.2. SOURCE OF AC POWER SUPPLY:

(a) In RE area, traction supply from both up and down catenary will be provided through AT Transformer with auto changeover arrangement at all wayside stations and other critical locations. Separate fuse/Circuit breaker arrangement to be provided for telecom equipment when common source of supply is used.

(b) Local supply shall be single phase or 3 phase depending upon the load requirement.

(c) Three independent sources of power supply should be arranged for all critical telecom installations. Diesel generator/Solar power back up shall be installed wherever local supply is unreliable and both AT supply (up and down) are not provided.

(d) PROVISION OF SOLAR BASED POWER SUPPLY SYSTEMS: Solar based power supply system can be planned where reliable power supply is not available and;

(i) Clear and sunny weather is generally available throughout the year.

(ii) Sufficient space free from shadow and any other obstruction is available for installation of the solar panels.

(iii) Proper cleaning of dust particles, tree leaves or any other foreign material from the surface of solar panels is ensured.

(iv) Adequate provision is made for storage of power for at least five continuous sunless days.

(v) Anti theft arrangement shall be provided at all vulnerable locations.

16.3. DIESEL GENERATOR SUPPLY

16.3.1 Diesel Generator Capacity: The capacity of the generators shall be calculated based on the present load requirements plus the anticipated increase of load, if any, in the next five years period. Load requirements for all the equipment including aviation lights & emergency lighting of equipment room shall be included. Operation of the air conditioners at all critical telecom locations shall be done from dedicated/standalone diesel generators also only in exceptional circumstances on temporary basis. Normally it should be planned with all other sources of power supply available with Railways.

16.3.2 Installation of Diesel Generator Set :

(a) Diesel Generators: Silent DG sets (with acoustic enclosure) only shall be used. It shall be equipped with an auto start/stop mechanism. The diesel generators shall be installed as per the manufacturer’s instructions. All mountings shall be rugged, durable and sufficiently strong to withstand vibrations occurring in the area of the site. Anti-vibration cushion should be provided between the floor of the DG Room/shed and the DG set. Diesel Generator should be earthed as per manufacturer's specifications.

(b) Exhaust Gas: Exhaust gas shall be thrown outside the building through suitable exhaust pipes properly fitted & mounted. The exhaust pipes must be wrapped with heat insulation to protect staff from burn injury in case of accidental touch. All flexible pipe connections shall be screwed or flanged. A suitable silencer shall be fixed at the end of the exhaust pipe, if required.

(c) Type of cooling: All diesel generators shall be air cooled type.

(d) Fuel Tanks: The capacity of the tank shall be adequate to store fuels for at least 24 hours of operation at full load.

(e) Wiring and Cabling: The cables and wires from the generators shall be drawn through rigid conduits or enclosed in proper channels.

16.3.3 Control System of Diesel Generator Sets:

(a) The control system of the diesel generator sets shall broadly have following capabilities:

(i) Detection of AC mains failure.
(ii) Detection of deviation of the mains supply voltage and frequency beyond prescribed limits (230 V ± 5%, 50Hz±2Hz).
(iii) Detection of overheating of engines.
(iv) Detection of high/low output voltage and frequency from the generator.
(v) Detection of restoration of AC mains supply.
(vi) Detection of low lubricant oil pressure
(vii) Detection of V belt failure.
(viii) Hour meter: To monitor the total operative time of DG Set.

(b) The control system shall generate alarm condition in case of fault conditions such as:
- High engine temperature
- Low oil pressure
- Generator overload
- Generator output voltage beyond limits.

(c) Remote alarm monitoring / remote operating features should preferably be provided. In case of fault conditions, the control system shall shut down the diesel generator and lock it out of service until the same is manually reset by the maintenance personnel.

(d) The control system shall incorporate manual controls to permit:

- Testing of generator sets.

- Bypass the automatic control systems and connect the generator output to the load.

16.4 AC POWER SUPPLY DISTRIBUTION ARRANGEMENTS

16.4.1 Notwithstanding this Clause all existing installations shall continue with existing arrangement of AC Power Supply Distribution for Telecom Equipments. However new installation shall follow the guidelines stipulated herein.

16.4.2 Incoming AC Power Supply from AT Transformer (through Automatic Changeover), Local Power Supply, Diesel Generator Power Supply, Solar Panel Power Supply shall be terminated in an AC Distribution Board.

16.4.3 This AC Distribution Board shall have facility of changeover from one incoming source to other.

16.4.4 Incoming AC Power Supply on AC Distribution Board shall be terminated through MCCBs & MCBs of adequate capacity.

16.4.5 Outgoing Single Phase AC Power Supply for individual Telecom Equipment from AC Distribution Board shall be through MCBs of adequate capacity.

16.4.6 Integrated Surge & Transient Protection Devices shall be provided in AC Distribution Rack for sensitive Telecom Equipments. Surge & Transient Protection shall be as per guidelines/specifications issued by RDSO.

16.4.7 AC Distribution Board shall have sufficient spare capacity to accommodate anticipated future expansion. AC Distribution Board can be “wall mounted metallic enclosure” or “floor mounted cubicle”.

16.5 DC POWER PLANT SYSTEM

16.5.1 Battery Chargers and Voltage Stabilizers: All Telecom installations shall be provided with float cum boost charger of adequate capacity in N+1 or N+2 as per latest RDSO specification. Charger Capacity should be minimum C/10 + load where C is the AH of the battery. Single Phase 48 V DC Power Plant are categorized as below depending upon Stability of Incoming Power Source;
(i) Suitable for incoming power supply range from 165 V AC to 260 V AC.
(ii) Suitable for incoming power supply range from 90 V AC to 300 V AC.

16.5.2 Number of Battery Banks & Mode of Operation: One set of battery on float mode working should normally be planned. At stations prone to lightning, two sets of battery banks shall be planned either with manning or with charger having feature to work automatically in charge-discharge mode of operation.

16.5.3 Type and Capacity of Battery: In a controlled environment where temperature is not very high or where batteries can be accommodated in temperature controlled equipment room area, VRLA batteries can be used. Where temperature is normally on the higher side, low maintenance secondary cells should be provided. The batteries shall be of adequate capacities to deliver the full load for a period of at least 12 hours duration throughout its useful life, considering future requirement.

16.5.4 Load requirement: The load requirement shall be calculated based on the present load plus the anticipated increase of the load, if any, in the next five years period.

16.5.5 SMPS Based Telecom Integrated Power Supply: It is used in Auto Float Rectifier-cum Float-charger (FR-FC) and/or Float Rectifier cum Boost Charger (FR-BC) mode as a regulated DC power source; DC-DC Converters are for various DC power supply requirements of Telecom equipment at Railway Stations such as 25W VHF Set, VF Repeater, Gate Telephone, Way Station Control Telephone, Magneto Telephone, STM1/4 OFC Equipment, PD MUX, Router, Switches etc.

16.6 DC POWER SUPPLY DISTRIBUTION ARRANGEMENT

16.6.1 Incoming DC Power Supply shall be terminated in a DC Distribution Board. DC Distribution Board can be “wall mounted metallic enclosure” or “floor mounted cubicle”.

16.6.2 Incoming DC Power Supply on DC Distribution Board shall be terminated through DC MCB of adequate capacity.

16.6.3 Outgoing DC Power Supply for individual Telecom Equipment from DC Distribution Board shall be through DC MCBs of adequate capacity.

16.6.4 DC Distribution Board shall have sufficient spare capacity to accommodate anticipated future expansion.

16.7 REQUIREMENT OF POWER SUPPLY ROOM(S):

16.7.1 Wherever secondary batteries are used, the stabilisers, chargers, distribution boards and the changeover switches shall be installed in a separate room adjacent to the battery room.

16.7.2 Wherever VRLA batteries are used, the stabilizers, chargers, distribution boards and the changeover switches may be kept in the same room as VRLA Batteries.

16.7.3 Power Supply Room(s) shall be dry, cool, well lighted and well ventilated. Exhaust fans shall be provided to remove fumes in all Power Supply Rooms where secondary batteries are installed.

16.7.4 It is desirable that the window glasses shall be frosted or painted wherever necessary to prevent direct sun rays falling on the cells.

16.7.5 The Power Supply Room(s) shall have a water sink and universal (5A & 15A) electric power plug for connection to the hand lamp.

16.7.6 The Power Supply Room(s) where secondary batteries are installed shall be provided with acid resistant tiles on floor and the walls up to 1.5 M.

16.7.7 A thermometer to measure the room temperature should also be kept in the battery room.

16.7.8 All cable entry points should be rodent proof.

16.8 REMOTE MONITORING AND CONTROL SYSTEM:

16.8.1 The arrangement shall be approved by PCSTE of the Railway. It shall have the following features.

(a) All OFC Communication System shall have the facility of remote monitoring and control of the power plant systems.

(b) The control system of the power plant shall provide following vital alarms to the remote monitoring system through NMS / Data Logger/ Mobile app/software using mobile communication facilities etc.

- Mains failure
- Diesel Generator failure
- Battery set failure
- Charger failure
- Low level of fuel tank
- Low Voltage
- Monitoring of voltages wherever feasible

(c) The control system shall be capable of accepting and reacting to following vital commands from the remote monitoring centre.

- Start diesel generator
- Switch off the diesel generator set
- Changeover from charger no. 1 to charger no. 2 or vice versa.
- Changeover from battery set 1 to battery set 2 or vice versa

16.9 MAINTENANCE

16.9.1 Maintenance of Diesel Generator Set:

i. Fuel tank shall be cleaned periodically. Fuel shall be filled through a removable wire gauze filter which shall form part of fuel tank. Before filling up, unused fuel shall be decanted/replaced if the DG set has been idle for a considerable time.

ii. Level of lubricating oil shall be checked (before every engine start by using a suitable dip stick, provided with the engine, wherever manual start is in vogue) and proper care shall be taken to maintain desired / recommended level. Lubricating oil shall be changed periodically as per manufacturers' data for engine hour run.

iii. Diesel generator sets shall be overhauled in accordance with manufacturer's recommendation. Checking and cleaning of parts shall be done once in every three months or as the situation warrants. It is preferable to have them overhauled by the manufacturer or his authorised representative.

iv. Automatic Starting Device shall be tested periodically for effective starting during power failures and low voltage conditions.

v. The no-load and on-load voltages of the alternator shall be maintained within limits and the Governor adjusted during periodic maintenance to the RPM specified and a steady output of 50Hz. The DG set shall run for 5-10 minutes on load to verify its proper working during periodic maintenance check.

vi. A log book shall be maintained at every location which shall bear the history of performance and maintenance of Diesel Generator Set together with the signatures of the maintainers and SSE(Telecom).

vii. Wherever auto start is not reliable, the same shall be disconnected and steps taken for manual start during power failure and also to stop the engine as soon as power supply resumes. Steps should be taken to rectify the auto start as early as possible.

viii. The log book shall be maintained as per proforma given in APPENDIX-I.

16.9.2 Maintenance Of Power Supply system

(a) The working of battery charger shall be checked for proper working of switches, fuses etc.

(b) The power equipment shall be cleaned by a blower or any other device to remove dust.

(c) Wiring shall be checked to ensure that they are in good condition and connections are properly tightened up.

(d) Record of voltage and load current of all power equipment shall be maintained.

16.9.2.1 Maintenance Of Secondary Cells:

(a) Cable to connect battery terminals and load should use proper colour code of wires. Red and blue wire should be used to connect positive and negative terminals.

(b) The battery room shall be kept well ventilated, free from water, oil and dust. Surroundings of batteries shall be kept clean. Acid proof reusable hand gloves and Hydrometer to be provided and Hydrometer Should be kept on a Wall Mounted Stand in the Battery Room.

(c) Connecting cables shall be flexible and sufficiently long to prevent strain on the battery terminals. Connecting lugs shall be fitted to battery posts / terminals by using suitable nuts/bolts & tightened by using flat and spring / serrated washers. Lugs at the end of conductors, utilized for making connections, shall be crimped and/or brazed.

(d) The electrical connections shall always be kept tight. Check nuts should also be used to maintain firm connections.

(e) The terminals and connections of battery cells shall be coated with pure vaseline or petroleum jelly to prevent corrosion. Grease shall not be used.

(f) In LMLA Battery sets, the electrolyte shall be maintained at the correct level by topping up with only distilled water as and when necessary. Electrolyte loss due to spillage shall be replenished with proper amount of electrolyte of the same specific gravity as that of remaining electrolyte in the cell. Electrolyte of proper specific gravity prepared by using industrial grade acid and distilled water shall only be added with cells in fully charged condition and after sufficient time has been allowed to cool down the cells to room temperature. Electrolyte to a cell shall be added gradually in minimum quantity so as to attain the same specific gravity as that of other cells in the battery bank after a few cycles of charge/ discharge. Electrolyte shall not be added under any other circumstances. Each cell shall be tested as per maintenance schedule so that its voltage and specific gravity are within specified limits. Test results shall be recorded in the battery history card as per APPENDIX-II.

16.9.3 Periodic maintenance schedule of Power Supply Equipments is given in Appendix-III.

16.9.4 Records And Reports:

The inspector in-charge of Telecom Installation and remote control centre shall arrange to maintain:

(a) The record of interruptions of main power supply and utilisation of the DG set with details of each duration.

(b) Record of supply and utilisation of diesel fuel.

(c) Prepare monthly interruption reports of mains supply/upkeep/utilisation of DG set and send to Sr.DSTE/Dy.CSTE(Tele).

16.9.5 Records And Reports By Sr.DSTE/Dy.CSTE(Tele):

Sr.DSTE/Dy.CSTE(Tele) shall analyse the monthly report and take follow up action with concerned divisional officers as to minimise the interruption of the main power supply. Consistent long duration interruptions of the main supply and the follow up action taken should be brought to the notice of Chief Communication Engineer through special reports. He will also take follow up action to overcome the other problems in order to improve the performance of telecom system to the required level of efficiency.

APPENDIX I

____________Railway __________Division

FUEL CONSUMPTION LOG BOOK

1. Name of Station

2. Date of Commissioning

3. Location

4. Description of Generator
(Make, Capacity in KVA, Voltage,
Power Factor, Speed in RPM, Frequency,
No. of Phases, Type of Excitation etc.)

5. Description of Engine
(Make, BHP, Speed in RPM, No. of Cylinders,
Capacity of Fuel Tank, Fuel, Standard Rate
of Consumption, Type of start)

Date	Time of Start	Time of Close	Hours worked	Fuel filled in litres	Signature

APPENDIX II

SECONDARY BATTERY (LMLA) HISTORY CARD

________Railway __________ Division

Section _________

Battery Particulars

No. of cells	Installation date
Capacity (AH)	Circuit reference
Battery set No.	Charging current
Battery set voltage	Charger make
Battery make	Charger capacity
Specific Gravity as per Manufacturer's recommendation	Cell Voltage as per Manufacturer's recommendation

Battery Measurement & Maintenance

		Cell Number													Work done & remarks	Signature &Designation
Date	Parameter	1	2	3	4	5						22	23	24		
	Cell Voltage															
	Specific Gravity															
	Cell Voltage															
	Specific Gravity															
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	Specific Gravity															
	Cell Voltage															
	Specific Gravity															

APPENDIX III

MAINTENANCE SCHEDULE FOR POWER SUPPLY SYSTEM

EQUIPMENT	ITEM	TELECOM TECHNICIAN	JUNIOR ENGINEER	SR.SECTION ENGINEER
Battery Chargers	Cleaning of all connections	Fortnightly	-	-
	Tightening of all connections	Monthly	-	-
	Checking of working	Weekly	Monthly	Quarterly
	Measurement of voltages & load current	Weekly	Monthly	Quarterly
Batteries	Cleaning & tightening of all connections	Fortnightly	-	-
	Measurement of voltages and gravity	Fortnightly	Monthly	Quarterly

MAINTENANCE SCHEDULE OF THE DG SET

QUIPMENT	ITEM	TELECOM TECHNICIAN	JUNIOR ENGINEER	SR.SECTION ENGINEER
Generator	Measurement of voltage on load/OFF load	Fortnightly	Monthly	Quarterly
	Load current	-do-	-do-	-do-
	Checking of lubricant	-do-	-do-	-do-
	Checking of self-start battery	-do-	-do-	-do-

MAINTENANCE OF SOLAR PANEL

EQUIPMENT	ITEM	TELECOM TECHNICIAN	JUNIOR ENGINEER	SR.SECTION ENGINEER
Solar cell	Cleaning of Solar panel	fortnightly	-	-
	Measurement of terminal voltage of solar panel	fortnightly	Monthly	Quarterly
	Measurement of current of solar panel	-do-	-do-	-do-

-x-x-x-

CHAPTER XVII

ACCIDENT COMMUNICATION

SECTION A: COMMUNICATION AT ACCIDENT SITE

17.1 Communication from the site of accident is to be established as soon as an accident takes place. For this purpose, Loco Pilots (drivers) of all trains shall be provided with portable control telephones, 5 Watt Walkie Talkie set and CUG mobile SIM. Wherever MTRC is commissioned using GSM-R, TETRA/LTE, MTRC mobile handset/Cab radio set shall be provided in lieu of portable control telephone. Portable control telephones shall be 4 wire type for underground cable territory, As soon as an accident occurs, LP/ALP (Loco pilot/assistant Loco pilot) shall establish communication with control office and the adjacent stations using any one of the instruments provided to him.

17.2 Guards of all trains are also provided with similar sets as given to Locopilot. Guard of the train shall also establish communication with control office and the adjacent stations as soon as an accident occurs.

17.3 Additional means of communication shall be provided at accident site progressively within the shortest possible time as under:

- Mobile phones/ MTRC phones/Fixed Cellular Telephones (FCT) of multiple service providers wherever network coverage exists.
- Provision of Railway telephone / telephones.
- Provision of BSNL telephone / telephones.
- Facility of Video capture and its transmission
- Facility of Data transmission through WiFi

17.4 Accident Relief Trains (ART) are located at strategic locations of each division and are provided with telecommunication equipment for providing additional facilities as under:

- PA system shall be established for making important announcements.
- Megaphones shall be given as per need at site.
- Walkie-talkie sets shall be distributed as per need.
- Magneto communication as required at site.
- Communication through satellite phone as per need at site.

All CUG phones available with officers, staff and with ART shall be used.

It is desirable to send pictures/ videos of accident spot to Divisional / Zonal / Headquarters/ Railway Board using e-mail/Whatsapp or other similar means for which extension of internet/railnet to site may be required.

SECTION B: ACCIDENT INFORMATION FOR PUBLIC

17.5 As soon as information regarding an accident is received, accident information number (telephone number 1072 and other telephone numbers for the purpose) shall be activated and manned. This number shall normally be at the zonal/divisional headquarters. Adequate personnel shall be posted by the commercial branch to meet the demand depending on the seriousness of the accident. Number of lines for this number shall be suitably augmented depending on the demand.

SECTION C: GENERAL GUIDELINES FOR MAINTENANCE OF ARTs

17.6 ARTs are provided with equipment as detailed in section D. The equipments are to be periodically tested to ensure their satisfactory working at all times. Testing / Inspections shall be carried out as under (Please refer the latest instructions from Railway Board/Accident Manual)

- Complete testing by ART SSE/JE with nominated staff: once in 15 days.
- Inspection by ADSTE/DSTE: once in 3 months.
- Inspection by Sr.DSTE: once every year.

17.7 A register is to be maintained in the ART for making entries for testing of equipment (Section - D)

17.8 Whenever the ART returns from accident spot, equipments are to be immediately checked for their proper working.

17.9 Any shortfall / missing equipment should be replaced with good working equipment at the earliest.

17.10 All equipment having shelf life, viz. jointing kits, torch cells etc., shall be replaced in due time.

SECTION D: ART EQUIPMENT

17.11 The indicative list of minimum essential equipments to be provided in ART shall be as under (Please refer the latest instructions from Railway Board) :

A) General (Common for RE as well as Non RE Area)

S.No.	Final Item	Final Qty.
1.	Inspection Book,, latest copy of WTT for all sections covered by ART.	1 No.
2 (a)	Desk Type Electronic Magneto Telephone	4 Nos.

2 (b)	Torch Cells R-20 size, 1.5V for Desk Type Electronic Magneto Telephone	12 Nos.
3.	PVC Insulated, PVC Sheathed twin core cable	500 Mtrs.
4.	Microphones for cordless PA system	2 Nos.
5.	Loudspeaker Horn type 5/10 Watts	2 Nos.
6 (a)	Amplifier of minimum 20 watts Power output (having interface for cordless microphone) and operating voltage of 12 VDC	2 Nos.
6 (b)	12 Volts Storage battery for 6(a) alongwith appropriate Battery charger	2 Sets.
7.	Megaphones complete with batteries (minimum 10 watts each)	4 Nos.
8.	Portable stand for loudspeaker with adjustable height from 1.5m to 3m.	2 Nos.
9.	Field service telephone cable PVC insulated (D-8) alongwith 6 pin Emergency Plug	4 Drums of 500 Mtrs. each.
10.	Push button Caller ID Phone	4 Nos.
11 (a)	Walkie-Talkie Sets (5Watts-VHF) with 100% spare batteries.	30 Nos.
11 (b)	Battery Charger for 11(a) (two position charger with rapid charging)	8 Nos.
12.	Digital Multimeter	2 Nos.
13.	Power extension Board with drum (50mts) with adequate points.	4 Nos.
14.	Hand held Rechargeable LED Torch	4 Nos.
15.	Jointing Kit & material for cables and wires- This is required to be decided by the Railways themselves according to their local needs for different ARTs.	

16.	Tool Box Containing	2 Sets.
16 (a)	Soldering Iron-10W/12Volts, 10W/220Volts & 65W/220Voits	1 No. each
16 (b)	Long Nose Plier-200 mm	1 No.
16 (c)	Cutter Diagonal-200 mm	1 No.
16 (d)	Box Spanner 6, 6.5 & 5 mm	1 No. each
16 (e)	Hammer Steel 750 grams	1 No.
16 (f)	Hammer Wooden	1 No.
16 (g)	Adjustable Spanner 300 mm	1 No.
16 (h)	Screw Driver-200 mm	1 No.
16 (i)	Screw Driver-250 mm	1 No.
16 (j)	Mains Tester (230 Volts)	1 No.
16 (k)	Electrical Insulation Tape 12 mm x 15 meters	2 Nos.
16 (l)	Rasin Core	500 grams.
16 (m)	Combination Plier	1 Nos.
17.	Portable Digital Voice Recorder with inbuilt microphone and playback with sufficient memory and provision of data transfer through Pen drive/Hard Disk.	2 Nos.
18.	4 Wire way station equipment with control phone.	2 Nos.
19.	Smart Phone with charger and SIM of different service provider (Minimum requirements 6 inch display, 4G, VoLTE, Dual SIM, 4GB RAM and 128GB memory)	4 Nos.
20.	Satellite Phone (SAT Phone/ISAT phone2/Inmarsat Phone) which supports audio & text features with charging unit.	1 No.

21.	All in one color inkjet printer (A4 size paper) with Fax, Scan, Copy and print facility.	1 No.
22.	Auto Dialling System from Emergency Socket	1 No.
23.	CAT -6 cable along with required accessories	2 box of 305 meters each
24.	Laptop with required configuration and accessories to suit communication needs at accident site.	1 No.
25.	Hot Spot 4G Dongle (Different Service Provider)	4 Nos.
26.	Power Bank of 30000 mAH for mobile charging	4 Nos.
27.	FCT with SIM of different service provider	4 Nos.
28.	6 Core flexible OFC Cable with one pair of media convertors for outdoor purpose	500 mtrs.
29.	24 fibre OFC Splice enclosure	2 Nos.
30.	LAN Extender for extending Ethernet	2 Pair.
31.	Rechargeable LED Search Light	2 Nos.
32.	VHF Set (Semi-Duplex) of 25W each with accessories including telescopic pole/mast, Antenna-GP Type and battery and charger	1 Set.
33.	Folding Table	2 Nos.
34.	Chair	8 Nos.
35.	Beach/Garden Umbrella	2 Nos.
36.	Lightweight prefabricated Water Proof Tent/ Tent kabuli (medium)	1 No.
37.	Telecom Cable Route plan of Division	1 No.
38.	Set Up for Live Streaming of Video from accident siteto	1 Set.

	be provided as per latest RDSO specifications/guidelines for accident site communication.	
39	MTRC mobile handset for MTRC covered area	2 Nos
40	4Wire Portable Control Telephone with dry cells	2 Sets.
41	1:1 isolating Transformer	2 Nos.
42	V-SAT terminal set *	1 Set.
43	Single/multi SIM LTE Router Operating voltage 12 V DC & with PoE port with LTE Data SIMs	

* V-SAT terminals have been provided in 68 Divisional ARTs (43 manual tracking and 25 auto tracking) with Indian Railways' own V-SAT hub at New Delhi.

B) <u>Specific Equipments Required for ARTs having beats in Non-RE area having overhead lines</u>

S.No.	Final Item	Final Qty.
1.	2 Wire Portable Control Telephone with dry cells and telescopic pole of minimum 6 meters height with its bracket opening space atleast 350 mm.	2 Nos.
2.	Overhead control alignment charts	1 Set.

17.12 Adequate space shall be provided in the ART for housing all the equipment. For keeping any additional equipment in ART, approval of competent authority (for items: PCSTE, for space : DRM) should be taken.

17.13 The telecom equipment shall be properly housed to avoid the equipment rolling off during the movement of ART.

17.14 Adequate packing shall be provided for sophisticated equipment like satellite phones, walkie-talkie sets, All in one Printer, PA equipment etc.

17.15 Sophisticated equipment shall not be stacked one above the other, unless packed in proper protective boxes and arrangements are provided to secure them properly. Stacking arrangement is to be planned in such a way that it should be possible to pick out specific equipment without disturbing the all other stacked equipment.

17.16 A regular power supply shall be made available nearest to the ART location by electrical department, where it is normally stationed. Further arrangements shall be made by the telecom department for extending power supply for charging batteries for PA system, VHF batteries etc. for its satisfactory working.

SECTION E: ARME EQUIPMENT

The indicative list of minimum essential equipments to be provided in ARME shall be as under (Please refer the latest instructions from Railway Board) :

S.No.	Final Item	Final Qty.
1.	Inspection Book	1 No.
2	Bell Hailer 6 VDC	3 Nos.
3	4 Wire Emergency Portable Control Telephone Set with accessories	1 Set
4	Hand Held Walkie Talkie Sets with Battery Charger	10 Sets.
5	Charging facility for Laptop, Cell phone and Camera	1 Unit (HLC No. 67)
6	Fixed Cellular Terminal (FCT)	4 Nos.
7	VHF set, 25 Watts alongwith accessories	2 Nos.
8	Multimeter Digital alongwith toolkit	1 No.
9	Hand held Torch of 3 Cells complete with dry cells	4 Nos.
9(a)	Torch Cells	36 Nos.
10	Satellite Phone	1 No.
11	Wireless PA System	1 Unit
12	Light Weight Synthetic Pre-fabricated water proof tents for communication centre at site and Telecom equipments.	1 No.
13.	Emergency Socket Plan of the division / Neighbouring division	1 Set
14	Push Button Auto Telephone with tone/pulse	2 Nos.

15	Digital Voice Recorder	1 No.
16	Field service Telephone Cable insulated PVC (D-8 Wire)	500 Meters
17	5 Pair Switch Board Cable with EC Plug and Socket	500 Meters
18	Flexible Wire	100 Meters
19	4 Wire Auto Tone Dialler	1 No.
20	Portable gen set minimum 1 KVA with fuel for 8 hrs back up at site.	1 set

SECTION F: STAFF FOR ART

17.17 Every ART shall have nominated telecom staff. The incharge shall generally be SSE/JE and shall be assisted by 3 telecom technicians and 2 helpers.

17.18 The nominated staff shall test the ART equipment as per schedule and ensure satisfactory working of all equipment.

17.19 The nominated staff shall respond immediately whenever an accident takes place and proceed by ART to the site of accident.

17.20 The nominated staff shall be responsible for establishing communication as detailed in para 17.3 & 17.4, immediately on reaching the site of accident.

SECTION G: INSTRUCTIONS FOR TESTING OF ART EQUIPMENT

17.21 All active devices shall be tested for their satisfactory operation.

17.22 Charging of batteries shall be carried out as per requirement. The requirement may vary depending on the battery and the self-discharge characteristics of the battery.

17.23 Wherever feasible, batteries shall be separated from the equipment and protected properly to minimize the self-discharge.

17.24 Primary cells viz., torch cells shall be replaced as soon as deterioration in performance is observed. In any case, the cells shall be replaced at interval not exceeding one year. Leak proof cells only shall be used.

17.25 Items to be checked/tested during Inspection :

Detailed guidelines are given below:

While inspecting the telecom equipments in ART, the following guidelines related to the equipments shown against them may be observed

1. Portable Telephone Set:
   a) Check for any physical damage to the phone, wires, cords and the plug.
   b) Condition of dry cells; change if due.
   c) Quality of speech both ways.

2. Magneto Telephone/Desk Type Electronic Magneto Telephone:
   a) Check for any physical damage to the phones & wires.
   b) Condition of dry cells / Torch Cell; change if due.
   c) Quality of speech both ways.
   d) Ring Test.
   e) Check cable's continuity & insulation.

3. Megaphones:
   a) Condition of dry cells; change if due.
   b) Quality of speech and condition of volume control.
   c) Working of the Siren.

4. P.A. System:
   a) Functional Test.
   b) Quality of reproduction of the amplifier.
   c) Condition of mike cords.
   d) Condition of Loud Speaker wires.
   e) Functional test in the case of cordless mike.
   f) Condition of standby battery 12V.

5. Walkie – Talkie sets:
   a) Functional test.
   b) Quality of speech.
   c) Condition of battery.
   d) Battery swapping after charge.

6. 25W VHF set:
   a) Physical check of set, antenna, feeder, mike and battery cord
   b) Functional test.
   c) Condition of 12V storage battery.

7. Way Station Control Equipment:
   a) Functional test (Ring & Speech).

8. Auto Dialler:
   a) Functional test.

9. All in One Printer:
   a) Physical check.
   b) Functional test.

10. Digital Voice Recorder:
    a) Functional test.
    b) Condition of dry cells; change if due.

11 VSAT system if part of ART
    a) Physical check and functional test

12. Checking of Records:
    a) Availability of all material as per checklist.
    b) Inspection book for record of inspections.
    c) Record of charging of storage batteries & walkie-talkie batteries.
    d) Record of replacement of dry cells.

SECTION H: ARRANGEMENTS AT DISASTER MANAGEMENT CONTROL ROOMS AT HEADQUARTERS / DIVISIONS

17.26 The following facilities shall be available in the disaster management control rooms at headquarters and divisions:

a) BSNL Phones – 2 Nos with ISD facility.
b) b) Railway Telephones – 3 Nos with STD facility.
c) All in one Printer – 1 No. connected to BSNL line and 1 No. connected to railway line.
d) Facility to extend section control to the disaster management control. The concerned section control in whose jurisdiction the accident takes place, shall be connected.
e) Hot line between Headquarters and divisional disaster management control rooms shall be provided.
f) Important telephone numbers of hospitals / doctors /officials of state and district administration and other important functionaries be kept ready.

-x-x-x-

CHAPTER XVIII

MOBILE TRAIN RADIO COMMUNICATIONS - GSM-R

18.0 GSM-R :

18.1 Introduction:

Mobile Train Radio communication is a digital wireless network based on GSM-R (Global System for Mobile Communication-Railway) designed on EIRENE (European Integrated Railway Radio Enhanced Network) Functional requirement specification (FRS) and System Requirement specification (SRS)

The Basic features of GSM-R are

Point to Point call	Allows user to make a distinct call.
Voice Broadcast call	Allows groups of user to receive common information.
Voice Group call	Allows groups of user to make calls within /among the groups.
Emergency call	Allows user to call controller by short code or button during emergency.
Functional addressing	Allows a user or an application to be reached by means of a number, which identifies the relevant function and not the physical terminal.
Location dependent addressing	Provides the routing of mobile originated calls to the correct controller e.g. relative to the geographic area.
eMLPP (enhanced Multi-Level Precedence and Preemption)	Allows resource preemption for priority calls

Fig.1 illustrates the system architecture. In this architecture a mobile station (MS) communicate with a base station subsystem (BSS) through the radio interface. The BSS is connected to the network switching subsystem (NSS) using the A interface.

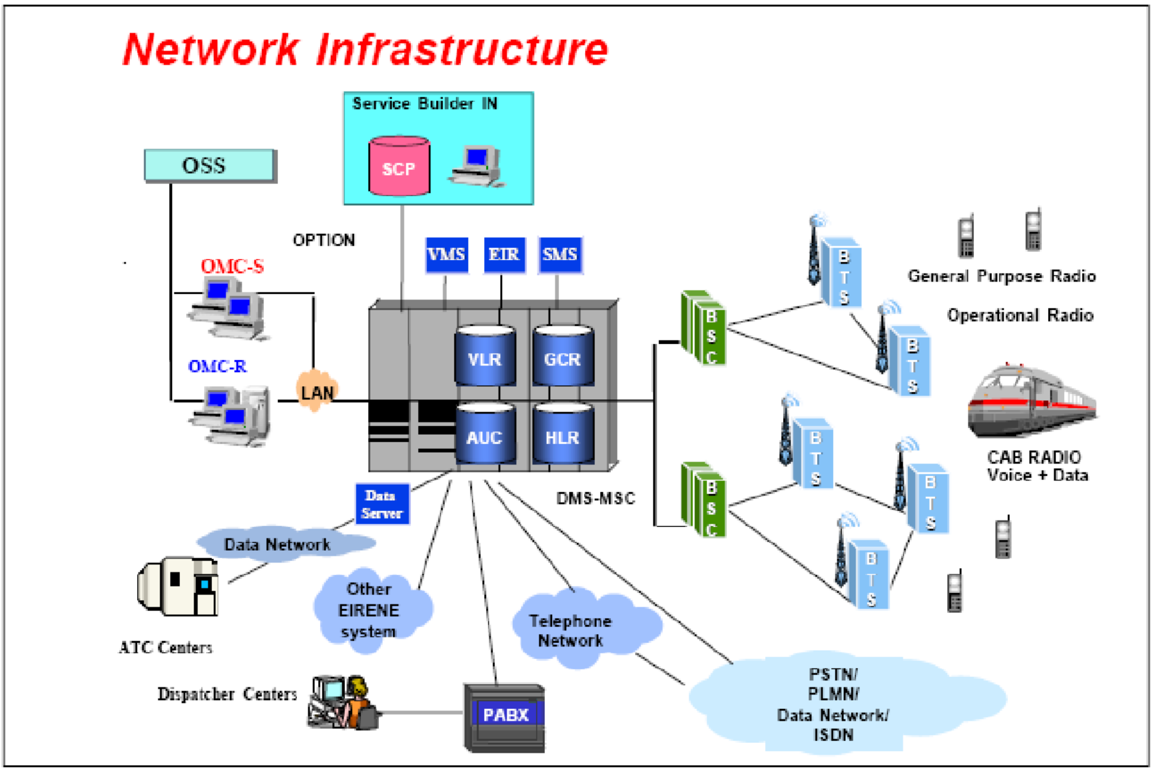


Fig.-1

Interface	Interfaces Description
U_m	Radio link between MS and BTS- Air interface
A_{bis}	Between BTS and BSC, PCM 2 Mb ps
A_{ter}	Between BSC and TCU, PCM 2 Mb ps
A	Between TCU and MSC, PCM 2 Mb ps
B	Between MSC and VLR,
C	Between MSC and HLR
D	Between HLR and VLR
E	Between two MSCs

18.1.1 The system consists of following sub systems :

a) Mobile Station (MS)
b) Base Station Sub system (BSS)
c) Network and switching sub system (NSS)
d) Operating sub system (OSS)
e) Dispatcher
f) Cab Radio
g) Power Supply Arrangement

18.2 Radio interface and frequency used in GSM-R :

The Radio link uses both FDMA (Frequency Division Multiple Access) and TDMA (Time Division multiple Access) . The 900 MHz frequency bands for down link and up link signal are 935-960 MHz and 890-915 MHz respectively.

Frequency Used for GSM-R in Eastern Railway

Spot Frequencie are

Uplink (MS To BTS)	**Dnlink (BTS to MS)**
907.8 MHz	952.8 MHz
908.0 MHz	953.0 MHz
908.2 MHz	953.2 MHz
908.4 MHz	953.4 MHz
908.8 MHz	953.8 MHz
909.0 MHz	954.2 MHz
909.2 MHz	954.2 MHz
909.4 MHz	954.4 MHz

18.3 <u>Numbering Scheme for MS and Cab Radio :</u>

18.3.1 International Mobile Subscriber Identity (IMSI)– It is used to identify the called MS. It is not known to the user and is used by network only. IMSI is stored in SIM, the HLR and the serving VLR. The IMSI consists of three parts : A three digit Mobile country Code (MCC), a two digit Mobile Network Code (MNC) and a Mobile Station Identification Number (MSIN).

The directory number dialed to reach a mobile subscriber is called the mobile subscriber ISDN (MSISDN) which is defined by the Numbering Plan. This number includes a country code and a national destination code which identifies the subscriber's operator. It is stored in the HLR.

International Mobile Subscriber Identity (IMSI) for Railway Network.

Railway	MCC	MNC	MSIN	
			HLR Identification Code	
Zone	405	48	3 digit*	0000000-9999999
Example				
Eastern Railway	405	48	250	0000000-9999999

18.3.2 <u>Mobile Subscriber ISDN number :</u>

- **Mobile Subscriber ISDN Number (MSISDN) for Railway Network.**

CC (2D)	AC (2D)	MSC Code (3D)		Subscriber No.		
		Zone (2D)	CT8 (1D)	HQ/ Divn.(1D)	Dept.(1D)	Subscriber Number
+91	99	2 Digit*	8	0-9	0-9	XXXX
Example- For Eastern Railway						
+91	99	25	8	0-9	0-9	XXXX

*Numbering Scheme for Mobile Train Radio Communication Network of Indian Railways circulated as per RDSO.

18.3.3 National EIRENE Numbers :

National EIRENE Numbers are used specifically for Railway purposes and consist of three parts.

i) Call type (CT)
ii) User ID No
iii) Function code (FC)

The call type prefix identifies the user number dialed. The call type distinguishes between the different types of user numbers that are allowed within the national EIRENE numbering plan. The call type prefix tells the network how to interpret the number dialed. It is one digit long.

The user identification Number can be one of the following:

- Train Running Number for TFN (Train Functional Number)
- Engine Number for EFN (Engine Functional Number)
- Coach Number for CFN (Coach Functional Number)
- Shunting team location number
- Maintenance team location number
- Train controller location number

National EIRENE Calls

Functional Numbers [handled by Functional Addressing (FA) service]
CT=2-3-4-6

Dialed digits	Description
2+TRN+FC	Train Functional Number
3+EN+FC	Engine Functional Number
4+CN+FC	Coach Functional Number
6+LN+TT+Y+XX	Shunting & maintenance Functional Number

Where:	TRN:	Train Running Number	(5-8 digits)
	EN:	Engine Number	(8 digits)
	CN:	Coach Number	(9 digits)
	FC	Function Code	(2 digits)
	LN:	Location Number	(5 digits)

TT:	Team Type	(1 digit)
Y:	Team Member	(1 digit)
XX:	Team Number	(2 digits)

Train Functional Number is used for calling the driver by its train number. The following numbering scheme is used in the Railway.

Functional Number of driver in Rajdhani Express for Thursday is as follows.

2	4	2301	0	01
Call Type	Thursday	Train Number	Schedule Train for link train - 1 for special train - 2	Driver for Guard - 80

User can register itself as a driver / guard of any train from their handset by dialing 091 i.e. Railway access code following the above digits for a specific train .

For details, uniform numbering plan circulated by RDSO may be referred.

18.4 Brief description of sub system :

18.4.1 Mobile Sub system (MS) :

The MS consists of two parts

i) Subscriber Identity Module (SIM)
ii) Mobile Equipment (ME)

The SIM is removable and can be moved from one terminal to another. It is authenticated via a personal Identity Number (PIN) between four to eight digit. This PIN can be deactivated or changed by the user. If PIN is entered incorrectly in three consecutive attempts, the phone is locked for all but emergency calls, until a PIN unblocking key (PUK) is entered.
The SIM contains subscriber information and International Mobile Subscriber Identity (IMSI).

18.4.2 ME is a Mobile hand set equipped with a soft touch key pad and display screen. Some additional key (button) is provided to meet the special features of GSM-R (emergency call etc.). Though ME having a robust structure, it should be kept in safe position to prevent mechanical damage.

18.5 Power Supply :

18.5.1 The ME is equipped with power supply arrangement (Li-ion battery). It is a maintenance free battery having detachable independent charger to recharge the battery after discharge. Charging indication on ME screen shows the status of charging.

18.5.2 The ME can be dynamically registered and deregistered in the network for different functional numbers as per requirement of the subscriber (ME) by keying from the key pad in a programmed manner and monitoring the action in the display unit of ME.

18.6 Base Station Sub system (BSS) :

The BSS connects the MS and the NSS.
The BSS contains of three parts.

i) Base transceiver Station (BTS).
ii) Base Station Controller
iii) Trans Coder Unit.

18.6.1 Base Transreceiver Station (BTS) :

The BTS performs channel coding/decryption. It contains transmitter and receivers, antennas, the interface to the PCM facility and signaling equipment specific to the radio interface in order to contact the MEs. It processes the signaling and speech required for Mes in air interface at one side (via antenna) and with BSC in Abis interface (through PCM 2Mb/s in OFC network) at the other side.

The general architecture of the Base station is based on the following modules:

- The Compact Base Common Function (CBCF) performs all common functions such as concentration, transmission, supervision and synchronization. A CBCF can be dimensioned according to traffic.

- The Power Amplifiers (PA) amplify the RF signal delivered to antenna through the TX combiner. Each PA is physically independent unit, characterized by its frequency band, output power can be controlled independently.

- The Driver receiver units (DRX) amplify the RF signals (two, for diversity), process the TDMA frames and drive the power amplifier. Each DRX is associated with one RF channel, connected to the Frequency Hopping bus (FH bus) in order to allow base band hopping and packed as a physically independent unit. One TRX is then made up of one PA and one DRX. Depending on frequency band , a specific DRX is available to support EDGE (e-DRX).

- The Transmission Combiners (TX combiners) combine the RF signals delivered by several power Amplifiers and duplex them with the received signals. A variety of coupling modules can be selected, depending on the type of combining (duplexer, hybrid), the frequency band and the configuration (number of TRXs and antennas).

- The reception multicouplers (LNAs + RX –splitters) pre-amplify and split the received signal towards the DRX receivers. A variety of RX-splitters can be selected, depending on the frequency band.

- The Alarm module (RECAL) collects internal and external alarms. The number of external alarms is up to 8.

- Fan tray is kept at the bottom of the cabinet for keeping the module inside cabinet cool by air circulation inside cabinet.

- Power supply card to receive 48V DC supply from external source and to cater required supplies to different active modules inside BTS cabinet.

- CPCMI board on front panel inside BTS cabinets equipped with different LEDs to indicate different status of the equipment.

18.6.1.3 <u>System Specification :</u>

Power Supply = - 48 V DC.
PA Tx – Power = 30 W.
Rx Sensitivity = -110 dBm.

18.6.1.4 <u>Power Supply :</u>

48V/16 Amp. DC supply is provided for the BTS cabinet. Low Maintenance lead-acid battery with capacity 300AH with a Battery Charger (230V AC/48V – 50 Amp. DC) shall be kept in float condition with load for this purpose.

18.6.1.5 <u>Cooling Arrangement :</u>

Cooling arrangement is necessary for keeping the ambient temperature below a certain level to prevent system shut down due to high temperature.

For this purpose minimum two window type air conditioning machines are to be installed and run alternatively for 12 hrs. each.

The BTS is a very temperature sensitive equipment. Normally the BTS stations are unmanned. Hence for monitoring the health of the unmanned station some parameters are required to be monitored from a centralized location of the network. For this purpose following parameters are to be monitored from the central maintenance location through OSS.

a) High temperature
b) Battery voltage low
c) Fire alarm
d) AC Machine failed
e) Charger failed
f) AC mains failed.

18.6.2 <u>Base Station Controller (BSC) :</u>

In the BSS network, the BSC performs the tasks related to the BSS equipment management & supervision and to the GSM call processing, mainly:

- BTS supervision
- Radio channel allocation
- Radio channel Monitoring
- Traffic management
- TCU management
- OMC-R link management
- Handover procedures
- Operation and maintenance request from the OMC-R processing
- BSS configuration data and software storage
- BSS performance counters management
- Failure detection and processing

18.6.3 Trans coder unit (TCU)

The TCU carries out speech encoding/ decoding and rate adoption in data transmission. It is designed to reduce the number of PCM links needed to convey radio speech & Data channels between BTS,BSC & MSC. It enables code conversion of 16 Kbps channel from the BSC into 64 Kbps channels for MSC in both directions.

18.6.3.1 Functional Overview :

It performs the following main tasks related to communication switching and transcoding:

- Switching: the TCU manages a time –division multiplexer connecting the BSC and MSC.
- PCM link management: Using the configuration data provided by the BSC, the TCU configures and monitors the PCM links on the A and Ater interfaces.
- Transcoding and rate adaptation: Coding/decoding of the speech frames and rate adaptation of data frames.
- TCU equipment management: OA&M functions: initialization , startup, clock synchronization from A-interface links, supervision , fault management, software and configuration management.

18.7 Network and Switching Subsystem (NSS):

The NSS supports the switching functions, subscriber profiles and mobility management. The basis switching function in the NSS is performed by the MSC. This interface follows a signaling protocol used in the telephone network. The MSC also communicates with other network elements external to GSM utilizing the same signaling protocol. The current location of an MS is usually maintained by the HLR (Home Location Register) and VLR (Visitor Location Register). When an MS moves from the Home System to Visited system, its location is registered at the VLR of the visited system. The VLR then informs the MS's HLR of its current location. The authentication center (AuC) is used in the Security data management for the authentication of subscribers.
NSS &BSS installed in some sections of Indian Railways are of M/s Nortel or M/s Siemens make.

18.7.1 GSM MSC Configurations and Functions (Typical for –M/S Nortel)

The GSM DMS-MSC is supported in different configurations that allow combining functionalities on a single node. The following configurations are supported;

- An integrated Visitor location Register (VLR) to hold the temporary subscriber data while the subscriber is in the MSC's area as well as authentication and ciphering provided by the AuC.

- An optional integrated Service Switching Point (SSP) functionality to support intelligent Network based services in the most efficient and effective manner.

18.7.2 The MSC is responsible for:

- Call Processing, switching & routing of traffic, supplementary services.
- Connections to external services e.g. PSTN.
- Visitor Location Register (VLR) for subscriber location management.
- Service Switching Point (SSP) functionality for the IN network.
- Billing facilities to feed the billing system (billing system could be proposed if required).
- Switching and Network Management activities.

18.7.3 <u>Data Bases</u>

Home Location Register (HLR)	Data base for management of mobile subscribers, stores the IMSI, Mobile station ISDN number (MSISDN) and current visitor location register (VLR) address. Keep track of the services associated with each MS and HLR may be used by Multiple MSC's.
Visitor location Register (VLR)	Catches some information from the HLR as necessary for call control and service providing for each mobile currently located in the geographical area controlled by VLR connected to one MSC and is often integrated into the MSC.
Authentication center (AuC)	A protected data base which has a copy of the secret key stored in each subscriber's SIM card. This Secret is used for authentication and encryption over the radio channel. Normally it is located close to HLR.
Equipment Identity (EIR) Register	Contains a list of all valid mobile station equipment within the network, where each mobile station is identified by its International Mobile Equipment Identity (IMEI)

18.7.4 Signalling support

This provides support for the basic signaling functionality as defined by GSM Phase 2+ standards.

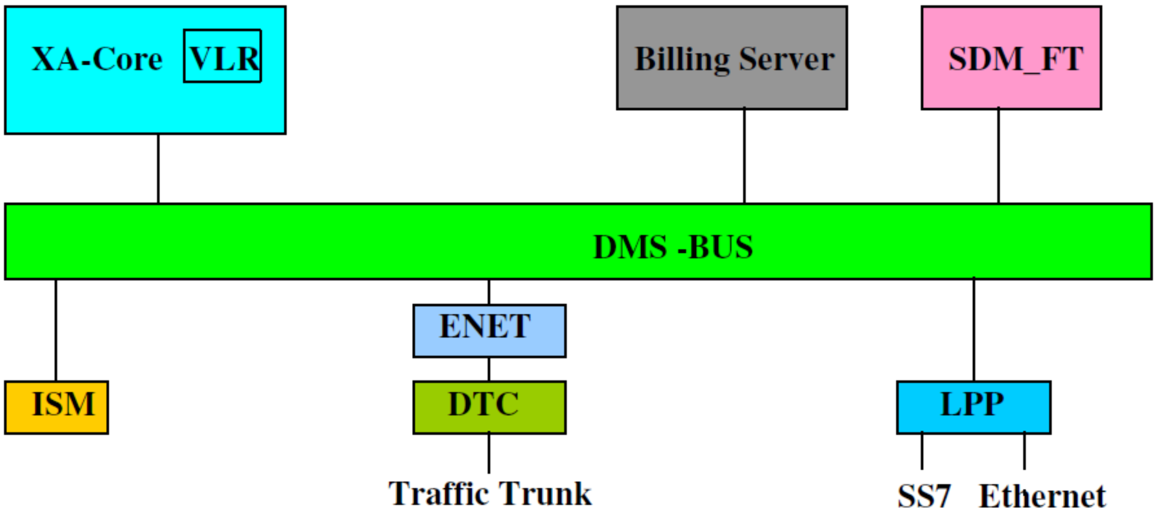
The major protocols supported are:

- DTAP via the Direct Transfer Message. This is the interface between the MSC and Mobile Station.
- RANAP- This is the signaling protocol used between the MSC and BSC
- MAP- This is the interface between the NSS functions (MSC, VLR, HLR, EIR).
- A Interface- is an open interface defined between the BSS network and the MSC.
- ISUP- The MSC conform to the ITU and ETSI standards (Blue Book and White Book) for ISUP interconnects supporting both ETSI v1 and ETSI v2. In addition some National PSTN interconnects are implemented.

18.7.5 Hardware Description (Nortel Specific):

The DMS-MSC is member of the DMS (Digital Multiplex Switch) family of switching products, capable of providing the switching functionality and advanced services required in a GSM and UMTS wireless network.

The major functional components of the DMS architecture are given below.



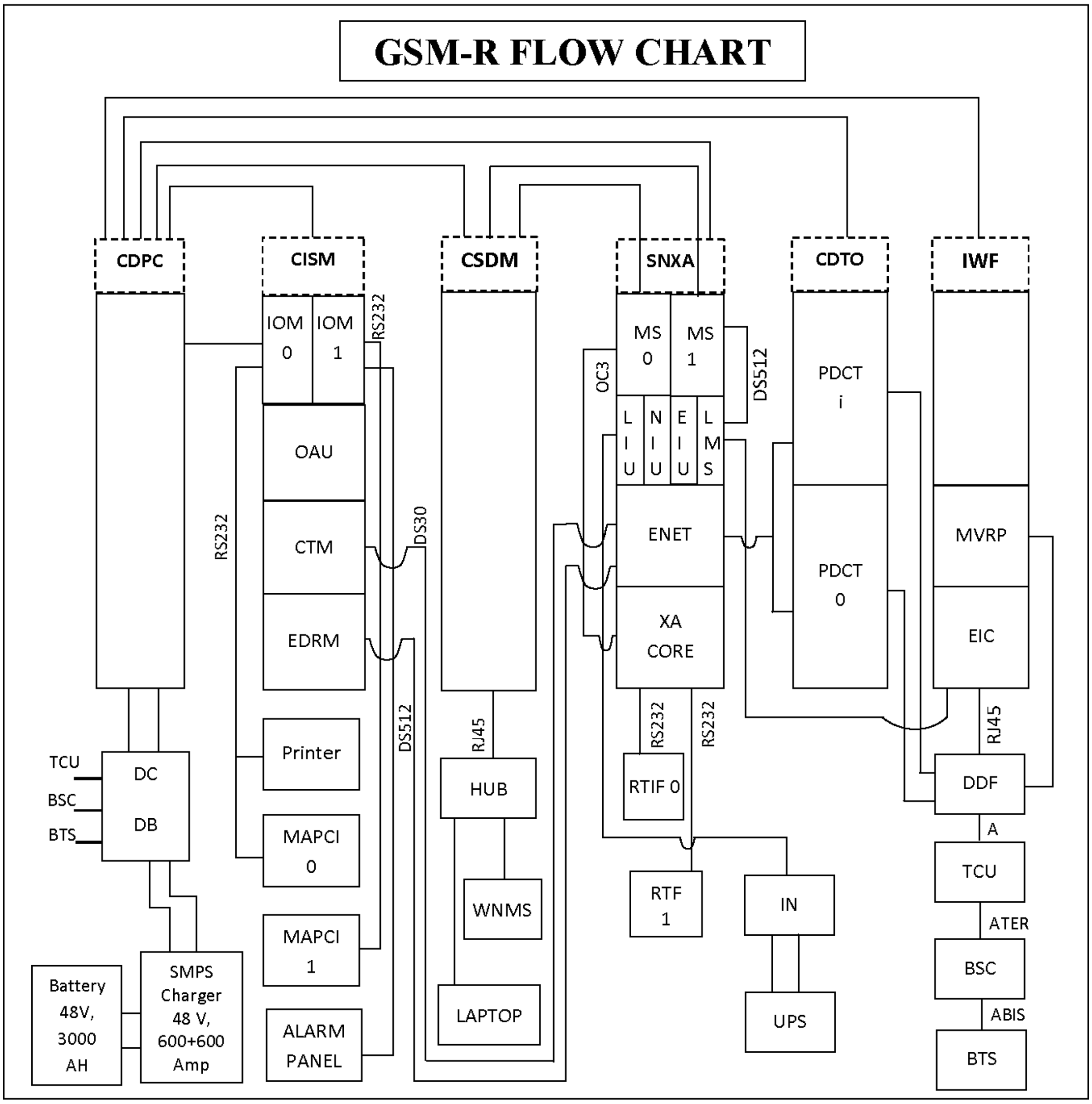
18.7.6 MS functional architecture

XA-Core	The XA-Core (extended Architecture) is the control component of the system and performs call, services, and mobility related processing and maintenance functions. XA-Core is implemented as a multiprocessor system built up of identical processing element (PE's) each running the same software load and with the same software and hardware configuration. These identical but independent PE's access a single shared memory system.
DMS-BUS	The DMS-Bus provides a high capacity communication mechanism between all the DMS components by operating at 128 Mbit/s through put. The DMS-Bus also provides the central system clock for synchronization of the DMS (MSC or

	HLR) system. The DMS0 Bus consists of duplicated message Switches (MS), which, under normal conditions, operate, in load sharing mode. In the event of a bus failure, the full traffic load is routed via the duplicate bus.
ENET	The Enhanced Network(ENET) and Digital Trunk Controllers (DTC) handle all of the traffic switching and connectivity functionality for the DMS. The ENET is the switching matrix that provides interconnection between peripheral modules using time division multiplexing. It is a single-stage, fully non-blocking n*64 kbits/s switch with constant low delay (128 µs). The ENET is duplicated for reliability and is flexible for provision of a wide range of port connections through modular growth (4K increments)
DTC	The DTC (Digital Trunk Controller) peripheral provides the physical interface to E1 or T1 digital carriers allowing termination of PSTN or BSC trunk connection. The DTC02 generation provides the operator with increased density of E1s (doubled) over the existing DTCOs whilst supporting all the capabilities of the previous system. The DTCOi peripheral provides the physical interface to E1 PRI, allowing termination of PABX and ISDN connection.
LINK PERIPHERAL PROCESOR	The Link Peripheral Processor (LPP) provides support for CCS7 messaging support interface to other UMTS network nodes and to PSTN/ISDN and BSC. Each SS7 connection is terminated by high capacity processing units called Link Interface Units(LIU). The LPP also provides LAN connectivity through the use of Ethernet Interface units (EIU). The LPP distributed processing architecture provides support for the MTP and SCCP layers of SS7 allowing the DMS-Core to concentrate on providing call processing and application support.
SDM-FT	The SDM-FT (Super Node Data Manager-Fault Tolerant) is high performance computing platform that provides the operational, administration, maintenance and provides support functions for NSS network. The SDM0FT acts as a data collection, data processing, and local mediation entity between the network element (MSC,HLR) and the management systems.
ISM (Integrated Services Module)	The Integrated Services Module (ISM) provides auxiliary and support functionality such as Recorded Announcement machines, Conference Circuits , plus the Input/Output modules for access and storage.
MSC IWF HOST	MSC connects to the Mobile-side interworking function over a Mobile-side IWF trunk (MIT). MSC connects to the network-side interworking function over a Network-side IWF trunk (NIT). These are Conference of Postal and Telecommunications Administrators (CEPT) 30 channel Pulse Code Modulation (PCM) known as PCM30 trunks that are

	used for bearer channel connectivity. For signaling connections to the IWF host, MSC connects to the IWF unit through a user Datagram Protocol/Internet Protocol (UDP/IP) application over Ethernet. The IWF is necessary for GSM-R deployment of the ERTMS (European Train Management System)

18.8 GSM-R FLOW CHART



18.9 Function of Intelligent Network :

i) Mapping the functional number with corresponding MSISDN.

ii) Location Dependent Addressing.

iii) Registration

iv) Deregistration

v) Interrogation

vi) Force deregistration
vii) Virtual Private Network

18.10 Operating Sub system (OSS) :

Operating sub system consists of

a) Operation and Maintenance Center for Radio (OMC-R).
b) Operation & Maintenance Center for NSS (OMC-S).

18.10.1 OMC-R Functions :

The OMC-R is made up of servers and work stations. Each WorkStation or X-terminal provides the operating staff with a Graphical User Interface, called Human Machine Interface.

The server centralizes the O&M functions dedicated to the BSS network elements and thus allow consistent management of the BSS network elements.

The following O&M functions are provided:

- **Security Management**: to manage user profiles in order to control the user's. access to functions provided by the OMC-R.
- **Configuration management** : To manage the resources to be supervised. Examples of resources that can be managed: PCM links, SS7 and traffic channel on A interface, cells, list of frequencies allocated in each cell, list of adjacent cells of a given cell, frequency hopping laws implemented in the cells, TDMA frame.
- **Performance management**: Values of counters are collected from the BSS network element and reports are generated and displayed to the users. Thresholds can be defined and associated with the counters to generate alarms for maintenance purpose.
- **Fault management**: the OMC-R handles even reports received from the network elements and related to the anomalies. Alarm messages can be generated with a severity from these reports by using criteria defined by the user.

The following internal functions are provided:

- **Server administration**: Supervision, switch –over and backup of the servers and stations.
- **Common functions**: inter-user mail (running within an SMS-C server), management and execution of commands file, calendar for the deferred or periodic execution of a command or a command file, on-line help.
- **File transfer management**: downloading and activation of the software released dedicated to TCU, BSC, BCF and TRX is centralized via the OMC-R.

18.10.2 <u>OMC-S Functions :</u>

The Operation and maintenance center of the NSS part (OMC-S) is able to achieve different kind of functions.

NSS configuration management:
- BSCs, Location areas, Cells.
- Terrestrial links, etc..
- Software configuration (downloading, file transfer).
- MSRN and handover number management.

Fault management:
- Detection.
- Presentation.
- Re-configuration.

Performance management:
- Traffic control.
- Service quality monitoring.

Security management:
- User Profiles.
- Session monitoring.

OMC-S operation:
- System Management.
- OMN management.
- File transfer operations.

OMC-R windows shows the physical and logical views.
- Physical views means how they are located
- Logical view means how they are connected.

18.10.3 Alarm Display

Alarm can appear on any object. The current alarm classification, colors and letters are:

- Minor (Yellow,m)
- Major (Orange, M)
- Critical (Red,C)

To see the alarm select the object/ hardware then click the right hand mouse button pointing to the menu and select show alarm and click. The window describes time of alarm occured, type and fault number, identity and location of object / hardware from where the alarm is originated.

18.11 Dispatcher :

The D1CORA – P (Dispatcher) fulfill a series of functional requirements :-

(i) Five registers on the display with 55 DA – Keys each.
(ii) Outgoing calls also possible via key pad and telephone book.
(iii) Touch sensitive display.
(iv) Monitoring, Conference, Call Transfer and Call Forwarding.
(v) System status display, error management.
(vi) User specific settings (Volume, Microphone ON/OFF, clearing mode).
(vii) Accept, Send emergency call.
(viii) Functions Management.

It consists of an audio module and a touch panel module.

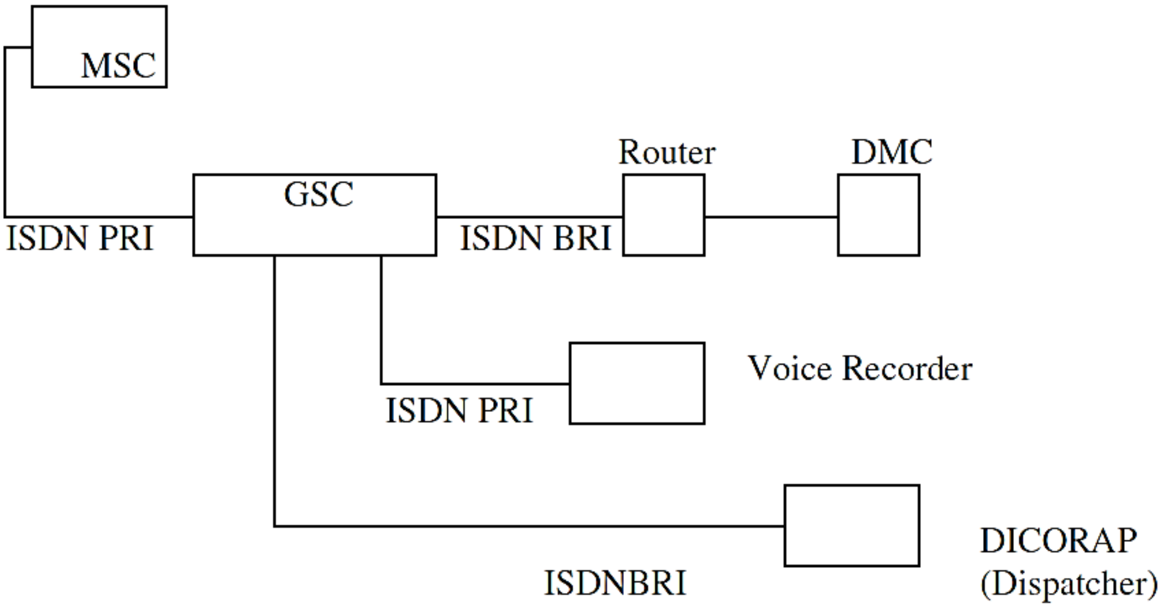
(a) Audio Module :

(i) Hand set.
(ii) Loud Speaker.
(iii) Interlock Key.
(iv) Two Emergency Keys (N1, N2) and an interlock key.
(v) Hands free key.
(vi) Microphone Key (for muting the microphone).
(vii) Key for monitoring Loud Speaker ON/OFF.
(viii) Gooseneck Microphone.
(ix) Head Set.
(x) Interface to the main module.

(b) Touch Panel Module.

(i) Screen Unit.
(ii) Industrial PC.
(iii) ISDNBRI Interface.
(iv) Audio Module Interface.
(v) Voltage Supply.

18.11.1 Block Diagram of dispatcher connection. Dispatcher is connected with MSC through the ground switch (GSC) equipment.



18.11.2 Voice Recorder stores voice that is established through dispatcher. At present 120 voice channels can be directly connected.

18.11.3 GSC consists of the following shelves.

(i) BGT DATA – Connects DMC.
(ii) BGT PSU.
(iii) BGT UIF – ISDN BRI/PRI.
(iv) BGT PRI – Connect Dispatcher.

GSC requires uninterrupted AC Power Supply.

18.12 <u>Cab Radio :</u>

Cab Radio - It is suitable for voice and Data Communication. It can be used with ETCS for train control. It consists of three units.

(i) Radio
(ii) Operating Units MMI
(iii) Antenna

18.12.1 Cab Radio consists of the following components :

(i)	MT2	::	Mobile Termination. 2nd Generation.
(ii)	SCOI	::	System controller with dual serial data port and parallel I/O.
(iii)	GPI	::	General purpose interface: for serial data transmission and control of MMI.

(iv)	PAI	::	Public Address Intercom.
(v)	SV2	::	Power supply, DC/DC converter for internal supply.
(vi)	FCM	::	Filter and connector module.

Key features of MT.

(i) Operation in the R-GSM,E-GSM and P-GSM bands.
(ii) Mobile Station Class 2 (8 watt transmission output).
(iii) All ASCI features.
(iv) All GSM phase supplementary services.
(v) Robust design : electrical and mechanical design for use in Rail road environment.
(vi) Full duplex data communication.
(vii) SIM commands for editing and using EIRENE and ASCI specific fields of the SIM card.
(viii) SIM tool kit.
(ix) Testing and diagnosis are possible both on line during operation and off line.

18.12.2 S.C. (System Controller)

The most important functions of the SC are :

(i) Initialization of the entire Cab Radio.
(ii) Self test and status monitoring.
(iii) Fault and protocol logging.
(iv) Administration of the service interface for diagnosis, configuration and software down load.
(v) Administration of the configuration data.
(vi) Registration and De-registration of the functional numbers.
(vii) Call control functionality for all connected terminal devices i. e. operating components, train loud speaker, train telephone and remote data transmission terminal devices.
(viii) Handling of priority and pre-emption within the scope of eMLPP.
(ix) Automatic acceptance of emergency calls.
(x) Configuration of high priority calls.

18.12.3 General Purpose Interface

The general purpose interface component is used for simultaneous control of up to two operating units MMI with voice and control circuits or a single MMI with one remote data transmission application.

18.12.4 Public Address Intercom

The Public Address & Intercom PAI component services to connect the trains loud speaker and the train telephone to the Cab Radio. It has the following interfaces.

(i) A symmetrical audio output to the train loud speaker.
(ii) A symmetrical input/output to the train telephone – including optical coupler for evaluation of the conditions for the connection to the locomotive driver or the central control station.
(iii) 4 optical coupler inputs for UIC control of the train loud speaker.
(iv) 4 optical coupler outputs for UIC control of the train loud speaker.

18.12.5 <u>SV2 :</u> DC – DC converter.

The DC-DC converter SV2 serves for generation of operating voltages (13V and 5V) that are required for internal supply of power to the components of the Cab Radio. The DC on board supply of locomotive with nominal voltage between 24V and 110V DC serves as the Power source.

The DC-DC converter SV2 offers potential separation and protection against transient voltages. Voltage fluctuations and EM influences according to the requirements of locomotive.

The DC-DC converter has a status LED on the front side of the housing. It lights constantly when both voltage outputs and the internal temperature lie with in the permitted range.

A signal corresponding to the LED is provided as a power fail signal with TTL level at the back panel bus and can be processed by the SC.

Two SV2s can be connected in parallel without external circuitry, where by the tolerances of the output voltages are still met. This increases the redundancy of the system.

18.12.6 <u>Filter and Connector Module FCM</u>.

FCM takes on the following tasks in the Cab Radio voice section :-

(i) Connector panel – the solid connectors for power supply, MMIs, Data Interfaces and UIC interface are connected mechanically and electrically to the panel.
(ii) Power distribution – The on board 24-110V DC power supply is distributed among the two DC converters SV2 and optional SV3.
(iii) The consumer voltage 24V of the battery circuit or optional module SV3 is run to the connectors of MMI and via the coupler relay to the control circuit of the UIC – 568 interface.
(iv) Filter function – The input and output voltages are protected by course protection elements and filters against transients from the locomotive power supply.

18.12.7 <u>Operating Unit MMI (Man Machine Interface)</u>

The operating unit is an important components of the Cab Radio. It serves for input of commands via the keyboard and provides the user with comprehensive information on a display. The inputs are entered via function keys (hard keys) with fixed functions as well as soft keys with functions that can be dynamically adapted.

Components of the MMI.

. Monochrome Display.
. Key Board.
. PC Board.
. LED indicators.
. Audio Amplifier.
. Charging Unit for the driver mobile telephone.
. Housing.

The following hard keys are present :

(i) RESET
(ii) Selection Key Up x DM
(iii) Enter Key
(iv) Emergency Call button
(v) Call to train conductor.
(vi) Call loc-loc
(vii) Call in the train (train announcement)
(viii) Button for calling the Station Master.

18.12.8 Soft Keys

No permanent functions are assigned to the soft keys. The function of the key depends on the currently activated train radio application (GSM-R or analog) and the configured operating level.

18.12.9 LED Indicators :

A total of 7 LEDs are available which are only activated as required.

. Emergency call indicator next to emergency call button.
. One LED next to each of the hard key for SM, train controller.
. Two status LEDs.
. All LEDs can be controlled from the SC via the RS422 interface.

18.12.10 Power Consumption :

The average power consumption is 18W. If the device in the idle mode, the maximum power consumption is 3W i. e. dark display.

18.13 Power supply arrangement of GSM-R system :

18.13.1 Power supply arrangement at NSS site. It is a centralized site consists of

a) MSC (D.C. supply)
b) IN (A.C. supply)
c) OSS (OMC-R and OMC-S) (A.C. supply)
d) Dispatcher (A.C. supply)

(N.B.: Dispatcher may be located at some other place also as per the requirement of Railways).

All the equipments are run by a uninterrupted (-)48V DC supply and 230V AC supply.

The network capable to cater up to 500 erlang need –48V supply capable to cater up to 233 Amp. (Typical for a system by M/s.Nortel).

The 230V AC UPS (15KVA) supply for an installation to cater up to 500 erlang (Typical for a system by M/s.Nortel).

18.14.0 Installation of the system :

Installation of the system should be done as per firms guide line and under supervision of Firm's Engineer.

18.14.1 Site selection for NSS equipment Room :

The NSS equipment room should be specious and the floor should be robust and strong enough to carry the equipment loads. The equipment loads are mentioned in the equipment catalog. Site selection should also cater for future expansion, if any.

18.14.2 Cooling Arrangement :

The system is very sensitive to high temperature. So, it is necessary to provide necessary cooling arrangement round the clock for the NSS equipment room.Two sets of Air conditioners system with sufficient capacity as per size of room, working alternatively, should be provided to equipment room to maintain controlled temperature.

As the battery & charger require to supply 233 Amp. DC current (-48V DC), the Battery capacity is very high. It should be at least 3000 AH in duplicate and the charger should be selected as SMPS based charger with hardware redundancy.

230V AC UPS supply with 15KVA capacity is also required for running different servers and OMS-S, OMC-R terminals. These servers should not shut down suddenly due to power failure. Hence, UPS supply, 15KVA should have redundancy in hardware also. Load sharing of the UPSs is the preferred mode of operation

18.15 Commissioning of GSM-R

Commissioning of GSM-R requires following steps.

- Uninterrupted DC & AC Power supply should be ensured first
- Software loading should be done for each and every equipment. Proper license of software and operating system used should be handed over to Railways by the firm
- Stand Alone Test (SAT-I)- The test needs to cheek all the NSS & BSS equipments in room separately. The test is to be carried jointly by

Railway as well as firms representative. Firm's representative through the OMC-S & OMC-R terminal will exercise and show the stand alone system capability as the equipment should perform. The test procedure should be decided jointly beforehand. Checking of hardware and its redundancy, energisation of any hardware and deenergisation, dumping of data in the MMS devices and rebooting of system etc through OMC-S, OMC-R terminals are some of the tests which are carried out.

- System Acceptance Test (SAT-II) - The system has its own features. All these features and applications are to be simulated and tested jointly by the Railway and firms representative. These tests are also for compliance of the system to EIRENE FRS& SRS.
- Radio Acceptance Test (RAT)- Radio level testing i.e. signal strength. Outside interference, coverage, QPS, handover rate etc through out the geographical area along the Railway track covered by the GSM-R is to be tested with running trains by the firms representative and Railway jointly.
- As and when satisfactory result appear in the above tests in SATI, SAT-II & RAT, the system will be commissioned.
- Installation of fire alarm system & smoke detector.
- The equipment room, Battery room and OSS room at NSS center and equipment room, Battery rooms at other wayside installation should be provided with fire alarm system and smoke detectors.
- Fire fighting system should be also be installed in sufficient quantity at the NSS and other way side installations.

18.16 Maintenance

18.16.1 Network and switching subsystem

18.16.1.1 The system requires stable power supply and controlled temperature. Due to variation of the above two parameters, the system may shut down. Any shut down event may cause loss of data . Hence reliable power supply AC (UPS) and DC should be ensured by periodical checking of redundancy of hardware as well as its capability.

18.16.1.2 Daily maintenance of NSS site

a. All the racks should be physically viewed for any abnormal, alarm or other indication.
b. The OSS terminals should be monitored for viewing any physical alarm and abnormalities. If any abnormality is observed immediate action will be taken to restore.
c. To exchange signaling information, speech & data from BTS to BSC and vice versa, OFC link or any standard link is to be used. There should be two paths of OFC link (2Mb/s E1), one in forward direction and other in reverse direction to improve system reliability. As and when normal path gets disconnected, the reverse path will take care of the system. To ensure the health of both the paths of 2 Mb/s E1s a daily check sheet should be maintained as below.

Date	E1 number	Normal path disconnected at (Hrs)	Normal path reconnected at (Hrs)	Performance at reverse path	Reverse path disconnected at (Hrs)	Reverse path reconnected at (Hrs)	Performance at normal path	Remarks

d) Recording of daily data regarding equipments, Air-conditioning machine, Chargers, Battery, UPS etc.

e) Management & recording of data of A/C machine performance.

Date	AC machine Numbers										Remarks	Name & Sig. of Technician	Supervisor's remarks
	Time	1	2	3	4	5	6	7	8	9			
	On												
	Off												
	On												
	Off												
	On												
	Off												
	On												
	Off												

f) Equipments (Typical for M/S Nortel installation)

Date	Alarm on physical verifications of different Racks									
	CPDC	CISM	CSDM	SNXA	CDTO	IWF	IN	BTS	TCU	BSC

Alarm on different terminals					
RTIF	MAPCI	WNMS	OMC-R	HUB	IN

Alarm on verifications of different Power Supply Unit									
SMPS Charger	Isolation Tx	UPS	Room Temperature			Remarks	Name of Sig. of Tech.	Name of Sig. of Supervisor
			Bty Room	Eqpt Room	O&M Room			

18.16.1.3 Any defect noticed during daily checking of remote alarms like health of BTS, physical parameters of BTS equipment room (Temperature, Battery voltage, A/C Machine fail etc), health of E1 s etc should be attended immediately by the maintenance team and a record should be maintained at NSS center. Vehicle support should be provided to SSE for attending site in emergency and for tower maintenance activities.

Date	Time	Fault	Informed to whom (Time & Date)	Date & Time of rectification	Remarks	Name & Sig of staff	Name & Sig of Supervisor

18.16.1.4 If the MSC is connected to any Railway exchange, the link between MSC & Rly exchange should be monitored daily and the same should be recorded in the following table.If there is backup E1 path for exchange connectivity, same should also be tested periodically.

Date	Call initiated from any exchange phone to mobile		Performance	Call initiated from any mobile to exchange phone		Performance	Name & Sig of Tech/Supervisor tested
	Exchange Tel.No.	Mobile No.		Exchange Tel.No.	Mobile No.		

18.16.1.5 Daily testing of dispatcher

Date	Call initiated from dispatcher to mobile no	Performance	Call initiated from any mobile to dispatcher Normal call & emergency call	Performance	Name & Sig of Tech/Supervisor tested

18.16.1.6 Daily Testing of Group call , Broadcast call.

Date	Group call initiated from Mobile No. to other Mobile Nos. (Record Mobile nos.)	Performance	Broadcast call initiated from Mobile No.	Performance	Name & Sig of Tech/Supervisor

18.17.0 Other periodical checking of GSM-R

18.17.1 Biweekly

i)Taking of back up of MSC & BSC

18.17.2 Monthly

i) Proper health cheek-up of smoke detector (heat detector, control panel.)
ii) Checking of ground connections of all the equipments and earth bars.

18.17.3 Quarterly

i) Checking of antenna coupling point at tower top.
ii) Cleaning of earthing points of tower top.
iii) Testing of VSWR of antenna & cable (should be less than 1.3,
If VSWR is greater than 1.3 then cleaning of power splitter is required).
iv) Signal strength testing at site.

18.17.4 Half yearly

i) Measuring of earth.
ii) Cleaning of filter Pads of fan trays.

For more details refer maintenance manual of a system.

-x-x-x-

CHAPTER XIX

MOBILE TRAIN RADIO COMMUNICATION - LTE

19.0 This chapter covers basic technical information of Long Term Evolution (LTE), Evolved Packet Core (EPC) and LTE based Mobile Train Radio Communication System. This document is based on Specifications of LTE and FRMCS developed by 3rd Generation Partnership Project (3GPP) and International Union of Railways (UIC).

19.1 With GSM, ERA and UIC added extra functionality and called it GSM for Rail, GSM-R. So far the indication is that UIC will try a different approach with LTE and try to get as much functionality into the regular LTE standard, thereby not needing to add extra specific functionality for railways. There are some indications that LTE will end up with more functionality that is valuable to the railway industry than GSM did in its time. The Mobile Train Radio Communication System with LTE technology is in the development stage.

19.2 The International Union of Railways, UIC a global organization for Railway has set up Future Rail Mobile Communications System (FRMCS) project to prepare the necessary steps towards the introduction of a successor of GSM-R. The Future Railway Mobile Communication System - FRMCS has been prepared by UIC in order to have a Mobile Train Communication System based on LTE.

19.3 Limitations of GSM-R:-

19.3.1 As the communication demands increased and the capabilities of electronic devices evolved, it has become necessary to support data communication as much as voice communication. GSM-R does not provide packet-switched transmission. Therefore, data communication must be delivered by Circuit-Switched Data (CSD), which cannot assign the network resources based on the actual demand. This means that data is transmitted over virtual circuits, just like voice frames. Being bursty in nature, data sources send varying amounts of data at irregular intervals. Such a bursty transmission does not fit well into a fixed circuit provided by GSM-R. As a result, circuits are often underutilized and network resources are wasted.

19.3.2 GSM-R is becoming an obsolete technology. The predicted obsolescence of GSM-R is by 2030.

19.4 LTE: Long Term Evolution:-

19.4.1 Long Term Evolution (LTE) is the latest family of mobile communication standards (4G) developed by 3rd Generation Partnership Project (3GPP). The main requirements for the new access network are high spectral efficiency, high peak data rates, Short round trip time as well as flexibility in frequency and bandwidth.

19.5 Components of Long Term Evolution (LTE):-

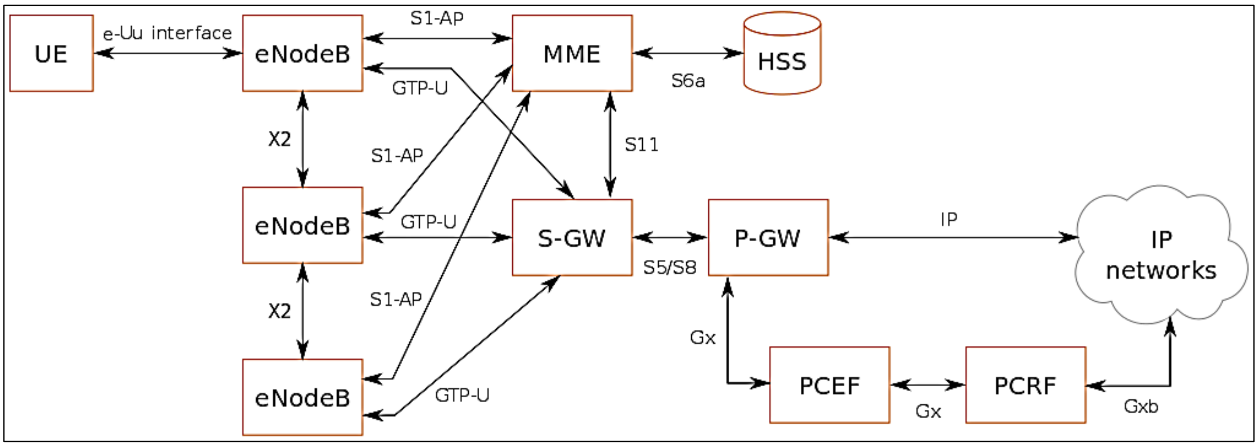


Fig.-1: Basic EPS Architecture with E-UTRAN Access (Source: 3GPP.org)

19.5.1 The key components of the LTE network sub-system are mentioned below:

19.5.1.1 **E-UTRAN: eNodeB (Equivalent of BSS in GSM-R)**
(Evolved Universal Terrestrial Radio Access Network)

The Evolved NodeB (eNodeB) is the base station for LTE radio. eNodeB is the RAN (Radio Access Network) node in the network architecture that is responsible for radio transmission to and reception from **UEs**(User Equipment) in one or more cells. The eNodeB is connected to EPC nodes by means of an S1 interface. The eNodeB is also connected to its neighbor eNodeBs by means of the X2 interface.

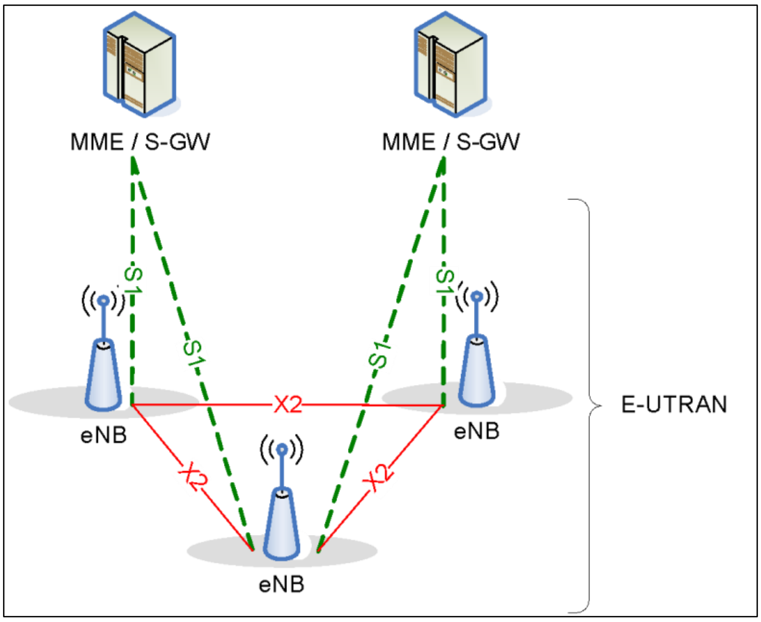


Fig. 2: LTE Architecture (Source: 3GPP.org)

19.5.1.2 **Serving Gateway (S-GW):**

The gateways (Serving GW and Packet Data Network GW) deal with the user plane. They transport the IP data traffic between the User Equipment (UE) and the external networks.

The Serving GW is the point of interconnect between the radio-side and the EPC. As its name indicates, this gateway serves the UE by routing the incoming and outgoing IP packets.

It is the anchor point for the intra-LTE mobility (i.e. in case of handover between eNodeBs) and between LTE and other 3GPP accesses. It is logically connected to the other gateway, the PDN GW.

19.5.1.3 **Packet Data Network Gateway (PDN-GW):**

The PDN GW is the point of interconnect between the EPC and the external IP networks. The PDN GW routes packets to and from the PDNs. The PDN GW also performs various functions such as IP address / IP prefix allocation or policy control and charging. 3GPP specifies these gateways independently but in practice they may be combined in a single "box" by network vendors.

19.5.1.4 **Mobility Management Entity (MME):**

The MME deals with the control plane. It handles the signalling related to mobility and security for E-UTRAN access. The MME is responsible for the tracking and the paging of UE in idle-mode. It is the termination point of the Non-Access Stratum (NAS).

19.5.1.5 **Home Subscriber Server (HSS):**

The HSS (for Home Subscriber Server) is a database that contains user-related and subscriber-related information. It also provides support functions in mobility management, call and session setup, user authentication and access authorization.

19.5.1.6 **Policy and Charging Rules Function (PCRF):**
The Policy and Charging Rules Function (PCRF), is a combination of the Charging Rules Function (CRF) and the Policy Decision Function (PDF), and ensures the service policy and sends Quality of Service (QoS) information for each session begun and accounting rule information. These policies are enforced in the eNodeB.

19.5.1.7 **Policy and Charging Enforcement Function (PCEF):**
The Policy and Charging Enforcement Function (PCEF) performs policy enforcement and service data flow detection, allowing data flow through the implemented P-GW. It is also responsible for the QoS on IP packets in the P-GW. The PCEF enforces rules that allow data packets to pass through the gateway.

19.5.1.8 **IP Multimedia Core Network Subsystem (IMS)**:
IMS is an all-IP system designed to assist mobile operators deliver next generation interactive and interoperable services, cost-effectively, over an architecture providing the flexibility of the Internet. These services include voice, pictures, text and video, or any combination of these with existing services. IMS has become the core component within 3G, cable TV and next generation fixed telecoms networks which deliver Internet Protocol multimedia to mobile users.

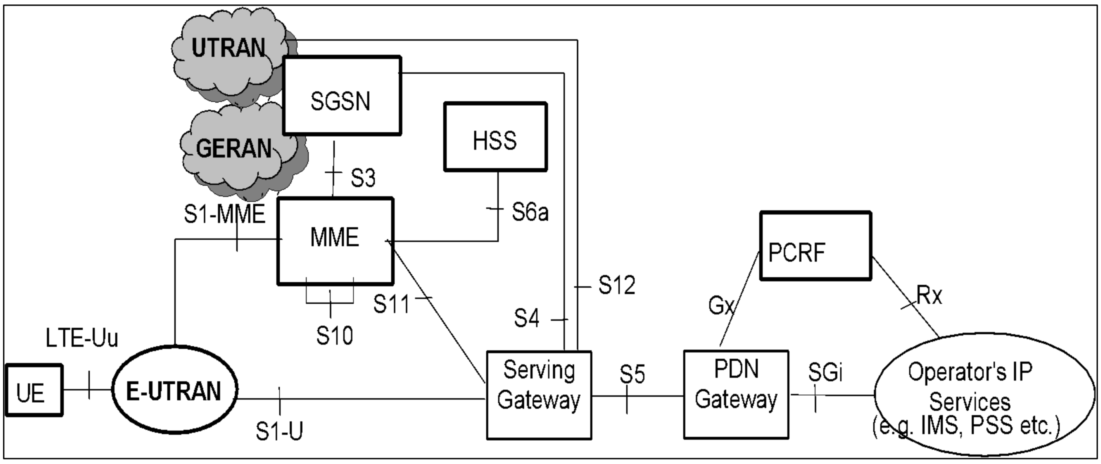


Fig.3: Non-roaming architecture of 3GPP Accesses (Source: 3GPP.org)

19.6 Features of Long Term Evolution (LTE):-

19.6.1 LTE is fully packet-switched IP-based mobile communication standard from 3GPP. Both real time services and datacom services will be carried out by IP protocol. LTE network assigns the network resources to users and applications depending on the actual transmission demand.

19.6.2 LTE introduces a simplified core network called Evolved Packet Core (EPC) with fewer elements than in the legacy standards.

19.6.3 The new access solution, LTE, is based on OFDMA (Orthogonal Frequency Division Multiple Access) and in combination with higher order modulation (up to 64QAM), large bandwidths (up to 20 MHz) and spatial multiplexing in the downlink (up to 4x4) high data rates can be achieved.

For the downlink, OFDMA (Orthogonal Frequency Division Multiple Access) is used and for the uplink SC-FDMA (Single Carrier - Frequency Division Multiple Access) is used which is also known as DFT (Discrete Fourier Transform) spread OFDMA.

The new radio interface offers much higher spectral efficiency than any other legacy mobile communication standard. Modulation and coding schemes are dynamically chosen in LTE based on the radio conditions and the traffic demand. The link adaptation mechanism allows the network to balance between throughput and reliability of the radio transmission.

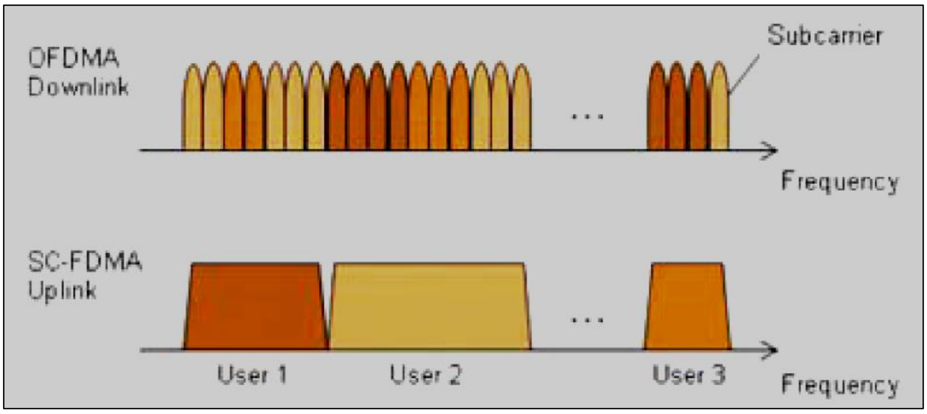


Fig.-4: OFDMA and SC-FDMA (Source: 3GPP.org)

19.6.4 Frequency:

LTE is developed for a number of frequency bands – E-UTRA operating bands- currently ranging from 450 MHz up to 5.925 GHz. LTE supports both the time division duplex technology (TDD) as well as frequency division duplex (FDD).

19.6.5 Spectral Flexibility:

19.6.5.1 E-UTRA shall operate in spectrum allocations of different sizes, including 1.4, 3, 5, 10, 15 and 20 MHz as per 3GPP/ETSI in both the uplink and downlink. Operation in paired and unpaired spectrum are supported.

19.6.5.2 The system shall be able to support content delivery over an aggregation of resources including Radio Band Resources (as well as power, adaptive scheduling, etc) in the same and different bands, in both uplink and downlink and in both adjacent and non-adjacent channel arrangements. A “Radio Band Resource” is defined as all spectrum available to an operator.

19.6.6 Peak data rate (Spectral Efficiency):

19.6.6.1 Instantaneous downlink peak data rate of 100 Mb/s within a 20 MHz downlink spectrum allocation (5 bps/Hz)

19.6.6.2 Instantaneous uplink peak data rate of 50 Mb/s (2.5 bps/Hz) within a 20MHz uplink spectrum allocation)

19.6.6.3 The highest theoretical peak data rate on the transport channel is 75 Mbps in the uplink, and in the downlink, using spatial multiplexing, the rate can be as high as 300 Mbps.

19.6.7 Transmission Latency: The LTE (4G) supports low transmission latency both in User plane and Control Plane. The time taken for data to travel in the air interface between UEs (mobile) to eNodeB (base station) is achieved to be less than 5 ms (User Plane) and time taken for a UE to switch from standby IDLE state to ACTIVE state is less than 100 ms (Control Plane). The User Plane and Control Plane transmission latency are further improved in the 5G system.

19.6.8 Control-plane capacity :

At least 200 users per cell should be supported in the active state for spectrum allocations up to 5 MHz.

19.6.9 Mobility:

19.6.9.1 E-UTRAN should be optimized for low mobile speed from 0 to 15 km/h.

19.6.9.2 Higher mobile speed between 15 and 120 km/h should be supported with high performance.

19.6.9.3 Mobility across the cellular network shall be maintained at speeds from 120 km/h to 350 km/h.

19.6.10 Coverage:

The Coverage i.e. Cell range depends on various factors like Cell edge throughput requirement, available spectrum and spectrum efficiency and mobility target etc. Approximate Cell ranges for 700 MHz LTE and its Cell edge throughput are given below:-

	700 MHz LTE Spectrum & cell range			
Cell Edge User Throughput (Kbps)	512	256	128	64
UL Cell Range (Km)	0.70	1.21	3.37	8.48

19.6.11 Enhanced Multimedia Broadcast Multicast Service (MBMS) :

19.6.11.1 While reducing terminal complexity: same modulation, coding, multiple access approaches and UE bandwidth than for unicast operation.

19.6.11.2 Provision of simultaneous dedicated voice and MBMS services to the user.

19.6.11.3 Available for paired and unpaired spectrum arrangements.

19.6.12 Co-existence and Inter-working with 3GPP Technology :

19.6.12.1 Co-existence in the same geographical area and co-location with GERAN/UTRAN on adjacent channels.

19.6.12.2 E-UTRAN terminals supporting also UTRAN and/or GERAN operation should be able to support measurement of, and handover from and to, both 3GPP UTRAN and 3GPP GERAN.

19.6.12.3 The interruption time during a handover of real-time services between E-UTRAN and UTRAN (or GERAN) should be less than 300 msec.

19.6.13 Architecture and migration :

19.6.13.1 Single E-UTRAN architecture

19.6.13.2 The E-UTRAN architecture shall be packet based, although provision should be made to support systems supporting real-time and conversational class traffic

19.6.13.3 E-UTRAN architecture shall minimize the presence of “single points of failure”

19.6.13.4 E-UTRAN architecture shall support an end-to-end QoS

19.6.13.5 Backhaul communication protocols should be optimized

19.6.14 Radio Resource Management requirements :

19.6.14.1 Enhanced support for end to end QoS

19.6.14.2 Efficient support for transmission of higher layers

19.6.14.3 Support of load sharing and policy management across different Radio Access Technologies

19.6.15 Complexity :

19.6.15.1 Minimize the number of options

19.6.15.2 No redundant mandatory features

19.6.16 LTE is the latest family of mobile communication standards. Hence, it has much lower obsolescence risk than any of the previous standards.

19.7 Mobile Train Radio Communication System (LTE) :-

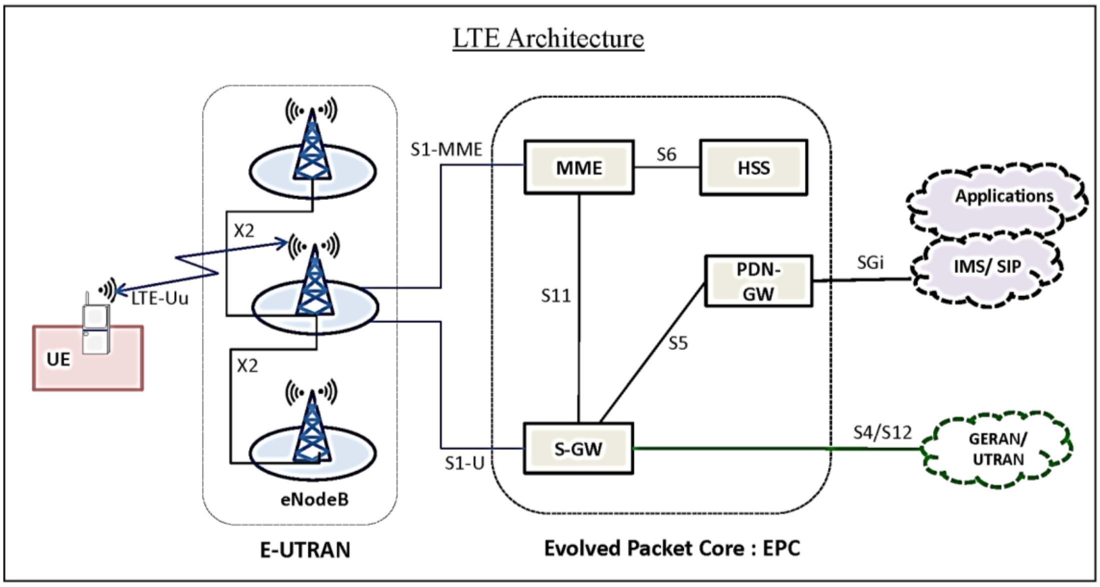


Fig.5:- LTE Architecture

LTE for Railways consists of User Equipment, Evolved Universal Terrestrial Radio Access Network, Evolved Packet Core, IP Multimedia Subsystem (IMS)/ Session Initiation Protocol (SIP) Core and various Applications/Solutions Servers on LTE. The LTE systems are compatible with modern train automation systems like European Train Control System (ETCS) or similar and also interoperable with other legacy mobile communication systems such as GSM and UMTS.

19.8 Communication Requirement of Railways through LTE (Future Railway Mobile Communication System):-

This section looks at various Railway requirements/features as listed by UIC and how it can be satisfied using the LTE based architecture. Indian Railways may include its all other specific requirements as implemented in GSM-R.

19.8.1 Users in FRMCS:

The following users are those identified to be users within this document and may not be necessarily conclusive within FRMCS:-

- Driver(s)
- Controller(s)
- Train staff:
    - Train conductor(s)
    - Catering staff
    - Security staff
- Trackside staff:
    - Trackside maintenance personnel
    - Shunting team member(s)
- Railway staff (excl. all of above):
    - Engine scheduler(s)
    - RU operator(s)
    - Catering scheduler(s)
    - IM operator(s)
    - Engineering personnel
- Station manager(s)
    - Station personnel
    - Depot personnel
    - Etc.
- Members of the public:
    - Passengers (on trains, on platforms, at stations, etc.)
    - Other persons (on platforms, at level crossings, etc.)
- Systems:
    - ATC on-board system
    - ATO on-board system
    - On-board system
    - Ground system
    - Trackside warning system
    - Trackside system
    - Sensors along trackside
    - Trackside elements controlling entities (such as, for example, for level crossings)
    - Applications (such as, for example, those for monitoring lone workers, for remote controlling of elements)
- Network operator
- Public emergency operator

19.8.2 **Communication requirements:-**

- Critical: applications that are essential for train movements and safety or a legal obligation, such as emergency communications, shunting, presence, trackside maintenance, ATC, etc.
- Performance: applications that help to improve the performance of the railway operation, such as train departure, telemetry, etc.
- Business: applications that support the railway business operation in general, such as wireless internet, etc.

These are the following sub-sections which are in line with the UIC FRMCS document.

Critical Communication Applications
Performance Communication Applications
Business Communication Applications
Critical Support Applications
Performance Support Applications
Business Support Applications

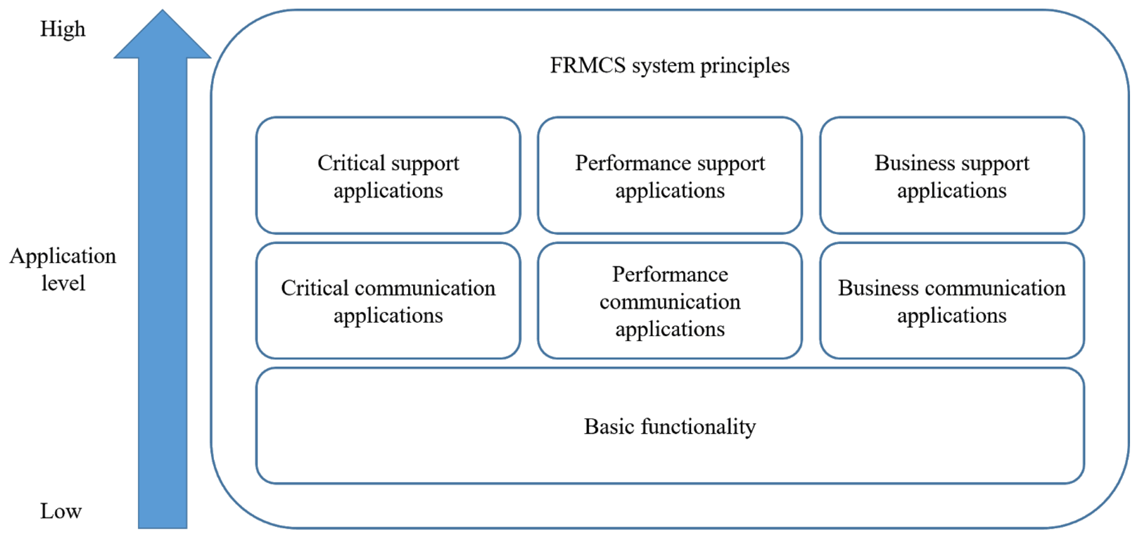


Fig.-6: Grouping of FRMCS Applications (Source: uic.org)

19.8.3 Critical Communication Applications:-

19.8.3.1 On-train outgoing voice communication from the driver towards the controller(s) of the train:
The driver shall be able to initiate a voice communication to any controller that was, is, or will be responsible for the movement of the train.

19.8.3.2 On-train incoming voice communication from the controller towards a driver:
An authorized controller shall be able to set up a voice communication to a driver.

19.8.3.3 Multi-train voice communication for drivers including ground user(s):
The driver shall be able to set up a voice communication with entitled ground user(s) and/or other drivers. A ground user shall be able to set up a voice communication with drivers and other entitled ground user(s). The selection could be based on the location of the train, on the track configuration, etc. using a functional identity. The voice communication can be bi-directional or uni-directional.

19.8.3.4 Banking voice communication:
Drivers of different locomotives within the same train shall be able to set up voice communication. During the ongoing voice communication an entitled controller can connect to the communication without any action of the driver(s). The driver is able to invite an entitled controller to connect to the communication.
Note – the different locomotives within the same train may or may not be coupled mechanically and/or electrically.

19.8.3.5 Trackside maintenance voice communication:
A trackside worker or controller shall be able to set up a voice communication with other authorized users. The voice communication can be bi-directional or unidirectional.

19.8.3.6 Shunting voice communication:
A shunting user shall be able to set up an uninterrupted voice communication with other shunting users and/or with entitled controller(s). The voice communication could be a user-to-user or multi-user communication. The entitled controller and other shunting users are addressed by the system automatically (for example, based on location, operational situation etc.).

19.8.3.7 Public emergency call:
A user is able to make a public emergency call.

19.8.3.8 Ground to ground voice communication:
A ground user shall be able to set up voice communication to another ground user.

19.8.3.9 Automatic train control communication:
The provision of a reliable communication bearer to support the implementation of radio based ATC systems. The ATC system shall have a reliable communication bearer in order to ensure efficient data transfer between the on-board system and the ground system. (for example ETCS L2/L3, CBTC, CTCS) , or between a train and other trains or between a train and other trackside elements. This application provides the communication bearer for this data,

19.8.3.10 Automatic train operation communication:

- The ATO system shall have a reliable communication bearer in order to ensure efficient data transfer between the on-board unit and the ground system, or between a train and other trains or between a train and other trackside elements. This application provides the communication bearer for this data.

- The ATO system components (on-board unit, the ground system or other ATO entities in the trackside) may broadcast information to other ATO system components.
- This application may include real time video between the on-board and the ground system (for example a train mounted front camera) or between other ATO system components.

19.8.3.11 Data communication for Possession management:
The application shall support the processes involved in taking possession of an area of railway infrastructure for engineering purposes (for example for track maintenance).

19.8.3.12 Trackside maintenance warning system communication:
The trackside maintenance warning system shall be able to initiate data communication to trackside maintenance workers in the appropriate area.

19.8.3.13 Remote control of engines communication:
It shall be possible to set up data communication between an engine and a ground based system in order to control the engine. The remote driver can operate the engine via the ground system.

19.8.3.14 Monitoring and control of critical infrastructure:
It shall be possible to set up data communication between infrastructure systems and a ground based or train based system in order to monitor or control critical infrastructure such as train detection, signals and indicators, movable infrastructure, level crossing elements, including barrier controls vehicle sensors, lighting controls and alarms.

19.8.3.15 Railway emergency communication:
An authorized user shall be able to set up a railway emergency communication to other users within an automatically configured area or group, which is based upon the originator's location or characteristics and those users likely to be affected by the emergency

19.8.3.16 On-train safety device to ground communication:
Based on a critical situation in the train (for example, triggered by a Driver Safety Device (DSD)), a voice and/or data communication is automatically set up towards a ground user (controller or ground system).

19.8.3.17 Public train emergency communication:

- This application allows any entitled user involved in train operations to alert, via a voice and/or data communication, the drivers of the concerned trains of a safety related incident in the vicinity of railway infrastructure; for example, at a platform environment or a level crossing: a person falling from a platform or slipping between train and platform or a car being stuck on a level crossing. An entitled user in this case could be a member of the public.

- The controller of the affected track/line(s) shall also be made aware of the alert and shall be able to have voice communication with the alert initiator.

19.8.3.18 Working alone:
The system shall be able to monitor the status (location, movements, health, etc.) of a user working alone. Once the application is active, the application can trigger voice and/or data communication applications based on the status of the worker.

19.8.3.19 Voice Recording and access to the recorded data:
It shall be possible to enable the recording of, and access to, communication content and the communication related data in order to support analysis.

19.8.3.20 Data recording and access:
It shall be possible to enable the recording of, and access to, communication content and the communication related data in order to support analysis.

19.8.3.21 Shunting data communication:
A shunting user (e.g. the shunting leader) shall be able to set up an uninterrupted data communication with other shunting users (e.g. the driver) and/or with entitled controller(s)/traffic control system. The purpose of this data communication is issuing request/commands and confirmations related to shunting operation. The entitled controller and other shunting users are addressed by the system automatically (for example, based on location, operational situation etc.).

19.8.3.22 Train integrity monitoring data communication:
The train integrity monitoring system shall have a reliable communication bearer in order to ensure safety related data be transfered between the components monitoring train integrity. The FRMCS system shall provide the communication bearer for this data exchange.

19.8.3.23 Public emergency warning:
A user is able to receive a public emergency warning initiated by the Public Safety Authority.

19.8.3.24 On-train outgoing voice communication from train staff towards a ground user:
The train staff shall be able to initiate a voice communication to any ground user.

19.8.3.25 On-train incoming voice communication from a ground user towards train staff

A ground user shall be able to initiate a voice communication to train staff.

19.8.3.26 Railway staff emergency communication:
An authorized user, is able to set up a railway staff emergency communication to other users within an automatically configured area or group. The area or group is based upon the originator's location or characteristics and includes those users likely to assist the originator with the emergency.

19.8.3.27 Critical Real time video:
This application facilitates the data communication for real time transmission of video images ("video images" may also refer to images coming from other sources, e.g. lidar and/or radar sensors) for critical railway operation. This includes the control of camera movements and –zoom.

19.8.3.28 Critical Advisory Messaging services- safety related:
A user shall be able to send and/or receive critical messages, safety related, like (predefined or any) text or pre-recorded voice messages to instruct railway staff about the usage of the infrastructure (for example speed restrictions, overriding of a stopping point). Messages can be exchanged on user-to-user or on multi-user level.

19.8.3.29 Virtual Coupling data communication:
The Virtual Coupling system shall have a reliable communication bearer in order to ensure that the safety related data is transferred between the components making part of the Virtual Coupling system. The FRMCS system provides the communication bearer for this data exchange.

19.8.3.30 On-train wireless backbone communications:
The enabling of a train-wide communication network requires the provision of a reliable communication bearer to support the implementation of the Wireless Train Backbone (WLTB). The WLTB shall have a reliable communication in order to ensure the efficient data transfer between the on-train Wireless Train Backbone nodes of each rolling stock element in a single train. The FRMCS system provides the communication bearer for this data exchange.

19.8.3.31 Train parking protection:
An authorized user shall be able to store information about the protection means of a parked train in a centralized application. The information can be entered manually or be generated by a sensor.

19.8.4 <u>Performance Communication Applications:-</u>

19.8.4.1 Multi-train voice communication for drivers excluding ground user(s):

A driver shall be able to set up a voice communication to all drivers within an automatically configured area that is based upon the originator's location.

19.8.4.2 On-train voice communication:
A member of the train staff shall be able to initiate a voice communication with one or multiple other members of the train staff (of the same train)

19.8.4.3 Lineside telephony:
A user shall be able to set up a voice communication to an entitled controller via lineside telephony.

19.8.4.4 On-train voice communication towards passengers (public address):

- A user shall be able to broadcast voice information to all passengers of one or multiple trains.
- The broadcasted information could be real-time or pre-recorded.

19.8.4.5 Station public address:

- A user shall be able to broadcast vocal information to all passengers at specific locations such as station concourses and platforms.
- The broadcast information could be real-time or pre-recorded.

19.8.4.6 Communication at stations and depots:
The station or depot user shall be able to set up a voice communication with other user(s).

19.8.4.7 On-train telemetry communications:
It shall be possible to set up data communication between on-train systems (on the same train or between 2 different trains) or between on-train systems and a ground based system.

19.8.4.8 Infrastructure telemetry communications:
It shall be possible to set up data communication between infrastructure systems and/or a ground based system (for example, to support demand forecasting and response, equipment supervision etc.).
Note: the data communication can be permanent or intermittent.

19.8.4.9 On-train remote equipment control:
A ground based system shall be able to initiate a data communication to relevant on train systems for control purposes,

19.8.4.10 Monitoring and control of non-critical infrastructure:
It shall be possible to set up data communication between non-critical infrastructure systems and railway staff or a ground based or an on-board system in order to monitor and control those infrastructure systems remotely.

19.8.4.11 Non-critical Real time video:
This application facilitates the data communication for real time transmission of video images for non-critical railway operation. This includes the control of camera movements and –zoom.

19.8.4.12 Wireless on-train data communication for train staff:
Train staff shall be able to use intranet/internet services via a wireless connection in a train.

19.8.4.13 Wireless data communication for railway staff on platforms:
It shall be possible for railway staff or railway systems to use intranet/internet services via a wireless connection in railway areas (for example platforms, station areas etc.).

19.8.4.14 Train driver advisory - train performance:
A user shall be able to set up data communication to provide advisory information to the train driver in order to optimize the train journey (for example Driver Advisory System (DAS), Traffic management (TM), Power consumption management).

19.8.4.15 Train departure data communications:
A user shall be able to set up data communications with other involved users to support the station departure processes.

19.8.4.16 Messaging services:
A user shall be able to send and receive non-critical messages like text, recorded voice (for example voicemail), data, pictures, video. Messages can be exchanged on user-to user or a user-to-multi user level.

19.8.4.17 Transfer of data:
Transfer of recorded data for post-accident/incident analysis (for example, CCTV, JRU, energy metering data), or any other data that requires to be transferred between users, for example, data from train staff, time table data.

19.8.4.18 Record and broadcast of information:
A user shall be able to record a voice or a video information that can subsequently be transmitted to selected users based on their identity and/or location.

19.8.4.19 Transfer of CCTV archives:
A user shall be able to bulk transfer CCTV archives between on-board systems or between on-board system and a ground system.

19.8.4.20 Real time video call:
A user shall be able to setup a real time video call to other user(s).

19.8.4.21 Augmented reality data communication:

- A user shall be able to setup an augmented reality data communication to the ground system. The ground system overlays information to the video stream presented to the user.
- Once a user is connected to the ground system, the controller is able to view the augmented reality images visible for the user.
- The controller is able to add information (or guidance) via the ground system in the augmented reality view which is visible to the user.

19.8.5 <u>Business Communication Applications :-</u>

19.8.5.1 Information help point for public:
A member of the public shall be able to set up a voice communication with the responsible ground user or train staff.

19.8.5.2 Emergency help point for public:
A member of the public shall be able to set up an emergency voice communication that will be automatically routed to the most appropriate ground user, train staff or driver.

19.8.5.3 Wireless internet on-train for passengers:
It shall be possible for passengers to use internet services via a wireless connection in a train.

19.8.5.4 Wireless internet for passengers on platforms:
It shall be possible for passengers to use internet services via a wireless connection in railway area(s) (for example platforms, station area(s) etc.).

19.8.6 <u>Critical Support Applications:-</u>

19.8.6.1 Assured Voice Communication
The Assured Voice Communication application shall provide a clear indication to the users as soon as an end-to-end voice communication link is broken or as long as the end-to-end communication link is active.

19.8.6.2 Multi user talker control:
- The system shall be able to limit the number of simultaneous talkers in a multi-user voice communication.
- An entitled user shall be able to select and de-select user(s) being able to talk in a multi-user voice communication.

19.8.6.3 Role management and presence:
- A user shall be able to register and deregister to one or more functional identity/ies. A user is able to see which other functional identities are present within a certain context (for example train, region, communication group, Railway Emergency Communication, etc.). Further it shall be possible for the user to identify at any time the function / person who is talking (for example driver, train staff, maintenance staff, platform staff, controller, etc.).

- This application will be responsible for handling the railway role management of the users including the identity registration and deregistration processes.

19.8.6.4 Location services:
The system shall be able to store and provide the location of the user(s) or devices.

19.8.6.5 Authorization of communication:
The system shall be configurable, so that access to voice and data communications can be controlled through the use of identities.

19.8.6.6 Authorization of application:
The system shall be configurable, so that access to applications can be controlled through the use of, for example: identity; user; user-to-user; multi-user; location, etc. The system is able to authorize access to applications.

19.8.6.7 QoS Class Negotiation:
The system shall be able to assign different QoS classes in order to fulfill the level of communication quality required by the applications.

19.8.6.8 Safety application key management communication:
The applications on board shall be able to authenticate the source of the messages received as a trusted source, and shall be able to detect corruption of the messages received.

19.8.6.9 Assured data communication:
The assured data communication application shall provide a clear indication to the users as soon as an end-to-end data communication link is broken or as long as the end-to-end communication link is active.

19.8.6.10 Inviting-a-user messaging:
A user can send a message to another user(s) inviting him to join the ongoing voice communication.

19.8.6.11 Arbitration:
The system shall be able to perform arbitration between communications competing for the attention of the user.

19.8.7 <u>Performance Support Applications:-</u>

None applicable.

19.8.8 <u>Business Support Applications:-</u>

19.8.8.1 Billing information:
An entitled user shall be able to obtain information for any type of on-network communication from the FRMCS system in order to be able to generate bills.

19.9 LTE System Architecture for Indian Railways:-

Installing an Ultra-high-speed LTE based communication corridor along IR network would cater to the current and future data and voice needs for Train-Ground and Train-Train communication for improved train operations, passenger safety and passenger security services and remote rail asset monitoring & management. The applications of LTE can be classified under the following three broad categories:-

19.9.1 Passenger Safety & Service:

- Advanced Signalling systems like European Train Control System (ETCS) Level 2/Train Collision Avoidance System (TCAS).
- Emergency communications from train to control, train to stations and between train to train, etc.
- Increased carrying capacity (throughput) Advanced signaling systems allow more trains to run across a given point or segment of the track which effectively increase the carrying capacity (throughput) of the same fixed civil and electrical infrastructure.

19.9.2 Live surveillance camera feeds from trains will ensure security of passengers coupled with video analytics, this can help in prevention and detection of crime, not only in Indian Railways network but also outside in the peripheral areas.

19.9.3 Internal improved Railway management:

- Staff communication system.
- Remote monitoring of Railways asset to improve their availability.

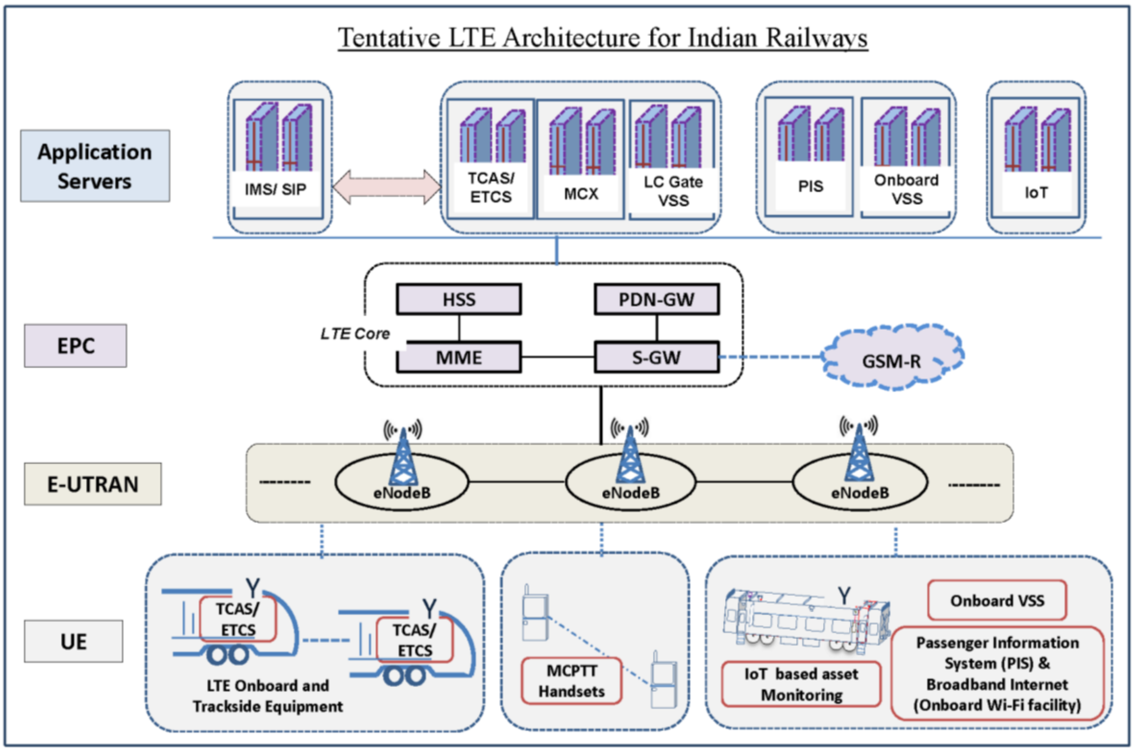


Fig.-7: LTE-R System Architecture for Indian Railways

19.9.4 Indian Railway envisages following applications/facilities which will fuel growth in data usage on deploying LTE technology:

i) Indian Railway Automatic Train Protection System (IRATP) through Train Collision Avoidance System (TCAS) which is planned for up gradation to ETCS Level 2 in future or any other similar systems as specified by Indian Railways.
ii) Mission Critical Push To Talk (MC PTT) application
iii) Video Surveillance System in locomotives for Level Crossing Gate/ Tunnels/ Bridges.
iv) Onboard Passenger Information System (PIS) consisting of passenger information display and passenger announcement system.
v) Internet of Things (IoT) based Asset reliability monitoring.
vi) Onboard Video Surveillance System (VSS) for Passenger Security.
vii) Broadband Internet on Running Train (Onboard Wi-Fi facility through LTE).

19.10 TRAI Frequency Band Allocation:-

5 MHz (paired) Spectrum in 700 MHz band (703-748 MHz Uplink & 758-803 MHz Downlink, also specified as Band 28 in 3GPP/ETSI standards) has been allocated to Indian Railways for implementing above services.

19.11 LTE FDD System Throughput :-

Transmission Mode/System Bandwidth	No of Useable Resource Block	SISO	Transmit	MIMO 2x2	All Transmission Mode	
		Downlink Peak (Mbps)	Downlink Peak (Mbps)	Downlink Peak (Mbps)	Uplink Peak (Mbps) 16 QAM	Uplink Peak (Mbps) 64 QAM
1.4 MHz	6	4.4	4.4	8.8	3	4.4
3 MHz	15	11.1	11.1	22.1	7.5	11.1
5 MHz	25	18.3	18.3	36.7	12.6	18.3
10 MHz	50	36.7	36.7	75	25.5	36.7
15 MHz	75	55.1	55.1	110	37.9	55.1
20 MHz	100	75	75	150	51	75

Table.-2: LTE FDD System Throughput

19.12 **Uniform Numbering Scheme for Mobile Communication Network for Indian Railways :-**

A) All mobile users in the LTE network must be assigned a certain addresses or identities in order to identify, authenticate and localize them. The following numbers and identities are assigned for administration of each mobile station in the network.

i) IMSI : International Mobile Subscriber Identity

The IMSI is a string of decimal digits, up to a maximum length of 15 digits, which identifies a unique subscription. The IMSI consists of three fields: the mobile country code (MCC), the mobile network code (MNC), and the mobile subscription identification number (MSIN).

- Mobile country code (MCC): The MCC is the first field of the IMSI and is three digits in length and identifies a country.
- Mobile network code (MNC): The MNC is the second field of the IMSI, it is two or three digits in length and is administered by the respective national numbering plan administrator.
- Mobile subscription identification number (MSIN): The MSIN is the third field of the IMSI, it is up to 10 digits in length, and is administered by the relevant MNC assignee to identify individual subscriptions.

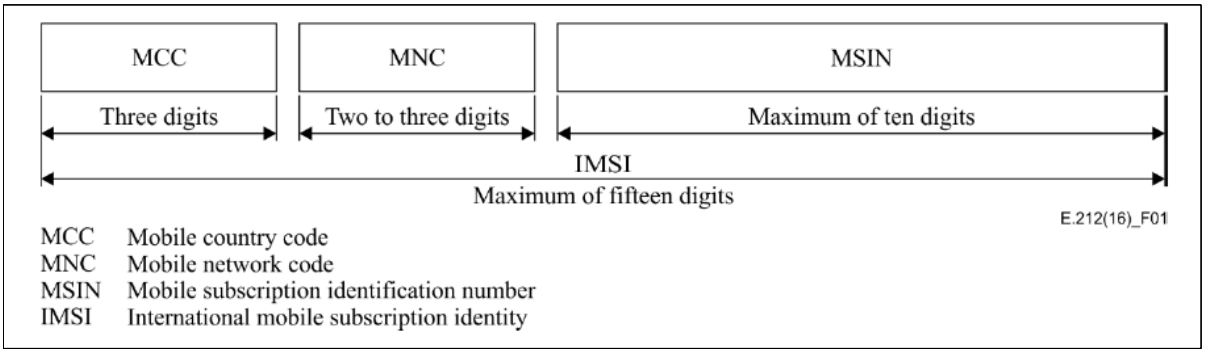


Fig.-8 : Structure and Format of IMSI (Source ITU)

ii) MS ISDN : Mobile Subscriber International Subscriber Directory Number

Mobile Station/Subscriber International Subscriber Directory Number (MSISDN) is a number (Mobile Phone Number) used to identify a mobile phone number internationally.

The MSISDN composition follows the international ISDN numbering plan with the following structure:

- Country Code (CC), up to three digits;
- National Destination Code (NDC), typically two or three digits;
- Subscriber Number (SN), a maximum of 10 digits.

The structure of the MSISDN will then be as shown in figure:

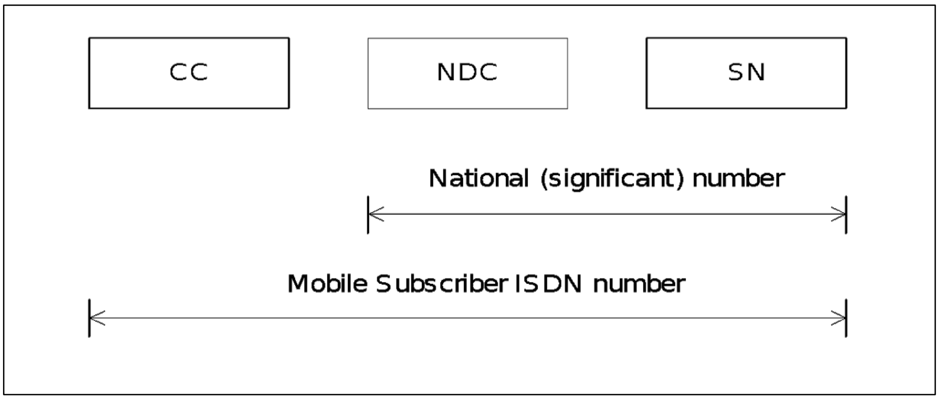


Fig.-9 : Number Structure of MSISDN (Source 3GPP)

RDSO has approved and issued Uniform Numbering Scheme for Mobile Communication Network (GSM-R) for Indian Railways. The same scheme shall be applicable for LTE.

The IMSI and MSISDN for Indian Railway shall be as below:-

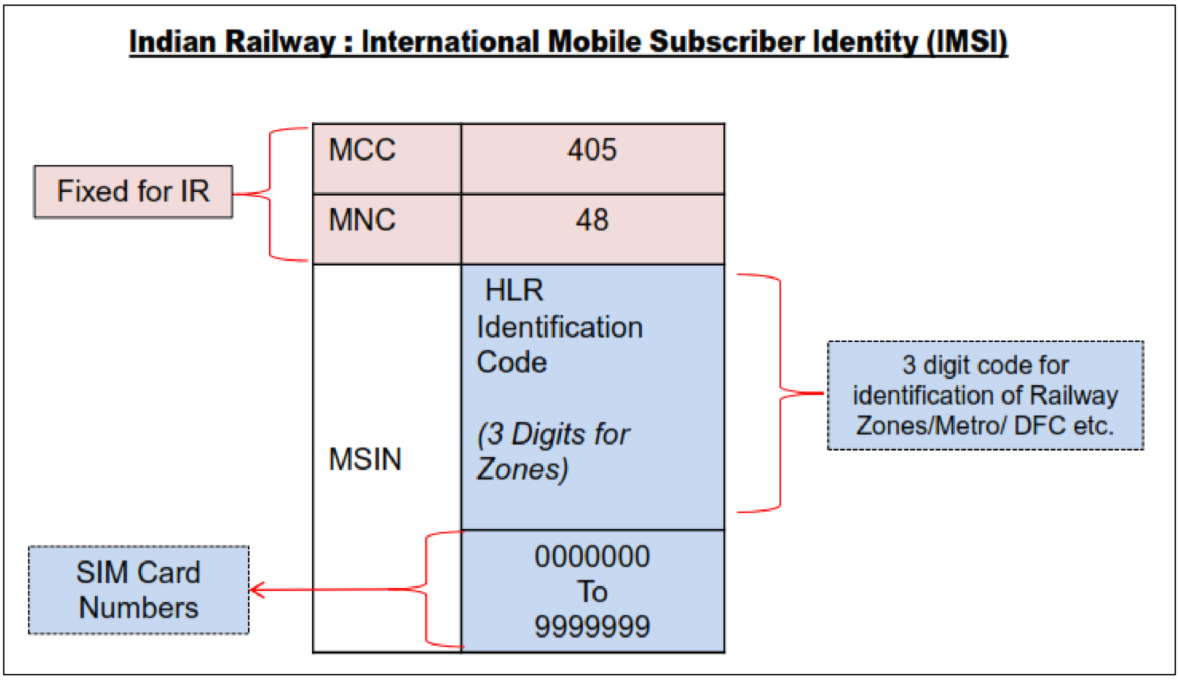
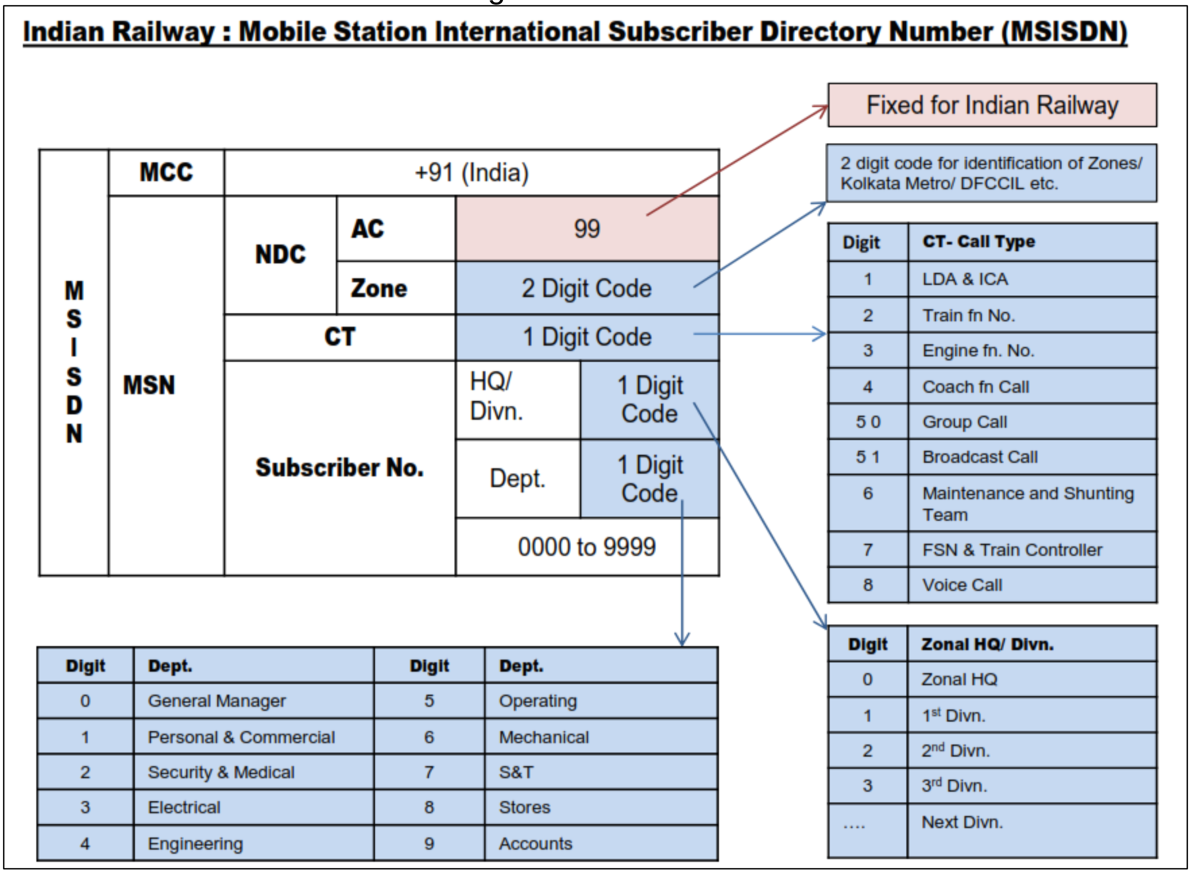


Fig.-10 : IMSI



Digit	CT- Call Type
1	LDA & ICA
2	Train fn No.
3	Engine fn. No.
4	Coach fn Call
5 0	Group Call
5 1	Broadcast Call
6	Maintenance and Shunting Team
7	FSN & Train Controller
8	Voice Call

Digit	Dept.	Digit	Dept.
0	General Manager	5	Operating
1	Personal & Commercial	6	Mechanical
2	Security & Medical	7	S&T
3	Electrical	8	Stores
4	Engineering	9	Accounts

Digit	Zonal HQ/ Divn.
0	Zonal HQ
1	1st Divn.
2	2nd Divn.
3	3rd Divn.
….	Next Divn.

Fig.-11 : MSISDN

19.14 Adaptation of LTE on Indian Railways:-

Indian Railway is migrating from GSM-R to LTE for Railway Automation System and-Broadband Services. It is proposed that the future projects of Railway Automation System and Broadband Services may be designed with LTE. It is also required that LTE system proposed for Indian Railways should be fit for bearer network for TCAS/ETCS Level 2/3 for desired speed.

-x-x-x-

CHAPTER XX

SOUND DISTRIBUTION SYSTEM

20.1 SYSTEM

20.1.1 Sound distribution system on the railways include transmission of:

(a) Announcement to passengers and other railway users at Railway station areas, inside coaches, information regarding arrival, departure and late running of trains and also important information pertaining to railway traffic.

(b) Speeches and musical programmes for railwaymen and guests in closed auditoriums or open grounds.

(c) Announcements and musical programmes for workshop staff in shops, halls and hospitals.

(d) Public address system during VVIP public functions

20.2 SPECIFICATION & PERFORMANCE PARAMETERS

20.2.1 Types of services - There are two types of services:

(a) "A" Category - desirable where high quality sound reproduction (both intelligibility and fidelity) is aimed at.

(b) "B" Category - employed where prime consideration is intelligibility.

20.2.2 USES: The uses of two types of services are as follows:

(a) `A' category service may be used where the acoustic conditions are fairly good for the listeners and it is possible to provide adequate acoustic treatment such as auditorium, indoor conference hall.

(b) `B' Category service may be used where the acoustic conditions are not favourable such as at railway platforms and other outdoor areas where high quality music/voice requirements are not feasible. High reverberation or high noise level conditions will require this type of service.

20.2.3 TECHNICAL REQUIREMENT FOR QUALITY OF REPRODUCTION FOR 'A' CATEGORY

i) Frequency response - The frequency response of the entire system excluding the voice coils of the loudspeakers shall be within ± 3 dB from 100 to 10000 Hz.

ii) Harmonic distortion - The total harmonic distortion of the entire system excluding the voice coils of the loudspeakers shall not exceed 5% at the rated output of the amplifier.

iii) Signal-to-noise ratio - The signal-to-noise ratio under normal operating conditions of the amplifying system as a whole with flat operation of the tone control shall not be worse than 50 dB.

NOTE: The normal operating conditions are those where sound pressure level of 70 to 80 dB is maintained.

iv) SENSITIVITY - System should be capable of direct operation from input voltage ranging 0.5mV to 1.5 V.

v) Reverberation time (for indoor installation only) - The reverberation time should be as per Annexure B and clause 20.2.8.

20.2.4 TECHNICAL REQUIREMENTS FOR QUALITY OF REPRODUCTION FOR `B' CATEGORY:

i) Frequency response - The frequency response of the entire system excluding the voice coils of the loudspeakers shall be within ± 3 dB from 100 to 7500 Hz. The frequency range can be further limited up to 4000 Hz to improve speech intelligibility in noisy and reverberant locations.

ii) Harmonic distortion - The total harmonic distortion of the entire system excluding the voice coils of the loudspeakers shall not exceed 5% at the rated output of the amplifier.

iii) Signal to noise ratio - The signal-to-noise ratio under normal operating conditions of the amplifying system as a whole with flat operation of the tone control shall not be worse than 40 dB.

NOTE - The normal operating conditions are those where sound pressure level of 70 to 80 dB is maintained.

iv) Sensitivity - System should be capable of direct operation from input voltage ranging 0.5 mV to 1.5 V.

v) The test procedure for measurement of above parameters are given in Annexure-E.

20.2.5 ACOUSTIC SURVEY

a) Objective - The objective of an acoustic survey is to determine the acoustic defects in relation to the location of the sound sources so that the necessary acoustic correction can be done to ensure an optimum, acceptable sound distribution.

b) Acoustic defects - The acoustic defects are:

i. Echo
ii. Flutter
iii. Reverberation
iv. Multiple decay rates.

20.2.6 ECHO

(a) The sound reflection reaching a listeners ear at least 1/15th of a second after the original sound is termed as echo.

(b) The effect of echo is aggravated by any focussing provided by any part of the same building or nearby building. This is mainly confined to the frequency range above 1000 Hz and this is because of the highly directional nature of higher frequencies.

20.2.7 Flutter

(a) Where parallel surfaces like side walls exist, there is a tendency for the sound energy to decay in a series of steps, rather like a series of echoes of diminishing intensity, where the interval between successive steps is the time for sounds to be reflected from one surface to the opposite surface. The effect is flutter.

(b) Flutter is predominant for frequencies above 1000 Hz and the aural effect is a hardness or harshness, particularly noticeable in speech.

20.2.8 Reverberation

(a) Reverberation is an accumulation of echoes, one interfering with and masking the other, so that the individual echoes cannot be distinguished. It is the persistence of sound by reflection from surrounding surfaces after the source sound has ceased.

(b) The effect of reverberation is the garbling of speech and distortion of music.

(c) A certain optimum reverberation is required for enhancing the effect of music or speech; too short a reverberation time produces a `dead' effect and in smaller rooms, this will affect the speech delivery of a speaker.

(d) The reverberation time, a measure of reverberation, is defined as the time taken for a sound to decay in its intensity through a range of 60 decibels.

(e) The reverberation time is calculated as follows:

$$T = \frac{0.01524\ V}{2.3\ S \log_{10} (1-a)}$$

Where,

T - is the reverberation time in seconds.
V - is the volume in cubic metres.
S - is the total surface area in sq. metres.
a - is the average absorption coefficient of the surface.

20.2.9 Multiple decay

(a) Even when the reverberation time approaches the optimum, there may be something lacking in the quality of the sound, if more than one rate of decay is present.

(b) Large areas of flat unbroken surfaces or acoustically coupled unequal volumes, as in the case of an auditorium wherein the portion under balcony and the rest of the portion are having different reverberation times cause such an effect.

20.3 GENERAL REQUIREMENTS

20.3.1 Composition of sound distribution system - Sound distribution system consists essentially of a microphone, an amplifier, a number of loudspeakers, connecting cables and sectionalising transformers, preamplifiers, power supply units, voltage regulating devices. Standby equipments are also provided as necessary.

20.3.2 Sound power and ambient noise level - Taking into account such factors as audience absorption and maximum ambient noise level, the mean level of sound power shall be 5 to 15 dB above the ambient noise level. In quiet places like waiting rooms and refreshment rooms, sound level should be higher by 5 dB; in closed auditoriums 5-10 dB; in railway platforms 10 dB; in station concourses, loco sheds, outdoor stadiums and similar noisy places 12 to 15 dB.

20.3.3 Electrical Power Requirement : A nomogram connecting the various design quantities; such as volume to be covered, required sound pressure level, reverberation time of the hall and the loudspeaker efficiency to determine the required electrical power output of the amplifying system, and the method of use of the nomogram are given in Appendix B. However, care should be exercised in using the nomogram as this is applicable only to hall having good acoustics and negligible feedback effect from the loudspeaker-microphone installation. A standby suitable battery operated audio system shall also be provided during VVIP function to avoid total interruption of service.

20.3.4 Circuit Plans and Operating Instructions –

a) Complete block diagrams and schematic diagrams for the equipment installed should be prepared and made available along with the circuit diagrams for each of the equipment, at the place where the central equipment is located. The layout and sizes of the wiring and cabling should also be indicated. The loudspeaker load connected to each output line and the particulars of the line transformer should be indicated. The operating instructions should also be made available along with rating of fuses to the operating staff.

b) Approval of plans for the proposed installation should be obtained from the competent authority.

c) The location of the central equipment, loudspeakers, microphones etc. should be fixed by the engineer and the accommodation reserved at an early stage.

20.3.5 Requirements for a playback - When music or announcements are recorded on any storage media and later fed through sound distribution systems, care should be taken to see that the reverberation characteristics of the place in which the original recordings are made do not downgrade the quality of playback through the sound distribution system. Because the reverberation characteristics of the place of original recording and of the place in which the recording is played back are additive.

20.3.6 Conformity of Specifications - All materials equipment and other components of the installation should conform to RDSO specification of Public Address System and the relevant Indian Standard Specifications wherever these are applicable. Some relevant IS specs. are given in Annexure `D'.

20.3.7 Acoustic corrections:

(a) Requisites for acoustic correction - The type and extent of acoustic defects are to be known, so that the acoustic corrections can be applied.

(b) Effect of parallel walls - Parallel wall surfaces must be avoided as far as possible.

(c) Effect in smaller rooms - The smaller rooms require greater attention since they develop spatial sound patterns due to resonances at different frequencies as decided by the dimensions of the room.

(d) Effects of side walls - Random reflections from the side walls will reduce the flutter and high efficiency absorbing material may be used on the side walls to reduce the flutter.

(e) Areas opposite to sound source - Curvilinear surfaces and large areas of reflection opposite to the sound normally give rise to echo and they must be avoided.

(f) Method of acoustic correction:

(i) After calculating the reverberation time, the surface area requiring acoustic treatment may be calculated depending on the optimum reverberation time chosen.

(ii) While calculating the reverberation time, adequate allowance for the absorption by audience is to be given. Normally 50% to 65% occupation of the seats can be considered. One occupied seat will amount to 33 absorption units which can be defined as the product of area in square metres and absorption coefficient.

(iii) The calculations in para above must be repeated for six different frequencies, e.g., 128 Hz, 256 Hz 512 Hz, 1024 Hz, 2048 Hz 4096 Hz and the type of acoustic material must then be properly chosen. Absorption coefficients for common materials are given in Annexure - A.

20.3.8 MICROPHONES

20.3.8.1 Use of microphones:

(a) Moving Coil Microphone - These are commonly used and have robust construction. Normally low impedance microphones are used as these permit the use of long microphone lines. These should have uni-directional characteristics which help in reducing acoustic feedback/howling specially in indoor sound systems.

(b) Condenser Microphone - Due to smaller size condenser microphones are commonly used for lavallier application either as Tie Pin Type or as Neck Type. These microphones require 1.5 V batteries to power electret condenser cartridges. These microphones have higher sensitivity compared to moving coil microphones.

20.3.8.2 Sensitivity - Sensitivity of the microphone shall be of the order of -55dB relative to 0.0002 dyne/cm for an impedance of 50 ohms.

20.3.8.3 Frequency response - the microphone chosen should have uniform frequency response within ± 3.0 dB from 100 to 10000 Hz.

20.3.8.4 Connecting microphones -

(a) Use of more than one microphone may be essential in large stages. In such cases, output from several microphones should be mixed in a mixing system and the common output fed to the amplifier, where the amplifier itself is capable of mixing individual microphone inputs, separate mixing system is not required.

(b) The microphone plugs and sockets should be of multi-contact (three or more) type and freely interchangeable.

20.3.8.5 Siting of microphone and loudspeaker

(a) Sound distribution system, especially in a closed hall, has the risk of acoustic feed-back from the loudspeaker to the microphone causing singing. Siting of microphones and loudspeakers should be such that there is good pick-up of speaker's voice without abnormal rise in bass and good distribution with uniform coverage without acoustic feedback. The microphone should be sited normally in an acoustic shadow.

(b) It is also desirable to create the illusion that sound is being heard directly. There should not be cases of sound from the loudspeaker, or reflected sound from the walls, reaching the audience after the sound from the speaker has reached directly.

(c) Microphone should be, as far as possible, behind the loudspeaker in order to minimize the acoustic feedback. The correct distance between microphone and source should be pre-determined and arranged to be constant as far as possible. It is important to see that if the level of reverberant sound or the surrounding noise near the microphone is high, the distance between microphone and source shall be reduced. The sound source should be directly towards the microphone, as otherwise the high notes, which are highly directional, would not be satisfactorily picked up by the microphone and thereby the clarity of the speech sound reproduced by the system will be poor.

(d) In 25 KV AC electrified area, the microphone siting should aim at avoiding the electrostatic or electromagnetic induction either in the equipment or in the lead from the microphone to the amplifier.

20.3.8.6 WIND SHIELDS:

Microphones, when used outdoors, may have to be fitted with some means of protection against wind. However, it is desirable that performance of microphones should not be adversely affected by such windshield.

20.3.9 LOUDSPEAKERS

20.3.9.1 Criteria for determining the loudspeakers required - The number of loudspeakers, their location, height, direction and the power input to the loudspeakers installed will have to be decided with the object of maintaining the intensity of reproduced sound above the local noise level as prescribed in Para 20.3.2 so that the masking effect of noise over the signal could be reduced considerably.

20.3.9.2 The loudspeakers used should have adequate power handling capacity and should normally be of high efficiency type.

20.3.9.3 Loudspeakers used for "A" Category reproduction should have effective frequency range of 100 to 10,000 Hz. (The response of the speaker system within the environment after installation should be considered as the effective frequency response). For this reproduction, directional type of loudspeakers (column) should be used.

The vertical directivity pattern of the system should be such as to feed the audience at uniform level, avoid harmful level, reverberant sound or echo, and feedback of energy to the microphones. In the horizontal plane, the directivity should be uniform across the width of the hall.

20.3.9.4 Column type loudspeakers:

(a) Column loudspeakers are ideal for obtaining the vertical directivity pattern and should be installed in all important stations/locations. The height of column and number of speakers in it determine the directivity. A wide range of high quality reproduction may be obtained by employing multiunit type, wherein the whole frequency range will be covered by two or three groups of speakers arranged in separate columns, but mounted close to each other and connected through a properly designed dividing network.

(b) The directivity pattern of such speakers should be such as to provide sufficient intelligibility at all points of the seated area and avoid feedback to microphone, dead spot and echo.

(c) For best results, the column loudspeakers shall be installed vertically at a height of 1.5 m above the platform level and inclined at an angle of 8 degree to 10 degree towards the ground.

20.3.9.5 For "B" Category reproduction, the loudspeaker should have useful response from 100 to 7,500 Hz. Cabinet/horn type loudspeaker should be adequate for such purposes.

20.3.9.6 Cone type loudspeakers with wooden/metal cabinets - Cone type loudspeakers of appropriate power output may be used in comparatively quiet covered areas like waiting rooms, retiring rooms, etc.

20.3.9.7 Horn type loudspeakers - Horn type loudspeakers are suited to open platform and large halls with high roofs. They shall be so placed and their size so chosen that their radiation may not be in opposition and also the reflections from the roof and walls are avoided. An electrical filter to cut off low frequencies may be used with the line matching transformer to avoid damage to the voice coil at low frequencies.

20.3.9.8 Connecting loudspeakers -

(a) When single or a number of loudspeakers are connected to the same output circuit, matching transformers shall be used with each loudspeaker so that it consumes the rated power.

(b) All the loudspeakers in each group should be connected in parallel and in phase across the output line.

(c) The pair of wires from each group should be terminated on the announcers panel at the amplifiers end, so that the line could be isolated from the output of the amplifier in case of any line fault or changed over to a standby amplifier, if provided.

(d) These transformers should have at least the minimum frequency characteristic required of the public address system. The power handling capacity of the transformer used with a loudspeaker should not be less than the power to be absorbed by the speaker. These should have several taps on primary and or secondary to give multiple turns ratio.

(e) These transformers enable the loudspeakers, through the selection of proper turns ratio, to take an input of predetermined value of audio load from the amplifier, at the same time, care being taken not to overload the loudspeaker. Where the constant voltage output line from the amplifier is used, the total wattage of loudspeaker load should not exceed the rated power of the amplifier.

(f) When a single loudspeaker unit is to be connected to the amplifying system, its impedance should be matched to the source (amplifier) impedance so as to consume the rated power, if such option is available at both the loudspeaker and the amplifier, otherwise voltage matching transformer shall be used.

20.3.10 AMPLIFYING SYSTEMS

20.3.10.1 CAPACITY OF AMPLIFIERS -

The output power of the amplifying system should be so chosen as to be capable of establishing at any point amongst the audience, a sound level of 80 dB during operation, the gain controls of the amplifying system should be so set that the signal reach each member of audience at comfortable listening level, that is during weak passage the signals are distinctly audible at each point, while during loud passage these do not cause annoyance. The amplifying system should have a gain sufficient to deliver the required output power.

The amplifiers should preferably be in multiples of 60 W. rates capacity, one for each group instead of using high power sets for the entire installation.

20.3.10.2 Input - In addition to the required number of microphone input channels, the amplifier must have a audio/video player input channel. It shall be possible to control the proportion of the levels of the signals mixed.

20.3.10.3 Sensitivity - As the input voltages required to be amplified may range from 0.5 mili volt to 1.5 V, the amplifying system should have a sensitivity sufficient to operate directly from the lowest and highest input voltages to be met with.

20.3.10.4 Frequency response - The frequency response of the amplifiers should be within + 3.0 dB from 100 to 10000 Hz for "A" Category reproduction and from 100 to 7500 Hz for "B" Category reproduction.

20.3.10.5 Matched impedance working - For matched impedance working, the output impedance of the amplifier should be such as to operate into the range of impedances presented by the load.

20.3.10.6 The output transformer of the amplifier should have impedance tapping of 4,8 & 16 ohms to enable operation with loudspeakers of these standard impedances. For constant voltage working, the transformer should be provided with 70 to 100 volts constant voltage tappings.

20.3.10.7 High power amplifiers should incorporate safeguard against excessive voltage or current rise in case of open circuit condition or short circuit conditions respectively, in output circuit.

20.3.10..8 Standby amplifiers -

(a) Standby amplifiers shall be provided so that announcement is not held up due to defects in the working of amplifiers.

(b) Seamless automatic changeover or Easy changeover arrangement for switching from the defective amplifiers to the standby amplifiers by the announcer without the aid of any technical staff is preferable.

(c) Provision should be available for easy localisation and rectification of faults in any part of the installation.

20.3.10.9 Installation :

(a) All equipment should be robustly made and designed for continuous operation. Equipment should be securely installed in such a manner as to have convenient access to all sides of it. Access by unauthorised persons should be guarded against. Precautions should be taken to keep away dust from the equipment, especially if earth moving machines, concrete mixers etc. are working in the immediate vicinity of the accommodation provided.

(b) When the number of equipment is not large, they may be placed on a table and wired. The positioning of the equipment should be such that the lengths of the inter-connecting cables are kept minimum for convenience.

(c) In case the number of equipment is large, it is desirable to mount them in racks of suitable dimensions. The racks may be of metal or wood and either in one piece having compartments or different sections of uniform width assembled together. Each compartment of section shall contain one item of equipment. The height of the rack will depend on the number of equipment to be mounted and accommodation available, ensuring that all manual controls are within easy reach.

(d) Switches should be provided for isolating any faulty section of the equipment thereby facilitating operation and avoiding danger to the operating personnel. The arrangement made should enable the remaining part of the equipment to be available for use.

(e) The patch cords if used should be tested and neatly arranged to avoid obstruction and should be easily identifiable. Necessary safety measures should be adopted to avoid accidental contacts with high voltage points in the rack.

f) Insulation required in 25 kV ac electrified area - The amplifier along with the cable and loudspeakers shall be such as to withstand a dielectric strength test voltage of 1000 AC rms for two seconds, when applied between the terminals of the speaker and the body.

20.3.11 POWER SUPPLY

20.3.11.1 Power supply

(a) It shall be ensured that reliable mains power supply is available near the proposed location of the announcing equipment.

(b) The installation should be normally operated from 230 V single phase 50 Hz AC mains supply.

(c) A voltage regulating device will have to be provided, if the regulation of the power supply is poorer than ±5%.

(d) When only DC supply is available, if necessary, an inverter of required capacity should be provided to convert DC supply into AC supply.

(e) If no mains supply is available, petrol or oil engine driven generating set of required capacity giving 230 volts single phase 50 Hz, AC should be used. Such a generating set should be located away from central equipment and microphones and preferably in another building at some distance from the hall having sound distribution installation to avoid noise (Electrical & Mechanical) produced by the generating system.

(f) All amplifiers should preferably be capable of operating on 12 V/24 VDC Car Battery besides on 230 V, 50 Hz AC supply.

20.3.12.WIRING AND CABLING

20.3.12.1 Microphone Cables -

(a) These cables carry low level signal currents and are, therefore, susceptible for electrical interference. Twisted pairs of conductors with sufficient insulation, screened continuously with close mesh of tinned copper braid shall be used. The copper braiding should be sheathed with an insulated covering. The microphone cables shall be isolated from power, loudspeaker and telephone cables by providing Separate ladder or duct.

(b) Joints in the cables should be avoided as far as possible.

(c) The plugs and sockets used for microphones cables should have strong self-cleaning contacts so as to eliminate noise and they shall be non-reversible and have sufficient number of pins to connect not only the main conductors but also the cable shields.

(d) Microphone cables should be laid without sharp bends as far as possible. Inside buildings, they may be laid on the floor along the walls or under the carpet to avoid damage due to any heavy object falling on them and cutting them.

(e) In 25 kV ac electrified areas, cables with their shields earthed must be used, if electromagnetic induction is anticipated.

(f) The plugs and sockets for loudspeaker connections should be of a type that cannot be easily or accidentally inserted in electric or power circuits.

(g) The speaker cable should be twin core rubber or PVC insulated lead-covered cables. These should be rated for 250 volts insulation and should be isolated from microphone cable and power cable.

20.3.12.2 Distribution and connecting cables - The cables chosen for distribution and connections should be such that the line losses do not exceed the values specified in Annexure C.

20.3.12.3 Additional requirements in 25 kV ac electrified area – The additional requirements are:

a) In the electrified areas, the length of parallelism between the loudspeaker circuit and catenary system should be limited to 1.2 Km. Where this length is exceeded, suitable sectionalising transformers shall be provided.

b) A minimum separation of 5 metres between the nearest wiring of the loudspeaker and the catenary system shall be kept.

c) Screened cables & wires or cables & wires in metallic conduit should be used in electrified areas, so as to eliminate the effects of induction both electromagnetic and electrostatic. The cable screening conduit shall be effectively earthed at both the ends. If sectionalising transformers are provided, earthing of the cable screen should be done on the two sides of the transformers. The value of this earthing resistance should be as low as possible and shall not exceed 5 ohms.

d) The screened cables used for working the loudspeakers shall have a screening factor of 0.5 within the field intensity of 50V/Km to 450 V/Km at 50 Hz.

e) It is desirable to run a main cable for the loudspeaker circuits as far away as possible from the catenary system and connect the loudspeaker at different points by distribution cables run at right angles to the catenary system.

(f) Wiring for equipment should also be screened (sheathed).

20.3.13 EARTHING AND OTHER SAFETY PRECAUTIONS

20.3.13.1 General - The layout and wiring of cables for loudspeakers shall, as far as possible, be so done as to ensure safety and avoidance of the obstructions in the normal functioning of the installation. The Indian Electricity Rules 1956 and the Indian Standard Code of Practice for Electrical Wiring and Fittings in Buildings (IS:732-1958) shall be followed, as far as they are applicable for wiring loudspeaker installations.

20.3.13.2 Earthing -

(a) Proper earthing of the entire installation (with appropriate earthing of the individual equipment also) is absolutely essential to avoid danger from any possible shocks to the users of the equipments, the operating personnel or the audience.

(b) Earthing connections to the nearby water mains are of usually lower resistance than any form of buried earth electrode system. An equipment of installation may be satisfactorily earthed by means of connection to the nearest water supply mains by a good soldered joints. In the absence of a suitable water main, the earthing may be done by connection to other efficiently earthed objects.

(c) The use of two or more separate earthing connections at different points on the system is inadvisable due to risk of trouble from circulating currents. The earth connection from water supply mains or other earthed electrode should be brought to an earth-busbar in the equipment room. The earthing connection to the installation equipments should be drawn from this earth-bus bar.

The screening leads of a microphone should have a separate insulated lead run direct to the earth connection. It shall not be connected to the electrical earthing of the installation which gives rise to hum.

21.3.13.3 Earthing leads - A fairly heavy cable (such as 7/0.75 mm VIR in conduit) or bare copper wire (4.0 mm dia) is normally satisfactory as the earthing connection lead. If bare copper wire is used, care should be taken to run it insulated from other metallic objects all along its length.

20.3.13.4 Earthing in 25 kV AC electrified area -

(a) All the sheaths/screens of wires/cables and metallic conduits must be earthed at both ends.

(b) In electrified areas, the metal mounting of the cone type loudspeakers and the body of the horn type loudspeakers shall be earthed. The resistance of this earthing shall not exceed 10 ohms.

20.3.13.5 Safety requirements for amplifiers operated from electric mains - The amplifier or amplifiers operating from mains supply shall conform to the requirement specified in IS:9302 - Mains operated audio amplifiers.

20.3.13.6 Fire and Explosion risk – The installation of the system in a situation, where there may be a possibility of an explosion, or in an inflammable atmosphere, should as far as possible, be avoided. However, if it becomes necessary to have the installation in such a situation, it should not be vulnerable to fire explosion risks. At such locations, fire extinguishers of appropriate type should be provided near the operators and smoke/fire detecting system with alarms should also be provided

20.4 MAINTENANCE

20.4.1 General conditions of wiring and components of the entire system to be checked once every year.

20.4.2 The frequency response and the noise level of the amplifier shall be checked annually and relevant parameters are to be recorded in Table I, II, III, IV& V. Wiring arrangements have been shown in figures 1, 2 & 3.

20.4.3 The earthing arrangement shall be maintained properly and inspected once in a quarter. Alternating current induction hum at 50 Hz and its harmonics also should be checked.

20.4.4 INSPECTION AND TESTING

20.4.4.1 The completed permanent installation should be inspected and tested by the ADSTE/DSTE to ensure that the work is being carried out in a satisfactory manner and that the materials and components used conform with the standard practice. Temporary installation may be similarly tested and inspected by SSE/JE.

20.4.4.2 Routine inspection of the installation shall be carried out at intervals in accordance with the manufacturer’s instructions or as specified from time to time.

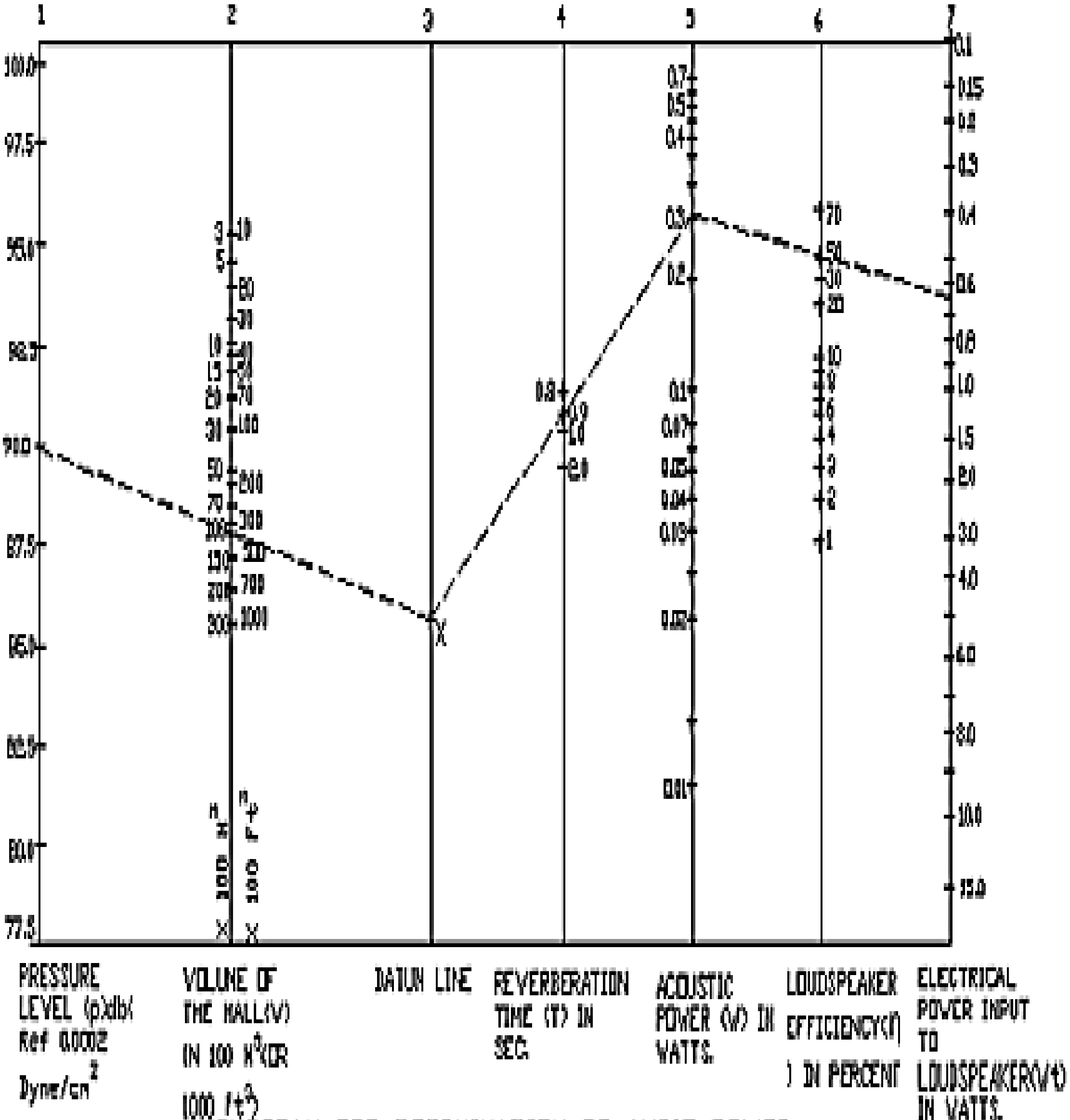
20.3.15.3 A log book shall be kept in which details of all routine attention, faults and tests should be carefully recorded for scrutiny.

ANNEXURE - A

Para 20.3.7 f (iii)

Absorption coefficient at 512 Hz

Brick Wall-lime plaster	...	0.03
Brick wall opening	...	0.02
Wood work	...	0.05
Concrete glasses tile	...	0.015
Carpet	...	0.15 to 0.21
Heavy curtain	...	0.35 to 0.5
Cellotex 1" thick	...	0.8
Acoustic plaster	...	0.3
Hair felt	...	0.4
Glazed windows	...	0.027
Gypsum plaster	...	0.028
Plywood chair	...	0.03



NOMOGRAM FOR DETRMINATION OF AUDIO POWER

SUPPOSE A SOUND PRESSURE OF 90 db IS REQUIRED FOR A ROOM OF VOLUME 100 M^3 WITH REVERBERATION TIME 0.9 SECONDS. DRAW A STRAIGHT LINE CONNECTING 90 db POINT IN LINE 1 WITH 100 M^3 POINT IN LINE 2 AND EXTEND THIS TO CUT THE DATUM LINE 3 AT X. CONNECT X TO 0.9 SEC. POINT IN LINE 4 AND EXTEND TO CUT LINE 5 AT 0.3 WATTS. IF LOUDSPEAKER EFFICIENCY BE 50%, DRAW A STRAIGHT LINE CONNECTING 0.3 WATT POINT IN LINE 5 TO 50% POINT IN LINE 6 AND EXTEND TO CUT LINE 7 AT 0.65 WATT. THE ELECTRICAL POWER INPUT TO L.S. SHOULD BE 0.65 WATT TO GIVE THE DESIRED RESULT.

ANNEXURE - C

Para 20.3.12.2

LOUDSPEAKER CABLE SIZES AND LENGTHS FOR SPECIFIED LINE LOSSES

(i) Low Impedance Lines = 15% Power loss.

Wire Size	Maximum length of loudspeaker cables in Meters for load impedance in ohms				
mm	2	4	8	16	32
2.06	30	60	120	240	480
1.60	20	40	80	160	320
1.32	12.5	25	50	100	200
1.00	7.5	15	30	60	120
0.80	4.5	9	18	36	72

(ii) High Impedance Lines = 5% power loss.

Wire Size	Maximum length of loudspeaker cables in Meters for load impedance in ohms		
mm	100	250	500
1.60	300	750	1500
1.32	200	500	1000
1.00	120	300	600
0.80	75	187.5	375
0.63	50	125	250

(iii) Maximum length to transmit upper frequency.

Wire size	Max.length of loudspeaker cables in mtrs for load impedance in ohms.			
mm	300	5000	7000	10000
2.65	1150	1150	900	820
2.06	1200	950	750	600
1.60	900	730	600	520
1.32	750	580	460	410
1.00	600	460	380	320
0.80	...	380	300	260
0.63	...	...	...	200

ANNEXURE - D
(Para 20.3.6)

IS	1881	Code of practice for indoor installation of PA system.
IS	1882	Code of practice for outdoor installation of PA system.
IS	1302	Methods of measurement on audio amplifier.
IS	7741	Specification for loudspeakers.
IS	9302	Mains operated audio amplifier.
IS	9551	Specification for high fidelity audio equipment and system.
IS	2748	Methods of measurements on microphones.
IS	12420	Circular audio connectors.
IS	5608	LF wires and cables with PVC insulation and PVC sheath.
IS	1596	Polyethylene insulated cables for working voltages upto and including 1100 V
IS	732	Code of practice for electrical wiring and fitting in buildings.

ANNEXURE - E

Para 20.2.4 (v)

TEST PROCEDURE FOR SOUND DISTRIBUTION SYSTEM

TEST-I FREQUENCY RESPONSE Para 20.2.3 (i)/20.2.4 (i)

1.1 The test set up shall be as per figure-1.

1.2 A tone of 0.5 mV at different frequencies shall be fed from signal generator to the amplifying equipment.

1.3 For each frequency, input level and corresponding output power at loudspeaker point shall be noted.

1.4 Repeat 1.2 & 1.3 with tone of 1.5 V.

TEST-II SENSITIVITY TEST (Para 20.2.3 (iv)/20.2.4 (iv)

2.1 The test set up as per Figure - 2.

2.2 Tone of 1 KHz shall be fed from the oscillator at different input voltages starting from 0.5 mV and in steps of 100 mV, 500 mV, 1 V and 1.5 V and record corresponding sound pressure level. It should be 70 to 80 dB.

TEST-III RELATIVE SOUND PRESSURE LEVEL

3.1 The test set up shall be as per Figure-2.

3.2 A tone of 1 Khz at 0.5 mV shall be fed through power amplifier to the loudspeaker system.

3.3 The level of received tone shall be measured at different spot with the sound level meter (measures directly in dB).

TEST-IV SIGNAL TO NOISE RATIO (Para 20.2.3 (iii)/20.2.4 (iii)

4.1 The test set up shall be the same as Figure-2.

4.2 In the vacant situation of the auditorium, the environmental noise shall be measured by sound level meter with signal Generator disconnected and power amplifier ON.

4.3 The above measurement should be done at the same spots where relative sound pressure levels were measured.

4.4 The noise level should be then compared with signal levels recorded in Test-III.

TEST-V REVERBERATION TIME (Para 20.2.3(v)

5.1 The test set up shall be as per Figure-3.

5.2 Amplifier is adjusted to give the highest practical sound level.

5.3 Gain of recorder is adjusted to give maximum deflection of the tracer styles.

5.4 Level recorder is started and audio tone to the speaker is then cut off allowing the recorder to produce continuous record during the whole of the decay period.

5.5 Time taken for the sound level to decay by 60 dB after the source is abruptly switched off is to be noted from the level recorder. This is reverberation time.

5.6 The above mentioned reverberation time to be found out for different locations.

TABLE OF TEST - I

Sr.No.	Input Signal Level	Frequency(Hz)	Output Voltage	Load Resistance	Power of Sound Pressure Level
	0.5 mV & 1.5 mV	100 Hz. 500 Hz 1000 Hz 1500 Hz 2000 Hz 3000 Hz 4000 Hz 5000 Hz 6000 Hz 7000 Hz 8000 Hz 9000 Hz 10,000 Hz			

TABLE OF TEST -- II

Sr.No.	Frequency (Hz)	Input Signal Level	Sound Pressure Level in dB.
	1 KHz	1.5 mV 100 mV 500mV 2 V 2.5 V	

TABLE OF TEST -- III

SR.NO.	LOCATION NO.	SOUND PRESSURE LEVEL IN dB.

TABLE OF TEST -- IV

Sr. No.	LOCATION No. (Same As Test III)	Sound Pressure Level in dB.	NOISE LEVEL IN dB	S/ N RATIO

TABLE OF TEST -- V

Sr. No.	**POSITION OF MEASUREMENT**	Sound Pressure Level With Tone ON	Time Taken to decay the level by 60 dB

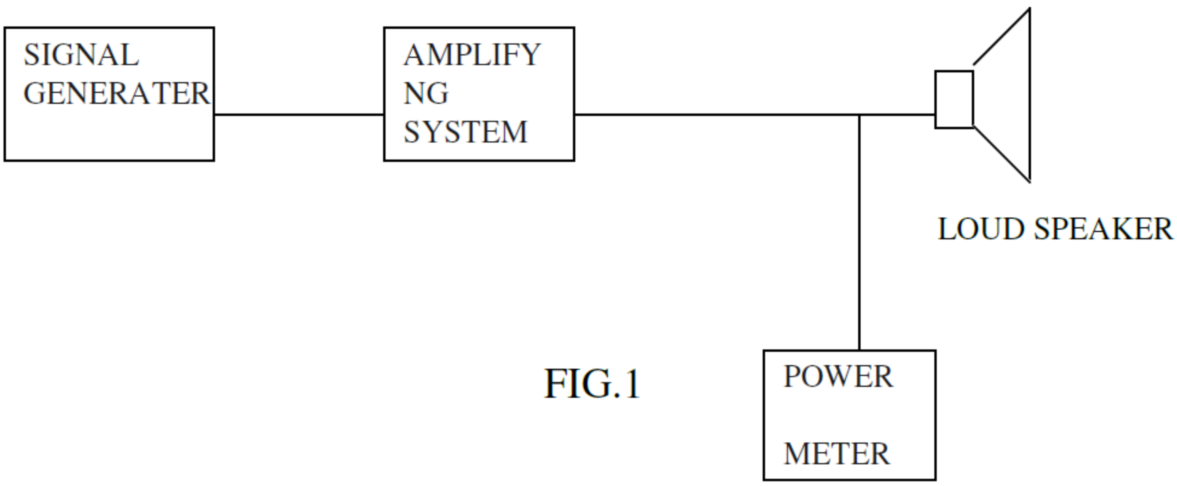


FIG.1

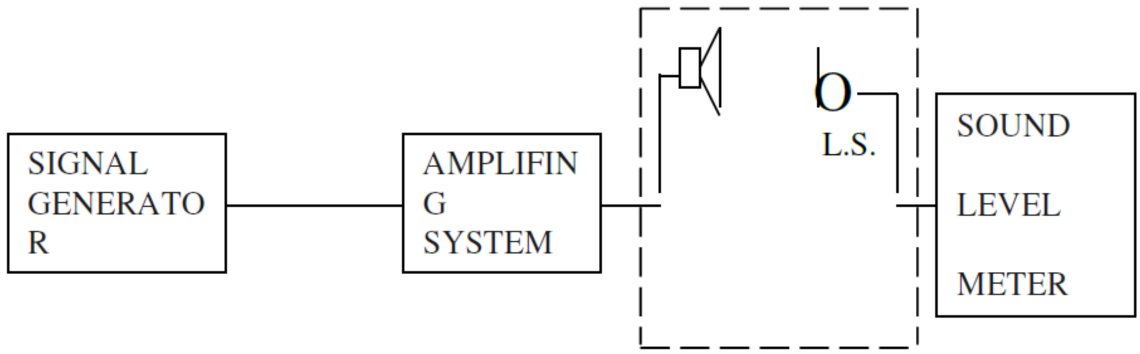


FIG.2

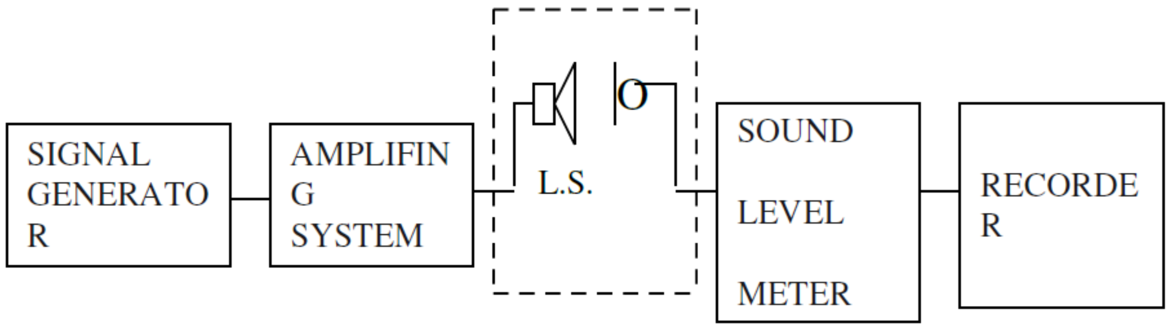


FIG.3

-x-x-x-

CHAPTER XXI

PASSENGER INFORMATION SYSTEM

21.1 The following type of Passenger Information systems are provided by the Telecom department for Indian Railways.

21.1.1 Interactive Voice Response System (IVRS):

Interactive Voice Response System, the technical system giving the information of Train Running, Passenger PNR etc. on a PSTN / Mobile Network through a centralized database, which is at present maintained at CRIS or through NTES servers.

21.1.2 Prerecorded Announcement and Auto Announcement System:
It is either an IVRS System, generally provided as a stand alone system, to give the information to the public on PSTN Telephone regarding Train Running Information or to work as an Announcement System on Platforms with suitable interface to PA system.

21.1.3 Train Indicator:

It is a display device which gives the information regarding running of Train Arrival / Departure timing and Platform No. etc. The system is either operated locally at a particular station or can be fed from Central location. They are mainly provided at Platforms and Public utility locations.

21.1.4. Coach Guidance System:

It is a display device, which indicates the position of each coach from engine with description of train number and Coach Position.

21.1.5. GPS Clock/Master Slave Clock:

(a). Master Clock is a Controlling Clock in Railway premises, which drives the other Slave Clocks in the same or remote premises to keep uniform timing. Slave Clocks are the clocks in the Railway premises driven by the Master Clock.

(c). GPS clocks may be provided independently or used to work as Master Clock / Slave clock. Master clock can drive all slave clocks either in the same premises such as in the control office or through separate networking to a distant location.

<u>SECTION - A</u>

21.2 PROVISION OF PASSENGER AMENITIES (TELECOM) AT STATIONS

21.2.1. The requirement of Passenger Amenities Systems related with telecom department at Stations should be based on the guidelines issued by the

Commercial Directorate and works proposed by the commercial department from time to time. The provision of Passenger Amenities at various categories of Railway Stations shall be provided in lines with recommendations laid down by commercial directorate/consultative committee and shall be ascertained accordingly.

SECTION - B

21.3 INTEGRATED PASSENGER INFORMATION SYSTEM (IPIS)

1. Integrated Passenger Information System is used for giving train arrival/departure information and any other video/image/alert information to passengers, which includes different type of display i.e. Single Line, Multiline, True colour indoor and outdoor video display, At a glance, coach guidance and PC based announcement system, placed at various places of the station with feature of networking, Operations from local/remote operator and remote monitoring from a central place.

2. It shall consist of following sub systems-
   - (a) Auto Announcement System
   - (b) Train Indicator Boards-
     Multi Line display Board
     Single Line display Board
     Train at a glance Boards
     LED TV/monitor type display board
   - (c) Coach Guidance Boards.

3. It shall be possible to choose one or more of these subsystems at a station.

4. The Data is entered by the data entry operator / Enquiry cum Reservation Clerk/Station Master. The software shall show the the status of various components as well as the messages being displayed.

5. Messages announced on the Platform PA system shall synchronize with the information shown on the display board.

6. The software driving the IPIS system shall have the following salient features:

   a. The software should have a GUI and shall be user friendly. It should get the requisite commands from the operator in as less number of clicks as possible.
   b. The software should support bilingual characters (English & Devnagari) and enable displaying of information in English & Hindi both and regional language.
   c. The software for train indication boards shall display Train number, Train name, and expected departure/arrival time of Trains, platform no. etc.

d. Provision should be made in software for alteration in the Time Table of Train. It should be possible for Railways to change/ add the details of trains to be displayed by the system at the time of change of timetable.
e. All the software and licenses shall be in the name of Railways and only licensed software shall be used.
f. The software for coach guidance system should have preloaded information of coach composition of all the trains arriving or departing from the station. When the train is likely to arrive at station or depart from the station, the concerned operator is required to enter the train number and update position of coaches i.e., from ENGINE to GUARD Brake Van.
g. It shall be possible for software to acquire updated data of running trains from NTES/ COIS or any central server & process updated data of running trains to display on various types of display boards, coach guidance systems and announcement on PA system. The auto derived information has to be cross examined by the local operator and the same has to be got corrected before announcement/display.
h. There shall be provision for adding a new coach type in the coach master database.
i. Provision shall be made for the operator to send announcement related to train number, platform numbers, and arrival/ departure just by entering the train number, platform number and status in conditions -
    - Late arrival of trains.
    - Platform No. of arriving/ arrived trains and change in platform No.
    - Right time arrival of trains.
    - Departure of trains at scheduled or unscheduled time.
    - Announce/display that trains is arriving/ departing shortly or terminated or and Current status of the train.
    - Cancellation of train
    - Route Diversion of train
    - Any other message required to be announced/ displayed regarding train arrival/departure.
j. Voice files used in announcement for hour, minute and status (i.e.बजकर, बजे etc.) shall be recorded by the same announcer & same shall be used.
k. Announcements of newly added trains shall be automatic without any recording to be modified unless the train name or station name is specific.

SECTION - C

21.4 AUTO Announcement System:

21.4.1 The system shall be PC/Server based with user friendly GUI for the announcement of various messages related to train operations/safety etc.

21.4.2 Fixed audio messages shall be recorded in digital format and shall be added to audio files list in the PC/Server.

21.4.3 It should be possible to make repeated announcements without affecting other operations. It should be possible for the operator to stop the announcements being played.

21.4.4 Software shall be user friendly to the maximum extent so that addition and alterations can be done by the Railway Engineer without the help of suppliers and programmer. For any newly added train, it shall be possible to record a file externally and attached to the train through user interface. The application shall take care of placing the recorded file at the appropriate internal application folder. However, any newly added train shall automatically play unless the train name or station is specific.

21.4.6 The system shall have provision to select messages and language for announcement. The announcement shall be fluent and professional enough to avoid unnatural pauses between two pieces of voice clips.

21.4.7 The entire voice recording for this system shall be done in a sound proof professional studio.

21.4.8 This system shall be provided at the Stations so as to cover the Concourse, Platform area and other important locations such as waiting rooms etc. The type of Speakers, Mikes, Acoustical environment, Type of Loudspeaker, Wiring and Cabling, Earthing and other Safety precaution should be of standard make and as per RDSO specification.

SECTION - D

21.5 TRAIN INDICATION BOARD

21.5.1 General

It is a display device which gives the information regarding running of Train Arrival / Departure timing and Platform No. etc. The system is either operated locally at a particular station or can be fed from Central location. They are mainly provided at Platform and Public utility location.

21.5.1.1 Various types of Train Indication boards and the places where these are to used as described below:

a) Multiline (multi & mono colour), Multiple row Single/Double face train indicators at the entrance of platforms as per the need of the stations and number of platforms at concourse / lobby. Multi Colour multiline train indicator displays train information and any other video information to passengers, commercials advertisement, entertainment programs etc.

b) Single line Single/Double faces train indicators at platforms at various locations along with platform length with clear visibility.

c) At-A-Glance Display Board Single/Double faces train indicators along with coach composition at various locations like FOB, Main entrance of the platform.

d) LED TV/Monitor type display Boards shall be used at enquiry office, waiting halls, VIP rooms, crew lobby etc.

21.5.1.2 All Display Boards should be given unique identification code/address and their status is to be reflected and made available on screen of the operating console as a health monitoring system.

21.5.1.3 At the time of accidents/derailments, these display boards may be used to display slogans/ messages in rolling, flashing & steady mode.

21.5.1.4 The Indicator system should be designed in such a way that the operator has to do a minimum number of operations for initiating and completing the entire process of a data entry.

21.5.1.5 Surge and lightning protection arrangement should be provided at 230V AC mains end and output of power supply, so as to protect the electronic modules from damage. The arrangement may include GD tubes, MOVs and fuses etc.

21.5.1.6 The system should be designed to suit the 25 KV AC traction areas. Proper earthing arrangement should be provided for grounding the shield of the data cable to prevent the EMI & RFI interference. However earthing for 230 volt AC power supply should be made separate.

21.5.1.7 Electrical power supply for all Train indication Boards shall be provided from a centralized place.

21.5.1.8 Ease of maintenance and immunity to failures should be the primary consideration in the designing of the system.

21.5.2 Operating Console (Central Data Controller):

The operating console should be installed in the announcer's cabin or at remote locations at Station. It should have required software and provision of data entry for train no. time table of Trains, PF. No. & Expected Arrival / Departure time etc.

1) The workstation and associated equipment should be installed in a secure manner so that only required equipment are accessible to the operator.
2) Adequate arrangement for housing the wires e.g. cable duct etc. should be made in the 19" housing cabinet. (All the wires, termination arrangement etc. required for interfacing should be provided. Any casing, capping, conduit, guide ladder etc. if required should be provided as per site requirement)

21.5.3 Laying of Data and Power Cable over Steel Bridges /under Platform sheds:

i. The laying of data and power cable over metallic structure under platform sheds and at FOBs should be carried out in separate DWC/HDPE/PVC pipe suitably fixing the same along the route or preferably a common arrangement of cable tray inside platform sheds for all such type of cabling should be done for better aesthetics and security.

ii. Suitable metallic clamps should be fixed at regular intervals (not more than 5 mtrs) to hold the pipes carrying the cable along with the metallic structures/ girders to avoid any sagging of the Data & power cable.

21.5.4 The Standard Personal Computer, keyboard, monitor, UPS & other accessories should be preferably housed in standard 19” cabinet.

21.5.5 General Requirement of Installation / Mounting and Wiring of the Display Boards:

i. The display board should generally be hung from the metallic structure of the roof of the platform & FOBs.

ii. The metallic hanging arrangement should be capable enough to bear the full mechanical load of the display boards and should be able to prevent any accidental dislocation of the display board which may be hazardous for the safety of the passengers and should be designed to prevent swinging of the display boards due to strong wind or movement of the trains or vibration.

iii. In general the display boards should be hung from the platform/FOBs roof by using G.I. angles. One end of this G.I. angles should be fixed with the metallic structure of the platform shed by using suitable metallic clamps, other end of the G.I. angles should be rigidly fixed with the inner side walls/clamp holes of the display boards. The length of the down angles for individual display boards may vary as per site requirement.

iv. Wiring of the data cable and power cable should be done through the PVC /HDPE or DWC pipe separately. The PVC/HDPE or DWC pipe should be properly fitted with the wall / roof / floor of the platform with standard fixing material like clamps, elbows, T joints, Straight joints, four way & three way junction boxes.

v. Termination of the data cable should be done by using proper terminal strips or by using proper connector of standard size of branded/reputed make.

vi. The data cable & power cable from top of the display unit should be taken through flexible corrugated pipes to improve the aesthetics. No loose wire/exposed terminations, wires etc. should be visible outside of the display board.

vii. While installing display boards at platforms, care should be taken that no display boards should obstruct visibility of any signal. This aspect should be jointly checked with Signal supervisor before installation.

21.6 COACH GUIDANCE SYSTEM

21.6.1 General

The Coach Guidance System alongwith at-a-glance display board enables the passengers to locate their coach for the Train on which they wish to travel.

21.6.2 At-a-Glance Display Board.

(a) At a Glance Display Board at Entry to station lobby.

It is essential that at entry or at lobby a display board is provided to guide the passenger the Train No., Platform No., to which Train is arriving / standing, the position of coach with respect to engine. On the platform at various locations suitable indicator with respective coach location board may be provided giving the details of Trains No. and Coach No.

1) A suitable Display board indicating the Train No. Platform No. arrival / departure time along with position of the coaches with respect to engine should be provided.
2) There should be provision for blanking the complete display board to ensure that no stray dots lights up when there is no data signal from the operating console.
3) The information displayed on the display boards should be clearly visible under normal ambient conditions. Proper weather protection and glare protection (hood) as per site requirement should be provided to achieve the optimum visibility of the display boards.
4) All boards should have input power_ON indication outside the board.

(b) Coach guidance boards

1. The system consists of coach guidance boards at Station and platform operated through PC workstation at remote location / control offices or at Stations.
2. Protection Arrangement: The equipment should be mounted in metallic housing of industrial grade to avoid entry of dust and rise of temperature with necessary earthing etc. to provide complete EMI & RFI protection.
3. Coach Guidance Display Board should conform to the typical layout and should be approved by Railways depending on location and need.
4. Double face coach guidance display board should be provided on platforms

21.6.3 Installation Arrangements of Coach Guidance System:

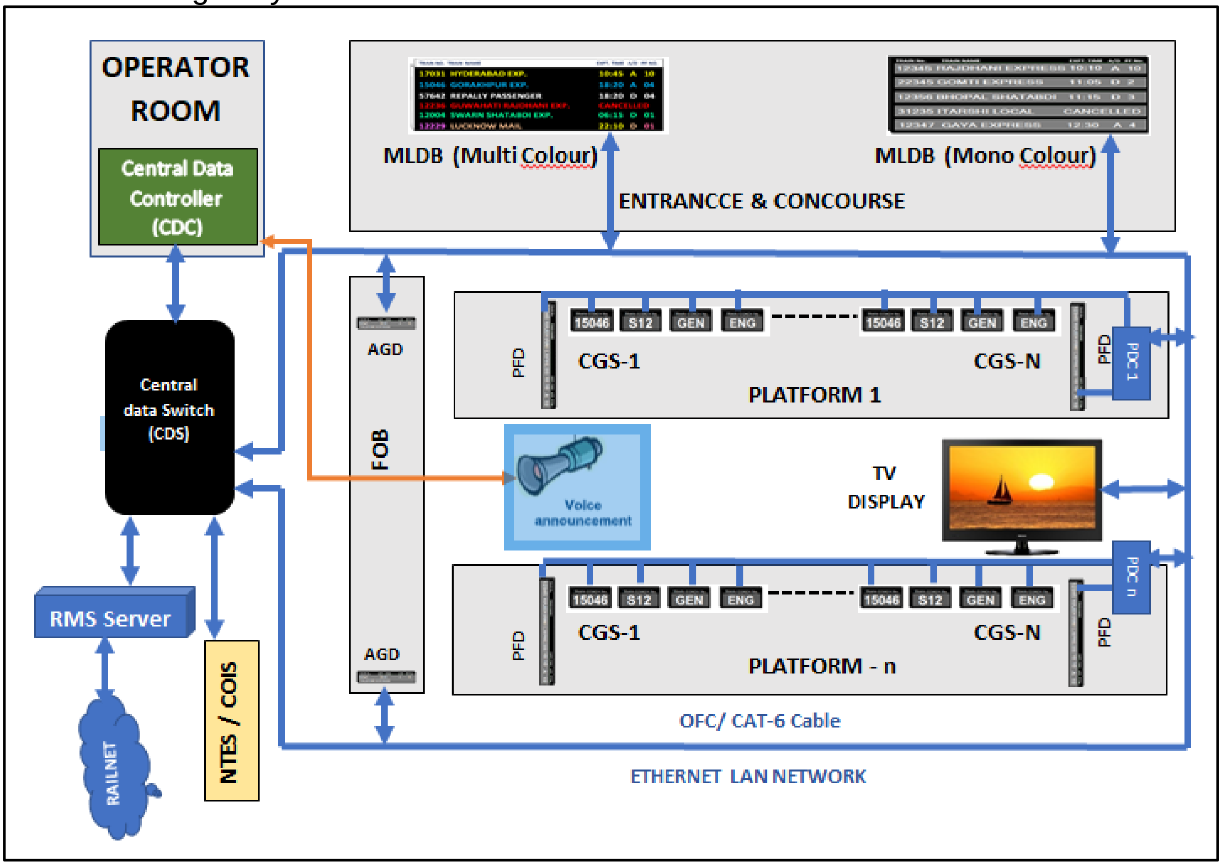
Mechanical fixing arrangement for installation of single/double face LED display board should be designed to prevent swinging of LED display boards due to strong wind / vibration due to movement of the trains .For installation of coach guidance display board on uncovered portion of the platform shall be provided using GI pipe of minimum 3-inch diameter with suitable size of shelter.

SECTION - E

21.7 IP based IPIS

1) Looking into the prevalence and widespread domination of IP technology, IP based Integrated Passenger Information system has also been designed for Indian Railways.
2) It includes a PC based announcement system for announcing train information to passengers, LED display boards & coach guidance display boards for displaying train information to passengers.
3) All the devices in this system are IP enabled that facilitates monitoring each and every board. The remote monitoring server when connected to Railnet shall enable monitoring from anywhere on Indian Railways.
4) It uses Optical Fiber based communication network for connecting display boards and other components of IPIS.
5) Smart monitors and TVs can also be used as Display Boards in this system.

This system has central server with necessary software to perform the function of IP based IPIS. The data of all the trains Arriving/Departing from that station is fed into the server. Along with voice clips of the train name, Train No., station, starting station and destination station. The train No. platform and time and status of the train to be displayed are selected by operator and automated information is generated for display on LED display boards and audio announcement on PA system. Brief schematic describing working of system is under.



SECTION - F

21.8 GPS/MASTER & PLATFORM (SLAVE) CLOCKS

21.8.1 General

GPS/Master Slave Clocks are utilized in Control Office / Stations to maintain uniform timing for Train operation.

21.8.2 Requirements of Master Clock:

i. The Master Clock shall be capable to drive number of Slave Clocks as per requirement either in one location or distributed in various other locations.

ii. The Master Clock shall be based on microprocessor based technology utilizing GPS.

iii. It should be controlled by GPS as time base. The accuracy of the Clock should be better than $\pm$ 5 Sec. per week over the expected temperature range, which can generally be achieved only through a GPS based system.

iv. The design construction and reliability of equipment should be based on modern technology and standards using commercially available solid-state components. The modules and components should be plug in type.

v. The Master Clock should work on main power supply of 230 V AC single phase 50 Hz.

vi. The Master Clock should be equipped with LED based or 7 segment numeric display in 24 Hrs. mode to show the real time even in case of mains power supply failure in Hours, Minutes & Seconds.

vii. Adjustment switches shall be provided on the Master Clock to set the time. These switches should be located at the rear of the unit so that any accidental operation of the switches does not change the Master Clock time.

viii. The Master Clock should be immune to EMI noise / Power transients, spikes etc. It should display time on both sides.

ix. The Master Clock should transmit data through a pair of conductor to the Slave Clocks.

x. Railways can have GPS Clock in control office to work as Master Clock. This can drive all slave clocks either in same premises or through separate networking to distant location.

xi. Where wiring is not feasible, Master GPS clock shall be used in place of slave clock. In case of non-availability of GPS signals at critical locations such as indoor locations , slave clocks are to be provided and it should be wired with GPS master clock placed at suitable location.

xii. The Master Clock shall meet the Technical Specification of RDSO.

21.8.3 Requirement of Digital Platform (Slave) Clock:

i. Digital Platform (Slave) Clock operated by Master Clock should be capable of receiving continuous serial data through a pair of conductors.

iii. In case of AC main power supply failure the display of Slave Clock shall be automatically synchronized with the Master Clock whenever main power supply restores.

iv. Slave Clock shall be capable to work on 230 V AC single phase 50 Hz.

v. Suitable mechanical fixing arrangement as per site requirement shall be provided for hanging at adequate level for better visibility on both the sides.

vi. Technical requirement of Digital Platform (Slave) clock should be as per RDSO specification.

-x-x-x-

CHAPTER XXII

SATELLITE COMMUNICATION SYSTEM

22.1 Very Small Aperture Terminal (VSAT) Network

22.1.1 Introduction

VSAT provides Point to Point or Point to Multi Point data connectivity using Geostationary Satellite as repeater location. As satellite is being used as repeating stations, the data originating and terminating point can be anywhere on the earth. VSAT network in Indian Railways is typically used for UTS/PRS & FOIS connectivity and as Accident Site Communication for voice, data and video transmission. Railway is using them to provide connectivity between various Railway data networks and remote locations where the normal data connectivity is not available or provision of the same is not feasible.

22.1.2 IR VSAT Network Components

a) The Indian Railway VSAT network works in a Star architecture and consists of
   i. Hub Earth Station
   ii. Remote Earth Station
   iii. Satellite Transponder & Space Link
   iv. Network Control Centre
   v. Interface Equipment

b) The IR VSAT network provides transparent transmission links that can work with any network using suitable Interface equipment.

c) IR Satellite network operates in Ku Band and operates on up link frequency of 13.75 to 14.5 GHz and down link Frequency of 10.70 to 12.75 GHz. Uplink frequency is the carrier frequency on which Hub or remote earth station transmits the Signal to Satellite. Down Link Frequency is the Carrier frequency on which Satellite transmits the Signal to Hub or remote earth station.

22.2 Hub Earth Station

22.2.1 IR's present HUB Earth station is situated at New Delhi station. It is the Heart of the entire Network. The communication between remotes or remote to external networks is established through Hub Earth Station only. It is responsible for collecting the data from enterprise LANs, Address Translation, converting data into IF and RF Signals and transmitting them to Satellite and further to remote earth stations/terminals, maintaining the integrity checks for all remote earth stations, time synchronization for all remote earth stations, tracking of Satellite, converting the RF received from Remote to Data Signals in appropriate format to be delivered at Enterprise level etc. The NDLS Satellite Hub has now been upgraded to the latest HX Satellite technology.

SALIENT FEATURES OF HX NETWORK

A. **Network Efficiency**: The new configuration will be able to provide 12Mbps of out-route and 7.4Mbps in-route from currently 6.5Mbps & 5.1Mbps respectively, hence Indian railways will get 65% more bandwidth in the existing transponder space.

B. **Bandwidth**: Large bandwidth pool availability for all the users after going on a single network.

C. **Troubleshooting:** Single window troubleshooting.

D. **Mobility solution:** HX platform is having capability to support mobility applications. HX 200 modem used in A-route ART VSAT system is capable of collecting Lat Long parameters automatically through GPS, this facility was not available in old HN network equipment.

E. **Advanced Technology:** HX network works over DVB-S2 technology with Adaptive Coding Modulation (ACM), the world's most successful satellite industry standard.

F. **AIS:** Adaptive Inroute Selection (AIS) for maximum bandwidth efficiency.

G. **QoS:** Service level control providing the ability to have multi-level QoS offerings.

H. **Flexibility in configuration**: Flexible configurations with multiple networking topologies: star, mesh, and multi-mesh.

I. **CIR**: Each remote link can be independently configured with unique Committed Information Rates (CIRs).

J. **Capability**: Able to work over 02 different transponders on the same satellite for a single network.

22.2.2 The transmission of a signal up to the satellite and back down is called a hop. Transmission delay for one hop is between 240msec. and 270msec.

22.2.3 Railway has hired 12 Mhz frequency space on GSAT 18 for their VSAT Network.

22.2.4 To adjudge the availability of Satellite communication, a link budget calculation is done taking the least available Satellite Power, Antenna Size, transponder sizing for receive and transmit segments etc.

22.2.5 All transponder space is allocated by the Department of Space.

22.3 <u>Remote Earth Station</u>

22.3.1 Remote Earth Station consists of

i) A Parabolic Antenna

ii) An outdoor unit called ODU, which has a Block Up Converter (BUC) to transmit and Low Noise Block (LNB) to receive signal.

iii) Indoor Unit

iv) Power Supply Arrangements

v) Protection and Earthing Arrangements

22.3.2 Indoor Unit interacts with the Antenna System as well as external data devices through Ethernet LAN ports. A typical remote earth installation over Railway has been shown in Annexure-4.

22.3.3 All remote installations require feeding of latitude and longitude information which determines its location with respect to Satellite as well as Hub Earth Station along with some other hub related parameters to make remote sites live in the network.

22.4 Interface Equipment

22.4.1 The VSAT Network is interfaced with the external data devices by using Router or Router Switch combinations at Hub Earth Stations. At Remote Station, Ethernet LAN output is provided as standard interface. This can directly be connected to any device having Ethernet interface.

22.4.2 The applications Servers like FOIS Server of Railway, IP Exchange for Voice Networks and MPEG Server for Video Streaming applications and Web Servers for providing Internet application have to be interfaced with VSAT network through a router switch combination only.

22.5 Network Control Center

22.5.1 Network Control Center is responsible for administering and managing the whole of the VSAT Network as well as each of the applications working on the Network. This is carried out through Network Management System specific to Network as well as using other tools mostly SNMP based.

22.5.2 This Center also generates various analysis reports for Network part for day to day operation.

22.5.3 One of the most important parameters is analyzing the traffic flow and taking corrective actions for optimum working of all applications. This has been described in detail in Bandwidth Management para.

22.5.4 This Center also tracks the performance/status of all the remote sites connected and get them attended in case of any fault.

22.6 Bandwidth Management

22.6.1 Management of Bandwidth is a very important parameter on VSAT networks as the cost of Bandwidth on Satellite is very high.

22.6.2 Ku Band VSAT Networks work on Shared bandwidth principles. Here only priorities and grouping of traffic can be defined. Priorities can be defined for a group consisting of Data Transmitting device, Data Receiving Device etc. within the group each member will have an equal right for the bandwidth. Therefore as more and more members of the group become active, each one will get less bandwidth. As more and more members become dormant, the available bandwidth for the remaining members will be higher. Priorities can be set for different groups based on sensitivity of applications. Therefore a high priority group will get precedence for bandwidth allocation than a lower priority group. This results in a very effective utilization of Bandwidth.

22.7 Miscellaneous

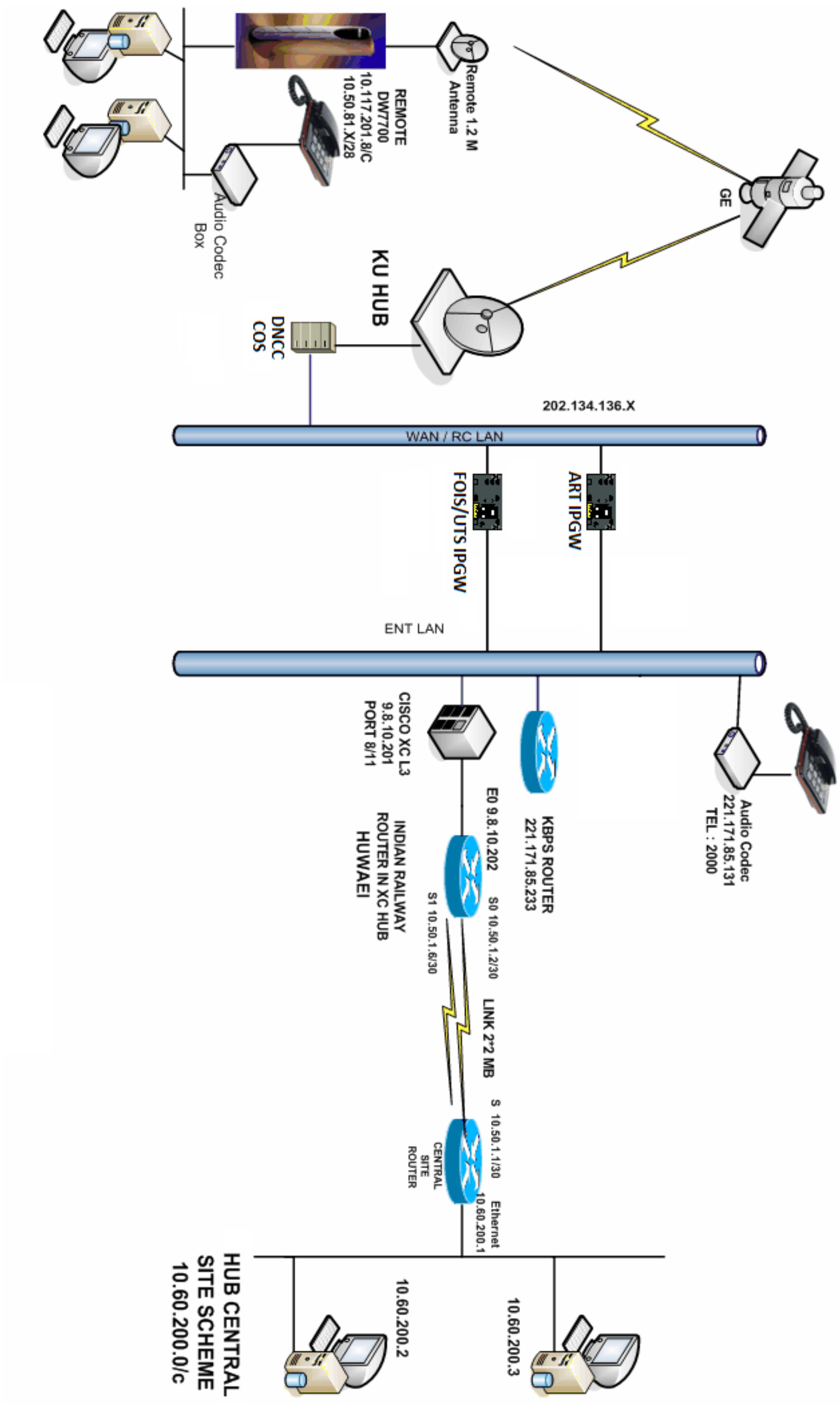
22.7.1 The performance of VSAT equipment both at Hub Earth Station and Remote Earth Station is affected by ambient conditions.

22.7.2 Hub Equipment generates a very high amount of heat. Continuous heat dissipation and marinating Normal temperature is an extremely important consideration for proper functioning of VSAT Hub Equipment.

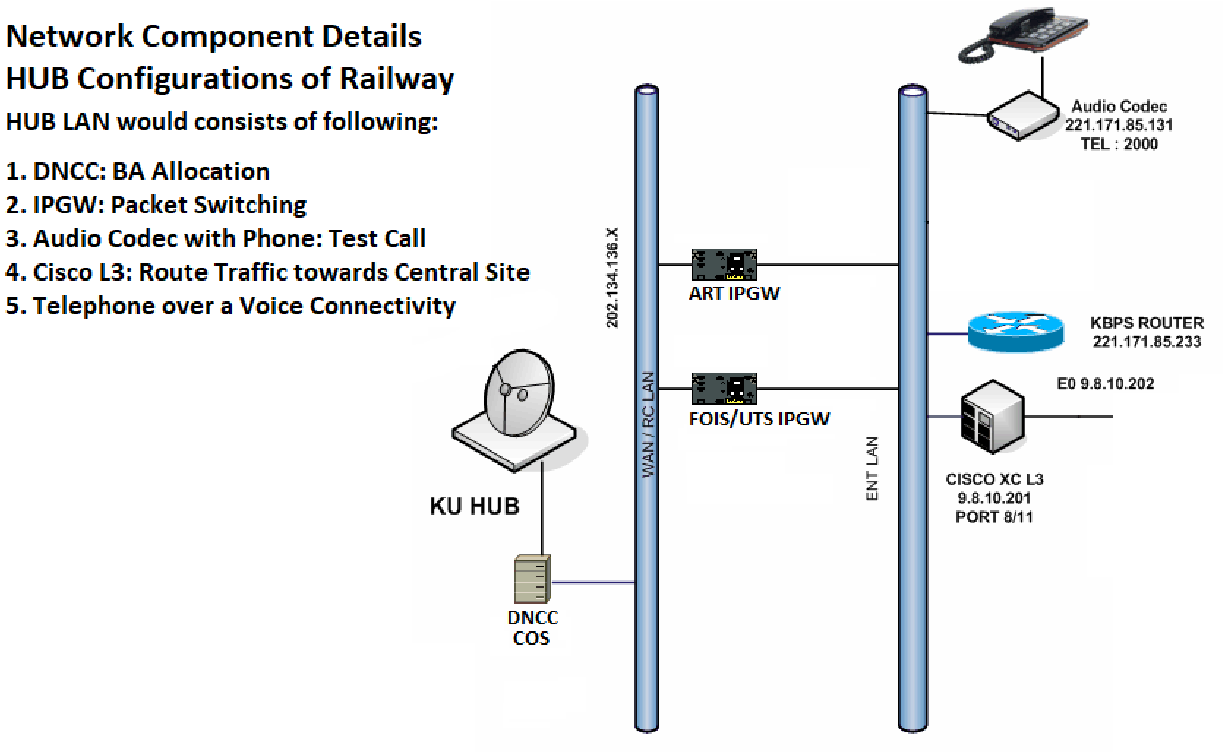
22.7.3 Some of the important items which are considered necessary for proper functioning of Remote Earth Station are as given below

i) Maintain the Room Temperature.
ii) Use On line UPS.
iii) Very Good Quality Earthing to be maintained.
iv) Dust free environment to be maintained.
v) Sufficient air circulation & access to Indoor Unit be there.
vi) Switch on the VSAT first and then switch on other accessories.
vii) Follow the Switch on Sequence strictly.
viii) Report any Problem related to any equipment to Hub.
ix) While doing so report full Problems and complete observations to Hub.
x) Use the Computer only for Intended applications.
xi) Make Sure your Computers are Virus FREE.
xii) Log all activities related to equipment failures & Engineer visits in a Log Book.
xiii) Allow authorized and Trained People only to operate the system.
xiv) Do not switch on the VSAT immediately after switching off.
xv) Do not Move the Indoor Unit after installation.
xvi) Do not keep any article on Indoor Unit.
xvii) Do not obstruct the air vents in front of the Indoor Unit.
xviii) Do not use an air cooler (water) for cooling.
xix) Do not Bend IFL cable.
xx) Do not use the PC for any other application.
xxi) Do not do any local servicing of the equipment.
xxii) Do not shift the equipment from one place to another in absence of trained persons.
xxiii) Do not load any software programs on the PC except the application.

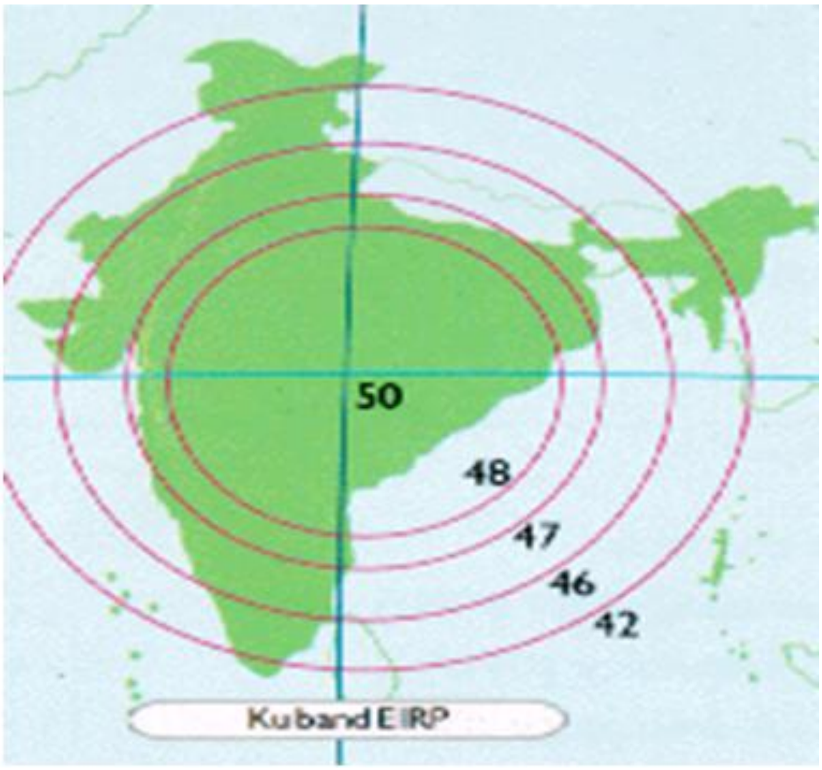
Annexure-1


Remote 1.2 M Antenna
REMOTE
DW7700
10.117.201.8/C
10.50.81.X/28
Audio Codec Box
GE
KU HUB
DNCC
COS
202.134.136.X
WAN / RC LAN
FOIS/UTS IPGW
ART IPGW
ENT LAN
CISCO XC L3
9.8.10.201
PORT 8/11
KBPS ROUTER
221.171.85.233
Audio Codec
221.171.85.131
TEL : 2000
E0 9.8.10.202
S0 10.50.1.2/30
INDIAN RAILWAY
ROUTER IN XC HUB
HUWAEI
S1 10.50.1.6/30
LINK 2*2 MB
S 10.50.1.1/30
CENTRAL
SITE
ROUTER
Ethernet
10.60.200.1
10.60.200.2
10.60.200.3
HUB CENTRAL
SITE SCHEME
10.60.200.0/c

Annexure-2


Network Component Details
HUB Configurations of Railway
HUB LAN would consists of following:
1. DNCC: BA Allocation
2. IPGW: Packet Switching
3. Audio Codec with Phone: Test Call
4. Cisco L3: Route Traffic towards Central Site
5. Telephone over a Voice Connectivity
Audio Codec
221.171.85.131
TEL : 2000
202.134.136.X
ART IPGW
KBPS ROUTER
221.171.85.233
E0 9.8.10.202
FOIS/UTS IPGW
WAN / RC LAN
ENT LAN
KU HUB
CISCO XC L3
9.8.10.201
PORT 8/11
DNCC
COS

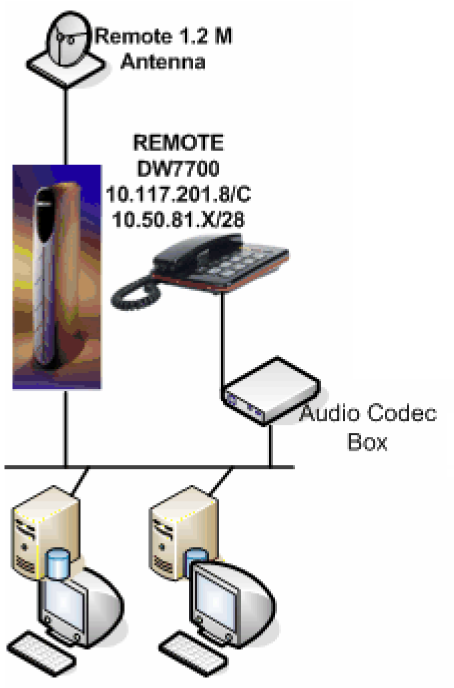
Annexure-3



Network Component Details
Remote Configuration

Remote LAN consists of following:

1. Remote 1.2M Antenna
2. HX90 IDU Unit
3. Remote Computers running Applications
4. Audio Codec Box
5. Telephone over a Voice Connectivity



Annexure-5

Remote Indoor Unit HX90 Platform

- Inbound HIS 512Kbps /1Mbps
- MPLS QoS
- DHCP server and relay support
- IGMPv2 for multicast to LAN
- VLAN Tagging
- ICMP support (pings, etc.)
- Embedded web server for remote status query and configuration
- NAT/PAT
- RIP V1/RIPv2/BGP
- DNS caching and preload
- VRRP
- Dynamic coding ACM/AIS
- CLTC and CLPC
- CBR/CIR/BE
- Static and Dynamic Addressing
- Inroute IP header compression
- RTP header compression
- PEP and inroute prioritization
- PEP and TCP payload compression
- Secondary satellite frequency support
- CBR support for real-time applications
- VADB

-x-x-x-

CHAPTER XXIII

PROTECTION OF TELECOM EQUIPMENTS AGAINST LIGHTNING

SECTION A

INTRODUCTION

23.1 GENERAL

Suitable protection arrangements shall be provided in telecom installations to protect the equipments from lightning and ensure safety of operational & maintenance staff.

23.2 PRINCIPLES OF PROTECTION:

The protection system shall provide a very low impedance parallel path to the ground in such a manner that discharge current due to lightning is transmitted to the earth through this path, instead of passing through the equipment.

SECTION B

COMPONENTS OF PROTECTION SYSTEM & INSTALLATION

23.3 LIGHTNING ARRESTER:

23.3.1 The lightning arrester shall consist of lightning spike to the earth electrode. The material and the size of the conductor shall be as given below:

MATERIAL	SIZE
G.I. WIRE	8mm dia
G.I. STRIP	20mm x 3mm

23.3.2 The lightning conductors shall be drawn in most direct possible path avoiding bends, upturn or kinks.

23.4 EARTH TERMINATION:

These are parts of the lightning protection system intended to distribute the discharge current into the general mass of the earth. The earth termination shall consists of suitable earth electrodes and underground conductors.

23.5 EARTH ELECTRODE:

23.5.1 Electrode Material & Size: Galvanised iron pipes or angles shall be used. In protected installations solid copper rod may also be used.

23.5.2 The size of the different types of electrodes shall be as under;

TYPE	SIZE
G.I. Pipe	Length >=2.5M Internal Diameter >= 38mm
G.I. ANGLE	Length > = 2.5M Cross section: 50 mm x 50mmx5mm
Copper Rod	Length >= 2.5 M Diameter= 16mm

23.6 INSTALLATION OF THE ELECTRODE:

The electrodes shall have a spike at one end and a clamp at the other end for connecting earth lead. The electrodes shall be directly driven in the earth up to a depth of atleast 2.5 M. Where rock is encountered at a depth less than 2.5M, the electrode shall be driven inclined by about 30 degrees to the vertical. In hard soil, hole for the electrode may be drilled by earth auger or by manual trenching. The top of the electrode shall be about 30 cm above the ground. After inserting the electrodes, the hole shall be filled with earth properly and water should be spread to ensure good contact between electrode and filling.

23.7 USE OF MULTIPLE ELECTRODES:

In cases where a single electrode is not sufficient to provide the desired earth resistance, more than one electrode shall be used. The separation of the electrodes shall be about 4 M.

23.8 CALCULATION OF THE NUMBER OF ELECTRODES:

Approximate calculation of the number of electrodes required to get desired value of earth resistance, can be made using the guidelines given in Annexure-A

23.9 ARTIFICIAL TREATMENT OF SOIL:

In soils of high resistivity, even multiple earth electrode may not provide desired earth resistance. In such cases the soil should be artificially treated with salt and charcoal in appropriate proportion. Earth pits of 600 mm dia and 2.5 M depth shall be formed by excavation and the electrode shall be placed at the centre of the pit. The pit shall be filled alternatively with layers of common salt & charcoal, each layer of about 2.5cm thick, up to a depth of about 20 cm from the ground level. The pit shall be filled several times with water, which shall be allowed to be soaked in the ground. After this treatment, the pit shall be covered with excavated earth and water shall be sprayed to ensure good electrical contact. This earth electrode should be cleaned at least once in two years or whenever it is found that the resistance is above required value by excavating the earth and the process of filling with layers of salt and charcoal to keep the earth resistance to the required level.

23.10 BONDS:

Bonds made of mild steel clamps with galvanised nuts & bolts shall be used to connect the lightning protection system with other metallic structures like metallic poles, water pipes etc. The bonds shall have more cross sectional area than the main lightning conductor and it shall be protected against corrosion.

23.11 JOINTS:

23.11.1 As far as possible joints shall be avoided in lightning conductors and underground earth conductors.

23.11.2 The joints shall be crimped, riveted, welded or soldered so as to ensure minimum electrical impedance for the surge current.

23.11.3 All joints of bimetallic elements shall be protected from corrosion by covering the joint with loaded grease or M-seal compounds.

23.12 TESTING POINT:

A clamp between earth termination at the electrodes and the down conductors shall be provided to facilitate isolation of the two sections & measurement of earth resistance. This joint, known as testing point, shall be made of mild steel with galvanised nuts & bolts.

23.13 TOWER GROUND RING:

This is the earthing system to be provided at the foot of towers used for telecom applications.

This shall consist of earth electrodes and under ground tinned bare copper conductor forming the ground ring as shown in FIG-1 & 2.

Earth electrodes shall be installed at an interval of about 4 Meter surrounding the tower foundation. Bare tinned copper conductor of 38 sq. mm shall be burried at least 2.5M below the ground level and at a distance of 0.5M from the tower foundation. The conductor shall be soldered /clamped /welded to the electrodes to provide good electrical connection. Each leg or two diagonal legs of the tower shall be connected to the tower ground ring with 2 nos. of 6mm dia copper wire.

23.14 EXTERNAL GROUND RING:

The external ground ring is the earthing system surrounding the plinth of the building, housing telecom equipment. This shall be constructed in the same manner as tower ground ring. The layout is shown in Fig 1.

23.15 INTERNAL GROUND RING:

This is the earthing arrangement to be provided inside the equipment room. This shall consist of earth bus bar(25 mm x 5mm copper flat or 38mm sq. bare tinned copper conductor) installed surrounding the equipment room 0.5m below the ceiling or 0.5 M above the floor level. The layout is shown in Fig. 2.

23.16 **SINGLE EARTH SYSTEM:**

The telecom installations shall use single earth system in which the different earth connections from equipments, towers, DC power supply, metallic structures etc. shall be interconnected to each other through low resistance earthing conductors. This method is recommended to keep all the points to be earthed at approximately same potential level in order to reduce the possibility of side flash & subsequent damages.

SECTION C

PROTECTION ARRANGEMENT AT AC MAINS SUPPLY

23.17 **AC MAINS EARTHING SYSTEM:**

The A.C. mains earthing system shall be as per the rules and regulation issued by local power supply agency.

23.18 **TERMINATION OF OVERHEAD POWER LINES:**

If mains supply is provided through overhead lines, the over head lines shall be terminated about 100M away from the building of sensitive telecom installation such as telephone exchange, radio relay or optical fibre installations.

23.19 **CONNECTION FROM LOW VOLTAGE MAINS:**

Connection for low voltage mains shall be drawn through underground cable. The power cable sheath must be fully insulated from the earthing network of the telecom equipments.

23.20 **SEPARATION BETWEEN MAINS EARTH & TELECOM EARTH**

The protective earth of telecom system shall not be connected to the earth of mains power supply system. A minimum distance of 10 M is desirable.

23.21 **PROTECTION ARRANGEMENT ACROSS AC MAINS SUPPLY TO TELECOM INSTALLATIONS:**

Low voltage lightning discharger of nominal rating of 650V shall be provided across the 230 V mains power supply as shown in Fig 1 & 2. In case of high tension supply (11KV or above) are terminated near the telecom installation, suitable pole mounted high voltage arrester shall be provided.

SECTION D

PROTECTION ARRANGEMENT ACROSS DC POWER SUPPLY

23.22 PROTECTION AT DC POWER SUPPLY:

Suitable protection arrangement consisting of avalanche diode and L-C network shall be provided at the DC power supply point at the power distribution board and in heavy lightning prone areas, at the input terminals of the equipment. The rating of the diode shall be at least 20% above the nominal supply voltage.

SECTION E

PROTECTION OF UNDERGROUND CABLE

23.23 PROTECTION AT SUBSCRIBER PREMISES:

In heavy lightning prone areas, the underground cable shall be terminated with line protector arrangement consisting of gas discharge (GD) tubes & MOVR.
The specification of the protection arrangement is given in Annexure-B.

23.24 PROTECTION AT CABLE JUNCTION /TERMINATION BOXES:

The metallic sheath or armour of the cable shall be earthed. In the cable termination/junction box, the sheath should be connected to the metallic body of the box which shall be earthed. In non metallic boxes a separate provision shall be made to earth the cable sheath.

23.25 PROTECTION AT TRANSMISSION/SWITCHING END:

The metallic sheath shall be earthed and protective device as mentioned in Para 23.23 above shall be provided for each pair including unused pairs.

23.26 PROTECTION AT TRANSITION POINT BETWEEN OVERHEAD LINES & UNDERGROUND CABLE

If the distance of the overhead lines drawn from the cable termination box exceeds 500 meters, protection arrangement consisting of GD tube & MOVR shall be provided for each pair of the conductor including unused pairs & the common earth point shall be connected to earth electrodes.

SECTION F

PROTECTION FOR CIRCUITS ON OVERHEAD WIRES

23.27 The protection arrangements similar to those of underground cable shall be provided. Every tenth pole of the overhead alignment shall be provided with earthed lightning arrestor to reduce the intensity of discharge current along the overhead line.

SECTION G

PROTECTION ARRANGEMENTS IN MICROWAVE, UHF & TRAIN RADIO STATIONS

23.28 **PROTECTION ARRANGEMENTS FOR RADIO STATIONS**

The lightning surges in microwave, UHF & train radio stations may get entry into the equipment through any of the following paths-

- Tower, waveguide or radio frequency coaxial cable
- AC mains power supply
- Over head telephones wires or underground telecommunications cables.

Adequate protection arrangement shall be provided in each case to protect the equipment from damages.

23.29 **RISK INDEX:**

The degree of protection required and the protection devices necessary to be installed shall be based on the RISK INDEX of the particular location. A method for calculation of the risk index is given in Annexure-C.

23.30 **PROTECTION ARRANGEMENT OF RADIO TOWERS:**

23.30.1 PROVISION OF TOWER GROUND RING:

Tower ground ring as mentioned in para 23.13 shall be provided for all towers.

23.30.2 PROVISION OF LIGHTNING SPIKE:

Lightning spike as mentioned in para 23.3 shall be provided for all towers, on the top of the tower.

23.30.3 PROTECTION FOR TOWERS SITUATED ON GROUND:

In case of towers erected directly on ground the lower legs act as down conductors & no separate lightning conductor from lightning spike to earth is necessary. Each tower leg shall be connected to the tower ground ring by 2 no. of 14mm dia copper wire.

23.30.4 PROTECTION FOR TOWERS ON THE TOP OF BUILDING:

The tower legs shall be connected to lightning conductors which shall be drawn along the building wall and connected to the earth termination at ground. At least two number of such conductors shall be drawn. The earth termination shall be constructed in the same manner as the tower ground ring.

23.31 PROTECTION ARRANGEMENTS OF RADIO RELAY STATIONS WITH HIGH RISK INDEX:

The protection arrangement as given in Fig-1 shall be taken for stations with risk index 80 or more. The arrangement shall consist of the following:

(a) TOWER GROUND RING;
(b) EXTERNAL GROUND RING;
(c) INTERNAL GROUND RING;

23.31.1 The tower ground ring shall be connected at two places to the external ground ring with 6mm dia bare tinned copper conductor laid in underground trenches.

23.31.2 The waveguide run shall be connected to the tower metal structure at the top and the bottom. The waveguide portion inside the building shall be connected to the tower ground by 6mm dia copper wire.

23.31.3 The external metallic sheath of RE coaxial cable shall be earthed in the same manner as in case of waveguide.

23.31.4 Following shall be connected to the internal ground ring:

(a) The battery charger positive terminal, earth terminals of microwave/UHF/train radio/Optical fibre equipments, Multiplexing equipments.

(b) The earth terminal of lightning ARRESTER & MOVRs provided in the DC circuits.

(c) All conduits, battery trays, battery chargers, cable trays, jumper wire cable trays.

(d) All incidental metal objects such as ducts, distribution frame, metal door frames etc.

For all these connections 4mm dia copper or 6mm dia copper clad steel wire shall be used.

23.31.5 Each rack /equipment shall have separate earth connection to the internal ground ring.

23.31.6 The internal ground ring is to be bonded to the external ground at 4 corners of the building with 6 mm copper wire.

23.32 **PROTECTION SCHEME FOR RADIO STATIONS WITH LOW RISK INDEX:**

Protection arrangement as per Fig 2 shall be provided.

23.32.1 The protection arrangement shall consist of :
(a) TOWER GROUND RING
(b) INTERNAL GROUND RING

The internal ground ring shall be connected to the tower ground ring by 6MM dia copper at minimum two places.

23.32.2 Following shall be connected to the internal ground ring

(a) Battery charger positive.
(b) Ground terminal of the microwave radio & multiplexing equipment.
(c) Ground terminal of lighting arrestors across the charger.
(d) Ground terminal of GD tube & MOVR.

23.32.3 The waveguide portion inside the building near the branching filter shall be connected to the tower ground ring with 6mm copper wire. The waveguide support ladder shall be connected to tower ring.

23.32.4 The waveguide shall be connected to tower structure at the top and the bottom.

SECTION H

PROTECTION ARRANGEMENT FOR TELEPHONE EXCHANGES

23.33 The protection system of telephone exchanges shall be similar to the radio relay station excepting that no tower earth is required. Suitable protection arrangement with fuse, GD tube and MOVR shall be provided.

23.33.1 EARTHING REQUIREMENT:

External ground ring similar to the radio relay stations shall be provided for telephone exchanges.

23.33.2 Three stage system consisting of fuse, GD tube and MOVR shall be provided in the line side of the electronic telephone exchanges. However, for exchanges where above protections are inbuilt in the design of MFG and line cards, no separate protection is required.

23.33.3 Lighting protection arrangement as described in para 23.22 shall be provided across DC supply voltage at the power distribution board.

23.33.4 Metallic structures, chassis, racks etc. shall be connected to the external earth in the same manner as in radio relay stations.

SECTION I

INSPECTION & TESTING

23.34 The complete protection arrangement should be inspected and tested by ASTE/DSTE/Sr.DSTE to ensure that the work has been completed in a satisfactory manner and the material and components used conform to the standard.

23.35 Routine inspection of the installation, particularly the earth resistance shall be taken twice a year by the SE/SSE incharge of the station and Earth connections of all installation should be checked thoroughly two months in advance of every monsoon season and remedial measures should be taken well in advance of monsoon.

23.36 A log book shall be kept in which details of the measurement and inspection should be recorded for scrutiny by higher officials.

ANNEXURE-A

Para 23.8

CALCULATION OF EARTH RESISTANCE & NUMBER OF ELECTRODES

The approximate earth resistance of the rod/pipe electrodes can be calculated by the following formulae.

R = 0.75 X o/L if 25 < L/d < 100

= o/L if 100 < L/d < 600

= 1.2 o/L if 600 < L/d < 300

where, o = Resistivity of earth in Ohm.M
L= Length of the electrode in M.
d= Diameter of the electrode in M.

Assuming a value of 'o'=40, L=2.5M , d = 38 mm
the value of R comes out to be = 12 ohms.

Thus with one electrode the earth resistance is 12 ohms.

If the desired earth resistance is equal to R(d), the no. of electrodes required to achieve the above resistance can be approximately calculated by
R(d) = (1.5/N) x R where,

R= Resistance of single electrode
N= No. of electrodes installed in parallel at a distance of 3 to 4 M interval.

Thus to get earth resistance of 1 ohm the total no. of electrodes required
N= 1.5 x 12= 18

The representative values of soil resistivity in various parts of India are given for ready reference.

Representative values of soil resistivity in various parts of India

S. No.	Locality	Type of soil	Order of resistivity in ohm meter	Remarks
1	**2**	**3**	**4**	**5**
1	Kakarepar, Surat Distt. Gujarat	Clayay black soil	6-23	Underlying bedrock Deccan trap
2	Taptee Valley	Alluviium	6-24	-do-
3	Narmada Valley	Alluvium	4-11	Underlying bedrock-sand stones, shale and limestones, Deccan trap,

				and geneises.
4	Purna Valley(Deogaon)	Agricultural	3-6	Underlying bedrock Deccan trap.
5	Dhond, Bombay	Alluvium	6-40	-do
6	Bijapur Distt. Mysore State	(a) black cotton soil (b) Moorm	2-10 10-50	-do-
7	Carimenapenta, Nellore Distt., Andhra Pradesh.	Alluvium(Highly clayey)	2	Underlying bedrock geniuses.
8	Kartee	(a) Alluvium (b) Alluvium	3-5 9-21	Underlying bedrock sand-stone, trap or geniuses.
9	Delhi (a)Najafgarh (b)Chhatarpur	(a) Alluvium(dry, sandy soil) (b) Loamy to Clayey soil) alluvium(Saline) Dry Soil	75-170 38-50 1.5-9 36-109	-do- -do- -do- Underlying bedrock quartzites
10	Korba, M.P.	(a) Moist Clay (b) Alluvium soil	2-3 10-20	Underlying bedrock sand-stones or shale.
11	Cossipur, Calcutta.	Alluvium	25(Approx)	--------------
12	Bhagalpur Bihar	(a) Alluvium (b) Top Soil	9-14 24-46	Underlying bedrock traps, sand -stones or gneisses.
13	Kerala(Trivendrum Distt)	Leteritic Clay	2-5	Underlying bedrock leterite charnockite or ghanites.
14	Bharatpur	Sandy, loam(saline)	6-14	------
15	Kalyadi, Mysore.	Alluvium	60-150	Underlying bedrock gneisses.
16	Kolar Gold fields	Sandy surface	45-185	-do-
17	Wajrakarur, Andhra Pradesh	Alluvium	50-150	-do-
18	Koyna, Satara Distt.	Lateritic	800-1200(dry)	Underlying bed-rock sand-laterite or trap.
19	Kutch-kandla	(a) Alluvium(clayey) (b) Alluvium(Sandy)	4-50 60-200	Underlying bedrock sand-stone, shale or trap. -do-
20	Villupuram Madras	Clayey sands	11	Underlying bedrock-granite.
21	Ambaji, Banaskantha, Gujarat.	Alluvium	170	Underlying bedrock-sand-stones and gneisses.

22		(a) Alluvium (b) Lateritic soil	2-5 300 (approx)	Underlying bedrock sand-stones and gneisses. -do-
Note: The soil resistivities are subject to wide seasonal variation as they depend very much on the moisture content.				

ANNEXURE – B

Para23.23

PROTECTION ARRANGEMENT FOR SUBSCRIBERS LINES

General Specification:

i) Response Time	- < 1 micro sec.
ii) Protection level	- ~ 22 V
iii) Discharge current	- > 10 KA
iv) Insulation resistance	- > 10^{8} Ohms
v) Capacitance	- ~ 3 pf
vi) Series resistance	- 20 Ohms

Specification of Gas Arrestor: (Discharge Tube)

i) DC spark over voltage - 300 - 500 V.

ii) Impulse spark over voltage (1 KV/micro sec.) 800V

iii) Nominal impulse discharge current (8/20 micro Sec. wave) - 10 KA

iv) Insulation resistance at (100 VDC) - 10^{10} Ohms

v) Capacitance - 2.5 pf

Specification of MOVR:

i) Protection level voltage	- 22 V
ii) Surge current at (8/20 micro sec. wave)	- upto 50 amps.
iii) Average power dissipation	- 0.02 W
iv) Insulation resistance	- > 100 M.Ohms.
v) Capacitance	- ~ 2 pf

ANNEXURE - C

CALCULATION OF RISK INDEX BASED ON VARIOUS FACTORS AFFECTING RISK OF LIGHTNING AND CONSEQUENTIAL DAMAGE

1. **Usage of Structure:**

   If the structure is generally occupied by a large number of people, the consequential damage could be quite high. In case of radio relay installations, since they can be treated as places occupied by a limited number of people and having a tall outdoor metallic structure, the value of the index is 4.

2. **Type of construction:**

   A steel framed building is self-protecting against lightning while brick buildings require greater degree of protection. In case of Radio Relay installations:-

   i. For reinforced concrete building with any roof other than metal- index is 2.
   ii. For Brick, plain concrete or masonary with any roof other than metal or thatch - the index is 4.
   iii. Reinforced concrete with metal roof - 7
   iv. Brick, plain concrete, masonary with metal roofing the index is - 8.

3. **Contents or consequential effects:**

   If the installation contains equipment, damage to which will seriously disrupt normal working, then such an installation requires a higher level of protection. In case of radio relay installations, the value of the index is 6.

4. **Degree of Isolation:**

   In closely built-up towns and cities, the lightning hazard is not as great as in the open country. For radio relay installations, the index value is

   i. For structures located in a large area of structures of trees of the same or greater height, for example in a large town or forest-2.

   ii. For structures located in an area with few other structures or trees of similar height-5.

   iii. For structures completely isolated or exceeding at least twice the height of surrounding structures or trees- 10.

   iv. or radio relay stations with no motorable approach roads to the top and attendant difficulties in transporting equipment and reaching the station after sun-set, an index value of 10 is to be added to the values at (i) to (iii) above,

v. For radio relay stations situated on rocky soil where it is difficult to get a good earth connection an index value of 10 is to be added to the values of (i) to (iv) above.

5. **Type of Terrain:**

An installation in a hilly or mountainous area is more susceptible to damage than a building in plains and flat terrain. In case of radio-relay installations;

i. Situated on flat terrain at any level - index value is 2.
ii. Hill terrain - index value is 6.
iii. Mountainous terrain between 500 m to 1000 m- index value is 8.
iv. Mountainous terrain above 1000m - index value is 10.

6. **Height of Structures:**

Taller structures are subject to greater hazards, than smaller structures and therefore lightning protection is more desirable in tall structures. In case of Radio Relay installations, since the height of the tower is the deciding factor, the following index values are to be adopted:-

Height of Structures (Height of tower, or height of building + tower in meters where tower is mounted on the building)

Exceeding	Not Exceeding	Value of Index
-	10 meters	2
10 meters	15 meters	4
15 meters	20 meters	5
20 meters	20 meters	8
20 meters	30 meters	11
30 meters	35 meters	16
35 meters	40 meters	19
40 meters	45 meters	22
45 meters	55 meters	30
55 meters	60 meters	32
60 meters	70 meters	35
70 meters	80 meters	37
80 meters	90 meters	39
90 meters	100 meters	40

Structures higher than 55m require protection in all cases.

7. **Lightning Prevalence:**

Isokaraunic level (IKL) refers to the number of thunders storm days in a year at a particular place: the map at Appendix B shows the Average IKL in different parts of the country". The risk of lightning strike increases with the IKL but the severity of lightning storms , as distinguished from their frequency of occurrence is much greater in some locations than in others. Hence the need for protection at certain places may not be in direct proportion to IKL.

The value of the index as a function of IKL is as under:-

Number of thunderstorms days per year

Exceeding	Not Exceeding	Value of Index
-	5	4
5	10	8
11	15	13
16	20	18
21	-	21

Examples of Index Figure Calculations:

a) Secunderabad Station S.C.Rly(situated in crowded areas)

	Factor	Category	Risk Index
1	Usage of structure	Occupied by limited number of people	4
2	Types of construction	RCC with tower on top	7
3	Contents of consequential effects.	Communication network of Indian Railways	6
4	Degree of Isolation	Height exceeds twice the height of surrounding structures.	10
5	Type of terrain	Flat terrain	2
6	Height of structure	60m(Tower and Building)	32
7	IKL	28	21
	Index Figure= 4+7+6+10+2+32+21-= 82		

b) Peddagutta (situated on an isolated hill) S.C.Rly

1	Usage of structure	Same as above (in a)	4
2	Type of construction	RCC Building with tower on top	7
3	Contents	Same as above (in a)	6
4	Degree of isolation	On an isolated hill	10+10+10
5	Type of Terrain	Mountainous terrain between 500 to 1000m.	8
6	Height of structure	10-15m(Building tower)	4
7	IKL	43(Approx.)	21
	Index figure	= 80	

c) Ongole - SC Rly (along the East Coast)

1	Usage of Structure	Same as above (in a)	4
2	Type of construction	RCC building with other than metallic roof	2
3	Contents	Same as above (in a)	6
4	Degree of Isolation	Height exceeding twice the surround structure	10

5	Type of Terrain	Hill terrain	6
6	Height of structure	Height of tower is 90m	39
7	IKL	25	21
	Index figure:	88	

d) New Delhi- N.Rly(situated in crowded area)

1	`Usage of structure	Same as above (in a)	4
2	Type of construction	RCC building with other than metallic roof.	2
3	Contents	Same as above (in a)	6
4	Degree of Isolation	Located in the midst of structure of comparable height	2
5	Type of Terrain	Flat terrain	2
6	Height of structure	Height of tower(50m)	30
7	IKL	38	21

Index Figure: 67

e) Bilaspur- S.E.Railway

1	Usage of structure	Same as above (in a)	4
2	Type of construction	RCC building without metal roofing	2
3	Contents	Same as above (in a)	6
4	Degree of Isolation	Exceeds double the height of structures surrounding	10
5	Type of terrain	Flat terrain	2
6	Height of structure	Ht. of tower 90m	39
7	IKL	34(approx)	21
	Risk Index=	84	

f) Surat- W.Rly(along the West coast)

1	Usage of structure	Same as above (in a)	4
2	Type of construction	RCC building without metal roofs	2
3	Contents	Same as above(in a)	6
4	Degree of isolation	Exceeds double the height of the surrounding structures	10
5	Type of Terrain	Flat	2
6	Height of structure	Height of tower (50m)	30
7	IKL	4	

Risk Index: 58

g) Uruli (Central Railway)

1	Usage of structure	Same as above (in a)	4
2	Type of construction:	RCC building without metal proof	2
3	Contents	Same as above (in a)	6
4	Degree of Isolation	exceeds double the height of surrounding structures.	10+10
5	Type of Terrain	Hill terrain	6
6	Height of structure	50m tower	30
7	IKL	21	

Risk Index : 89

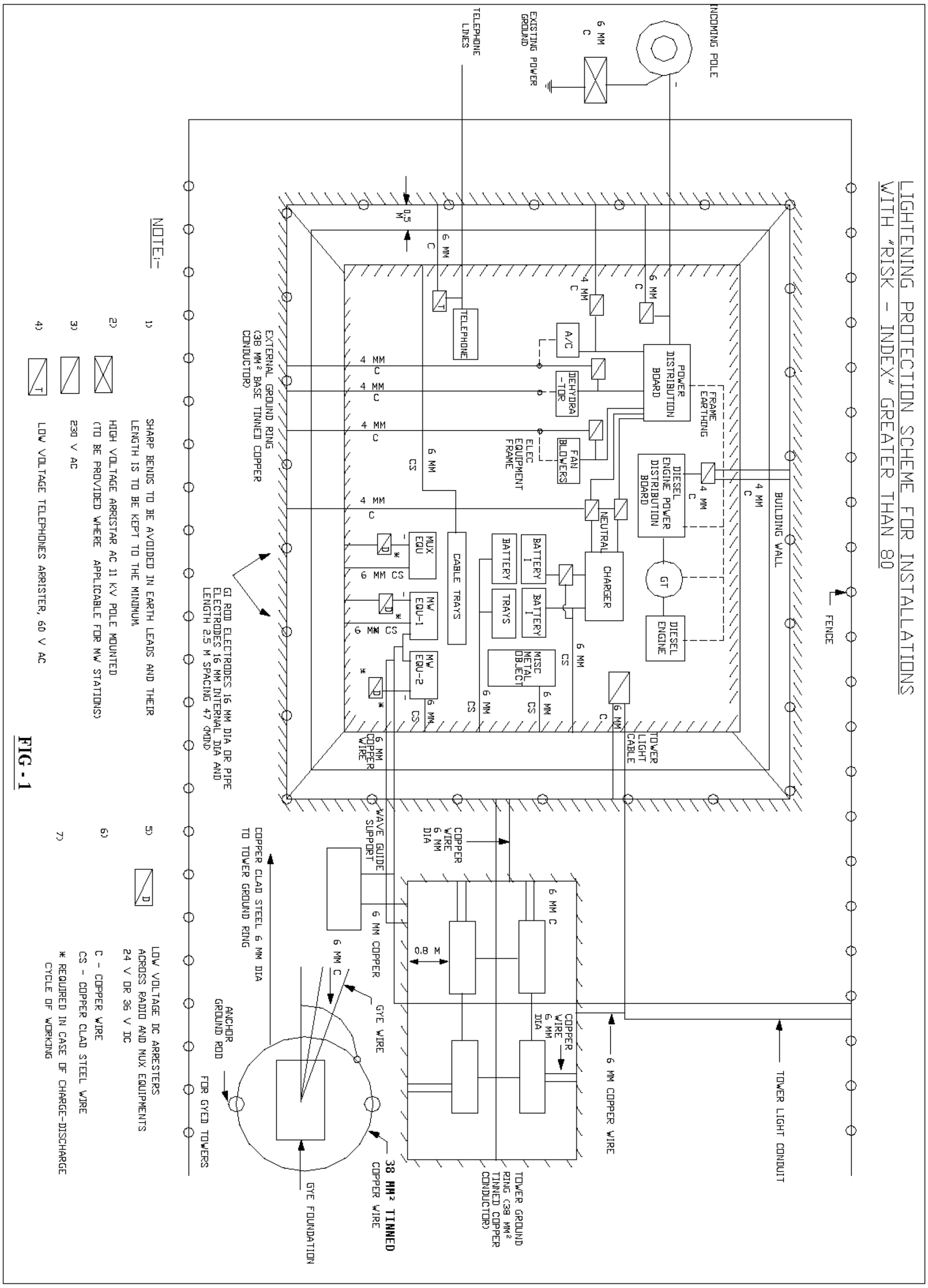
ISO XERAUNIC DATA
(Reproduced from IS 2309-1969)

S.No.	Name of Place	Annual Thunderstrom days
1	Gilgit	7
2	Skardu	5
3	Gulmarg	53
4	Srinagar	54
5	Dras	3
6	Kargil	2
7	Leh	3
8	Jammu	26
9	Dharamshala	13
10	Amritsar	49
11.	Pathankot	4
12.	Mandi	46
13	Ludhiana	12
14	Simla	40
15	Patiala	26
16	Ambala	9
17	Hissar	27
18	Delhi	39
19	Bikaner	10
20	Phalodi	14
21	Sikar	17
22	Barmer	12
23	Jodhpur	23
24	Ajmer	26
25	Jaipur	39
26	Kankroli	36
27	Mount Abu	5
28	Udaipur	38
29	Neemuch	28
30	Kota	27
31	Jallawar	40
32	Mussorie	61
33	Roorkee	74
34	Najibabad	36
35	Mukteshwar	53
36	Meerut	-
37	Bareilly	34
38	Aligarh	30
39	Agra	25
40	Mainpuri	23
41	Baharaich	31`
42	Gonda	22
43	Lucknow	18
44	Kanpur	26
45	Fatehpur	24
46	Jhansi	20
47	Allahabad	51
48	Varanasi	51

49	Azamgarh	1
50	Gorakhpur	11
51	Kathmandu	74
52	Motihari	38
53	Darbhanga	10
54	Patna	33
55	Gaya	38
56	Daltonganj	73
57	Hazaribagh	73
58	Ranchi	34
59	Chaibasa	70
60	Jamshedpur	66
61	Purnea	52
62	Sabour	76
63	Dumka	63
64	Darjeeling	28
65	Jalpaiguri	68
66	Malda	59
67	Asansol	71
68	Burdwan	39
69	Khargpur	76
70	Calcutta	70
71	Sagar Island	41
72	Dhubri	8
73	Tejpur	27
74	Dibrugarh	98
75	Sibsagar	103
76	Shillong	75
77	Cherrapunji	49
78	Silchar	33
79	Kohima	34
80	Imphal	49
81	Deesa	7
82	Dwarka	5
83	Jamna Nagar	8
84	Rajkot	12
85	Ahmedabad	11
86	Dohad	17
87	Porbundar	3
88	Varaval	3
89	Bhavnagar	11
90	Baroda	8
91	Surat	4
92	Gwalior	53
93	Guna	33
94	Nowgong	59
95	Satna	41
96	Sagar	36
97	Bhopal	44
98	Jabalpur	50
99	Umaria	37
100	Ambikapur	29
101	Indore	34
102	Hoshangabad	37
103	Pachmarhi	30

104	Seoni	51
105	Pendaiah	56
106	Raipur	34
107	Chindawara	27
108	Kanker	37
109	Jagdalpur	35
110	Balasore	81
111	Chandbali	75
112	Angul	81
113	Bhubaneshwar	46
114	Puri	33
115	Gopalpur	34
116	Jharsuguda	85
117	Sambalpur	67
118	Titlagarh	24
119	Rajgangpur	1
120	Dhahanu	1
121	Nasik	17
122	Maligaon	13
123	Akola	20
124	Amraoti	32
125	Nagpur	45
126	Gonda	10
127	Aurangabad	34
128	Bombay	16
129	Aligarh	12
130	Ahmadnagar	10
131	Parbhani	32
132	Pune	22
133	Mahabaleshwar	14
134	Ratnagiri	6
135	Sholapur	23
136	Miraj	25
137	Vengurla	39
138	Najibabad	36
139	Hanamkonda	43
140	Hyderabad	28
141	Khammam	26
142	Kalingapatnam	20
143	Vishakhapatnam	46
144	Rentichintala	42
145	Masulipatnam	20
146	Ongole	25
147	Kurnool	29
148	Anantapur	22
149	Nellore	18
150	Bidar	15
151	Gulbarga	34
152	Bijapur	9
153	Belgaum	31
154	Raichur	17
155	Gadag	21
156	Bellary	22
157	Karwar	27
158	Honawar	5

159	Chikalthana	24
160	Mangalore	36
161	Hassan	26
162	Bangalore	46
163	Mysore	44
164	Kozhikode	39
165		
166	Cochin	69
167	Allopey	51
168	Trivandrum	68
169	Vellore	25
170	Madras	47
171	Cotacamud	24
172	Salem	69
173	Cuddalore	37
174	Coimbatore	40
175	Tiruchirapalli	41
176	Nagapattinam	15
177	Kodikanal	82
178	Madurai	39
179	Pambam	5
180	Tuticorin	14
181	Cape Comorin	68
182	Port Blair	62
183	Car Nicobar	18
184	Minicoy	20



LIGHTENING PROTECTION SCHEME FOR INSTALLATIONS WITH "RISK - INDEX" GREATER THAN 80
INCOMING POLE
6 MM C
EXISTING POWER GROUND
TELEPHONE LINES
FENCE
BUILDING WALL
0.5 M
POWER DISTRIBUTION BOARD
FRAME EARTHING
TELEPHONE
A/C
DEHYDRA -TOR
FAN BLOWERS
ELEC EQUIPMENT FRAME
DIESEL ENGINE POWER DISTRIBUTION BOARD
GT
DIESEL ENGINE
NEUTRAL
CHARGER
BATTERY I
BATTERY
TRAYS
CABLE TRAYS
MUX EQU
MW EQU-1
MW EQU-2
MISC METAL OBJECT
TOWER LIGHT CABLE
6 MM COPPER WIRE
4 MM C
6 MM CS
6 MM C
EXTERNAL GROUND RING (38 MM² BASE TINNED COPPER CONDUCTOR)
GI ROD ELECTRODES 16 MM DIA OR PIPE ELECTRODES 16 MM INTERNAL DIA AND LENGTH 2.5 M SPACING 4? (MIN)
WAVE GUIDE SUPPORT
COPPER WIRE 6 MM DIA
6 MM COPPER
0.8 M
COPPER CLAD STEEL 6 MM DIA TO TOWER GROUND RING
GYE WIRE
ANCHOR GROUND ROD FOR GYED TOWERS
38 MM² TINNED COPPER WIRE
GYE FOUNDATION
TOWER GROUND RING (38 MM² TINNED COPPER CONDUCTOR)
6 MM COPPER WIRE
TOWER LIGHT CONDUIT
NOTE:-
1) SHARP BENDS TO BE AVOIDED IN EARTH LEADS AND THEIR LENGTH IS TO BE KEPT TO THE MINIMUM.
2) HIGH VOLTAGE ARRISTAR AC 11 KV POLE MOUNTED (TO BE PROVIDED WHERE APPLICABLE FOR MW STATIONS)
3) 230 V AC
4) LOW VOLTAGE TELEPHONES ARRISTER, 60 V AC
5) LOW VOLTAGE DC ARRESTERS ACROSS RADIO AND MUX EQUIPMENTS 24 V OR 36 V DC
6) C - COPPER WIRE
CS - COPPER CLAD STEEL WIRE
7) * REQUIRED IN CASE OF CHARGE-DISCHARGE CYCLE OF WORKING

FIG - 1

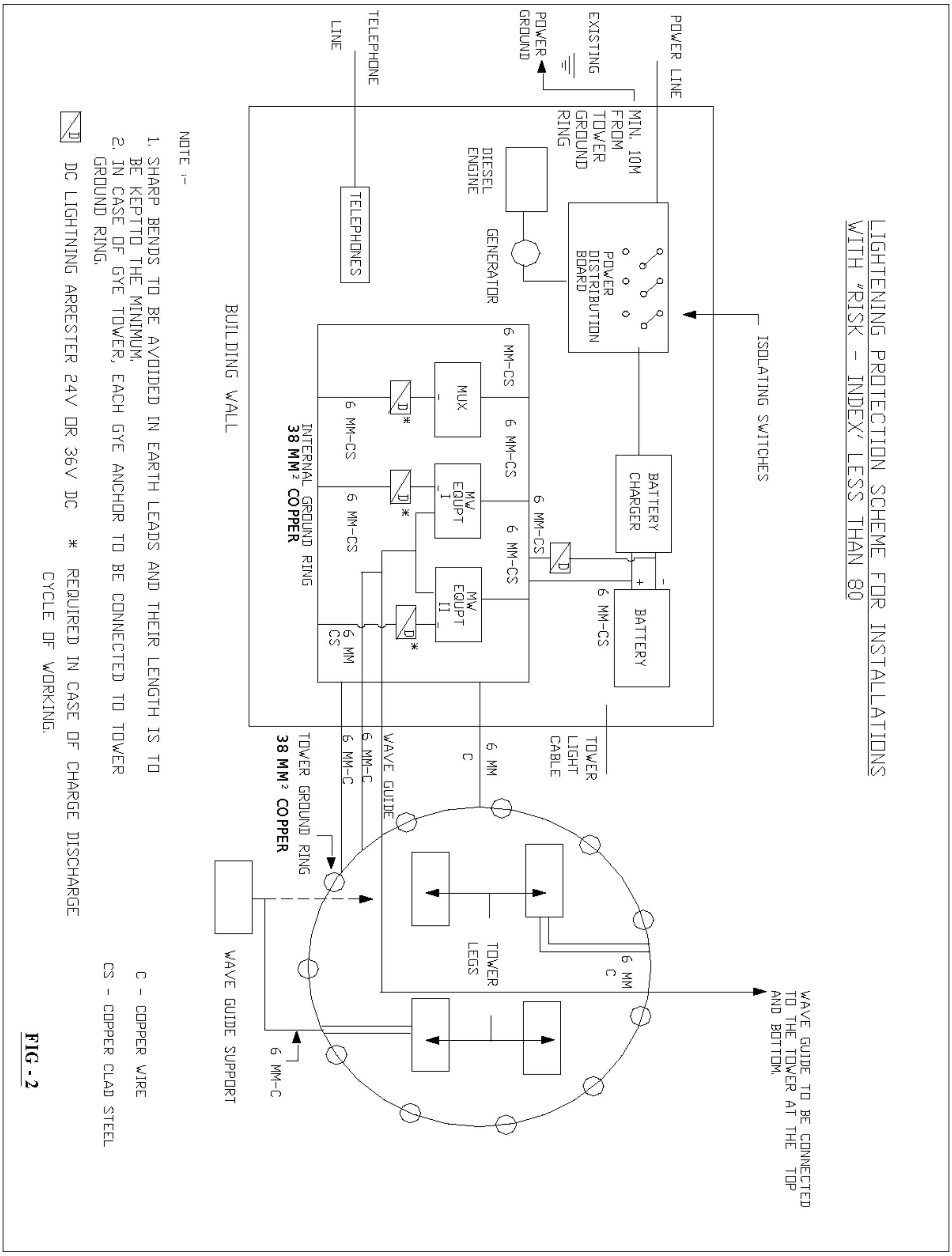

LIGHTENING PROTECTION SCHEME FOR INSTALLATIONS
WITH "RISK - INDEX' LESS THAN 80
POWER LINE
EXISTING
POWER GROUND
TELEPHONE LINE
MIN. 10M FROM TOWER GROUND RING
DIESEL ENGINE
GENERATOR
POWER DISTRIBUTION BOARD
ISOLATING SWITCHES
TELEPHONES
BATTERY CHARGER
BATTERY
6 MM-CS
MUX
MW EQUPT I
MW EQUPT II
INTERNAL GROUND RING
38 MM² COPPER
6 MM CS
BUILDING WALL
TOWER LIGHT CABLE
6 MM C
WAVE GUIDE
6 MM-C
TOWER GROUND RING
38 MM² COPPER
TOWER LEGS
WAVE GUIDE TO BE CONNECTED TO THE TOWER AT THE TOP AND BOTTOM.
WAVE GUIDE SUPPORT
NOTE :-
1. SHARP BENDS TO BE AVOIDED IN EARTH LEADS AND THEIR LENGTH IS TO BE KEPTTO THE MINIMUM.
2. IN CASE OF GYE TOWER, EACH GYE ANCHOR TO BE CONNECTED TO TOWER GROUND RING.
DC LIGHTNING ARRESTER 24V OR 36V DC
* REQUIRED IN CASE OF CHARGE DISCHARGE CYCLE OF WORKING.
C - COPPER WIRE
CS - COPPER CLAD STEEL

FIG - 2

-x-x-x-

CHAPTER XXIV

INSTRUCTIONS FOR PROTECTION TO STAFF

SECTION A - GENERAL

24.1 Scope of instructions-

The instructions in this chapter are not exhaustive. Any carelessness on the part of the staff will not be absolved by the absence of instructions detailed in this chapter.

24.2 Handling by authorized personnel-

All equipment shall be handled only by duly authorized staff. All connections and alterations, other than day to day operation and maintenance, are to be carried only by staff specially trained for the particular work. In order to ensure safe working environment for the Telecom staff working on track and also keeping in view the hardship faced by them during extreme weather conditions, provision of special protective gears has been made for the Technicians/Maintainers and Helpers of Telecom;

A. Rain Coat with Waterproof coat and trouser.
B. Winter Jacket
C. Clothing for Subzero climate
   i. Jacket, ii. Trouser, iii. Gloves, iv. Snow boots, v. Cap.
D. Safety Shoes(with Steel Toes)
E. Luminous vest
F. LED rechargeable torch

The Dress Allowance for the eligible staff shall continue to be followed .The colour scheme of uniform for Technicians/Maintainers and Helpers of Telecom Department for both men/women - Shirt/Kurta shall be of Sky Blue and Trouser/Salwar shall be Navy Blue.

SECTION B - PROTECTIVE AND SAFETY DEVICES

24.3 Periodical checking- The condition of the equipment and correct functioning of protective and safety devices shall be checked periodically by the authorized personnel, as recommended by the OEM.

24.4 Checking under fault conditions-When the protective and safety devices have operated under fault conditions, check shall be carried out on the devices for their correct functioning before resetting them for use.

24.5 Altering and disconnecting safety devices-

The safety devices shall not be altered or disconnected without specific approval of the competent authority., except for replacements.

SECTION C- FIRST AID

24.6 First aid-

Since electrical shock may result in the interruption of natural breathing, all staff shall be familiar with the methods of artificial respiration. It is essential that staffs are equipped with the knowledge of first aid. Charts explaining such methods should be exhibited in a prominent place where high voltages are in use. Names of staff trained in first aid shall also be displayed.

24.7 First Aid Box-

First aid box shall be kept in major telecom installations having more than 6 staff.

SECTION D - ACID

24.8 Battery rooms

a. Battery rooms shall be provided with good ventilation.
b. Acid-proof tiles shall be provided on the flooring where acid is handled. It shall be ensured that the floor is kept dry and free from fallen acid.

24.9 Storage of acid-
Acid shall be kept in a cool dry place.

24.10 Diluting the acid

a. Acid should always be added to water, when dilution is needed.
b. Where acid is handled, a board containing the legend “DO NOT ADD WATER TO ACID” with a pictorial representation shall be hung at a suitable place.
c. While handling the acid containers, suitable rubber gloves shall be used.

SECTION E – FIRE

24.11 Safe working in battery room-

Breaking of the connection in a circuit in which current is being carried or the lighting of naked flame in the battery room must be avoided.

24.12 Training in firefighting-

The personnel should be given periodical training through nodal department in firefighting with the basic equipment provided.

24.13 Preventive measures-

(1) Railways shall provide Automatic Fire Detection & Alarm System linked with data logger as per latest RDSO specification at Telecom installations like major Exchanges, Test Room/Telecom Control Room, Data Centre locations, CCTV Control & Equipment Rooms, Main Switching Centre (MSC) & Base Station Controller (BSC) of MTRC, main OFC centres /Quad repeater stations, Satellite Hubs, etc. Single Automatic Fire Alarm and Detection System with common control panel may be provided to cover both Signalling & Telecom installations at way side stations or where both are located close by, if feasible.

In case the system is already provided for signalling installations at any station, then same may be extended for Telecom installations, if feasible. However, where existing signalling alarm system cannot be extended, Telecom system can have independent fire alarm. Wherever Telecom installations are located at considerable distance from signalling installations then independent Automatic Fire Detection and Alarm System may be provided

(2)

a. All safety recommendations provided by the manufacturer of equipment and batteries to be followed.
b. Waste material used in cleaning the equipment should not be allowed to accumulate in a corner and should be disposed off in a proper manner.
c. Dangerous growth of vegetation near the equipment or feeder lines or masts must not be allowed.
d. The roofs of buildings must be kept clear of leaves or combustible materials.
e. Smoking should be prohibited in petrol/Diesel storage rooms and battery rooms. 'No Smoking' sign with a Cigarette and red cross shall be displayed.
f. Oil, paints, etc. should not be stored near the equipment.
g. Petrol storage rooms should not have sparking equipment emitting sparks like buzzers, relays, fuses, etc.
h. Handling of petrol such as filling in engine tanks, etc. should not be done while the medium and high power transmitters are radiating in close proximity.
i. Lighting of fire for cooking etc. within compound walls shall be strictly prohibited.
j. Buckets filled with sand, water shall be hung at a convenient place.

24.14 Fire Extinguishers

1 **TYPES OF FIRE:**

(i) A Class :
Wood, charcoal, jute, cloth, etc. – water is sufficient to extinguish the fire.

(ii) B Class: Oil, petrol, grease, paints etc. – foam is sufficient to extinguish the fire.

(iii) C Class: electrical fire – water is not used, only CO2 is used.

2 (a) Basic fire fighting equipment should be kept in places with fire risk and it shall be ensured that they are in good condition. Expiry date should

be clearly mentioned on them. Notices of instructions for using the fire fighting equipment shall also be provided. Provision of refilling of fire extinguisher should be ensured.

(b) All electrical installations shall be provided with gas type fire extinguishers. Water should not be used to extinguish electrical fires.

(c) In confined places where even the minimum ventilation is not available, vaporising liquid extinguishers should not be used since they may be poisonous and cause harmful physiological effects.

24.15 Precautions during the time of fire.

(a) Alarm must be given in accordance with local regulations.

(b) All forced air-cooling devices must be stopped.

(c) Equipment involved must be disconnected immediately at the supply source.

(d) Spreading of the fire should be prevented. Cover the nose and mouth with wet cloth to protect oneself from smoke going inside the body.

SECTION F- ELECTRICITY

24.16 Removal of fuses- Fuses shall be removed or replaced only after the circuit has been completely de-energised. A non-conductive fuse extractor shall be used to remove knife or cartridge type of fuses from their holders. Fuses should be replaced with the correct rated fuses.

24.17 Handling circuit breakers

(a) In the case of manually operated circuit breakers, the face shall be kept turned away from the circuit breaker, while closing.

(b) While working on non-closed type of circuit breakers, the use of safety goggles is recommended.

24.18 Provision of labels

(a) All switches and cut-outs from which power may possibly feed shall be secured in open position and suitable label shall be provided. After completion of the work, the label shall be removed only by the person who originally put on the label..

(b) Sign boards warning danger with legends in appropriate languages may be hung at suitable places where radio frequency voltage or high dc or ac voltages are encountered.

(c) When more than one repair party is engaged, each party shall provide the label which will be removed after completion of the work by the respective party. If switch locking facilities are available; it shall be locked in the open position and the key retained by the person incharge of the work.

24.19 Working on live circuit:

(a) As far as possible work on live circuits with voltages over 150V peak to be avoided unless specially trained.

(b) The following protective measures shall be taken while working on live parts:
    (i) Provision of ample light for illumination.
    (ii) Removal of loose clothes and metallic personal accessories.
    (iii) Provision of insulation from earth such as provision of rubber floor mats near electrical distribution boards used in battery rooms.
    (iv) Use of only one hand where practicable, keeping the other hand free.
    (v) Do not use wet cloth, wet hand and naked wire while working in Live circuit.

24.20 Safety guards and covers.

(a) Suitable protective guards and wire nets shall be provided to prevent staff from making accidental contact at the dangerous voltage and radio frequency high power radiation.
(b) All covers used for protection against accidental contact with high voltages shall normally be kept closed and opened for maintenance or repair only by authorised staff.

24.21 Safety design and installation practices

(a) Insulated current carrying parts in the equipment shall be located in such a manner that they are not subjected to abrasion or mechanical damage.
(b) Where cables pass through metallic parts, insulating bushings shall be provided.
(c) External conductors connected to the equipment at points within the case shall be so arranged that their terminals are not subject to strain when any outer covering is protected from abrasion and that they are prevented from getting twisted.
(d) Guard interlocking switches shall be so arranged mechanically, that inadvertent operation is impossible.
(e) The accessibility in equipment and guards shall be so designed that the operator shall not have access to live parts other than those at extra low voltages.
(f) If the operator is required to have access to parts of equipment which are dangerous while the equipment is in operation, the covers provided to guard such parts shall not be removable with the equipment switched on or shall themselves switch the current “off” when the covers are removed.

24.22 Earthing

(a) Accessible metallic parts including hinged components which might become live in the event of a fault, shall be earthed on all equipment and shall be so constructed that these parts are permanently and reliably connected to an earth terminal or contact.
(b) If the body of the earthing terminal is part of the metal frame or enclosure, a screw or nut of brass or other metal less resistant to corrosion should be provided.

(c) It should not be possible to loosen the earth terminal screw without the aid of a tool.
(d) If the equipment or any components are connected by a plug and a socket device; while inserting the plug in the socket, the earth contact shall make its circuit before the current carrying contacts engage and when the plug is withdrawn from socket, it shall break its circuit after the live contacts break their contacts.
(e) All tall metallic structures shall be suitably earthed strictly.

24.23 Handling electrical equipment:

(a) While isolating the equipment from the mains supply the disconnection shall be done with the operation of the switches as well as by removal of the fuses. Disconnection should be for both phase and neutral.
(b) The disconnection shall be checked once again before commencing the work on the equipment.
(c) Since the electrical charge retained by the electrical machinery, when switched off, may cause a severe shock in some cases, the output terminals shall be earthed, before the mains are handled.
(d) To ensure that the capacitors are discharged rapidly, after their source of potential has been switched off, or disconnected, their live terminations, shall, have a discharge path which is either permanent or is applied so that the capacitors are discharged to a safe potential wherever practicable . Capacitors wired permanently across the mains supply shall be shunted by a resistance so that the discharge time of the capacitor shall not be greater than 100 mili second.

24.24 Handling radio equipment:

(a) Breaking of energised radio frequency output circuits shall be avoided as far as possible.
(b) While energising a radio transmitter, it shall be ensured that no one is at work on the equipment or aerial system, no tools or testing equipment are left in or on the equipment, and all testing apparatuses are removed.
(c) Where other equipment is used close by, measures shall be taken to prevent shock or injury to staff due to radio frequency energy picked up from an adjacent aerial or equipment.
(d) The aerial should be disconnected from the transmission line to prevent introduction of any dangerous voltages due to aerial pick up.
(e) Staff shall not be permitted to go near the aerial installations, unless it is definite that no danger exists.
(f) All areas in which radio frequency power density in excess of 0.01 watt per sq cm is known, or suspected to exist must be considered as hazardous areas, and personnel shall be prohibited from doing any work, while the set is energised.
(g) Direct visual examination from the radiation path of any microwave radiator reflector, wave guide, horn or any highly concentrated beam or radiating system during the period of transmission must be avoided.

(h) Staff who must remain in the microwave beam for any length of time shall be provided with and required to wear devices for eye protection with a wire mesh spring.
(i) If more than one transmitter is working on a site, care should be taken to avoid burns from radio frequency pickup from the working transmitters.
(j) All external conductors or metal parts carrying current where radio frequency power may exceed 5 W peak envelope shall be deemed to be live, and shall be protected accordingly. All external circuits and accessories fed with radio frequency where the power may exceed 5W shall be made inaccessible as far as practicable. Where such circuits cannot be made inaccessible, warning devices shall be displayed.

24.25 Protective measures for Telecommunication lines entering 25KV substation/switching posts.

When telecommunication lines enter 25KV sub-stations and switching posts (Feeding posts, section and sub-sectioning posts), the following protection measure shall be taken to protect the staff and the Telephone equipment against any fault occurring on the Traction side.

(a) Each Telecommunication line before its connection to telecom equipment shall be protected with suitable lightning arrestors and fuses.
(b) A common earthing shall be used for earthing of the lightning arrestors and all metallic bodies of sub-stations/switching posts so that no potential difference may arise between these bodies in case of a fault occurring on the Traction Side.

24.26 Precautions in ac electrified area

(a) Instructions issued from time to time by administrations dealing with electrifications must be strictly followed.
(b) Precautions are required to be taken on account of the following:
    i) Proximity of a live conductor.
    ii) Pressure of return current in rails.
    iii) Induction in all metallic bodies situated close to overhead equipment.
(c) Any contact, direct or indirect, with the 25KV line is dangerous and shall be strictly avoided.
(d) Whenever staff has to work on installations which are in direct or indirect contact with the rails, they shall:
    i) Use tools (insulated and non-insulated) in the manner approved by the PCSTE of the Railway.
    ii) Observe the provisions of Chapter XX of the Way and Works Manual, supplemented by 'Instructions for Railway Staff Working on Tracks Equipped with 25KV, 50 Hz ac traction (see Annexure A).
    iii) The metallic body and supporting frame of the equipment shall be earthed and the resistance of this earthing shall not exceed 10 ohms. There should not be any possibility of simultaneous human contact with metallic bodies connected to different earth.

iv) Any equipment and portion thereof including the supporting structure falling within 2 meters of the 25KV live contact wire or any metal part electrically connected to this conductor shall be protected by an iron screening, of approved design, solidly connected to the structural work. The iron screen shall be connected to an earth not exceeding 10 ohms in resistance.

(e) Each time staff has to work on telecommunication circuits along the 25 KV ac line. the following ‘protective measures must be observed:

i) As a general rule, use rubber gloves and use tools with insulated handles and must wear shoes while working in RE area.

ii) When the work to be done is meticulous and rubber gloves cannot be used, special precautions should be taken by splitting the circuit into sections by earthing them.

iii) Before cutting the armour or the lead or the aluminium sheath of the cable or the wires in the cable, establish as a general rule, an electrical connection of low ohmic resistance between two parts of the armour and the sheathing and the wires that are to be separated by cutting.

iv) Whenever the main telecommunication cable is tapped by derivation cables, the tapping shall be through protective transformers to maintain physical separation between the main and derivation cable conductors.

v) When more than one repair party is engaged, each party shall provide the label which will be removed after completion of the work by the respective party. If switch locking facilities are available, it shall be locked in the open position and the key retained by the person incharge of the work.

vi) While opening an underground telecommunication cable joint, the cable sheath and armouring which may be at a higher potential than the earth should not be touched without first connecting to a local earth installed temporarily for the purpose.

vii) As the phantom circuit for block working is derived directly from the main cable, through the plastic insulated conductors, the terminals in the derivation cable termination box on which these plastic insulated conductors for block working are terminated, shall be painted red. The maintenance staff should take necessary precautions while working on cable termination boxes.

viii) In VF repeater stations and cable huts, a caution board shall be displayed to indicate that the maintenance staff must use rubber gloves and stand on rubber mats while working on the cable termination and equipment. The issue of special instructions to the personnel likely to have access to the cable conductors, sheath and terminations, of the cable sections between sectionalising points, must be done. The marking of any accessible part of the installations or apparatus connected to the line that may be raised to a dangerous potential must be done.

ix) While working on the telecommunication equipment installed on the overhead equipment switching posts, maintenance staff should ensure that the lightning arresters and the fuses connected in the line are in proper working condition before commencing the work.

24.27 Tools to be provided with insulating sleeves in 25 KV AC area.

(a) Tools which are used in signal and telecommunication circuits and on any current carrying parts of signal and telecommunication equipment are required to be insulated to protect the staff from ac induced voltages.
(b) The handles of these tools shall be provided with insulating sheath of rubber or plastic materials of approved type sufficient to withstand 3000 V.
(c) The following tools shall invariably be insulated:
    i) Screw driver.
    ii) Pliers.
    iii) Any other tools, whose handles are metallic and which are required for the above purposes.

SECTION G – WORKSHOPS

24.28 Regulation of factories Act - All the safety regulations enjoined in 'Factories Act' shall be complied with.

SECTION H - HANDLING OF MATEIRALS, TOOLS AND METERS

24.29 Crane or hoist, handling materials - While materials are being handled by crane or hoist or a winch, care shall be taken that the personnel are away from the danger zone.

24.30 Correct handling of tools - Wherever it is noticed that the tools are not properly handled by the staff, the correct method should be taught so that the workmen do not injure themselves by using wrong methods.

24.31 Voltage handling of tools - While making voltage tests on transmitters, the meter must be insulated from the ground and the test leads shall be able to withstand the high voltages.

SECTION I - TOOLS, GLOVES, BELTS AND HELMETS

24.32 Tools in wireless stations - The tools employed in a wireless station shall be as per Para 24.27

24.33 Gloves

(a) Where high voltages are employed, suitable rubber gloves shall be provided**, but while working on radio frequency circuits, use of rubber gloves is prohibited.**
(b) The gloves shall be designed such that they will not slip off during use, but shall be easy to take off.

24.34 Belts - Safety belts of approved design may be provided for staff working on poles or masts. The belts shall not be less than 7.5 cm wide and shall be made 5 mm thick, good quality, non-fibrous leather.

24.35 Helmets - Helmets of approved design may be provided for staff liable to work in fire fighting and in places of workshop where overhead cranes or hoists are working or where small objects such as nuts, bolts, tools, stones, etc., are likely to fall from above.

ANNEXURE A

Para 24.26(d) (ii)
SUPPLEMENT TO CHAPTER XX OF THE WAY AND WORKS MANUAL
(Relevant Paras)

Instructions for Railway staff working on tracks equipped with 25KV single phase, 50 Hz ac traction overhead equipment and on or adjacent to such requirement.

1. The instructions lay down precautionary measures to be observed by railway personnel working on the tracks equipped with 25 KV ac overhead equipment.

2. Precautions are required to be taken on account of the following:

2.1 Proximity of a live conductor - The risk of direct contact would occur while working very close to a live conductor.

2.2 Pressure of return current in rails- The return current in the rails may cause a potential difference:
- between rail and the surrounding mass of earth.
- between the two ends of a fractured rail.
- between the two rails at an insulated joint.
- between earth and any other metallic mass.

2.3 Induction in all metallic bodies situated close to overhead equipment- It is important to note that induced voltage may appear at any instant in metallic masses in the vicinity of traction conductors .

3. The precautions laid down must be followed under all circumstances in sections equipped for 25KV single phase, 50Hz ac traction in addition to those in para 2003

3.1 No work shall be done within a distance of 2 meters from the live parts of the overhead equipment without a on 'permit to work' (see para 2003)

3.2 No fallen wire or wires shall be touched unless power is switched off and the wire or wires suitably earthed. In case the wires drop at a level crossing, the gatekeeper shall immediately make arrangements to stop all road traffic, power is switched off and the wires duly earthed.

4. During maintenance or renewal of track, continuity of the rails serving electrified tracks shall be maintained by provision of temporary metallic jumpers of approved design for bridging the gap which would be caused during removal of fishplates or rails.

5. Use of rails as foot path, a seat or for such other purposes is strictly prohibited.

6. In electrified tracks the use of steel measuring tape or long metallic wires shall be avoided.

N.B.: Para references given here refer to paras of the Way and Works Manual

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CHAPTER XXV

FAULT CONTROL PROCEDURES

25.1 INTRODUCTION:

This chapter discusses the Fault Control Procedures for Railway's Telecommunication Network both at Divisional Level as well as Zonal Level.

In a typical Railway Telecom Network scenario, following types of Telecom Network co-exist

- **Transmission**

    - Optical Fibre Cable Network
    - Telecom Quad Cable Network
    - Local Area Networks
    - PIS Networks in a station
    - CCTV Network

- **Switching**

    - Electronic Telephone Exchanges
    - IP Telephone Exchanges

- **Data Networks/Others**

    - Mobile Train Radio Communication system
    - VHF/UHF Simplex Trans-receivers
    - FOIS, UTN, Railnet, Data logger Network
    - WiFi system

It is indeed very necessary to establish well defined Fault Control Procedures for satisfactory maintenance of such diverse Railway Telecommunication Networks so as to meet the demanding requirements of Indian Railways in the 21st Century.

25.2 TYPICAL TELECOM FAULT CONTROL SET-UP ON A RAILWAY

Typical telecom fault control set-up on a Railway shall consist of the following:

1. **ZONAL S&T CONTROL SET-UP**
2. **DIVISIONAL TELECOM FAULT CONTROL SET-UP**

The Zonal S&T Control Set-up shall be one for the entire Zonal Railway.

The Divisional Telecom Fault Control Set-up shall be established in each Division of the Zonal Railway.

25.3 ZONAL S&T CONTROL SET-UP

25.3.1 It shall be manned by SSE/JE (Telecom) in a general shift. Three SSE/JE (Telecom) shall be earmarked and should man the Zonal S&T Control set-up round-the-clock in case of emergencies.

25.3.2 The Zonal S&T Control Room shall also function as an Emergency Telecom Control Room in case of Emergencies requiring immediate telecom facilities/restoration. The emergencies may consist of the following:

- Major Rail Accidents
- Cyclones
- Breaches

25.3.3 When the Zonal S&T Control Room functions as the Emergency Telecom Control Room, the Divisional Telecom Fault Control Rooms of the affected Division(s) shall report their positions to the Zonal S&T Control Room which in turn shall advise the Telecom Officials at HQs of the latest developments.

25.3.4 The Zonal Telecom Fault Control Room shall function under the direct control of Dy. Chief Signal & Telecom Engineer (Tele) or any other officer designated by the Chief Communication Engineer of the Railway.

25.4 DIVISIONAL TELECOM FAULT CONTROL SET-UP

25.4.1 The Divisional Telecom Fault Control Set-up shall monitor all telecom networks over the Division and shall be headed by a Senior Section Engineer (Telecom) in a general shift. Adequate number of Senior Section Engineers (Telecom)/ Jr. Engineers (Telecom) and Technicians assisted with helpers shall monitor the Fault Control Room round-the-clock.

25.4.2 All the Telecom Networks in 25.1 shall be monitored by the Divisional Telecom Fault Control Room.

25.5 A. OFFICE TOOLS/TELECOM FACILITIES TO BE PROVIDED AT THE ZONAL S&T CONTROL ROOMS

Following Office Aids/Telecom Facilities shall be provided for satisfactory functioning of the S&T Control Rooms

- AUDIO/VIDEO conference facilities with Divisions and Railway Board.
- Zonal level NMS of Various Networks.
- PC system with LAN connection, printer.
- The up-to-date network diagrams of all the networks monitored should be available for ready reference.
- Hotline Communications between various Telecom Fault Control Rooms.

25.6 B. OFFICE TOOLS/TELECOM FACILITIES TO BE PROVIDED AT THE DIVISIONAL TELECOM FAULT CONTROL ROOMS

Following Office Aids/Telecom Facilities shall be provided for satisfactory functioning of the Telecom Fault Control Rooms

- AUDIO/VIDEO conference facilities with Divisions and Railway Board
- Divisional level NMS of Various Networks
- PC system with LAN connection, printer
- Network Monitoring System of all the Networks monitored by them.
- Control patching facility
- The up-to-date network diagrams of all the networks monitored should be available for ready reference.
- Proper flow diagram to trace faults in various Telecom systems should be available
- Hotline Communication between various Telecom Fault Control Rooms

25.7 PROCEDURE FOR FAULT REPORTING TO ZONAL S&T CONTROL ROOM & ITS FUNCTIONS

25.7.1 Each of the Divisional Fault Control Rooms shall report their daily positions to the Zonal S&T Control Room by the following communication means:

- By telephone
- By common shared folders in network
- By E-Mail
- By other convenient electronic IT platforms

PCSTE should approve the mode of regular communication to be followed by field telecom staff / divisional control room for reporting/sending/informing to Zonal control room. All emergency reporting from field/divisional control room should be immediately through telephone.

25.7.2 Any unusual occurrences, any link breakdowns or Channel Interruptions of vital circuits e.g. PRS data circuits, Inter-Railway or Inter Division Administrative Trunk Circuits, Control Hotlines from Zonal Hqs to Divisions, shall invariably be reported to Zonal Telecom S&T Room immediately on their occurrence on Telephone followed by other approved means

25.7.3 Monthly, Quarterly & Annual Telecom System Performance Reports of the Division shall be communicated to the Zonal Telecom Fault Control Room, as per specified proforma.

25.7.4 A uniform Application Program shall be loaded on the Computers in every S&T Control Room at Zonal Levels. This shall ensure transparency of Data Transmission between Fault Control Rooms of the Divisions.

25.7.5 The Zonal S&T Control Room shall compile Monthly, Quarterly & Annual Telecom System Performance Reports of the Railway as per specified proforma, for reporting to Railway Board.

25.7.6 When during emergencies, the Zonal S&T Control Room functions as an Emergency Telecom Control Room, following additional functions shall get automatically assigned:

- Maintaining very close coordination with the Divisional Telecom Fault Control Room.
- Liasioning with RCIL/BSNL/MTNL/other service providers at Hqs, if required, for providing additional telecom facilities. For this, Telephone Nos. with Designations of concerned RCIL/BSNL/MTNL/ other service providers officials shall be kept up-to-date in the Control Room.
- Mobilising additional telecom resources as per site requirements.

25.7.7 A Disaster Management Plan detailing out the action to be taken in Emergencies shall be prominently displayed in the Control Room.

25.7.7 S&T Control should ensure that minimum essential telecom needs with divisions and zones are provided at the accident site in least time.

25.8 PROCEDURE FOR FAULT REPORTING TO DIVISIONAL TELECOM FAULT CONTROL ROOM & ITS FUNCTIONS

25.8.1 Telecom Supervisors in the Division shall report the periodic, daily or unusual occurrence report of the Telecom gears under them to the Divisional Control Room by the following communication means:

- By telephone
- By common shared folders in network
- By E-Mail
- By other convenient electronic IT platforms

SrDSTE/Co should approve the mode of regular communication to be followed by field telecom staff for reporting/sending/informing to Divisional control room. All emergency reporting from field should be immediately through telephone.

25.8.2 The Divisional Telecom Fault Control Room shall compile the Monthly, Quarterly & Annual Communication System Performance Reports of the Division as per specified proforma for communicating to the Zonal Control Room.

25.8.3 Liasioning with RCIL/BSNL/MTNL/ other service providers at Divisional level, if required, for providing additional telecom facilities. For this Telephone Nos. with Designations of concerned RCIL/BSNL/MTNL/ other service providers officials, shall be kept up to date in the Control Room.

25.8.4 Mobilising additional telecom resources as per site requirements in case of emergencies.

25.8.5 A uniform MIS Program shall be provided in every Telecom Fault Control Room at Divisional Level and S&T control room at Zonal HQ. This shall ensure transparency of Data Transmission between Fault Control Rooms.

25.8.6 A disaster Management Plan detailing out the action to be taken in Emergencies shall be prominently displayed in the Control Room.

25.8.7 Telecom Control should ensure that minimum telecom needs with divisions and zones are provided at the accident site in least time.

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CHAPTER XXVI

INSPECTION

26.1 ANNUAL INSPECTION PROGRAMME CALENDAR

At the start of the Financial Year, JEs/SSEs shall prepare the inspection programme calendar of their respective jurisdiction and shall submit to ADSTE/DSTE for approval as per the mandated Inspection Requirements. ADSTE/DSTE should visit all the telecom installations under their jurisdiction at least once in a year.

26.2 ADHERENCE TO ANNUAL INSPECTION SCHEDULE

The annual inspection schedule should be strictly adhered to. Any deviation should be reported to the higher authority explaining the circumstances which necessitated the deviation.

26.3 INSPECTION REPORT

Each inspection conducted by the officials shall be followed by an inspection report. The report should indicate the state of working of the installation, efficiency of the services rendered including performance of AMC/ARC, any specific problems along with suggestions for the improvement of services.

26.4 SUBMISSION OF INSPECTION REPORT

The inspection report should be submitted to the next higher authority within one month time.

26.5 MONITORING THE INSPECTION WORK

An inspection register should be maintained indicating the installation inspected, actual date of inspection, date of submission of report.

26.6 COMPLIANCE REPORT

Strict action should be taken to ensure prompt compliance of the points noted in the inspection reports. Such a compliance report should be submitted as a matter of course within one month of inspection and ordinarily all action should be completed within three months time.

26.7 REVIEW OF EARLIER INSPECTIONS

During surprise/scheduled inspections, the progress of compliance of earlier inspection reports should be checked by the inspecting officer. The inspecting officer may carry with him earlier inspection report on similar installation to serve as a guideline.

26.8 LOCATING WEAK POINTS

The inspection should be meaningful and the inspecting officers should cover all points affecting the efficiency of the services and should particularly inspect to locate weak points before it can lead to any failure or complaint.

26.9 ANNUAL SCHEDULE OF INSPECTION

The annual schedule of inspection which shall be conducted by Divisional officials are given in Annexure-A.

26.10 QUALITY OF INSPECTION

The report of the inspections carried out by the Officers will be reviewed by the next higher authorities. If it is felt by the reviewing officer that the report is inadequate or inspection has not been carried out properly covering all the important aspects, the reviewing officers will send his comments immediately to the inspecting officers concerned. In extreme cases he may even ask the inspecting officer to carry out the supplementary inspection to cover the remaining points.

26.11 INSPECTION REGISTER

Every installation shall maintain inspection register duly bound and page numbered. This will be kept as important permanent document. All the report of inspections/formal visits will be filed in the inspection book. Remarks of any surprise/casual visit will be recorded by the visiting officer on the space in the inspection register. The compliance report of the points noted in the register shall be sent to the inspecting officers for record as well as it should be maintained in inspection register for future reference.

26.12 During the inspection by Officers, they should check the availability and maintenance of documents and equipment manuals required for proper maintenance of equipment. They should also see that the staff working under them are regularly updating their knowledge in line with the changes in telecom field and plan for sending for training where found necessary.

ANNEXURE – A

ANNUAL INSPECTION SCHEDULE OF OFFICERS

SN	ITEM	SR. DSTE	DSTE/ADSTE
1.	MTRC NETWORK	10% STNS/YEAR	ALL STATIONS AT LEAST ONCE IN A YEAR
2.	TELEPHONE EXCHANGES	ALL EXCH. EXCEEDING 512 LINES ONCE IN A YEAR	ALL EXCHANGES ONCE IN A YEAR
3.	CONTROL OFFICE & TEST ROOMS	ALL CONTROL OFFICES ONCE IN SIX MONTHS	ALL CONTROL OFFICES ONCE IN A MONTH
4.	PA SYSTEMS AT RLY STATIONS/TRAIN INDICATION BOARDS & CLOCKS	ALL MAJOR STATIONS ONCE IN A YEAR	ALL MAJOR STATIONS ONCE IN SIX MONTHS OTHER STATIONS ONCE IN A YEAR
5.	OUTDOOR OFC/QUAD CABLE & EMERGENCY SOCKETS	ONE INSPECTION IN EACH CONTROL SECTION YEARLY	INSPECTION OF 100% IN A YEAR
6.	ACCIDENT RELIEF TRAIN	as per accident manual and RB instructions	as per accident manual and RB instructions
7.	INDOOR OFC/QUAD CABLE SYSTEM	10% OF STATIONS IN A YEAR	ALL STATIONS IN A YEAR
8.	VIDEO SURVEILLANCE SYSTEM	ALL MAJOR STATIONS IN A YEAR	ALL STATIONS YEARLY
9.	TELECOM EQUIPMENT OF DATA NETWORK FOR UTS, PRS, FOIS, RAILNET ETC.	ALL MAJOR STATIONS IN A YEAR	ALL STATIONS YEARLY
10.	TELECOM STORE DEPOTS IN A YEAR	10% OF STORE DEPOTS IN A YEAR. HQ OFFICERS - AT LEAST ONE DEPOT IN A YEAR.	ALL STORE DEPOTS IN A YEAR

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CHAPTER XXVII

PAINTING

27.1 SECTION A- EQUIPMENT TO BE PAINTED

Paint on equipment acts as a protective barrier between the equipment casing and the corrosive environment and it provides good aesthetics and ensures its long life. Normally the equipment should be procured with life-long painting which is achieved through modern painting techniques like Powder Coating etc. However in case it requires to be repainted, the same needs to be done before damage to the equipment (casing) takes place.

27.1.1 Items of equipment requiring painting

(a) The following are the main items of telecommunication equipment that need regular painting:

i. Antenna towers.
ii. Emergency telephone socket posts and socket box.
iii. Marking on OHE masts for the position of telecommunication cable joints. (Normally Electrical department provides marking on OHE masts for the position of Emergency Socket post where available)
iv. Battery stands.
v. Telephone stands.
vi. Train control telephone apparatus.
vii. Modem stands.
viii. Outdoor telecom items made of metallic case exposed to rains and direct heat.
ix. Cable route marker
x. Poles & Boards of passenger amenities boards

(b) The following are the main items of telecommunication equipment that need occasional painting.

- Control room equipment.
- Way station control equipment.
- Equipment racks and ladders

27.1.2 Colouring scheme

(a) All wood work shall be finished with natural colour varnish.

(b) As far as possible the original colour scheme adopted by the manufacturers may be followed in repainting. Where the same colours are not available, the repainting must be done with paints having colours near about the original.

(c) Emergency telephone socket posts shall be painted with alternatively black and white paints for 15 cms length each.

(d) Marking on OHE masts for the position of telecommunication cable joints and Emergency Socket post where available is to be of red paint.

27.1.3 Interval of painting:

(a) The general principle for fixing intervals has been based on the following:
   (i) All wood work is polished once in 2 years.
   (ii) All outdoor equipment painted once in 3 years.
   (iii) All indoor equipment is painted once in 4 years.

(b) The paintings on the emergency telephone socket posts and on OHE masts for cable joints and emergency socket where available shall be done once in a year

(c) The above intervals may be suitably modified for any particular area after taking into account the corrosive effect of atmosphere and weather conditions.

27.1.4 Painting programme

(a) Each SSE/JE shall be responsible to see that the telecommunication equipment under his charge is duly painted and clean.

(b) Each SSE/JE shall draw out a schedule of painting for all the equipment under his charge. The quantities required shall be worked out on the basis of scale of paints to be fixed by the Sr.DSTE and work to be executed by an outsourcing agency.

27.1.5 Painting register – Each SSE/JE must maintain a painting register, one page or more being allotted to each equipment on his section. Record of the painting work done with dates of commencing and completing the work must be regularly entered in this register.

27.1.6 Inspection

(a) Each SSE/JE must see that the outsourced painters are making satisfactory progress and that the painting work is in accordance with the instructions.

(b) Each SrDSTE shall see that the painting programme is strictly adhered to and that it is completed in due time. He shall, during the course of his inspection, also see that all the equipment and apparatus is kept properly painted in accordance with the instructions.

27.2 SECTION B- GENERAL INSTRUCTIONS

27.2.1 Precautions

Paints shall be stored in a cool dry place away from flame or naked light. All containers should be kept securely closed when not in use to avoid loss of material due to skinning and contamination. Paints, especially quick drying paints, shall not be left open to the atmosphere.

27.2.2 Mixing of paints

Paints from pigments and pastes must be prepared in accordance with standard specifications. Linseed oil turpentine shall not be added to ready mixed paints. Mixing of kerosene with paints is forbidden.

27.2.3 Painting of steel works

(a) The surface of metal should be clean and free from dirt, scale, deteriorated old paint and rust and should be preferably dry before application of paint. Painting should be done preferably during dry weather.

(b) For a new steel work, 3 coats of paints shall be applied. After the first two coats of an approved primer, the third paint of the specific colour and quality shall be applied. When repainting a structure, if the old paint does not show any signs of blistering, scaling or cracking, it need not be scraped off. It may be used as a foundation for the new coat.

(c) When there are patches of blistering, scaling or cracking, these patches should be cleaned down to the steel and treated in a manner as recommended for a new structure.

(d) The surface of metal should be cleaned by scrapping, chipping or scrubbing with brickbats. No chemical of any kind must be used. Old paint may be burnt, if necessary, and then scrapped off.

(e) Paint should be applied with brushes and spread evenly, smoothly and as thin as possible. Rags or waste cotton should not be used for the application of paint.

(f) Brushes should be thoroughly cleaned in proper driers after use.

27.3 SECTION -C PAINTING OF TELECOM TOWERS

(a) Telecom Towers are to be painted as per requirement of Civil Aviation Regulations. Normally every telecommunication tower shall be painted with international orange and international white colors alternatively each with 5 meter band, starting with international orange at the top.

(b) Repainting of Towers should preferably be done every five years or earlier depending on the conditions of the towers and climatic condition of the place. Before repainting work is undertaken, previous paint is to be scrapped taking care that galvanization of the members does not get affected.

(c) In case telecom towers in the Railway Boundary are leased / used to any PSU/other agency, SSE/Telecom of section shall monitor the timely painting of the tower through such agencies. Any Deficiency noticed shall be conveyed to concerned agencies with information to Sr.DSTE for ensuring timely corrective action by such agencies.

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CHAPTER XXVIII

DRAWINGS AND SPECIFICATIONS

SECTION A

STANDARD DRAWINGS

28.1 INDIAN RAILWAY STANDARD DRAWINGS

(a) Indian Railway Standard Drawings designated by the code word IRS have been issued by Director General, Research Designs and Standards Organisation, Lucknow. The telecommunication drawings are marked IRS (TC) - 'TC' stands for 'Telecommunication'. The particulars of the drawings and their reference numbers are detailed in an Index of Indian Railway Standard Signal and Telecommunication Drawings including advanced drawings IRS (TC) issued by Research Designs and Standards Organisation. This index shows all the IRS (TC) drawings arranged alphabetically as well as serially in the order of their numbers. Each drawing number is either prefixed with the letters 'TCA' or letters 'TC'.

(Note - 'TCA' stands for a telecommunication equipment assembly and 'TC' stands for a part of a telecommunication equipment assembly.)

(b) New designs and drawings which are accepted for adoption as standards have the word 'Advance' suffixed to their number, e.g. TC.50 (Advance) pending their final adoption as Indian Railway Standard Drawing. For such drawings the manufacturers shall have a sample approved by the purchaser before undertaking the bulk manufacture.

28.2 Supply of drawings

(a) Standard drawings - A set of all IRS (TC) drawings must be supplied to each Sr.DSTE office, DSTE/ADSTE field office and to each field supervisor as required. IRS drawings should not be traced by the Railways. Copies should be obtained from the Director General (S&T), Research Designs and Standards Organisation, Ministry of Railways, Lucknow.

(b) In addition to the standard drawings, each Sr.DSTE office, DSTE/ADSTE field office and to each field supervisor as required must have editable (preferably in digitised form) copies of the following telecom items :

i. Jurisdictions of maintenance staff, telecommunication equipment maintenance staff
ii. Charts for maintenance staff of underground telecommunication cables and OFC.
iii. Charts showing distribution of section and deputy control telephones.
iv. Charts of underground cables for local telephone exchanges.
v. Telecommunication cable route plan of sections.

vi. A chart indicating the exact location of the emergency telephone socket post indicating distance from nearby OHE masts No. in RE area & nearby Hectometers post No. in Non RE area and the jurisdiction of maintenance staff w. r. to these emergency telephone socket post.

vii. Route plan /locations of VHF stations.

viii. Route plan of train radio or wireless communication system, if any.

ix. Optic fibre and quad cable route plan

x. Network Diagram of circuits configured alongwith protection path for all important channels (Control channels, PRS/UTS channels, Datalogger channels, CCTV channels, BSNL hired channels etc.)

xi. Network Diagram of Railnet alongwith its IP addressing scheme

SECTION B

SPECIFICATIONS

28.3 INDIAN RAILWAY STANDARD SPECIFICATIONS: Approved specifications of Telecom directorate are available on RDSO website. Specifications for material and equipment used for telecommunication purposes have been drawn out by Research Designs and Standard Organisation, Ministry of Railways, Lucknow and are titled 'Indian Railway Standard Specifications'. These specifications are issued under fixed serial number, e.g., TC.12-66 : the letter TC denoting 'Telecommunication', the number '12' representing the serial number of the specification and the final number '66' indicating the year of original adoption as standard, or in the case of major revision, the year of last revision (a case of reissue) .Any minor amendment is done and indicated as Amd1, Amd2 and so on until the Specification is revised when all these amendments are merged into main body of the Specification as revision 1 and so on.

However this is done in two stages as described below;

New Draft specifications are prepared based on directives from Railway Board/requirement of Zonal Railways related to introduction of new technology/product identified during MSG/TCSC/other review meetings. New specifications as RDSO/SPN is prepared by Dir/JD RDSO by taking into account other related specifications and comments/ feedback from railways and RDSO /SPN number is given by concerned JE/SSE/RDSO after entering into register No. TC-R- 0008. This specification is circulated to customer and field inspecting units for comment by Dir/JD. RDSO/SPN along with comments of customers is discussed in Telecom Standard Committee (TCSC) meeting. Recommendations made by TCSC are put up to the Railway board for approval. After approval from Railway Board, RDSO/SPN is accordingly modified/ updated & issued for use by Railways/other users. Copies of this specification are sent to Approved Vendors, field Inspection units and Railways. The specifications are reviewed from time to time based on experience/ feedback from railways and/ or manufacturers and are updated as necessary. When sufficient feedback is received from fields during product stabilisation phase after its installation in fields for a reasonable period of time and technological growth in product/specification is also stabilised, RDSO/SPN is given IRS number after making entry into register.

28.4 Other specifications - Specifications issued by Telecommunication Engineering Center (TEC) or the British Standards Institution and the Indian Standards Institution have also been adopted for items of equipment used for telecommunication purposes for which no IRS specification exists.

28.5 Supply of specifications - Each Sr.DSTE office should have a copy of all Indian Railway Standard (Telecommunication) specifications. Copies of such British Standard and Indian Standard Specifications that are generally required may also be kept.

28.6 Availability

i. Indian Railway Standard Specifications are obtainable from RDSO's Railnet and Internet websites.
ii. British standard and Indian Standard Specification are obtainable from the Director, Bureau of Indian Standard, Manak Bhavan, 9-Bahadur Shah Jafar Marg, New Delhi - 110 002.

SECTION C

MAINTENANCE OF DRAWINGS AND SPECIFICATIONS

28.7 Folders - Standard drawing and specifications should be maintained in a block form separately bound in suitable folders. New drawings and specifications should on receipt be promptly added to the respective folders. Obsolete or cancelled drawings and specifications must be destroyed. Torn or defaced drawings should be replaced.

28.8 Responsibility.

(a) Each Sr. Section Engineer shall be responsible for :

(i) The standard drawings are properly maintained and kept up to date in respect of new drawings issued and old ones cancelled.
(ii) The staff working under him understand and carry out work in accordance with standard drawings. Any mistake in drawings that may come to his notice should be promptly intimated to the Sr. DSTE for arranging correction.

(b) Each Sr. DSTE shall be responsible to see that:

(i) The standard drawings and specifications in his custody are kept upto date and that the obsolete and cancelled ones are destroyed.

(ii) All SSEs /JEs keep their standard drawings upto date.
(iii) The staff properly understand and carry out work in accordance with standard drawing.
(iv) Any mistake in the standard drawings and specification, which comes to his notice, is promptly intimated to the PCSTE for arranging correction.

SECTION D

ADDENDA AND CORRIGENDA AND ACCOUNTAL

28.9 Addenda and Corrigenda

(a) British Standard Specifications - British Standard Year Book is published by the British Standards Institution, Victoria Street, London SW1. It contains a list of upto date British Standards in numerical order and also gives a brief description of each.

(b) Indian Standard Specifications - The ISI Hand Book of publications contains upto date list of Indian Standards and is available from the Director, Bureau of Indian Standard, Bahadur Shah Jafar Marg, New Delhi-110 002.

(c) Standard Drawings - Railway should publish list of standard drawings for the information of the staff. Addenda and corrigenda slips should be issued to these lists regularly once in six months incorporating particulars of drawings issued, modified or cancelled.

28.10 Accountal of Standard Drawings and Specifications -

All Indian Railway Standard Drawings and specifications must be accounted for in the same way as other books of reference.

SECTION E

INDIAN RAILWAY STANDARD EQUIPMENT

28.11 Indian Railway Standard Designs.

(a) Where Indian Railway Standard Designs exist, they should invariably be followed for all new works and no modification of such designs should be introduced without the prior approval of the Railway Board.

(b) Defects, if any, in standard designs noticed under service conditions or modifications, which appear to be desirable should be brought to the notice of the Director General, Research Designs and Standards Organisation, Ministry of Railway, Lucknow, for examination in consultation with the telecommunication standard committee.

28.12 Requisitioning of materials.

(a) All materials and equipment must normally be indented in accordance with Indian Railway Standard Drawings and Specifications. Indian Standard Specifications, TEC or British Standard Specification should only be quoted for items for which an IRS Specification does not exist.

(b) No alteration or modification to or divergence from IRS drawings shall be permitted without the specific sanction in writing of the Director General, Research, Designs and Standards Organisation, Ministry of Railways, Lucknow. In the case of deviations having been decided upon before placing an order, the indenting authority concerned shall quote such sanction in the order. When deviations are decided upon or desired after the placing of an order, the necessary sanction shall be obtained in writing by the Inspectorate concerned in consultation with the indenting authority.

(c) It shall be the responsibility of the SrDSTE/DyCSTE, DSTE, ADSTE & SSE to see that reference of correct drawings and specifications along with latest amendment/revision is given for all materials indented.

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CHAPTER XXIX

BOOKS OF REFERENCE

29.1 **BOOKS OF REFERENCE:**

Where the books of reference are not provided in softcopy and also not available in an official railway website, hard copies of it should be supplied to officers, supervisors and technicians for their use in day to day official works. Few hard copies of all such books should always be available at each major telecom unit. A statement showing the various books and their distribution is at Annexure A.

29.2 **RESPONSIBILITY:**

All officials to whom books of reference have been supplied shall be responsible for

a) their safe custody and good order,

b) pasting all addenda and corrigenda slips promptly and seeing that these are up to date to the last slip as notified from time to time, and

c) returning all books issued to them for personal use prior to retirement or resignation or transfer from the railway service.

29.3 **INSPECTION:**

Each Senior Divisional Signal & Telecommunication Engineer/ Divisional Signal & Telecommunication Engineer shall make periodical checks to see that Inspectors maintain their books of reference up to date and in good order. Each Inspector shall, likewise, see that the staff under him maintains their books of reference up-to date and in good order.

29.4 **ACCOUNTAL:**

All books of reference should be accounted for in the same way as tools and plant items.

29.5 **REPORTS OF TELECOMMUNICATION STANDARD COMMITTEE, TECHNICAL PAPERS AND JOURNALS:**

Each Senior Divisional Signal & Telecommunication Engineer should arrange to have the under-mentioned technical literature in his office library:

a) All IRS and SPN Specifications pertaining to Telecommunication, relevant BSS, ISS & DOT (TEC) specifications.

b) Reports of Telecommunication Standards Committee Meetings.

c) Proceedings & Technical papers issued by Institution of Telecom Engineers, India; Institute of Electronics & Telecommunication Engineers, Institution of Railway Signal & Telecommunication Engineers.

d) Technical Bulletin and other technical papers on telecommunication matters published by the Railway Board.

e) Technical books and journals of interest on telecommunications.

f) Copies of technical instructions and reports, Technical Advisory Notes issued by RDSO on different items of work relating to telecom.

g) Equipment manuals of all telecom equipment of division.

29.6 RESPONSIBILITY OF Sr.DSTE:

The Senior Divisional Signal & Telecommunication Engineer should encourage his supervisors and other staff to study these reports, proceedings, papers and journals, online available resources from IRISET, RDSO etc. so as to enhance their knowledge and to keep themselves informed about the up-to-date developments, methods and techniques in telecommunications.

ANNEXURE –A
Para 29.1
STATEMENT SHOWING THE VARIOUS BOOKS OF REFERENCE AND THEIR DISTRIBUTION AMONG STAFF

Item No.	Publications	Scale for									
		Office of				Personal possession of					
		PCSTE	Sr.DSTE	DSTE/ADSTE	SSE/(Tele)	PCSTE	CCE	Sr.DSTE	DSTE/ADSTE	SSE/(TELE)	JE/TECHNICIAN
1	2	3	4	5	6	7	8	9	10	11	12
1.	Telecommunication Manual	1	1	1	1	1	1	1	1	1	1
2.	General and Subsidiary Rules	1	1	1	1	1	1	1	1	-	-
3.	Stores Manual	1	1	-	1	-	-	-	-	-	-
4.	Pass Manual	1	1	-	1	-	-	-	-	-	-
5.	Schedule of dimensions	1	1	1		1	1	1	1		
6.	Payment of wages act with notifications as issued.	1	1	1	1	-	-	-	-	-	-
7.	The hours of employment regulations with notifications as issued.	1	1	1	1	-	-	-	-	-	-
8.	Working Time table & Appendix thereto	1	1	1	1	1	1	1	1	1	1
9.	Accident Manual	1	1	-	1			-	-	-	-
10.	IRS & SPN Drawings(Telecom)	1	1	1	1	-	-	-	-	-	-
11.	IRS & SPN Specifications (of telecom items)	1	1	1	-	-	-	-	-	-	-
12.	Railway Standard Drawings	1	1	1	1	-	-	-	-	-	-

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CHAPTER XXX

Wi-Fi

30.1 Introduction:

30.1.1 A wireless network or Wireless Local Area Network (WLAN) serves the same purpose as a wired one - to link a group of computers/IP enabled devices like mobiles, Smart TV, IP Telephone, IP Camera etc. It is used to augment Railnet to connect many devices supporting Wi-Fi wireless connectivity.

30.1.2 Railnet is the general purpose Enterprise Wide Area network of Indian Railways. Wi-Fi network is allowed to be established as a part of Railnet.

30.1.3 Wi-Fi is also provided by Railways at Railway stations through Railtel and other private agencies for extending the internet to Passengers.

30.1.4 For other networks like FOIS etc. Wi-Fi access can be established if the same is permitted by the Railway Board.

30.1.5 Wi-Fi is also used as a method of connecting two networks or a single device with a network wirelessly, like a CCTV camera where the feasibility of providing a wired network is difficult, costly or time consuming.

30.2 Technology:

30.2.1 Wi-Fi networks operate using radio frequency (RF) technology, in the free band mostly at 2.4 GHz and 5GHz in public band.

30.2.2 An access point (AP) is used for providing a wireless network. The access point is connected to the wired network (Railnet) to provide Railnet/Internet services to its clients. An access point works as a combination of Router, switch and Wireless Radio in one device.

30.2.3 Wireless controllers are used in the LAN to manage the access points. These wireless controllers manage the access points, control the RF power and try to reduce the interference in the WLAN besides providing many advanced user management features.

30.2.4 Nowadays most of the devices like computers and laptops are provided with built-in Wi-Fi feature for connecting to access points, but if not, the device can be made wireless through the use of an add-on adapter plugged into an empty expansion slot or USB port and providing the necessary software

30.2.5 Wireless network is a shared network, more computers connected to a wireless access point the less data each will be able to send and receive. Wireless network's speed can vary greatly and the range of the access point can vary too.

30.2.6 The closer to an access point, the stronger is the signal and faster is the connection speed. The range and speed of wireless networks also depends on the environment in which the access point is operating.

30.2.7 Interference is an issue with any form of radio communication. The potential for interference is especially great indoors, where different types of building materials (concrete, wood, drywall, metal, glass etc.) can absorb or reflect radio waves, affecting the strength and consistency of a wireless network's signal.

30.2.8 Interference can be minimized by relocating wireless networking hardware or using access points with special antennas that enhance capacity of radio link using methods like MIMO (Multiple Input-Multiple Output).

30.3 Wi-Fi in Offices/Residences

30.3.1 Wi-Fi has become a necessary access technology in the Enterprise LAN. Wi-Fi network is allowed to be established as part of Railnet. Equipment that provides both 5GHz and 2.4 GHz access may be used.

30.3.2 Security is an important element of Wi-Fi usage in prevention of unauthorized access. The following security measures are used for improved security of networks using Wi-Fi.

a. SSID hiding.

b. Mac filtering.

c. Static IP addressing.

d. Use of Strong Passwords for both the device admin as well as the WiFi access.

e. Use of strong end to end encryption standards like WPA.

f. Changing the default IP address and password of the access point.

30.3.3 In the offices, Wi-Fi access points can be provided as personnel equipment or as a service. It is however desirable to provide Wi-Fi as a service.

30.3.4 As a personnel access point, WPA-2 security shall be configured and the security key shall be handed over to the user.

30.3.5 For the Wi-Fi as a service in the office areas the following shall be followed:

a. Wi-Fi shall be provided through access points that should be configured as extended service sets whenever possible. Wireless controllers shall also be provided in the network to manage and control all the access points centrally using NMS and to automatically adjust the RF band/power of the access point to reduce the inter-ference and increase the throughput.

b. In a typical office environment (data use) 20-25 users per access point is a good number when designing. In view of the increased use of net and Wi-Fi, the system should be upgraded to ensure that each user gets sufficient bandwidth for satisfactory use of the facility provided.

c. All access points should be powered through UPS to ensure uninterrupted working.

d. The access points may preferably be powered using PoE from the switch port.

e. To ensure smooth roaming, the same SSID should be used on all the access points within the same campus/building.

   The Wi-Fi access point shall be configured to authenticate users using IEEE 802.1x MAC authen-tication through a radius server. Such a system shall allow only authorized Wi-Fi users to roam across the Wi-Fi zone and access Railnet securely. WPA-2 access keys must also be configured and it must be kept the same for all the access points in this scenario.

f. Wireless controllers should be planned in redundancy so that in case of failure of one, the other is able to manage all the access points centrally using NMS.

30.3.6 In case an access point is provided for a group of users on a temporary basis, MAC binding should also be configured in the access point in addition to the WPA-2 security key.

30.3.7 Railnet has been made available in many railway quarters. Currently it has been extended using DSLAM and DSL modems. Wi-Fi access with Fibre at Home may be provided in the residences as well.

30.3.8 In the residence, the device working as a Wi-Fi access point should be configured with WPA-2 security and the key shall be made available to the users. If possible, MAC binding shall also be configured taking in the possible devices that may connect to the Wi-Fi access point in a residence.

30.4 Fault Diagnosis:

30.4.1 **Hardware:** The equipment is provided with visual indications by which the status of the equipment can be known. The next option is by login into the equipment and test the equipment with standard instructions given by the manufacturer.

30.4.2 **Software:** The software part like firmware of access point / managed equipment can be checked or upgraded to higher versions depending on the type of the fault encountered.

30.4.3 **Media / Channel:** The media which actually connects to an access point can be checked with the testing facility given on the interface device or through measuring instruments.

30.5 Installation / Environment:

30.5.1 The equipment should be installed in a dust free environment and temperature within the room shall be maintained as per the equipment manufacturer data sheet.

30.5.2 Uninterrupted Power supply should be provided to increase the life of the equipment as well as to keep up the availability of the access point. The capacity of the UPS shall be decided taking into consideration availability of local power supply.

30.5.3 The availability of the electrical earth having value within the limits is as per standards is to be ensured.

30.6 Maintenance Schedule:

i. The equipment shall be kept clean and tidy without dust.

ii. Any other checks suggested by manufacturers.

30.7 Do's and Don'ts:

30.7.1 **Do's:**

i. Take the printouts of the configuration and document them.
ii. Softcopy of the configuration files shall be stored each time the configuration is changed so that it will be useful for uploading the configuration when needed and reduce the down time.
iii. Protect the cables connecting the access point and ensure protection from rodents where cabling is done through false ceiling.
iv. Train the staff and update the knowledge to maintain the network more efficiently.
v. Change the password periodically.
vi. Keep the operation and maintenance manual handy.
vii. Do proper lacing of internal wiring.

30.7.2 **Don’ts:**

i. Do not change the IP addressing scheme and IP address of the working network without the written permission of the Network Administrator.
ii. Do not change the configuration without the permission of the Network Administrator.
iii. Do not share the passwords with your colleagues.
iv. Never use water to clean the equipment.

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CHAPTER XXXI

IP ADDRESSING - IPV4/ IPV6

31.0 An Internet Protocol address (IP address) is essential to each device connected to a computer network that uses the Internet Protocol for communication. It serves both network interface identification and location addressing.

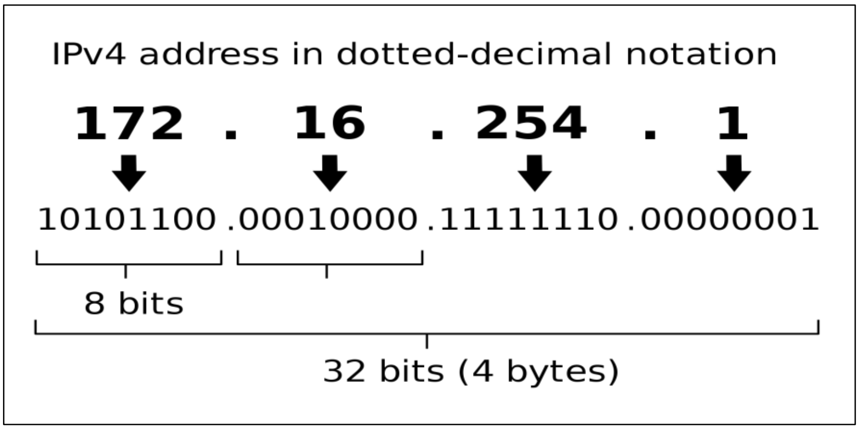
31.1 The IP address space is managed globally by the Internet Assigned Numbers Authority (IANA), and by five regional Internet registries (RIRs) responsible in their designated territories for assignment to local Internet registries, such as Internet service providers, and other end users.

31.2 Two versions of IP addressing are in common use in the Internet today. The original version of the Internet Protocol is Internet Protocol version 4 (IPv4) which majority of users are familiar with. The next version of IP addresses is called IPv6.

31.3 IPv4 addressing Scheme

31.3.1 An IPv4 address has a size of 32 bits, which limits the address space to around 4.29 billion (2^{32}) addresses. Of this number, some addresses are reserved for special purposes such as private networks (~18 million addresses) and multicast addressing (~270 million addresses).

31.3.2 IPv4 addresses are represented in dot-decimal notation, consisting of four decimal numbers, each ranging from 0 to 255, separated by dots, e.g., *172.16.254.1*



31.4 Sub-networks

31.4.1 IP networks may be divided into sub-networks. For this purpose, an IP address consists of two parts: the *network prefix* in the high-order bits and the remaining bits called the *rest field* or *host identifier* used for host numbering within a network. The subnet mask notation determines how the IP address is divided into network and host parts.

31.4.2 Subnet mask is a number that identifies the number of bits used for the network part of the IP address. Subnet mask is also represented as a 32 bit number. If n number of bits represent the network part of the address, its 32 bit representation is n one's followed by (32 - n) zeroes. This may then be represented in dotted decimal notation.

31.5 Private addresses

31.5.1 Computers not connected to the Internet that communicate only with each other via TCP/IP, need not have globally unique IP addresses. Such private networks are widely used and typically connect to the Internet with network address translation (NAT), when needed.

31.5.1.1 Special IP address ranges that are used for special purposes are:

0.0.0.0/8 – addresses used to communicate with the local network
127.0.0.0/8 – loopback addresses
169.254.0.0/16 – link-local addresses (APIPA)
The special purpose IP addresses cannot be used for networking.

31.5.1.2 **Private/ Public IP addresses**

The IANA (Internet Assigned Numbers Authority) reserves the following IP address blocks for use as private IP addresses:
10.0.0.0 to 10.255.255.255
172.16.0.0 to 172.31.255.255
192.168.0.0 to 192.168.255.255
The above ranges of the IP addresses can be used by anyone for an Intranet network.
Except private & special purpose IP addresses all IP addresses of class A, B & C are public or global IP addresses.

31.5.2 **Private addressing scheme of Indian Railways**

31.5.2.1 IPv4 Private addresses allotted by the Railway Board are being used in the Data networks of IR. The private address space chosen for these networks are 10.0.0.0/8. The IP addresses are then further divided as per allotment among various zones and divisions for each of the individual data networks.

31.5.2.2 The 10.0.0.0/8 network address has been further subnetted to 10.X.0.0/16 network by Railway board and allocated to Zonal Railways, divisions , RDSO,PSUs and Training Institutes.

31.5.3 **Public IP address is required for giving access of any intranet service to the Public through internet**

31.5.4 Private IPs are free and need not require any permission for using these IP addresses.

31.5.5 Private IP addresses within the same local network must be unique and cannot be repeated.

31.5.6 Private IP addresses cannot communicate in the public domain and are not able to use Internet services. In this case, the connection to the Internet is possible via NAT (network address translation) features of networking which logically replaces the private IP address with a public one.

31.5.7 For availability of Internet facility minimum one public IP address is must for any Intranet network. Through NAT at Intranet gateway level private IP addresses are logically hidden and public IP addresses represent the Intranet traffic like a mediator in public domain.

31.5.8 An Internet Service Provider(ISP) is a company that provides Internet access to organizations and home users.

31.5.9 ISPs are responsible for making sure you can access the Internet, routing Internet traffic, resolving domain names, and maintaining the network infrastructure that makes Internet access possible.

31.5.10 At Present RCIL is the ISP for Indian Railways.

31.5.11 All Railnet users are able to access internet service through public IP used at Gateway level of RCIL through NATing.

31.6 IPv6 addressing Scheme

31.6.1 In IPv6, the address size was increased from 32 bits in IPv4 to 128 bits, thus providing up to 2^{128} (approximately 3.403×10^{38}) addresses. This gives virtually unlimited unique addresses for future use.

31.7 Important features of IPV6

31.7.1 **Sufficient** address space for the near future**.**

31.7.2 **Enhanced security:** IPSec (Internet Protocol Security) is built into IPv6 as part of the protocol. This means that two devices can dynamically create a secure tunnel without user intervention

31.7.3 **Header improvements:** the packed header used in IPv6 is simpler than the one used in IPv4. The IPv6 header is not protected by a checksum so routers do not need to calculate a checksum for every packet making transmission efficient.

31.7.4 **No need for NAT:** since every device has a globally unique IPv6 address, there is no need for NAT.

31.7.5 **Stateless address auto configuration:** IPv6 hosts can automatically configure themselves with an IPv6 address even without a DHCP server.

31.8 Addressing Scheme

31.8.1 The 128 bits of IPV6 is represented as 32 hexadecimal numbers arranged in 8 quartets of 4 hexadecimal digit separated by a colon":″

31.8.1.1 Not case sensitive for A, B, C, D, E and F

31.8.1.2 Omission of ZEROS

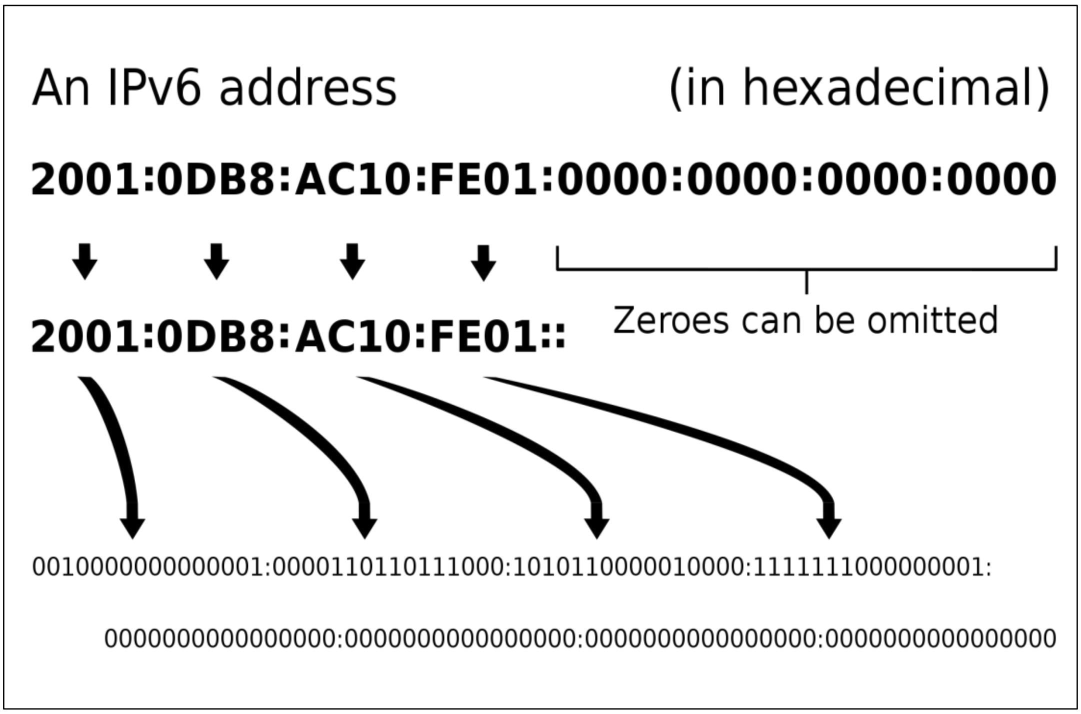
31.8.1.3 Leading zero in any quartet can be omitted.

31.8.1.4 Four successive zeros in a Quartet can be substituted by one zero.

31.8.1.5 Replacing Successive Fields of Zeros with "::”

31.8.1.6 Multiple quartet with zero can be represented as :: but only once in a address

Example: 2001:0DB8:AC10:FE01:0000:0000:0000:0000



31.9 IPv6 Migration

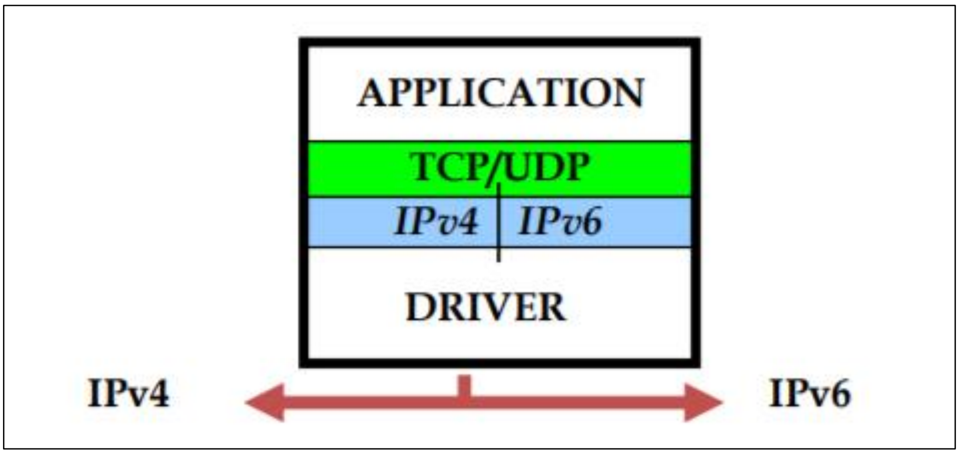
31.9.1 IPv6 and IPv4 are not compatible. Migration from IPv4 to IPv6 will be done in near future. Until IPv6 completely supplants IPv4, which is not likely to happen in the foreseeable future, a number of so-called transition/migration mechanisms are needed so that both coexists and work together. Various stakeholders will have to become thorough with the knowledge of IPV6 and the migration strategies. These trained man- power will handhold railways to migrate Railnet and other networks from IPv4 to IPv6 when the migration boom occurs.

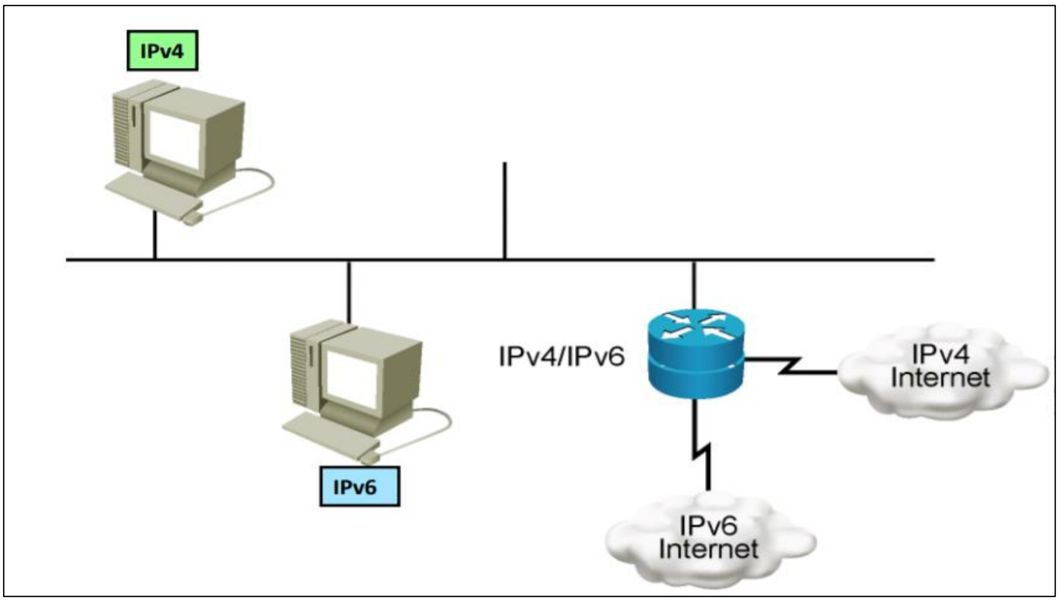
31.9.2 There are basically 3 methods for migrating from IPv4 to IPv6 that are prevalent today.

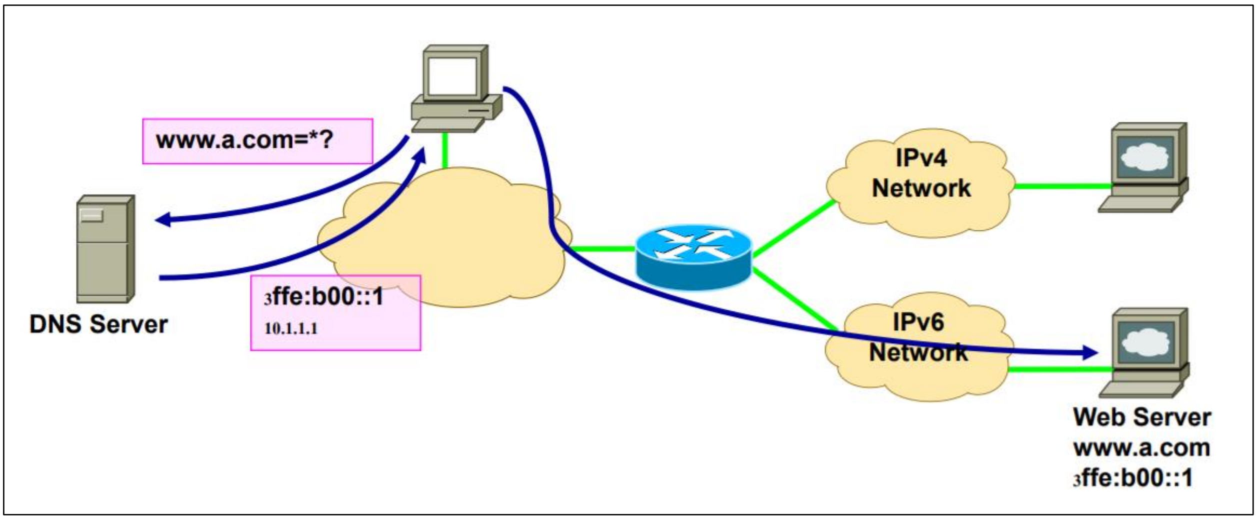
31.9.2.1 Dual Stack Method

31.9.2.1.1 It allows IPv4 & IPv6 to coexist in the same device & network.

31.9.2.1.2 In the dual stack method all the devices like PCs, switches, routers, ADSL modems etc. dual stacked i.e. these equipment will use both IPv4 drivers as well as IPv6 drivers. This will allow both IPv4 and IPv6 to coexist and gradual transition from IPv4 to IPv6 can happen. Here, the computer decides whether to use IPv4 or IPv6 based on sets of rules. DNS servers are also used to decide if IPv6 or IPv4 is used.





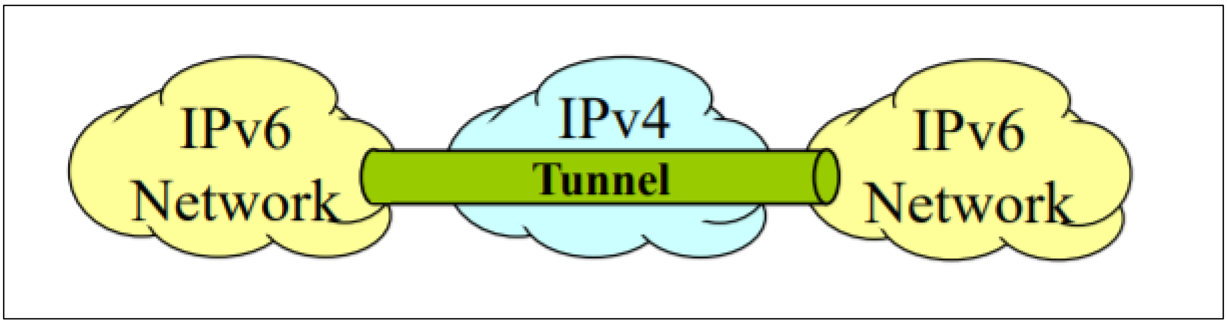


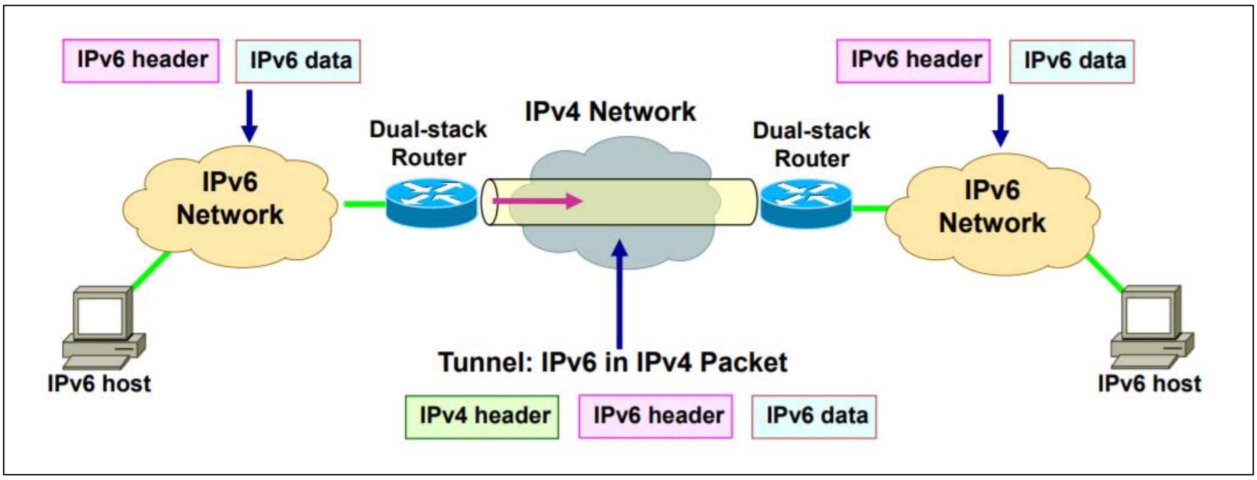
31.9.2.2 Tunneling

31.9.2.2.1 It allows IPv6 hosts to communicate over IPv4 infrastructure.Tunneling encapsulates IPv6 traffic within IPv4 packets.Allows isolated IPv6 end system and routers to communicate without the need to upgrade the IPv4 infrastructure that exists between them.

31.9.2.2.2 Following tunneling configurations exist:

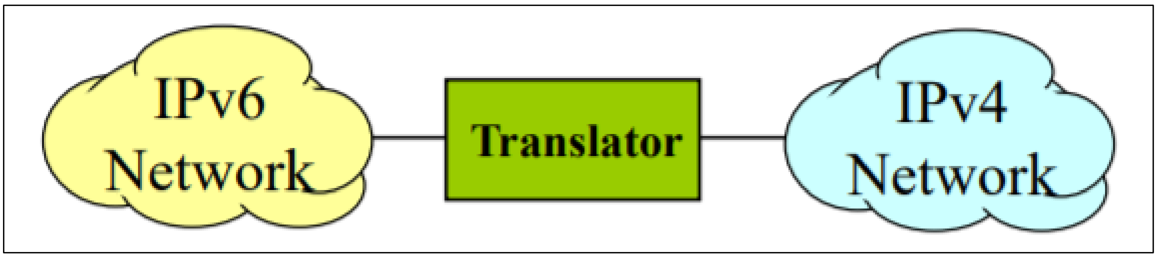
- Router-to-Router
- Host-to-Router and Router-to-Host
- Host-to-Host



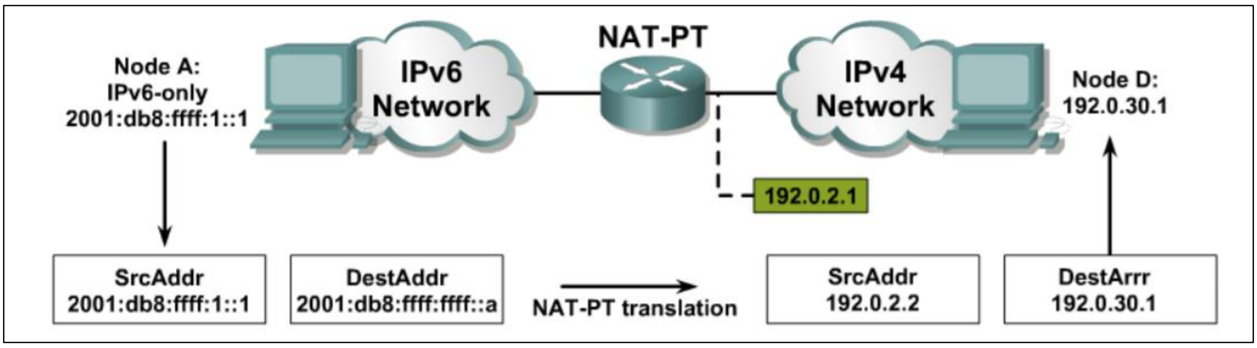


31.9.2.3 Translation [SIIT and NAT64] (Stateless IP/ICMP Translation)

31.9.2.3.1 In the SIIT and NAT64 method all the devices like PCs, switches, routers, ADSL modems etc. are configured with IPv6 address only, the gateways are configured with SIIT and NAT64 protocol and with DNS-64, the gateways will connect external IPv4 as well as IPV6 network.



31.9.2.3.2 This allows communication between IPv4 only and IPv6 only end stations. The job of the translator is to translate IPv6 packets into IPv4 packets by doing address and port translation and vice versa.



31.9.2.3.3 This method seems to be the most preferred method to migrate IPv4 to IPv6.

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CHAPTER XXXII

TUNNEL COMMUNICATION

32.1 Indian Railway has provided various sizes of tunnels on the IR network of varying lengths. These tunnels can broadly be categorized in three categories i.e. tunnels less than 500 meters, more than 500 meters to 5Km and tunnels more than 5Km length. Requirement of integrated communication needed for the above categories will be slightly different.

Tunnel Communication system in tunnels where ever provided on Indian Railway shall be able to provide communication need to the following:

(i) Tunnels less than 500 meters length.
(ii) Tunnels more than 500 meters to 5 Km length.
(iii) Tunnels more than 5 Km length.

32.2 Type of communication Systems in Tunnels:

32.2.1 Radio Communication System:

Following communications are to be extended as per Railway Requirement in Tunnels for communication during maintenance and constructional blocks, communication in the train in between Guard & Driver, Emergency radio communication between driver, guard, station master & Cabin, Train Control etc:

(i) VHF Simplex: The frequency Bands 146-163MHz for VHF Simplex communication are allotted in Indian Railways.The VHF simplex communication being the lifeline of train operation, Tunnel Radio System should be able to provide an uninterrupted radio communication between the radios located anywhere inside a tunnel (inner tunnel) and also between radios of other tunnels(inter tunnel) of the same network.

(ii) LocoTrol: The present frequency Bands 424 - 430 MHz for LocoTrol are allotted in Indian Railways.

(iii) GSM-R/LTE: The frequency Bands 876-915 MHz(Uplink) & 921-960 MHz(Downlink) for GSM-R are allotted and 700 MHz band are recommended to be allotted for LTE in Indian Railways.

(iv) TCAS: The frequency Bands 405-512 MHz for TCAS are allotted in Indian Railways.

(v) TETRA: The frequency Bands 370-430 MHz for TETRA are allotted for Railways.

The Tunnel Radio System shall provide an uninterrupted radio communication inside tunnel with the headquarters and operation centers and handheld devices of the tunnel operator’s staff, emergency staff and trains which pass the tunnel. It shall be possible to continuous coverage over the entire length of the tunnel, clear audio throughout with no interference, reliable system operation under harsh tunnel environmental conditions, trunked radio channels across many bands and ease of system operation and maintenance.The communication of all channels in the tunnel shall be independent, simultaneous and failure-free.

32.2.1.1 System details for Tunnel communication:

(i) Master unit:

The Master Unit is used to convert signals from RF to light when fibre fed repeaters is used at the remote end of the optical link. Master Unit shall be used in more than 500 meters lengths tunnels.
Master Unit system may consist of following sub-system:

(a) Channelized VHF Simplex Off-Air Repeater and VHF Simplex Optical Master Unit.

(b) GSM-R/LTE Off-Air Repeater and GSM-R/LTE Optical Master Unit.

(c) Channelized TCAS/ LocoTrol/ TETRA Off-Air Repeater and TCAS/ LocoTrol/ TETRA Optical Master Unit.

(ii) Optical remote unit:

Optical Remote unit is used at the remote end to convert Optical Signal to RF Signal and then transmit it into Leaky cable in the particular area to cover the tunnel for the wireless communication. It is connected to Master Unit.

Optical Remote Units to accept for VHF Simplex, LocoTrol, GSM-R/LTE, TETRA and TCAS. Remote unit are Monitored, Controlled and Alarmed Remotely from the Master Unit over Fibre and Remotely using an Ethernet Modem. Optical Remote unit shall be used to provide coverage in more than 500 meters lengths tunnels.

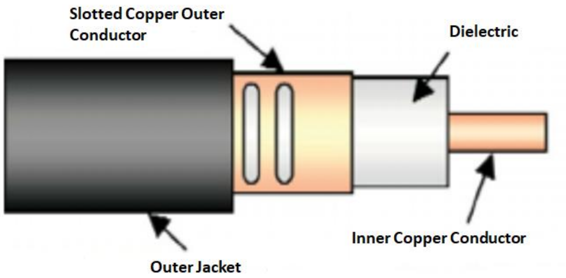
(iii)Off-Air Channelized Repeater:

For less than 500 meters Tunnels are to be covered with High Gain Off-Air Channelized Repeaters feeding Dual Radiating Cable Systems. The Repeaters cover VHF Simplex/LocoTrol, GSM-R/LTE, TETRA and TCAS communication per Bore.

(iv) Leaky Cable:

For Wireless communication (VHF Simplex, LocoTrol, GSM-R/LTE, TCAS and TETRA) inside the tunnel FRLS-0H (Flame retardant Low Smoke Zero Halogen) rated Leaky cable shall be provided to minimize accumulation of smoke inside the tunnel in case of accidental fire. Two 7/8” Leaky Cable shall runs per tunnel tube length for VHF Simplex, LocoTrol, GSM-R/LTE, TCAS and TETRA communication.

7/8" Leaky Cable is a type of RF coaxial cable which has gaps or slots in its outer conductor to allow the radio signal to leak into or out of the cable along its entire length so the cable functioning as extended antennas.



(v) Antenna for system:

For Tunnels less than 500 meters, Antenna shall be installed at tunnel site for VHF Simplex, LocoTrol, GSM-R/LTE, TCAS, TETRA etc. For Tunnels more than 500 meters, Antennas shall be installed on a Tower for VHF Simplex, LocoTrol, GSM-R/LTE, TCAS, TETRA etc. The wireless system and tower with antenna to be installed should have the SACFA clearance as applicable.

(vi) Optic Fibre cable:

Master Unit at Base station shall be connected to the tunnel optical remote unit through Fibre Junction Box. Video Surveillance System and PA Systems shall also be connected through same Optic Fibre system.

(vii) Power supply unit for Master unit, Optical Remote unit/Repeater in Tunnels:

For Tunnel Communication, power supply unit with battery backup (230VAC 50Hz or -48 VDC) for Master Unit, Optical Remote unit/Repeaters should be required.

(viii) Fibre Junction Box:

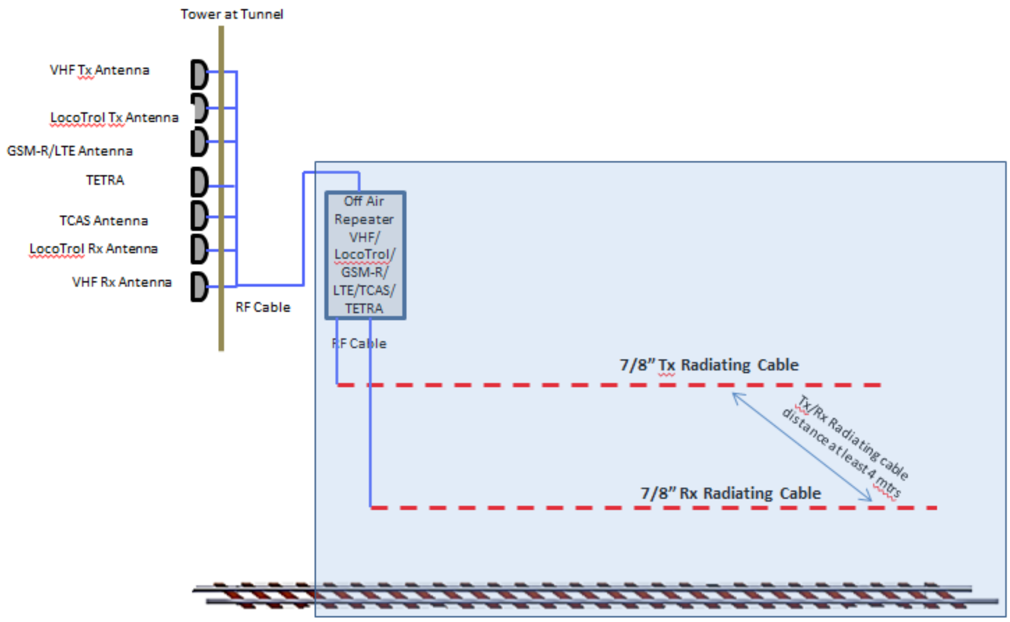
Fibre Junction box is required for more than 500 meters tunnel lengths.

(ix) Optic Fibre & Copper Cable:

Optic Fibre & Copper Cable ring should be provided in the tunnel to connect various facilities like PA system, CCTV cameras, etc. Cables (OFC,Quad etc) should be laid in PVC/DWC pipes.

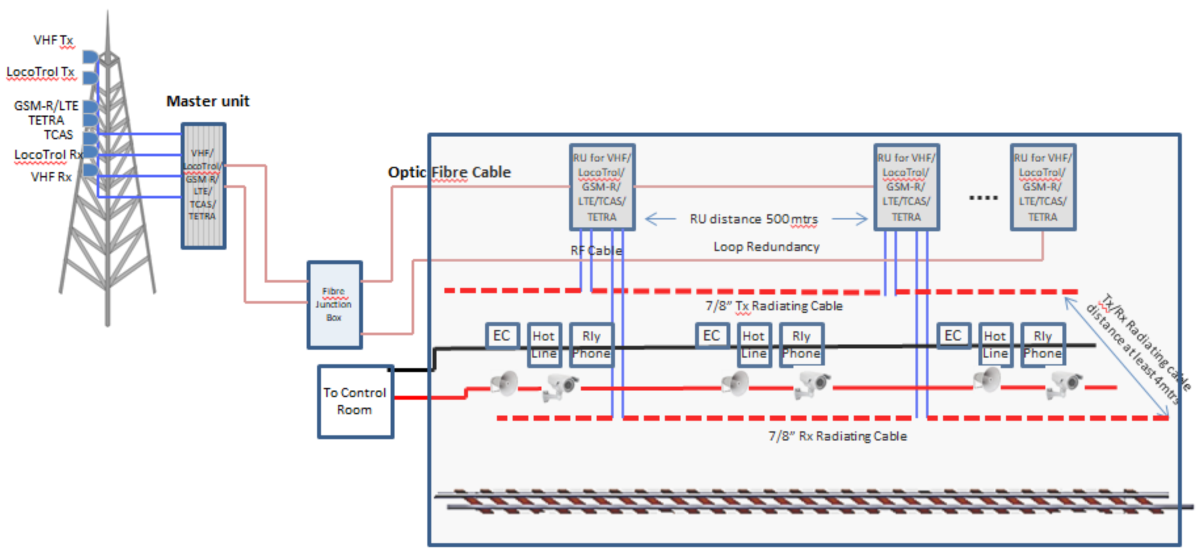
32.2.1.2 Tunnel communication diagram for different lengths of tunnels:

(i) Tunnel communication for less than 500 mtrs. lengths:



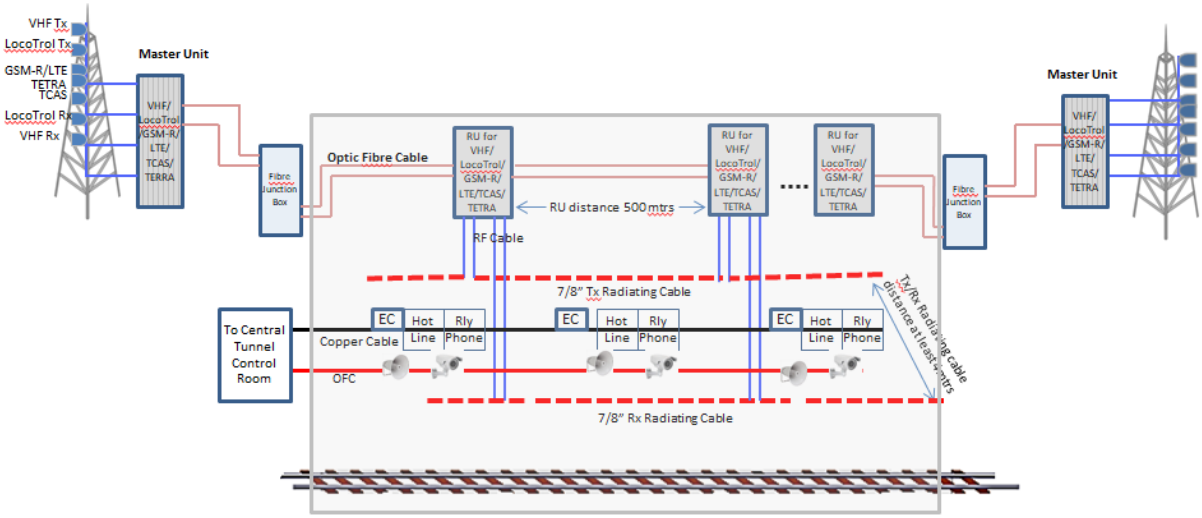
Tunnel communication System for less than 500 mtrs. length

(ii) Tunnel communication for more than 500 mtrs. to 5 Km lengths:



Tunnel communication system for more than 500 meters to 5000 meters length

(iii) Tunnel communication for more than 5 Km lengths:



Tunnel communication system for more than 5000 meters

32.2.2 Emergency Telephone:

It should be recommended that Emergency Telephone should be installed at the key point in tunnel-cross passages, on escape walkways, on tunnel walls at every 250 meters and shafts. Telephone should be able to function properly and work in the tunnel environment with a potentially high noise and poor light. It is recommended that they should be installed with a sound hood to avoid noise-affecting conversation. Emergency Telephone should be linked to the existing Emergency Control communication system and terminated at the Divisional Control Room.

32.2.3 Public Addressing System:

A Public address system shall be provided to inform/warn maintenance and service staff and give instructions to people in abnormal conditions during incident. Therefore loudspeakers shall be installed every 100 m in the tunnel. PA System should be installed at more than 500 meters Tunnel lengths.

32.2.4 Hotline Telephone:

Hotline Telephone Services should be extended to Tunnel Maintenance Boxes. These shall be connected to Central Tunnel Control Room/Divisional Control Room.Regular Railway Telephone Services should be extended to Tunnel Maintenance Boxes at appropriate locations. These Railway phones shall be connected to Divisional Railway Telephone Exchange.

32.2.5 Control and Monitoring System:

IP based Video Surveillance System shall be provided inside tunnels to ensure that there are no blank spots over the tunnels. The camera should perform well in low light scenario inside the tunnels. All the camera feed shall be transferred to the Tunnel Control Center/Divisional Control Room for viewing, recording and monitoring of tunnels through cameras.

32.3 Maintenance of system:

(i) Transmitting frequency and power of the system are to be checked once in a month. Normally these measurements are done by the system internally and can be checked through PC/Laptop connected with Master Unit.

(ii) Power Supply System:

- (a) Input and output voltage & currents-Weekly
- (b) Specific gravity of each cell - weekly

(iii) Antenna system along with Radiating cable and connectors: Antenna system at Master location and leaky cable connections inside the tunnels are physically checked weekly basis for any damage or break down.

(iv) On weekly basis check the Master unit for any fault alarm(s). If some fault alarms are noticed, connect the Laptop/PC and pinpoint the actual fault for rectification.

(v) Emergency Communication (EC) socket-Weekly

(vi) Hotline Telephone Services & Regular Railway Telephone- Monthly

(vii) Integrated Digital PA System -Monthly

(viii) Video Surveillance System- Monthly

32.4 Inspection:

All Systems and communication media installed inside the tunnels must be inspected every month by SSE/JE/TELE.

32.5 Failure report:

(i) System's failure must be reported to the controlling officer daily in the morning.

(ii) Monthly statement of a failure must be reported in the PCDO to Headquarter.

32.6 Tools and plant required for maintenance of equipment:

(i) Optical power meter

(ii) Hydrometer

(iii) Digital Multimeter

(iv) Line Tester

(vi) Fibre splicing machine

(vii) Basic tools like screw drivers and spanner sets

(viii) Three handheld radios programmed with the working frequencies

(ix) Reference screen shot prepared when the complete system is in satisfactory working condition.

(x) A Laptop

(xi) Connecting cables supplied along with system.

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END