

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.

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 \pm 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. Time 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. 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 ASTE/DSTE. The records of the tests and maintenance schedule shall be maintained in the relevant pro-forma.

- (c) ASTE/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 14.3.13 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.

(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 – (ASTE/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 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.

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 through 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			