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Abstract

In today's life telecommunication is the major part of our life. Every moment we connect to each other and bounded to each other using telecommunication technology. There are a number of techniques using in the real world for telecommunication but all depend upon its performance and service quality. Consider a situation: two persons are talking on their phone. They are so engrossed in their conversation that even a fire cannot disturb their conversation. But behind this a number of systems are working to get in touch the two persons. Though now a day's telecom is mainly dominated by mobile telephony, the landline is not a concept of the past due to the integration of services it provides today (e.g. ISDN). Majority of all communications in the industry are still dependent on ISDN. The phone instrument is connected to a horde of technology. A lot of factors can lead to failure in communications as will be clarified further. All services work with the switching network at its core. And the switch is the most critical component of a Telecom Network as will be evident in this report.

Company Profile

RailTel Corporation a "Mini Ratna (Category-I)" PSU is one of the largest neutral telecom infrastructure providers in the country owning a Pan-India optic fiber network on exclusive Right of Way (ROW) along Railway track. The OFC network covers all important towns & cities of the country and several rural areas covering 70% of India's population. RailTel with strong nationwide presence is committed to bring cutting edge technology and offer innovative services to the Indian Telecom market.

RailTel is in the forefront in providing nationwide Broadband Telecom & Multimedia Network in all parts of the country in addition to modernization of Train operations and administration network systems. With its Pan India high capacity network, RailTel is working towards creating a knowledge society at various fronts. Presently, RailTel has created over 45000 RKMs of fiber network connecting over 4500 cities/towns on the network including several rural areas.

The network is supported by multiple of 10G/2.5G based STM-64/16 system rings. In addition, RailTel has also provided over 10500 KM of network with DWDM systems with 100G/400G capacity which is targeted to be further expanded to additional 14000 KM within a year to cover all major cities of the country. RailTel also has a MPLS network with core on 10G capacity along with NGN system to support various IP enabled services.

Equipped with an ISO 9001:2008 certification, RailTel offers a wide gamut of managed telecom services to Indian Telecom market. The service includes Managed lease lines, Tower collocation, MPLS based IP-VPN, Internet and NGN based voice carriage services to Telecom Operators, Internet Service Providers, MSOs, Enterprises, Banks, Govt. Institutions/dept., Educational Institutions/Universities, etc. RailTel is aggressively entering into Enterprise services market with launch of its various services like Data Center, Rail wire, Telepresence, etc. Recently RailTel has also acquired Unified License.

Telecommunication

***Telecommunication** is the transmission of signs, signals, messages, words, writings, images and sounds or information of any nature by wire, radio, optical or other electromagnetic systems. Telecommunication occurs when the exchange of information between communication participants includes the use of technology. It is transmitted either electrically over physical media, such as cables, or via electromagnetic radiation. Such transmission paths are often divided into communication channels which afford the advantages of multiplexing. Since the Latin term **communicatio** is considered the social process of information exchange, the term **telecommunications** is often used in its plural form because it involves many different technologies.*

Early means of communication over a distance included visual signals, such as beacons, smoke signals, semaphore telegraphs, signal flags, and optical heliographs. Other examples of pre-modern long-distance communication included audio messages such as coded drumbeats, lung-blown horns, and loud whistles. Modern technologies for long-distance communication usually involve electrical and electromagnetic technologies, such as telegraph, telephone, and teleprinter, networks, radio, microwave transmission, fiber optics, and communication satellites.

Technologies of telecommunication

1. PDH (Plesiochronous Digital Hierarchy)

2. SDH (Synchronous Digital Hierarchy)

3. WDM (Wavelength Division Multiplexing)

4. ASON (Automatically Switched Optical Network)

5. OTN (Optical Transport Network)

Optical Fiber

An optical fiber or optical fiber is a flexible, transparent fiber made by drawing glass (silica) or plastic to a diameter slightly thicker than that of a human hair. Optical fibers are used most often as a means to transmit light between the two ends of the fiber and find wide usage in fiber-optic communications, where they permit transmission over longer distances and at higher bandwidths (data rates) than electrical cables. Fibers are used instead of metal wires because signals travel along them with less loss; in addition, fibers are immune to electromagnetic interference, a problem from which metal wires suffer excessively.

Structure:-

Optical fibers typically include a core surrounded by a transparent cladding material with a lower index of refraction. Light is kept in the core by the phenomenon of total internal reflection which causes the fiber to act as a waveguide.

There are 2 types of fibers based on their mode of propagation/transmission. Fibers that support many propagation paths or transverse modes are called multi-mode fibers (MMF), while those that support a single mode are called single-mode fibers (SMF).

Multi-mode fibers generally have a wider core diameter and are used for short-distance communication links and for applications where high power must be transmitted.

Single-mode fibers are used for most communication links longer than 1,000 meters (3,300 ft.).

Losses in fiber optics:-

Being able to join optical fibers with low loss is important in fiber optic communication.

For applications that demand a permanent connection a fusion splice is common. In this technique, an electric arc is used to melt the ends of the fibers together. Another common technique is a mechanical splice, where the ends of the fibers are held in contact by mechanical force. Temporary or semi-permanent connections are made by means of specialized optical fiber connectors.

Attenuation or losses in fiber-optics due to various factors are:-

- *Bending loss occurs when an optic fiber is made to bend which makes the laser/light to get deflected and thereby attenuates the signal.*
- *Dispersion loss in an optic fiber occurs when the light travelling within the cable gets dispersed, which mainly occurs due to variation or change of reflective index.*
- *Scattering losses in optical fiber are due to microscopic variations in the material density, compositional fluctuations, structural in homogeneities and manufacturing defects.*
- *Fiber optic splicing is another type of loss in optical fibers. By joining two fibers end-to-end, splicing aims to ensure that the light passing through it is almost as strong as the pure fiber itself; but no matter how good the splicing is loss is inevitable.*
- *Connector losses or insertion losses in optical fiber, are the losses of light power resulting from the insertion of a device in a transmission line or optical fiber.*

Need of optic fiber in communication:-

Fiber is preferred over electrical cabling when high bandwidth, long distance, or immunity to electromagnetic interference is required. Optical fiber is used by many telecommunications companies to transmit telephone signals, Internet communication, and cable television signals.

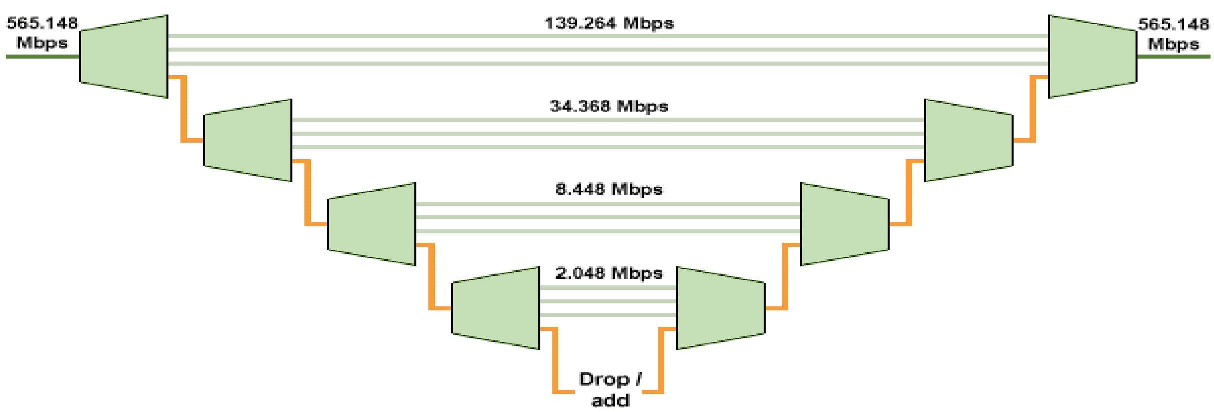
<u>*Plesiochronous digital hierarchy (PDH)*</u>

<u>*Introduction*</u>*:-*

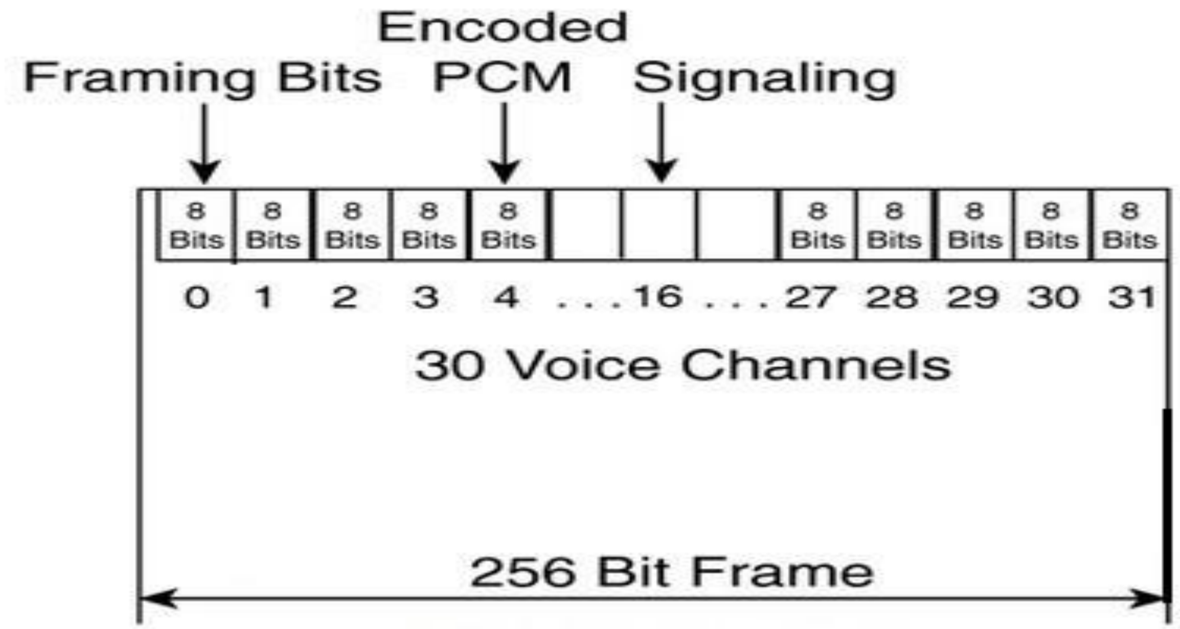
*The **plesiochronous digital hierarchy** (**PDH**) is a technology used in telecommunications networks to transport large quantities of data over digital transport equipment such as fibre optic and microwave radio systems. The term plesiochronous is derived from Greek plēsios, meaning near, and chronos, time, and refers to the fact that PDH networks run in a state where different parts of the network are nearly, but not quite perfectly synchronized.*

Traditionally, digital transmission systems and hierarchies have been based on multiplexing signals which are plesiochronous (running at almost the same speed). Also, various parts of the world use different hierarchies which lead to problems of international interworking; for example, between those countries using 1.544 Mbit/s systems (U.S.A. and Japan) and those using the 2.048 Mbit/s system.

To recover a 64 Kbit/s channel from a 565 Mbit/s PDH signal, it's necessary to demultiplex the signal all the way down to the 2 Mbit/s level before the location of the 64 Kbit/s channel can be identified. PDH requires "steps" (565-140, 140-34, 34-8, 8-2 demultiplex; 2-8, 8-34, 34-140, 140-565 multiplex) to drop out or add an individual speech or data channel. This is due to the bit-stuffing used at each level.



E1 Frame Structure:-



1-E1 Frame = 32 Channels (30 Voice Channels)

1 Channel (1 byte) = 8 bits

*Total number of bits in 1-E1 frame = 8*32 = 256 bits*

Time period of each frame = 125 µs

Frame rate = 1/125µs = 8000 frame/s

*Bit rate of each channel (byte) = 8*8000 bit/s = 64 Kbit/s*

*Bit rate of E1 frame = 32*64 Kbit/s = 2048 Kbit/s = 2.048 Mbit/s*

E1 frame = 2.048 Mbit/s (30 Voice Channels)

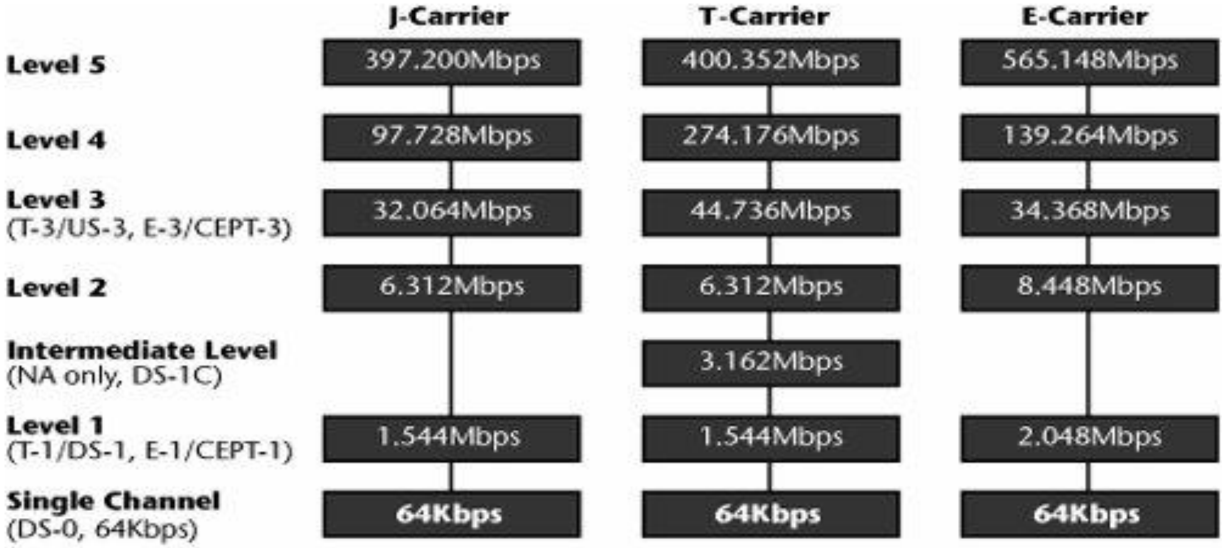
E2 frame = 8.488 Mbit/s (120 Voice Channels)

E3 frame = 34.368 Mbit/s (480 Voice Channels)

E4 frame = 139.264 Mbit/s (1920 Voice Channels)

E5 frame = 565.148 Mbit/s (7680 Voice Channels)

Transport Network Infrastructure:-



PDH Disadvantages:-

- *Plesiochronous system, i.e., No central clock, each stage having its own clock.*
- *Specialized equipment required for interwork two hierarchies.*
- *Low level tributary access require full system de-multiplex.*
- *No monitoring overhead.*
- *No management overhead.*
- *No common standard among vendors.*
- *Only point to point communication.*
- *No standard optical interfaces.*
- *Lack of in-band capacity for network management.*
- *No standardized network protection mechanisms.*
- *Support only linear topology.*

Synchronous digital hierarchy (SDH)

Introduction:-

Synchronous optical networking *(**SONET**) and **synchronous digital hierarchy** (**SDH**) are standardized protocols that transfer multiple digital bit streams synchronously over optical fiber using lasers or highly coherent light from light-emitting diodes (LEDs). At low transmission rates data can also be transferred via an electrical interface. The method was developed to replace the plesiochronous digital hierarchy (PDH) system for transporting large amounts of telephone calls and data traffic over the same fiber without synchronization problems.*

SDH (Synchronous Digital Hierarchy) is a standard for telecommunications transport formulated by the International Telecommunication Union (ITU), previously called the International Telegraph and Telephone Consultative Committee (CCITT). SDH was first introduced into the telecommunications network in 1992 and has been deployed at rapid rates since then. It's deployed at all levels of the network infrastructure, including the access network and the long-distance trunk network. It's based on overlaying a synchronous multiplexed signal onto a light stream transmitted over fibre-optic cable. SDH is also defined for use on radio relay links, satellite links, and at electrical interfaces between equipment. The comprehensive SDH standard is expected to provide the transport infrastructure for worldwide telecommunications for at least the next two or three decades.

Synchronising SDH:-

The internal clock of an SDH terminal may derive its timing signal from a Synchronization Supply Unit (SSU) used by switching systems and other equipment. Thus, this terminal can serve as a master for other SDH nodes, providing timing on its outgoing STM-N signal. Other SDH nodes will operate in a slave mode with their internal clocks timed by the incoming STM-N signal. Present standards specify that an SDH network must ultimately be able to derive its timing from a PRC.

Basic SDH Signal:-

The basic format of an SDH signal allows it to carry many different services in its Virtual Container (VC) because it is bandwidth-flexible. This capability allows for such things as the transmission of high-speed packet-switched services, ATM, contribution video, and distribution video. However, SDH still permits transport and networking at the 2 Mbit/s, 34 Mbit/s, and 140 Mbit/s levels, accommodating the existing digital hierarchy signals. In addition, SDH supports the transport of signals based on the 1.5 Mbit/s hierarchy.

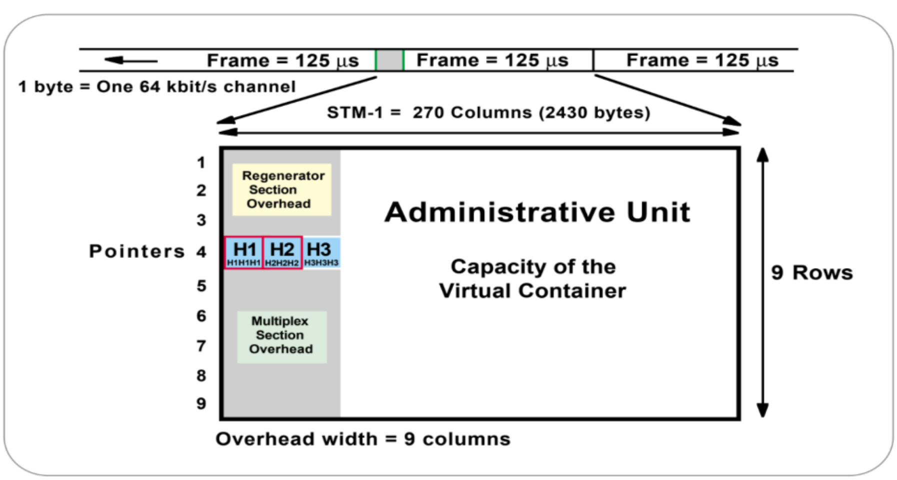
SDH Transmission Hierarchies:-

SDH	SDH Capacity	Bit Rate	Abbreviated
STM-0	21 E1	51.84 Mbps	51 Mbps
STM-1	63 E1 or 1 E4	155.52 Mbps	155 Mbps
STM-4	252 E1 or 4 E4	622.08 Mbps	622 Mbps
STM-16	1008 E1 or 16 E4	2488.32 Mbps	2.4 Gbps
STM-64	4032 E1 or 64 E1	9953.28 mbps	10 Gbps
STM-256	16128 E1 or 256 E1	39813.12mbps	40 Gbps

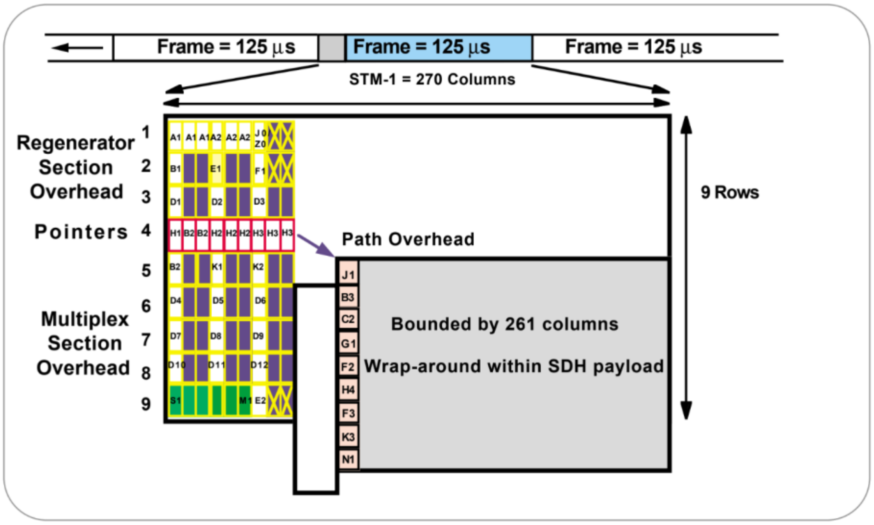
SDH Frame Structure:-

The STM-1 frame is the basic transmission format for SDH. The frame lasts for 125 microseconds, therefore, there are 8000 frames per second.

The STM-1 frame consists of overhead plus a virtual container capacity. The first nine columns of each frame make up the Section Overhead, and the last 261 columns make up the Virtual Container (VC) capacity. The VC plus the pointers (H1, H2, H3 bytes) is called the AU (Administrative Unit).



Carried within the VC capacity, which has its own frame structure of nine rows and 261 columns, is the Path Overhead and the Container. The first column is for Path overhead; it's followed by the payload container, which can itself carry other containers.



Virtual Containers can have any phase alignment within the Administrative Unit, and this alignment is indicated by the Pointer in row four. Within the Section overhead, the first three rows are used for the Regenerator Section Overhead, and the last five rows are used for the Multiplex Section Overhead.

The STM frame is transmitted in a byte-serial fashion, row-by-row, and is scrambled immediately prior to transmission to ensure adequate clock timing content for downstream regenerators.

Frame Characteristics:-

- *270 Columns and 9 Rows.*
- *Row-by-row transmission.*
- *Time period of each frame = 125 µs.*
- *Each byte represents 64 Kbps.*
- *Total bytes = 270*9 = 2430 byte.*
- *Each byte = 8 bit.*
- *Total bits = 2430*8 = 19440.*
- *Frame frequency = 8000.*
- *Data rate of one byte = 8*8000 = 64 Kbps.*
- *Data rate of each frame = 19440*8000 = 155 Mbps.*

Virtual Container:-

SDH supports a concept called virtual containers (VC). Through the use of pointers and offset values, VCs can be carried in the SDH payload as independent data packages. VCs are used to transport lower-speed tributary signals. Above figure illustrates the location of a VC-4 within the STM- 1 frame. Note that it can start (indicated by the J1 path overhead byte) at any point within the STM-1 frame. The start location of the J1 byte is indicated by the pointer byte values.

Virtual containers can also be concatenated to provide more capacity in a flexible fashion.

Parameters of the virtual containers:-

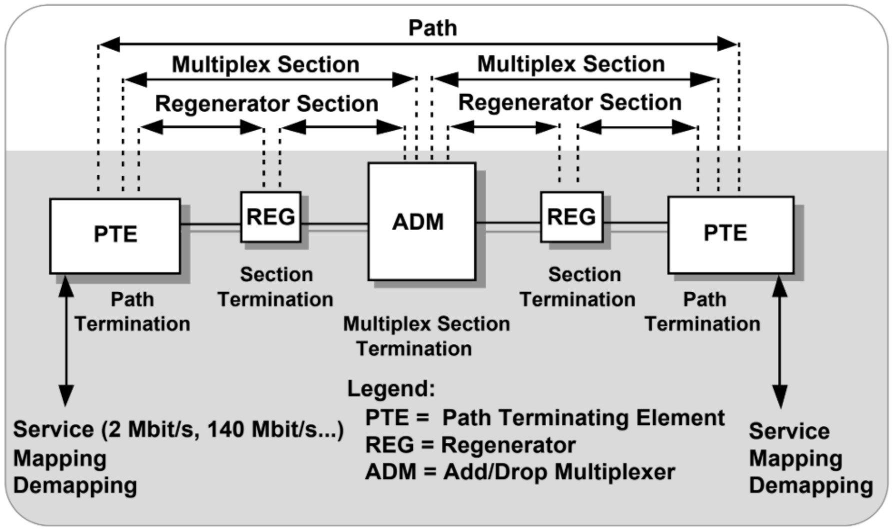
SDH	***Digital Bit Rate***	***Size of VC***
VC-11	*1.728 Mbps*	*9 rows, 3 columns*
VC-12	*2.304 Mbps*	*9 rows, 4 columns*
VC-2	*6.912 Mbps*	*9 rows, 12 columns*
VC-3	*48.960 Mbps*	*9 rows, 85 columns*
VC-4	*150.336 Mbps*	*9 rows, 261 columns*

SDH Overhead:-

The SDH standard was developed using a client/server layer approach. The overhead and transport functions are divided into layers. They are:

- ***Regenerator Section***
- ***Multiplex Section***
- ***Path***

The layers have a hierarchical relationship, with each layer building on the services provided by all the lower layers.



Regenerator Section Overhead:-

The Regenerator Section Overhead contains only the information required for the elements located at both ends of a section. This might be two regenerators, a piece of line terminating equipment and a regenerator, or two pieces of line terminating equipment.

The Regenerator Section Overhead is found in the first three rows of Columns 1 through 9 of the STM-1 frame.

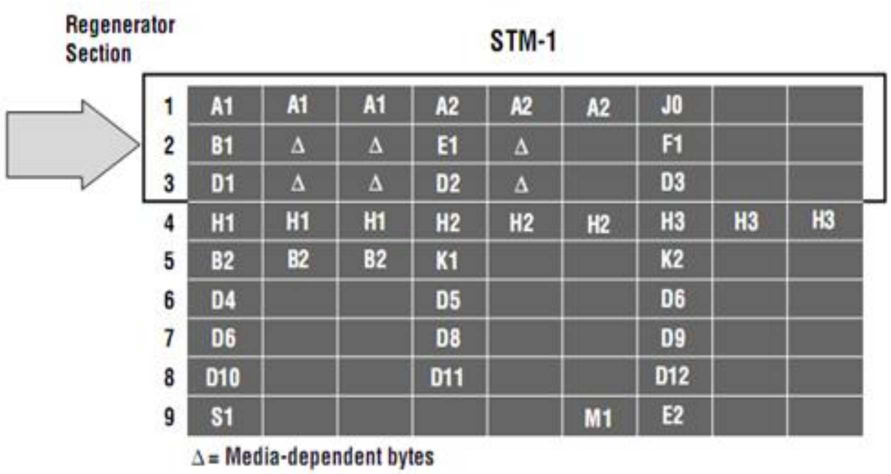


Table: - Regenerator Section Overhead (RSOH)

Byte	***Description***
A1 and A2	***Framing bytes –*** *These two bytes indicate the beginning of the STM-N frame.*
J0	***Regenerator Section (RS) Trace message –*** *It's used to transmit a Section Access Point Identifier so that a section receiver can verify its continued connection to the intended transmitter.*
B1	***RS bit interleaved parity code (BIP-8) byte –*** *This is a parity code (even parity), used to check for transmission errors over a regenerator section.*
E1	***RS order wire byte –*** *This byte is allocated to be used as a local order wire channel for voice communication between regenerators.*
F1	***RS user channel byte –*** *This byte is set aside for the user's purposes.*
D1, D2, D3	***RS Data Communications Channel (DCC) bytes –*** *These three bytes form a 192 Kbit/s message channel providing a message-based channel for Operations, Administration and Maintenance (OAM) between pieces of section terminating equipment. The channel can be used from a central location for control, monitoring, administration, and other communication needs.*

Multiplex Section Overhead:-

The Multiplex Section Overhead contains the information required between the multiplex section termination equipment at each end of the Multiplex section (that is, between consecutive network elements excluding the regenerators).

The Multiplex Section Overhead is found in Rows 5 to 9 of Columns 1 through 9 of the STM-1 frame.

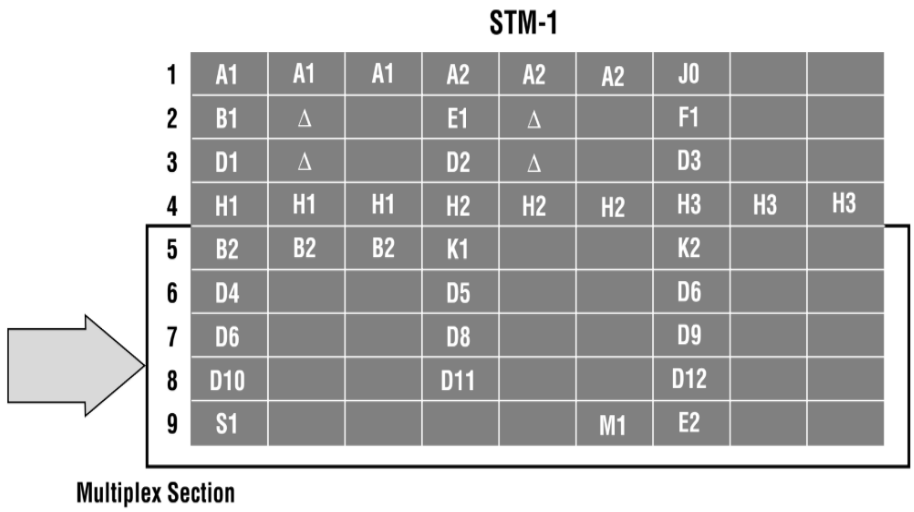


Table: - Multiplex Section Overhead (MSOH)

Byte	*Description*
B2	***Multiplex Section (MS) bit interleaved parity code (MS BIP-24) byte –*** *This bit interleaved parity N x 24 code is used to determine if a transmission error has occurred over a multiplex section. It's even parity, and is calculated overall bits of the MS Overhead and the STM-N frame of the previous STM-N frame before scrambling.*
K1 and K2	***Automatic Protection Switching (APS channel) bytes –*** *These two bytes are used for MSP (Multiplex Section Protection) signaling between multiplex level entities for bi-directional automatic protection switching and for communicating Alarm Indication Signal (AIS) and Remote Defect Indication (RDI) conditions.*
D4 to D12	***MS Data Communications Channel (DCC) bytes –*** *These nine bytes form a 576 Kbit/s message channel from a central location for OAM information (control, maintenance, remote provisioning, monitoring, administration and other communication needs).*
S1	***Synchronisation status message bytes (SSMB) –*** *This byte are used to carry the synchronisation messages.*

M1	***MS remote error indication –*** *The M1 byte of an STM-1 or the first STM-1 of an STM-N is used for a MS layer remote error indication (MS-REI).*
E2	***MS order wire byte –*** *This order wire byte provides a 64 Kbit/s channel between multiplex entities for an express order wire. It's a voice channel for use by crafts persons and can be accessed at multiplex section terminations.*

Path Overhead:-

The Path Overhead is assigned to, and transported with the Virtual Container from the time it's created by path terminating equipment until the payload is demultiplexed at the termination point in a piece of path terminating equipment.

The Path Overhead is found in Rows 1 to 9 of the first column of the VC-4 or VC-3.

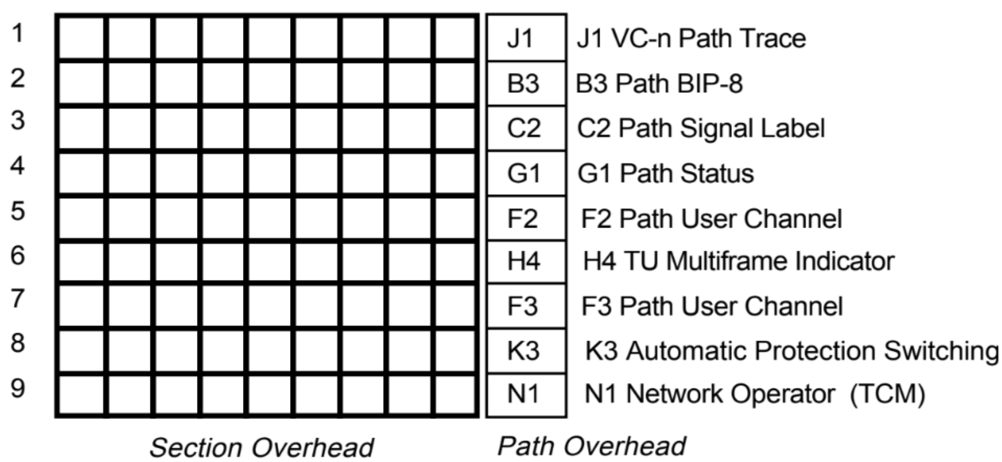


Table: - Higher-Order Path Overhead (VC-4/VC-3)

Byte	***Description***
J1	***Higher-Order VC-N path trace byte –*** *This allows the receiving terminal in a path to verify its continued connection to the intended transmitting terminal.*
B3	***Path bit interleaved parity code (Path BIP-8) byte –*** *This is a parity code (even), used to determine if a transmission error has occurred over a path.*

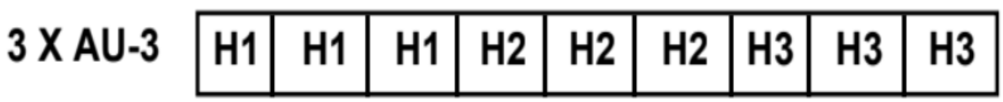
C2	***Path signal label byte –*** *This byte specifies the mapping type in the VC-N.*
G1	***Path status byte –*** *This byte is used to convey the path terminating status and performance back to the originating path terminating equipment. Therefore the bi-directional path in its entirety can be monitored.*
F2	***Path user channel byte –*** *This byte is used for user communication between path elements.*
H4	***Position and Sequence Indicator byte –*** *This byte provides a multi frame and sequence indicator for virtual VC-3/4 concatenation and a generalized position indicator for payloads.*
F3	***Path user channel byte –*** *This byte is allocated for communication purposes between path elements and is payload dependent.*
K3	*This byte is use for higher order path Automatic Protection Switching(APS)*
N1	***Network operator byte –*** *This byte is allocated to provide a Higher-Order Tandem Connection Monitoring (HO-TCM) function.*

Table: - Lower-Order Path Overhead (VC-12/VC-11)

Byte	***Description***
V5	*This byte provides the functions of error checking, signal label, and path status of the VC-2/VC-1 paths.*
J2	*This byte is used to repetitively transmit a Lower-Order Access Path Identifier so that a path receiving terminal can verify its continued connection to the intended transmitter.*
N2	*Allocated for Tandem Connection Monitoring for the VC2, VC-12, and VC-11 level.*
K4	*Allocated for APS signaling for protection at the Lower-Order path level.*

Pointers:-

SDH provides payload pointers to permit differences in the phase and frequency of the Virtual Containers (VC-N) with respect to the STM-N frame. Lower-order pointers are also provided to permit phase differences between VC-1/VC-2 and the higher-order VC-3/VC-4.



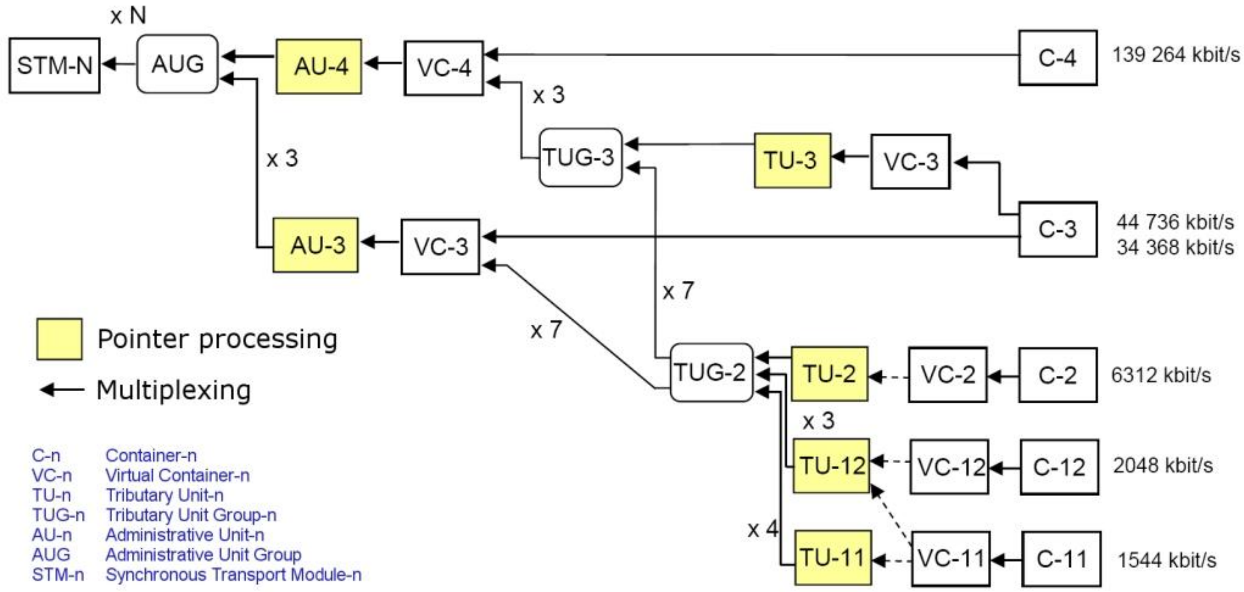
Payload Pointers:-

When there's a difference in phase or frequency, the pointer value is adjusted. To accomplish this, a process known as byte stuffing is used. In other words, the VC payload pointer indicates where in the container capacity a VC starts, and the byte stuffing process allows dynamic alignment of the VC in case it slips in time.

Table: - Pointers

Byte	***Description***
H1 and H2	***Pointer bytes –*** *These two bytes, the VC payload pointer, specify the location of the VC frame. It's used to align the VC and STM-1 Section Overheads in an STM-N signal, to perform frequency justification, and to indicate STM-1 concatenation.*
H3	***Pointer action byte –*** *This byte is used for frequency justification. Depending on the pointer value, the byte is used to adjust the fill input buffers. The byte only carries valid information in the event of negative justification, otherwise it's not defined.*

SDH Multiplexing:-



The multiplexing principles of SDH follow, using these terms and definitions:

- ***Mapping –*** *A process used when tributaries are adapted into Virtual Containers (VCs) by adding justification bits and Path Overhead (POH) information.*

- ***Aligning –*** *This process takes place when a pointer is included in a Tributary Unit (TU) or an Administrative Unit (AU), to allow the first byte of the Virtual Container to be located.*

- ***Multiplexing –*** *This process is used when multiple lower-order path layer signals are adapted into a higher-order path signal, or when the higher-order path signals are adapted into a Multiplex Section.*

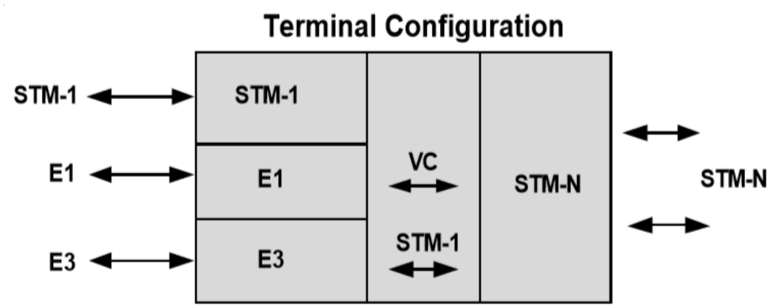
- ***Stuffing –*** *As the tributary signals are multiplexed and aligned, some spare capacity has been designed into the SDH frame to provide enough space for all the various tributary rates. Therefore, at certain points in the multiplexing hierarchy, this space capacity is filled with "fixed stuffing" bits that carry no information, but are required to fill up the particular frame.*

Network Elements:-

Terminal Multiplexer

The path terminating element (PTE) acts as a concentrator of E1s as well as other tributary signals.

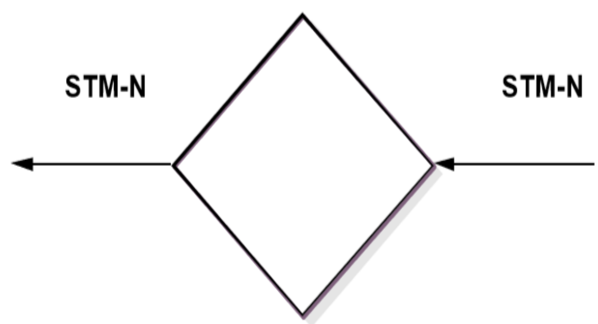
Its simplest deployment would involve two terminal multiplexers linked by fiber with or without a regenerator in the link. This implementation represents the simplest SDH link (Regenerator Section, Multiplex Section, and Path, all in one link).



Regenerator

A regenerator is needed when, due to the long distance between multiplexers, the signal level in the fiber becomes too low.

The regenerator recovers timing from the received signal and replaces the Regenerator Section overhead bytes before re-transmitting the signal; the Multiplex Section overhead, path overhead, and payload are not altered.

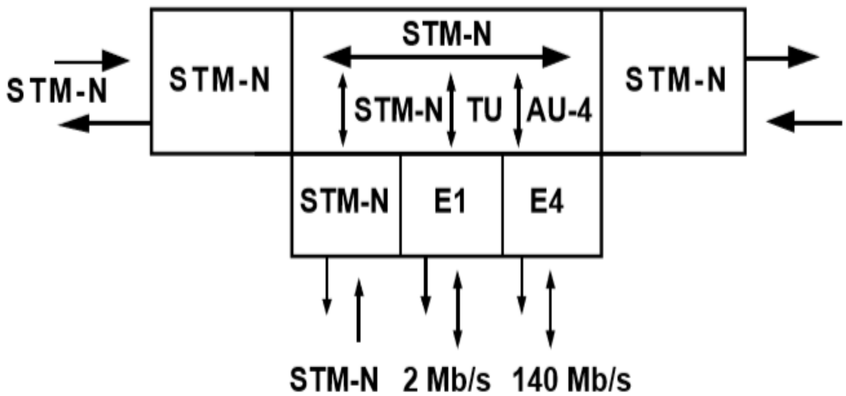


Add/Drop Multiplexer

One of the major advantages of SDH is its ability to Add and Drop tributaries directly from higher-order aggregate bit streams.

A single-stage multiplexer/demultiplexer can multiplex various inputs into an STM-N signal. At an add/drop site, only those signals that need to be accessed are dropped or inserted. The remaining traffic continues through the network element without requiring special pass-through units or other signal processing.

In ring-survivability applications, drop-and-continue provides alternate routing for traffic passing through interconnecting rings in a "matched nodes" configuration. If the connection cannot be made through one of the nodes, the signal is repeated and passed along an alternate route to the destination node.

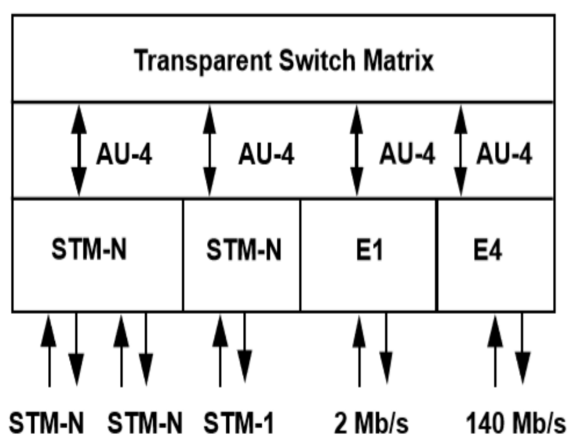


Digital Cross-connect

Digital Cross-connect interfaces SDH signals and possibly high-rate tributaries. It accesses the STM-N signals, and typically switches at an AU-4 level.

DCS devices can be used for "grooming" telecommunications traffic, switching traffic from one circuit to another in the event of a network failure, supporting automated provisioning, and other applications. Having a DCS in a circuit-switched network provides important flexibility that can otherwise only be obtained at higher cost using manual "DSX" cross-connect patch panels.

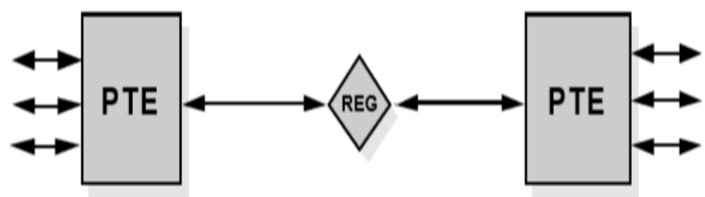
One major difference between a cross-connect and an add/drop multiplexer is that a cross-connect may be used to interconnect a much larger number of STM-1s.



Network Configurations:-

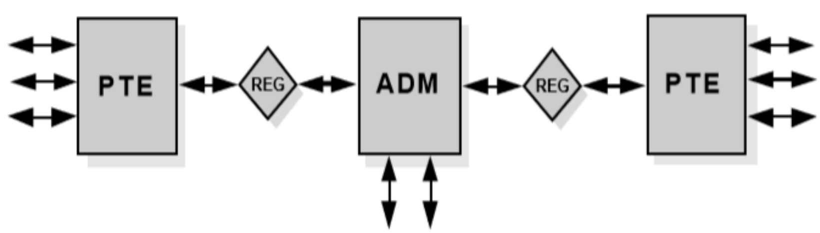
Point-to-Point

The simplest network configuration involves two terminal multiplexers linked by fiber with or without a regenerator in the link.



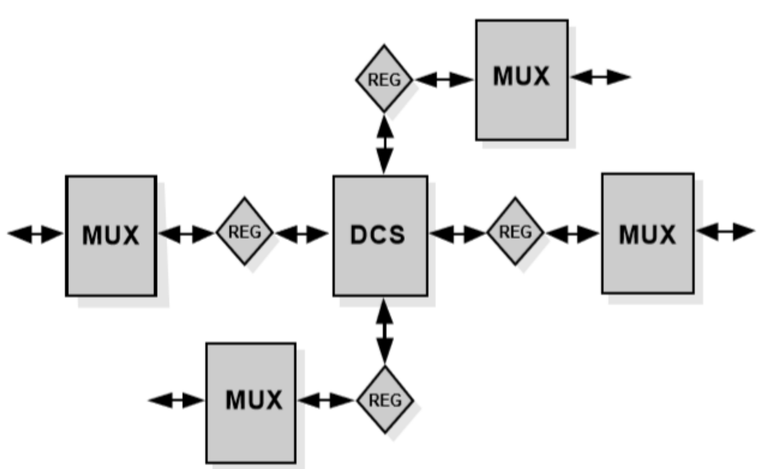
Point-to-Multipoint

A point-to-multipoint (linear add/drop) architecture includes adding and dropping circuits along the way. The SDH ADM (add/drop multiplexer) is a unique network element specifically designed for this task.



Mesh Architecture

The meshed network architecture accommodates unexpected growth and change more easily than simple point-to-point networks. A cross connect function concentrates traffic at a central site and allows easy re-provisioning of the circuits.



Ring Architecture

The SDH building block for a ring architecture is the ADM (see Figure 28). Multiple ADMs can be put into a ring configuration for either Bi-directional or Uni-directional traffic. The main advantage of the ring topology is its survivability; if a fiber cable is cut, for example, the multiplexers have the local intelligence to send the services affected via an alternate path through the ring without a lengthy interruption.

The demand for survivable services, diverse routing of fiber facilities, flexibility to rearrange services to alternate serving nodes, as well as automatic restoration within seconds, have made rings a popular SDH topology.

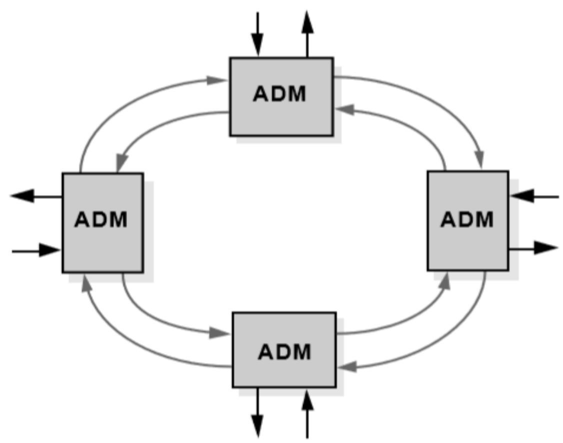


Table: - Path Level Alarms

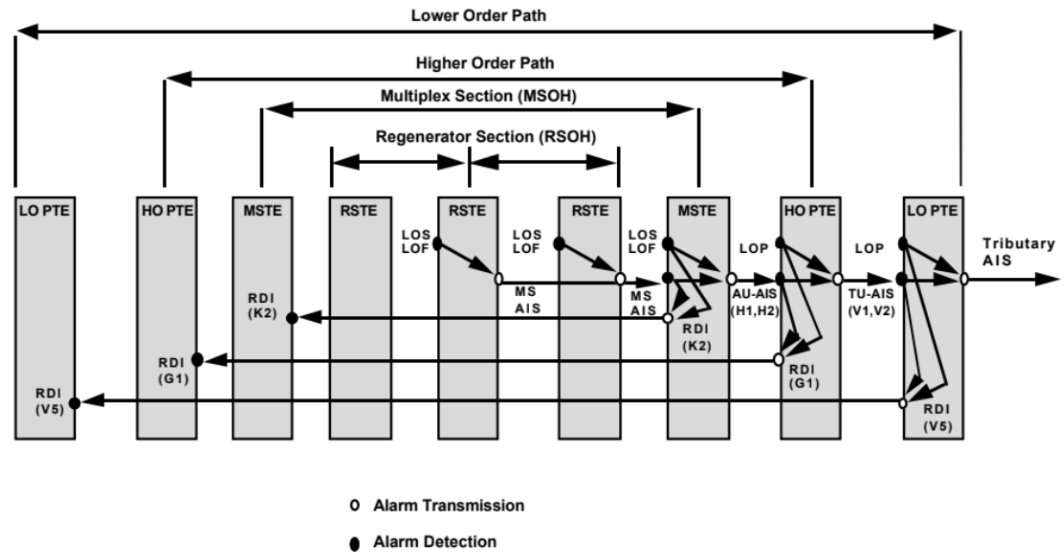
Description	***Severity***	***Probable Cause***	***Service Affecting***
ATM loss of cell delineation	*Major*	*Degraded Signal*	*Yes*
Concatenation mismatch	*Minor*	*Payload Type Mismatch*	*No*
Path alarm indication signal (AIS-P)	*Minor*	*AIS*	*No*
Path loss of pointer (LOP-P)	*Major*	*Loss Of Pointer*	*Yes*
Path remote defect indication (RDI-P)	*Minor*	*Far End Receiver Failure*	*No*
Path signal degrade (BER [bit error rate])	*Major*	*Degraded Signal*	*Yes*
Path signal failure (BER)	*Major*	*Excessive BER*	*Yes*

Path trace failure	*Minor*	*Path Trace Mismatch*	*No*
Path unequipped (UNEQ-P)/ Payload label mismatch (PLM)	*Major*	*Signal Label Mismatch*	*Yes*
Loss of Multiframe(LOM)	*Major*	*Loss of Frame*	*Yes*

Table: - Card Level Alarms

Description	***Severity***	***Probable Cause***	***Service Affecting***
Receive loss of signal (LOS)	*Critical*	*Loss Of Signal*	*Yes*
Receive loss of frame (LOF)	*Critical*	*Loss Of Frame*	*Yes*
Transmit laser failure	*Critical*	*Laser failure*	*Yes*
Synchronization failure	*Critical*	*Timing Problem*	*Yes*
Circuit pack failure	*Critical*	*Replaceable Unit Problem*	*Yes*
Line signal degrade (BER [bit error rate])	*Major*	*Degraded Signal*	*Yes*
Circuit pack card code mismatch	*Minor*	*Replaceable Unit Type Mismatch*	*No*
Line alarm indication signal (AIS-L)	*Minor*	*AIS*	*No*
Line remote defect indication (RDI-L)	*Minor*	*Far End Receiver Failure*	*No*
Circuit pack overheating	*Major*	*Line Card Problem*	*Yes*

Interaction between defects in forward and backward directions, according to the different SDH levels.



<u>*SDH Advantages*</u>*:-*

- *Powerful management (Overhead structure to handle with multiple signal levels and performing management tasks).*
- *Standard optical interfaces.*
- *Standard digital interfaces.*
- *Vendor independent.*
- *Synchronous Digital structure.*
- *Easy cross connection.*
- *Easy add and drop (SDH performs single stage multiplexing).*
- *Reliability (automatic repair mechanism).*
- *Direct access to lower order tributaries.*
- *Compatible to transport PDH signals.*
- *Support various topologies ring, bus, star, mesh, etc.*
- *It provides both electrical and optical input interfaces.*
- *Switching protection is offered by rings.*
- *Provisioning of services to preferred routes.*

Small form-factor pluggable (SFP):-

A small form-factor pluggable (SFP) transceiver is a compact, hot-swappable, input/output transceiver used in data communication and telecommunications networks. SFP interfaces between communication devices like switches, routers and fiber optic cables, and performs conversions between optical and electrical signals. SFP transceivers support communications standards including synchronous optical networking (SONET)/synchronous digital hierarchy (SDH), gigabit Ethernet and fiber channel. They also allow the transport of fast Ethernet and gigabit Ethernet LAN packets over time-division-multiplexing-based WANs, as well as the transmission of E1/T1 streams over packet-switched networks.

SFP is also called a mini gigabit interface converter (GBIC) because its function is similar to the GBIC transceiver but with much smaller dimensions.

The SFP transceiver is specified by the SFP Transceiver Multisource Agreement (MSA), which was developed and is followed by different transceiver manufacturers.

SFP Transceivers have a wide range of detachable interfaces to multimode/single-mode fiber optics, which allows users to select the appropriate transceiver according to the required optical range for the network.

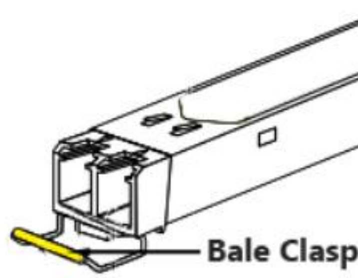
SFP transceivers are also available with copper cable interfaces, which allows a host device designed primarily for optical fiber communications to also communicate over unshielded twisted pair networking cables. Modern optical SFP transceivers support digital diagnostics monitoring (DDM) functions, also known as digital optical monitoring (DOM). This feature gives users the ability to monitor the real-time parameters of SFP, such as optical output power, optical input power, temperature, laser-bias current and transceiver supply voltage.

Types of SFP:-

SFP Types	***Transceiver Type***	***Connector***	***Distance***	***Data Rate***
SFP Fiber Module	*SX, MX, LX, EX, ZX, EZX, BX*	*LC Duplex*	*100m-160km over MMF or SMF*	*100Mbps/ 1000Mbps*
	CWDM/DWDM SFP	*LC Duplex*	*10km-120km over SMF*	
SFP Copper Module	*1000BASE-T*	*RJ45*	*100m over Copper Twist Pair Cable*	*1000Mbps*
	10/100BASE-T	*RJ45*	*100m over Copper Twist Pair Cable*	*100Mbps*
	10/100/1000BASE-T	*RJ45*	*100m over Copper Twist Pair Cable*	*1000Mbps*

SINGLEMODE SFP COLOR CODING:-

SFPs are identified by the color of the Bale Clasp.



Single mode SFPs uses this color coding:

- *Gray color coded bale clasp designates the 1470 nm SFP*
- *Violet color coded bale clasp designates the 1490 nm SFP*
- *Blue color coded bale clasp designates the 1510 nm SFP*
- *Green color coded bale clasp designates the 1530 nm SFP*
- *Yellow color coded bale clasp designates the 1550 nm SFP*
- *Orange color coded bale clasp designates the 1570 nm SFP*
- *Red color coded bale clasp designates the 1590 nm laser SFP*
- *Brown color coded bale clasp designates the 1610 nm SFP*
- ***The color of the compatible fiber optic patch cord or pigtail is yellow.***

SFP Transceiver Block Diagram