"Measurements Of Optical Parameters On 40 Channel 10G Huawei DWDM System"

Abstract
This project "Measurements Of Optical Parameters On 40 Channel 10G Huawei DWDM System" is intended to get the real time perfomance characteristics of the DWDM system which has been operated by the Bharath Sanchar Nigam Limited (from Telephone Bhavan, Hyderabad, India) for telecommunications throughout the India, at each component level and to suggest respective measures for the better functioning of the overall system.

With today's seemingly limitless demand for transmission capacity, service providers often cope with extreme fiber usage and exhaust across significant portions of their networks.

. The telecommunications industry has so far met these needs by using dense wavelength division multiplexing (DWDM) systems. In allowing both new and existing fiber optic links to carry several channels simultaneously, DWDM can optimize the use of current facilities whilst offering greater capacities for the future. At the beginning of the 1980s, time domain multiplexing (TDM) made it possible to increase the bit-rate Wavelength division multiplexing (WDM), the simultaneous transmission of multiple signals at different wavelengths over a single fiber proved to be a more reliable

The disadvantage of this WDM technique was that the multiplexed signal had to be separated each time before being electrically regenerated. Demands for new data services, home office and internet applications all contribute to the pressure being placed on service providers worldwide. Although 10 Gbps seems to be a sufficiently high bit-rate for most networks today, this level of capacity may not be enough in the long term.

The respective suggestions for the better improvement of the DWDM System has been accepted by the BSNL authoritie's.

1. Introduction:

The nature of the paper is to explain the drawbacks faced by the current technology of Telecommunications faced by the BSNL, India. This is the first of its kind to work on the Real Time DWDM System to find the demerits and to propose the drawbacks of the system that we presently use. The contribution of the paper is to propose the respective suggestions in a cost effective way for the better possible working of the Telecommunucations via Optical fiber by using DWDM system.The system performs the following main functions:

Generating the signal—The source, a solid-state laser, must provide stable light within a specific, narrow bandwidth that carries the digital data, modulated as an analog signal. Combining the signals—Modern DWDM systems employ multiplexers to combine the signals. There is some inherent loss associated with multiplexing and demultiplexing. This loss is dependent upon the number of channels but can be mitigated with optical amplifiers, which boost all the wavelengths at once without electrical conversion.

Transmitting the signals—The effects of crosstalk and optical signal degradation or loss must be reckoned with in fiber optic transmission. These effects can be minimized by controlling variables such as channel spacings, wavelength tolerance, and laser power levels. Over a transmission link, the signal may need to be optically amplified.

Separating the received signals—At the receiving end, the multiplexed signals must be separated out. Although this task would appear to be simply the opposite of combining the signals, it is actually more technically difficult.

Receiving the signals—The demultiplexed signal is received by a photodetector.

2. Transmission Challenges

Transmission of light in optical fiber presents several challenges that must be dealt with. These fall into the following three broad categories:

1. Attenuation—decay of signal strength, or loss of light power, as the signal propagates through the fber.

2. Chromatic dispersion—spreading of light pulses as they travel down the fiber.

3. Nonlinearities—cumulative effects from the interaction of light with the material through which it travels, resulting in changes in the light wave and interactions between light waves.

Each of these effects has several causes, not all of which affect DWDM. The discussion in the following sections addresses those causes that are relevant to DWDM.

Light Sources and Detectors

Light emitters and light detectors are active devices at opposite ends of an optical transmission system. Light sources, or light emitters, are transmit-side devices that convert electrical signals to light pulses. The process of this conversion, or modulation, can be accomplished by externally modulating a continuous wave of light or by using a device that can generate modulated light directly. Light detectors perform the opposite function of

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light emitters. They are receive-side opto-electronic devices that convert light pulses into electrical signals.

Typical characteristics of light source

PROPERTY	LED	LASER	SINGLE LASER
Spectral width (nm)	200–100	1–5	0–2
Rise time (ns)	2–250	0.1–1	0.1–1
Modulation B.W (MHz)	< 300	< 2000	~ 2000
Coupling efficiency	Very low	Moderate	Moderate
Compatible fibre mode	M.M. (Si and GI)	M.M. GI & SM	Single
Temperature sensitivity	Low	High	High
Circuit Complexity	Simple	Complex	Complex
Lifetime (hours)	10^5	10^4–10^5	10^4–10^5
Costs	Low	High	Highest
Path length	Moderate	Long	Very long
Data rate	Moderate	High	Very high

Multichannel DWDM transmission system

A DWDM system can be described as a parallel set of optical channels, each using a slightly different wavelength, but all sharing a single transmission medium or fiber. The functionality of a multichannel DWDM transmission system when various 10 Gbps signals are fed to optical transmission modules the optical output signals are converted to defined wavelengths in the 1550 nm window via wavelength transponders. An optical DWDM coupler (multiplexer) then 'bunches' these optical signals together on one fiber and forwards them as a multiplexed signal to an optical fiber amplifier (OFA).

Depending on path length and type of fiber used, one or more OFAs can be used to boost the optical signal for long fiber spans. At termination on the receiving end, the optical signals are preamplified, then separated using optical filters (demultiplexer) before being converted into electrical signals in the receiver modules. For bidirectional transmission, this procedure must be duplicated in the opposite direction to carry the signals in that particular direction Comparision of Amplifiers:

	EDFA	EWDA	SOA	Units
Output Power	>15	>12	>13	dBm
Gain	>24	>20	>25	dB
Noise figure	<6	<6	<8	dB
Max G Deviate	<0.75	<0.75	<0.1	dB/nm
PDG	<0.3	<0.5	<0.5	dB p-p
Power Usage	1	1	1	Watts

In SONET/SDH systems, the limiting parameters are digital whereas in DWDM systems, with high power and high number of channels, it is usually the analog impairments which limit the transmission. These impairments on singlemode fibers can be divided into linear and nonlinear effects.

3. Limiting Factors:
What causes PMD?

Fiber optic cables are not perfect and contain fabrication defects where the:

a. core is not perfectly circular along its overall length
b. core is not perfectly concentric with the cladding
c. fiber can be twisted, tapered, or bent at some points along the span.

At any given signal wavelength the PMD is a unstable phenomenon in contrast to the chromatic dispersion which is relatively stable.

So, one of the two orthogonal polarisation modes can experience a increase in propagation velocity if it sees a lower refractive index and the other way

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round. Actually the index randomly varies along a long-haul fiber span.
The PMD of a long fiber link is dependent on wavelength and fluctuates in time as a result of temperature variations, external mechanical constrains etc.

The maximum permissible PMD values for various bit values are shown in the following table:

Gbps	Max PMD (ps)	PMD coefficient for 400km
2.5	240	<2.0
10	10	<0.5
40	2.5	<0.125

The PMD measurements must be performed:
   a.   during the fiber fabrication process (plant)
   b.   during the cable fabrication process (plant)
   c.   after installation of the cable (field)
   d.   at the planning to upgrade an existing network (field)
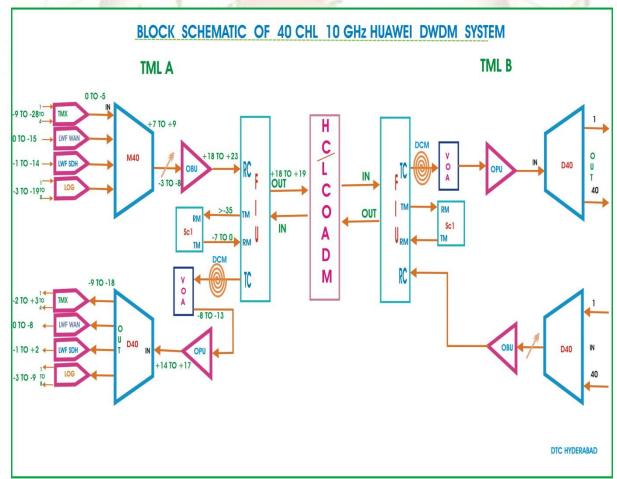
The first level concerns the fiber manufacturer
The second level is also essential. Even if the different fibers used in a cable are low in PMD, the assembling process may cause additional effects like stress which create higher PMD
The third level takes place once the cable is installed in the field.
During installation the cable can be crushed, kinked or otherwise physically damaged.
The last level of PMD testing occurs when telephone companies need to test existing cables, in order to upgrade network systems at a higher bit rate.

Annexure:

There are four types of chords:
1. LOG chord means Lower Order Giga Bit Ethernet Chord
2. TMX chord means Transponder Multiplexer Chord

3. LWF WAN means Line Wavelength Filter Wide Area Network
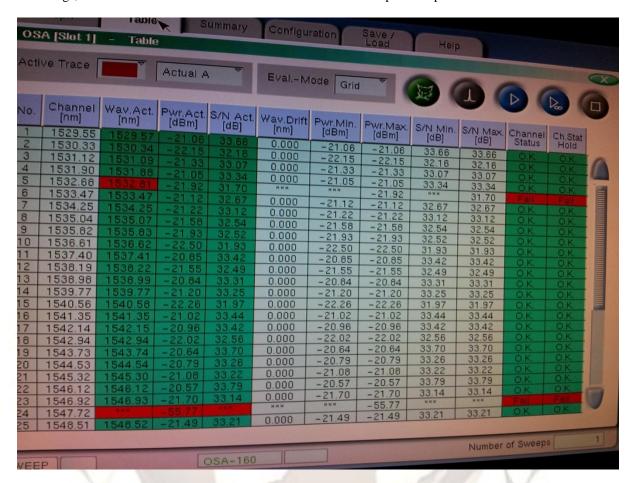4. LWF SDH means Line Wavelength Filter SDH
40 lambda or channels= 40 slots
 LOG chords=8,16,24,32,40(5slots)
TMX chords=3,4,5,6,11,12,13,14,19,20,21,22,27,28,29,30,35,36,37,38(20slots)
LWF chords=1,2,7,9,10,15,17,18,23,25,26,31,33,34,39(15slots)

In readings, if Power= -60 indicates that the line is not used or the respective optical fiber cable is faulted.

Conclusion:
In designing DWDM systems, limiting physical effects (particularly nonlinear) need to be taken into account.

Impairment	Cause	Effect	Compensation
Attenuation	Material Absorption	Decrease of Peak Power	Shorter spans, Purer fiber material
CD	Wavelength Dependent Group Velocity	a. Decrease of Peak Power b. Pulse Broadening. c. Bit errors	Use of Fibers or Modules with CD values. (DCF / DCM)
PMD	Fiber Imperfections due to statistically changing refractive index	a. Decrease of Peak Power b. Distortion of Pulse shape c. Bit errors	New Fiber with low PMD values, Exact fiber Geometry, Carefull fiber Laying (No Stress).
FWM	Interference of Signals	a. Power transfer to	Use of Fibers with CD,

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		Original signal to New signal Frequencies b. Production of Sidebands (Harmonics) c. Channel Crosstalk d. Bit errors	Irregular Channel Spacing.
SPM	Intensity dependent Refractive Index. (Kerr Effect)	a. Spectral Broadening. b. Initial Pulse Compression c. Accelerated Pulse Broadening.	Use of fibers with CD.
XPM	Intensity dependent Refractive Index. (Kerr Effect)	a. Spectral Broadening. b. Initial Pulse Compression c. Accelerated Pulse Broadening.	Use of fibers with CD.
SRS	Inetraction of photons with Optical photons.	a. Decrease of Peak Power. b. Decrease of OSNR. c. Cross talk in especially in Bidirectional DWDM Systems and Bit errors	Careful power level Design.
SBS	Interaction of Photons with Accoustic photons.	a. Decrease of Peak Power. b. Decrease of OSNR. c. Signal Instability. d. Optical crosstalk In especially Bidirectional DWDM systems. e. Bit errors.	Spectral broadening of the light source.

Parameters effecting impairment (denoted by "X"):

Parameter	Noise	CD	PMD	FWM	SPM	XPM	SRS	SBS
Channel Spacing				X		X		
No of Channels	X		X	X		X	X	X
Channel Power			X	X	X	X	X	X
No of spans	X		X	X	X	X	X	X
Channel bit-rate	X	X	X		X	X		X
Fiber effective area				X	X	X	X	X

Empty spaces in the table donot necessarily mean the impairment is not effected by the parameter. However there are parameters which are not represented in the table. For example Mechanical Stress effects PMD while temperature has an impact on both PMD and CD. In 40 Gbps transmissions the DCMs have to be adjustable to correct the CD value which itself varies with temperature.

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