Derived method to measure Receiver Sensitivity and Receiver Overload for optical ports of Transponder in DWDM System

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Abstract — This article covers the signal sensing capability of optical ports in an optical network and a derived procedure to measure parameters related to signal sensing capability for optical ports of transponder of a DWDM system. Attenuation, RS and RO are key factor during transmission and optical strength of light signal in an optical network depends on these parameters. Basic concept and theory of attenuation, RS and RO is discussed. Experimental Procedure for measure RS and RO for a traditional SDH system is discussed in this paper. On basis of this, a derived arrangement and procedure is defined to measure RS and RO for client side and line side optical ports of transponder in a DWDM system. A description for signal flow in this new arrangement is also discussed. Experimental results to calculate RS an RO with this derived arrangement for different types of client side and line side ports are also given in this article.

Keywords — DWDM, Receiver Sensitivity, Receiver Overloading, Optical Ports, Acceptance Testing, SDH, Transponder, Attenuation

INTRODUCTION

DWDW stands for Dense Wave Division Multiplexing. It is the new era of optical communication. DWDM is a technology by which we can transmit multiple optical signals through a single fiber cable simultaneously. Idea of DWDM based on basic characteristics of light. We all know that light wave with different wavelength can travel together without distorting each other. Light waves of 7 different colors travel together without affecting each other which form white light and can be separated and recombine with the help of prism. It was first discussed in Newton's classic experiment on dispersion of white light, which define white light have different component color which travel along each other and can be separate and re align. These component colors of white light will be depend on that wavelength of their light wave. Each color wave belongs to a particular band of wavelength and all these light waves can travel simultaneously without affecting each other. Figure shown below is the arrangement used in Newton's experiment to show this property of light.

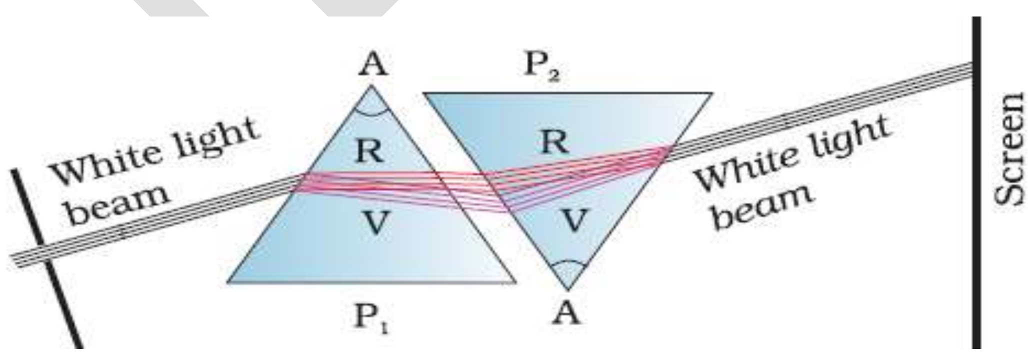


Fig-1. Schematic diagram of Newton's classic experiment on dispersion of white light

Same fundamental we use in DWDM. Multiple light signals with different wavelength transmit through single optical fiber cable.

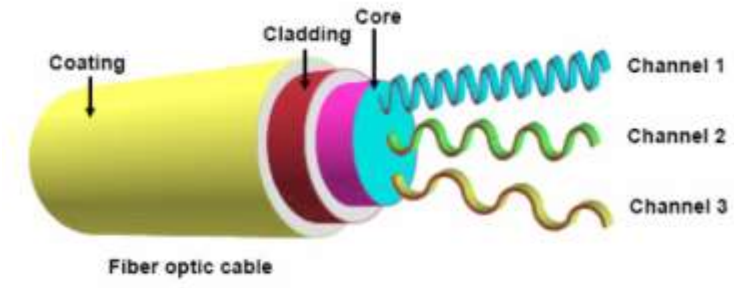


Fig-2. Propagation of different optical wavelengths in single optical fiber in a DWDM system

Light signal of one wavelength will not affect light signal of other wavelength and all light signals will survive simultaneously. Standard optical signal of 1310 nm and 1550nm is tuned with particular wavelength .for DWDM these wavelengths belong to C band. After this tuned signals multiplexed. As this multiplexed signal has to travel for a long distance, hence first amplify and then transmitted over optical fiber cable.

Transponder- Transponder is one of the basic components of a DWDM system. Transponder receives optical signal from external equipment on its client side optical port, tuned them at predefined wavelength of a C-Band and then send it to multiplexer from its line side optical port. Vice versa happens at receiver end. Hence transponder has two type of optical ports, client and line side optical ports which deal with different type of optical signal. Light signal on optical ports of transponder which are coming from long distance, are degrade because of attenuation over fiber. Hence selection of optical ports for transponder will be done on the basis of attenuation over the network as it will decide optical strength of Rx signal at transponder. Therefore attenuation over the path and sensing and overloading capabilities of both types of optical port should be measured for successful design, implementation and operation of a DWDM system.

Attenuation- Attenuation is the loss of optical power of a light signal in optical fiber communication. It may also define as reduction in the intensity of light as it propagates within the fiber. Hence it is also known as transmission loss throughout the length, as it reduces optical strength of light signal. Reduction in optical streangth will cause poor quality of light signal and increase error probability. Further reduction even after certain limit may cause insensitivity of signal at receiver and will lead to traffic outage. Hence attenuation is a measure factor consider during design and operation of DWDM network. In optical fiber communication attenuation is usually expressed in decibels per unit length (dB/km). Types of attenuation in DWDM system-

i. **Fiber loss-** Fiber loss is defined as attenuation of optical strength during light signal pass through optical fiber. Fiber loss happen because of composition of core cladding material ,composite shape of waveguide, preparation and purification technique and implementation of network. Main causes of attenuation in fiber are

   a. **Absorption loss-** it is caused by absorption of light signal by itself. It is also cause by impurities in fiber.
   b. **Scattering loss-** interaction of photons with glass in fiber cable cause scattering of photons which cause degradation in intensity of light signal.
   c. **Bending loss-** it is induced by physical stress applied on the fiber. More stress on fiber, may cause complete loss of signal and even damage optical fiber permanently.

ii. **Insertion loss-** In a DWDM system light signal has two paths through different type of passive components like MUX, DMUX, and patch panel etc. loss of intensity of light signal due to these components known as insertion loss.

iii. **Connection loss-** Different types of connectors and couplers are used in DWDM system to connect different cables and components .every time these connectors introduced in the network, they will increase attenuation on light signal.

Receiver sensitivity (RS) - Receiver sensitivity of Optical Receiver Port is defined as the minimum acceptable values of optical strength of light signal for that port. It means after certain degrade in intensity of light signal, optical ports are unable to distinguish optical pulses and cause errors on signal. Minimum threshold value of signal that can be sense properly is termed as Receiver sensitivity or Optical receiver sensitivity.

Receiver overload (RO) - Receiver overload of Optical Receiver Port is defined as the maximum acceptable values of optical strength of light signal for that Port. It means after a certain increment in intensity of light signal, optical ports are unable to handle optical pulses and cause errors of signal. Maximum threshold value of signal that can be sense properly is termed as Receiver sensitivity or Optical receiver sensitivity.

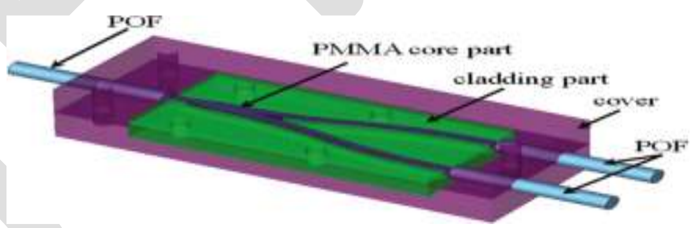
TRADITIONAL ARRANGEMENT TO MEASURE RS/RO IN SDH SYSTEM

Components of arrangement-

i. **SDH/Ethernet Analyzer-** SDH analyzer is a testing device which is capable to generate a SDH optical signal and receive and analyze an incoming SDH optical signal. If incoming SDH signal has any alarm or error then SDH analyzer is capable to read it and analyzed its intensity. Ethernet also work in same way but for Ethernet signal.

ii. **Variable Optical Attenuator-** Variable Optical Attenuator, also termed as VOA is a device which is capable to generate attenuation on light signal. This attenuation can be vary as per requirement using increasing or decreasing button without making any physical change in system.

iii. **50/50 Coupler-** 50/50 coupler is used to send one optical signal in to two directions. It is just like a T connector in RF network. One incoming signal will be transmitted from two outputs. Signals from both outputs are similar and twins to each other.



iv. **Optical Power Meter-** Optical power meter testing device which is used to measure optical intensity of light signal.

v. **Optical Fiber Parch chords (for connectivity) -** These are the fiber cable use to connect different equipments and test devices.

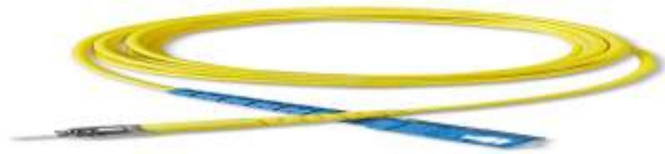


Diagram-

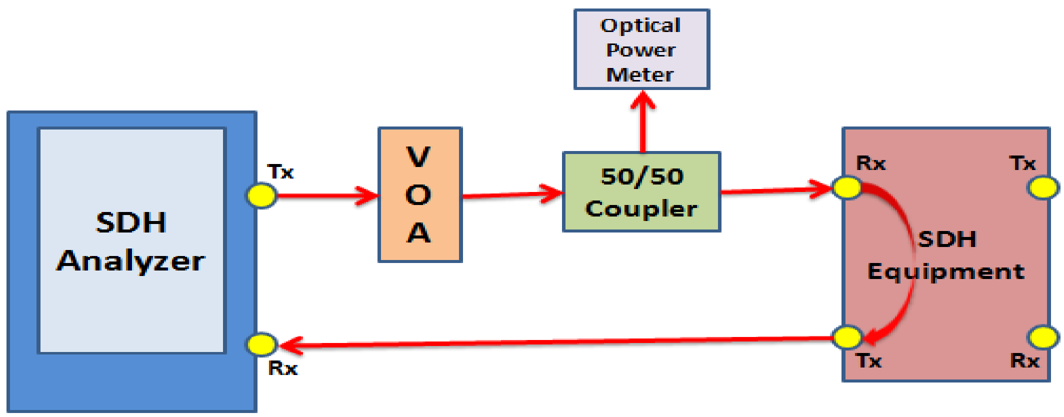


Fig-3. Traditional arrangement to measure RS/RO in SDH System

Arrangement and Theory-

In this traditional arrangement the transmit side port of the SDH analyzer is connected with Variable Optical Attenuator (VOA). SDH analyzer may have multiple types of ports. We have to select as the configuration of the Optical port of equipment which is undergone testing. VOA will apply attenuation as per our requirement on optical signal and send it to the output. Output of VOA is connected to 50-50 coupler. It will transmit same signal in two directions, one will go to the Rx of optical port under testing and other will go to optical power meter. Measurement of the optical strength of light signal at Rx will be same as the optical strength of light signal at power meter. If we change attenuation from VOA then same effect will observe on both light signal of 50-50 coupler output. In this way we are able to know what optical power is received by the Rx of optical port under testing. Signal of this Rx port will be logically loopback to the Tx of same port using EMS software. Hence the same signal will be retransmitted from the Tx of optical port under testing. This Tx of optical port will be connected to Rx of SDH analyzer where the quality of incoming light signal will be analyzed and recorded. As this signal is under loopback hence SDH analyzer should receive the same signal which it transmitted. If not so, there is some error in this optical circuit.

Test Procedure - Experiment will start with initial working state. Now we start the analyzer. Light signal from SDH analyzer will go to VOA where we can put attenuation as per our requirement. Then light signal will go to 50-50 coupler from where it will transmitted in dual direction, one to

i. **RS -** In initial working state light signal quality will be good and Rx of analyzer will show no error. Now we will start increasing attenuation from VOS which will cause decrease in optical strength of light signal at Rx of optical port. Same optical strength will be measured on optical power meter. At the same time we will analyzed the quality of light signal on Rx port of analyzer. After certain increase in attenuation of signal we will see errors on the receiver of analyzer. This error observed due to low strength light signal at Rx of Optical Testing port and it is unable to sense the signal correctly. Optical pulses of light signal are either missed or read wrongly by Optical port. The point at 1x10-12 BER will be consider as at threshold point and value of optical power of light signal at Rx of Optical port under testing will be Receiver Sensitivity of this optical port.

ii. **RO -** Again we will start SDH analyzer with initial working state. This time we will start decreasing attenuation on light signal. Change of strength of light signal on optical port will be measured on optical power meter. After a certain increment

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in optical power of light signal we will observe errors on analyzer. It is because Rx of optical port is unable to read such high intensity light signal. The point at 1x10-12 BER will be considered as the threshold point. And optical strength of light signal at Rx of optical port under test will be defined as the receiver overload of this optical port.

DERIVED ARRANGEMENT TO MEASURE RS/RO FOR CLIENT SIDE OPTICAL PORT OF TRANSPONDER-

Diagram-

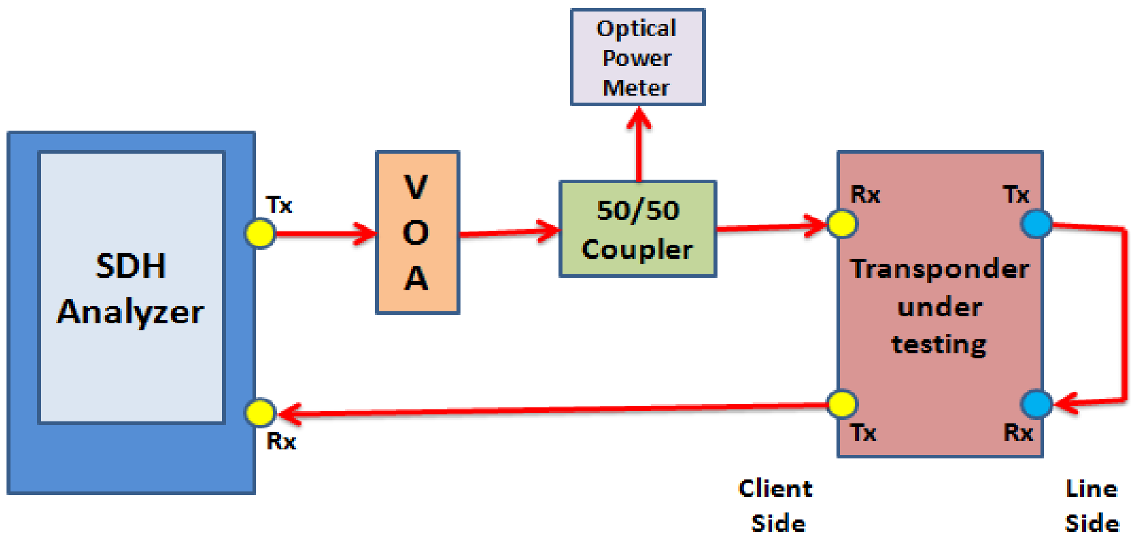

Fig-4. Derived arrangement to measure RS/RO of client side optical ports of transponder

Arrangement - This arrangement is same as in SDH system with little difference as logical cross connect is not available in transponder of DWDM system .hence we are unable to give logical loop back of Rx to Tx. Therefore input light of Rx of client optical port will be tuned on specific wavelength and will transmit out from line side Tx of transponder. As we know Tx and Rx of line side of transponder work on same wavelength. We will loop back this line side Tx of transponder to line side Rx of transponder with the help of a lopping fiber cable .signal from line side Tx will receive at line side Rx of transponder which will retune to standard light signal and out from client side Tx from where it will go to line side of transponder.

Test procedures-

i. **RS -** Experiment start with initial working state .now we slowly increase the attenuation from VOA and signal strength will start to decrease the point where BER will be on threshold value will be noted .the optical strength of light signal at client side RX of transponder will be consider as receiver sensitivity of this optical port.

ii. **RO -** Experiment start again with initial state .now we will slowly decrease the attenuation from VOA which will cause increase in the optical strength of light signal. After a certain value ,BER measure at SDH analyzer will reach at its threshold value at this point the value optical at client side Rx of transponder will be define as receiver overload for this port.

DERIVED ARRANGEMENT TO MEASURE RS/RO FOR LINE SIDE OPTICAL PORT OF TRANSPONDER –

Diagram-

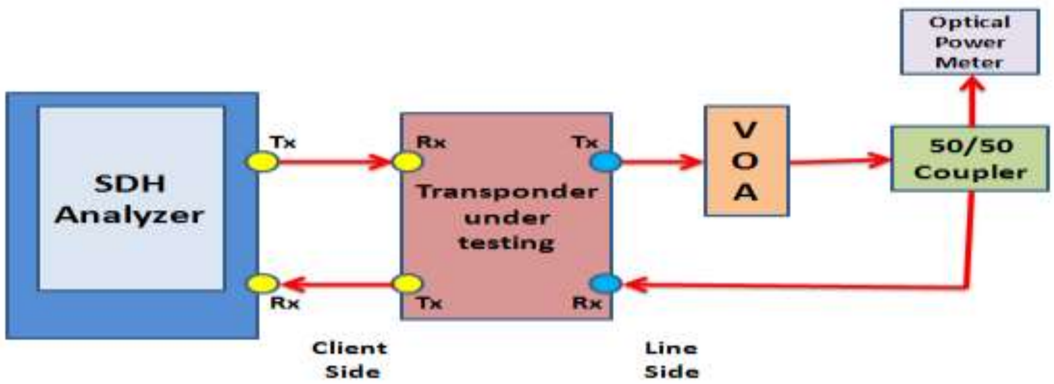

Fig-5. Derived arrangement to measure RS/RO of line side optical ports of transponder

Arrangement - This arrangement is very different from previous one. in this the transmit of analyzer is connected directly with client side Rx of transponder, same like it connected with any other network equipment during operations. Now standard optical signal from analyzer will be tuned to specific wavelength and will transmit from line side Tx .this line side Tx will connect to the input of VOA. Output of VOA will connect to 50/50 coupler from where one output will to optical fiber and other will to line side Rx of transponder module. Optical strength of light signal at RX can be measure3 on power meter. Now this tuned signal wavelength signal will retuned to standard signal at transponder and from client side Tx it will transmit to Rx port of analyzer.

Test Procedure - Experiment will start with initial working state. Now slowly increase attenuation from VOA. This will cause decrease in optical strength of light side signal at line side Rx .after a certain decrement in optical strength of light signal, the reading at analyzer will reach on threshold for BER. This point will be consider as thresholds and value of optical power of light signal at line side Rx will be define as RS. Now with similar arrangement we can calculate RO by decreasing the attenuation from VOA. Optical power at line side Rx at threshold point of BER on analyzer will be consider as RO.

RESULT

Our experiment will give us the value of RS AND RO for client side and line side optical ports of transponder. As client side port are connected to standard network hence they are manufactured with RS and RO as per standard defined by ITU. We also find same value for client side optical port during our experiment. Different optical ports have different RS/RO as per their configuration. As STM1/STM4 use in access network and have to travel less distance so RS/RO is low for them. But STM16/STM64 use on core network and has to travel at large distance. Hence RS and RO value is high. Similarly for short haul optical ports RS/RO value is low while for long haul optical port RS/RO value is high.

Optical Port Type	Receiver Overload	Receiver Sensitivity
S-1.X	-8 dBm	-28 dBm
L-1.X	-10 dBm	-34 dBm
S-4.X	-8 dBm	-28 dBm
L-4.X	-8 dBm	-28 dBm
S-16.X	0 dBm	-18 dBm
L-16.2	-9 dBm	-28 dBm
I-64.2	-1 dBm	-18 dBm
S-64.2a	-8 dBm	-18 dBm
S-64.2b	-1 dBm	-14 dBm
L-64.2a	-9 dBm	-26 dBm

Table-1. Results for client side optical ports

As line side is internal part of DWDM system it does not have to maintain as per industry/ITU standards. It is manufacturer dependent and may vary with photodiode use for line side of transponder.

Port/Diode Type	Receiver Overload	Receiver Sensitivity
2.5G PIN Type	0 dBm	-18 dBm
2.5G APD Type	-9 dBm	-28 dBm
10G PIN Type	0 dBm	-14 dBm
10G APD Type	-9 dBm	-21 dBm

Table-2. Results for line side optical ports

CONCLUSION

RS and RO play an important role in transmission network design of an optical network, Network operation and fault troubleshooting. In this article we have discussed a derived arrangement and procedure to measure RS and RO for optical ports of a DWDM system. Then we evaluated RS and RO for different types of optical ports. Experiment results shows that different type of optical port have different value of RS/RO. Light signal on client side optical port from locally placed equipment will have low attenuation, hence has good optical strength. In such case short haul optical ports will be used by network designer. But light signal from some remote equipment has to travel a long distance over fiber cable and hence applied with high attenuation and has low optical strength. Hence long haul optical ports will be used in such case. Similarly designer can plan for different line side optical ports as per requirement or availability. A part from network design RS/RO also play vital role during network operation and fault troubleshooting. Optical engineers have to maintain optical strength of light signal within the range of RS and RO for stable and efficient network. In case of fault or fiber cut, they will consider it as a reference point and restore the network with defined range of RS and RO. Therefore we can conclude that RS and RO of optical ports as vital optical parameters in a DWDM system.

REFERENCES:

[1]. John M. Senior and M. Yousif Jamro, Optical Fiber Communications: Principle and Practice, Pearson Education Ltd., 2013

[2]. I. P. Kaminow, et al, ―A Wideband All-Optical WDM Network‖, IEEE Journal on Selected Areas in Communications, Vol.14, No. 5, June 1996, pp. 780 - 799.)

[3]. Yan Sun, Atul K. Srivastava, Jianhui Zhou, James W. Sulhof, Optical Fiber Amplifiers for WDM Optical Networks, Bell Labs Technical Journal (January–March 1999).

[4]. Introduction to DWDM Technology by Cisco Systems (2001).

[5]. G. P. Agrawal, Lightwave Technology: Components and Devices (Wiley, Hoboken, NJ, 2007).

[6]. Melián, B., Laguna, M., and Moreno, J.A., "Capacity expansion of fiber optic networks with WDM systems: Problem formulation and comparative analysis", (2004) 461- 472.

[7]. DWDM Fundamentals by JDSU.

[8]. Aysegül Gençata, Narendra Singhal, and Biswanath Mukherjee, 'Overview of optical communication networks:Current and future trends' in M. Ilyas and H.T. Mouftah, The Handbook of Optical Communication Networks, CRC Press, 2003.

[9]. Testing devices pictures from www.google.com

[10]. Gerd Keiser, Optical Fiber Communications, McGraw Hill Education India Pvt. Ltd.