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**RESEARCH ARTICLE**

# 10Gbps Data Transmission and Implementation of DWDM Link

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## *Abstract*

There is an increasing demand for Dense Wavelength Division Multiplexing systems to support a set of network requirements like span length, total distance, capacity etc. The capacity increase in fibre optic communication systems has been achieved mainly by deploying more fibre links, populating more wavelength channels per fibre link through Dense Wavelength Division Multiplexing (DWDM). The simplest application of DWDM technology in core networks is the point-to-point link. Each wavelength channel is used to transmit one stream of data individually. In optical fibres, after a long haul, the signals intensity was greatly attenuated, therefore, it should be amplified. Here, EDFA is used as the optical amplifier. The design and implementation of a 4λ DWDM point-to-point fibre optic link and its analysis is done in this paper.



## I. INTRODUCTION

In order to meet the ever-increasing demand in telecommunication capacity, fiber optic communication systems have been evolving dramatically over the past decade. The fiber optic communication traffic growth has been at a rate of about 2 dB per year, representing a traffic increase of a factor of 100 in 10 years. The capacity increase in fiber optic communication systems has been achieved mainly by deploying more fiber links, populating more wavelength channels per fiber link through dense wavelength-division-multiplexing (DWDM), and increasing the data rate per wavelength channel. In addition to increased capacity, the cost per bit in terms of both capital and operational expenditure has been decreased to sustain the traffic growth. Increasing the data rate per wavelength channel is regarded as an effective way to provide both increased capacity and lowered cost per bit. Indeed, in most fiber optic transmission systems, the channel data rate has been upgraded from 2.5Gbps to 10Gbps, and 40Gbps is under active deployment. [3]

Development of DWDM technology began in the late 1980s using the two widely spaced wavelengths in the 1310nm and 1550 nm(or 850nm and 1310nm) regions, sometimes called wide band WDM. Two to eight channels were used in the second-generation narrow band WDM of the early 1990s. By the mid 1990s, dense WDM (DWDM) systems were emerged with 16 to 40 channels and spacing from 100 to 200GHz. By the late 1990s DWDM systems had evolved to the point where they were capable of delivering 64 to 160 parallel channels, densely packed at 50 or even 25GHz intervals. The progression of the technology can be seen as an increase in the number of wavelengths accompanied by a decrease in the wavelength spacing.

Several recent technological advances constitute the enablers of increased data rate per wavelength. Among these, advanced detection schemes such as differential detection, self-coherent detection (SCD), and digital coherent detection (DCD), provide major breakthroughs. These advanced detection schemes, together with advanced optical modulation formats, increase system tolerance to optical noise and/or transmission impairments such as chromatic dispersion (CD) and fiber nonlinearity, which are limiting factors for high-speed optical transmission. Moreover, advanced detection schemes enable high spectral-efficiency (SE) optical modulation formats supporting higher data rates in systems originally designed for lower data rates.

The simplest application of the DWDM technology in core networks is the point-to-point link. Each wavelength channel is used to transmit one stream of data individually. The DWDM wavelength multiplexer combines all of the lightwave channels into one light beam and pumps it into one single fiber. The combined light of multiple wavelengths is separated by the demultiplexer at the receiving end. The signals carried by each wavelength channel are then converted back to the electrical domain through the O/E converters (photodetectors). In this way, one wavelength channel can be equivalent to a traditional fiber in which one light beam is used to carry information. The wavelength channels in one fiber can be used for both directions or two fibers are used with each for one direction. The advantage of the point-to-point DWDM links is that it increases the bandwidth by creating multiple channels with low costs. The limitation of this approach, however, is that the bandwidth of each wavelength channel may not be fully utilized due to the speed of the electrical devices, which is referred to as the well-known electro-optic bottleneck. [1]

DWDM technology is known as a kind of technology coupling and transmitting optical signals of different frequency (wavelength) to an optical fiber by using the tremendous bandwidth of SMF's low-loss area in DWDM system, which is not only conducive to the realization of switching and recovery in optical networks but also convenient to the expansion and upgrade, and thus the further realization of transparent and high survivability optical networks. DWDM technology is now in a mature development period. With the development of the society, the requirement of people to communication quality and speed is higher and higher. How to use the optical bandwidth huge resources and to upgrade the capacity of fiber-optic communications systems is an important subject.

DWDM will continue to provide the bandwidth for large amounts of data. In fact, the capacity of systems will grow as technologies advance that allow closer spacing, and therefore higher numbers, of wavelengths. Recently more than 1000 channel Ultra-Dense Wavelength Division Multiplexing (UDWDM), with a spacing of 6.25GHz at 1310nm region was demonstrated.

But DWDM is also moving beyond transport to become the basis of all-optical networking with wavelength provisioning and mesh-based protection. Switching at the photonic layer will enable this evolution, as will the routing protocols that allow light paths to traverse the network in much the same way as virtual circuits do today. These and other advances are converging such that an all-optical infrastructure can be envisioned.

## II. BLOCK DIAGRAM

DWDM is a transmission technique which can multiplex many different wavelengths onto a single fiber medium. It is done by increasing the data carrying capacity of the fiber. DWDM refers to the close spacing of the channels. By this technique, the data rate per wavelength channel is increased. It provides increased capacity and lowered cost per bit. The block diagram of DWDM system is shown in figure.1.

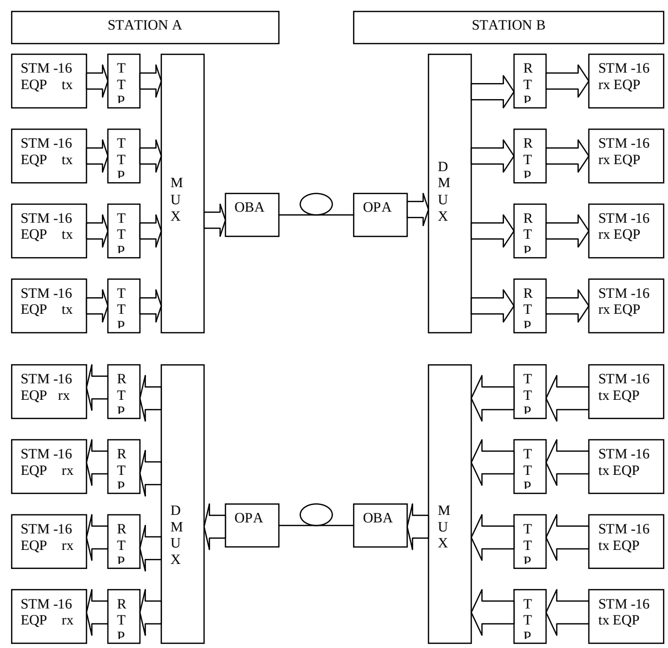


**Figure 1: Block diagram of DWDM system**

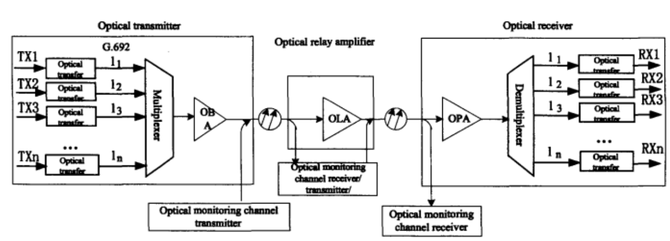


**Figure 2: Block diagram of DWDM transmission system**

The basic working principle of DWDM is to multiplex several or even several dozens of optical channel signals with different nominal wavelengths into one fiber for transmission. Each optical fiber carries several service signals. The working principles are illustrated in Figure.2.


**Figure 3: Mux, Demux and expander cards**

At the transmitting end, the optical transmitter of each channel $TX_I$ ... TXn send optical signals with different wavelengths ($\lambda_1$, $\lambda_2$, ... $\lambda n$, corresponding to optical frequency f1, f2 ... fn). Each optical channel carries different service signals, such as standard SDH signal, ATM signal, Ethernet signal, and then, the multiplexer will multiplex these signals into one optical wave and after being amplified by the booster amplifier, these signals can be transmitted in one fiber.

After the demultiplexer at the receiving end demultiplexes the optical channel signals, it will input them to the relevant optical receiver of each channel RX1 ... RXn. Thus, the fiber transmission capacity will be increased by several multiples or even several dozen multiples.

During optical transmission, the OLA will amplify optical signals. The functions of Optical Supervisory Channels are to transmit the NE management and monitoring information related to the DWDM system, enabling the NMS to manage the DWDM system effectively. The Block diagram shown above illustrates the DWDM system used in this paper. Its working is the same as explained above except that OLA is not employed here.

## III. HARDWARE SETUP AND TESTING

The technical parameters of the chosen transmission system like centre frequency of each channels, input attenuation of optical filters, amplifier gain etc are taken from hardware specification. Trans transponder cards, Receive transponder cards, Multiplexer and Demultiplexer cards, expander cards, Optical Booster Amplifier cards, Optical Preamlifier cards, power meter etc are needed to carry out the experiments and to take the readings.

The basic components of the DWDM system needed for doing the experiments are shown in figure 3 and figure 4. The multiplexer, demultiplexer and the expander cards are shown in figure 3. The overall DWDM system components are shown in figure 4. It shows the four trans transponder cards, four receive transponder cards including the multiplexer, demultiplexer and the expander cards. The STM-16 equipment from which the 2,5Gbps signal is taken is shown in figure 5. The experiments are done in node A and node B assuming them as two stations.

**Figure 4: DWDM system components.**

**Figure 5: STM – 16 equipment.**

*A.Power meter measurements*

The transmission of 1310 nm and 1550nm over the DWDM system is done. Then the sensitivity of the individual transponder is measured. The transportation of STM-16 over DWDM employing 4 wavelengths is carried out and booster amplifier output is measured. The maximum transmission distance possible for DWDM system is found out through link budget analysis. To find out the maximum transmission distance, 2.5Gbps input signal is given to four channels of node B from the STM-16 equipment. The optical booster amplifier of node B is connected to a10dB attenuator. Other port of the attenuator is connected to optical pre amplifier of node A. optical booster amplifier of node A is connected to one port of optical attenuator. Other port of optical attenuator is connected to optical preamplifier of node B. optical attenuator is varied from minimum until the alarms at the optical booster amplifier or at the optical pre amplifier is ON.

## IV. RESULTS AND DISCUSSIONS.

Experiments done in hardware shows that 1310nm cannot be transmitted over DWDM system and 1550nm can be transmitted. When 1550nm is given to the input port of transponders from the STM-16 equipment, and when the output of booster amplifier is checked, the signal is found to be amplified. The transponder response is found to be linear and irrespective of the input, the output of the transponder is constant till it reaches its sensitivity. The response of the transponder is shown in figure 6. The receiver sensitivity is found to be -25dBm. The loss/km is assumed to be 0.3dB. Thus, the transmission distance possible for transponder is found. ie, 0.3 X L = 25. Normally, the transponder can work upto a distance of 80Km. Then, by the power meter measurements taken, the output of the booster amplifier at the node A and node B was found to be constant. The measurements are shown in table I and II. Thus, the gain of the EDFA is constant at 13dB irrespective of the input. Link budget analysis shows that DWDM equipment can work upto 150Km with system margin.

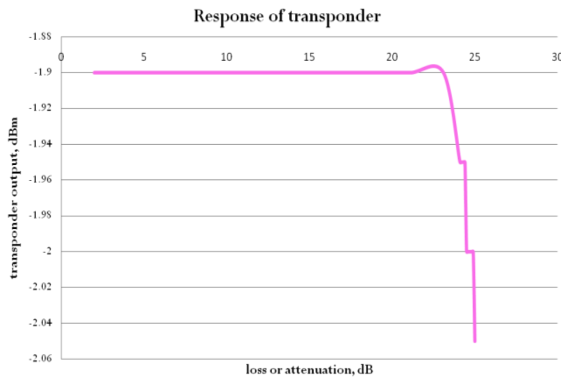


**Figure 6: Response of transponder.**

**TABLE I**
**BOOSTER AMPLIFIER OUTPUT OF NODE A**

| No: of channels | Booster output |
|---|---|
| Single channel | +13.5 |
| Two channel | +13.55 |
| Three channel | +13.55 |
| Four channel | +13.5 |

**TABLE II**
**BOOSTER AMPLIFIER OUTPUT OF NODE B**

| No: of channels | Booster output |
|---|---|
| Single channel | +12.75 |
| Two channel | +12.65 |
| Three channel | +12.65 |
| Four channel | +12.65 |

## IV. CONCLUSIONS.

The technical parameters of the chosen transmission system were taken from hardware specification. From the experiments done, it is concluded that 1310nm cannot be transmitted over DWDM system. Link budget analysis showed that DWDM equipment can work upto a distance of 150Km with system margin. The response of the transponder is linear and it can work upto a distance of 80Km. Irrespective of the input, the output of the transponder is constant, till it reaches its sensitivity. EDFA is a constant gain amplifier with a gain of 13dB irrespective of the input.

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