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EFFECT OF INCREASE IN CHANNELS ON BER (BIT ERROR RATE) OF MULTICHANNEL SYSTEM

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Abstract: The basic aim of this paper is to see how increase in channels per system produces effects on the Bit Error Rate of the system.

Keywords: Bit Error Rate, Wavelength division multiplexing system, Dense wavelength division multiplexing system, Time division multiplexing.

I. INTRODUCTION

As the pressure mounts to deliver more services over existing bandwidth, network operators can rely upon the multi-wavelength system solution that enables dramatic bandwidth increase over a single optical fiber. Confronted by the need for more capacity, carriers have three possible solutions i.e. by installation of new fiber, investment in new TDM technology to achieve faster bit rates and deploying dense wavelength division multiplexing system. We have three approaches to this: installing new fiber to meet the capacity needs, high speed TDM, DWDM. Let us discuss them one by one.For years, carriers have expanded their networks by deploying new fiber and transmission equipment. For each new fiber deployed, the carrier could add capacity up to 2.4 Gb/s. Unfortunately, such deployment is frequently difficult and always costly. While this varies from place to place, installing new fiber can be a daunting prospect, particularly for carriers with tens of thousands of route miles. In many cases, the right-of-way of the cable route or the premises needed to house transmission equipment is owned by a third party, such as a railroad or even a competitor. Moreover, singlemode fiber is currently in short supply owing to production limitations, potentially adding to costs and delays. For these reasons, the comprehensive deployment of additional fiber is an impractical, if not impossible, solution for many carriers.As indicated earlier, STM–64/OC–192 is becoming an option for carriers seeking higher capacity, but there are significant issues surrounding this solution that may restrict its applicability. The vast majority of the existing fiber plant is single-mode fiber (SMF) that has high dispersion in the 1550 nm window, making STM–64/OC–192 transmission difficult. In fact, dispersion has a 16 times greater effect with STM–64/OC–192 equipment than with STM–16/OC–48. As a result, effective STM–64/OC–192 transmission requires either some form of dispersion compensating fiber or entire new fiber builds using non-zero dispersion shifted fiber (NZDSF) which costs some 50 percent more than SMF. The greater carrier transmission power associated with the higher bit rates also introduces nonlinear optical effects that cause degraded wave form quality.

The effects of Polarization Mode Dispersion (PMD) which, like other forms of dispersion affects the distance a light pulse can travel without signal degradation is of particular concern for STM-64/OC–192. This problem, barely noticed until recently, has become significant because as transmission speeds increase, dispersion problems grow exponentially thereby dramatically reducing the distance a signal can travel. PMD appears to limit the reliable reach of STM–64/OC–192 to about 70 kms on most embedded fiber. Although there is a vigorous and ongoing debate within the industry over the extent of PMD problems, some key issues are already known.

a. PMD is particularly acute in the conventional singlemode fiber that comprises the vast majority of the existing fiber plant, as well as in aerial fiber.
b. Unlike other forms of dispersion that are fairly predictable and easy to measure, PMD varies significantly from cable to cable. Moreover, PMD is affected by environmental conditions, making it difficult to determine ways to offset its effect on high bit rate systems.
c. As a result, carriers must test nearly every span of fiber for its compatibility with STM–64/OC–192 in many cases, PMD will rule out its deployment altogether.

Dense wavelength division multiplexing (DWDM) is a fiber optic transmission technique that employs light wavelengths to transmit data parallel by bit or serial by character. DWDM system enables service providers to accommodate consumer demand for ever increasing amounts of bandwidth. DWDM is a crucial component of optical networks that allows the transmission of e-mail, video, multimedia, data, voice, asynchronous transfer mode (ATM), synchronous optical network/synchronous digital hierarchy (SONET/SDH), respectively over the optical layer.

Dense Wavelength Division Multiplexing (DWDM) is a technology that allows multiple information streams to be transmitted simultaneously over a single fiber at data rates as high as the fiber plant will allow (e.g. 2.4 Gb/s). The DWDM approach multiplies the simple 2.4 Gb/s system by up to 16 times, giving an immense and immediate increase in capacity using embedded fiber. A sixteen channel system (which is available today) supports 40 Gb/s in each direction over a fiber pair, while a 40 channel system under development will support 100 Gb/s, the equivalent of ten STM–64/OC–192 transmitters. The benefits of DWDM over the first two options adding fiber plant or deploying STM–64/OC–192 for increasing capacity are clear. Fig. 1 shows how the multiwavelength systems have evolved over the years:

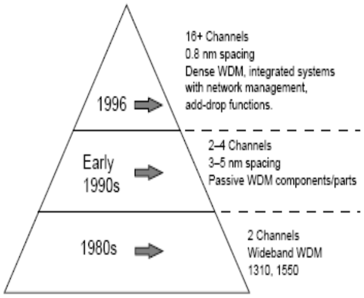

Fig. 1: Evolution of WDM

WDM systems are divided in different wavelength patterns, *conventional* or *coarse* and *dense* WDM. Conventional WDM systems provide up to 16 channels in the 3rd transmission window (C-band) of silica fibers around 1550 nm. DWDM uses the same transmission window but with denser channel spacing. Channel plans vary, but a typical system would use 40 channels at 100 GHz spacing or 80 channels with 50 GHz spacing. Some technologies are capable of 25 GHz spacing (sometimes called ultra dense WDM). New amplification options (Raman amplification) enable the extension of the usable wavelengths to the L-band, more or less doubling these numbers.

In a simple WDM system, each laser must emit light at a different wavelength, with all the lasers_ light multiplexed together onto a single optical fiber. After being transmitted through a high bandwidth optical fiber, the combined optical signals must be demultiplexed at the receiving end by distributing the total optical power to each output port and then requiring that each receiver selectively recover only one wavelength by using a tunable optical filter.

Each laser is modulated at a given speed, and the total aggregate capacity being transmitted along the high-bandwidth fiber is the sum total of the bit rates of the individual lasers. An example of the system capacity enhancement is the situation in which ten 2.5-Gbps signals can be transmitted on one fiber, producing a system capacity of 25 Gbps.

II. EXPERIMENTAL SETUP

The experimental setup in Fig. 2 contains data source, Continuous wave laser source, Mach Zender modulator, driver, splitter, combiner, spectrum analyzer, and a power meter. The data source produces data at a rate of 10 GB/s or higher in the form of ones and zeroes. This data is then transferred to the driver which is a device that is used to convert the binary zeroes and ones into electrical format i.e. NRZ or RZ format. The signal is then passed on to Mach Zender modulator. A modulator is a device that modulates carrier signal according to the modulating signal. Here the modulating signal is the one passed on from the driver and the carrier signal wavelength is provided by the continuous wave laser.

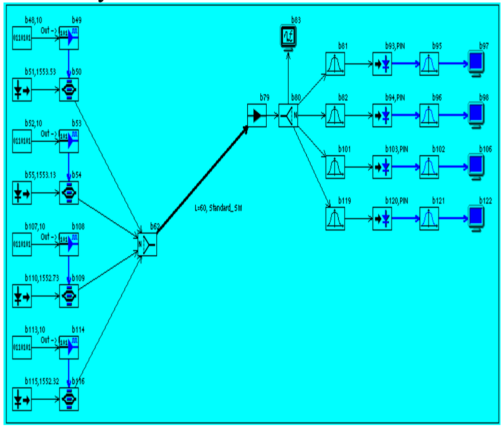

Fig. 2: WDM system setup

It must be noted that the optical signal is transmitted at a particular wavelength generated by the continuous wave laser and at a particular power level. The four optical signals of particular wavelengths and power are multiplexed through combiner and are transmitted through the optical fiber cable. The optical signal at the receiving end is passed on to EDFA pre-amplifier with high gain which is further given to splitter through which multiple analyzing components can be attached to make analysis of the received signal.

The received signals are separated using individual optical band pass filters and are then given to photodiodes (PIN type or APD type). The signal is further passed on to electrical filters to filter out the noise quantities from the original signal. Furthermore these signals are individually given to BER analyzer.

III. RESULTS AND DISCUSSIONS

In this experimental setup four lasers have been used each with different center frequencies namely 192.975THz, 193.025THz, 193.075THz, and 193.125THz respectively. the length of the fiber used is 60 kms.

We have noted through BER analyzer the BER of individual channels at the receiving end. The channel of 192.975THz frequency has a BER of $6.23552\text{x}10^{-18}$, 193.025THz has a BER of $4.13187\text{x}10^{-18}$, 193.075THz frequency has a BER of $4.46212\text{x}10^{-17}$, and 193.125THz frequency has a BER of $8.52501\text{x}10^{-18-}$ respectively.

However it must be noted that we can gradually increase the channels from 1 to 4 and we can see the effect of increase of channels on individual channel BER taking into account all the channels collectively. Fig. 3 shows plot of power density vs. frequency of individual 4 channels. Fig. 4 shows eye pattern for 192.975THz frequency channel, Fig. 5 shows eye pattern for 193.025THz frequency channel, Fig. 6 shows eye pattern for 193.075THz frequency channel, and Fig. 7 shows eye pattern for 193.125THz frequency channel

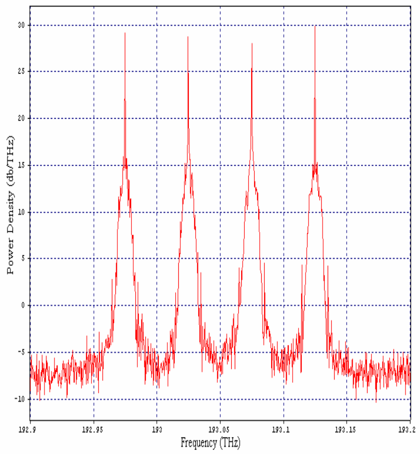

Fig. 3: Power density vs. Frequency

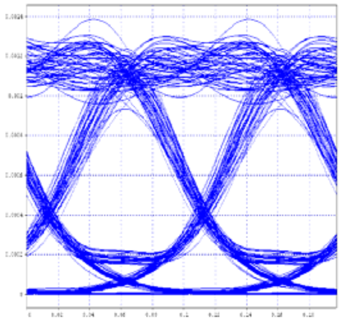

Fig. 4: Eye pattern for 192.975THz frequency channel

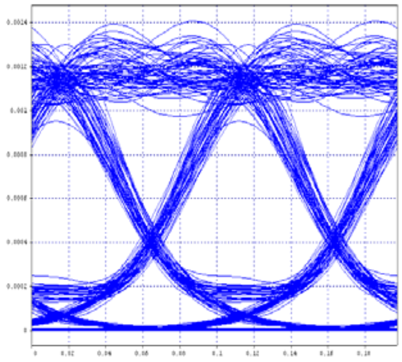

Fig. 5: Eye pattern for 193.025THz frequency channel

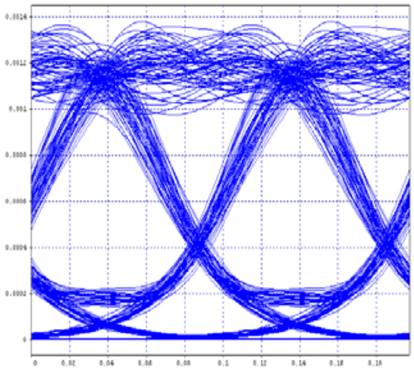

Fig. 6: Eye pattern for 193.075THz frequency channel

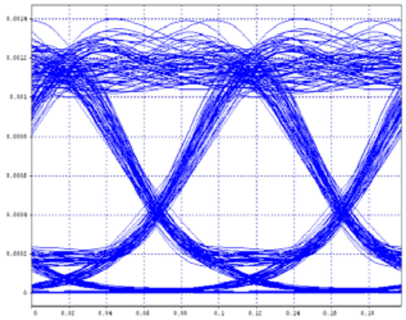

Fig. 7: Eye pattern for 193.125THz frequency channel

CONCLUSION

Bit error rates for each of the channels have been calculated and correspondingly eye patterns are plotted for each of the 4 channels.However it must be noted that we can gradually increase the channels from 1 to 4 and we can see the effect of increase of channels on individual channel BER taking into account all the channels collectively.

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