SPECTRUM SLICING OF A BROADBAND LIGHT SOURCE

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ABSTRACT

Since the inception of optical fiber communication in 1974, their transmission capacity has experienced a tremendous increase in the years after. Several technology advances spurred its growth. But its use was kept to long haul applications like intercity links and international links, because of its initial capital cost. The use of *Wavelength Division Multiplexing* offered a further boost in fiber transmission capacity. The basis of WDM was to use multiple sources operating at slightly different wavelengths to transmit several independent information streams over the fiber. Laser diodes were the traditionally used sources because of its narrow spectral width which in turn reduces the losses and gives out light with more power which is used to carry data over a long range. But, in today's era where data rate is of more importance, immaterial of whether it is long or short haul, a technology was required which will make the short haul communication using optics, cheaper and affordable. Thus *Light Emitting Diode* was forced to play the role of light source instead of the laser. But since LED is having a very broad spectrum, most of its power would be wasted. So a technique called *Spectral Slicing* was brought up to nullify this aspect of LED so as to be useful in WDM systems. By using LED the cost of the system will also be kept low. This work here, demonstrates the spectral slicing technique which can be used in WDM systems. The slicing component used here is a Tunable Band-pass Filter. The output power received using this method was compared with another method which was done using *Arrayed Waveguide Grating* (AWG) and also with a mathematical model. Power budget analysis is done where by, the probable link distance that a system using spectral slicing technique by tunable band-pass filters, can cover is found to be about 15-30 km. Also, a cost based analysis is done, using the common market prices of the major components, to prove that this technique reduces the cost to an extend that the need for lasers is never inevitable in the case of short haul communications.

ABSTRAK

Komunikasi menggunakan optikal fiber bermula sekitar tahun 1974. Semenjak itu, kapasiti penghantarannya meningkat dengan mendadak. Kemajuan dalam teknologi lain juga membantu perkembangannya. Walaubagaimanapun, disebabkan kos permulaan yang tinggi, ia hanya digunakan untuk perhubungan antara-bandar dana antarabangsa. Namun begitu, kapasiti penghantaran melalui fiber terus berkembang dengan penggunaan *Wavelength Division Multiplexing* (WDM). Asas bagi WDM adalah pelbagai sumber panjang gelombang padar kadar yang berbeza digunakan untuk menghantar beberapa jalur informasi bebas melalui fiber. Laser diod digunakan, sebelum ini, sebagai sumber kerana ia mempunyai lebar spektrum yang kecil untuk mengurangkan kehilangan sinar dan bagi menghasilkan sinar yang bertenaga untuk penghantaran jarak jauh. Tetapi, pada zama sekarang dimana kadar data lebih bermakna, jarak dekat atau jauh adalah tidak penting. Teknologi diperlukan bagi memastikan komunikasi jarak dekat menggunakan optik adalah murah dan mampu di laksanakan. Oleh yang sedemikian, diod pancaran cahaya (LED) boleh memainkan peranan sebagai sumber cahaya alternatif kepada laser. Namun begitu, LED mempunyai spektrum yang lebar, yang akan menyebabkan kesemua tenaganya dibazirkan begitu sahaja. Untuk menghidari masalah diatas, teknik yang dipanggil pemotongan spektrum boleh digunakan. Dengan menggunakan LED , kos keseluruhan sistem juga dapat dikurangkan. Projek ini mempersembahkan teknik pemotongan spektrum yang boleh digunakan didalam system WDM. Untuk sistem WDM ini, penapis lulus jalur digunakan sebagai agen pemotong. Output daripada teknik ini dibandingkan dengan output yang diperolehi melalui kaedah *Arrayed Waveguide Grating* (AWG) dan model matematik. Analisa budjet tenaga di lakukan dimana jarak hubugan sistem yang menggunakan teknik pemotongan spektrum dengan penapis lulus jalur, adalah diantara 15-30 km. Kos analisa juga dilakukan dengan mengambil kos semasa komponen-komponen didalam sistem ini, bagi membuktikan bahawa kaedah yang dinyatakan diatas dapat mengurangkan kos – di mana sumber laser boleh digantikan dengan cahaya LED untuk komunikasi jarak dekat.

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LIST OF ABBREVIATIONS AND SYMBOLS

AWG	-	Arrayed Waveguide Grating
dB	-	Decibel
DWDM	-	Dense Wavelength Division Multiplexing
EDFA	-	Erbium Doped Fiber Amplifier
FSR	-	Free Spectral Range
GHz	-	Giga Hertz
Gbps	-	Giga Bits per Second
LED	-	Light Emitting Diode
Mbps	-	Mega Bits per Second
PON	-	Passive Optical Network
SM	-	Single Mode
SNR	-	Signal to Noise Ratio
TBF	-	Tunable Bandpass Filter
WDM	-	Wavelength Division Multiplexing
WGR	-	Waveguide Grating Router
nm	-	Nano Meter
μm	-	Micro Meter
ns	-	Nano Second

CHAPTER 1

INTRODUCTION

1.1 Optical Fiber Communication

Our current "age of technology" is the result of many brilliant inventions and discoveries, but it is our ability to transmit information, and the media we use to do it, that is perhaps most responsible for its evolution. Progressing from the copper wire of a century ago to today's **fiber optic cable**, our increasing ability to transmit more information, more quickly and over longer distances has expanded the boundaries of our technological development in all areas. Today's low-loss glass fiber optic cable offers almost unlimited bandwidth and unique advantages over all previously developed transmission media.

Advantages of Fiber Optic System

- The ability to carry much more information and deliver it with greater fidelity than either copper wire or coaxial cable.
- Fiber optic cable can support much higher data rates, and at greater distances, than coaxial cable, making it ideal for transmission of serial digital data.
- The fiber is totally immune to virtually all kinds of interference, including lightning, and will not conduct electricity. It can therefore come in direct contact with high voltage electrical equipment and power lines. It will also not create ground loops of any kind.
- As the basic fiber is made of glass, it will not corrode and is unaffected by most chemicals. It can be buried directly in most kinds of soil or exposed to most corrosive atmospheres in chemical plants without significant concern.

- Since the only carrier in the fiber is light, there is no possibility of a spark from a broken fiber. Even in the most explosive of atmospheres, there is no fire hazard, and no danger of electrical shock to personnel repairing broken fibers.
- Fiber optic cables are virtually unaffected by outdoor atmospheric conditions, allowing them to be lashed directly to telephone poles or existing electrical cables without concern for extraneous signal pickup.
- A fiber optic cable, even one that contains many fibers, is usually much smaller and lighter in weight than a wire or coaxial cable with similar information carrying capacity. It is easier to handle and install, and uses less duct space. (It can frequently be installed without ducts.)
- Fiber optic cable is ideal for secure communications systems because it is very difficult to tap but very easy to monitor. In addition, there is absolutely no electrical radiation from a fiber.

1.2 The Basic Blocks of a Fiber Optic Transmission Link

The basic fiber optic transmission system consists of the following three elements– Transmitter, Fiber Optic Cable and Receiver. These basic blocks are shown in the figure 1.1.

The **Transmitter** converts an electrical analog or digital signal into a corresponding optical signal. The source of the optical signal can be either a light emitting diode, or a solid state laser diode. The most popular wavelengths of operation for optical transmitters are 850, 1300, or 1550 nanometers.

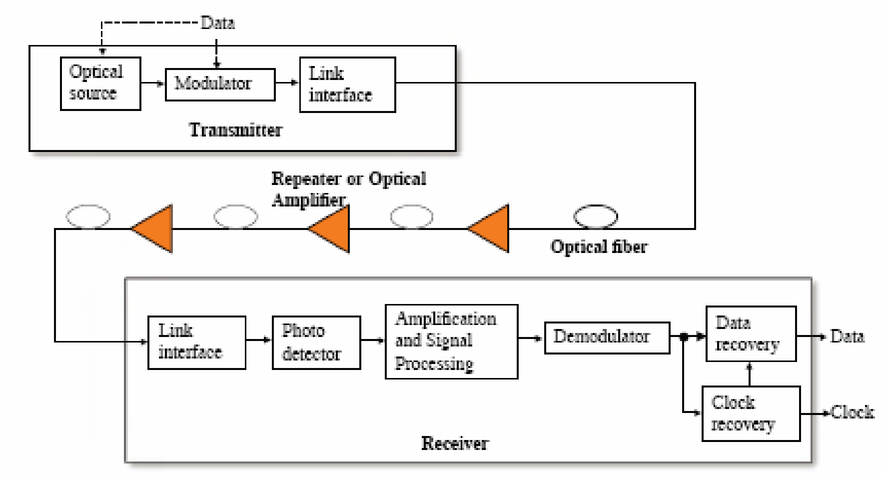

Figure 1.1 Basic blocks of a fiber optic system

The **Fiber Cable** consists of one or more glass fibers, which act as waveguides for the optical signal. Fiber optic cable is similar to electrical cable in its construction, but provides special protection for the optical fiber within. For systems requiring transmission over distances of many kilometers, or where two or more fiber optic cables must be joined together, an optical splice is commonly used.

The **Receiver** converts the optical signal back into a replica of the original electrical signal. The detector of the optical signal is either a PIN-type photodiode or Avalanche-type photodiode.

1.3 Wavelength Division Multiplexing

Wavelength Division Multiplexing (WDM) is a technology for transmitting many different signals through one optical fiber cable using different optical carriers which have different wavelength. At first, wavelength division multiplexing was used with only two wavelengths - 1310 nm and 1550 nm. However, this was suitable only for limited applications- for example; applications in which analog optical-cable television signals co-existed with digital optical-telecommunication signals. WDM takes advantage of the fact that different wavelengths of light can be transmitted over a single fiber simultaneously. The light sources of different wavelengths can be combined using suitable components like couplers, splitters etc. At the receiving end the principle is the same as using a prism to separate the wavelengths (frequencies) in white light. Commonly, some type of diffraction grating is used, which bends light as a function of its wavelength. Combining a few wavelengths is relatively straightforward and equipment has been commercially available since 1996. This is sometimes referred to as Simple or Sparse Wave Division Multiplexing. At present, efforts are concentrated on putting large numbers of wavelengths onto a single fiber, and this is referred to as Dense Wave Division Multiplexing (DWDM). The state-of-the-art now is 300 λ's or wavelengths. It is expected that upwards of 1000 may eventually become possible very soon and this will permit many terabits per second of data to be transmitted over a single fiber. The ever-growing trends of Optical networks in terms of bandwidth and cost are shown in figures 1.2 & 1.3.

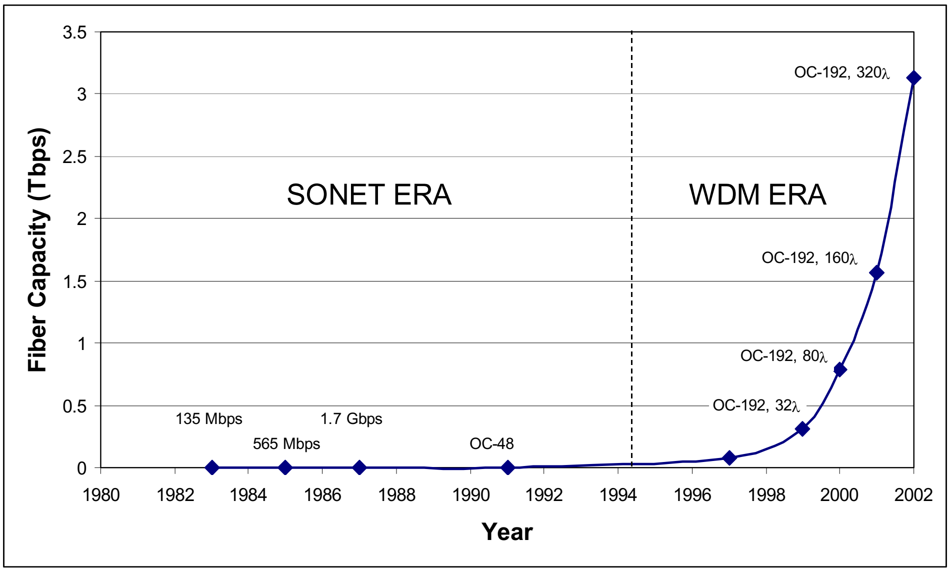

Figure 1.2 Optical Network Bandwidth Trendline

Source: Nortel Networks

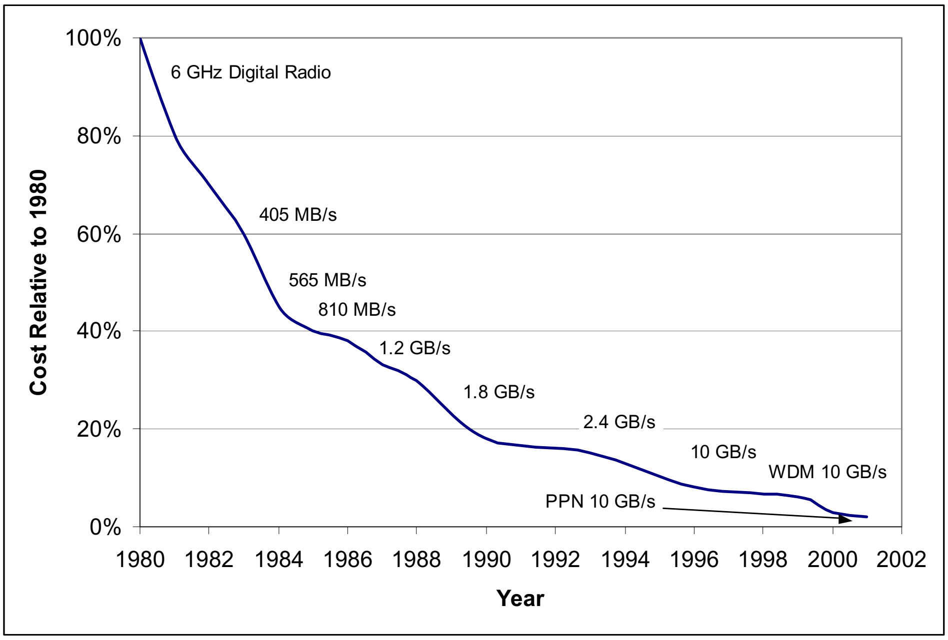

Figure 1.3 Digital Transmission Cost Trends, 1980-2001
Source: Qtera Networks/NGN99

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