Wave Division Multiplexing Systems

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Abstract-:

Wavelength-division-multiplexing (WDM) technology is now recognized as one of the key technologies in optical communications systems. This is because it has great potential to enhance system design and flexibility. This paper deals with the following: A comprehensive study of the communication system using optical fibers, a comprehensive study of the advantages of using optical fibers in communications systems, analyze and study WDM technology and identify its types, and comparison between CWDM and DWDM.

الملخص :

تُعرف الآن تقنية تعدد الإرسال بتقسيم الطول الموجي (WDM) باعتبارها إحدى التقنيات الرئيسية في أنظمة الاتصالات البصرية. وذلك لأنه يتمتع بإمكانيات كبيرة لتعزيز تصميم النظام ومرونته. يتناول هذا البحث ما يلي: دراسة شاملة لمزايا استخدام الألياف الضوئية في أنظمة الاتصالات، تحليل ودراسة تقنية WDM والتعرف على أنواعها، والمقارنة بين DWDM و CWDM

1. The general system

An optical fiber communication system is similar in basic concept to any type of communication system.

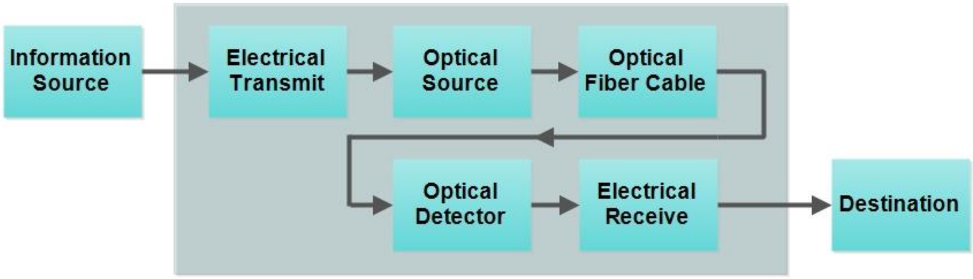


Figure (1) : Optical Fiber Communication System.

For optical fiber communications system as shown in Figure (1), the information source provides an electrical signal to a transmitter comprising an electrical stage which drives an optical source to give modulation of the light wave carrier. The optical source which provides the electrical–optical conversion may be either a semiconductor laser or light emitting diode (LED). The transmission medium consists of an optical fiber cable and the receiver consists of an optical detector which drives a further electrical stage and hence provides demodulation of the optical carrier. Photodiodes (*p*–*n*, *p*–*i*–*n* or avalanche) and, in some instances, phototransistors and photoconductors are utilized for the detection of the optical signal and the optical–electrical conversion. Thus there is a requirement for electrical interfacing at either end of the optical link and at present the signal processing is usually performed electrically [1].

1.1 Advantages of optical fiber communication

2. Enormous potential bandwidth. The optical carrier frequency in the range 10^{13} to 10^{16} Hz (generally in the near infrared around 10^{14} Hz or 10^{5} GHz) yields a far greater potential transmission bandwidth than metallic cable systems (i.e. coaxial cable bandwidth typically around 20 MHz over distances up to a maximum of 10 km) or even millimeter wave radio systems (i.e. systems currently operating with modulation bandwidths of 700 MHz over a few hundreds of meters).

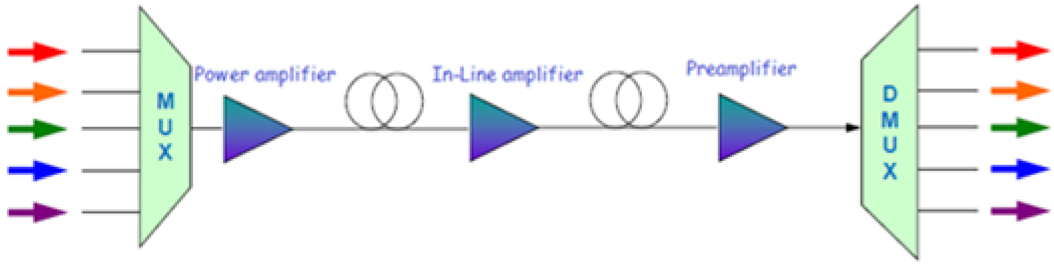
3. Small size and weight. Optical fibers have very small diameters which are often no greater than the diameter of a human hair. Hence, even when such fibers are covered with protective coatings they are far smaller and much lighter than corresponding copper cables.
4. Electrical isolation. Optical fibers which are fabricated from glass, or sometimes a plastic polymer, are electrical insulators and therefore, unlike their metallic counterparts, they do not exhibit earth loop and interface problems. Furthermore, this property makes optical fiber transmission ideally suited for communication in electrically hazardous environments as the fibers create no arcing or spark hazard at abrasions or short circuits.
5. Immunity to interference and crosstalk. Optical fibers form a dielectric waveguide and are therefore free from electromagnetic interference (EMI), radio frequency interference (RFI), or switching transients giving electromagnetic pulses (EMPs).
6. Signal security. The light from optical fibers does not radiate significantly and therefore they provide a high degree of signal security.
7. Low transmission loss. The development of optical fibers over the last 20 years has resulted in the production of optical fiber cables which exhibit very low attenuation or transmission loss in comparison with the best copper conductors.
8. Ruggedness and flexibility. Although protective coatings are essential, optical fibers may be manufactured with very high tensile strengths.
9. System reliability and ease of maintenance. These features primarily stem from the low-loss property of optical fiber cables which reduces the requirement for intermediate repeaters or line amplifiers to boost the transmitted signal strength.
10. Potential low cost. The glass which generally provides the optical fiber transmission medium is made from sand – not a scarce resource. So, in comparison with copper conductors, optical fibers offer the potential for low-cost line communication.

2. Types of WDM Systems:

WDM stands for Wavelength Division Multiplexing.

WDM is a technology which multiplexes several signals on a single fiber by using different wavelength to carry different signals, WDM system is shown in Figure (2).

This allows for a multiplication in capacity, in addition to enabling bidirectional communications over one single fiber.



F Figure (2) : Wave Division Multiplexing System.

With the exponential growth in communications, caused mainly by the wide acceptance of the Internet, many carriers are finding that their estimates of fiber needs have been highly underestimated. Although most cables included many spare fibers when installed, this growth has used many of them and new capacity is needed.

Three methods exist for expanding capacity:

1) Installing more cables.

2) Increasing system bit rate to multiplex more signals.

3) Wavelength division multiplexing.

Installing more cables will be the preferred method in many cases, especially in metropolitan areas, since fiber has become incredibly inexpensive and installation methods more efficient (like mass fusion splicing) But if conduit space is not available or major construction is necessary, this may not be the most cost effective.

Increasing system bit rate may not prove cost effective either. Many systems are already running at SONET OC-48 rates (2.5 GB/s) and upgrading to OC-192 (10 GB/s) is expensive, requires changing out all the electronics in a network, and adds 4 times the capacity, more than may be necessary.

The third alternative, wavelength division multiplexing (WDM), has proven more cost effective in many instances. It allows using current electronics and current fibers, but simply shares fibers by transmitting different channels at different wavelengths (colors) of light. Systems that already use fiber optic amplifiers as repeaters also do not require upgrading for most WDM systems. the capacity of optical communication systems can exceed 10 Tb/s because of a large frequency associated with the optical carrier. In practice, however, the bit rate was limited to 10Gb/s or less until 1995 because of the limitations imposed by the dispersive and nonlinear effects and by the speed of electronic components. Since then, transmission of multiple optical channels over the same fiber has provided a simple way for extending the system capacity to beyond 1Tb/s. Channel multiplexing can be done in the time or the frequency domain through time-division multiplexing (TDM) and frequency-division multiplexing (FDM), respectively. The TDM and FDM techniques can also be used in the electrical domain. To make the distinction explicit, it is common to refer to the two optical-domain techniques as optical TDM (OTDM) and wavelength-division multiplexing (WDM), respectively. The development of such multichannel systems attracted considerable attention during the 1990s. In fact, WDM light-wave systems were available commercially by 1996.

Each communication channel is allocated to a different frequency and multiplexed into a single fiber. At the destination wavelengths are spatially separated to different receiver locations[2].

Here we explain the types of WDM systems and the applications of each.

1. **WDM**: The concept was first published in 1978, and by 1980 WDM systems were being realized in the laboratory. The first WDM systems combined only two signals (wavelengths) (1310nm/1550nm).We have talked about it in the previous section[3].

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2. **CWDM** : Coarse WDM a technology for un-amplified, lower channel count applications. Less cost than DWDM. Ideal for Metro Access applications. Characterized by wide channel spacing over a wide optical spectrum – 20 nm spacing from 1270 – 1610 nm.

- Standard channel plan developed by the ITU in 2002.
- 20 nanometer spacing between channels.
- Starting at 1270nm and going thru 1610nm.
- 18 Channels.

3. **DWDM**: DENSE WDM, Dense wavelength division multiplexing (DWDM) refers originally to optical signals multiplexed within the 1550 nm band, which are effective for wavelengths between approximately 1525–1565 nm (C band), or 1570–1610 nm

(L band). It was originally developed to replace SONET/SDH optical-electrical-optical (OEO) regenerators. for transporting extremely large amounts of data traffic over metro or long distances in telecom networks.

- Standard channel plan developed by the ITU in 2002.
- 400, 200, 100, and now 50 GHz spacing between channels.
- Starting at 1530nm and going thru 1560nm.
- 80 Channels.

4. **UDWDM**: Ultra Dense WDM, multiplexing up to 320 channels, 50 GHz spacing with 4 carriers per wavelength.

- Standard channel plan developed by the ITU.
- 12.5 GHz spacing between channels.
- Starting at 1530nm and going thru 1560nm.
- 320 Channels[4].

In Figure (3) we show the operating wavelengths of the WDM systems.

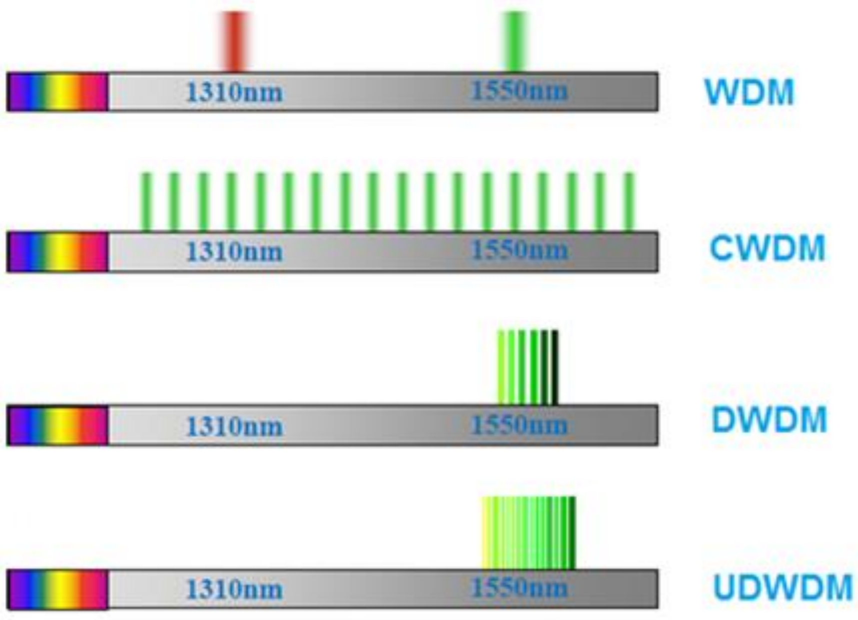

Figure (3) : Types of WDM Systems.

In the Figure below we explain the carriers and the channels for each type.

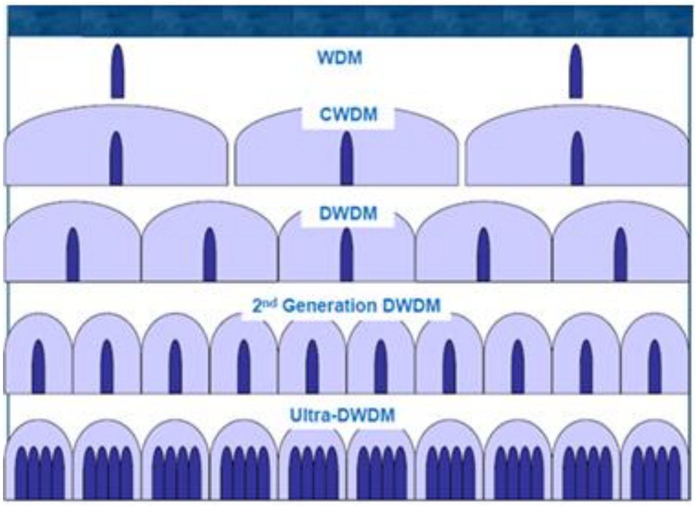

Figure (4) : The carries and the channels for each type.

3 Conclusion

There are differences between CWDM and DWDM systems and here we compare between them in Table (1) [5].

Table (1) : Comparison between CWDM and DWDM.

CWDM	DWDM
Short-range communication	Long-haul transmission
Uses wide range frequencies	Narrow frequencies
Wavelengths spread	Tightly packed wavelengths
Breaks the spectrum into big chunks	Dices the spectrum into small pieces
Light signal is not amplified	Signal amplification is used
Low cost compared to DWDM	High cost
Simple implementation	Complex implementation

We see from the table that we can use DWDM systems to transmit large amounts of data over long distance telecom networks.

In metro networks we can use both CWDM and DWDM systems, CWDM is the most cost efficient but it has limitations in the distance and the capacity.

References

[1] Senior John M. and Jamro M. Yousif, Optical Fiber Communications Principles and Practice, Pearson Prentice Hall, Third edition (2009)

[2] Jim Alverson, Nagamani Pathuri and Anupriya Krishnan, "Wavelength Division Multiplexing", work paper

[3] Introduction to Wavelength Division Multiplexing, http://en.wikipedia.org/wiki/Wavelength-division_multiplexing

[4] Joe Coffey RCDD, "Introduction to Wave Division Multiplexing", work paper

[5] Work paper on optical amplifiers, http://www.slideshare.net/Eng_Ahmad/wdm-amp-optical-amplifiers, (2010)

[6] Govind P. AGRAWAL, "Fiber-Optic Communication Systems", A John Wiley & sons,Third Edition (2002)

[7] Professor Z Ghassemlooy, "Optical Fibre Communication Systems", Electronics & It Division School of Engineering Sheffield Hallam University U.K.