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Radio Frequency the realm for Wavelength Division Multiplexing in Avionics

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***Abstract*— By taking into account the field of optical communication, it is necessary to comprehensively consider every term contributing to its evolution. Modern systems utilize fibre optic transmission at a higher level for advanced system configurations also the distribution and transmission of RF modulated signals over optical fibre has lead into efficient use of optics. The present paper gives details of Wavelength Division multiplexing, its types and its implementation in optics. It has a further involvement of application of WDM in RF Avionics. Thereby leading to a well suited system with acquired accuracy.**

***Keywords*— WDM, RF, CWDM, DWDM, Avionics.**

I. INTRODUCTION

Optics has proved to be a boon for Communication in the optimized globe. Its advanced emergence and rapid progress has enhanced communication in many aspects. Wavelength Division Multiplexing (WDM) is one of those many features, having raised the bandwidth limits. Indeed WDM has its own unique importance. It has made us visualize a large bandwidth era, the present need. WDM has come up as a breakthrough in communication. Use of gigantic wavelength is ubiquitous in today's high-tech developing world. With the same ease RF also specifies ample of share in communication sector. The ease of smart application can be done by combining RF Avionics with WDM [1]. Need of today's prioritize technology is to make use of a very compact, economically stable along with a quality approach. The same will be served for WDM in Avionics which gets a boost in the RF sector.

II. WAVELENGTH DIVISION MULTIPLEXING

When it comes to discussion, optical fibre has enumerative significant features out of which availability of a large bandwidth proves to be vital. Wavelength Division Multiplexing (WDM) is simply modulation of more than one wavelength and then transmitting the same over a single optical network simultaneously [2]-[7]. Large bandwidth availability is accompanied by viable separation i.e., non-overlapping informative waves. Thus, avoids the possibility of interference, when operated within proper limits. These features, enable the simultaneous transmission of different types of information in modulated form. Hence it is conveniently used in Local Area Networks (LAN) wherein there is due requirement of accessing for multiple consumers. Provided the spectrum used, the bit rate can be varied due to its direct relation with the spectrum and the fibre length.

WDM shows its wide range undersea applications which have a key investment in undersea cable networks.

A. WDM Components

WDM has a predefined structure wherein the complete process is well arranged. Firstly considering the Tunable Optical Filters, these are essential at the receiver ends so as to select the desired output accordingly as and in the way needed by the consumer. There are several methods used for their construction, of which the prominent are use of gratings and piezoelectric mechanism. Up then comes the Multiplexers and the Demultiplexers, the essential components of WDM. These are used for combining the wavelengths at the input and selecting the wavelengths at the outputs. One of the types is Grating-based which uses the phenomenon of Bragg diffraction. Add-drop Multiplexers are prominent in adding and dropping out the channels accordingly. Star Couplers are another component whose function is to combine the optical signal entering from its multiple input ports and divide them equally among its output ports according to the requirement. Next component is the wavelength routers; it is a device combining the functionality of multiplexers and demultiplexers with star couplers. They, after selecting the required wavelengths are coupled accordingly. Thereafter we have optical cross connectors. These prove to be of great use when it comes to wide-area network while maintaining the transparency. Wavelength convertors are simply devices to change input wavelength to a new wavelength though retaining the data content.

B. Types of WDM

There are two main types of WDM namely Dense Wavelength Division Multiplexing (DWDM) and Coarse Wavelength Division Multiplexing (CWDM)

1) Dense Wavelength Division Multiplexing (DWDM)

When there are more than say, eight active wavelengths per fibre then the multiplexing is known as DWDM. [4] It is described in terms of frequencies. Frequencies involved are generally narrow frequencies. In DWDM, there is tighter wavelength spacing, hence covering a complete of 40+ beams in a single fibre. It is commonly used for long-haul transmission. DWDM makes use of Erbium Doped-Fibre Amplifiers (EDFAs) as a supplement to the long distance transmission and for the purpose of regeneration. Yet being an efficient way of exploiting the available bandwidth, DWDM is not cost effective and is also somewhat difficult to implement. DWDM dices the beams finely, this gives rise to the requirement of efficient and high precision filters which will be capable of separating individual beam from others without interfering with the neighbouring ones. The DWDM have already stood up with its prominent use in real time application

as Data acquisition (DAS). Its functionality deals with converting analog waveforms into digital values. Wherein the signals are sampled acquainting physical parameters like intensity of light, temperature etc. their analog waveform is converted into zero's and one's binary information. This application integrates use of DAS system in future high energy physical experiments.

2) Coarse Wavelength Division Multiplexing (CWDM):

In CWDM, there exist fewer active wavelengths wherein the spectrum is broken down to big chunks. CWDM was discovered at a later phase of DWDM. It matches with the basic capabilities of DWDM provided at a lower capacity and lower cost. CWDM enables carriers to respond flexibly to diverse customer needs in metropolitan regions where fibre may be at a premium, it also allows an increase in the capacity of existing networks. CWDM being defined in terms of wavelengths is mainly employed for short-range communication. It uses wide-range frequencies and allows spreading of wavelengths far apart from each other. It implies the use of wide range frequencies unlike DWDM. Also in CWDM there is no any significance of amplifiers, the regeneration process is done at the node itself. It allows remote management path through optical management network using dedicated wavelengths [5]. As discussed earlier CWDM spans limited distance communication reasoning unamplified light signals. To comment on CWDM's application, the use of silica graded index multimode fibre (MMF) is made because it has tremendous variety of inbuilt application which reduces the implementation cost.

However, DWDM and CWDM are not really in competition as both fulfil distinct roles that largely depend upon carrier-specific circumstances and requirements. [8]

The fig. below shows relative difference between CWDM and DWDM systems.

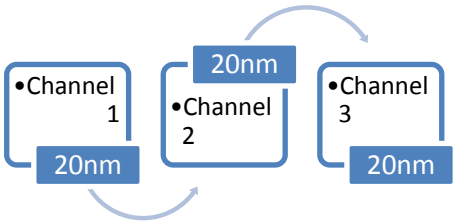

Fig. 1 Coarse Wavelength Division Multiplexing (CWDM)

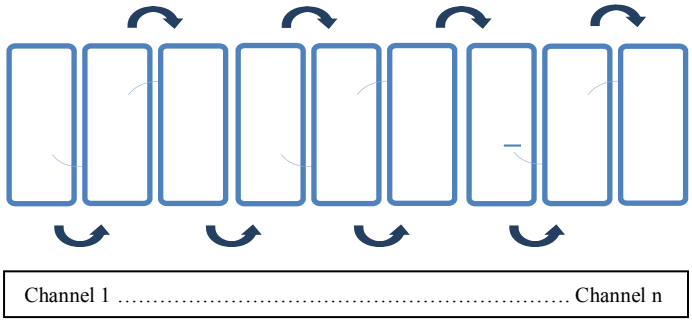

Fig. 2 Dense Wavelength Division Multiplexing (DWDM) Distance between two wavelengths varies between 0.4nm, 0.8nm, 1.6nm accordingly, as per the ITU standards.

III. WDM IN RF AVIONICS

A. *RF Frequencies and the concept of Radio over Fibre*

Frequencies in the range within which radio waves may be transmitted, are known to be the RF Frequencies. It is a rate of oscillation in the range of around 3 KHz to 300 GHz, which correspond to the frequency of radio waves, and the alternating currents which carry radio signals.

Radio over Fibre (RoF) is a technology wherein there occurs modulation of light by a radio signal and hence transmitting it over an optical fibre link. Considering an example of RoF systems, wireless signals are transported in optical form between a central station and a set of base stations before being radiated through the air. [6] Each base station is adapted to communicate over a radio link with at least one user's mobile station located within the radio range of said base station. The advantage is that the equipment for protocols can be centralized in one place, with remote antennas attached via fibre optic, serving all protocols. Hence greatly reducing the equipment and maintenance cost of the network. Hence, wireless signals being optically distributed to the base stations directly at high frequencies and then converted from optical to electrical domain at the base stations before being amplified and radiated by an antenna. Thereby resulting in no frequency up/down conversion at various base stations, and hence resulting into enabling of simple and rather cost-effective implementation at the base stations. The actual process is stated as follows.

1) Operation at transmitter:

It is the laser diode that converts RF signals to light. The basic principle is of direct modulation of the incoming RF signal onto the output of the laser diode. There is direct modulation of laser diode bias current by RF input signal at quiescent point. A monitor photodiode maintains the stability of the fixed operating point of the laser. For high performance (low noise and high dynamic range) Distributed Feedback (DFB) semiconductor lasers are used, Fabry-Perot (FP) lasers can also be utilised for the same purpose.

2) Operation at Receiver:

At the receiver location, light emitted from the transmitter emerges from the single mode optical fibre and is coupled into the receiver module using FC/APC connectors. Inside the receiver module a high speed PIN photodiode performs an optical to electrical conversion operation, and delivers an RF electrical signal output.

B. *Introduction to Avionics*

Avionics is something to do with a combination of electronics with the aviation systems. Out of the many requirements of avionics, one is data exchange at times. Existence of electronics in any field gives an essence of compactness without degrading the requirements. Hence the new emerging technologies are being much capable of serving in lieu of traditional ones.

C. Optical Communication for RF with Avionics

The combination of these two technologies has emerged as a bang on, for the Avionics system. The presence of an optical system is itself, nevertheless a best medium for transmission purpose as the optical networks have the ability to maintain transparency in the system thus maintaining efficiency of the system with minimum losses [3]. Now applying the concept of radio over fibre as stated earlier, there emerges a completely new environment combining-RF Frequencies, Optical Communication, and Avionics.

D. WDM in Optics for RF Avionics

Moving on a step further, along with the combination of RF Frequencies, Optical Communication and Avionics, existence of an additional term, modulation has made way for a technique, thus giving a significant contribution to the field of Communication. Starting with, the base simple bidirectional WDM filters provide quite a wide pass band. This allows us to consider the variations in the temperature. At room temperature, it is beneficial to situate the wavelength at the centre of the fibre thereby avoiding the possibility of drift of wavelengths outside WDM's cut-off.

This enables ready achievement of a two path fibre optic system. It results into many of the advantages along with some trade-offs which are not considerably prominent. Advantages read as, maximum use of available wavelength, thereby leading to reduction in the fibre cost and enhancing its use. Coming back to trade-offs, there is just minimum amount of loss.

Also, the beauty of a broadband WDM fibre optic transceiver is that, there is no significance for what RF frequency is being used or what modulation format is used. The WDM Fibre optic link has a long lifetime and can operate with various system formats.Well if one can put two wavelengths on a fibre, why not keep adding wavelengths to increase the benefits. Relating to an application for the stated combination, a four wavelength WDM transmission is possible [1]. Herein the four' WDM system is modulated using Radio Frequencies unlike that of the previous techniques which used digital data for modulation. This then is used for data exchanges. Thereby facilitating a more reliable and secure system which is a need for on board activities.

Also adding on to this, is availability of internet facilities on board, thereby enhancing the application and practicality of such a technology.

E. Future Scope

The spectrum width depends on the bit rate and length of the fibre. Optical communication in this way has a capacity to handle information in the range of gigabits/second speed. This is and will be proving to be very vital in the present and even the future. Taking into consideration the advantages, RF modulation technique can be used. But the fact that the metals, such as copper will not be able to carry RF signals to a long distance makes way for RF optics to come into picture. The paper just includes RF's optical use in Avionics but it can be also used for other uses as the above stated one.

IV. Conclusion

Taking into account the rapid growth in Communication System, it becomes necessary to have specific and proper study of the terms involved. Thus the paper gives a brief review of WDM along with RF, for one to understand it's ongoing together along with an example of Avionics. Here, also the use of RF frequencies in lieu of digital one's is focused which brings in advantages accordingly. Thereby getting acquainted with each term in an optimum way.

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