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Review on High Class Transmission in Optical Fiber Using Dense Space Division Multiplexing

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Abstract - The need for high transmission rate in the field of communication technology is continuously rising with the increase in demand for Faster, Robust, flexible and Cost Efficient transmission. However technologies like OFDM has already been applied in in optical fiber for high speed data transmission. But this technology limits its quantity of data transmission due to various limitations. Research and development of space division multiplexing (SDM) in optical communication technology towards achieving high-capacity transmission on the order of 1 petabit (Pbit) per second or more, which may be equivalent to a hundred to thousand times the capacity of existing optical fiber. A research work is proposed to describe the current scenario and future outlook efforts in Dense Space Division Multiplexing which aims to achieve a quantum leap in optical network capacity through the use of multi-core fiber.
Keywords - OFDM, WDM, SOA, EDFA, SDM, FFT, DSDM

I.INTRODUCTION

Multiplexing in communication system refers to the transmission of various signals through a single channel or medium. Two or more signals are combined to form a single signal and then fed to transmission channel. Multiplexing can be analog or digital depending upon requirements. This is done to use efficiently the channel bandwidth and to increase the reliability and efficiency of overall system. The process of combining signals is called multiplexing and reverse is called DE-multiplexing (separation of signals from single signal).

In the year of 1870s Multiplexing technology was first applied in the field of communication, and now a days it's a common practice in communication and various other fields like Information Technology. Multiplexing was first developed by George Owen Squier in the year of 1910.The multiplexed signal can be transmitted via different channels like wireless medium, wired channel, and the latest version optical fiber. Multiplexing divides the overall capacity of the communication medium into several logical channels, each channel is allotted to each message signal or segments that are to be transferred. There are many types of multiplexing techniques that are widely used in the field of communication. Eg: FDM, SDM, TDM, CDM.And there are few advanced version of multiplexing techniques that are implemented via optical fiber medium enabling wide range of bandwidth and exceptionally high transfer speed with minimised losses and ISI. Eg: OFDM, DSDM, SWDM. Dense space division multiplexing (DSDM) is an advanced version of Space-division multiplexing (SDM). In SDM method the channel is being divided into various logical sub channels/ pipes which are parallel spaced apart to each other. And each act as a separate channel for each signal. This offer excessively higher capacity and superior performance of medium as compared to single channel.This technology when applied firstly in the field of mobile cellular network gives an advantage of reduced power loss as in traditional times the position of the mobile was unknown to the transmitting station and the transmission antenna radiates signal in all directions. This results in wastage of power where there exists no mobile units. In addition frequency reuse becomes difficult as there are no separation in space between channels and it causes frequency and noise interference. The mobile unit antenna receives signals from all directions which may be already distorted due to interference. So it becomes difficult to communicate. SDM gives a solution to these problems along with the use of smart antennas. At both transmission and reception side a radiation pattern is adapted/ allotted to each user as a requirement to give highest gain in that particular direction of the user. This is done by adapting phase array technique.SDM technique provide MIMO (Multiple input/Multiple output) to the systems by increasing the number of antennas in wireless and number of channels in wired medium. The algorithm used in wireless is BLAST.This technique can be applied to optical fiber communication to increase the bandwidth and transfer speed of the signals. Allowing multiple inputs and multiple outputs of the signals (MIMO). But the bandwidth and transfer speed in an optical medium SDM limits to some extent with more losses and ISI problems.

For these problems to overcome a new approach have been discovered i.e. dense space division multiplexing (DSDM).

II.DSDM APPROACH IN OPTICAL FIBER COMMUNICATION

The main factor for finding SDM transmission depends upon spatial & spectral efficiencies. This method is applied to some SDM and WDM to relate spectral efficiency per fiber to special multiplicity of cross sectional area of fiber. The transmission criteria depends upon spatial multiplicity without polarization but includes aggregate special modes along with cores that are used for transmission. The limitations of number of cores and diameter difference of cores which make it less efficient to SDM as compared to DSDM. By considering fiber cross sectional area and no. of cores overall special efficiency can be obtained by dividing multiplying factor by fiber CSA (Cross Sectional Area)[1-5].
When we consider Fig 1. We will observe that the transmission in few mode fiber, the efficiency seems to be 3-6 times more efficient in category 'F', as compared to single mode fiber of category 'D', because the multiplexing technique used in the same cladding of 125μm diameter is in special mode. When we consider category 'A' it gives spatial efficiency on a higher side in the un-coupled multi core fiber transmission which increase with the increase in number of fiber cores 'N'[6-10]. Although increasing the number of cores the crosstalk in intercore of multimode fiber increases and this results that the higher order modulated signals will be hard to transmit over long distances with lower order of spectral efficiencies.
As far as concerned to increase spectral & spatial efficiencies higher scaling (technology) in single mode multicore fiber is needed to realize dense space division multiplex transmission.
When we look at multicore fiber transmission at category 'A' has low spatial efficiency with higher cores comparative to category 'E' which has lower cores just because of the smaller diameter of cladding category 'E'. However, spectral efficiency of 'E' is higher than that of few mode fiber transmission of category 'F' having same number of spatial multiplicity.
However this paper reviewed about the extensive research that has undergone to increase number of cores & spectral efficiency. Until now we came to the conclusion that multicore few mode fiber in 'C' category provides better spatial & spectral efficiencies[11-14].
This result came to the conclusion that multicore multimode fiber technology is feasible to transmit high capacity of data obviously with excessively higher transmission rate in a spatially efficient way.

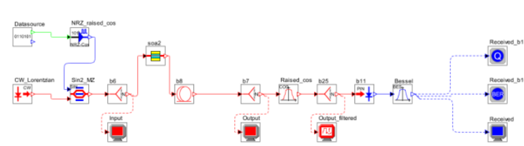

Fig 1: Space Division Multiplexing Experimental Efficiencies (Spatial & Spectral)

The delay in differential mode & crosstalk were introduced in single mode fiber. As a result to reduce these problems all few mode multicore were used. Design of proper refractive index profile help us to reduce differential mode delay in transmission via few mode fiber. However, this process of reducing delay makes the line in transmission mode complicated.To overcome these problems, unusual multiple input multiple output signal are employed which allow easy transmission of signal in dense mode division multiplexed mode. And hence there will be no need to fabricate several Multicore Few mode fiber which usually have undergo differential mode delay characteristics. Multicore & multimode dense space division multiplexed transmission system is shown in Fig 2. Based upon multicore few mode fiber optic technology, the development of first in first out devices were made with low loss, low crosstalk & high precision. However different typed of multiplexing demultiplexing technology has introduced according to different mode to fibers which include planar lightwave, photonic lantern etc. The silica planar lightwave multiplexing or demultiplexing however exhibit lower insertion loss mostly less than 5db along with coupling losses & high conversion efficiency. Moreover we have studied and simulated and silica based 6x6 multiple input and multiple output receiver which is being an example of dense space division multiplexing. The current status of DSDM transmission have reached up to 1 Pbps with 12x3 core fibers. However the studies are still in progress and will surely find an advantages of being capable of transmitting and receiving of data at excessively data rate and bulk transfer of data with more use of multiple input and multiple output providing minimum insertion loss, signal processing loss, higher efficiency and advanced amplification technologies etc.

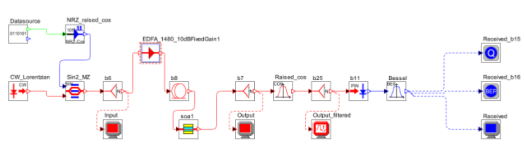

Fig. 2. An indicative representation of DSDM in optical medium

IV.ADVANTAGES

1. The transmission speed of about 1 Peta-bit per second Pb/s or more can be obtained through a single optical fibre of more cores.
2. It provides a large amount of bandwidth in each channel and also the same bandwidth can be used at a same time in different channels which are spaced apart.
3. It provides frequency reuse via different channels which is the most valuable use of DSDM.
4. Two different signals can use the same frequency.
5. It provides us with great means to achieve more system capability, scalability and flexibility.
6. It uses a combination of one or more other schemes such as TDM, FDM, CDM etc.

V.DISADVANTAGES

1. More number of switches needed.

2. The input is being splitted to transmit through multiple channels which results in the introduction of insertion losses on a higher grade.

3. It becomes difficult to add more inputs as well as outputs because of the difficulty to replace whole switch

4. Reverse link may be a problem: Interference problems

III.FUTURE SCOPE

Optical DSDM will dominate an excessively wide and efficient use of bandwidth at once in future, however this technology had already been serving in the field of wireless communication. But there exists some limitations like transfer rate and bandwidth allocations. These could only be overcome by the use of Optoelectronics. However this technology is currently overwhelmed with a bid of expensive cost capital. But the DSDM surely will dominate many more and big advantages in future and will be the promising technology to come forward in the field on information and communication technology.

VI.CONCLUSION

In this paper we have represented and reviewed about various advantages of DSDM along with SDM and some about various multiplexing technologies. A desired DSDM transmitter and receiver with its application and advantages have studied along with the processing blocks.Although SDM was discovered in some years ago around 1990s and it became useful in wired and wireless communications extensively. Although SDM technology has already been applied in optoelectronics filed but it restricts some limitations as we explained above. Thays why we adopted a new approach DSDM which is being recently discovered and its applications are still in process. DSDM has numerous of drawbacks and limitations which includes its reverse link problems and requirement of higher number of switches. These problems are however discussed and their remedies are resolved likely to be applied in the field of optoelectronics. At last, we come to the conclusion that DSDM is considered to be the most promising, reliable and efficient technology in the field of optical communication.

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