Network Analysis of Wavelength Division Multiplexing (WDM) using EDFA

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Abstract— OptiSystem software is used to design and simulate fibre-optic communications system which are useful for the understanding of each component of the fibre-optic communications system. This experiment will try to portray the working of a simple wavelength division multiplexing concept by using optisystem. It will demonstrate how the usage of EDFA is done in the practical scenario. Network is analyzed considering the Length, Pump power, Gain and Noise figure.

Key words: Optisystem; Wavelength division multiplexing; EDFA, Noise figure

I. INTRODUCTION
Wavelength division multiplexing is very advantageous as it has led to enhancement of transmission capacity and an important role in modern telecommunications networks. WDM has up and downstream signals using different optical wavelength hence it is a bidirectional multiplexing technique. WDM increases the transmission and reception capability of fibre optic cable systems; WDM technology transmits different types of data at distinct optical wavelengths over a single fibre channel. Hence large volumes of data, video or voice will be transmitted over a fibre backbone. Erbium Doped Fiber Amplifier is an optical fiber that has been lightly doped (1000 ppm) with a rare earth element erbium. It has active medium of 10-30 meter length of. The host fiber material is made of silica or Tellurite glass. It operates in the C-Band which is limited to 1540 to 1560 nm. Optical fiber amplifiers use external photon injection to amplify the light signals. The external source directly raises electrons to an excited state and then at the arrival of the signal photon there will be a stimulated emission and a photon of the same wavelength will be produced.

II. SIMULATION OF WAVELENGTH DIVISION MULTIPLEXING EXPERIMENT
WDM works on a basic principle where light signals with different wavelengths are put together initially, and then coupled to fibre optic cable lines in the same fibres for transmission. At the receiver end different wavelengths are separated by signal processing, restores the original signal and sends them to different terminal.

WDM consists laser, wavelength division multiplexing, optical demultiplexer and optical spectrum analysers etc. The light source composed of four lasers with emission frequencies of 193.1THz, 193.4 THz, 193.7 THz, and 194.0 THz respectively. The light signals are combined together through the WDM combine, and then coupled into the optical fibre. The signal Wavelength demultiplexer separates the combined signal in the terminal which is represented by optical spectrum analyser.

III. SIMULATION OF OPTICAL FIBRE AMPLIFICATION EXPERIMENT
Using ideal MUX the signal and pump light are combined together. Then they enter into the erbium-doped fibre amplifier. We observe the amplification by seeing the spectrums before and after amplified.,. The centre wavelength of the signal light and pump light used here are 1550nm and 980 nm respectively.

IV. EDFA-WDM OPTICAL NETWORK ANALYSIS
Wavelength-division multiplexing (WDM) is a method that can use huge optoelectronic bandwidth mismatch, which is each end-user’s equipment need to operate only at electronic rate, but different end-users having multiple WDM channels may be multiplexed on the same fiber. EDFA is used as an optical amplifier that uses a doped...
optical fiber as a gain medium to amplify an optical signal. The doped fiber is given the signal which is to be amplified and a pump laser which are multiplexed resulting in the signal amplification by interacting with the doping ions. EDFA has low loss optical window of silica based fiber, large gain bandwidth, which is normally tens of nanometers and it can amplify more than enough to amplify data channels with the highest data rates without present any effects of gain narrowing. EDFA gain-flattened is important in long haul multichannel light wave transmission systems especially WDM. WDM system implementation using EDFA is difficult as the EDFA gain spectrum is wavelength dependent. The EDFA does not have to amplify the wavelength of the channels equally and frequently to have equalized gain spectra in order to obtain uniform output powers and similar signal-noise ratios (SNR). Output powers for different lengths at different pump powers and the Gain and Noise figure characteristics are analyzed.

![Fig. 4: WDM with EDFA circuit](image1)

### V. SIMULATIONS AND RESULTS

First analyze the output power with respect to pump power. As the pump power increases the output power will increase at each meter of the length. When the Length of the amplifier is increase, there will be more power used to transmit the signal in the system. However the output power will decrease after a certain point for any pump power.

![Fig. 5: Comparison of output power vs edfa length](image2)

Since the pump is at wavelength of 980nm, when the fiber length increase, the erbium ions will excite to the higher level where the lifetime of this higher level is approximately to 1us. Therefore, it will cause the increasing of the output power. After a certain length when the pump power is exhausted, the erbium ions will be unexcited resulting in the decrease of output power.

![Fig. 6: output power and noise figure at various pump power](image3)

Now we study the gain and noise figure which can be taken from the optical spectrum analyzer in the Optisystem software. Figure above shows the results. It clearly shows the gain flatness for the different pump powers from 150mW to 500mW for the power versus wavelength. The green wave in the result is representing the noise while the red symbol in the graph represent the sample wavelength. It can be observed that the noise is decreasing when the pump power is increasing.
VI. CONCLUSION

The simulation results show that the system implements the basic functions of WDM systems. In EDFA the effect of the increasing of pump power to the output power at different length of amplifier is the increasing of pump power will increase the output power at each meter of the length. This is because when the length of the amplifier increases, more power used will be to transmit the signal in the system. However after reaching certain length the output power will reduce for all pump powers. Since the pump is wavelength of 980nm, erbium ions will excite to the higher level when there is an increase in fiber length, lifetime of this higher level is approximately to 1us. Therefore, it will cause the increasing of the output power. However, the pump power is exhausted after a certain length when, the unexcited erbium ions will results in the decreased of output power. It showed the gain flatness for the different pump powers from 150mW to 500mW for the power versus wavelength. The green wave in the result is representing the noise which it shown that the noise is decreasing when the pump power is increasing while the red symbol in the graph represent the sample wavelength. The pump power of 150mW has the lowest gain and highest noise figure while the pump power of 500mW has the highest gain and lowest noise figure. Therefore, it shows that the pump power of 150mW and 500mW does not have a good performance. In this system we notice that the output OSNR increases with increase in the pump power. In EDFA we varied the length of the fiber and found the values of the output power whose results have been shown above. The same analysis was done for the Raman amplifier after which we came to the conclusion that whatever be the pump power variation i.e. it was varied from 120kW to 500kW, the readings for output power were the same for the respective lengths. In EDFA we fixed the length of the fiber and found the values of the gain. The same analysis was done for the Raman amplifier after which we came to the conclusion that whatever be the pump power variation i.e. it was varied from 120kW to 500kW, the readings for gain were the same. In EDFA we fixed the length of the fiber and found the values of the gain whose results have been shown above.

REFERENCES


[5] Tutorials for Optisystem by optiwave