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ENGINEERING

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EXPERIMENT NO. 1

Aim: Setting up fiber optic analog link.

Equipment required: OFT, two channel 20 MHz oscillator, function generator -1 MHz to 10 MHz

Objective:

The objective of this experiment is to set up an 850 nm fiber optic analog link. The linear relationship between the input signal and received signal is observed. The effect of the gain control on the received signal is also observed and finally the bandwidth of the link is measured.

Introduction:

This experiment is designed to familiarize the user with OFT. And analog optic fiber link is to be set in this experiment. The preparation of optical fiber coupling light in to it and coupling of fiber to the LED and detector are described in to appendix-A. The LED is used in is an 850nm LED. The fiber is multimode fiber with core diameter of 100μm. The detector is a simple PIN Detector.

The LED optical fiber power output is directly proportional to the current driving the LED. Similarly, for the PIN diode the current is proportional to the amount of light falling on detector. Thus, even though LED and PIN diode are non-linear devices. The current in PIN diode is directly proportional to the driving current of LED. This makes optical communication system linear system.

Table

Interface details for experiment 1

Sr. No.	Identification name	Function	Location
1.	P_{11} analog IN	Used to feed in analog sin V_{pp} signal.	Transmitter block.
2.	P_{32} P_{D1} output	PIN detector signal monitoring post.	Optical receiver block.
3.	P_{31}	Receive signal with amplification.	Optical receiver block.
4.	GAIN	Gain adjustment potentiometer	Optical receiver block.
5.	Sw8	Analog digital selection switch should be set to analog position. LED 850nm	Optical transmitter block.
6.	PIN detector		Optical transmitter block.
7.	I-01, I-02, I-03	Input output BNC's and posts. 1. For feeding IN signal to the experiment from function generator. 2. To observe signal from experiment oscilloscope.	

Procedure:

Setup: -

1. The interface used in experiment are summarized in above table. Identity them on the OFT with help of layout diagram. The block diagram of subsystem used in experiment is shown in fig. The 1m & 3moptical fiber provided with OFT are to be used. Ensure that the ends of the fiber are cleaned and prepared as described in appendix-A setting of analog link.
2. Set the switch Sw8 to the analog position switch the power ON. The power ON switch is located at top right hand corner.
3. Feed 1V_{pp} sinusoidal signal at 1KHz (with 0 dc). From function generator to analog in post P_{11} using following approach.
   a) Connect the BNC-BNC cable from function generator to BNC socket I- 03.
   b) Connect the signal post I-03 to the analog IN post using patch card.
   c) Connect one end of the one-meter fiber to the LED source. LED1 in optical text block. Observe the light output (Red light) at the other end of the fiber.
   d) Increase and decrease the amplitude level of sinusoidal signal.
   e) Connect other end of fiber to the detector PD_1 in optical receiver block. Input Output receiver link.
4. Feed a sinusoidal wave of 1 KHz, 1V_{pp} from function generator to P_{11}. The P_{11} detector output signal is available at bit 32 in optical receiver block.
4. Vary the input signal level driving the LED & observe the received signal at PIN detector plot the received signal peak to peak amplitude w.r.t. the input signal.
6. Apply a square wave or triangular wave with 1 V_{pp}& 0dc at input of transmitter at P_{11}. Vary the frequency and observe the output at P_{31}. Note the frequency signal at which received signal starts getting distorted.

Conclusion:

EXPERIMENT NO. 02

Aim: Setting up a fibre optical digital link

Equipments Required: OFT, 2 channel, 20 MHz oscilloscope, function generator, 1Hz-10MHz

Objective:

The objective of this experiment is to learn to set up 850 nm & 650 nm digital links and to measure the maximum bit rates supportable on these links. The setting up of a digital link is central to the rest of the experiments described in this manual.

Introduction:

The OFT can be used to set up two fibre optic digital links,one at a wavelength of 650 nm and the other at 850nm.LED1 in the Tx1 block,is an 850 nm LED and LED2,in the optical Tx2 block,is a 650 nm LED.

PD1,in the optical Rx1 block,is a PIN detector which gives a current proportional to the optical power falling on the detector. The received signal is amplified and converted to a TTL signal

PD2,in the optical Rx2 block, is another receiver which directly gives out a TTL signal. Both the PIN detectors can receive 650 nm as well as 850 nm signals,through their sensitivity is lower at 650 nm.

Procedure:

Setup :

1. The interfaces used in the experiment are summarized in table 2.1 identify them on the OFT with the help of the lay out diagram. The block diagram of the subsystems used in the experiment is shown in figure 2.2. Set the jumper and switches to start the experiment. Setting up a digital link at 850nm.
2. Set the switch SW8 to the digital position.
3. Connect 1m optical fiber between LED 1 & PIN diode PD1. Remove the shorting plugs of the coder data shorting links, S6 in the Manchester coder and S26 in decoder and clock recovery block. Ensure that the shorting plug of jumper JP2 is across the post B and A1.
4. Feed a TTL signal of about 20 KHz from the function generator to port B of S6. Use the BNC I/OS for feeding and observing signals as described in expt. 1. Observe the received analog at the amplifier post P31 on channel 1 of the oscilloscope. Note that the signal at P31 gets cutoff above 3.5V. Increase & decrease the GAIN and observe the effect.
5. Observe the received signal at post A of S26 on channel 2 of the oscilloscope while still observing the table.
6. Set the gain such that the signal at P31 is about 2V. observe the input signal from the function generator on channel 1 and received TTL signal at post A of S26 on channel 2. Vary the frequency of the input signal and observe the output response. What is the bit rate that can be transmitted on this digitl link?
7. Repeat steps 4, 5 & 6 with the 3m fiber.

Setting up a digital link at 650nm :

8. Use the 1m fiber and insert it into LED2. Observe the light output at the other end of the fiber. The output is a bright red signal. This is because the light o/p at around 650nm is in the visible range. The other end of the fiber should now be inserted into PD1.
9. Repeat steps 4, 5 & 6 with this new link.
10. Use the 3m fiber and set up the 650nm digital link between LED1 & PD1. Repeat steps 4, 5 & 6.

Setting up TTL to TTL Digital Link at 650nm :

11. Change the shorting plug in jumper JP2 across the posts B & A2. Use the 1m fiber to connect LED2 & optical receiver PD2.
12. Feed a TTL signal of 20 kHz at post B of S6 & observe the received TTL signal at post A of S26. Display both the signal on the oscilloscope on channels 1 & 2 respectively. Note that the GAIN control does not play any role now in the operation of the link. The receiver at PD2 is an integrated PIN diode and comparator that directly gives out a TTL signal. Vary the frequency and find maximum bit rate that can be transmitted on this link.
13. Repeat steps 11 & 12 using the 3m fiber.

Setting up a 850nm TTL to direct digital link :

14. Use the 1m fiber to connect LED1 &PD2. Feed a TTL signal of 20kHz at post B of S6 and observe the received signal at post A of S26. Display both the signal on the oscilloscope. An 850nm TTL to direct digital link is obtained. Vary the frequency and find the maximum bit-rate that can be trnsmitted on this link.
15. Repeat steps 14 with 3m fiber.
16. Change the shorting plug in JP2 to connect A1 & B. Using the 1m fiber connect LED1 &PD1. Let the GAIN control be at the minimum level. Feed a 20kHz TTL signal at post B of S6. Measure the peak to peak voltage at P31 and designate it as V1.
17. Now, connect the fiber between LED2 and PD1 without changing any other setting. Measure the peak to peak voltage at P31 and designate it as V2.
18. The factory setting for light output at the end of 1m fiber for LED1 is 3db higher than for LED. The pin diode current 'I' can be written as " i = p^p.
    Where, P is optical intensity of the light falling on the detector & P is the responsibility. The voltage at P31 is directly proportional to the the PIN diode T. Using the results of 16 & 17, compare the responsibilty of diode at 650 nm & 850 nm using the expression.
    (v1/v2) = (p1*P1)/(p2*P2)
    Where, P1 = 2P2

Table 2.1 Interface details of experiment 2

Sr. no.	Identification name	Function	Location
1.	SW8	A/D selection switch should be set to digital position	
2.	LED1 850 nm	850 nm LED	Optical TX1 block
3.	LED2 650 nm	650 nm LED	Optical TX2 block
4.	PD2	Optical receiver with TTL output	Optical RX2 block
5.	PD1	PIN detector	Optical RX1 block
6.	P31	PIN detector signal after gain	Optical RX1 block
7.	JP2	PD/PD2 Receiver select posts B & A1 should be shorted to select PD1	
8.	Gain control potentiometer	Optical RX1 block	
9.	S6 coded data	Manchester coded data shorting link. Post A:coded o/p Post B:i/p to TX1/TX2/Electrical posts A & B should be shorted.	Manchester coder block
10.	S26 coded data	Received Manchester coded data shorting link.post A:receiver o/p Post B:i/p to decoder & clock recovery block posts A & B should be shorted.	
11.	I/O1,I/O2,I/O3	I/O BNCs and posts for feeding in and observing signals	

The signal at P31 on channel 1. Note that the signal at S26 is the inverted version of the signal at P31. Vary the GAIN potentiometer setting. Note that even though the received signal at P31 changes with gain, the output at S26 does not reduce the gain till the signal at P31 is less than 0.5V. Note that the signal at S26 (to reduce the level below 0.5) now becomes all high. This is because the P31 signal is fed to the comparator-cum-inverter to give the signal at S26 as shown in fig. 2.3. The comparator references voltage is 0.55V and unless the signal amplitude is greater than 0.55V, the comparator output is high. Verify this.

Conclusion :

EXPERIMENT NO. 3

Aim: To measure the numerical aperture.

Equipments: OFT, Numerical aperture measurement unit.

Objective:

The objective of this experiment is to estimate the NA of 1mm diameter plastic fiber at 650nm.

Theory:

Numerical aperture (NA) of a fiber is measure of the acceptance angle of light in the fiber. Light which is launched at angle greater than this maximum acceptance angle does not get coupled to propagating mode in the fiber and therefore does not reach the receiver at other end of fiber. The numerical aperture is useful in computation of optical power coupled from an optical source to the fiber, from the fiber to a photo detector and between two fiber.

N.A= $n_0 \sin\theta a$

n_0=1 …….For air

N.A.= $\sin\theta a$

N.A.= $(n_1^{\,2} - n_2^{\,2})^{1/2}$

θa= Acceptance angle

n_0= refractive index of air

n1, n_2 = refractive index of core and cladding

Procedure:

1) Ensure that the cut planes of 1m plastic fiber are perpendicular to axis of fiber.

2) Insert one end of fiber into numerical aperture measurement unit as shown in figure. Adjust the fiber such that its tip is 10mm from the screen.

3) Gently tighten the screw to hold the fiber firmly in place.

4) Connect the one end of the fiber LED2 through the simplex connector. The fiber will project the circular patch of red light onto the screen. Let‘d’ be the distance between the fiber tip and the screen. Now measure the diameter of circular patch of

red light two perpendicular directions (BC and DE). The mean radius of patch is x=(BC+DE)/4.

5) Carefully measure the distance ‘d’ between tip of fiber and illuminated screen. The numerical aperture of fiber is given by,

$$N.A. = \sin\theta = x / (d^2 + x^2)^{1/2}$$

6) Repeat step two and five for different values of ‘d’. Compute the average value of numerical aperture.

Observation Table:

Sr. No.	**Height (d)**	**Diameter(mm)**			**NA**	**Angle (θ_a)**
		Horizontal(DE)	**Vertical(BC)**	**Mean(X=(BC+DE)/4)**		
1						
2						
3						
4						

Result: 1) Mean Acceptance angle :

2) Numerical Aperture :

= $\sin\theta a$

Conclusion:

EXPERIMENT NO. 4

Aim: Verification of helical wave pattern using MATLAB.

Software: MATLAB

Theory:

A ray which is transmitted without passing though a fiber axis. These rays, which greatly outnumber the meridional rays, follow a helical path though the fiber and are called as skew rays. The helical path traced through a fiber gives a change in direction of 2γ at each reflection, where γ is angle between the projection of the ray is two dimensions and the radius of the fibre core at the point of reflection. The point of emergence of skew rays from the fiber in air will depend upon number of reflections they undergo rather than the input conditions to the fiber. When the light input to the fiber a nonuniform, skew rays will therefore tend to have a smoothing effect on the distribution of the light as it is transmitted, giving a more uniform output.

The light wave is travelling through the optical fibre, which is travel through core without passing core axis is known as helical wave. This wave is also known as skew rays.

Source Code:

```
clc;
clear all;
close all;
t=0:pi/50:10*pi;
plot 3(sin(t),cos(t),t);
grid on;
axis square;
```

Output:

Conclusion :

EXPERIMENT NO.5

Aim: Verification of eye pattern using MATLAB

Software: MATLAB

Theory:

It is an oscilloscope display in which digital in which data signal from a receiver is repeatedly sampled and applied to the vertical input which the data rate is used to trigger horizontal sweep. For the creation of an eye pattern diagram the received signal output is sampled and super imposed on each other to get a long sting on random bits which looks like a human eye so termed as eye pattern. It shows thousands of bit display simultaneously. From an eye pattern, we can analyse quantity of signals in perfect system. We will get only series of signal line. An eye pattern shows noise filter and other effects.

Here the noise corresponds to intersymbol interference (ISI) which is observed due to the different paths at the waves reaching receiver from transmitter due to different paths there will be time mismatch of some signal reaching receiver causing aliasing or interference and act as a noise. The bit of eye pattern opening defines time interval over which received signal wave can be sampled without error. From intersymbol interference and it is apparent the preferred time. For sampling is the instant time at which the eye is open widest.

The sensitivity of system two timing error is determined by the rate of closer of the eye as a sampling time varied. The height of eye opening at a specified time varied the highest of an eye opening at a specified time defines a margin is the amount of noise required to cause the receiver to get an errors. It is given by distance between signal and zero amplitude point at the sampling rate.

Sr. No.	Eye Diagram	What is measured
1	Eye opening	Additive noise in the signal.
2	Eye width	Time synchronization and filter effects.
3	Eye overshoot/Undershoot	Peak distortion due to the itteruption in the signal path.

Source Code:

```
clc;
clear all;
close all;
Fs=10000;
Rs=100;
nSamps=Fs/Rs;
SNR=30;
trise=1/(5*Rs);
tfall=1/(5*Rs);
FrameLen=5000;
hSrc=commsrc.pattern('RiseTime', trise,'FallTime',tfall);
msgSymbols=generate(hSrc,FrameLen);
msgRx=awgn(msgSymbols,SNR,'Measured');
eyeObj=commscope.eyediagram('MinimumAmplitude',-
1.5,'MaximumAmplitude',1.5,'MeasurementDelay',0.006,'Colorscale','Log');
update(eyeObj,msgRx);
t=0:1/Fs:15/Rs-1/Fs;
idx=round(t*Fs+1);
hFig=figure('Position',[20 30 460 360]);
plot(t,msgRx(idx));
title('noisy NRZ signal');
xlabel('time(sec)');
ylabel('amplitude');
grid on;
```

Output:

Conclusion:

EXPERIMENT NO. :6

Aim: To study OTDR measurement.

Equipment: OTDR -JDSU(MTS 6000), optical fiber, etc.

Theory-

A measurement technique which is far movw sophisticated and which finds wide application in both lab and field is the use of optical time domain reflectometry (OTDR). This technique is often called back scatter measurement technique. It provides measurement on an optical link down its entire length giving information on the length dependence of the link loss. When the attenuation in the link varies with the length the average loss information is inadequate. OTDR also allows splice and connector losses to be evaluated as well as the rotation of any faults on the link. It relies upon the measurement and analysis of refraction of light which is reflected back in fibre NA due to Rayleigh scattering. Hence, back scattering method has advantage of being nondestructive and requiring access to one end of optical link only.

The backscattered optical power as a function of time Pra(t) is given by-

.5(Pi.S.VR.Wo.Vg).exp(-yVgt)

Where,

Pi=optical power launched in fibre

Vr=Rayleigh scattering coefficient

Wo=i/p optical pulse width

Vg=group velocity in fibre

V=attenuation coefficient/length

$$S=\frac{NA^2}{4xi^2}$$

A block schematic of backscatter measurement method is as shown in figure. A light pulse is launched in fibre in forward direction from an injection laser using either directional coupler or s/m of external lenses with beam splitter. A backscattered light is detected using APD receiver which drives an integrator in order to improve the received signal to noise ratio by giving an arithmetic average over a number of measurement taken at one point within a fiber. This is necessary as received optical signal power from particular point along the fiber length is at very low level compared with a forward power at that point by same 45 to 65 db.

A positive backscatter plot is shown in figure which shows the initial pulse caused by reflection and backscatter from the input coupler followed by along the tail caused by distributed Rayleigh scattering from the input pulse as it travels down the link Also shown in the plot as a pulse corresponding to the discrete reflection from a fiber joint as well as discontinuity due to excessive loss at fiber imperfection corresponding to Fresnel reflection in current the output end face of fiber. Such a plot yields the attenuation per unit length for fiber by simply computing the slope of curve over length required also location and insertion losses. Finally overall length can be determined from time difference between reflection fro fiber input and output end faces.

Conclusion-

EXPERIMENT NO. 7

Aim: Introduction to Optisystem and Study of Optical transmitter

Requirement: Optisystem software

Theory:

Optical communication systems are increasing in complexity on an almost daily basis. The design and analysis of these systems, which normally include nonlinear devices and non-Gaussian noise sources, are highly complex and extremely time-intensive. As a result, these tasks can now only be performed efficiently and effectively with the help of advanced new software tools. OptiSystem is an innovative optical communication system simulation package that designs, tests, and optimizes virtually any type of optical link in the physical layer of abroad spectrum of optical networks, from analog video broadcasting systems to intercontinental backbones. OptiSystem is a stand-alone product that does not rely on other simulation frameworks. It is a system level simulator based on the realistic modeling of fiber-optic communication systems. It possesses a powerful new simulation environment and a truly hierarchical definition of components and systems. Its capabilities can be extended easily with the addition of user components, and can be seamlessly interfaced to a wide range of tools.

Benefits

• Rapid, low-cost prototyping
• Global insight into system performance
• Straightforward access to extensive sets of system characterization data
• Automatic parameter scanning and optimization
• Assessment of parameter sensitivities aiding design tolerance specifications
• Dramatic reduction of investment risk and time-to-market
• Visual representation of design options and scenarios to present to prospective customers

Applications

• Optical communication system design from component to system level at thephysical layer

• CATV or TDM/WDM network design

• SONET/SDH ring design

• Transmitter, channel, amplifier, and receiver design

• Dispersion map design

• Estimation of BER and system penalties with different receiver models

• Amplified system BER and link budget calculations

Optical Transmitters (Optical System)

The role of the optical transmitter is to:

- convert the electrical signal into optical form, and
- launch the resulting optical signal into the optical fiber.

The most commonly used optical transmitters are semiconductor devices such as light-emitting diodes (LEDs) and laser diodes. The difference between LEDs and laser diodes is that LEDs produce incoherent light, while laser diodes produce coherent light. For use in optical communications, semiconductor optical transmitters must be designed to be compact, efficient, and reliable, while operating in an optimal wavelength range, and directly modulated at high frequencies

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In its simplest form, a LED is a forward-biased p-n junction, emitting light through spontaneous emission, a phenomenon referred to as electroluminescence. The emitted light is incoherent with a relatively wide spectral width of 30-60 nm. LED light transmission is also inefficient, with only about 1% of input power, or about 100 microwatts, eventually converted into launched power which has been coupled into the optical fiber. However, due to their relatively simple design, LEDs are very useful for low-cost applications.

Communications LEDs are most commonly made from Indium gallium arsenide phosphide (InGaAsP) or gallium arsenide (GaAs). Because InGaAsP LEDs operate at a longer wavelength than GaAs LEDs (1.3 micrometers vs. 0.81-0.87 micrometers), their output spectrum, while equivalent in energy is wider in wavelength terms by a factor of about 1.7. The large spectrum width of LEDs is subject to higher fiber dispersion, considerably limiting their bit rate-distance product (a common measure of usefulness). LEDs are suitable primarily for local-area-network applications with bit rates of 10-100 Mbit/s and transmission distances of a few kilometers. LEDs have also been developed that use several quantum wells to emit light at different wavelengths over a broad spectrum, and are currently in use for local-area WDM (Wavelength-Division Multiplexing) networks.

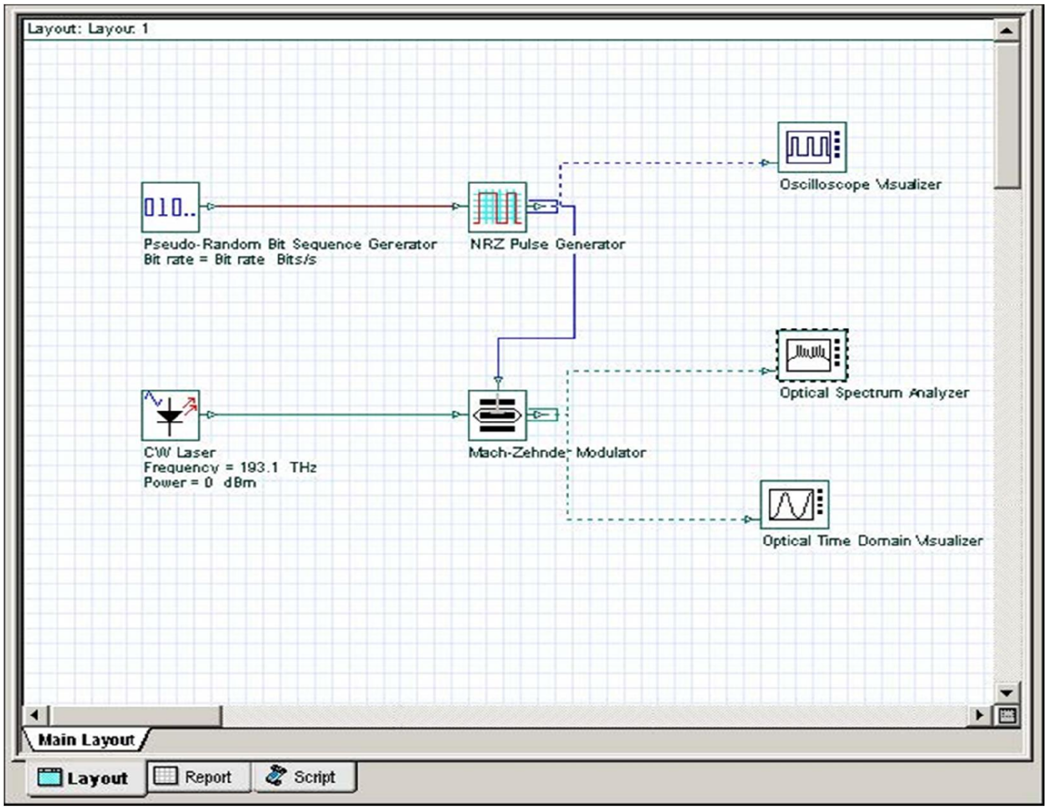
Today, LEDs have been largely superseded by VCSEL (Vertical Cavity Surface Emitting Laser) devices, which offer improved speed, power and spectral properties, at a similar cost. Common VCSEL devices couple well to multi mode fiber.

A semiconductor laser emits light through stimulated emission rather than spontaneous emission, which results in high output power (~100 mW) as well as other benefits related to the nature of coherent light. The output of a laser is relatively directional, allowing high coupling efficiency (~50 %) into single-mode fiber. The narrow spectral width also allows for high bit rates since it reduces the effect of chromatic dispersion. Furthermore, semiconductor lasers can be modulated directly at high frequencies because of short recombination time.

Commonly used classes of semiconductor laser transmitters used in fiber optics include VCSEL (Vertical-Cavity Surface-Emitting Laser), Fabry–Pérot and DFB (Distributed Feed Back).

Laser diodes are often directly modulated, that is the light output is controlled by a current applied directly to the device. For very high data rates or very long distance links, a laser source may be operated continuous wave, and the light modulated by an external device such as an electro-absorption modulator or Mach–Zehnder interferometer. External modulation increases the achievable link distance by eliminating laser chirp, which broadens the linewidth of directly modulated lasers, increasing the chromatic dispersion in the fiber.

Circuit diagram of transmitter



Conclusion:

EXPERIMENT NO : 8

Aim:- Study of EDFA using Optisystem

Requirement: Optisystem software

Theory:-

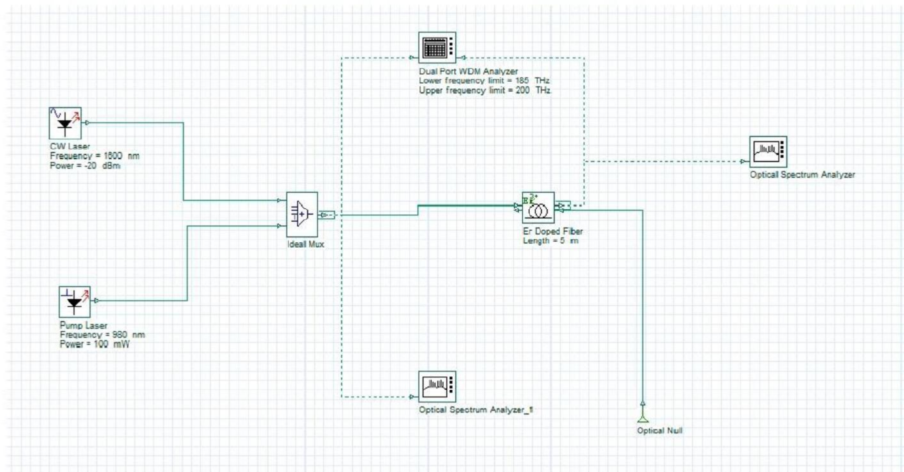
Undoubtedly, as one of the most key devices in the high speed optical communication system, the performance of optical amplifier is significant with respect of cost, energy consumption, the quality of signals, etc. The study on optical amplifier is always an open issue and concerned by many researches. At present, the erbium doped fiber amplifier (EDFA) is still one of the most widely-used optical amplifiers. But, considering its only 20 nm flat gain bandwidth, and the tremendous increase of data services in the optical transmission networks, EDFA system maybe not meet the future application of optical networks. Therefore, the study on optical amplifiers with high gain power and wide gain bandwidth has been paid much attention by many researchers. Among these studies, due to a wide gain bandwidth about100 nm, optical fiber Raman amplifiers, in short OFRA, has been regarded as one of the main potential amplifier devices, although its gain power is not high comparatively. Hence, that combines the advantages of the EDFA and OFRA to amplify light signals in *C* band and *L* band has become one of the hot topics in the field of optical communication and measurement Note that, because of the complex working principle, the output performance of both EDFA and OFRA systems are hardly affected by some designing parameters, e.g. pumping wavelength, pumping power, and doped fiber length. To optimize the output performance, many researchers have devoted to analyze the output characteristics of EDFA, OFRA, or the combined systems by the numerical calculation based on the rate equations, but, with strongly complicated and limited analyzing processes . On the other hand, taking the high cost of the optical devices and analyzer into account, it is a hard work to conduct the spectrum analysis of OFRA system though adopting the traditional experiments. In order to overcome such problems, the simulation ways have been used in the performance analysis of the optical devices by some researches, which are with the advantages of low complexity, fast speed, flexible configuration and vision. uses the

Optisystem software to analyze light transmission system simulates the features of the 1550nm fiber laser through FEM. And in our previous work, the output performance including the super fluorescent source, laser diode, and fiber laser (with the centre wavelength at 1550nm) by simulation are achieved to analyze and optimize Using the Optisystem software, we develop the analysis based simulation on EDFA system, re And according to the output spectrum and gain natures, our work will focus on discussing the parameters effects, and take the optimization of the output performance of system.

SIMULATION AND ANALYSIS ON THE EDFA SYSTEM

In Fig. 1, the typical EDFA system with forward pumping is demonstrated, consisting of five parts , i.e. the Continuous Wavelength (CW) laser array, the pumping source, WDM device, Erbium Doped Fiber (EDF) and Optical Spectrum Analyzers (OSA). In particular, the CW laser array is used to model the three optical signals from 1540-1560 nm, with the same interval (10 nm) and power (-20 dBm). And a semiconductor laser with the centre wavelength of 980 nm is chosen as the pumping source, whose output power is 100 mW. Here, assuming the WDM device is ideal and without any extra loss and two OSA devices are applied into the model to monitoring the output of optical signals and Amplified Spontaneous Emission (ASE) noise. Furthermore, for the EDF, its designed parameters are the length is 5 m, the NA value is 0.24 and erbium ion density is 1x1025 m-3, respectively. According to Ref Giles and Desurvire, 1991; Chang *et al*., 2008, not only the pumping power, but the length and density of EDF have the obvious effects to the output features of the EDFA system. But, considering the constant erbium ion density in Optisystem, the work is then concentrated on modelling the EDFA system with various lengths of EDF and pumping power.

Circuit Diagram of EDFA System



Outputs:

1. **Gain Vs Frequency**
2. **Gain Vs Power**
3. **Signal Power Vs Frequency**

Conclusion:

EXPERIMENT NO. -9

Aim: -Study of PSK system and it's utility in optical domain

Theory:-

PSK is Phase shift keying and is one of the digital information modulation technique. In this technique the phase of carrier signal is modulated with that of the information signal.

PSK used finite number of phase each assigns to unique pattern of binary digits usually each phase encodes on equal number of bits. Each symbol is represented by the particular phase demodulator which designed specifically for symbol set used by modulator, determine the of received signal and maps it back to the symbol. Thus receiving original data.

The PSK being the simple technique of modulation and has advantages over modulation. It is used in REIO standards which has been adopted for biometric passport's credit card etc. These are also appropriate for low cost passive transmitted. With the enhancement of PSK and m-array PSK. Utility of PSK in optical fiber.

An optical fiber is used as a transmission media trough which waves can be transferred with the continuous reflection at core cladding interface. If we apply AM technique for transmission of the particular signal through the fiber the modulated signal will have stream waves having different amplitude according to information signal so it not efficient technique to use with the fiber.

Also with help of FSK frequency shift keying we will get noise due compression & rarefaction in the modulated signal to with this we have an another efficient method for transmission of the information through optical fiber using PSK.

Source code :

```
clc;
closeall;
clearall;
t=0:pi/10:4*pi;
x=sin(t);
N=length(x);
subplot(2,2,1);
plot(x);
subplot(2,2,2);
stem(x);
for n=1:N
if x(n)==1;
z(n)=sin(t(n));
else
if x(n)==-1;
z(n)=sin(t(n));
else
z(n)=sin(t(n)+pi);
end;
end;
end;
subplot(2,2,3);
plot(z);
subplot(2,2,4);
stem(z);
```

Conclusion:

EXPERIMENT NO: 10

Aim: To study losses in optical fibre.

Theory :

Types of losses in optical fibre:

Material absorption losses :

Material absorption is a loss mechanism related to the material composition and the fabrication process for the fiber, which results in the dissipation of some of the transmitted optical power as heat in the waveguide. The absorption of the light may be intrinsic(caused by the interaction with one or more of the major components of the glass) or extrinsic (caused by impurities within the glass).

1) Intrinsic absorption:

An absolutely pure silicate glass has little intrinsic absorption due to its basic material structure in the near-infrared region. However, it does have two major intrinsic absorption mechanisms at optical wavelengths which leave a low intrinsic absorption window over the 0.8 to 1.7 μm wavelength range.

2) Extrinsic absorption:

Major extrinsic loss mechanism is caused by absorption due to water (as the hydroxyl or OH ion) dissolved in the glass. These hydroxyl groups are bonded into the glass structure and have fundamental stretching vibrations which occur at wavelengths between 2.7 and 4.2 μm depending on group position in the glass network. The fundamental vibrations give rise to overtones appearing almost harmonically at 1.38, 0.95 and0.72μm.

Linear scattering losses:

1) Rayleigh scattering :

Rayleigh scattering is the dominant intrinsic loss mechanism in the low-absorption window between the ultraviolet and infrared absorption tails. It results from in homogeneities of a random nature occurring on a small scale compared with the wavelength of the light. These inhomogeneities manifest themselves as refractive index fluctuations and arise from density and compositional variations which are frozen into the glass lattice on cooling. The compositional variations may be reduced by improved fabrication, but the index fluctuations caused by the freezing-in of density in homogeneities are fundamental and cannot be avoided.

2) Mie scattering:

The scattering created by in homogeneities is mainly in the forward direction and is called Mie scattering. Depending upon the fiber material, design and manufacture, Mie scattering can cause significant losses.

Nonlinear scattering losses:

The most important types of nonlinear scattering within optical fibers are stimulated Brillouin and Raman scattering, both of which are usually only observed at high optical power densities in long single-mode fibers.

1) Stimulated Brillouin Scattering:

Stimulated Brillouin scattering (SBS) may be regarded as the modulation of light through thermal molecular vibrations within the fiber. The scattered light appears as upper and lower sidebands which are separated from the incident light by the modulation frequency. The incident photon in this scattering process produces a phonon of acoustic frequency as well as a scattered photon.

2) Stimulated Raman Scattering:

Stimulated Raman scattering (SRS) is similar to SBS except that a high-frequency optical phonon rather than an acoustic phonon is generated in the scattering process. Also, SRS can occur in both the forward and backward directions in an optical fiber, and may have an optical power threshold of up to three orders of magnitude higher than the Brillouin threshold in a particular fiber.

Fibers bend loss:

Optical fibers suffer radiation losses at bends or curves on their paths. This is due to the energy in the evanescent field at the bend exceeding the velocity of light in the cladding and hence the guidance mechanism is inhibited, which causes light energy to be radiated from the fiber.

Conclusion: