A PROJECT REPORT ON

PHASE MODULATED COMMUNICATION SYSTEM

(IN PARTIAL FULFILMENT OF REQUIREMENT FOR THE DEGREE IN ECE)

ELECTRONICS AND COMMUNICATION ENGINEERING

UNDER THE GUIDANCE OF

Mr. ARINDUM MUKHERJEE (HoD (i/c))

DEPARMENT OF ECE

CIT, KOKRAJHAR

SUBMITTED BY:

GOKUL BORO (GAU-C-10/L-321)

SUDEM DAIMARY (GAU-C-10/222)

ADITYA SINGH (GAU-C-10/237)

HATHORKI BASUMATARY (GAU-C-09/138)

BIDU BHUSHAN BARMAN (GAU-C-10/L-324)

CENTRAL INSTITUTE OF TECHNOLOGY, KOKRAJHAR

KOKRAJHAR, ASSAM

ACKNOWLEDGEMENT

We owe our full gratitude to our Guide as well as our HoD in-charge Mr. Arindum Mukherjee towards the successive analysis of our project .

We also thankfull for his guidance and giving us the opportunity in gathering knowledge so far regarding the project and thereby hope to do better performance in the future work as per the project is concerned.

YOURS SINCERELY,

GOKUL BORO(GAU-C-10/L-321)

SUDEM DAIMARY(GAU-C-10/222)

ADITYA SINGH(GAU-C-10/237)

HATHORKI BASUMATARY(GAU-C-09/138)

BIDU BHUSHAN BARMAN(GAU-C-10/L-324)

CONTENTS: **PAGE NO.**

1.ABSTRACT

A communication system transmits information from one place to another, whether seperated by a few Kms. or by transoceanic distances. Information is often carried by an EM carrier waves whose frequency can vary from a few Mhz. to several hundred of Thz. Optical communication system use higher carrier frequency (~100Thz) in the visible or near infrared region of the EM spectrum. They are sometimes called Lightwave systems to distinguish them from microwave systems, whose carrier frequency is typically smaller by five orders of magnitude(~1Ghz).But when the information is to be conveyed over any distance , the information transfer is frequently achieved by superimposing or modulating the information on to an EM wave which acts as a carrier for the information signal. This modulated carrier is then transmitted to the required destination where it is achieved and the original information signal is obtained by demodulation. Sophisticated techniques have been developed for this purpose using EM carrier waves operating at radio frequencies as well as microwave and millimetre wave frequencies. However, communication may also be achieved using an EM carrier which is selected from the optical range of frequencies.

2. INTRODUCTION

All commercially available optical communication system use ON-OFF keying to carry information by the presence or absence of light. Neither the Phase nor Frequency of an optical signal is used to carry information. Phase modulated optical communication have been studied for a long time since the early date of optical communication. However, early works focussed on improving receiver's sensitivity that have become less relevant after the widely deployment of optical amplifier. But, because the usage of optical amplifiers to maintain a high optical power along the fiber link, current optical communication system fundamentally limited by balancing of both optical amplifier noises and fiber non-linearities.

In our study, a method of Phase Modulation technique is used in modern optical communication system since it demands higher and higher bandwidth and bit rates. The state of the art communication system already uses bit-rates of upto 40 Gbit/sec per channel.

3. WORKING PRINCIPLE

The process of Phase modulation consists of varying the phase of the carrier (LASER) linearly in proportion to the modulating signal(RF) such that maximum phase shift occurs during positive and negative peaks of the modulating signal(RF). We have applied the MACH-ZENDER MODULATOR (MZM) for modulation purpose. DIRECT and COHERENT DETECTION for demodulation purpose since it can be implemented using HETERODYNE or HOMODYNE downconversion by local oscillator (LASER) and balanced optical receivers.

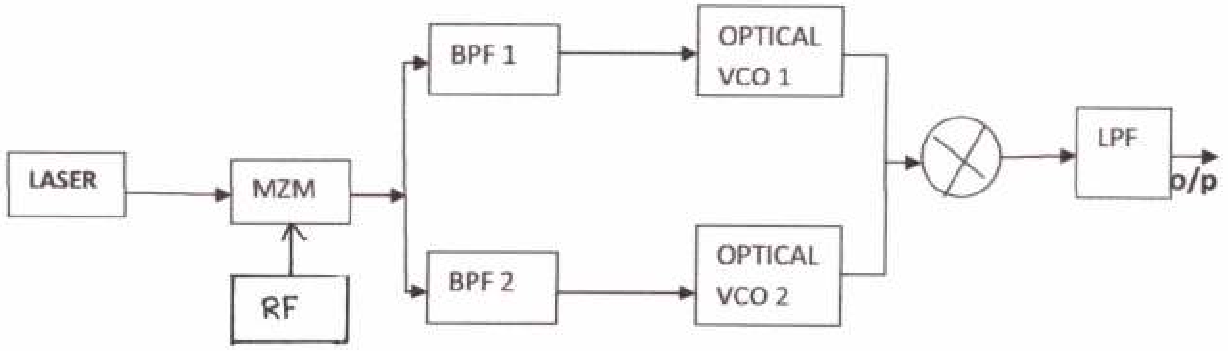


FIG: OPTICAL HETERODYNING

4. MODULATION TECHNIQUE

(i)MACH-ZEHNDER MODULATOR:

Since, the direct modulation of a laser is a cheap and also easy to adapt to low cost applications foe modulated distances or transmission rates; however, for advanced applications involving high data rates or long distance links, resorting to external modulation is a good solution. That's why, the most typical external modulator is the Mach-Zehnder modulator (MZM) which modulates the light generated in a laser operating in continuous wave mode. The MZM has typically an RF input and another input for a DC bias. The material for the MZM has electro-optical properties by which the phase of the optical wave propagating inside it receives a phase modulation proportional to the applied electric field.

(ii)REALISATION OF TRANSFER FUNCTION OF MZM USING MATLAB 2009:

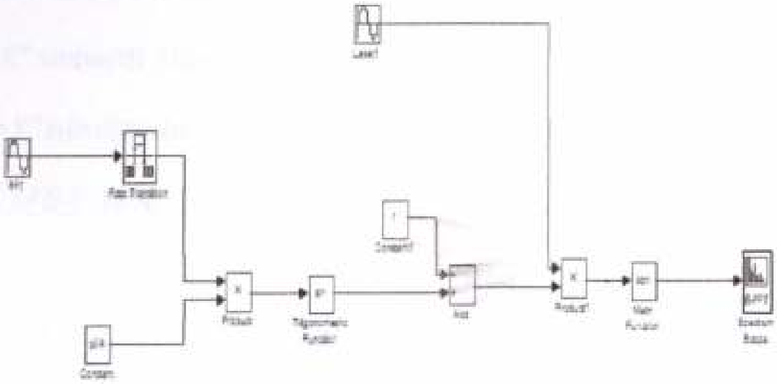


Fig:Mach-Zehnder Modulator(MZM)

The transfer function for MZM is given by:

$$T=K[1+\sin\{(\pi V_{RF})/V_{\pi}\}]=I_0/I_{in} \text{ ---------------(1)}$$

where, K=constant, V_{π}= phase shift when the voltage V_{RF} is applied.

Now, assuming,

I_{in}= A sin(ω_Lt)

V_{RF}= B sin(ω_mt)

V_π=π

Where, ω_L and ω_m are the laser frequency and RF frequency respectively.

I_0=K 'sin(ω_Lt) [1+sin(B sin(ω_mt))] ---(2)

We have, Jacobi-Augen series as-------

Sin (m sin ω_mt) = $2\sum_{n=0}^{\infty} J(2n+1)(m)\sin\,(2n+1)\omega t$

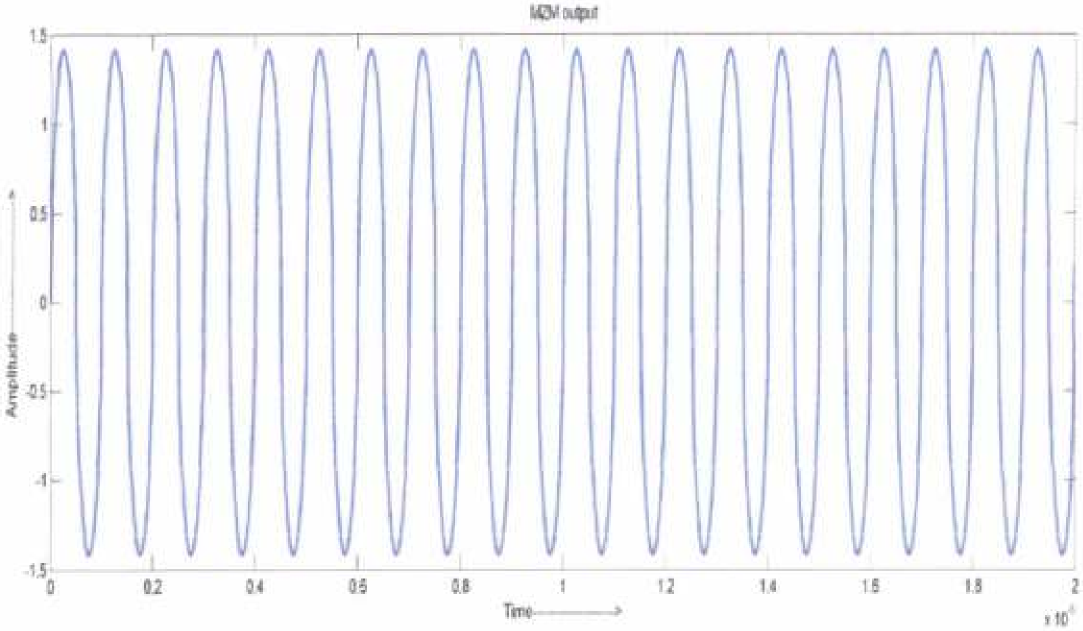
$= 2J_1(m)\sin\omega t + 2J_3(m)\sin 3\omega t + 2J_5(m)\sin 5\omega t + \ldots\ldots\ldots$-----------------(3)

Comparing equation (2) with equation(3), we get:

$I_0 \cong K'\sin(\omega_L t) + K''\sin(\omega_L t)\{2J_1(m)\sin\omega_m t + 2J_3(m)\sin 3\omega_m t\}$

$I_0 \cong K'\sin(\omega_L t) + K''J_1(m)[\cos(\omega_L-\omega_m)t - \cos(\omega_L+\omega_m)t] + K''J_3(m)[\cos(\omega_L-3\omega_m)t - \cos(\omega_L+3\omega_m)t]$

(iii)OUTPUT OF MZM USING MATLAB 2009:



5.SPECIFICATIONS OF MZM REALISATION:

RF1 PARAMETERS:

(1) AMPLITUDE→ 2

(2) FREQUENCY(rad/sec)→$2*\pi*50e^4$

(3) SAMPLE TIME→ $1/100\ e^4$

LASER1 PARAMETERS:

(1) AMPLITUDE→ 2

(2) FREQUENCY(rad/sec)→$2*\pi*0.5e^6$

(3) SAMPLE TIME→ $1/100\ e^6$

SPECTRUM SPECIFICATIONS:

(1) BUFFER SIZE→ 1024

(2) BUFFER OVERLAP→ 64

(3) WINDOW TYPE→ HAMMING

(4) WINDOW SAMPLING→ PERIODIC

(5) FFT LENGTH→ 2048

(6) NUMBER OF SPECTRAL AVERAGE→ 10

RATE TRANSITION PARAMETERS:

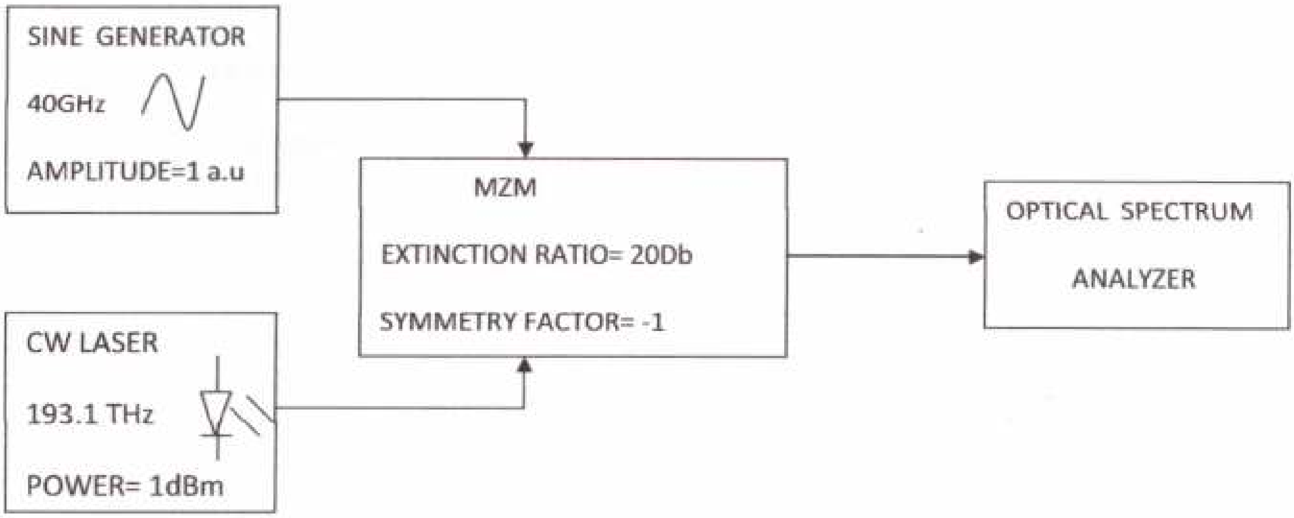
OUTPUT PORT SAMPLE TIME→ -1

AXIS PROPERTY:

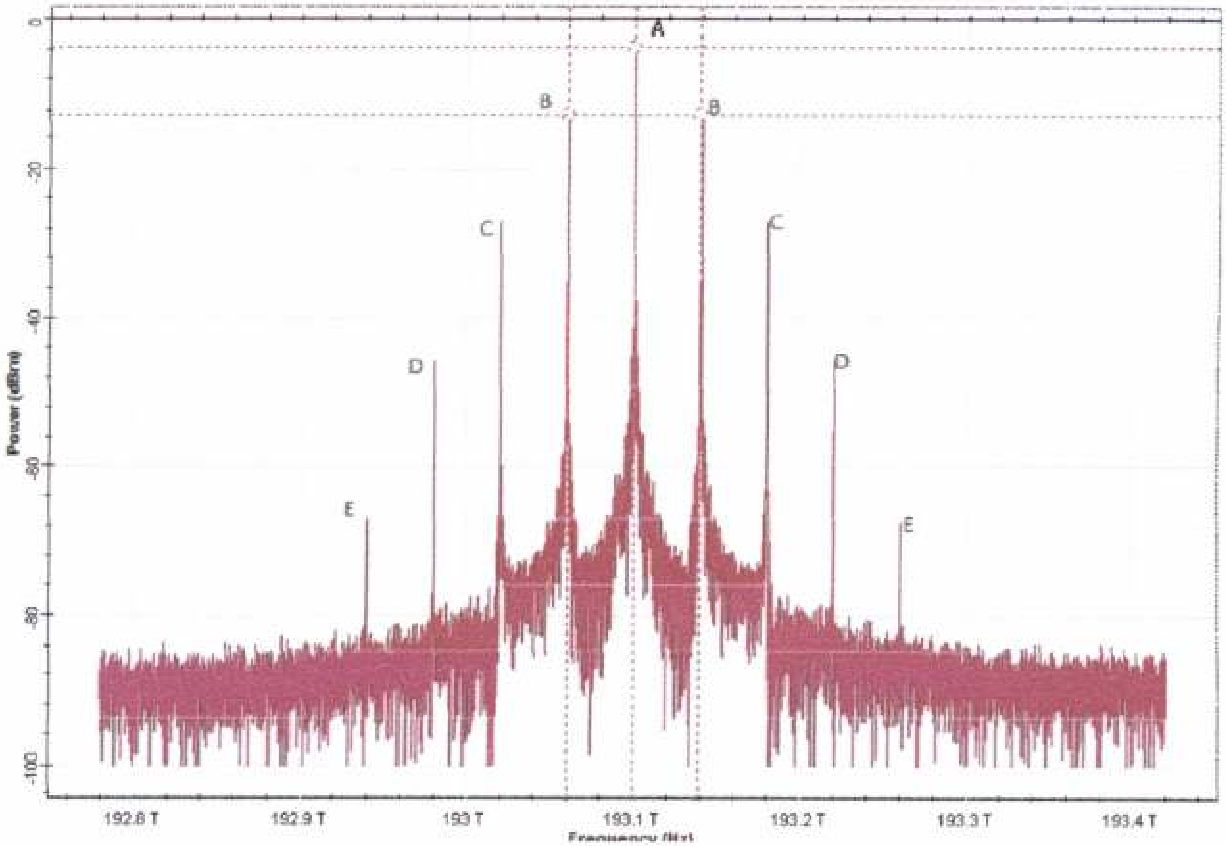
(1) FREQUENCY RANGE→ $+F_S/2$, $-F_S/2$

(2) Y-AXIS SCALING→ MAGN-SQUARD

6.REALISATION OF MZM USING OPTISYSTEM 11:



(i)OUTPUT OF OPTICAL ANALYZER USING OPTISYSTEM 11:



OBSERVATIONS:

ALONG X-AXIS→ FREQUENCY IN THz; ALONG Y-AXIS→ POWER IN dBm.

CARRIER FREQUENCY (THz): A→193.1

CARRIER AMPLITUDE (dBm): A→ -3.46912

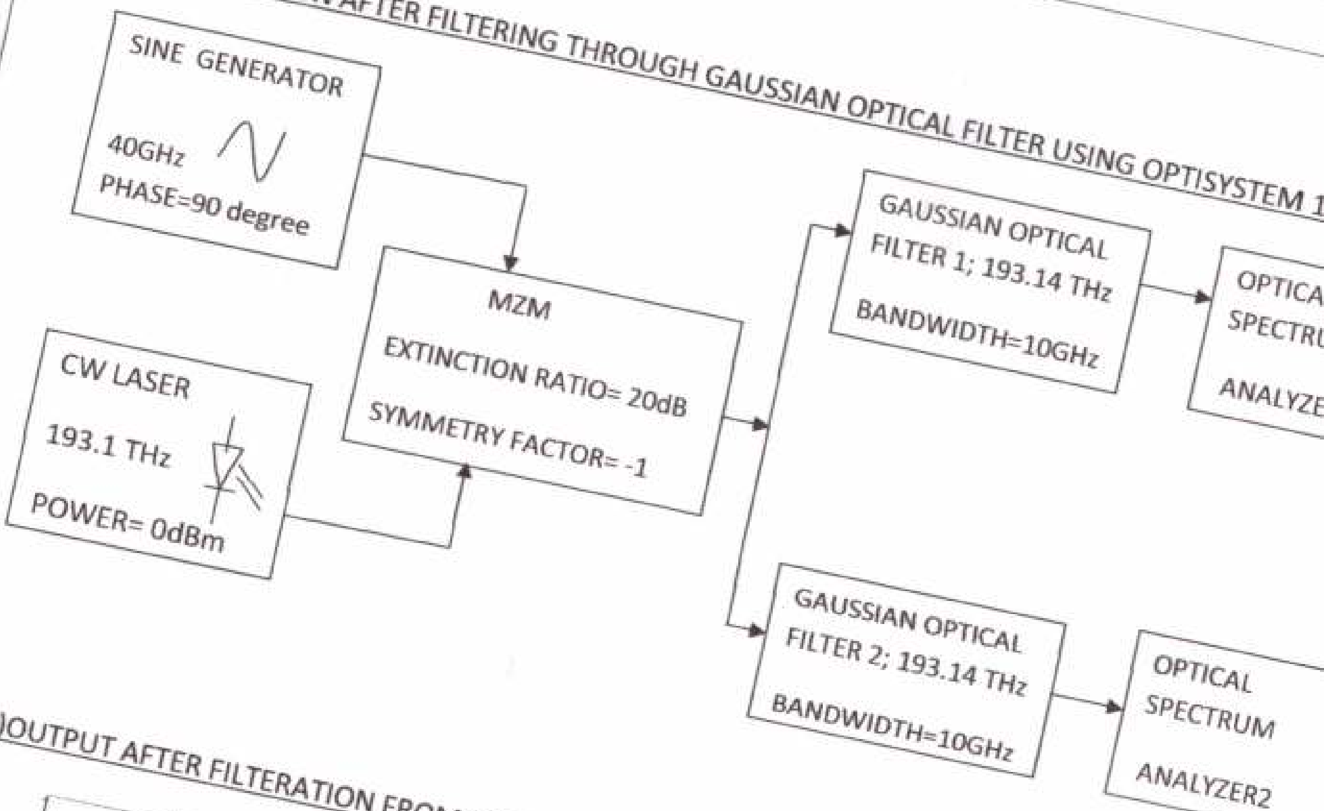
POSITIVE SIDE:

FREQUENCY(THz)	AMPLITUDE(dBm)	FREQUENCY SEPERATION(GHz)
B→193.14	*-12.2219*	*B-A →40*
C→193.18	*-27.4885*	*C-A →40*
D→193.22	*-46.0119*	*D-A →40*
E→193.26	*-67.5886*	*E-A →40*

NEGATIVE SIDE:

FREQUENCY(THz)	AMPLITUDE(dBm)	FREQUENCY SEPERATION(GHz)
B→193.06	*-12.2219*	*A-B →40*
C→193.02	*-27.4885*	*A-C →40*
D→192.98	*-46.0119*	*A-D →40*
E→192.94	*-67.5886*	*A-E →40*

(ii)REALISATION AFTER FILTERING THROUGH GAUSSIAN OPTICAL FILTER USING OPTISYSTEM 1



(iii)OUTPUT AFTER FILTERATION FROM OPTICAL ANALYZER IN OPTISYSTEM 11:

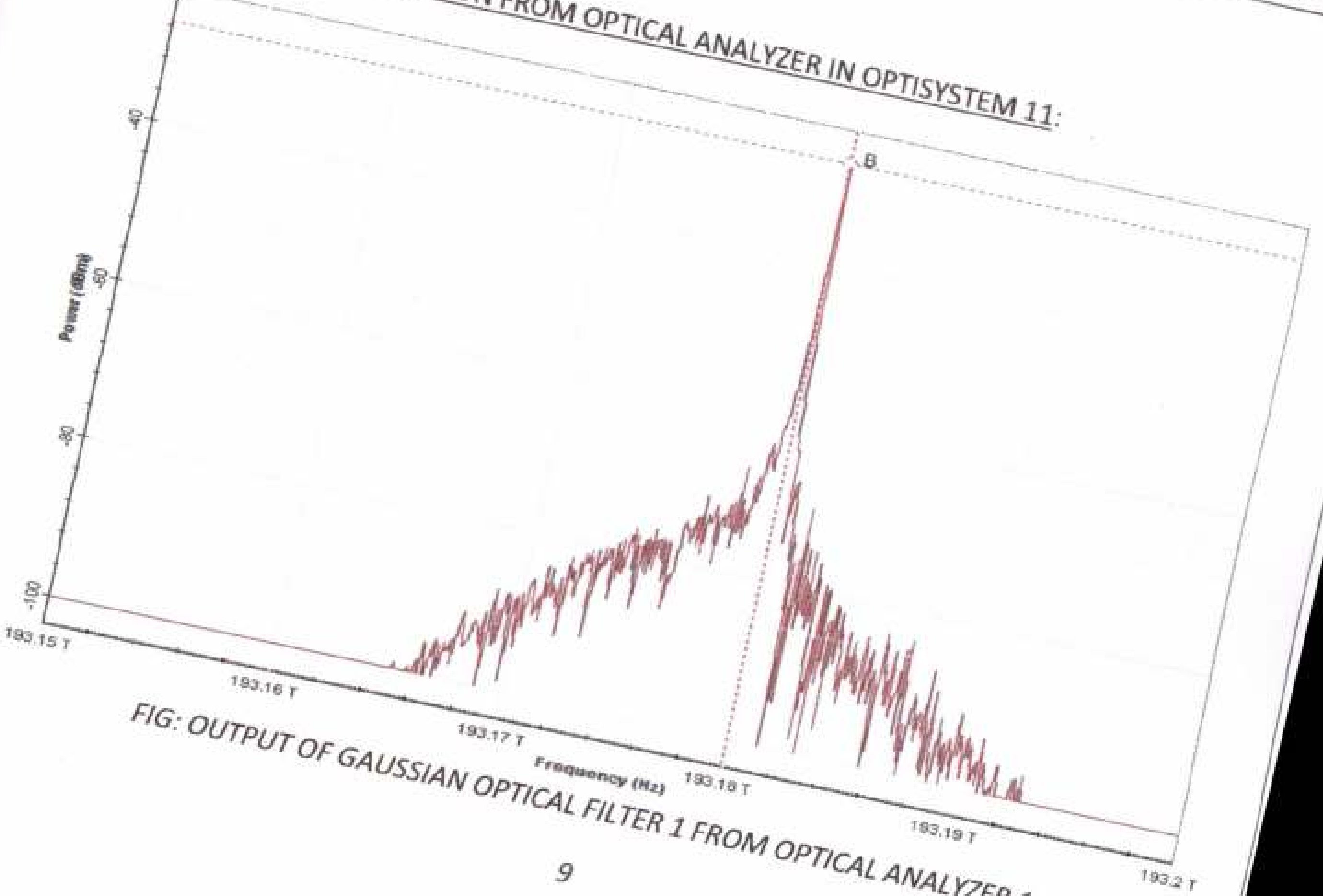
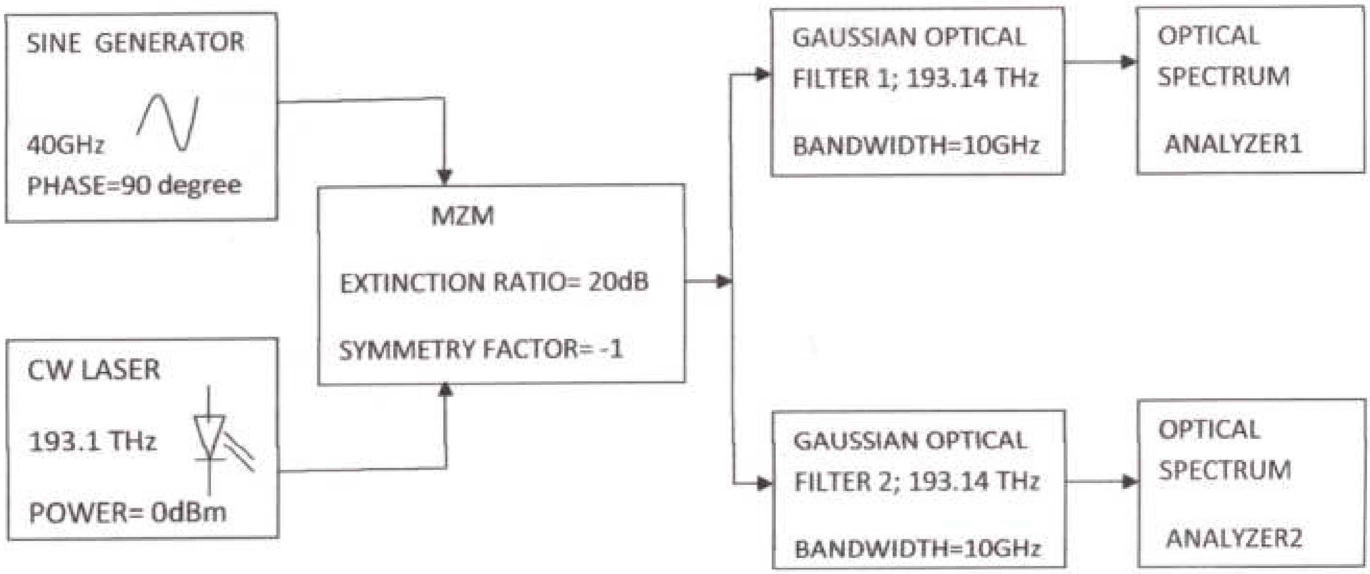


FIG: OUTPUT OF GAUSSIAN OPTICAL FILTER 1 FROM OPTICAL ANALYZER 1 (ii)REALISATION AFTER FILTERING THROUGH GAUSSIAN OPTICAL FILTER USING OPTISYSTEM 11:



(iii)OUTPUT AFTER FILTERATION FROM OPTICAL ANALYZER IN OPTISYSTEM 11:

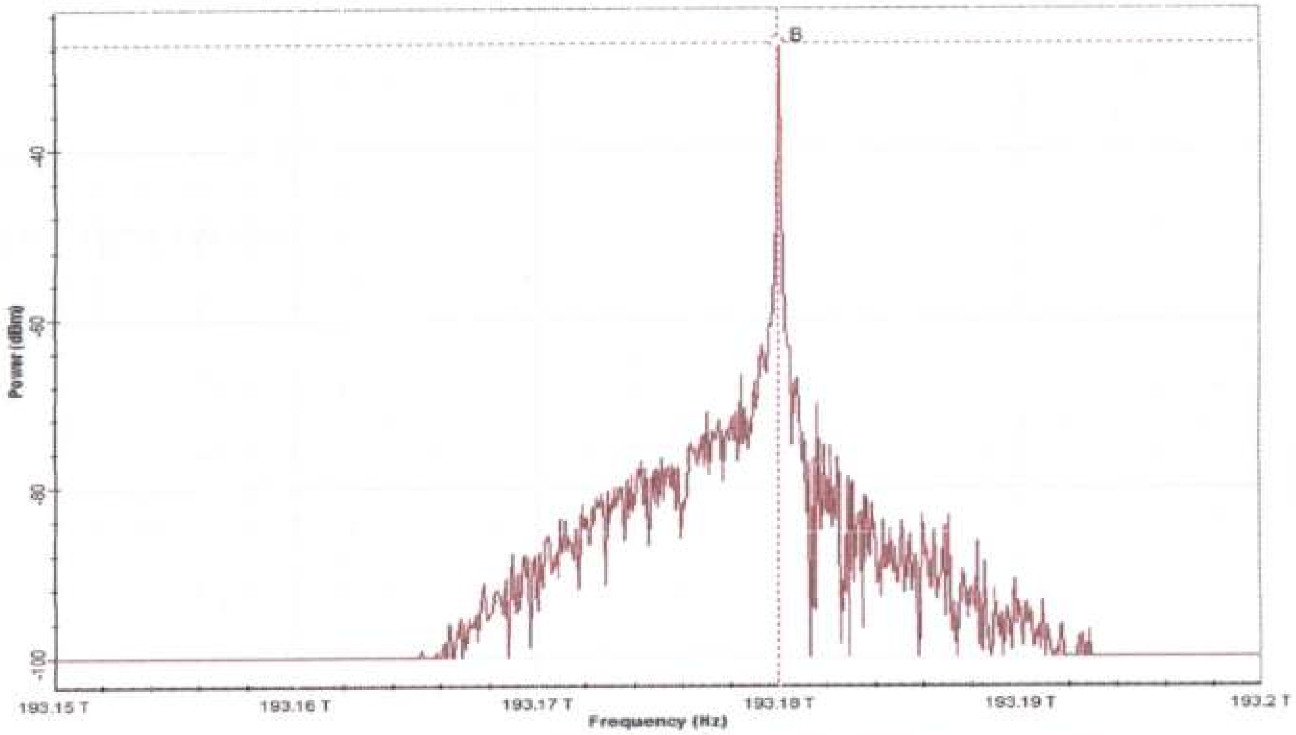


FIG: OUTPUT OF GAUSSIAN OPTICAL FILTER 1 FROM OPTICAL ANALYZER 1

(iv)OUTPUT AFTER FILTRATION FROM OPTICAL ANALYZER IN OPTISYSTEM 11:

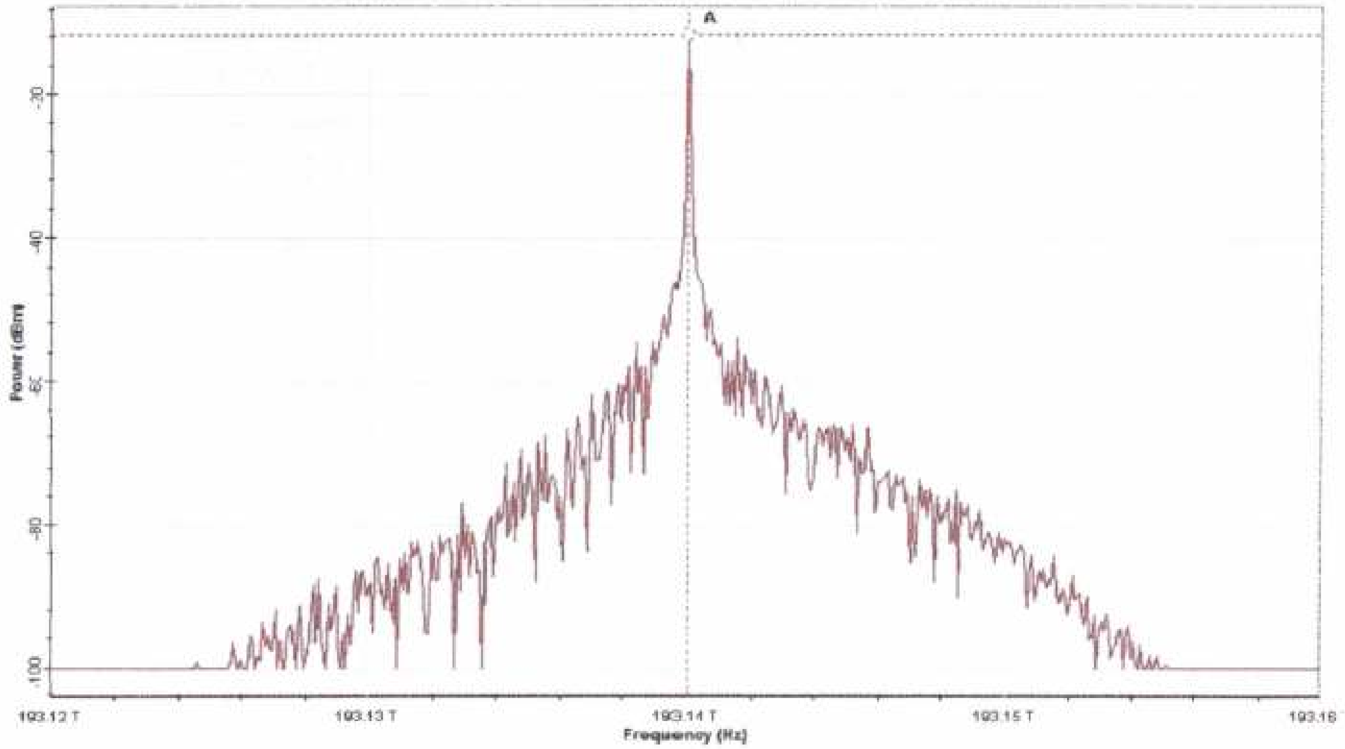


FIG: OUTPUT OF GAUSSIAN FILTER 2 FROM OPTICAL ANALYZER2

GRAPH:

FOR THE ABOVE TWO GRAPHS:

ALONG X-AXIS→ FREQUENCY IN THz

ALONG Y-AXIS→ POWER IN dBm

A→(CARRIER FREQUENCY) 193.14 THz; -12.306(dBm)→ AMPLITUDE

B→(SIDE BAND) 193.18 THz ; -27.4647(dBm)→ AMPLITUDE

FREQUENCY SEPERATION (GHz): B-A→40

7.DETECTION TECHNIQUES:

(1)DIRECT DETECTION:

The direct detection optical communication system essentially consists of a photodetector plus an amplifier with possibly additional signal processing circuits. Therefore , the receiver initially converts the optical signal, which is then amplified before further processing to extract the information carried by the optical signal.

(i)REALISATION OF DIRECT DETECTION USING MATLAB 2009:

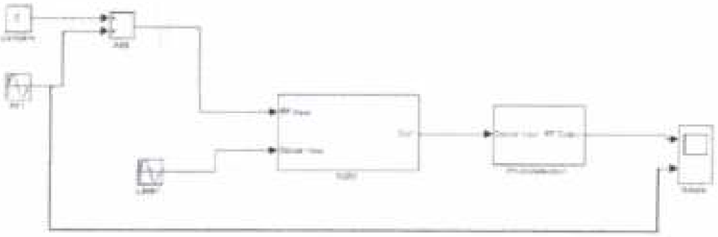


Fig: Direct Detection

Since, output of MZM=$\sqrt{1+f(t)}\cos(\omega 0t)$

Therefore, after squaring (i.e, photodetection) = $[\sqrt{1+f(t)}]^2\cos^2(\omega 0t)$

$$= [\tfrac{1+f(t)}{2}][1+\cos(2\omega 0t)]$$

Therefore, after low pass filtering, yield the baseband RF= K $[1+f(t)]$

Direct detection can only retrieve signals modulating the intensity of light.

(ii)OUTPUT AFTER DIRECT DETECTION USING MATLAB 2009:

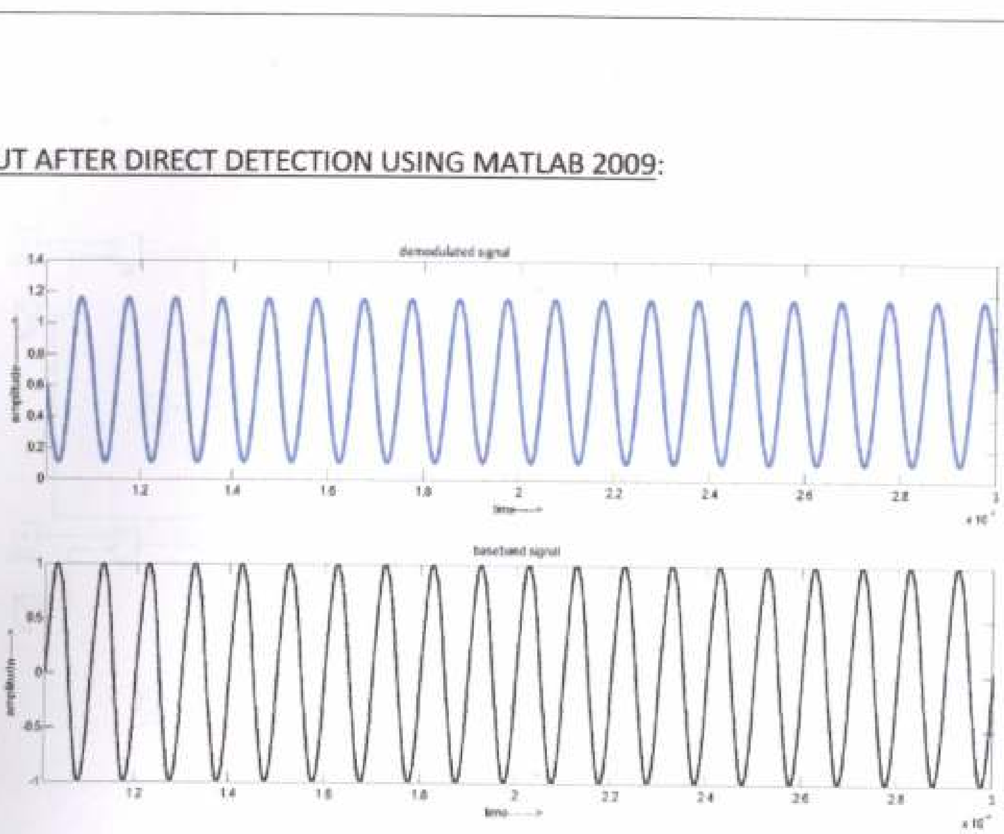


Fig: Demodulated signal after Direct Detection

RESULTS:

For one complete cycle:

Time= (3.7 – 3.6) $*10^{-4}$ sec

= $0.1*10^{-4}$ sec

F= 1/T= 100 KHz; PHASE DIFFERENCE= 180deg.

(2)COHERENT DETECTION:

Unlike Direct detection, in which the optical signal is converted directly into a demodulated electrical output, Coherent optical receivers first add incoming signal from a locally generated optical wave prior to detecting the sum. The photo current is a replica of the original signal which is translated down in frequency from the optical domain (around 10^5GHz) to the radio domain (upto several GHz) and where conventional electronic techniques can be used for further signal processing and demodulation. It is noted that coherent detection provides the greatest benefit for high speed systems operating at longer wavelengths. A potential improvement in receiver sensitivity using Coherent detection of upto 20dB can be obtained.

(iii)REALISATION OF COHERENT DETECTION USING MATLAB 2009:

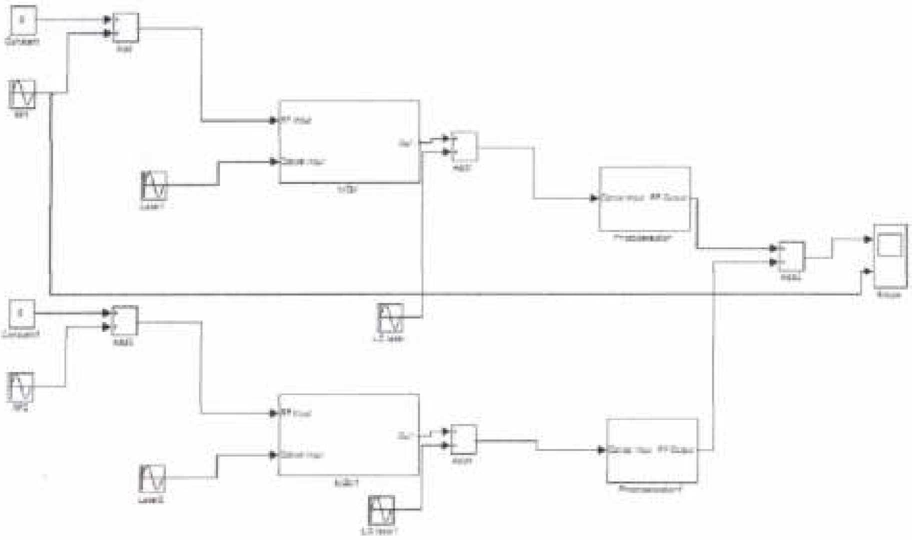


Fig: Coherent Detection

Output after 3db coupler= $\sqrt{(P1)[1+f(t)]}\cos(\omega_0 t)+\sqrt{(P2)}\cos(\omega_0 t)$

$PD_1= [E_1\sqrt{1+f(t)}\cos(\omega_0 t)+E_2\cos(\omega_0 t)]^2$

$= E_1^2[1+f(t)]\cos^2(\omega_0 t)+E_2^2\cos^2(\omega_0 t)+2E_1E_2\sqrt{1+f(t)}\cos(\omega_0 t)$

$PD_2= [E_1\sqrt{1+f(t)}\cos(\omega_0 t)-E_2\cos(\omega_0 t)]^2$

$= E_1^2/2\ [1+f(t)]+E_2^2/2-E_1E_2\sqrt{1+f(t)}$

$PD_1+PD_2=(E_1^2+E_2^2)+E_1^2 f(t)$

$=[1+f(t)]E_1^2+E_2^2$

$IF_{amp}=2\sqrt{P1P2f(t)}=4\,P1P2f(t)$

Therefore, output of $IF_{amp}\cong K\sqrt{1+(m1+m2)\cos(\omega 0t)}$; which is the Intensity Modulation.

Coherent detection can retrieve optical signals modulating the amplitude.

(iii)OUTPUT AFTER COHERENT DETECTION USING MATLAB 2009:

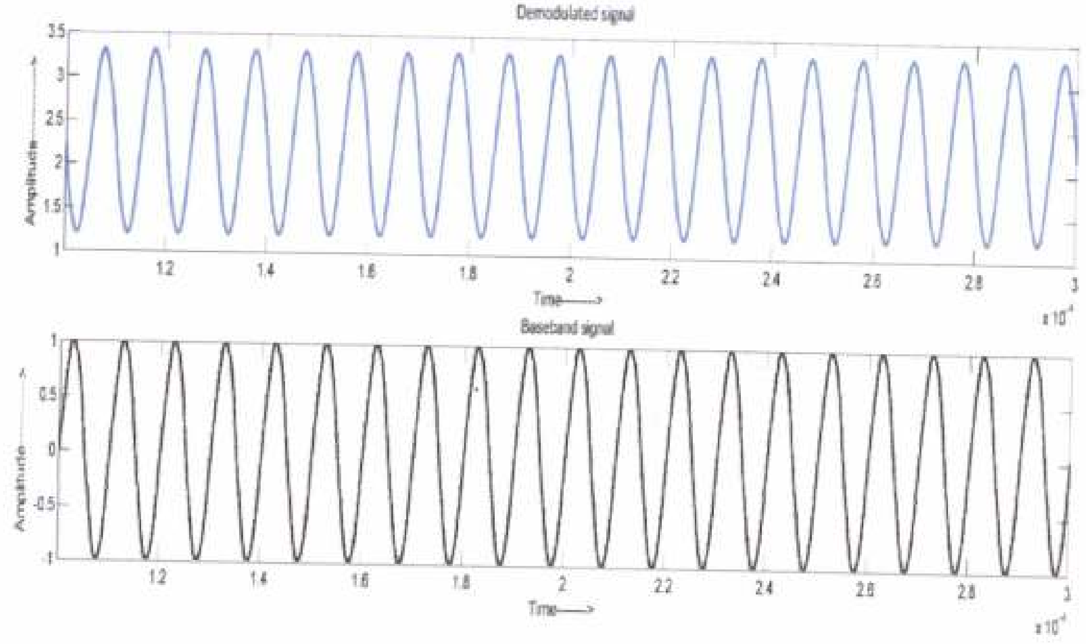


Fig: Demodulated signal after Coherent detection

RESULTS:

For one complete cycle:

T= $(1.6 - 1.5)*10^{-4}$

= $0.1*10^{-4}$

F= 1/T= 100KHz; PHASE DIFFERENCE= 180deg.

8.FUTURE WORK

1. Since, we have not yet considered the noise and its impact on the spectrum; so will be looking into it and try to find out its impact and try to reduce the same as it always present in any communication system.

2. Applications of the Phase modulated communication system.

3. Advantages and disadvantages of phase modulated communication system.

4. Improvement of the process.

9.CONCLUSION

After analysing and observing till now, we can say that the phase of the carrier(LASER) is linearly in proportion to the modulating signal(RF) .

Since, we have not yet considered the noise factor so we will be trying to reduce the noise as in every communication process noise can't be eliminated and it is a big challenge to every communication engineers. Hence, the RF engineers have been working on it.

10.REFERENCE

1. Optical communication system(OPT428), Govind P. Agarwal, Institute of Optics, University of Rochester,NY-14627

2. E-book "Fiber Optic communication System"—G.P. Agarwal.

3. "Optical Fiber Communications", J.M.Senior,

2nd edition, Pearson Education.

4. Phase Modulated Optical Communication System, Keang PO HO,

Institute of Communication Engineering, Deptt. of Electrical Engineering,

National Taiwan University, Taipei 106, Taiwan.