PRACTICAL WORK BOOK
For Academic Session 2014

Optoelectronics & Microwave Systems (EL-484) For B.E(EL)

Name:

Roll Number:

Class:

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LABORATORY WORK BOOK

FOR THE COURSE

EL-484 Optoelectronics & Microwave Systems

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Approved By: **Board of Studies of Electronic Department**

Introduction

This work book is designed to guide and gives useful information about the Fiber Optic Communications. People have used the light to communicate for years, today telecommunications companies use light and fiber optics to carry audio, video and data signals over wide areas around the world.

Fiber Optics is a field of technology that uses thin, flexible, transparent fibers to carry light. Fiber Optics combines the use of light, optics and electronics to transfer information.

The transparent fibers, called optical fibers are made up of glass or plastic. Light enters one end of the fiber, travels the length of the fiber, and exits the opposite end, optical fiber has many uses other then transmitting digital, audio and video signals it is also used to project images, remote sensing and indicating.

This work book will give the students thorough knowledge about the Optical Fiber and the problems associated in implementing the fiber network.

Optoelectronics & Microwave Systems Laboratory

CONTENTS

LAB No.1

Objective:

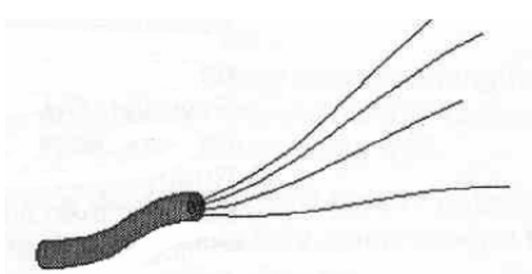
The objective of this experiment is to familiarize with Fiber Optic Trainer Board and observe communication through optical fiber. Analyze different input and output signals using oscilloscope.

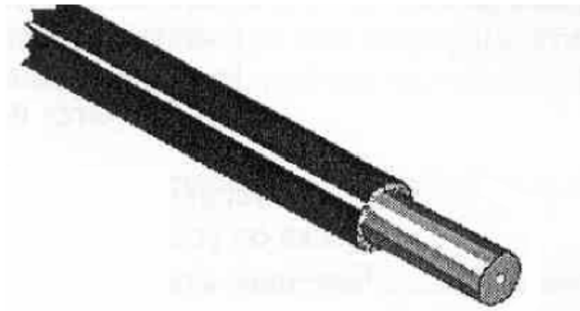
Apparatus:

- Base unit with fiber optic communication circuit board,
- Oscilloscope with two probes,
- Function generator,
- Multimeter, Plastic fiber optic cable (1 m long),
- Two-post connectors (4 pieces), Pins (4 pieces).

Theory:

People have used light to communicate for many years. Our prehistoric ancestors used small fires to signal each other. Lighthouses have been used to warn sailors for thousands of years. Sailors also use flashes of light to transmit and receive messages with Morse code.
Today, telecommunication companies use light and fiber optics to carry audio, video, and data signals over wide areas around the world. Fiber optics is a field of technology that uses thin, flexible, transparent fibers to carry light. Fiber optics combines the use of light, optics, and electronics to transfer information.
The transparent fibers, called optical fibers, are made of glass or plastic. Light enters one end of the fiber, travels the length of the fiber, and exits the opposite end. The light that is passed through an optical fiber, sometimes called a light pipe, has many uses. It is used for transmitting digital, audio, and video signals. It is also used for projecting images, remote sensing, and indicating.





Fiber-optic cables, which can consist of several optical fibers, have many advantages over using copper-wire cables. Several advantages of fiber optics are:

Wide bandwidth -Optical fiber can handle signals up to 1 THz (terahertz), which allows high speed data transfers up to 10 Gbps (625,000 pages of text per second, or 65,000 simultaneous telephone conversations over one fiber).

Low loss -The small signal loss in optical fiber allows the use of fewer repeaters.

EMI immunity -Optical fiber is unaffected by electromagnetic fields, such as RFI (radio frequency interference), and does not create electromagnetic interference.

Light weight -Optical fiber is up to nine times lighter and, therefore, is invaluable to the aircraft industry.

Small size -Optical fiber allows space savings in aircraft and submarines.

Safety -Optical fiber does not create electrical fire hazards and does not attract lightning.

Security -Optical fiber does not radiate energy, so illegal eavesdropping is extremely difficult.

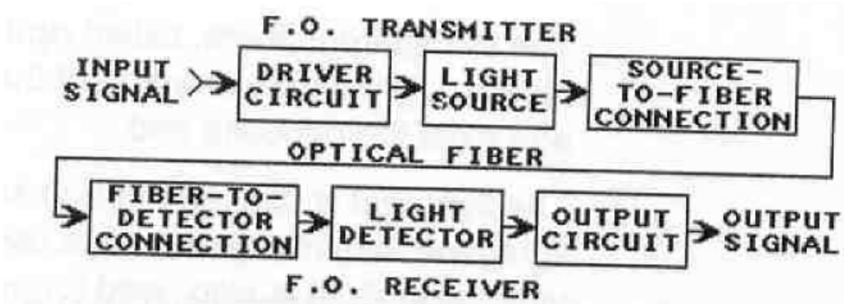
Ruggedness -Glass fiber is corrosion resistant and is 20 times stronger than steel.

When handling fiber-optic cables, you should keep several personal safety precautions in mind:

Never look directly into the end of an optical fiber. The light source could be a laser, or laser LED, which can actually burn living tissue inside your eyes and permanently blind you. Often, you cannot be certain that the light source is not a laser type, or that the light source is turned off.

Never deliberately break a glass optical fiber without properly protecting your eyes and skin. Glass splinters that are smaller in diameter than a human hair can puncture your skin and become embedded.

In the first exercise, you will become familiar with the twelve circuit blocks on your circuit board. You will examine and demonstrate typical fiber-optic circuits and how they are applied in practical situations.



Procedure:

- Locate the Analog Transmitter circuit block. Connect function generator output and CH1 oscilloscope probe to the input jack T-IN.
- Turn on the function generator and set for 10 kHz sine wave.
- Turn on oscilloscope and observe input signal at T-IN.
- Record:
  Frequency = _______________ $V_{peak-peak}$ = _______________, V_{mean} = ________ .
- In the Photo Transistor circuit block, set the range shunt to is Hi position, and connect the CH2 oscilloscope probe to Emitter post.
- Locate Fiber Optic Transmitter circuit block. Connect Anode and Cathode in Analog position by using two 2-post connectors.
- Connect one end of optical fiber to the Fiber Optic Transmitter and place other end to the hole in the top of the Photo Transistor's plastic block.
- Record:
  At CH1
  Input Frequency =______________________ .
  Input Voltage$_{peak-peak}$ = ______________________.
  Input Voltage$_{mean}$ = ________
  At CH2
  Emitter Output Frequency =_____________________
  Emitter Output Voltage$_{peak-peak}$ = ____________________ .
  Emitter Output Voltage$_{mean}$ = ___________________ .
- Repeat the previous step and record the same quantities with triangular and square waves.

Triangular Wave Input	Square Wave Input
Input Frequency	**Input Frequency**
Input Voltage$_{peak-peak}$	**Input Voltage**$_{peak-peak}$
Input Voltage$_{mean}$	**Input Voltage**$_{mean}$
Emitter Output Frequency	**Emitter Output Frequency**
Emitter Output Voltage$_{peak-peak}$	**Emitter Output Voltage**$_{peak-peak}$
Emitter Output Voltage$_{mean}$	**Emitter Output Voltage**$_{mean}$

- Locate Fiber Optic Receiver. Remove optical fiber from Photo Transistor and connect it to Fiber Optic Receiver jack.
- Place a 2-post connector in Analog position of Fiber Optic Receiver.
- Remove CH2 oscilloscope probe from Emitter post and clamp it to R-Out of Analog Receiver.
- Record the following quantities with sine, triangular and square waves at R-Out.

	Sine Wave Input	**Triangular Wave Input**	**Square Wave Input**
Output Frequency			
Voltage$_{peak-peak}$			
Voltage$_{mean}$			

- Locate Light Emitting Diodes circuit block. Remove optical fiber from Fiber Optic Transmitter and connect it to the hole of Red LED
- Remove signal generator and oscilloscope from the board.
- Measure voltage at R-In jack of Analog Receiver through multimeter.
- Repeat previous step with Green and Infra red LEDs.
- Compare which LED provided highest voltage reading at R-In.
  Voltage at R-In with Red LED = ____________________________ .
  Voltage at R-In with Green LED = ________________________________ .
  Voltage at R-In with Infra Red LED = ____________________________.

Voice Communication Over Optical Fiber:

- Use a two-post connector to connect Mic Out to the Analog Transmitter's T-In.
- Use a two-post connector to connect to the Analog Receiver's R-Out to Audio In.
- Locate Mic Amplifier. Set the Mic Amplifier's Level pot about a quarter turn from its fully CCW position.
- Locate Audio Amplifier. Set its Volume pot to fully CW position.
- Using finger, lightly scratch or tap the surface of the Microphone. Alternatively try blowing into the Microphone.
- If feed back (squealing sound) occurs, turn the Level pot CCW until the noise stops.

LAB No.2

Objective:
Investigate the propagation of light through an optical fiber. Calculate the light attenuation due to:
- Scattering and absorption.
- Numerical aperture mismatch.
- Core area mismatch.

Apparatus:
- Base unit with fiber optic communication circuit board,
- Multimeter, Plastic fiber optic cable (1m long),
- Plastic fiber optic cable (5m long),
- Glass fiber optic cable (1m long),
- Coupling sleeve.

Theory:
The power loss from the conversion of light energy to heat is called **Absorption** and the misdirecting or spreading of the light power is called **Scattering.**
The refraction index of the core changes gradually as the light moves away from the centre of the core, light travels through the fiber core reflects off the cladding because of the step change in the refractive index, as light moves towards the cladding , the gradual lowering of refractive index bends (refracts) the light, increasing the angle of incidence and when the angle of incidence becomes too large the light reflects back towards the center.
Optical fibers are not ideal waveguides therefore some of the input power is lost to the absorption and scattering. Impurities in the fiber material will absorb some of the optical power and dissipates it as heat. Absorption losses are affected by the core material and light wavelength.
Manufacturing variations in the density or composition of the fiber scatter some of the light. Imperfections in the core and the cladding are called microbends they cause additional scattering losses, which decrease as wavelength increases. Fiber manufactures specify the combined scattering and absorption losses in decibels per kilometer (db/km).
Snell's law describes how light behaves when it travels between two materials with different refractive indices and also predicts if the light will be refracted or totally refracted, total light refraction occurs when the incident angle (θ_1) is greater then the critical angle. The critical angle is calculated by setting θ_2 to 90° and solving for θ_1 since sin(90) is 1, the critical angle is arcsine (η_2/η_1).
The critical angle is the largest incident angle (θ_1) that will be refracted by the decrease in refractive index, light rays with an angle of incidence greater than the critical angle(θ_c) are totally refracted.
Acceptance cone is a three dimensional representation of light acceptance which measures twice the acceptance angle. A useful expression of a fiber's acceptance angle is its **Numerical Aperture (NA),** it is calculated by taking the sine of the acceptance angle (θ_A).

The NA mismatch losses in a fiber system occur because of using fibers differ in there Numerical Apertures at the transmitting and receiving end. When the transmitting fiber has the higher NA than the receiving fiber, some of the emitted light rays will fall outside the acceptance angle of the receiving fiber therefore they will be lost the same could be seen if the core area or the diameter of the two fibers mismatched.

Procedure:

Calculation of scattering and absorption losses:

- Locate Light Emitting Diodes and Photo Transistor circuit blocks. Connect the 1m plastic fiber optic cable between infra red (940 nm wavelength) LED and the Photo Transistor. Avoid excessive cable bending as it introduces unexpected losses and poor experimental results.
- Using a 3-pin range shunt select Hi measurement range.
- The voltage at Emitter post is proportional to the relative light power detected by the phototransistor. Measure this voltage across Emitter and Ground posts using a multimeter.

V_{EG} (For 1m cable at 940 nm wavelength) =______________________________ .

- Remove 1m plastic fiber optic cable. Connect a 5m plastic fiber optic cable between the infra red LED and photo transistor with above stated precautions.
- Measure the relative light power detected by the photo transistor in terms of voltage.

V_{EG} (For 5m cable at 940 nm wavelength) =____________________________ .

- The difference in power loss between the two lengths of optic fiber cable is due to the attenuation from the additional 4m of optical fiber. Calculate the attenuation of cable using the following formula.

$$\text{Cable attenuation (At 940 nm wavelength)} = \frac{1}{4} \times 10 \log \frac{V_{EG}\text{(For 1m cable)}}{V_{EG}\text{(For 5m cable)}}$$

Cable attenuation (At 940 nm wavelength) =_____________________________ dB/m.

- Now repeat the above steps for Red (635 nm wavelength) and Green (565nm wavelength) LEDs. Fill out the following observation column.

	V_{EG} for 1m cable	V_{EG} for 5m cable	Cable Attenuation

Red LED (635 nm)
Green LED(565 nm)

- Draw a graph between operating wavelength and cable attenuation.
- Write down the relation between operating wavelength and cable attenuation in your own words.

Comments:

Calculation of numerical aperture and core area mismatch losses:

- Locate Light Emitting Diodes and Photo Transistor circuit blocks. Connect the 1m plastic fiber optic cable between red LED and the photo transistor.
- Set the range shunt to Hi position.
- Measure the voltage across Emitter and Ground terminal, which is proportional to the light power delivered by the photo transistor.

V_{EG} (For plastic fiber only) = ____________________________ .

- Use coupling sleeve to connect 1m long glass fiber optic cable between the plastic cable and photo transistor.
- Set the range shunt to Lo position, this will make phototransistor 100 times more sensitive.
- Measure the relative power delivered to the photo transistor by the combination of plastic-glass cable across Emitter and Ground.
- Divide this value by 100 to correct for the phototransistor's Lo shunt setting.

V_{EG} (For plastic-glass combination) =____________________________ .

- Calculate the total attenuation between the plastic and plastic-glass cables using the following formula:

$$\textbf{Total Attenuation} = 10 \times \log \frac{V_{EG}\,\text{(For plastic fiber only)}}{V_{EG}\,\text{(For plastic-glass combination)}}$$

Total Attenuation = ____.

- Using following information calculate numerical aperture and core area mismatch losses.

NA_1 for plastic cable = 0.46; NA_2 for glass cable = 0.28
Attenuation due to NA mismatch = 20 log (NA_1/ NA_2)
Attenuation due to NA mismatch = ______________________

Diameter (D_1) for plastic cable = 980 µm; Diameter (D_2) for glass cable = 62.5 µm
Attenuation due to core area mismatch = 20 log (D_1/ D_2)
Attenuation due to core area mismatch = ________________________.

- Calculate other losses by subtracting NA and core area mismatch attenuation from the total attenuation.

Other Losses = Total attenuation — NA mismatch — Core area mismatch
Other Losses =

- Write the possible causes for other losses in your own words..

Comments:

- Now connect 1m long glass fiber between red LED and Photo Transistor.
- Measure the relative light power detected by photo transistor in terms of voltage across Emitter and Ground terminals using a multimeter.

V_{EG} (For glass fiber only) = ___________________________ .

- Use a coupling sleeve to connect the 1m plastic cable between the glass cable and the photo transistor.
- Measure the relative light power delivered to the photo transistor by the combination of glass-plastic cable.

V_{EG} (For glass-plastic combination) =___________________________ .

- Calculate the attenuation between the glass and glass-plastic cables by using following formula.

$$\textbf{Total Attenuation} = 10 \times \log \frac{V_{EG}\ \textbf{(For glass fiber only)}}{V_{EG}\ \textbf{(For glass-plastic combination)}}$$

- Compare the results of plastic-glass and glass-plastic combination cables.
- Give reasons for the difference in attenuation in both cases.

Comments:

LAB No.3

Objective:

Analyze the factors that introduce losses in fiber optic elements coupling. Evaluate coupling losses due to:

- Un-intercepted Illumination.
- NA Mismatch.
- Fresnel Reflection.

Theory:

The source to fiber connection in a fiber-optic transmitter is an optical and mechanical interface between the light source and one end of the optical fiber. Light attenuation at the source to fiber connection is known as coupling loss. Misalignment, Area mismatch, Numerical Aperture mismatch, Fresnel reflection and poor surface finish result in coupling losses between the light source and the optical fiber.

The light source an the optical fiber must be properly aligned to minimize losses. Lateral displacement causes some light to miss the end of the fiber. Angular misalignment causes some light to exceed the fiber acceptance angle. An area mismatch can cause a loss of power called Un-intercepted Illumination loss. If the diameter of the light at the fiber end is greater than the fiber's core diameter, not all the light is coupled into the end of the optical fiber, decreasing the separation distance Un-intercepted Illumination losses decreases.

A Numerical Aperture mismatch can cause a loss of power, called NA loss. If the NA of the light source is greater than the fiber's NA, not all the light is coupled into the end of the optical fiber. The NA of a light source can be determined by using the beam angle of the source.

The Fresnal Reflection is a partial reflection of light caused by a change in refractive index along the light path, it causes a loss of the power called reflection loss. Power loss due to Fresnel reflection can be determined by Loss (in db) = 10 x log(1-r).

Apparatus:

- Base unit with fiber optic communication circuit board,
- Multimeter,
- Plastic fiber optic cable (1m long),
- Plastic fiber optic cable (5m long),
- Glass fiber optic cable (1m long),
- Coupling sleeve.

Procedure:

- Locate Power Supply block, insert +5V and -5V shunts to Analog position.
- In the Photo Transistor circuit block, set the Range shunt to Hi position.
- Connect the Analog Transmitter to Fiber Optic Transmitter by inserting two-post connectors in the Analog position of Anode and Cathode.
- Connect 1 m glass fiber optic cable from the Fiber Optic Transmitter to the Photo

Transistor circuit block.

- Measure the voltage level at the photo transistor Emitter test point.

V_{FOT} = __________________________V.

- Move the 1 m glass fiber optic cable from the Fiber Optic Transmitter to the IRed in the Light Emitting Diodes circuit block. The other end of the cable should remain connected to the Photo Transistor.
- Move the Range shunt from its Hi position to its Lo position.
- Measure the voltage level at the Emitter test point.

V_{IRED} = __________________________V.

- Divide this value by 100 to compensate for the Hi to Lo range change.

V_{IRED} = __________________________V.

- Use these values to determine the output power difference between the two light sources.

$$\Delta P = 10 \log (V_{FOT} / V_{IRED})$$

ΔP=_____________________dB.

- Now calculate different coupling losses using the given values for your trainer board.

Un-intercepted Illumination Loss:

$$\text{Loss (UI)} = 20 \log (D_1 / D_2) \text{ dB}$$

Diameter of FOT = D_1 = 290 μm
Diameter of IRED = D_1 = 4000 μm
Diameter of Glass Fiber Optic Cable = D_2 = 62.5 μm.

Loss $_{UI}$ (FOT/Fiber) = ___________________ dB.
Loss $_{UI}$ (IRED/Fiber) = ___________________________ dB.

NA Mismatch Loss:

$$\text{Loss (NA)} = 20 \log (NA_1 / NA_2)$$

NA of FOT = NA_1= 0.49
NA of IRED = NA_1 = 0.259
NA of Glass Fiber Optic Cable = NA_2 = 0.275

Loss $_{NA}$ (FOT/Fiber) = _______________________ dB.
Loss $_{NA}$ (IRED/Fiber) = ______________________________dB.

Fresnel Reflection Loss:

$$\text{Loss (R)} = 10 \log (1 - \rho)$$

Where $\rho = [(n_2 - n_1) / (n_2 + n_1)]^2$

Refractive Index of air = n_1 = 1.00
Refractive Index of the core of Glass Fiber Optic Cable = n_2 = 1.5

ρ = ____________________.
Loss (R) = ____________________ dB.

- Add all the power losses to calculate the total coupling losses. **Coupling Losses (FOT/Fiber) = Loss (UI) + Loss (NA) + Loss (R)**

Coupling Losses (FOT/Fiber) = ___________________________dB.
Coupling Losses (IRED/Fiber) = __________________________dB.

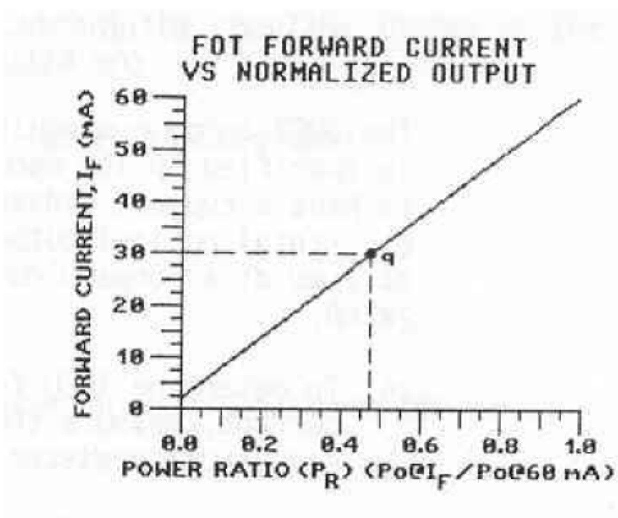
- Now calculate the input power to the fiber optic cable through FOT and IRed.

Input Power from FOT:

- Measure FOT forward current, remove the two-post connector from its Analog Cathode position.
- Set your multimeter to its 200 mA dc range and connect it across the Analog position of the FOT's Cathode jacks.

I_F (q) = ____________________________mA.

- The FOT manufacturer specifies that peak input power at a forward current of 60 mA is typically 25.12 μW (-16 dBm) and provides following graph for FOT forward current Vs normalized input.



- Determine the power ratio P_R for the calculated forward current I_F at operating point "q". Now calculate input power from FOT using the following relation.

$$P_{in}(FOT) = P_R \times P_{in}(60mA)$$

P_{in} (FOT) = ____μW.

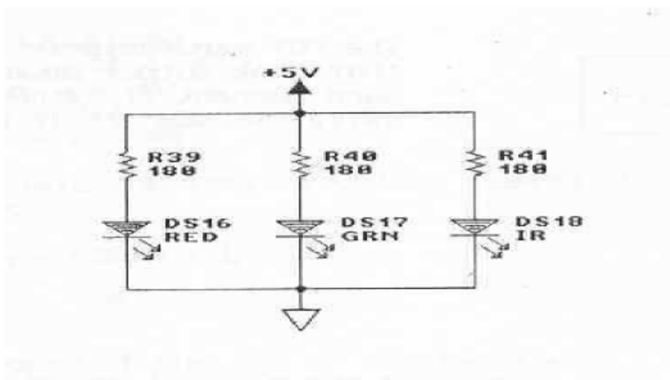
- Convert the calculated input power of the FOT from μW to dBm.

P_{in} (FOT) (in dBm) = 10 log $_{[Pin}$ (FOT) / 1 µW]

P_{in} (FOT) =________________________dBm.

Input Power from IRED:

- To determine input power from IRED, measure the current through resistor R41.



I_{R41} = _________________________ mA.

- As voltage drop across IRED is 0.7 V, calculate the radiated power of IRED using following formula.

Input Power from IRED = P_{in} (IRED) = 0.7 x I_{R41}
P_{in} (IRED) =____mW.

- Convert IRED's input power from mW to dBm.

P_{in} (IRED) (in dBm) = 10 log (Φ / 1 mW)
P_{in} (IRED) =____ dBm.

- Calculate output power at the other end of the fiber optic cable for FOT and IRED.

Output Power for FOT = Po (FOT) = P_{in} (FOT) – Coupling Losses (FOT/Fiber)
Po (FOT) = ____ dBm.

Output Power for IRED = Po (IRED) = P_{in} (IRED) – Coupling Losses (IRED/Fiber)
Po (IRED) = ____ dBm.

- Now determine the power difference between the two light sources.

¨P = 10 log [Po (FOT) / Po (IRED)] ¨P = dB.

- Compare the value of **¨P** calculated here to the value measured earlier.
- Write your comments for any difference.

Comments:

LAB NO.4

Objective:

The objective of this experiment is to present an exercise to troubleshoot fiber optic communication circuits.

- Circuit performance check.
- Trouble shooting experience after the insertion of a fault.

Theory:

The circuits should be troubleshooted in a logical and systematic way to eliminate possible causes of a malfunction until the defective component is located. Individual initiative and imagination combined with circuit knowledge and logical procedures are important elements of successful troubleshooting.

Speedy isolation of the circuit fault begins with a solid foundation of basic troubleshooting skills. The eight basic steps for troubleshooting a circuit fault are:

1. Analyze the symptoms.
2. Confirm the fault.
3. Visually inspect the circuit.
4. Do performance measurements.
5. Identify the faulty circuit section.
6. Identify the faulty component.
7. Repair the fault.
8. Verify the repair and circuit operation.

The troubleshooting begins after a symptom of a fault is noticed. In commercial electronic equipment, the symptoms of a circuit fault are usually noticed by your senses: hearing (radio static), sight (TV snow) and smell (the odor of a burnt component). By analyzing the symptoms, you can sometimes identify the specific circuit section or component causing the problem.

In most circuits, a circuit performance check, which consists of measuring one or two key voltage, current or resistance parameters usually at the input and output, will determine if there is a fault. Circuit performance specifications give the nominal values with percent tolerances for the circuit parameters.

This whole procedure of troubleshooting contains three sections:

1. Circuit Performance Check.
2. Guided Troubleshooting Procedure.
3. Troubleshooting Experience.

Apparatus:

- Base unit with fiber optic communication circuit board,
- Oscilloscope with two probes,
- Function generator,
- Multimeter,
- Plastic fiber optic cable (1 m long),
- Two-post connectors (4 pieces),
- Pins (4 pieces).

Procedure:

Circuit performance Check:

Connect the following analog fiber optic circuit.

- Locate Analog Transmitter block, place a two-post connector in the Mic-Out to T-In position.
- Locate Fiber Optic Transmitter block, place the Cathode and Anode two-post connectors in the Analog position.
- Locate Fiber Optic Receiver block, place a two-post connector in Analog position.
- Locate Analog Receiver circuit block, place a two-post connector in the R-Out to Audio-In position.
- Connect 1m glass fiber optic cable from Fiber Optic Transmitter to Fiber Optic Receiver.
- In the Mic Amplifier circuit block, connect a signal generator and the CH1 oscilloscope probe to the top of the 2.2 k~ resistor.
- Adjust the signal generator for a 200 $mV_{peak\text{-}peak}$, 1 kHz sine wave at the top of 2.2 k~ resistor.
- Connect the CH2 oscilloscope probe to the Mic Out test terminal.
- Adjust the Level pot for a 1.0 $V_{peak\text{-}peak}$ signal on CH2 at the Mic Out test terminal.
- Connect the CH1 oscilloscope probe to the R Out terminal in the Analog Receiver block.
- Set the fiber optic communication link's gain to unity by adjusting the Gain pot to obtain a 1.0 $V_{peak\text{-}peak}$ sine wave at R Out on CH1.
- In the Audio Amplifier circuit block, position the Audio Out shunt so that it only connects to the NC Pin. Connect the CH2 oscilloscope probe to the centre pin of the Audio Out connector.
- Adjust volume pot to obtain a 300 $mV_{peak\text{-}peak}$ sine wave at the centre pin on CH2.
- Complete following performance specification table for the analog fiber optic communication system.

Item	Nominal Value	Observed Value
V_{Gen}	200 $mV_{peak\text{-}peak} \pm 10\%$	
V_{MicOut}	1.0 $V_{peak\text{-}peak} \pm 20\%$	
$V_{T\text{-}Out}$	130 $mV_{peak\text{-}peak} \pm 40\%$	
Emitter Waveform	Sine Wave	
$V_{R\text{-}In}$	135 m $V_{peak\text{-}peak} \pm 75\%$	
$V_{R\text{-}Out}$	1.o $V_{peak\text{-}peak} \pm 20\%$	
V_{Audio}	300 m $V_{peak\text{-}peak} \pm 20\%$	
All Signals		
Frequency	1 kHz ± 10%	
Waveform	Sine Wave	

Troubleshooting Experience:

- A fault has been inserted in the circuit.
- Review all the items in the performance specification table. Start trouble shooting by confirming that a fault is in the circuit.

Item	Nominal Value	Observed Value
V_{Gen}	200 $mV_{peak-peak} \pm 10\%$	
V_{MicOut}	1.0 $V_{peak-peak} \pm 20\%$	
V_{T-Out}	130 $mV_{peak-peak} \pm 40\%$	
Emitter Waveform	Sine Wave	
V_{R-In}	135 m $V_{peak-peak} \pm 75\%$	
V_{R-Out}	1.o $V_{peak-peak} \pm 20\%$	
V_{Audio}	300 m $V_{peak-peak} \pm 20\%$	
All Signals		
Frequency	1 kHz ± 10%	
Waveform	Sine Wave	

- When you are confident that you have identified the fault, isolate the faulty block of the circuit.
- The circuit fault is a defective:

Fiber Optic Receiver:

Analog Transmitter:

Fiber Optic Transmitter:

Analog Receiver:

Any Other Component:

Repair the fault. Make performance check by measuring and observing input and output signal parameters to ensure that the circuit is operating properly.

Conclusion:

- Begin troubleshooting by analyzing the symptoms of the circuit.
- Make observations and measurements to confirm that the circuit actually contains a fault.
- A visual inspection of the circuit may indicate the fault.
- Performance checks help isolate the faulty component and permit an assumption about a possible fault.
- Circuit tests confirm or disprove the fault assumption.
- After the fault is located and repaired, repeat performance checks to confirm proper circuit operation.

LAB No.5

Objective:

To measure the optical power emitted by the LED.

Apparatus:

- Testing module MCM-40
- Multimeter
- optical power meter

Theory:

The commonest optical sources are light-emitting diodes(LED) and laser diodes (LD) . Both these diodes can be used to generate radiations at different wavelengths, corresponding to the windows where fibers show the minimum attenuation.

The **LED** is a particular diode which emits light through process of recombination of the electron-hole pairs due to a forward bias of the junction The optical power emitted is a function of the forward driving current .At present the LEDs in the 1st windows are made of gallium arsenide or of the ternary compound with aluminum (ALGaAs/GaAs), the LEDs in the 2nd e 3rd windows are made of indium gallium-arsenide-phosphide (InGaAsP/InP).

The most significant parameters of LED are:

- Output wave length
- Output spectral width
- Output optical power: it ranges in some tens of µW, and depends on the forward driving current.
- Frequency response.

Procedure:

Optical power emitted by LEDs

- Power the module
- Disconnect the jumper j 11-j 13 and connect the jumper j 12b, so that the circuit can be arranged as shown in fig 1. this configuration includes the LED at 660nm, forward polarized through the bias trimmer (p4)
- Measure the voltage v_{10} across the resistor of 10~ connected in the series of LED (between TP15 and ground). the forward current i_f crossing the Led in expressed by the following formula:

$I_F = v_{10}/10$ [v_{10} in mv, I_f in ma]

- observe the intensity of the light emitted by the LED
- Power increase as current increase.

Characteristic Curves of LEDs

- Disconnect the jumper j 11 -j 12 and connect the jumper j 1 3b, so that circuit can be arranged as shown in figure2. this configuration includes the LED at 820nm, forward polarized through the bias trimmer (p4)

- Measure the voltage V_f across the LED (between TP 14 and TP 15) and the voltageV 10 across the resistor of 10~ connected in the series of LED (between TP15 and ground). the forward current i_f crossing the Led in expressed by the following formula:

$$I_F = V_{10} / 10 \ [v_{10} \text{ in mv}, I_f \text{ in ma}]$$

  - Connect the LED to optical power meter through cable3(200/230)
  - Vary the BIAS trimmer P4 and measure V_f , V_{10} , I_F and optical power P_{out}
  - Plot the curve for the optical power of LED versus I_F and of I_F versus V_F
  - Change cable 3 with cable 4(50/125) and then with cable 5 (10/125) and observe the reading of optical power.

OBSERVATION:

Sr No	**V_f mV**	**V_{10} mV**	**$I_F = v_{10}/10$ mA**	**P_{out} dBm**

RESULT:

- Characteristic curves of LED source are observed.
- By changing the fiber optic cables it was observed that the optical power decreases as the Numerical Aperture of the cable decreases

Figure 1

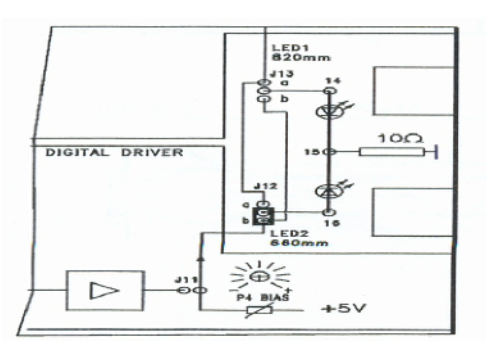
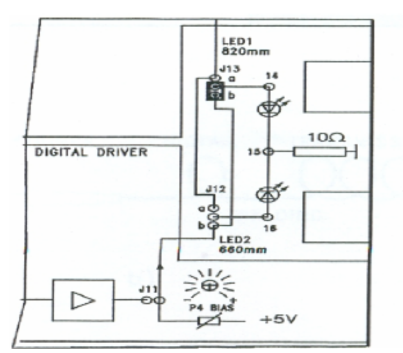


Figure 2



LAB NO. 6

Objective:

To observe the attenuation & coupling loss in optical fiber.

Apparatus:

- power supply psu or ps1
- Testing module MCM-40
- Multimeter

Theory

When the light crosses an absorbing medium, as in the case of optical fiber, the luminous energy decrease as distance increases. The loss in a fiber length **(attenuation)** is expressed by the ratio between the power entering one end of the fiber $_{(PIN)}$ and power coming out from the opposite end (Pout). Attenuation is normally measured in decibel:

$$\text{Att (dB)} = -10 \log (P_{out}/P_{in})$$

It can range fro some db/**m** for plastic fiber, to fraction of db/km for glass fibers.

The attenuation of the light signal due to the fibers depends on the wave length and on the material which the fiber has been constructed with . In glass fiber the main causes of attenuation are the absorption losses and the scattering losses. Combining these losses lead to plotting the intrinsic attenuation curve like that shown in the fig 1 whereas the fig2 shown the attenuation curve of a plastic fiber. Following losses leads to attenuation

Absorption loss: When the light photons have a certain value of energy, the atoms of glass of the core (SiO_2) absorb a part of this energy. This phenomenon depends on wavelength and there are two different absorption zones, occurring in the infrared spectrum and in the ultra violet spectrum. Furthermore, during the chemical process of glass manufacturing, various metallic impurities are trapped in the core, among these impurities there are also some ions OH- which provoke absorption peaks at discrete value of wavelength.

Scattering loss: They are due to the granular structure (at microscopic level) of the material which the fiber is constructed with. This structure includes some scattering centers which are material point that scatter the radiation in all directions, even backwards this phenomenon is called ***Rayleigh* scattering** or material scattering.

Other losses: In an optical fiber link, other can be due to too narrow loops in the path of the optical cable (Bending losses), or to junction of more lengths of fiber. Of course they are not intrinsic losses of the fiber, but they depend on cable laying.

Procedure:

Attenuation of the fiber with increase in length

- power the module
- Disconnect the jumper j13 and connect j7c-j9b-j10b-j11-j12b, so that the circuit can be arranged as it is shown in fig 1. This configuration includes the LED and the photodiode at 660 nm; moreover an alternating data signal (0/1) is applied to the input of the digital driver
- connect the LED to the photodiode through the cable # 1,ST-St adapter and cable 6
- set the bias trimmer (p4) to its intermediate position. connect j 1 5b and observe the waveform in TP24 (voltage detected by the assembly "photodiode +Tran impedance amplifier") on the oscilloscope
- Record the amplitude $_{vout1}$ of the square wave detected.
- Replace the cable # 1 (plastic fiber of 1 .5m) with the cable # 2(plastic fiber of 5 m) and measure the new amplitude $_{vout2}$ of the received signal, in TP24.
- Calculate V_{out2}/V_{out1}=………………………..

Coupling and bending Losses

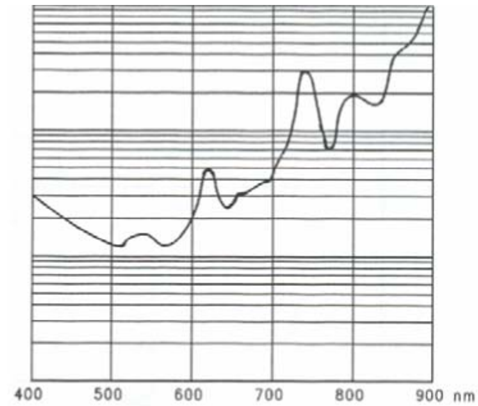
- keep the same condition of the previous test (LED and photodiode at 660 nm connected through the cable # 2)
- observe the waveform in TP24, on the oscilloscope
- looser the fiber connector inserted in the ST-ST adapter and gradually move it away from the same adapter (and hence from the second ST connector inserted in the adapter)
- note that the amplitude of the receive signal decrease as the connection is loosen, it also depends on the angle at which the connector of the source and of the detector are connected.
- Bend the fiber and observe the wave form it will be observed that for sharp bends the wave form is more attenuated as the bending losses increases.

Attenuation of the fiber as a function of wavelength

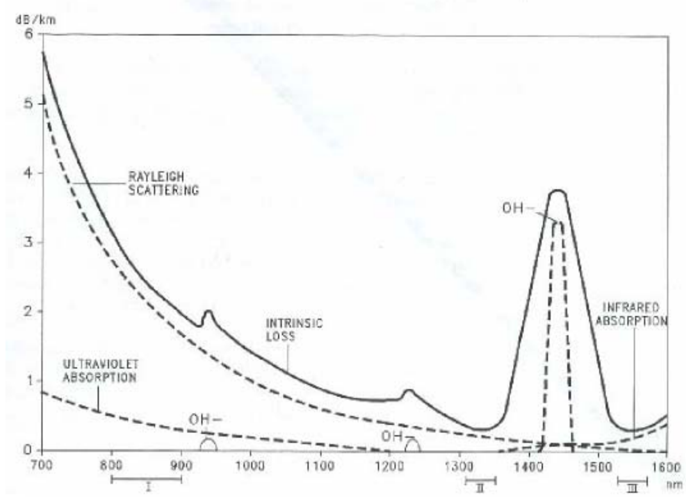
- remove the jumper j 1 2b and connect the j 1 3b, in order to use the LED and the photodiode at 820nm
- connect the LED 1 to the photodiode PD1 through the cable #1 (plastic fiber of 1 .5m)
- connect j 1 5a and observe the waveform in TP23
- record the amplitude $_{vout3}$ of the square wave detected
- replace the cable #1 (plastic fiber of 1.5 m) with the cable #2 (plastic fiber of 5 m) and measure the new amplitude $_{vout4}$ of the signal received, in TP23
- Calculate V_{out4}/V_{out3} =………………

Result:

- It has been observed that the attenuation increases as the cable length increases
- The plastic fiber cable offer greater attenuation at 820nm then on660nm



Typical attenuation curve of a plastic fiber



Typical attenuation curve of a single-mode glass fiber

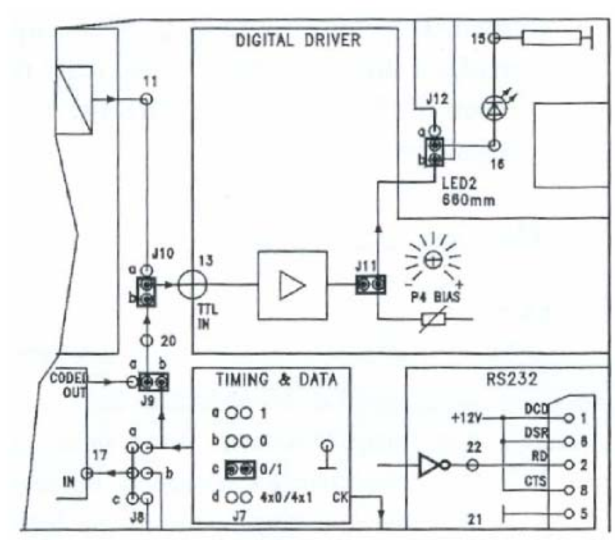


Figure 1

Lab No.7

Objective:

Describe the operational characteristics and parameters of Photodiode used as photo detector in fiber optic system.

Apparatus:

- power supply psu or ps1
- Testing module MCM-40
- Oscilloscope.

Theory

Photo detector can transform an optical incident signal into an electric signal. The main requirements of a photo detector are:

- High sensitivity that is capacity of absorbing the maximum quantity of incident radiation.
- High response rate, in order to detect very narrow light pluses
- Limited dimensions, low coast, reliability.

The commonest photo detectors used in fiber optic system are the PN and PIN photodiode and avalanche photodiodes (APD).

The operating principle of photo diodes is based on a particular property of semiconductor: that is, a photon absorbed by the semiconductor generates an electron-hole pair, Applying a reverse bias to a PN junction generates a reverse current proportional to the incident light radiation. The performance of a photodiode can be improved if a slightly doped layer, called I (intrinsic), is sandwiched between P and N layers. These diodes are called PIN photodiodes after detector the signal are amplified by

- high impedance amplifier or
- trans-impedance pre-amplifier

In the first case, the current (proportional to the light signal) generated by the photo detector crosses a resistor across which a voltage signal is developed, then this signal is amplified and in the trans-impedance pre-amplifier, the current is directly transformed into voltage, by effect of the feedback due to the resistance.

Hence $\mathbf{v_{out} = I_r \cdot R}$

As regards sensitivity and noise, high impedance pre-amplifier offer better performance, whereas trans-impedance show a broader pass band.

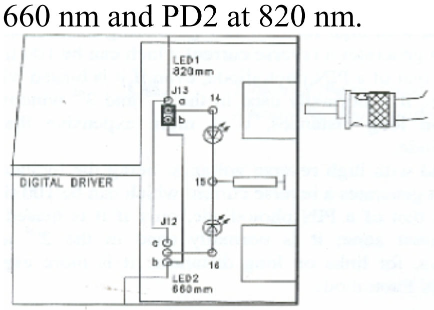
Procedure

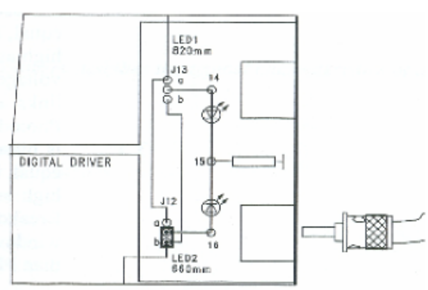
- Power the module
- Disconnect the jumpers j 11 -j 12 and connect the jumper j 1 3b, so to produce the circuit of fig 1. The configuration includes the LED at 820 nm, forward biased with the BIAS trimmer (P4). Turn p4 completely to the right (maximum bias voltage)
- Connect the LED 1 and the photodiode PD! (820 nm) through the cable #3 (fiber 200/230)
- Connect a volt meter (or the DC oscilloscope) to TP23, where the voltage supplied by the detector is measured. Consider that the measured voltage is proportional to the current generated by the photodiode.
- now shift the fiber from the LED 1 (820 nm) to the LED 2 (660 nm) remove the jumper j 1 3b and connect the jumper j 1 2b
- measure the new voltage at the out put voltage of the detector (TP23)
- Disconnect the jumper J11-J13 and connect the jumper J12b,so that the circuit can be arranged as shown in fig 2
- connect the LED 2 to the photodiode 660 nm (PD2), using the cable #2 (plastic fiber), the ST-ST adapter and the HP-ST connector
- connect a voltmeter (or the DC oscilloscope) to TP24, where the voltage generated by the detector is measured. consider that the measured voltage is proportional to the current supplied by the photodiode
- now move the fiber from the LED 2 (660 nm) to the LED 1 (820 nm).remove the jumper J12b and connect the jumper J13b
- measure the new voltage at the output of the detector (TP24)

Result:

- In the case when PD1 is connected with LED 2 the detected voltage is lower, because PD1 reaches its maximum sensitivity at 820nm
- In the case when PD2 is connected with LED 1 the detected voltage is lower (actually it coincides with the voltage measured without optical signal), because the photodiode PD2 reaches its maximum sensitivity at 660 nm and the attenuation of the fiber is higher at 820 nm than at 660 nm.

Therefore it can be concluded that that photo diode PD1 reaches its maximum sensitivity at 660 nm and PD2 at 820 nm.





Lab No.8

Objective:

The objective of this experiment is to analyze the operation of Manchester and B i-phase coders and decoders. Construct a digital transmission system applying these data codes to 8 multiplexed channels and analyze the decoding and de-multiplexing of these channels through a fiber optic cable.

Apparatus:

- MCM 40 fiber optic communication trainer board,
- Individual control unit SIS3,
- Fiber optic cables, Jumpers,
- Connecting wires,
- Oscilloscope with two probes.

Theory:

Data Coding:

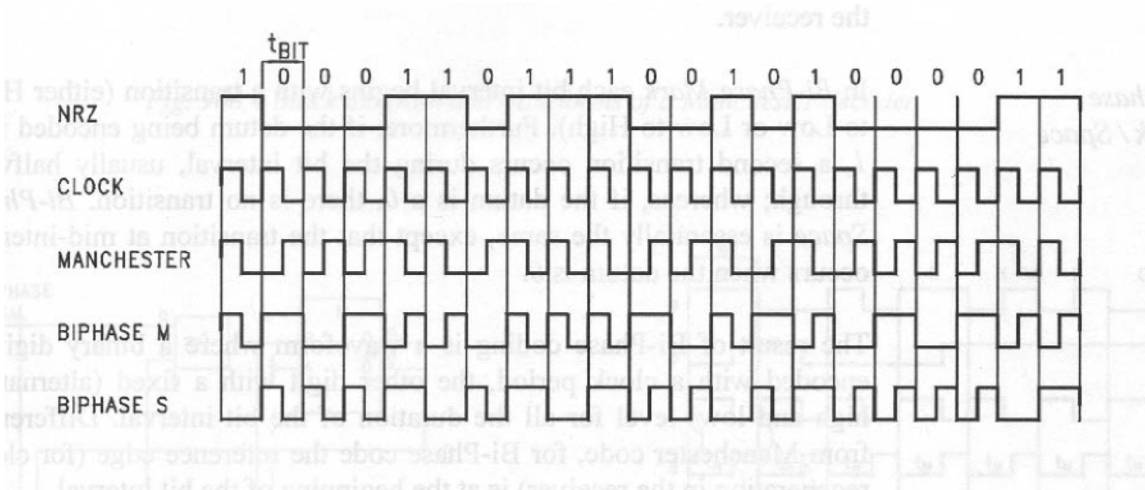
In digital communication systems, data bits are represented through electric signals. The simplest format uses two levels, to represent the binary digits 1 and 0. For example, +5V for 1 and 0 V for 0. Normally the level is kept fixed for the duration of a bit. This is called Non Return to Zero (NRZ) format.

In reception the signal is read in certain instants, to determine whether the arriving datum is 0 or 1. The reading or sampling must be carried out every bit interval and be clocked with the data signal. In some systems the Sync Pulse for correct sampling is transmitted separately from the data.

If the transmitted data contain long sequences of 0s or 1s, it is difficult or even impossible to extract the reception clock. To resolve this inconvenience, the NRZ data are properly coded before being transmitted. Two codes are used in fiber optic systems are Manchester and B i-Phase.

- **Manchester Code:**
  Manchester code inserts a transition at mid-interval. If the NRZ datum is 1, the transition will be from high to low level, if it is 0 the transition will be low to high level. Theses transitions can be used as reference edges for regenerating the clock in the receiver.

- **Bi-Phase Mark/Space Code:**
  In Bi-Phase Mark each bit interval begins with a transition, either high to low or low to high. If the datum being encoded is a 1, a second transition occurs at mid-interval. If the datum is 0, there is no transition. Bi-Phase Space is essentially the same, except that the transition at mid-interval occurs when the datum is 0. Differently from Manchester code, here the reference edge for clock regeneration in the receiver is at the beginning of the bit interval.



Data Multiplexing:

Multiplexing means using a single communication channel to transmit data coming from different channels in different time intervals, whereas demultiplexing is the process of subdividing the data in reception to so many channels in the same order.

The data coming from 8 different serial sources or from an 8 bit parallel byte arrive at the 8 inputs of the multiplexer. The multiplexer serializes the 8 inputs and extends the last bit to enable the insertion of the Sync Pulse. Then the sync pulse is used by the receiver to distribute the data on the 8 outputs correctly.

Procedure:

- Remove all the jumpers from the MCM 40 trainer board. Connect power cables from SIS3 control unit to the MCM 40. Turn the power switch on.
- Locate 8 Channel Multiplexer circuit block, set off Dip Switches from 1 through 8. Turn on Sync switch.
- Locate Data Encoder block, connect the jumper J8c. This will allow multiplexer output bits to get encoded.
- Connect jumper J9a and J10b. This will connect the Data Encoder to the Digital Driver.
- Locate Digital Driver circuit block, connect jumpers J11 and J13b for the optical transmission of encoded signal through 820 nm LED 1.
- Connect Optical Cable No. 3 (Step index glass optical fiber cable of 3 m length) between LED 1 and Photo Detector PD 1.
- Locate Digital Receiver circuit block, connect jumpers J15a and J16 to send the received signal to Data Decoder.
- Data Decoder is internally connected to 8 Channel Demultiplexer. LEDs will glow according to demultiplexer's output.

Observations:

- Draw a block diagram of the plugged in circuit and mention all the jumper connections on it. Attach this diagram in your practical work book.
- Locate Data encoder circuit block, connect the CH1 probe of the oscilloscope to Test Point No. 17 (TP17).
- Now turn on the Dip Switches from 1 through 8 alternately. Observe the changes in Data In waveform at TP17.
- Connect CH2 probe of the oscilloscope to TP19 in 8 Channel Multiplexer circuit block. Observe Sync Generator output and compare it with Data In.
- Locate Code Selector circuit block, set the first switch to Manchester Coding. Now observe the Manchester coded output at TP20 by connecting CH2 probe of oscilloscope to it.
- Take a printout or make a sketch of Coded Output in correspondence with Data In at TP17. Attach the printout or sketch in your practical work book.
- Now connect CH1 probe to TP14 in LED1 circuit block and CH2 probe to TP23 in PD1 circuit block. Observe and compare transmitted and received signals.
- Locate TP20 in Data Encoder and TP25 in Digital Receiver circuit blocks. Connect CH1 probe to TP20 and CH2 probe to TP25.
- Observe and compare both waveforms. Write your comments for any differences in the following box.

Comments:

- Now change the combination of Dip Switches and observe the change in Demultiplexer LEDs.
- Set the Code Selector switches to Bi-Phase Space.
- Connect CH1 probe to TP17 and CH2 probe to TP20, and, observe the Data In and Coded Output waveforms.
- Take a printout or make a sketch of Coded Output in correspondence with Data In at TP17. Attach the printout or sketch in your practical work book.
- Now set the Code Selector switches to Bi-Phase Mark. Repeat the above two steps.
- Observe other circuit parameters as well for Bi-Phase Space and Mark coding.

Attachments:
Please tick the attachments you provide:

- Block diagram of the plugged in circuit with all jumper settings. □
- Data In and Coded Output waveforms for Manchester coding. . □
- Data In and Coded Output waveforms for Bi-Phase Space coding. . □
- Data In and Coded Output waveforms for Bi-Phase Mark coding.. □

Lab No.9

Objective:

Analyze the characteristics of FM modulator. Construct a communication system consisting of FM modulator and demodulator, transmitter and receiver on optical fiber.

Apparatus:

MCM 40 fiber optic communication trainer board, Individual control unit SIS3, Fiber optic cables, Jumpers, Connecting wires, Oscilloscope with two probes, Voltmeter.

Theory:

The communication system described in this experiment uses a square wave as carrier signal generated by the FM modulator. But prior to modulation, the modulating signal is amplified, level shifted and limited in amplitude. These steps are needed in situations where:

- The FM modulator requires positive modulating voltages. If the analog signal to be transmitted is directly applied to the modulator, negative voltages can not be transmitted. Hence level shifting or taking DC offset transforms the negative voltages into positive region.
- It is also necessary for those signals which have very low frequencies and DC offset.

The output of the FM modulator is applied to a digital driver circuit which drives LED optical source. A plastic fiber optic cable provides a link between the transmitter and receiver.

The FM modulated signal coming from the photo detector and digital receiver is applied to the FM demodulator. Demodulation is carried out through a Phase Locked Loop (PLL) circuit. The output stage of the receiver is an amplifier with adjustable DC offset and Gain. This allows to obtain an output signal with the same amplitude and DC level of the starting signal.

Procedure:

- Remove all the jumpers from the MCM 40 trainer board. Connect power cables from SIS3 control unit to the MCM 40. Turn the power switch on.
- Locate FM Modulator circuit block, connect the jumper J4b. This will provide a DC voltage to the amplifier before the modulator.
- Connect the voltmeter to the Test Point 9 (TP9). Adjust DC Source P3 to obtain 0 V.
- Measure the voltage at TP10 after level shifter and amplitude limiter.

V_{TP10} =____________________________ V.

- Connect the CH1 probe of the oscilloscope to TP1 1 and observe the waveform of the carrier signal generated by the FM modulator.
- Measure following parameters of the carrier signal.

$V_{peak-peak}$ =________________________ V.
Frequency =________________________ Hz.
Time Period = __________________________Sec.

- Draw a sketch of the carrier signal using the above parameters. Attach it with your practical work book.
- Now connect voltmeter at TP10 and CH1 probe of oscilloscope at TP1 1.
- Move DC Source P3 to its initial position. Turn it gradually to obtain steps of 0.2 V at TP10. Measure the corresponding frequencies at TP1 1 and complete the following table.

S.No.	Voltage at TP10 (V)	Frequency at TP11 (kHz)
1	1.15	
2	1.35	
3	1.55	
4	1.75	
5	1.95	
6	2.15	
7	2.35	
8	2.55	
9	2.75	
10	2.95	
11	3.15	
12	3.35	

- Using the above values plot the characteristics curve of the modulator. Attach the graph with your practical work book.
- Locate Audio Sources circuit block, connect jumper J2 and J3, and, move jumper J4b to J4a. This will provide 1 kHz sine wave as modulating input to the FM modulator.
- Observe un-modulated waveform at TP9 by connecting CH1 probe of the oscilloscope.
- Observe modulated square wave at TP1 1 using CH2 probe.
- Locate Digital Driver circuit block, connect jumpers J10, J11 and J12b. This will connect the FM modulator to LED2 (660 nm) through the digital driver.
- Now connect LED2 to the Photodiode PD2 through the plastic fiber and the ST-HP adapter.
- Adjust P1 and P4 to their central positions.
- Locate Digital Receiver circuit block, connect jumper J15b. This will connect PD2 output to the digital receiver.
- Draw a block diagram of the circuit and mention all jumper settings. Attach the diagram with your practical work book.
- Observe the following waveforms and measure the corresponding values using oscilloscope.

S.No.	Waveform	Frequency	$V_{peak-peak}$	Time Period	V_{mean}
1	Modulating Sine Wave at TP9				
2	FM signal at TP 11				
3	Driving signal of the LED2 at TP 16				
4	Signal received by PD2 at TP24				
5	Received FM signal at TP25				
6	Demodulated signal at TP3 1				

- Adjust the DC Offset P6 and Level P7 in FM demodulator to obtain a signal with amplitude and DC offset equal to those of the transmitted signal (TP9) at TP3 1.
- Keep the previous conditions, disconnect jumper J2 in Audio Sources circuit block. Connect microphone to the Mic jack.
- Locate Audio Amplifier circuit block, connect jumpers J17b and J18a. This will connect the microphone as providing modulating signal and the modulated output can be heard through the speaker.
- Speak in the microphone, observe modulating speech signal at TP9 and modulated signal at TP1 1 through CH1 and CH2 probes of the oscilloscope.

Attachments:

Please tick the attachments you provide:

- Block diagram of the plugged in circuit with all jumper settings. ☐
- Sketch of the carrier signal. ☐

LAB No.10

Objective:

Construct an audio and video communication system consisting of audio and video sources, audio video multiplexer and demultiplexer, analog transmitter and receiver on an optical fiber.

Apparatus:

MCM 40 fiber optic communication trainer board, Individual control unit SIS3, Fiber optic cables, Jumpers, Connecting wires, Oscilloscope with two probes, Voltmeter.

Theory:

The fiber optic communication system in this experiment can be used for transmission of analog signals. Its frequency response ranges from 50 Hz to approximately 6 MHz, therefore it is suitable for transmission of video signals.

Audio and video sources are available. A sine wave of 1 kHz or the signal obtained from microphone modulates the frequency of a carrier at 5.5 MHz. The video generator generates a signal consisting of the 6 bar grey scale. These signals are multiplexed together and sent to analog driver for transmission over optical fiber.

The transmitted electric signal modulates the intensity of the optical power emitted by the source in a linear way. Therefore it is called Intensity Modulation.

The optical signal carried by the fiber is detected by the photodiode. This photodiode generates a current proportional to intensity of incident radiations. The received signal is applied to demultiplexer which consists of two filters. These filters separate audio and video signals from the applied input.

The received audio and video signals can be observed through an oscilloscope. Audio signal can also be sent to audio amplifier to be listened through a speaker.

Procedure:

- Remove all the jumpers from the MCM 40 trainer board. Connect power cables from SIS3 control unit to the MCM 40. Turn the power switch on.
- Locate Video Generator circuit block, connect the jumpers J1a, J1b and J1c. This will generate a 6 bar grey scale video signal at 15.5 kHz.
- Connect the CH1 probe of the oscilloscope to Test Point 1 (TP1) and observe the video signal with grey scale.
- Measure the following parameters of the video signal:

$V_{peak\text{-}peak}$ =________________________ V.
V_{mean} = ________________________ V.
Frequency = ____________________ kHz.
Time Period = ________________________ sec.

- Using the above parameters, sketch the 6 bar grey scale video signal and attach it with practical work book.
- Remove and connect the jumpers J1a, J1b and J1c in different combinations and observe the variations in the signal.
- Locate Audio Sources circuit block, connect jumpers J2 and J3 to apply 1 kHz sine wave to FM modulator, set Level P1 to its minimum value.
- Connect Video Generator and Video/Audio Multiplexer through jumper J5.
- Set the Modulator switch to On position.
- Connect CH1 probe to TP2 in Audio Sources circuit block to observe un-modulated signal.
- Connect CH2 probe to TP7 in Video/Audio MUX to analyze modulated signal.
- Connect jumper J6 to apply multiplexed video/audio signal to Analog Driver.
- Locate LED2 (660 nm), connect jumper J12a. This will connect the Analog Driver to LED2 for signal transmission.
- Adjust Level P2 to its intermediate position, connect voltmeter to TP15 and adjust Bias P5 to obtain a voltage of 300 mV.
- Observe the waveform at TP15.
- Now connect the LED2 to the Photodiode PD2 through the plastic fiber (cable no. 1) and ST-HP adapter.
- Connect the jumper J14b, this will apply received signal to the Analog Receiver which is internally connected to the Video/Audio Demultiplexer.
- Locate Audio Amplifier circuit block, connect jumpers J17a and J18a. This will connect the audio output to the speaker.
- Draw a block diagram of the plugged in circuit, mention all jumper settings on it. Attach the diagram with your practical workbook.
- Observe the following waveforms and measure the corresponding values using oscilloscope.

S.No.	Waveform	Frequency	$V_{peak-peak}$	Time Period	V_{mean}
1	Multiplexed video and audio signal at TP9				
2	Transmitted signal at TP1 6				
S.No.	**Waveform**	**Frequency**	$V_{peak-peak}$	**Time Period**	V_{mean}
3	Signal received by PD2 at TP24				
4	Multiplexed video and audio signal at TP32				
5	Received video signal at TP33				
6	Received and demodulated voice signal at TP35				

Troubleshooting Experience:

- Locate Faults Dip Switches, insert a fault in the circuit by setting the switch SW13 on.
- Observe the circuit parameters listed above. Which signal(s) are not available?

Answer:

- Which circuit block is not working properly?

Answer:

- Set the switch SW13 to off position and confirm the removal of fault.
- Insert another fault by setting the switch SW17 to on.
- Observe the circuit parameters listed above. Which signal(s) are not available?

Answer:

- Which circuit block is not working properly?

Answer:

- Set the switch SW13 to off position and confirm the removal of fault.

Attachments:

Please tick the attachments you provide:

- Block diagram of the plugged in circuit with all jumper settings. ☐
- Sketch of 6 bar grey scale video signal. ☐