OPTICAL FIBER
EC-701
EXPERIMENT LIST

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2 Study of 650 nm Fiber Optic Digital Link.

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Experiment 1

Objective:

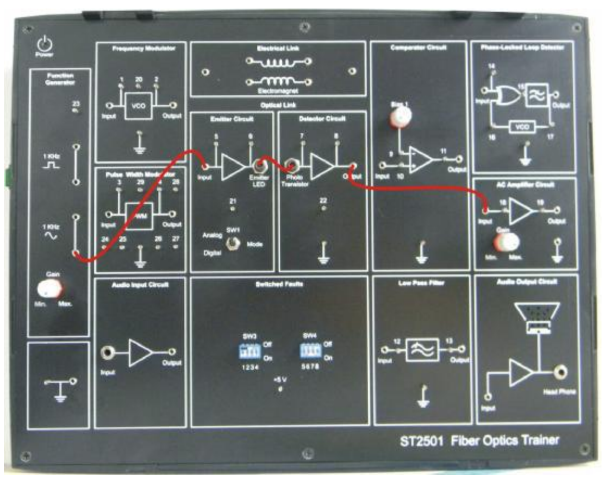
Study of 650 nm Fiber Optic Analog link.
Key Wrd- In this experiment we will study the relationship between the input signal and received signal.

Equipments Required:

1. ST2501 Trainer with power supply cord
2. Optical Fibre cable
3. Cathode ray oscilloscope with necessary connecting probe

Connection Diagram:

FIG. 1



Procedure:

1. Connect the power supply cord to the main power plug & to trainer ST2501.
2. Ensure that all switched faults are OFF.
3. Make the connections as shown in figure 1

a. Connect the function generator 1 KHz sine wave output to emitter input.
b. Connect the fiber optic cable between emitter output and detector input.
c. Connect the detector output to AC amplifier input.

4. On the board, put switch SW1 emitter driver to Analog mode.
5. Switch 'On' the power supply of the trainer and oscilloscope.
6. Observe the input to emitter (TP5) with the output from AC amplifier (TP19) on CRO.

Observation:

Both the input and output waveforms are same.

Experiment 2

Objective: Study of 650 nm Fiber Optic Digital Link.
Key Word- In this experiment we will study the relationship between the input signal and received signal.

Equipments Required:
1. ST2501 Trainer with power supply cord
2. Optical Fibre cable
3. Cathode ray oscilloscope with necessary connecting probe

Procedure:
1. Connect the power supply cord to the main power plug & to trainer ST2501.
2. Ensure that all switched faults are OFF.
3. Make the connections as shown in figure 2

a. Connect the function generator 1 KHz square wave output to emitter input
b. Connect the fiber optic cable between emitter output and detector input.
c. Connect the detector output to comparator input.
d. Connect the comparator output to AC amplifier input

4. On the board, put switch SW1 in emitter circuit to digital mode.
5. Switch 'On' the power supply of trainer and oscilloscope.
6. Monitor both the inputs to comparator (TP9 & 10). Slowly adjust the comparator bias preset, until DC level on the input (TP9) lies mid-way between the high and low level of the signal on the positive input (TP11)

Observations:
Observe the input to emitter (TP5) with the output from AC amplifier (TP19) and note that the two signals are the same.

Experiment 3

Objective: To obtain Intensity Modulation of the Analog Signal, transmit it over a fiber optic cable and demodulate the same at the receiver end to retrieve the original signal.

Equipments Required:
1. ST2501 Trainer with power supply cord
2. Optical Fibre cable
3. Cathode ray oscilloscope with necessary connecting probe

Procedure:
1. Connect the power supply cord to the main power plug & to trainer ST2501.
2. Make the connections as shown in figure 3.1.
a. Connect the Function Generator output marked 1 KHz sine wave to input of emitter.
b. Plug in a fiber optic link from output of emitter LED to the photo transistor of the detector.
c. Connect the detector output (TP 8) to input of the amplifier TP18.
3. On the board, put switch SW1 in emitter circuit to analog mode.
4. Turn the 1 KHz preset in function generator block to fully clockwise (maximum amplitude) position.
5. Switch 'On' the power supply of trainer and oscilloscope.
6. With the help of dual trace oscilloscope observe the input signal at emitter (TP 5). Also, observe the output from the detector. It should carry a smaller version of the original 1 KHz sine wave, illustrating that the modulated light beam has been reconverted back into an electrical signal.
7. The output from detector is further amplified by AC amplifier this amplifier increases the amplitude of the received signal and also removes the DC component, which is present at detector output. Monitor the output of Amplifier (TP19) and adjust the gain adjust preset until the monitored signal has the same amplitude as that applied to emitter input (TP 5)
8. While monitoring the output of Amplifier TP19 change the amplitude of modulating sine wave by varying the 1 KHz preset in the function generator block. Note that as expected, the amplitude of the receiver output signal varies.

Experiment 4

Objective: To obtain Intensity Modulation of the Digital Signal, transmit it over a fiber optic cable and demodulate the same at the receiver end to retrieve the original signal.
Equipments Required:

1. ST2501 Trainer with power supply cord
2. Optical Fibre cable
3. Cathode ray oscilloscope with necessary connecting probe

Procedure:
1. Connect the power supply cord to the main power plug & to trainer ST2501.
2. Make the connections as shown in figure 4.1.
a. Connect the 1 KHz square wave socket in function generator block to emitter input.
b. Connect an optic fiber link between emitter output & detector input with the help of the connector provided.
c. Connect the detector output to comparator non - inverting (+ve) input.
3. Put the mode switch in emitter block to digital mode. This ensures that signal applied to the driver input cause the emitter LED to switch quickly between 'On' & 'Off' states.
4. Switch 'On' the power supply of trainer and oscilloscope.
5. Examine the Input to emitter (TP5) on an oscilloscope this 1 KHz square wave is now being used to amplitude modulates emitter LED.
6. Examine the output of detector TP8. This should carry a smaller version of original 1 KHz square wave illustrating that the modulated light beam has been reconverted into an electrical signal.
7. Monitor both Input to comparator at (TP9 & 10) and slowly adjust the comparator bias preset until the DC level on the negative input (TP 9) lies midway between the high & low level of the signal on the positive input (TP10).This DC level is comparator's threshold level.
8. Examine the output of comparator at (TP11). Note that the original digital modulating signal has been reconstructed at the receiver.
9. Once again carefully flex the fiber optic cable; we can see that there is no change in output on bending the fiber. The output amplitude is now independent of the bend radius of the cable and that of length of cable, provided that detector output signal is large enough to cross the comparator threshold level. This illustrates one of the advantages of amplitude modulation of a light beam by digital rather than analog means. Also non-linear ties within the emitter LED & phototransistor causing distortion of the signal at the receiver output are the disadvantages associated with amplitude modulating a light source by analog means. Linearity is not a problem if the light beam is switched 'On' & 'Off'with a digital signal, since the detector output is simply squared up by a comparator circuit. To overcome problems associated with amplitude modulation of a light beam by analog means, analog signals are often used to vary or modulate some characteristic of a digital signal (e.g. frequency or pulse width.). The digital signal being used to switch the light beam 'On' & 'Off' The next two experiments illustrate how an analog signal can be used to modulate two specific characteristics of a digital signal

Experiment 5

Objective: Study of Frequency Modulation (FM)

Equipments Required:
1. ST2501 Trainer with power supply cord
2. Optical Fibre cable
3. Cathode ray oscilloscope with necessary connecting probe

Procedure:
1. Connect the power supply cord to the main power plug & to trainer ST2501.
2. Ensure that all switched faults are 'Off'.
3. Make the connections as shown in figure 5.1.

a. Connect the Function generator 1 KHz sine wave signal to frequency modulator input.

b. Connect the frequency modulator output TP2 to the emitter input at TP5.

c. Connect the optic fiber between the emitter circuit and the detector circuit.

d. Detector output TP 8 to comparator input at TP10.

e. Comparator output TP11 to the PLL detector input at TP14.

f. PLL detector output at TP17 to the low pass filter input at TP12.

g. Low Pass Filter output TP13 to A C Amplifier input.

4. Switch emitter driver to digital mode. This ensures that fast changing digital signal applied to the drivers input causes the emitter LED to switch quickly between 'On' & 'Off' states.
5. Turn the 1 KHz preset in the function generator block to fully anti-clockwise (zero amplitude) position.
6. Switch 'On' the power supply of trainer and oscilloscope.
7. Monitor the output of the voltage controlled oscillator (VCO) in the frequency modulator block (TP2). Note that the frequency of this digital signal is at present constant, since the modulating 1 KHz Sine wave has zero amplitude.
8. Examine the output of the detector (TP8) and check that the transmitted digital pulses are successfully detected at the receiver.
9. With the help of dual trace oscilloscope monitor both inputs to comparator. Now adjust the bias preset until the bias input at (TP9) is halfway between the top and bottom of the square wave on TP10. You will remember that the function of the

comparator is to ‘clean up’ the square wave after its transmission through the
fiber optic link.

10. The output of comparator drives the input of the PLL detector, which produces a signal whose average level is proportional to the frequency of the digital stream.

This average level is then extracted by low pass filter and amplified by AC amplifier to produce the original analog signal at the amplifiers output TP19.Examine TP19 and note that the output voltage is zero. This is expected since there is currently no modulating voltage at the transmitter.

11. While monitoring the input to the frequency modulator block TP1 and the
output from AC amplifier TP19 turn the 1 KHz preset to its fully clockwise maximum amplitude) position. Note that the modulating 1 KHz signal now appears at the amplifiers output. If necessary, adjust the amplifiers gain adjust preset until the two monitored signal are equal in amplitude.

12. In order to fully understand how this frequency modulation transmitter/ receiver system works, examine the inputs and outputs of all functional blocks within the system, using an oscilloscope.

Experiment 6

Objective: Measurement of Propagation or Attenuation Loss in the optical fiber

Equipments Required:
1. ST2501 Trainer with Power Supply Cord
2. Optical Fibre Cable
3. Cathode ray oscilloscope with necessary connecting probe

Procedure:
1. Connect power supply cord to the main power plug & to trainer ST2501.
2. Make the connections as shown in figure.
a. Function Generator 1 KHz sine wave output to input socket of emitter Circuit via 4 mm lead.
b. Connect 0.5 m optic fiber between emitter output and detector input.
c. Connect Detector output to amplifier input socket via 4mm lead.
3. Switch 'On' the power supply of trainer and oscilloscope.
4. Set the Oscilloscope channel 1 to 0.5 V/ Div and adjust 4-6 div amplitude by using X 1 probe with the help of variable potentiometer in function generator block at input of emitter.
5. Observe the output signal from detector (TP8) on CRO.
6. Adjust the amplitude of the received signal as that of transmitted one with the help of gain adjusts pot in AC amplifier block. Note this amplitude and name it $V1$.
7. Now replace the previous fiber optic cable with 1 m cable without disturbing any previous setting.
8. Measure the amplitude at the receiver side again at output of amplifier socket (TP19). Note this value end name it $V2$. Calculate the propagation (attenuation) loss with the help of following formula.

$$\frac{V_1}{V_2} = e^{-\alpha (L_1 + L_2)}$$

Where
a = loss in nepers / meter
1 nepers = 8.686 dB
L1 = length of shorter cable (0.5 m)
L2 = Length of longer cable (1 m)

Experiment 7

Objective : To measure to the Numerical Aperture (NA) of the fiber

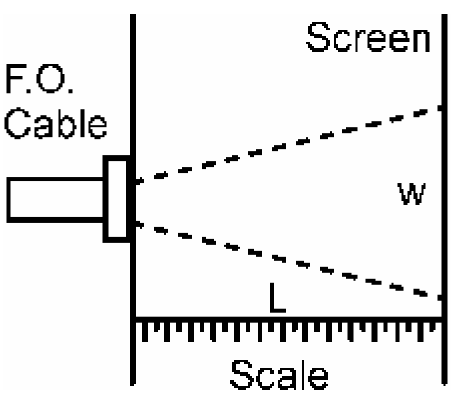
Theory : Numerical aperture refers to the maximum angle at which the light incident on the fiber end is totally internally reflected and is transmitted properly along the fiber. The cone formed by the rotation of this angle along the axis of the fiber is the cone of acceptance of the fiber. The light ray should strike the fiber end within its cone of acceptance else it is refracted out of the fiber.Consideration in NA measurement :It is very important that the optical source should be properly aligned with the cable and the distance from the launched point & cable be properly selected to ensure that the maximum amount of optical power is transferred to the cable.

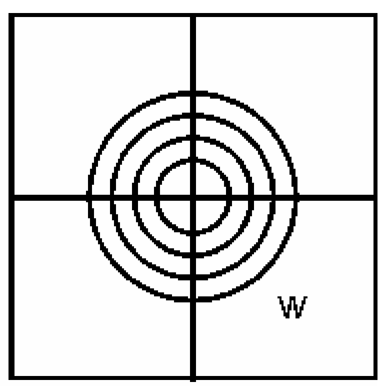
Equipment Required :
Numerical Aperture measurement Jig.

Procedure :
1. Connect power supply to the board

2. Connect 1 KHz sine wave to input of emitter circuit. Connect one end of fiber cable to the output socket of emitter circuit and the other end to the numerical aperture measurement jig. Hold the white screen facing the fiber such that its cut face is perpendicular to the axis of the fiber.

3. Hold the white screen with 4 concentric circles (10, 15, 20 & 25mm diameter) vertically at a suitable distance to make the red spot from the fiber coincide with 10 mm circle.





$$N.A. = \frac{W}{\sqrt{4L^2 + W^2}} = \text{Sin}\,\theta_{max}$$

4. Vary the distance between in screen and fiber optic cable and make it coincide with one of the concentric circles. Note its distance

5. Tabulate the various distances and diameters of the circles made on the white screen and compute the numerical aperture from the formula given above.

Inferences : The N.A. recorded in the manufacturer's data sheet is 0.5 typical. The variation in the observation is due to fiber being under filled. The Acceptance Angle is given by Sin max . The deviation from the Data sheet is again due to fiber being under filled.

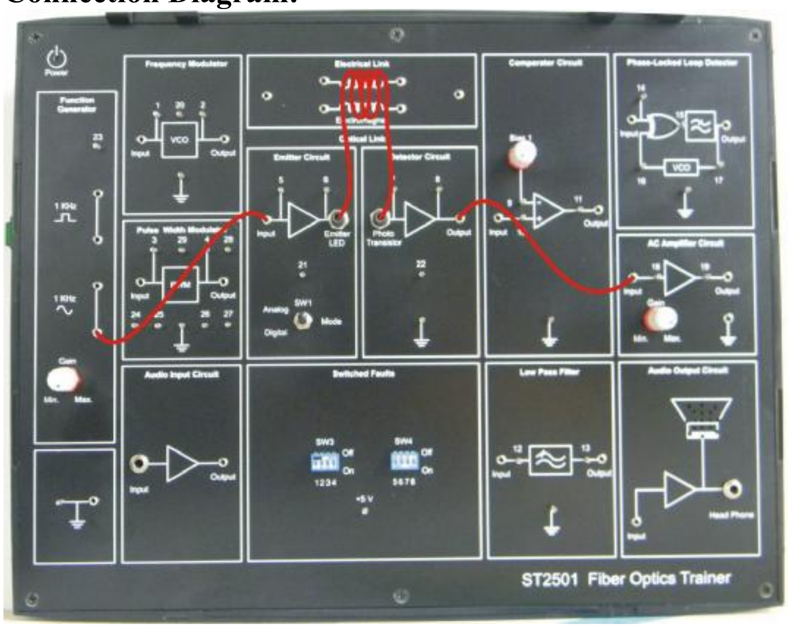
Experiment 8

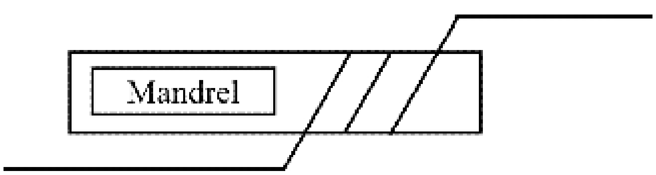
Objective: Study of Bending Loss

Equipments Required:

1. ST2501 trainer with power supply cord
2. Optical Fibre cable
3. Cathode ray oscilloscope with necessary connecting probe
4. Mandrel

Connection Diagram:





Procedure:

1. Connect power supply cord to the main power plug & to trainer ST2501.
2. Make the connections as shown in figure 8.1.

a. Function Generator 1 KHz sine wave output to input socket of emitter
Circuit via 4 mm lead.
b. Connect 0.5 m optic fiber between emitter output and detectors input.
c. Connect Detector output to amplifier input socket via 4mm lead.

3. Switch 'On' the power supply of the trainer and oscilloscope.
4. Set the Oscilloscope channel 1 to 0.5 V/ Div and adjust 4-6 div amplitude by
using X 1 probe with the help of variable pot in function generator Block at input of Emitter.

5. Observe the output signal from detector (TP8) on CRO.
6. Adjust the amplitude of the received signal as that of transmitted one with the help of gain adjusts potentiometer in AC amplifier block. Note this amplitude and name it $V1$.
7. Wind the fiber optic cable on the mandrel and observe the corresponding AC amplifier output on CRO, it will be gradually reducing, showing loss due to bends

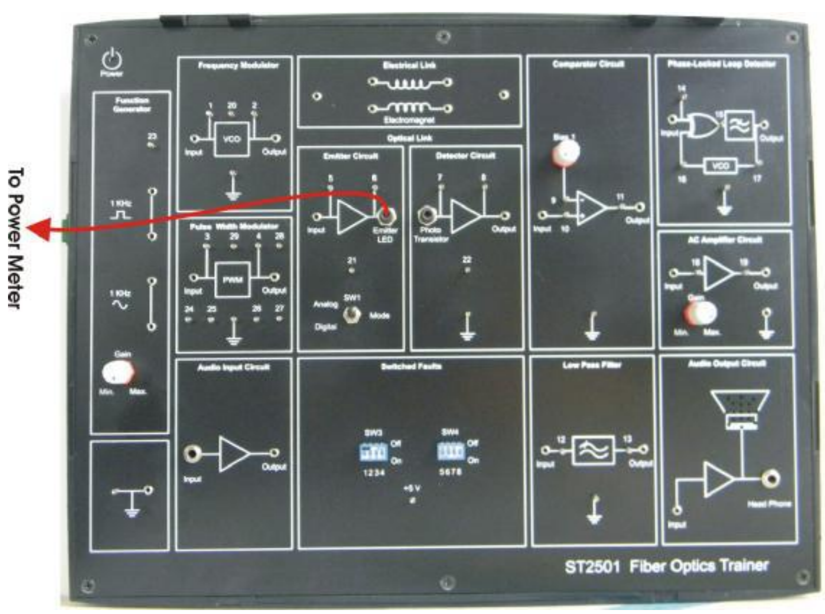
Experiment 9

Objective: Measurement of Optical Power using optical power meter

Equipments Required:

1. ST2501 trainer with power supply cord
2. Optical Fibre cable
3. Cathode ray oscilloscope with necessary connecting probe
4. Power Meter ST2551 with power supply cord

Connection Diagram:



Procedure:
1. Connect the Power supply cord to mains supply and to the trainer ST2501.
2. Ensure that all switched faults are ‘Off’.
3. Connect the fiber

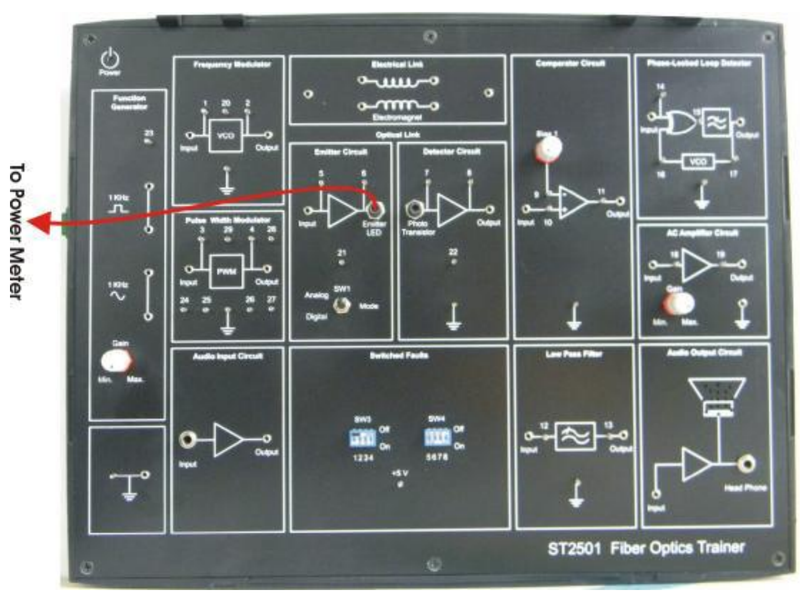
Experiment 10

Objective: Measurement of Propagation Loss in optical fiber using optical power meter

Equipments Required:

1. ST2501 Trainer with power supply cord
2. Optical Fibre cable
3. Cathode ray oscilloscope with necessary connecting probe
4. Power Meter ST2551 with power supply cord

Connection Diagram:



Procedure:

1. Connect the Power supply cord to mains supply and to the trainer ST2501.
2. Keep the mode switch in emitter circuit in analog mode.
3. Connect the 0.5m fiber cable in between the emitter LED & input of power meter.
4. Switch 'On' the power supply of trainer **ST2501& ST2551** (Keep the wavelength switch in 660 nm, position) and oscilloscope.
5. Note the reading in power meter.
6. Replace the 0.5m fiber cable with the 5 m cable without disturbing any setting.
7. Again note the reading in power. This reading will be lesser then the previous one, indicating that the propagation loss increases with increase in length.