

DEPARTMENT OF ELECTRONICS & COMMUNICATION
ENGINEERING

OPTICAL COMMUNICATION

LAB MANUAL

Dr. Gaurav Upadhyay (Laboratory Coordinator)
Semester-VI



Maulana Azad National Institute of Technology Bhopal-462003

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EXPERIMENT NO. 1

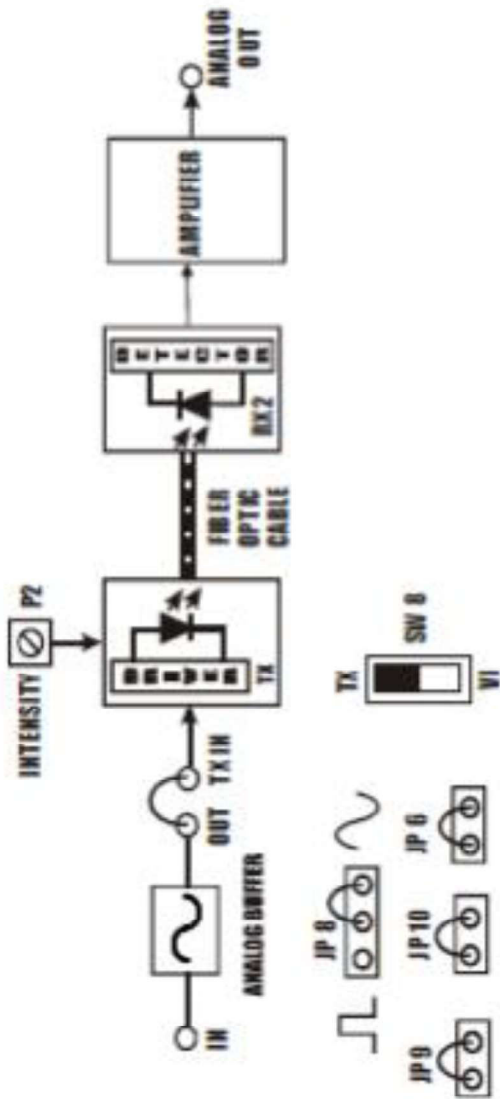
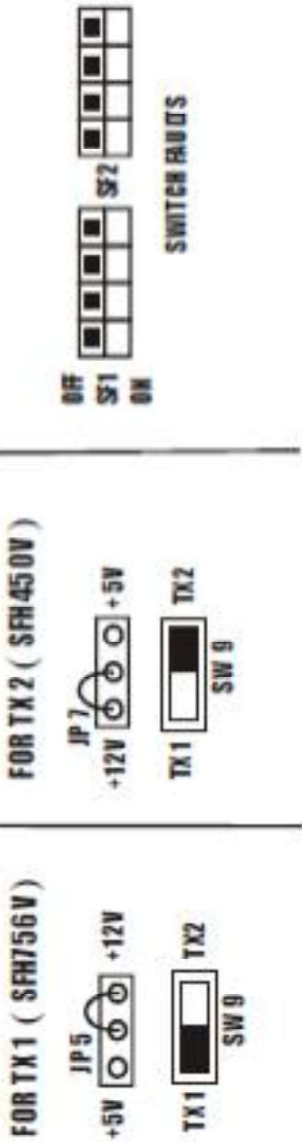


FIG. 11 BLOCK DIAGRAM FOR SETTING UP FIBER OPTIC ANALOG LINK

JUMPER SETTING DIAGRAM FOR ANALOG LINK



EXPERIMENT NO.1

NAME

Setting Up a Fiber Optic Analog Link & Bandwidth Measurement.

OBJECTIVE

The objective of this experiment is to study a 660 nm/ 950 nm Fiber Optic Analog Link. In this experiment you will study the relationship between the input signal & received signal.

THEORY

Fiber Optic Links can be used for transmission of digital as well as analog signals. Basically a fiber optic link contains three main elements, a transmitter, an optical fiber & a receiver. The transmitter module takes the input signal in electrical form & then transforms it into optical (light) energy containing the same information. The optical fiber is the medium, which carries this energy to the receiver. At the receiver, light is converted back into electrical form with the same pattern as originally fed to the transmitter.

Transmitter

Fiber optic transmitters are typically composed of a buffer, driver & optical source. The buffer electronics provides both an electrical connection & isolation between the transmitter & the electrical system supplying the data. The driver electronics provides electrical power to the optical source in a fashion that duplicates the pattern of data being fed to the transmitter. Finally the optical source (LED) converts the electrical current to light energy with the same pattern. The LED SFH756V supplied with the kit operates inside the visible light spectrum. Its optical output is centered at near visible wavelength of 660 nm. The emission spectrum is broad, so a dark red glow can usually be seen when the LED is on. The LED SFH450V supplied with the kit operates outside the visible light spectrum. Its optical output is centered at near infrared wavelength of 950 nm.

Receiver

The function of the receiver is to convert the optical energy into electrical form, which is then conditioned to reproduce the transmitted electrical signal in its original form. The detector SFH250V used in the kit has a diode type output. The parameters usually considered in the case of detector are its responsivity at peak wavelength & response time. SFH250V has responsivity of about 4 μA per 10 μW of incident optical energy at 950 nm and it has rise& fall time of 0.01 μsec .

PIN photodiode is normally reverse biased. When optical signal falls on the diode, reverse current starts to flow, thus diode acts as closed switch and in the absence of light intensity, it acts as an open switch. Since PIN diode usually has low responsivity, a trans impedance amplifier is used to convert this reverse current into voltage. This voltage is then amplified with the help of another amplifier circuit. This voltage is the duplication of the transmitted electrical signal, which can be amplified.

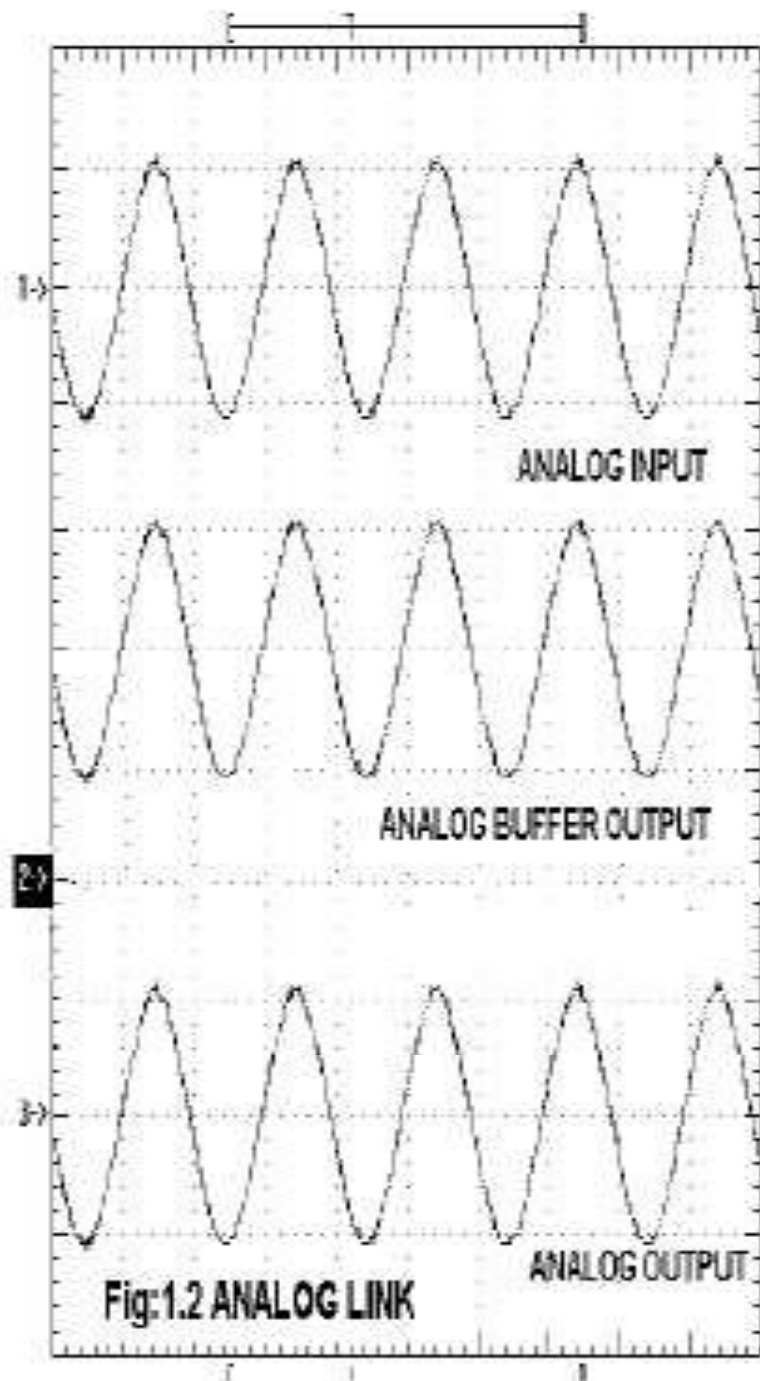
EQUIPMENTS

- FOL-A-P Kit with power supply
- Patch chords
- 20MHz Dual Channel Oscilloscope
- Function Generator
- 1-Meter Fiber Cable

NOTE: Keep Switch Faults In Off Position

PROCEDURE

- Make connections as shown in **FIG.1.1**. Connect the power supply cables with proper polarity to FOL-A-P Kit. While connecting this, ensure that the power supply is OFF.
- Keep switch **SW8** towards **TX** position.
- Keep switch **SW9** towards **TX1** position.
- Keep Jumper **JP5** towards **+12V** position.
- Keep Jumpers **JP6, JP9, JP10** shorted.
- Keep Jumper **JP8** towards **sine** position.
- Keep Intensity control pot **P2** towards **minimum** position.
- Switch ON the power supply.
- Feed about **2Vpp** sinusoidal signal of **1KHz** from the function generator to the **IN** post of Analog Buffer.
- Connect the output post **OUT** of Analog Buffer to the post **TX IN** of Transmitter.
- Slightly unscrew the cap of SFH756V (660nm). Do not remove the cap from the connector. Once the cap is loosened, insert the one-meter fiber into the cap. Now tighten the cap by screwing it back.
- Connect the other end of the Fiber to detector SFH350V (Photo Transistor Detector) very carefully as per the instructions in above step.
- Observe the detected signal at post **ANALOG OUT** on oscilloscope as shown in **FIG 1.2**. Adjust Intensity control pot **P2** Optical Power control potentiometer so that you receive signal of 2Vpp amplitude.
- To measure the analog bandwidth of the phototransistor, vary the input signal frequency and observe the detected signal at various frequencies.
- Plot the detected signal against applied signal frequency and from the plot determine the 3dB down frequency.
- Repeat the same procedure as above for second transmitter SFH450V by making the following changes. Analog bandwidth of SFH350 for TX1 SFH756 is about 300 KHz while for TX2 SFH450 is below 300 KHz.
- Keep switch **SW9** towards **TX2** position.
- Keep Jumper **JP7** towards **+12V** position.



Analog Bandwidth Measurement

PROCEDURE

- Make connections as shown in **FIG.1.1**. Connect the power supply cables with proper polarity to FOL-A-P Kit. While connecting this, ensure that the power supply is OFF.
- Keep switch **SW8** towards **TX** position.
- Keep switch **SW9** towards **TX1** position.
- Keep Jumper **JP5** towards **+12V** position.
- Keep Jumpers **JP6, JP9, JP10** shorted.
- Keep Jumper **JP8** towards **sine** position.
- Keep Intensity control pot **P2** towards **minimum** position.
- Switch ON the power supply.
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- Connect the output post **OUT** of Analog Buffer to the post **TX IN** of Transmitter.
- Slightly unscrew the cap of SFH756V (660nm). Do not remove the cap from the connector. Once the cap is loosened, insert the one-meter fiber into the cap. Now tighten the cap by screwing it back.
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- Keep switch **SW9** towards **TX2** position.
- Keep Jumper **JP7** towards **+12V** position.

EXPERIMENT NO. 2

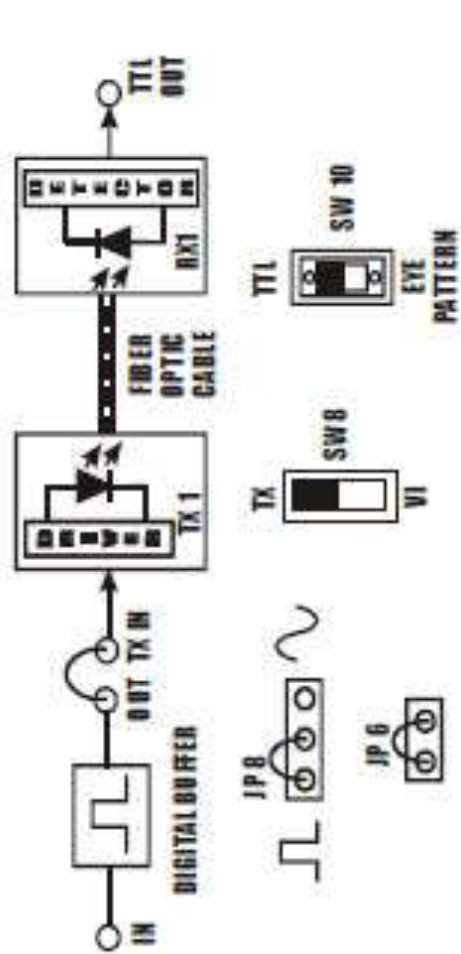
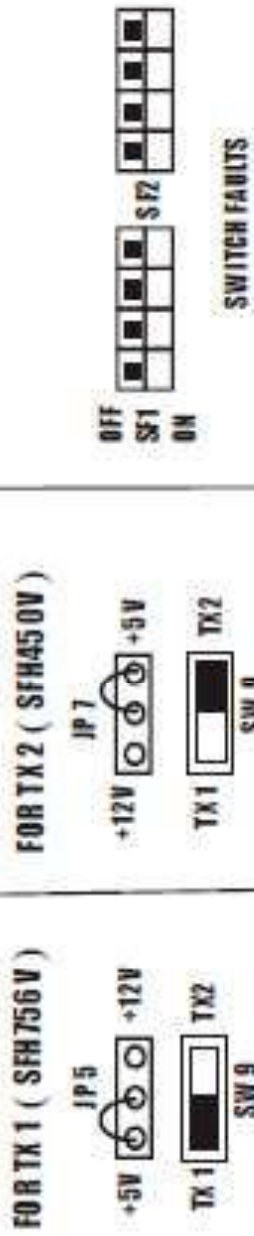


FIG. 2.1 BLOCK DIAGRAM FOR SETTING UP FIBER OPTIC DIGITAL LINK

JUMPER SETTING DIAGRAM FOR DIGITAL LINK



EXPERIMENT NO. 2

NAME

Setting Up a Fiber Optic Digital Link

OBJECTIVE

The objective of this experiment is to study a 660nm & 950nm Fiber Optic Digital Link. Here you will study how digital Signal can be transmitted over Fiber Cable & reproduced at the receiver end.

THEORY

In the Experiment No.1 we have seen how analog signals can be transmitted & received using LED, Fiber & Detector can be configured for the digital applications to transmit binary data over Fiber. Thus basic elements of the link remain same even for digital application.

Transmitter

LED, digital DC coupled transmitters are one of the most popular varieties due to their ease of fabrication. We have used a standard TTL gate to drive a NPN transistor, which modulates the LED SFH450V or SFH 756V source (Turns it on & off).

Receiver

SFH-551V is a digital opto-detector. It delivers a digital output, which can be processed directly with little additional external circuitry. The integrated circuit inside the SFH551V opto-detector comprises the photodiode device, a trans-impedance amplifier, a comparator and a level shifter. The photodiode converts the detected light into a photocurrent. With the aid of an integrated lens the light emanating from the plastic Fiber is almost entirely focused on the surface of the diode. At the next stage the trans-impedance amplifier converts the photocurrent into a voltage. In the comparator, the voltage is compared to a reference voltage. In order to ensure good synchronism between the reference and the trans-impedance output voltage, the former is derived from a second circuit of a similar kind, which incorporates a "blind" photodiode. The comparator derives a level shifter with an open collector output stages. Here a catch diode (similar to Schottky-TTL) prevents the saturation of the output transistor, thus limiting the output voltage to the supply voltage.

EQUIPMENTS

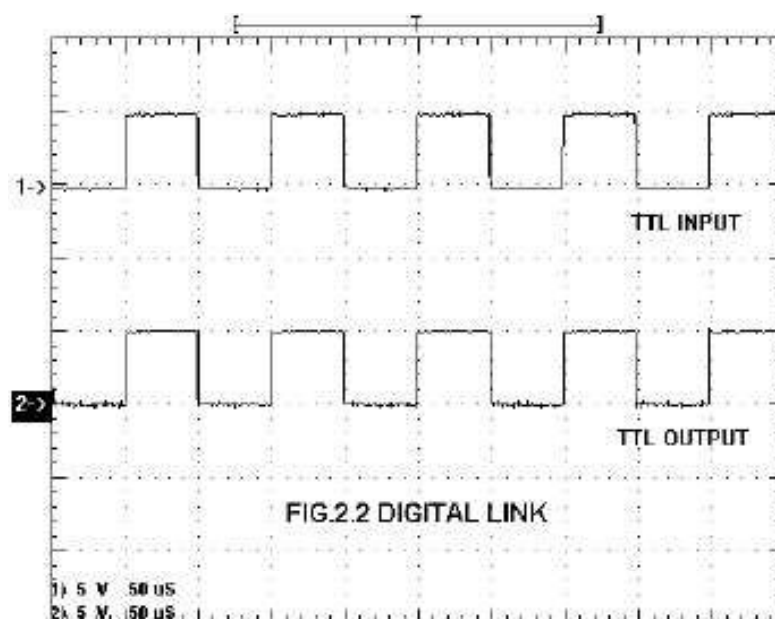
- FO-A-P Kit with power supply
- Patch chords
- 20MHz Dual Channel Oscilloscope
- Function Generator
- 1-Meter Fiber Cable

NOTE: Keep All Switch Faults In Off Position.

PROCEDURE

- Make connections as shown in **FIG.2.1**. Connect the power supply cables with proper polarity to FO-A-P Kit. While connecting this, ensure that the power supply is OFF.
- Switch ON the power supply.
- Feed **TTL** Square wave signal of **1KHz** from the function generator to the **IN** post of Digital Buffer.
- Connect the output post **OUT** of Digital Buffer to the post **TX IN** of Transmitter.
- Slightly unscrew the cap of SFH756V (660nm). Do not remove the cap from the connector. Once the cap is loosened, insert the One Meter Fiber into the cap. Now tighten the cap by screwing it back.
- Connect the other end of the Fiber to detector SFH551V very carefully as per the instructions in above step.
- Observe the detected signal at post **TTL OUT** on oscilloscope as shown in **FIG 2.2**.
- To measure the digital bandwidth of the phototransistor vary the input signal frequency and observe the detected signal at various frequencies.
- Determine the frequency at which the detector stops recovering the signal.
- This determines the maximum bit rate on the digital link.
- Keep switch **SW9** towards **TX2** position.
- Keep Jumper **JP7** towards **+5V** position.
- Repeat the same procedure above for second transmitter SFH450V by making the following changes.
- The digital bandwidth of SFH551 for TX1 SFH756 is 3MHz & for SFH450 it is 1MHz.

WAVEFORM



Measurement of Digital Bandwidth

PROCEDURE

- Make connections as shown in **FIG.2.1**. Connect the power supply cables with proper polarity to FO-A-P Kit. While connecting this, ensure that the power supply is OFF.
- Switch ON the power supply.
- Feed **TTL** Square wave signal of **1KHz** from the function generator to the **IN** post of Digital Buffer.
- Connect the output post **OUT** of Digital Buffer to the post **TX IN** of Transmitter.
- Slightly unscrew the cap of SFH756V (660nm). Do not remove the cap from the connector. Once the cap is loosened, insert the One Meter Fiber into the cap. Now tighten the cap by screwing it back.
- Connect the other end of the Fiber to detector SFH551V very carefully as per the instructions in above step.
- Observe the detected signal at post **TTL OUT** on oscilloscope as shown in **FIG 2.2**.
- To measure the digital bandwidth of the phototransistor vary the input signal frequency and observe the detected signal at various frequencies.
- Determine the frequency at which the detector stops recovering the signal.
- This determines the maximum bit rate on the digital link.
- Keep switch **SW9** towards **TX2** position.
- Keep Jumper **JP7** towards **+5V** position.
- Repeat the same procedure above for second transmitter SFH450V by making the following changes.
- The digital bandwidth of SFH551 for TX1 SFH756 is 3MHz & for SFH450 it is 1MHz.

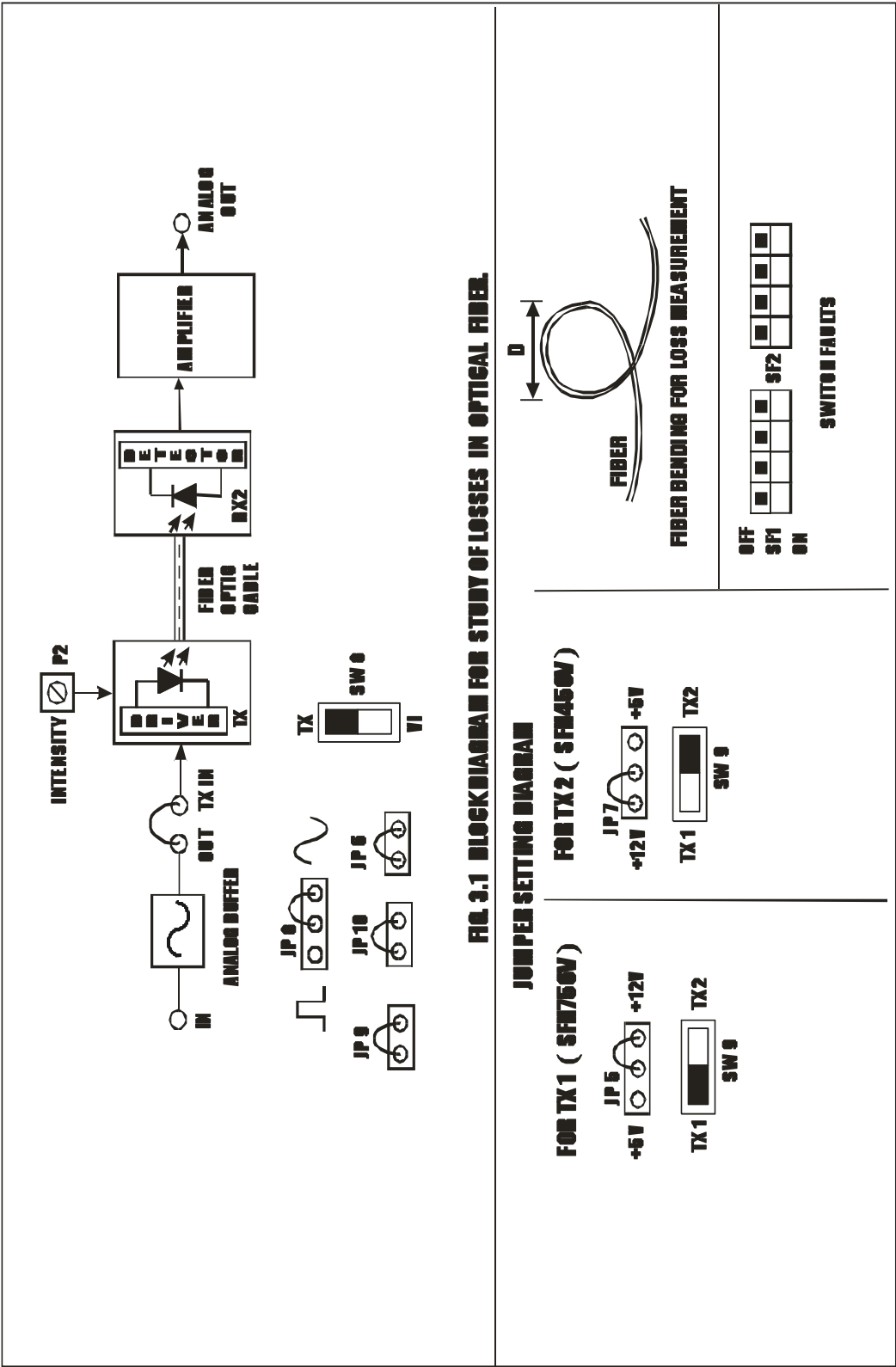
Calculation for Digital bandwidth

Cut off frequency = MHz

Bandwidth = 2 x cut-off frequency

= Mbps

EXPERIMENT NO. 3



EXPERIMENT NO.3

NAME

Study of Losses in Optical Fiber

OBJECTIVE

The objective of this experiment is to measure propagation loss & bending losses for two different wavelengths in plastic Fiber provided with the kit.

THEORY

Optical Fibers are available in different variety of materials. These materials are usually selected by taking into account their absorption characteristics for different wavelengths of light. In case of Optical Fiber, since the signal is transmitted in the form of light, which is completely different in nature as that of electrons, one has to consider the interaction of matter the radiation to study the losses in fiber. Losses are introduced in fiber due to various reasons. As light propagates from one end of Fiber to another end, part of it is absorbed in the material exhibiting absorption loss. Also part of the light is reflected back or in some other directions from the impurity particles present in the material contributing to the loss of the signal at the other end of the Fiber. In general terms it is known as propagation loss. Plastic Fibers have higher loss of the order of 180 dB/Km Whenever the condition for angle of incidence of the incident lights is violated the losses are introduced due to refraction of light. This occurs when fiber is subjected to bending. Lower the radius of curvature more is the loss. Other losses are due to the coupling of Fiber at LED & photo detector ends.

EQUIPMENTS

- FO-A-P Kit with power supply
- Patch chords
- 20MHz Dual Channel Oscilloscope
- Function Generator
- 1 & 3-Meter Fiber Cable

NOTE: Keep All Switch Faults In Off Position.

PROCEDURE

- Make connections as shown in **FIG.3.1**. Connect the power supply cable with proper polarity to FO-A-P Kit. While connecting this, ensure that the power supply is OFF.
- Keep **SW9** towards **TX1** position for SFH756
- Keep jumpers & **SW8** positions as shown in **FIG.3.1**.
- Keep Intensity control pot **P2** towards **minimum** position.
- Switch ON the power supply.

- Feed about 2Vpp sinusoidal signal of 1KHz from the function generator to the **IN** post of Analog Buffer.
- Connect the output post **OUT** of Analog Buffer to the post **TX IN** of Transmitter.
- Slightly unscrew the cap of SFH756V (660nm). Do not remove the cap from the connector. Once the cap is loosened, insert the 1 Meter Fiber into the cap. Now tighten the cap by screwing it back.
- Connect the other end of the Fiber to detector SFH350V (Photo Transistor Detector) very carefully as per the instructions in above step.
- Observe the detected signal at post **ANALOG OUT** on oscilloscope.
- Adjust Intensity control pot **P2** Optical Power control potentiometer so that you receive signal of 2Vpp amplitude.
- Measure the peak value of the received signal at ANALOG OUT terminal.
- Let this value be V1.
- Now replace 1 meter Fiber by 3 Meter Fiber between same LED and Detector. Do not disturb any settings. Again take the peak voltage reading and let it be V2.
- If α is the attenuation of the Fiber then we have.

$$\alpha_{dB} = (10/L1-L2) \log_{10} (V2/V1)$$
 Where α = dB / Km,
 L1 = Fiber Length for V1
 L2 = Fiber Length for V2
 This α is for peak wavelength of 660nm
- Now switch off the power supply.
- Keep **SW9** towards **TX1** position for SFH756
- Set the jumpers to form simple analog link using LED SFH450V at 950nm and phototransistor SFH350V (Photo Transistor Detector) with 1 meter Fiber Cable.
- Switch on the power supply.
- Repeat the same procedure as above again for this link to get α at 950nm.
- Compare the two α values.

Measurement of Bending Losses

- Set up the 660 nm analog link using 1-meter fiber as per procedure above.
- Bend the Fiber in a loop. (As shown in **FIG. 3.1**) measure the amplitude of the received signal
- Keep reducing the diameter of bend to about 2 cm & take corresponding out voltage readings. (Do not reduce loop diameter less than 1 cm).
- Plot a graph of the received signal amplitude versus the loop diameter.
- Repeat the procedure again for second transmitter.

L1 = 1meter fiber L2 = 3meter fiber

V1_o/p voltage at L1	V2_o/p voltage at L2	$\propto$ dB

EXPERIMENT NO. 4

EXPERIMENT NO. 4

NAME

Study of Numerical Aperture Of Optical Fiber

OBJECTIVE

The objective of this experiment is to measure the numerical aperture of the plastic Fiber provided with the kit using 660nm wavelength LED.

THEORY

Numerical aperture refers to the maximum angle at the light incident on the fiber end is totally internally reflected and is transmitted properly along the Fiber. The cone formed by the rotations 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 core.

Consideration In A Measurement

- It is very important that the source should be properly aligned with the cable & the distance from the launched point & the cable be properly selected to ensure that the maximum amount of Optical Power is transferred to the cable.
- This experiment is best performed in a less illuminated room.

EQUIPMENTS

FO-A-P Kit with power supply
Patch chords
1-Meter Fiber Cable
Numerical aperture measurement Jig
Steel Ruler

NOTE: Keep All Switch Faults In Off Position.

PROCEDURE

- Make connections as shown in **FIG.4.1**. Connect the power supply cables with proper polarity to FO-A-P Kit. While connecting this, ensure that the power supply is OFF.
- Keep Intensity control pot **P2** towards **minimum** position.
- Keep Bias control pot **P1** fully clockwise position.
- Switch ON the power supply.
- Slightly unscrew the cap of SFH756V (660nm). Do not remove the cap from the connector. Once the cap is loosened, insert the 1 Meter Fiber into the cap. Now tighten the cap by screwing it back.
- Insert the other end of the Fiber into the numerical aperture measurement fig. Adjust the fiber such that its cut face is perpendicular to the axis of the Fiber.
- Keep the distance of about 5mm between the fiber tip and the screen.
- Gently tighten the screw and thus fix the fiber in the place.
- Increase the intensity pot **P2** to get bright red light circular patch.
- Now observe the illuminated circular patch of light on the screen.
- Measure exactly the distance **d** and also the vertical and horizontal diameters **MR** and **PN** as indicated in the **FIG. 4.1**.
- Mean radius is calculated using the following formula
- **$r = (MR+PN)/4$**
- Find the numerical aperture of the Fiber using the formula

$$NA = \sin \theta_{\max} = r / \sqrt{d^2 + r^2}$$

Where $\theta_{\max}$ is the maximum angle at which the light incident is properly transmitted through the fiber.

$$d=OA \quad r= (MR+PH) / 4$$

MR (mm)	PH (mm)	$r = (MR + PH)/4$	d=OA	NA

EXPERIMENT NO. 5

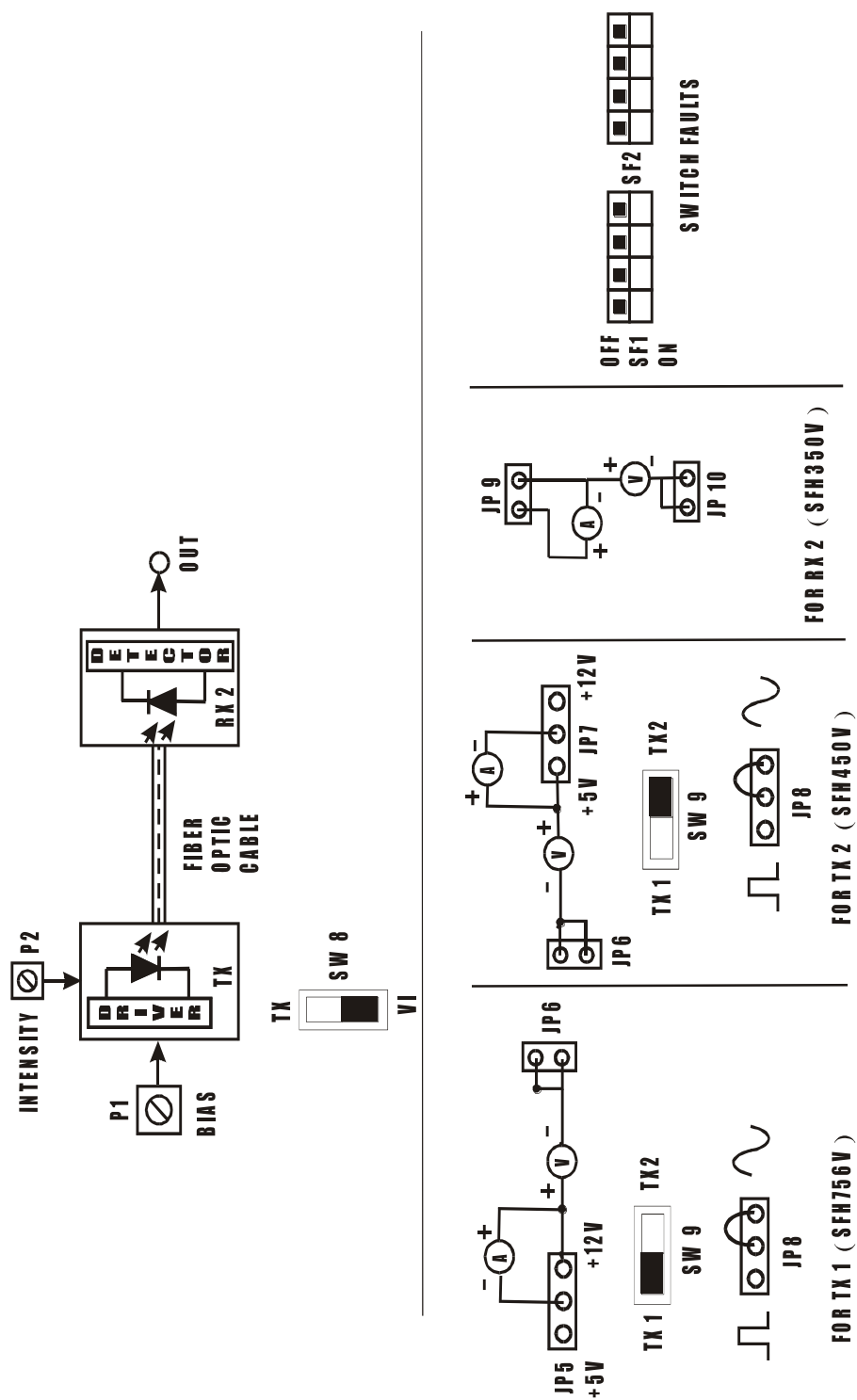


FIG.5.1 BLOCK DIAGRAM FOR CHARACTERISTICS OF FIBER OPTIC LED'S AND DETECTORS.

EXPERIMENT NO. 5

NAME

Study of Characteristics of Fiber Optic LED and Photo detector

OBJECTIVE

To study the characteristics of Fiber Optic LEDs and plot the graph of forward current v/s output optical energy and also to study the photodetector response

THEORY

In Optical Fiber communication system, Electrical signal is first converted into optical signal with the help of E/O conversion device such as LED. After this optical signal is transmitted through Optical Fiber, it is retrieved in its original electrical form with the help O/E conversion device such as photodetector. Different technologies employed in chip fabrication lead to significant variation in parameters for the various emitter diodes. All the emitters distinguish themselves in offering high output power coupled into the important peak wavelength of emission, conversion efficiency (usually specified in terms of power launched in optical Fiber peak wavelength of emission, conversion efficiency (usually specified in terms of power launched in optical Fiber for specified forward current) optical rise and fall times which put the limitation on operating frequency, maximum forward current through LED and typical forward voltage across LED. Photodetectors usually comes in variety of forms photoconductive, photo voltaic, transistor type output and diode type output. Here also characteristics to be taken into account are response time of the detector which puts the limitation on the operating frequency, wavelength sensitivity and responsivity.

EQUIPMENTS

FO-A-P Kit with power supply
Patch chords
Jumper to Crocodile connectors
1-Meter Fiber Cable
Voltmeter and Current meter 2Nos. each

NOTE: Keep All Switch Faults In Off Position.

PROCEDURE

- Make connections as shown in **FIG.5.1**. Connect the power supply cables with proper polarity to FO-A-P Kit. While connecting this, ensure that the power supply is OFF.
- Keep switch **SW8** towards **VI** position.
- Keep switch **SW9** towards **TX1** position.
- Keep Jumper **JP8** towards **sine** position.
- Keep Bias control pot **P1** towards **maximum** position & **P2** towards **minimum** position.
- Insert the jumper to crocodile connecting wires (provided along with the kit) in jumper **JP5, JP6, JP9** and **JP10** at positions shown in the fig 5.1.
- Connect the voltmeter and current meter with proper polarities to abovementioned jumpers.
- Switch ON the power supply.
- Slightly unscrew the cap of SFH756V (660nm). Do not remove the cap from the connector. Once the cap is loosened, insert the 1 Meter Fiber into the cap. Now tighten the cap by screwing it back.
- Connect the other end of the Fiber to detector SFH350V (Photo Transistor Detector) very carefully as per the instructions in above step.
- Vary intensity control pot **P2** to control current flowing through the LED.
- To get the V-I characteristics of LED, rotate **P2** slowly and measure forward current and corresponding forward voltage. Take number of such readings for various current values and plot V-I characteristics graph for the LED.
- For each reading taken above, find out the power, which is product of V and I. This is the electrical power supplied to the LED. Data sheets for the LED specify optical power coupled into plastic fiber when forward current was 10mA as 200uW. This means that the electrical power at 10mA current is converted into 200uW of optical energy. Hence the efficiency of the LED comes out to be approximately 1.15%.
- With this efficiency assumed, find out optical power coupled into plastic Optical Fiber for each of the reading. Plot the graph of forward current v/s output optical power of the LED.
- Data sheets for the phototransistor detector specified responsivity as 0.8mA for 10uW of incident optical energy.
- Find out the current flowing through phototransistor and voltage across it.
- Plot the graph for the responsivity of phototransistor. Find out the portion where detector response is linear.
- Insert the jumper to crocodile connecting wires (provided along with the kit) in jumper **JP5, JP7, JP8, JP9, JP10** at positions shown in the fig 5.1 and
- Repeat the same procedure & plot the graph for SFH450V.

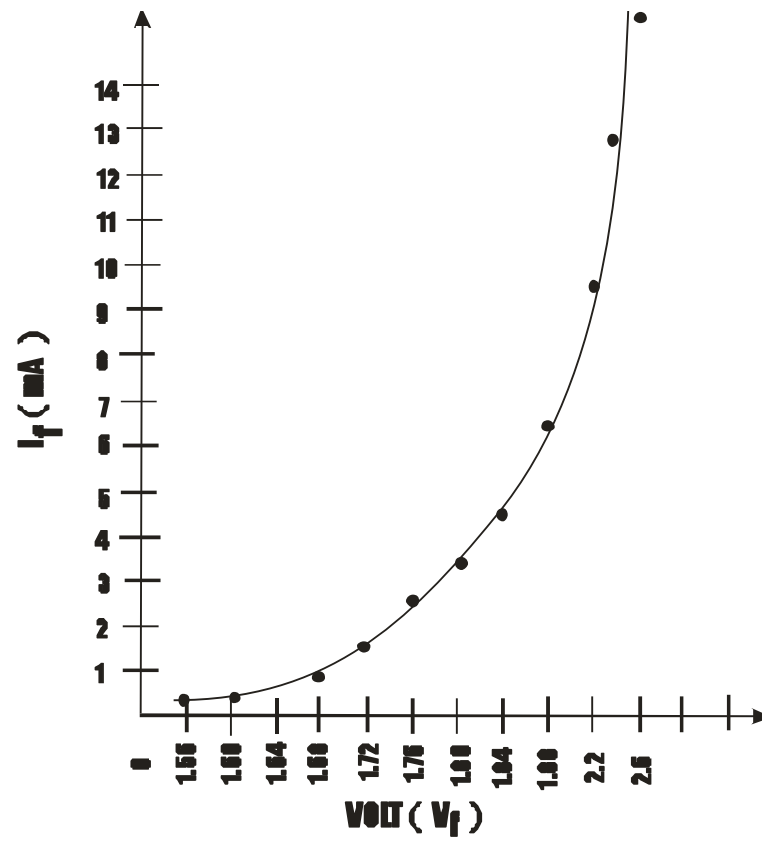
Table For VI Characteristics Of Fiber Optic Led Sfh756v & Detector SFH350v

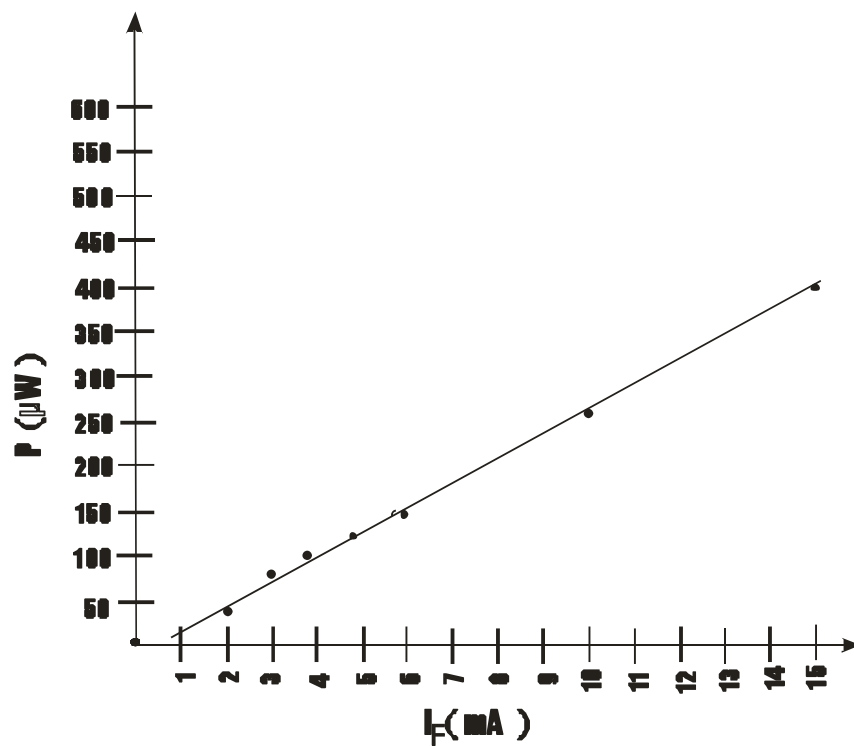
Vf Forward Voltage Of LED SFH756 (V)	If Forward Current of LED SFH756V (mA)	Electrical Power Pi = V * I (mW)	Optical Power of LED 756V Po = Pi * 1.15% (μW)	O/P Current Of SFH350 (mA)	Responsivity $R = \frac{0.8mA \cdot Po}{10uW}$ (mA)
1.565	0.223	0.349	4	0.06	0.32
1.600	0.397	0.635	7.3	0.143	0.584
1.640	0.728	1.19	13.6	0.335	1.088
1.680	1.165	1.2	13.8	0.64	1.1
1.720	1.67	2.87	33	1	2.64
1.760	2.23	3.92	45	1.45	3.6
1.800	2.8	5	57.5	1.96	4.6
1.86	3.8	7	80.5	2.76	6.4
1.9	4.5	8.5	97.7	3.36	7.86
1.960	5.4	10.58	122	4.21	9.76
2	6.2	12.4	142.6	4.85	11.40
2.2	10	22	253	8.6	20.24
2.3	15	34.5	396.75	13.3	31.7
2.38	22.4	53.3	613	19.8	49.9
2.42	27	65	751	23.5	60

(Above readings are for reference)

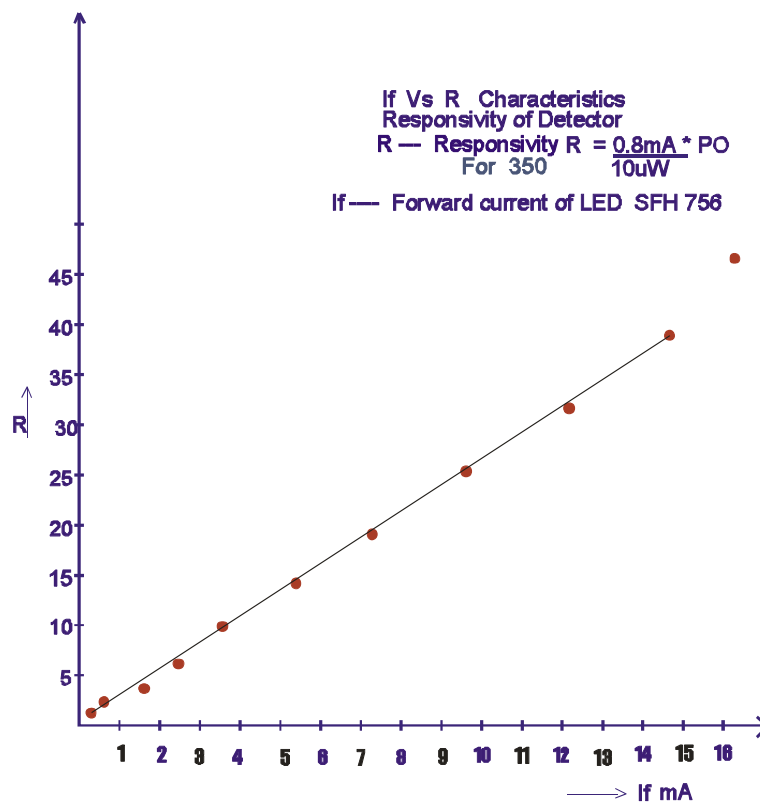
Table For VI Characteristics Of Fiber Optic Led Sfh 450v & Detector Sfh350v

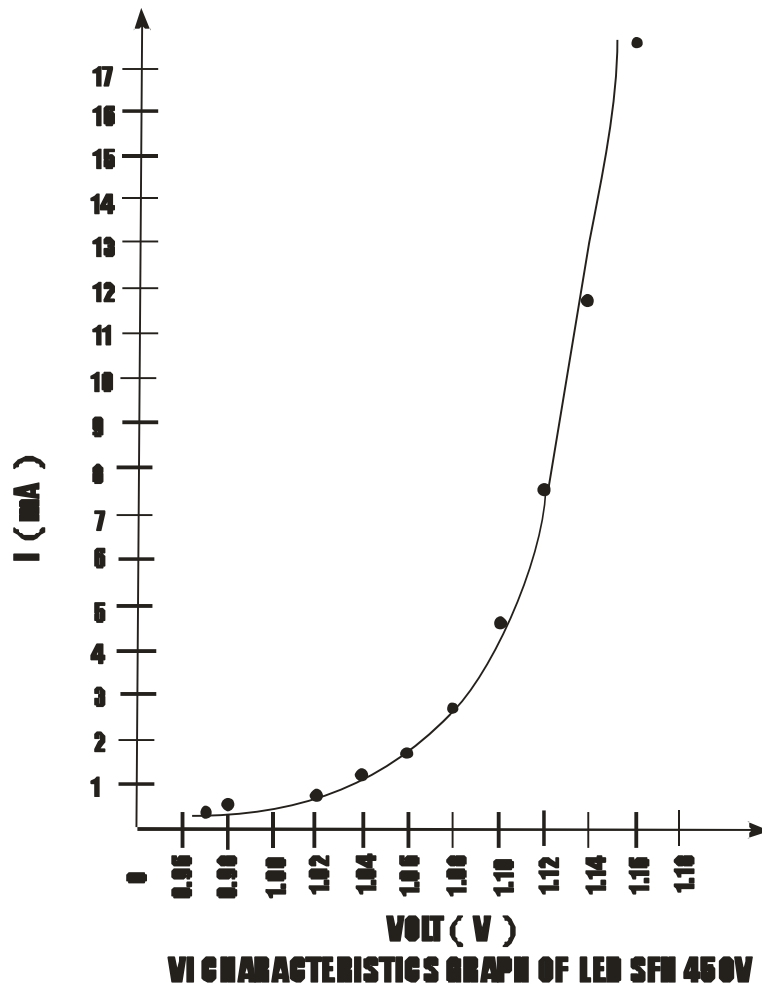
Vf Forward Voltage Of LED SFH450V	If Forward Current of LED SFH450V	Electrical Power Pi = V * I	Optical Power of LED 450V PO = Pi * 1.15%	O/P Current Of SFH350	Responsivity $R = \frac{0.8 \text{mA} \cdot PO}{10 \mu\text{W}}$
(V)	(mA)	(mW)	(μW)	(mA)	(mA)

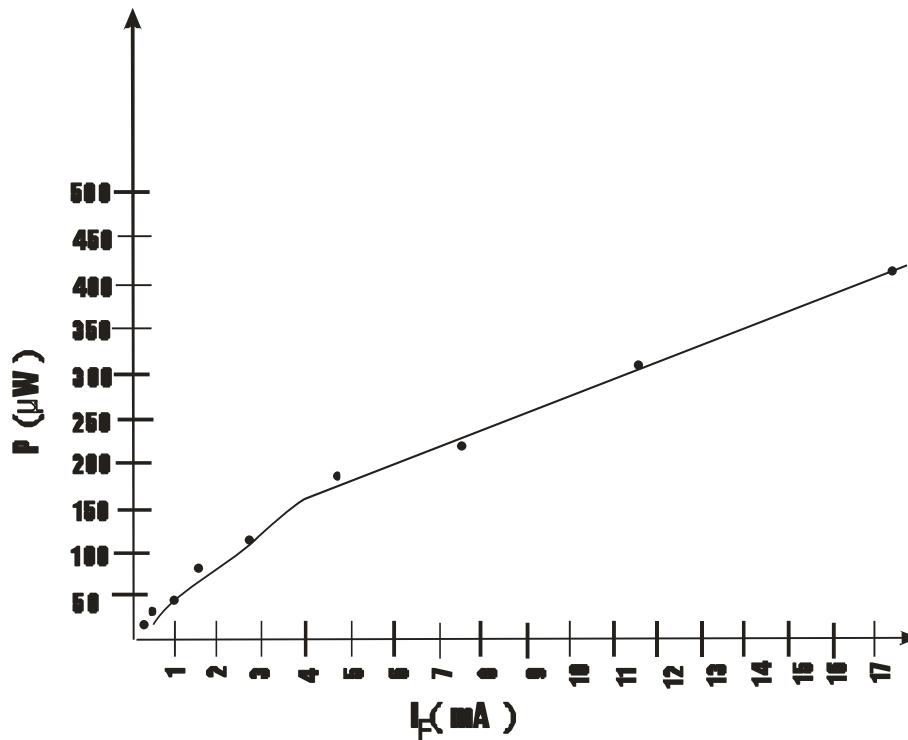
**V-I CHARACTERISTICS GRAPH OF LED SFH756V**



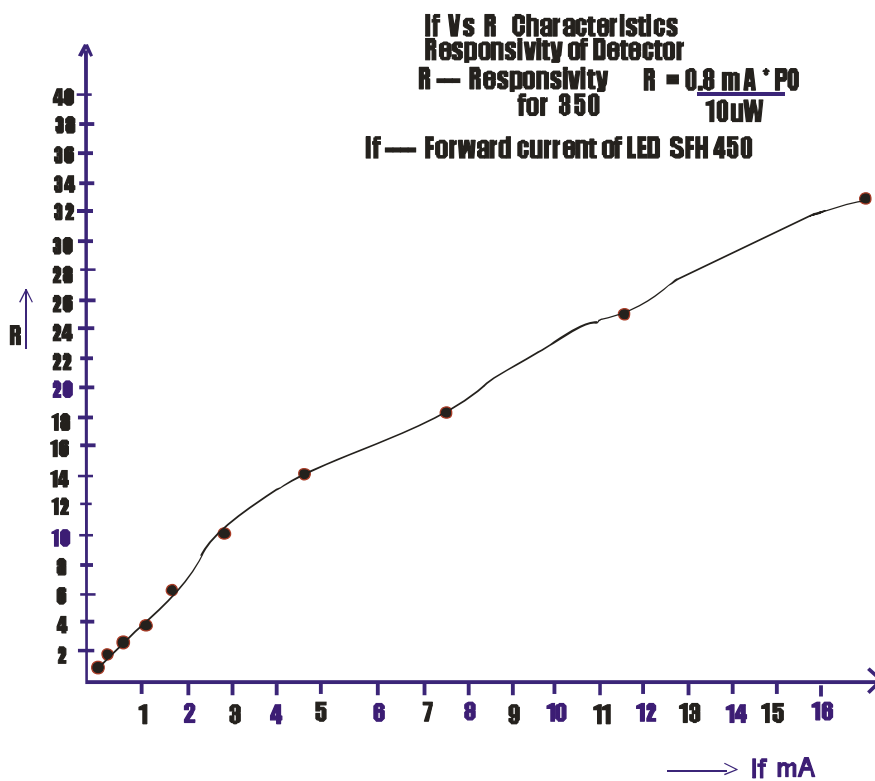
OPTICAL POWER VERSUS CURRENT GRAPH OF LED SFH756V







OPTICAL POWER VERSUS CURRENT GRAPH OF LED SFH 450V



EXPERIMENT NO. 6

EXPERIMENT NO. 6

NAME

Study of Time Division Multiplexing

OBJECTIVE

The objective of this experiment is to study simultaneous transmission of several signals using time division multiplexing.

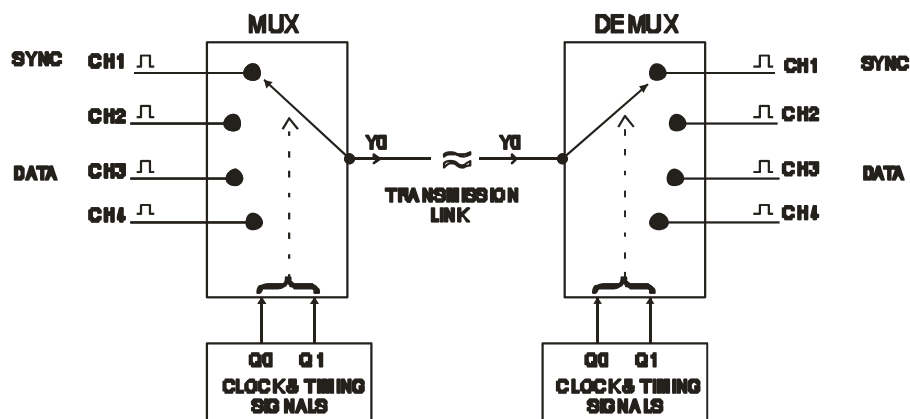
THEORY

In TDM various signals are sampled and transmitted for a fixed duration of time one after the other. At the receiving end, these signals are extracted in the same order & form of transmission.

TDM MUX

Using this technique, more number of data channels can be transmitted on a single transmission link. Hence multiplexing is also termed as Many I/P One O/P logic. The time slot for each channel repeats after regular intervals.

The above definition is explained with the help of an example given below:



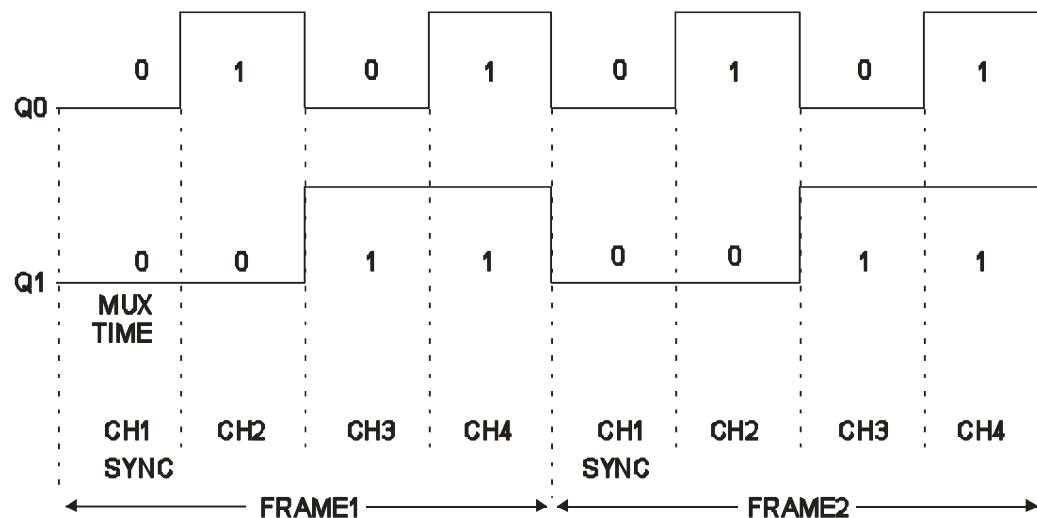
TDM COMMUNICATION

Suppose we need to transmit four channels on a single link, the TDM process is used as shown. CH1, CH2, CH3, CH4 are the four channels, Q0 & Q1 are the channel selection signals (Clock & Timing section). Depending on the condition of Q0, Q1 the channels are selected one by one. The 1st channel of the four is used to carry sync information. Then the data channels are selected sequentially.

The channel selection takes place as shown in table below:

Q1	Q0	CH1	CH2	CH3	CH4	Y0 (MUX OUTPUT)
0	0	✓				CH1
0	1		✓			CH2
1	0			✓		CH3
1	1				✓	CH4
0	0	✓				CH1

Now all the channels are multiplexed on a single link & are transmitted over the communication link.



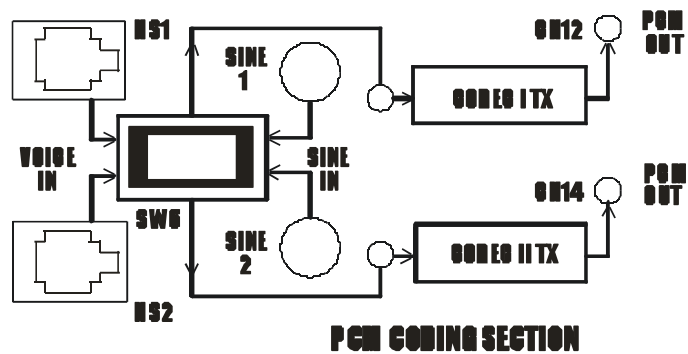
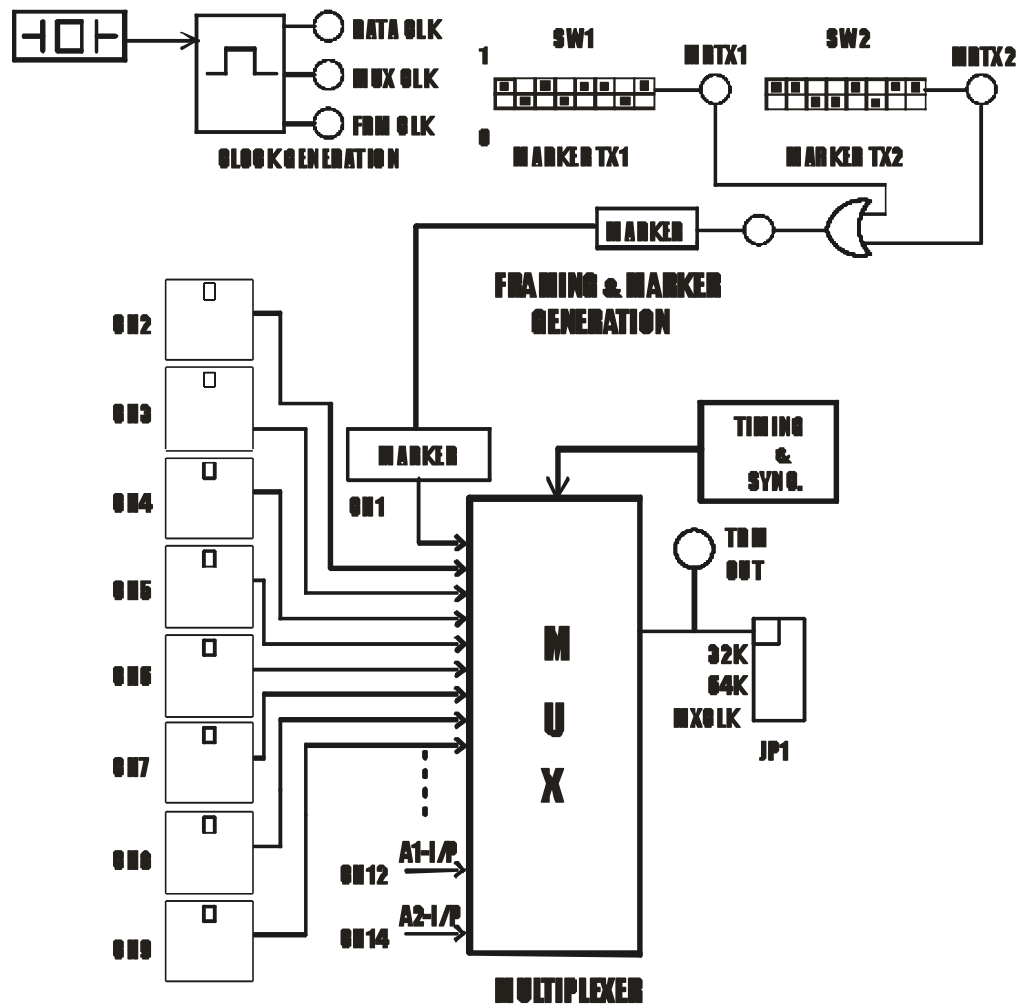
TDM DEMUX

At the receiver the same process is carried out to direct the information on corresponding receiving channels. Now as explained in previous section Q0, Q1 are selection clocks and Y0 is MUX data.

Data	Q1	Q0	CH1	CH2	CH3	CH4
Y0	0	0	Y0			
	0	1		Y0		
	1	0			Y0	
	1	1				Y0
	0	0	Y0			

The Q0 & Q1 here in demux section are used to select the channel where the mux output Y0 will be directed. Depending upon the condition of Q0 & Q1 the mux signal Y0 will be directed to CH1, CH2, and CH3 & CH4. The channel one carries the sync information & the rest channels carry the actual information.

EXPERIMENT NO. 7



EXPERIMENT NO. 7

NAME

Study of 16-Channel Digital TDM Generation

OBJECTIVE

The objective of this experiment is to study the technique of generation of TDM data.

THEORY

The basic TDM data includes

- A. Framing & Marker in TDM
- B. Digital data & PCM coded data in TDM

A. Study of framing & Marker in TDM:

Framing

The TDM transmission consists of these basic clock & timing signals on the basis of TX channel & information.

1. Data Clock : Determines maximum data rate of channels.
2. Mux Clock : Determines time slot for each channel.
3. Frame Clock : Determines no. of channels to be multiplexed.

In the FO-A-P trainer we have considered Data Rate = 1.024MHz.

A single channel will contain 8 bit data; hence the channel time slot or channel frequency will be 1MHz/8 i.e. 128 KHz.

i.e Mux Clock : 128KHz.

We have provided 16 channels for communication. So the frame clock becomes 128/16 i.e. Frame CLOCK = 8KHz. For selection of 16 channels we need at least 4SIGNALS(2n=16 hence n=4), they are QA, QB, QC & QD with clock frequencies of 64KHz, 32KHz, 16KHz & 8KHz respectively.

The waveforms & table shows how the framing is achieved in TDM & table below shows channel selection in TDM.

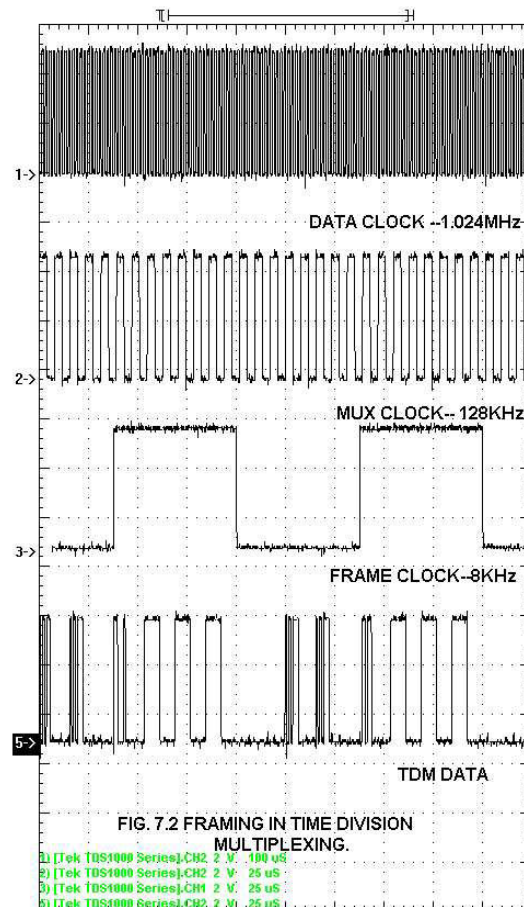
The FIG.7.2 shows how frame is formed in TDM.

The FIG.7.3 shows how markers are placed in a frame.

The table shows how the 16 channels are selected depending on the clock signals QA, QB, QC & QD.

QD	QC	QB	QA	CH 1	CH 2	CH 3	CH 4	CH 5	CH 6	CH 7	CH 8	CH 9	CH 10	CH 11	CH 12	CH 13	CH 14	CH 15	CH 16	O/P Y0
0	0	0	0	√																CH 1
0	0	0	1		√															CH 2
0	0	1	0			√														CH 3
0	0	1	1				√													CH 4
0	1	0	0					√												CH 5

0	1	0	1						√										CH 6
0	1	1	0						√										CH 7
0	1	1	1						√										CH 8
1	0	0	0							√									CH 9
1	0	0	1								√								CH 10
1	0	1	0									√							CH 11
1	0	1	1										√						CH 12
1	1	0	0											√					CH 13
1	1	0	1												√				CH 14
1	1	1	0													√			CH 15
1	1	1	1														√		CH 16



Marker used in Time Division Multiplexing is a unique bit pattern placed at some fixed position in the frame & is used to determine the start of the frame at the receiver. Some times a different marker is used in alternate framers to counter the possibility of data bits containing the marker sequence generating a false marker.

Double Marker

The marker is supposed to be a unique bit pattern in the data stream, which is identified at the receiver to identify the beginning of frame. Question arises, what happens if the marker pattern is contained elsewhere as data?

To avoid this situation, the receiver circuit is usually designed to detect a marker repeating itself one in a frame. It is only the repetition after a certain number of bits, which allows the bit pattern to be accepted as the marker. It is highly impossible that the data will have this pattern repeating at the same position in every frame. However, to avoid even this situation, the marker is sometimes chosen to be different in alternate frames.

EQUIPMENTS

- FO-A-P Kit with power supply
- Patch chords
- 20 MHz Dual Trace Oscilloscope
- 1 Meter fiber cable

OBSERVATIONS

Observe & measure the frequencies for **DATA CLK**, **MUX CLK** & **FRM CLK**(frame clock). Ref fig: 7.2.

Observe the marker at test point **MRTX1** on the channel & frame clock on the CRO channel. Ref fig: 7.3.

Observe the second marker MRTX2 & frame clock similarly at the output of **OR** gate.

Now observe the test point of marker i.e.channel-1 with respect to MRTX1 & MRTX2 and plot the waveform.

Observe the channel-1 signal with respect to the frame clock. You will find the markers are present alternately in each frame.

SWITCH FAULTS

Put switch **1 (SF1)** in Switch Fault section to **ON** position. This will open TX-marker signal at i/p of U9. This will open pin 8 of U9 (74LS150) i.e. channel one is removed at MUX section. No marker is transmitted and hence the receiver synchronization is disturbed.

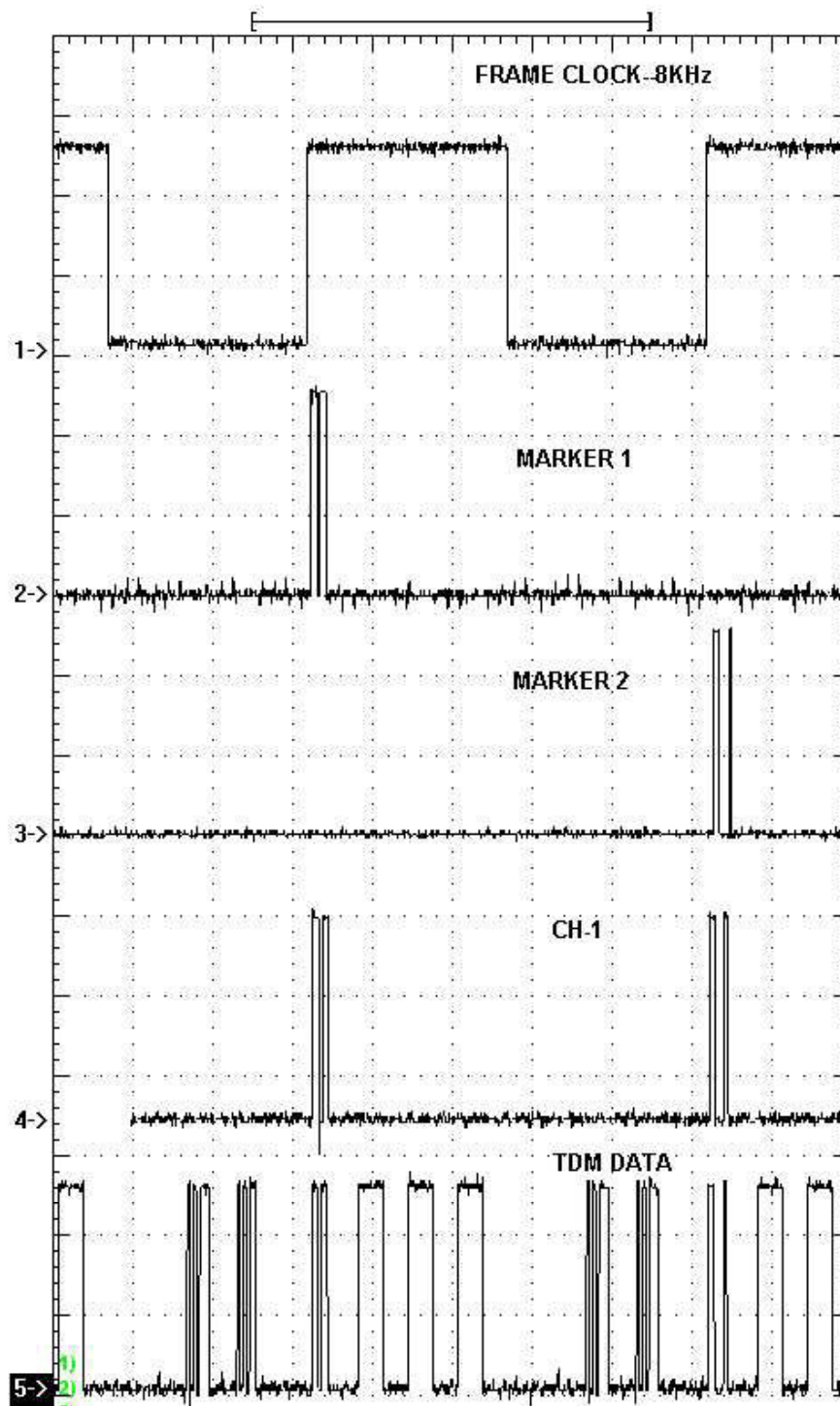


FIG7.3 MARKER IN TDM

B. Study Of Channel Inputs & PCM Data In TDM.

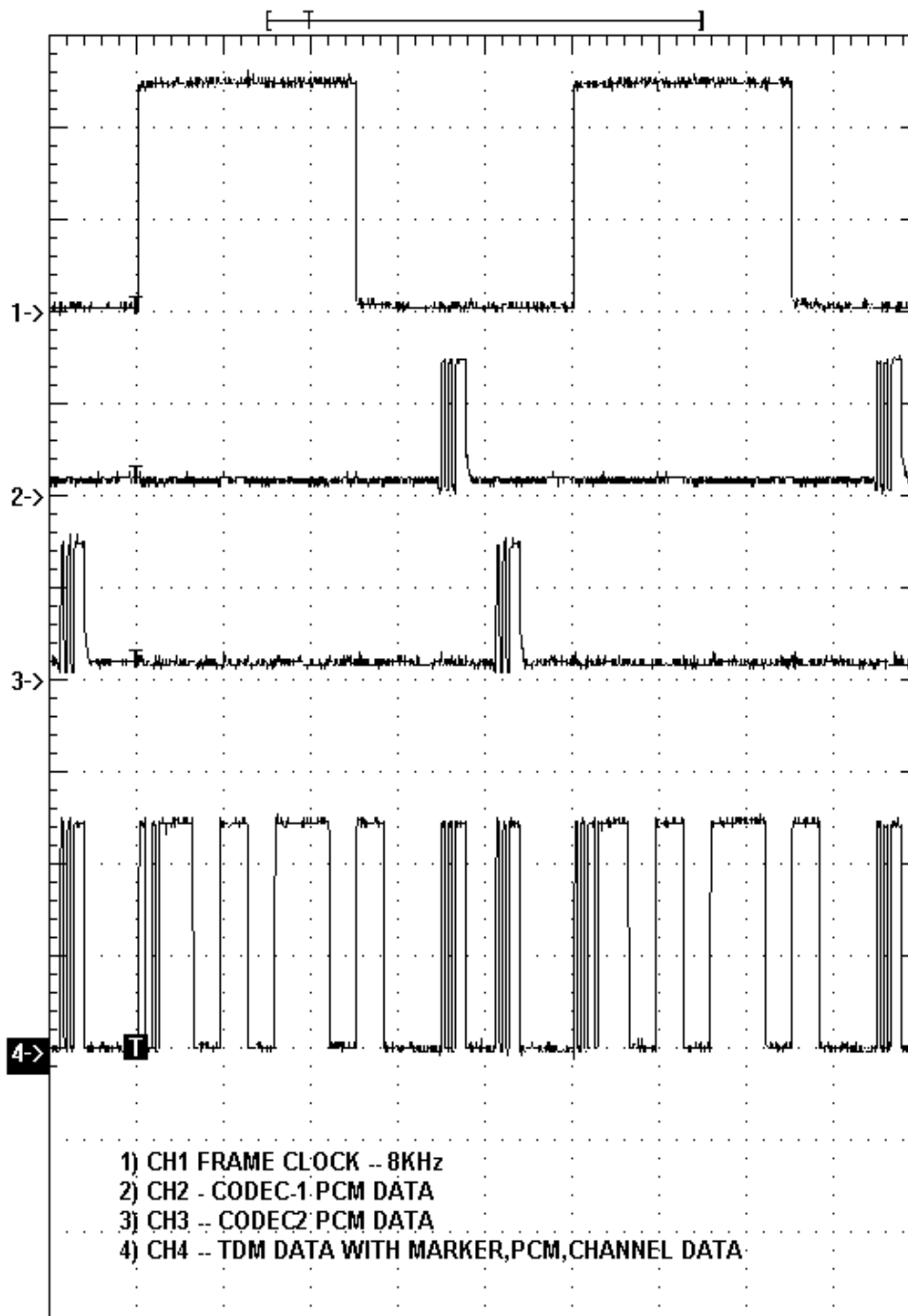
Once the frame is formed and marker is inserted for synchronization in the first channel, now remain the next 15 time slots free for data information. On the FO-A-P trainer kit we have used 8 ON/OFF switches as channel-2 to channel-9. Then next 2(10&11) slots are kept blank. In the 12th time slot the PCM data of codec-1 chip is inserted. Again 13th time slot is kept zero. In the 14th time slot the PCM data of codec-2 (IC14)is inserted. The 15th, 16th positions are again kept zero. The FIG.7.4 shows the complete Time Division Multiplexed Data.

OBSERVATIONS

- Observe the test points of **TDM OUT** with respect to the frame clock on CRO.
- Put the channel switch **ON & OFF** & observe the position of each channel in a frame. Observe how the frame repeats itself at regular intervals.
- Observe the marker **MRTX1 & MRTX2** with respect to the frame data & see how the two markers are transmitted in alternate frame.
- Observe the **PCM** coded voice data at the **PCM OUT** test points of codec 1 & codec 2 with respect to the frame clock & also with respect to the **TDM OUT** test point. Observe the position of **PCM** data in the frame.

SWITCH FAULTS

- Put switch **2 (SF1)** in Switch Fault section to **ON** position. This will open pin 4 of U9 (74LS150). The channel 6 signal goes in undefined state & o/p response is irrespective of the CH6 switch position.



EXPERIMENT NO. 8

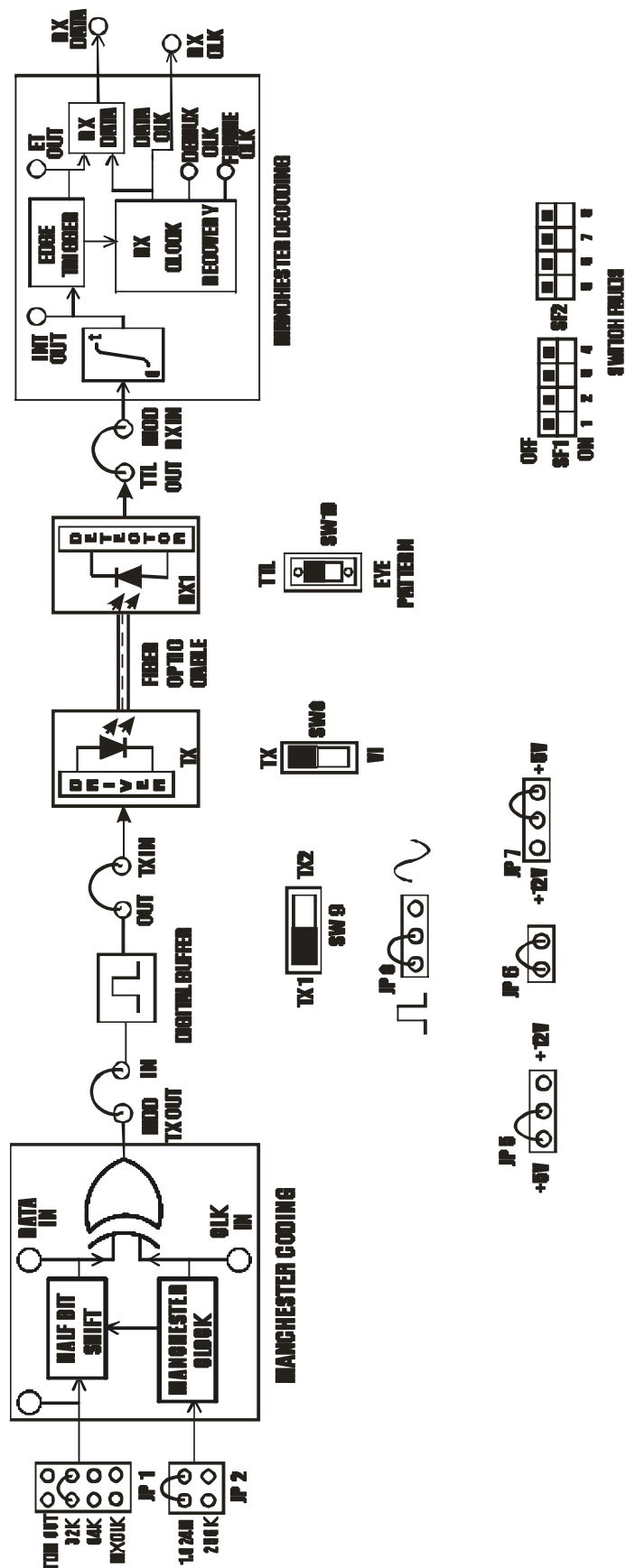


FIG. 9.1 STUDY OF MANCHESTER CODING AND DECODING.

EXPERIMENT NO. 8

NAME

Study of Manchester Coding & Decoding

OBJECTIVE

The objective of this experiment is to study the techniques of Manchester coding & decoding in digital communication

THEORY

A fiber optic digital communication system usually consists of the following:

- Optical transmitter including electrical to optical converter (E/O)
- Optical receiver including optical to electrical converter (O/E)
- Optical Fiber as data transmission medium
- Connectors, Couplers & Splicer
- Line Coder
- Line Decoder
- Timing recovery unit

In digital communication, the recovery of the clock used for transmission is essential. The Technique of timing recovery depends on the no. of “0” to “1” & “1” to “0” transitions. At times, one cannot ensure that the data to be transmitted has such transitions. To introduce the transitions in such a case, line coding is used. For low bit rate fiber optic transmission, the commonly used line coding technique is known as Manchester Coding, whereas for higher bit rates various coding schemes like mBnB coding schemes are used. Thus line coding is implemented in digital communication for the following reasons.

- For ease of timing recovery at the receiver
- To shape the spectrum of the signal as required by various elements in the communication system

The recovery of synchronous clock, synchronous both in terms of phase & frequency, at the receiver is a must for any synchronous digital link. A long string of zeros & ones, i.e. lack of transitions in data, could make the receiver clock lose synchronization. Line coding introduces sufficient transitions in the data for ease of clock recovery. Also a certain pattern of data, like a long string zeros or one, would result in a strong DC component in the transmitted signal. Such a DC component is often not desirable; line coding shifts the spectrum & avoids the DC component. Several methods of coding digital transmission for unique effects are possible each type of coding has inherent advantages. We will consider the simplest line coding technique as Manchester Coding. The data waveform is composed of a binary bit stream with each bit forming a cell, one clock period in length.

The Manchester coded waveform is generated in the following manner. If the Data bit is ‘1’, the waveform will be positive for the first half of the bit cell. For a ‘0’ data

bit, the first half of the bit cell will be a zero. A transition always occurs in the center of the bit cell, regardless of whether the bit is ‘1’ or ‘0’.

EQUIPMENTS

- FO-A-P Kit with power supply
- Patch chords
- 20 MHz Dual Trace Oscilloscope
- 1 Meter fiber cable

NOTE: Keep All Switch Faults In Off Position.

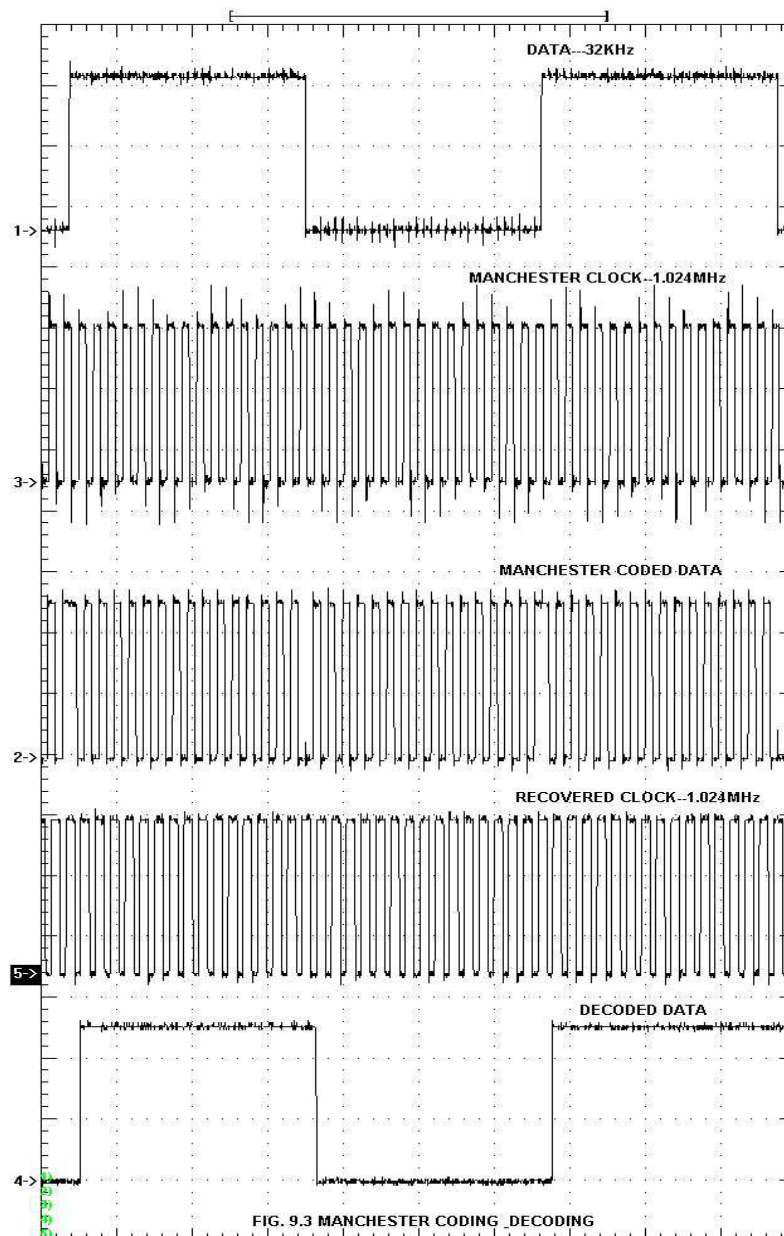
PROCEDURE

- Make connections as shown in diagram.
- Keep jumper & switch settings as shown in fig.
- Observe the Test points of **DATA IN&MCDTX OUT**. The **MCDTXOUT** shows that when Data is "1" the first half bit of data is high whereas the second half is zero. While for Data as "0" the first half is a "0" level & second half is "1" as shown in the waveforms.
- Select the fiber optic transmitter TX1 SFH756 using jumper & switch settings as shown in fig.9.2.
- Slightly unscrew the cap of SFH756V (660nm). Do not remove the cap from the connector. Once the cap is loosened, insert the one-meter fiber into the cap. Now tighten the cap by screwing it back.
- Slightly unscrew the cap of RX1 Photo Transistor with TTL logic output SFH551V. Do not remove the cap from the connector. Once the cap is loosened, insert the other end of fiber into the cap. Now tighten the cap by screwing it back.
- Observe the test points of **INT OUT, ET OUT**. The decoded output is obtained at **RX DATA** test point & the decoding clock at **DATA CLK** test point.FIG.8.2 shows Manchester coded & decoded signals for 32 KHz data input.(After inserting the fiber on both sides, align the fiber properly inside both SFH devices if required to get proper indication of o/p LEDs.)
- Observe the waveforms for other data by shifting **JP1** to **64 KHz & MX CLK**.
- Also observe the effect of changing Manchester clock by keeping **JP2** position at **256 KHz**. Now the Manchester coded output will be exact but the Manchester decoded output & clock may not match the data as the decoded clock circuit is tuned to 1.024MHz clock & not 256Khz.So for this observe only the Manchester coded data.

SWITCH FAULTS

NOTE: Keep the connections as per the procedure. Now switch **ON** corresponding fault switch button to **ON** position & observe the different effects on the output. The faults are normally used one at a time.

- Put switch **5(SF2)** in Switch Fault section to **ON** position. This will open pin 2 MCDCLK of U19 (74HC86). This will affect the Manchester coding and the Manchester coded o/p will be in a wrong format.
- Put switch **6(SF2)** in Switch Fault section to **ON** position. This will disturb the Manchester decoding o/p and data will be disturbed. R71 comes in parallel to PR1 & hence the RC time constant changes & RX CLK gets disturbed.



EXPERIMENT NO. 9

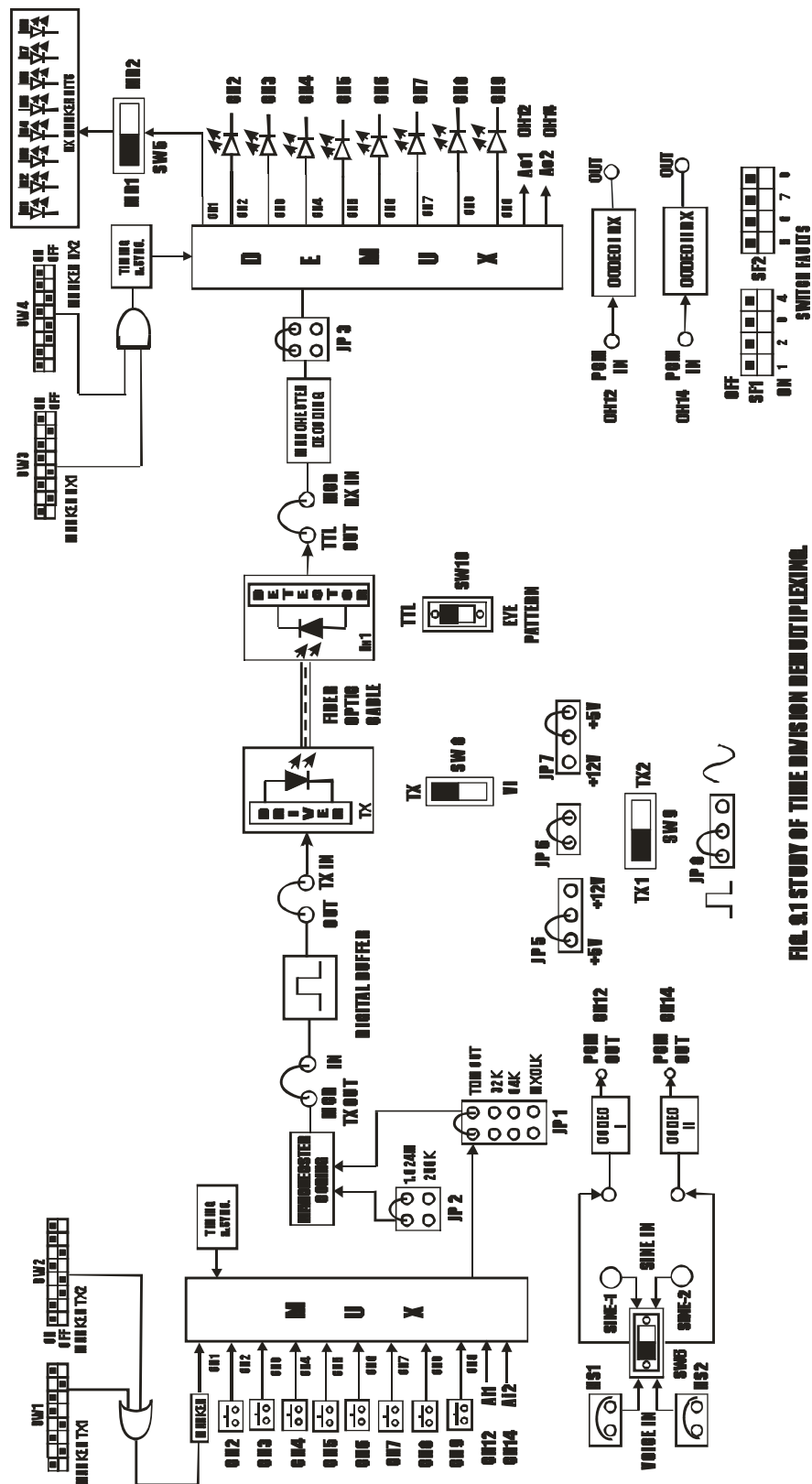


FIG. 9.1 STUDY OF TIME DIVISION DEMULTIPLEXING

EXPERIMENT NO. 9

NAME

Study of Time Division Demultiplexing

OBJECTIVE

To objective of this experiment is to study the process of Time Division Demultiplexing.

THEORY

The process of Time Division Demultiplexing is the process of having one input & many outputs.

The TDM data on a single link is separated on time basis, depending on the Q0, Q1, Q2 & Q3 clocks at the receiver section.

The Manchester coded data is first decoded and the original TDM data is obtained. Also the clock & Timing signals are generated using the RX clock. The marker from the recovered TDM data is compared with the RXMP1 & RXMP2. When the markers are identified or when they are found similar by the RX marker comparator, the comparator generates a detection (sync) pulse. Thus two sync pulses are obtained at the receiver one for each marker.

These sync pulses are used to synchronize the TDM Data with the receiver clocks. The marker RX1 is kept same as marker TX1 & marker RX2 is kept similar to marker TX2 as shown in the block diagram.

EQUIPMENTS

FO-A-P Kit with power supply
Patch chords
20 MHz Dual Trace Oscilloscope
1 Meter fiber cable

NOTE: Keep All Switch Faults In Off Position.

PROCEDURE

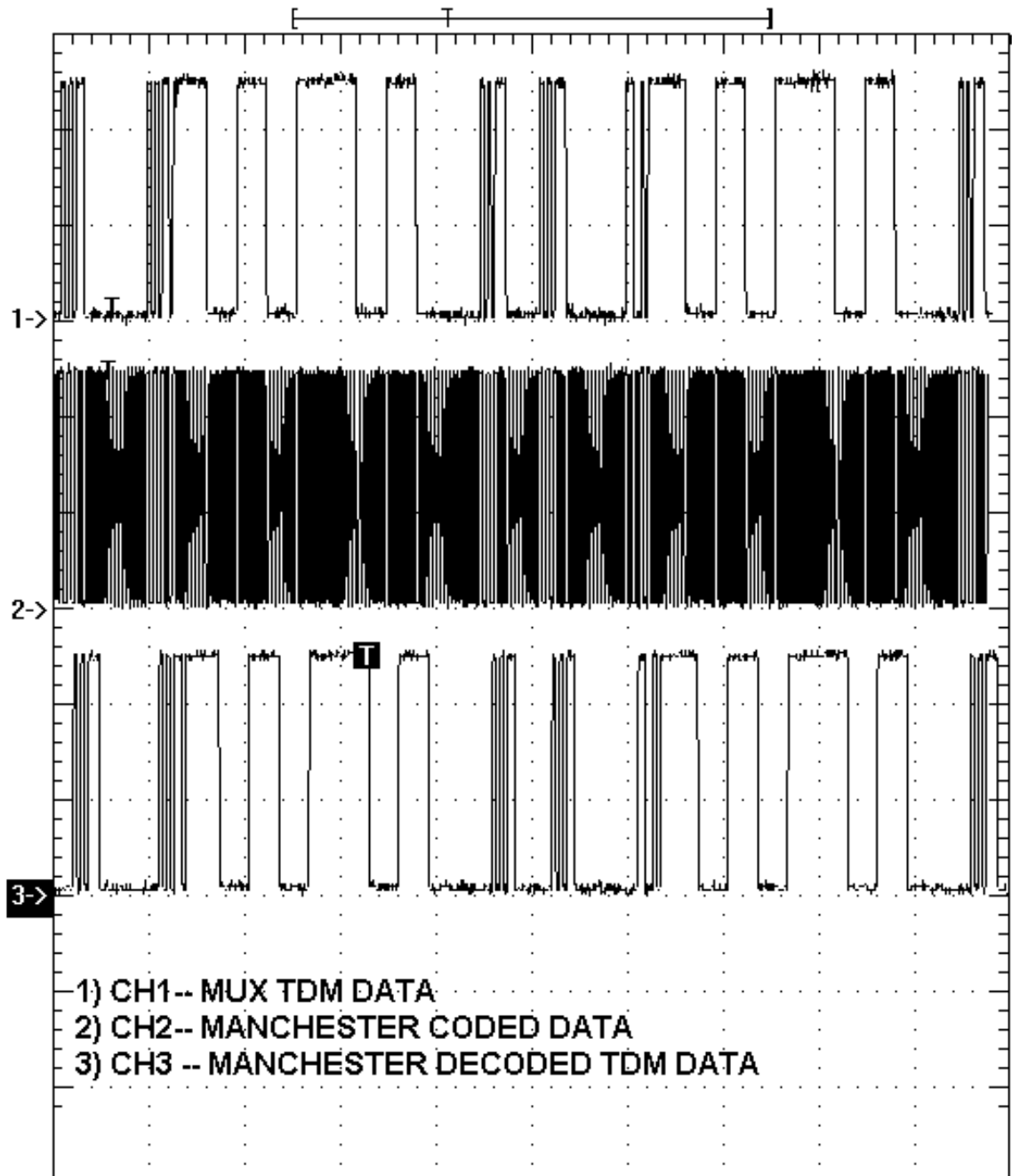
- Make the connections as shown in the diagram.
- Keep the jumper & switch settings as shown in fig.9.1.
- Select the fiber optic transmitter TX1 SFH756 using jumper & switch settings as shown in fig.9.1.
- Slightly unscrew the cap of SFH756V (660nm). Do not remove the cap from the connector. Once the cap is loosened, insert the one-meter fiber into the cap. Now tighten the cap by screwing it back.
- Slightly unscrew the cap of RX1 Photo Transistor with TTL logic output SFH551V. Do not remove the cap from the connector. Once the cap is loosened, insert the other end of fiber into the cap. Now tighten the cap by screwing it back.
- Observe the detected signal at post **TTL OUT** on oscilloscope.

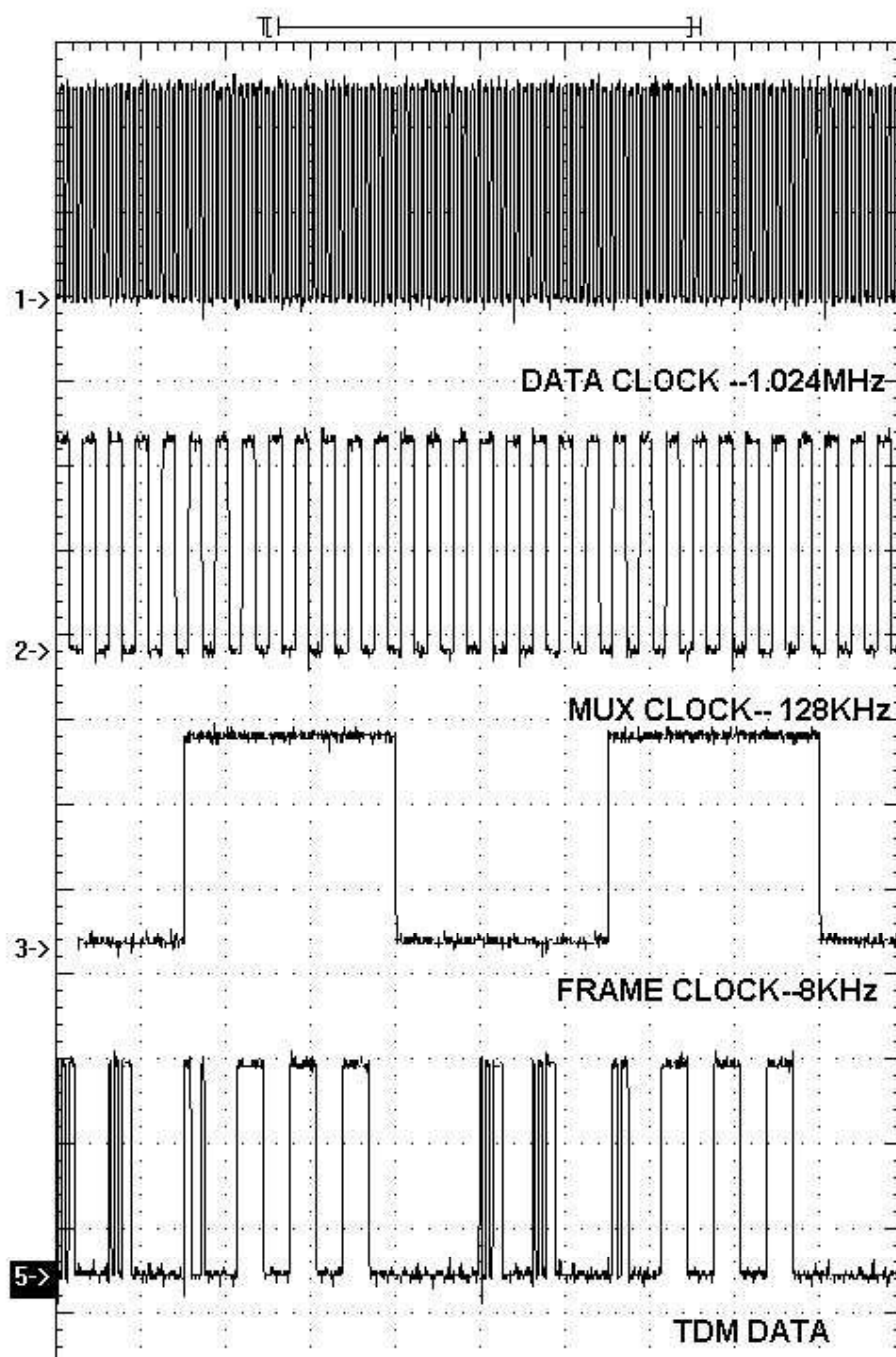
- Connect the received signal post **TTL OUT** to post **MCD RX IN**.
- Observe the integrated output at **INT OUT**, Observe edge triggered output at **ET OUT** as shown in fig.
- Observe the recovered clock as shown in FIG.9.3.at **RX CLK** post the duty cycles of the recovered clock is not the same as transmitter clock, but they are synchronized except for a slight transmission delay in the received clock.
- Observe decoded data at **RX DATA** post as shown in fig.9.4.
- Select marker 1 or 2 for display using switch SW5.
- Select **TX2 SFH450** using switch **SW9**& Repeat the above procedure. (After inserting the fiber on both sides, adjust the fiber alignment properly inside both SFH devices if required to get proper indication of o/p LEDs.)
- Repeat the above procedure for marker1 & 2 as given in the marker settings table below.

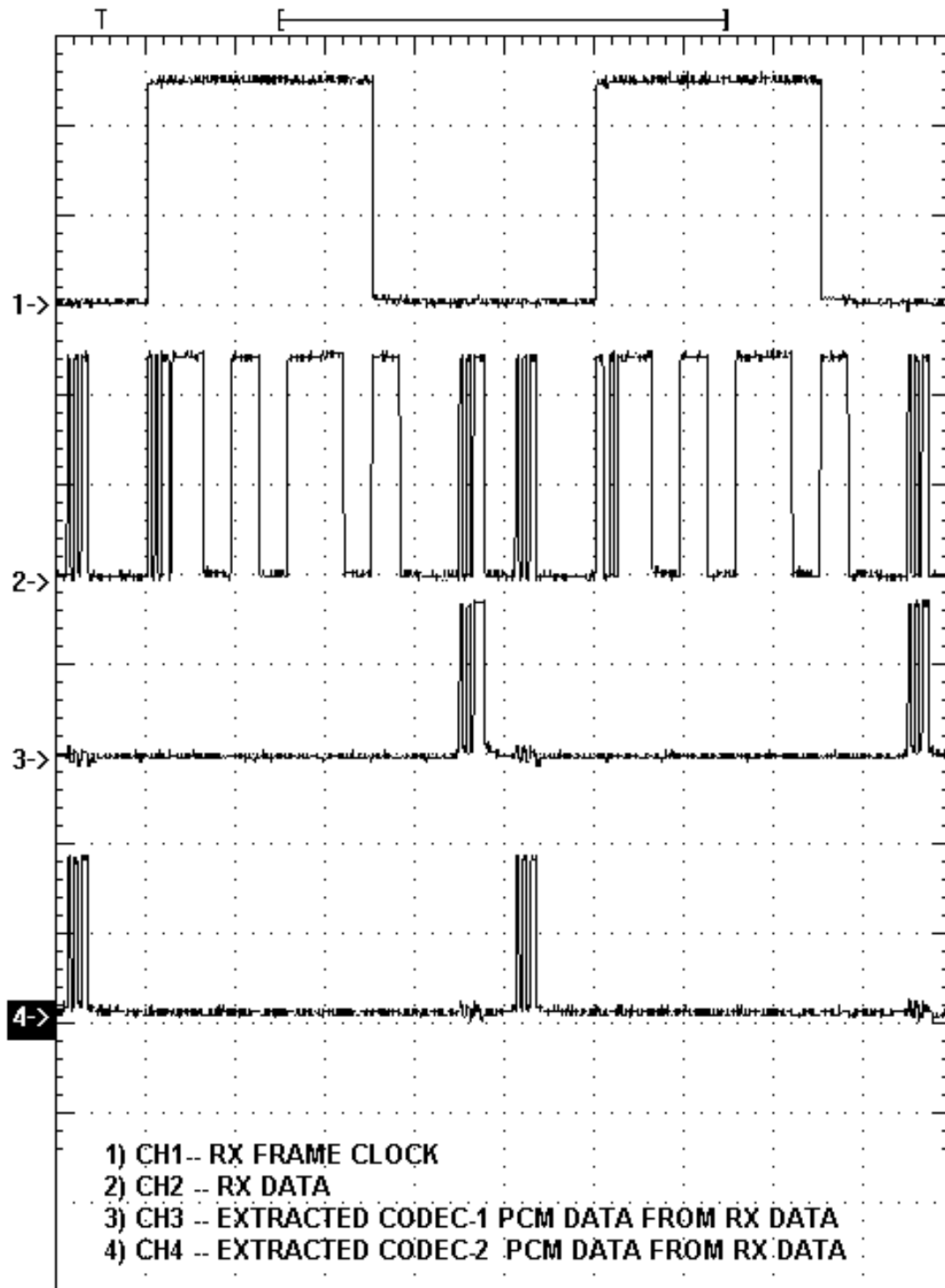
Note

The students can form hundreds of other combinations apart from the marker settings table. Few settings may not give proper TDM o/p. Avoid 4 consecutive 1's or 0's in single marker settings to get proper TDM data.

TX MARKER -1	TX MARKER -2
10010001	10110110
11011001	10110110
11011001	10001010
01011101	10001010
10101101	10001010
10101101	11001011
10111001	11001011
10110001	01101010
10011101	01100010
10010101	01011001



**FIG 9.3: FRAMING IN TIME DIVISION**

**FIG.9.4: EXTRACTED PCM DATA FROM RX DATA**

SWITCH FAULTS

Switch fault section on is provided with 8 switches. These switches can be used to simulate fault conditions in various parts of the circuit. In order to keep FO-A-P kit fully operational, all switches should be set to OFF position before use. Switch faults are introduced one at a time.

- Put switch **1(SF1)** in Switch Fault section to **ON** position. This will open TX-marker signal at i/p of U9. This will open pin 8 of U9 (74LS150) i.e. channel one is removed at MUX section. No marker is transmitted and hence the receiver synchronization is disturbed.
- Put switch **2(SF1)** in Switch Fault section to **ON** position. This will open pin 4 of U9 (74LS150). The channel 6 I/P of Mux section is opened & hence the channel 6 state in the TDM DATA becomes independent of the switch position & hence the CH6 O/P LED indication is irrespective of the CH6 switch position.
- Put switch **3(SF1)** in Switch Fault section to **ON** position. This will open pin 13 of U9 (74LS150). This will remove the MUX clock QC. Due to which few channels at the MUX o/p will be lost. Since they will not be selected.
- Put switch **4(SF1)** in Switch Fault section to **ON** position. This will open pin 8 of U12 (145502). The MSIRX1 signal is removed. This will disable the codec selection during demux and codec response cannot be observed.
- Put switch **5(SF2)** in Switch Fault section to **ON** position. This will open pin 2 MCDCLK of U19 (74HC86). This will affect the Manchester coding and the Manchester coded o/p will be in a wrong format.
- Put switch **6(SF2)** in Switch Fault section to **ON** position. This will disturb the Manchester decoding o/p and data will be disturbed. R71 comes in parallel to PR1 & hence the RC time constant changes & RX CLK gets disturbed.
- Put switch **7(SF2)** in Switch Fault section to **ON** position. This will open pin 20 of U24 (74HCT154). Demux clock Q4 will be removed from Demux IC and hence few channels at i/p will not be selected.
- Put switch **8(SF2)** in Switch Fault section to **ON** position. This will open pin 11 of U35 (74LS374). This will open the latching signal of U35 and marker settings hence the U35 will not accept new marker settings & will display the previous settings till the latch signal is connected.

EXPERIMENT NO. 10

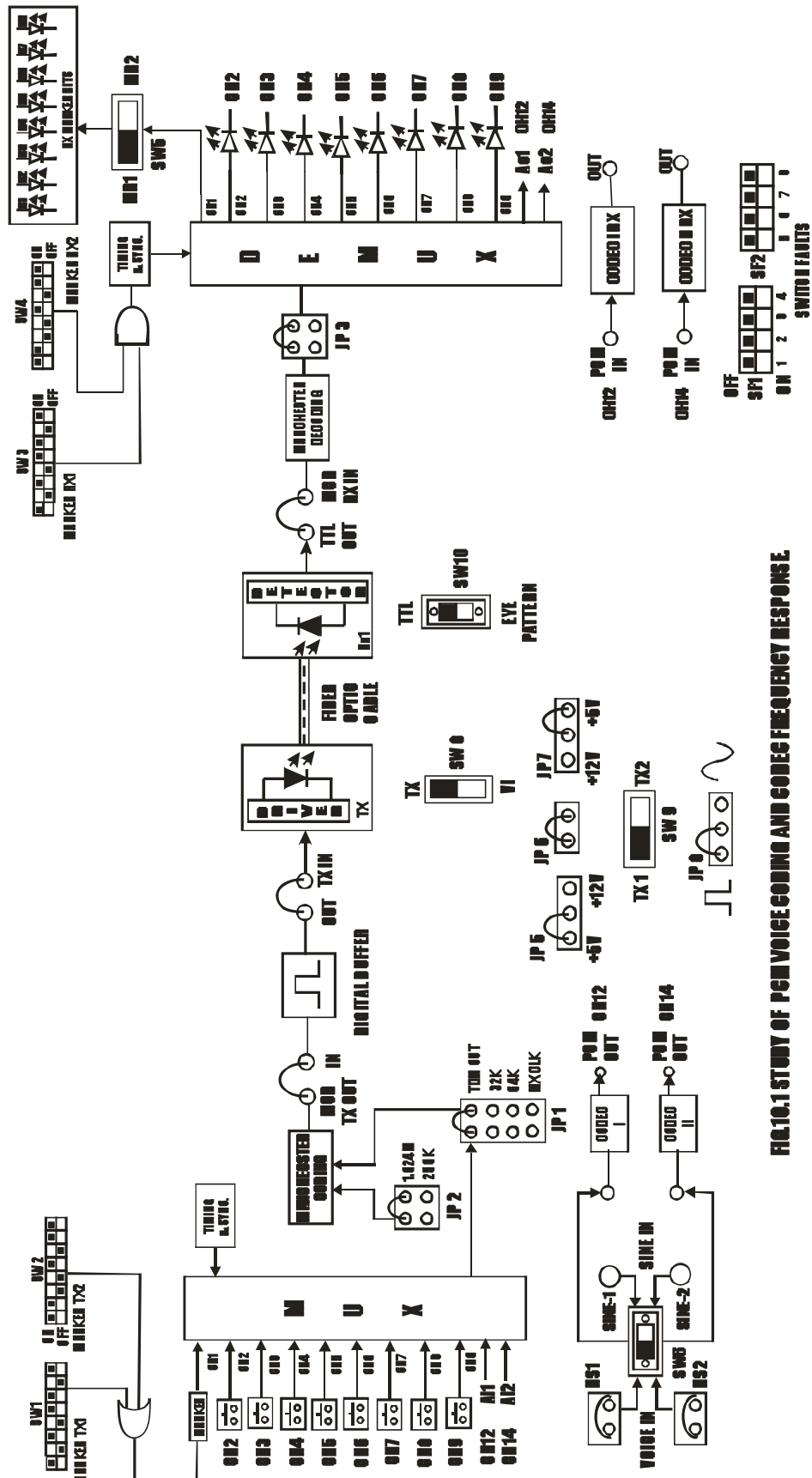


FIG.10.1 STUDY OF PCM VOICE CODING AND CODES FREQUENCY RESPONSE

EXPERIMENT NO. 10

NAME

Study of PCM Voice Coding And Codec Frequency Response

OBJECTIVE

The objective of this experiment is to study the linearized A-law PCM coding. The analog to digital conversion as well as the reverse process and the filtering characteristics of the CODEC chip 145502 used in this kit are also studied.

THEORY

Present techniques of voice communication use standards such as A-law / μ - law companded PCM voice coding at 64 Kbits/sec. When the analog speech signal is converted to pulse code modulation, it is first filtered using a low pass filter with a cut-off at about 3.4 KHz. The analog signal is sampled at 8KHz as per the Nyquist Criteria. Each sample is quantized and coded into eight bits per sample.

Actually the voice signal features something undesirable and that is its amplitude range varies greatly from one conversation to another. If the quantization levels are uniformly spaced then it certainly creates problems. If the amplitude of the signal is small, quantization levels have to be closely spaced. This gives proper resolution. But if the signal amplitude is large then this fine resolution will result in increasing the number of code bits.

Hence, normally a technique of unequal spacing of quantization levels is used. In the Fiber FOL-A-P kit, the audio signal from the telephone handset is processed using telephone interface chip. It is then applied to voice coder. This chip actually performs analog to digital conversion and vice-versa.

The digital data output is in pulse code modulated form. The CODEC chip used exhibits both A-law and u-law companding techniques. Here, we have selected A-law of companding. The digital output of CODEC is connected as i/p to the multiplexer. The received digital data is again converted into analog form by the chip. The clock considerations and other features of the CODEC chip used in this kit can be studied in details from the datasheets provided with the manual.

EQUIPMENTS

FO-A-P Kit with power supply
Patch chords
1 MHz Function Generator
20 MHz Dual Trace Oscilloscope

NOTE: Keep All Switch Faults In Off Position.

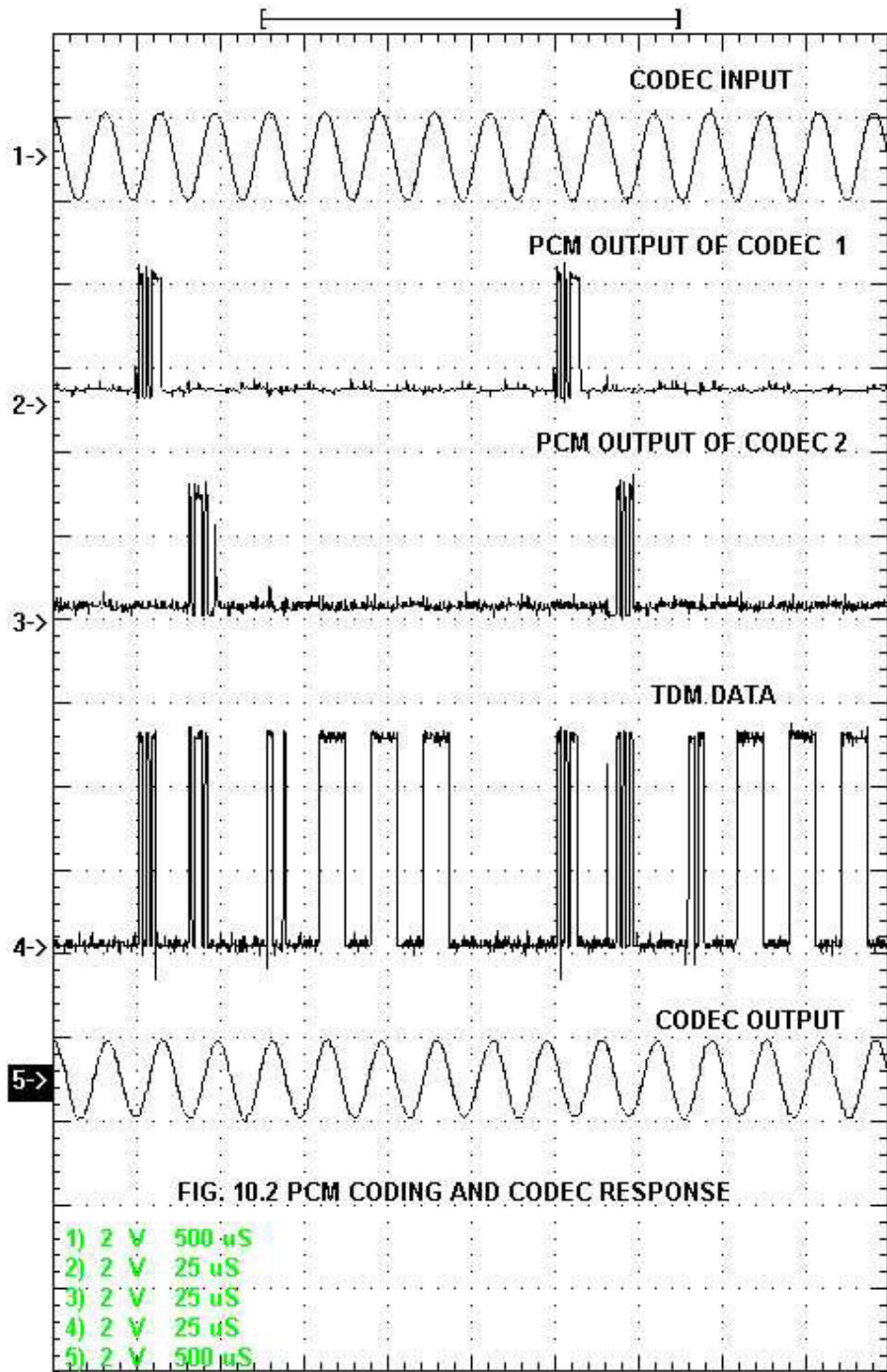
PROCEDURE

- Make connections as shown in fig.10.1. Connect the power supply cables with proper polarity to FOL-A-P Kit. While connecting this, ensure that the power supply is OFF.
- Now voice communication can be done between two audio channels using telephone handset.
- Observe the effect on voice signal at various test points.
- Keep the switch **SW6** towards **SINE IN** position.
- Feed a sinusoidal signal of 1 KHz and of amplitude up to 2Vpp to **SINE 1 & SINE 2** input terminals. This gives an analog input to both the CODECs.
- Observe the reconstructed waveform at **OUT** post for CODEC I RX and at **OUT** post for CODEC II RX as shown in fig. Compare both the applied input and the reconstructed signal on oscilloscope as shown in **FIG. 10.2**.
Draw waveforms. (The output signal may be delayed or phase shifted with respect to the input)
- Observe the signal changes at various test points.
- Vary the input frequency in steps and simultaneously observe the output signal. Measure the amplitude of the o/p signal for each input frequency.
- Find the frequency reading after which the response of the codec drops. This gives the bandwidth of the codec.
- Since it works for audio range we should get bandwidth at around 3.4 KHz.

SWITCH FAULTS

NOTE: Keep the connections as per the procedure. Now switch **ON** corresponding fault switch button to **ON** position & observe the different effects on the output. The faults are normally used one at a time.

- Put switch **4(SF1)** in Switch Fault section to **ON** position. This will open pin 8 of U12 (145502). The MSIRX1 signal is removed. This will disable the codec selection during demux and codec1 response gets disturbed or may not generate any signal.



EXPERIMENT NO. 11

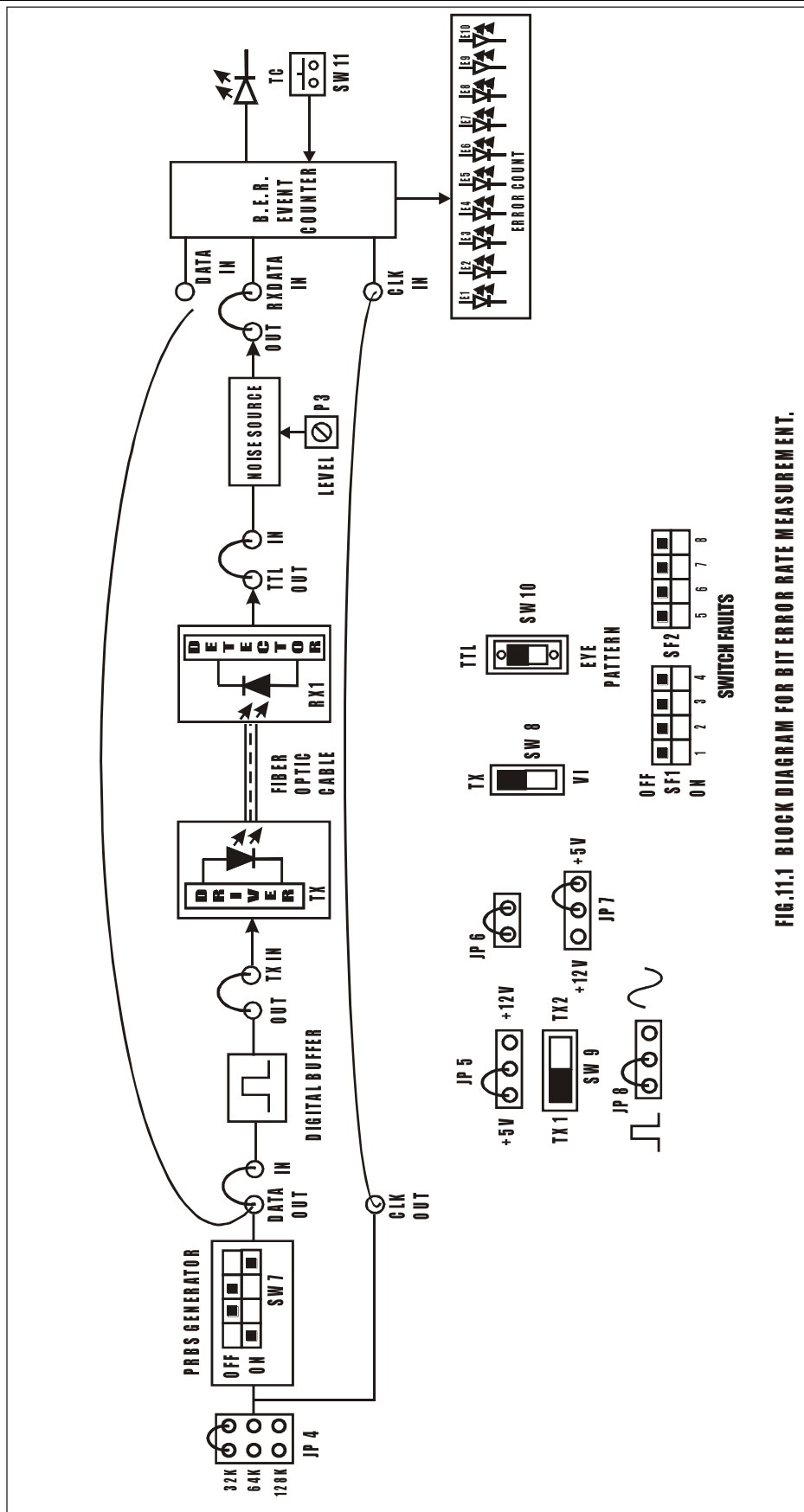


FIG.11.1 BLOCK DIAGRAM FOR BIT ERROR RATE MEASUREMENT.

EXPERIMENT NO. 11

NAME

Measurement of Bit Error Rate

OBJECTIVE

To measure Bit error rate

THEORY

Bit Error Rate

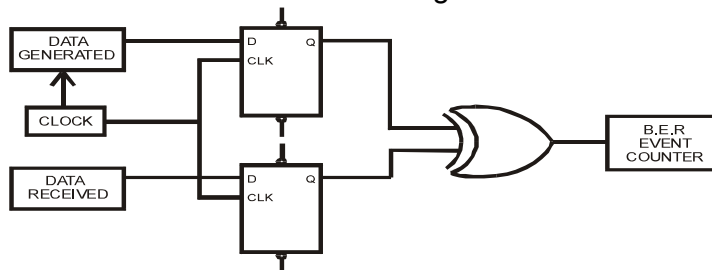
In telecommunication transmission, the bit error rate (BER) is a Ratio of bits that have errors relative to the total number of bits received in a transmission. The BER is an indication of how often a packet or other data unit has to be retransmitted because of an error. Too high BER may indicate that a slower data rate would actually improve overall transmission time for a given amount of transmitted data since the BER might be reduced, lowering the number of packets that had to be resent.

Measuring Bit Error Rate

A BERT (bit error rate tester) is a procedure or device that measures the BER for a given transmission. The BER or quality of the digital link is calculated from the number of bits received in error divided by the number of bits transmitted.

$$\text{BER} = (\text{Bits in Error}) / (\text{Total bits transmitted})$$

Using a bench test setup, this is easily measured by means of a comparator in which the transmitted bits are matched in an XOR gate with the received bits. Fig shows the schematic of the device used for the following measurements.



BIT ERROR RATE TESTER (B.E.R.T.)

If the bits are alike at the XOR gate input, when clocked in from the D flip flop, the output is low. If they are different, the XOR output goes high, causing an event count. The event counter can be set for various time periods. In general, the longer the time period, the more accurate is the count.

A random character generator and white noise source should be used for these measurements.

The number of bit errors is dependent upon the amount of noise entering the system. White noise or background noise has an average or RMS value that is exceeded periodically by peaks that may get raised many times that level. These peaks exist only for

a very short period of time. When the peak equals or exceeds the signal level, that is noise energy = bit energy, there is a 50/50 chance of error. The peak time periods can be calculated statistically from the error function.

In Link-B, PRBS sequence is generated by using a 4-bit right shift register whose feedback is completed by the EX-OR gate.

Let Initially 1001 be the 4-bit switch setting on the SW7.

Clock States D1D2D3D4

	ABC
1	10011
2	11000
3	01101
4	10110
5	01011
6	10101
7	11011
8	11101
9	11110
10	01110
11	00110
12	00011
13	10000
14	01000
15	00101
16	10011

Thus the sequence repeats constantly with a period corresponding to 16 clock states.

Length of sequence = $2^4 = 16$

Now the Pseudo Random Sequence pattern is C = 1010111100010011

EQUIPMENTS

FO-A-P Kit with power supply

Patch chords

1 Meter Fiber cable

Patch chords

20 MHz Dual Channel Oscilloscope

NOTE: Keep All Switch Faults In Off Position.

PROCEDURE

- Make connections as shown in fig.11.1. Connect the power supply cables with proper polarity to FO-A-P Kit. While connecting this, ensure that the power supply is OFF.
- Keep **PRBS** switch **SW7** as shown in fig.11.1 to generate PRBS signal.
- Keep switch **SW8** towards **TX** position.
- Keep switch **SW9** towards **TX1** position.
- Keep the switch **SW10** at fiber optic receiver output to **TTL** position.
- Select PRBS generator clock at 32 KHz by keeping jumper **JP4** at **32K** position.
- Keep Jumper **JP5** towards **+5V** position.

- Keep Jumpers **JP6** shorted.
- Keep Jumper **JP8** towards **pulse** position.
- Switch ON the power supply.
- Connect the post **DATA OUT** of PRBS Generator to the **IN** post of Digital Buffer and also to the **DATA IN** post of Bit Error Rate event counter.
- Connect the **OUT** post of Digital Buffer to **TX IN** post Transmitter.
- Slightly unscrew the cap of LED SFH756V (660nm). Do not remove the cap from the connector. Once the cap is loosened, insert the one-meter fiber into the cap. Now tighten the cap by screwing it back.
- Slightly unscrew the cap of RX1 Photo Transistor with TTL logic output SFH551V. Do not remove the cap from the connector. Once the cap is loosened, insert the other end of fiber into the cap. Now tighten the cap by screwing it back.
- Connect detected signal **TTL OUT** to post **IN** of Noise Source.
- Connect post **OUT** of Noise Source to post **RXDATA IN** of Bit Error Rate event counter.
- Connect post **CLK OUT** of PRBS Generator to post **CLK IN** of Bit Error Rate event counter.
- Press Switch **SW11** to start counter.
- Vary pot **P3** for **Noise Level** to observe effect of noise level on the error count.
- Observe the Error Count LEDs for the error count in received signal in time 10 seconds as shown in **FIG. 11.2**.

BER Measurement

As per the definition the BER is a ratio of Error bits (Eb) to Total bits Transmitted (Tb) in a period of time t seconds.

i.e. $BER = Eb / Tb$

For eg. in this experiment if PRBS data is transmitted at 32Kbits per second (i.e. jumper selection at 32KHz) for a period of 10 seconds.

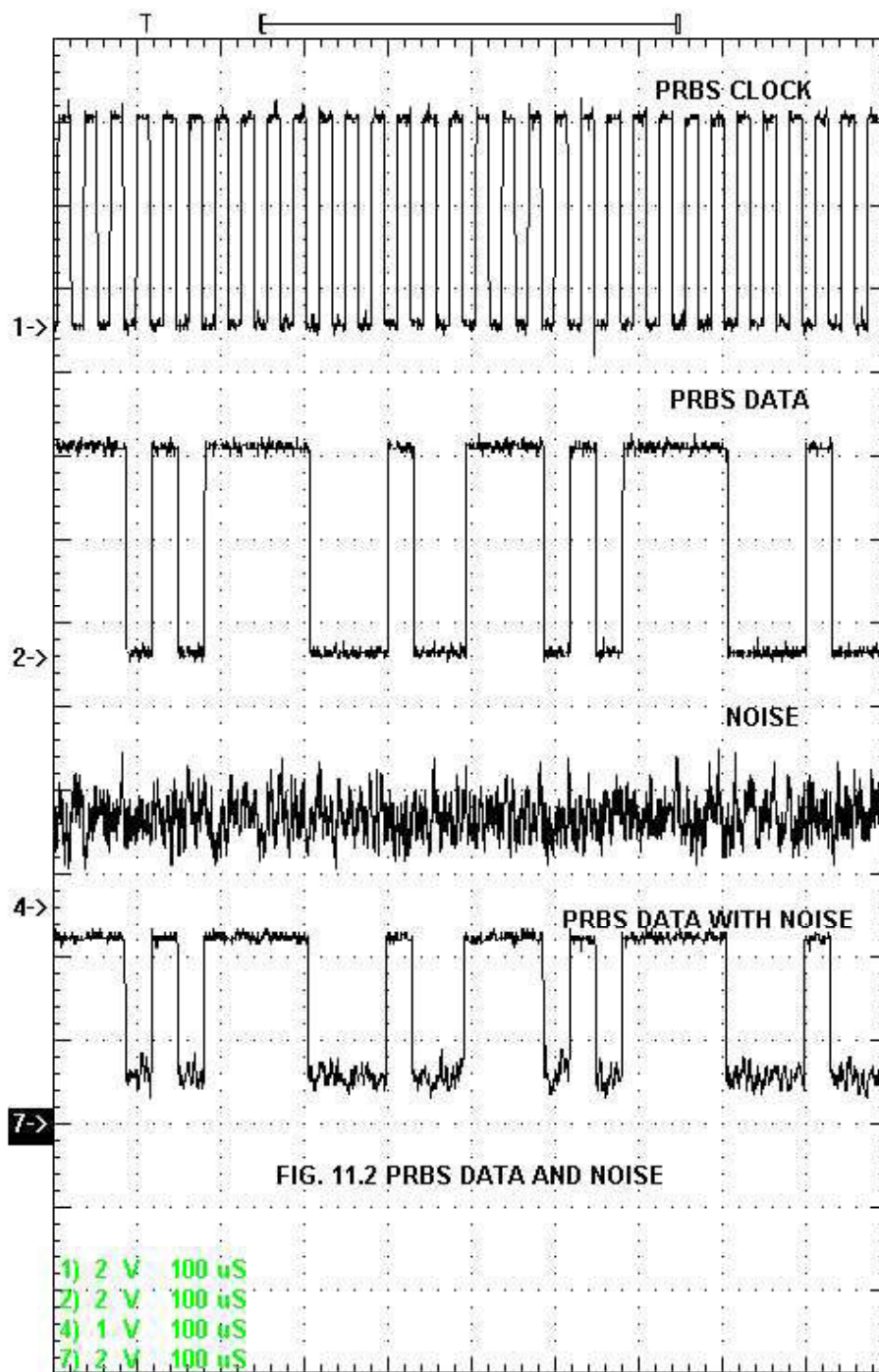
So total bits transmitted in 10 seconds (Tb) = 320Kbits.

The TTL OUT data & data with noise is fed to BER counter which compares the two data inputs at each clock input.

The counter displays the Error count (Eb) on LED in 10-bit binary form (e.g. 0000001010), which has to be converted in decimal form (it becomes 10) so the BER ratio then becomes

$$BER = 10 / (320 \times 10^3) \\ = 0.00003125$$

i.e. the channel Bit Error Rate ratio is 3.1×10^{-5} (3 / 100000) or in other words we can say that out of 100000 bits transmitted through the channel the channel gives 3 bits in error.



EXPERIMENT NO. 12

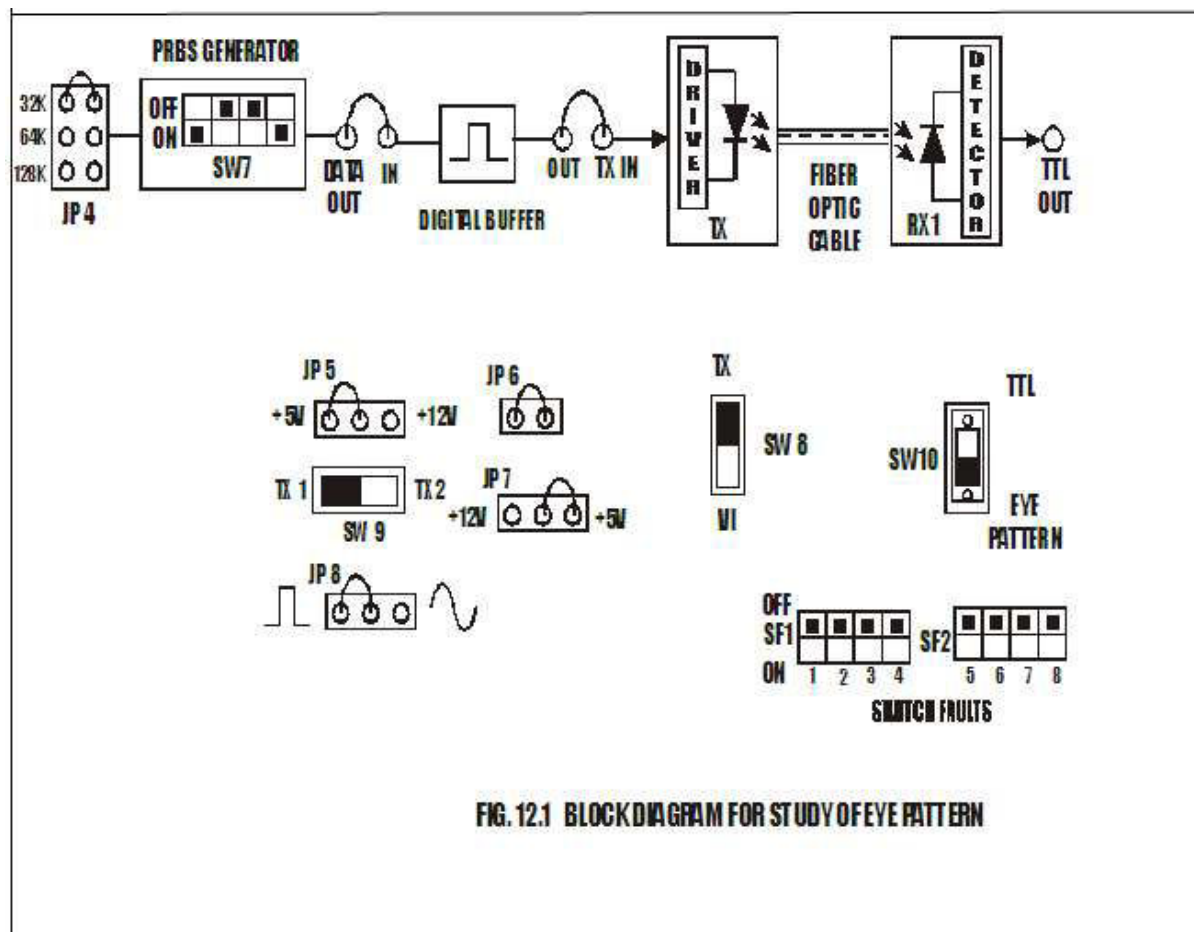


FIG. 12.1 BLOCK DIAGRAM FOR STUDY OF EYE PATTERN

EXPERIMENT NO. 12

NAME

Study of Eye Pattern

OBJECTIVE

The objective of this experiment is to study eye pattern using fiber optic link.

THEORY

The eye-pattern technique is a simple but powerful measurement method for assessing the data-handling ability of a digital transmission system. This method has been used extensively for evaluating the performance of wire systems and can also be applied to optical fiber data links. The eye-pattern measurements are made in the time domain and allow the effects of waveform distortion to be shown immediately on an oscilloscope.

An eye-pattern can be observed with the basic equipment shown in Fig. 12.1. The output from a pseudorandom data pattern generator is applied to the vertical input of an oscilloscope and the data rate is used to trigger the horizontal sweep. This results in the type of pattern shown in Fig. 12.2, which is called the **eye pattern** because the display shape resembles a human eye. To see how the display pattern is formed, consider the eight possible 4-bit-long NRZ combinations. When these sixteen combinations are superimposed simultaneously, an eye pattern as shown in Fig. 12.2 is formed.

To measure system performance with the eye-pattern method, a variety of word patterns should be provided. A convenient approach is to generate a random data signal, because this is the characteristic of data streams found in practice. This type of signal generates ones and zeros at a uniform rate but in a random manner. A variety of pseudorandom pattern generators are available for this purpose. The word pseudorandom means that the generated combination or sequence of ones and zeros will eventually repeat but that it is sufficiently random for test purposes. A pseudorandom bit sequence comprises four different 2-bit-long combinations, eight different 3-bit-long combinations, sixteen different 4-bit-long combinations and so on (that is, sequences of different N-bit-long combinations) up to a limit set by the instrument. After this limit has been generated, the data sequence will repeat.

A great deal of system performance information can be deduced from the eye-pattern display. To interpret the eye pattern, follow the procedure ahead.

An eye pattern, also known as an eye diagram, is an oscilloscope display in which a digital signal from a receiver is repetitively sampled and applied to the vertical input, while the data rate is used to trigger the horizontal sweep.

If the signals are too long, too short, poorly synchronized with the system clock, too high, too low, too noisy, or too slow to change, or have too much undershoot or overshoot, this can be observed from the eye diagram. An open eye pattern corresponds to minimal signal distortion. Distortion of the signal waveform due to inter symbol interference and noise appears as closure of the eye pattern.

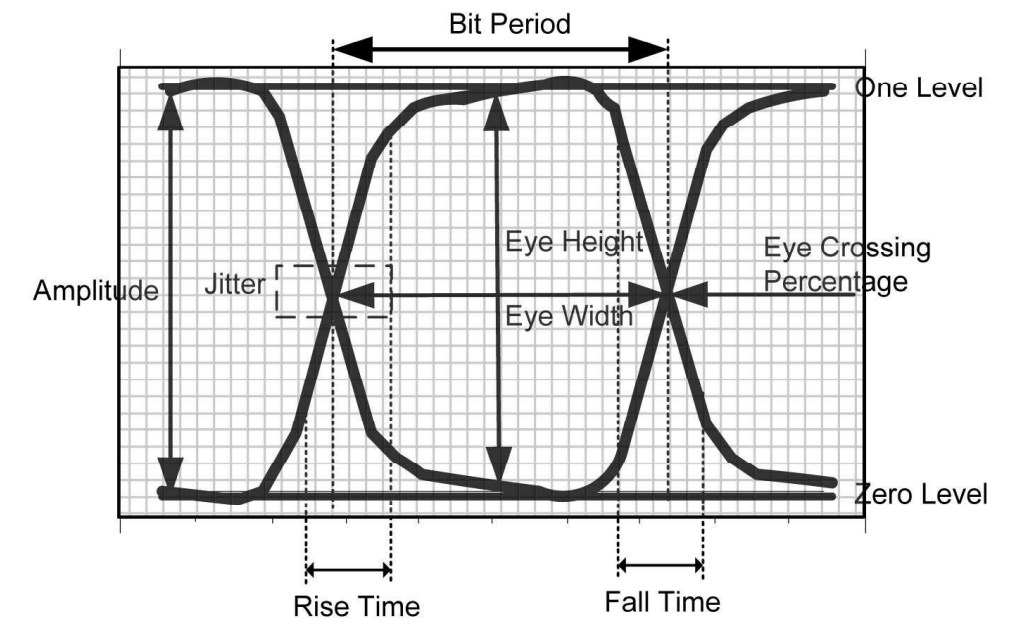


FIG 12.3: Measurement of eye pattern

EQUIPMENTS

FO-A-P Kit with power supply
 Patch chords
 1 Meter Fiber cable
 Patch chords
 20 MHz Dual Channel Oscilloscope

NOTE: Keep All Switch Faults In Off Position.

PROCEDURE

- Make connections as shown in fig.12.1. Connect the power supply cables with proper polarity to FO-A-P Kit. While connecting this, ensure that the power supply is OFF.
- Keep switch **SW7** as shown in fig.12.1. to generate PRBS signal.
- Keep switch **SW8** towards **TX** position.
- Keep switch **SW9** towards **TX1** position.
- Keep the switch **SW10** to **EYE PATTERN** position.
- Select PRBS generator clock at 32 KHz by keeping jumper **JP4** at **32K** position.
- Keep Jumper **JP5** towards **+5V** position.
- Keep Jumpers **JP6** shorted.
- Keep Jumper **JP8** towards **TTL** position.
- Switch ON the power supply.
- Connect the post **DATA OUT** of PRBS Generator to the **IN** post of digital buffer.
- Connect **OUT** post of digital buffer to **TX IN** post.
- Slightly unscrew the cap of LED SFH756V (660nm). Do not remove the cap from the connector. Once the cap is loosened, insert the one-meter fiber into the cap. Now tighten the cap by screwing it back.

- Slightly unscrew the cap of RX1 Photo Transistor with TTL logic output SFH551V. Do not remove the cap from the connector. Once the cap is loosened, insert the other end of fiber into the cap. Now tighten the cap by screwing it back.
- Connect **CLK OUT** of PRBS Generator to **EXT. TRIG.** of oscilloscope.
- Connect detected signal **TTL OUT** to vertical channel **Y** input of oscilloscope. Then observe EYE PATTERN by selecting EXT. TRIG KNOB on oscilloscope as shown in **FIG 12.2**. Observe the Eye pattern for different clock frequencies. As clock frequency increases the EYE opening becomes smaller.
- As change in frequency (at JP4) observed effect on eye diagram.
- Connect TTL OUT post to Noise source IN post.
- Observed the eye diagram with noise.

Frequency (Data Rate)	Amplitude (eye diagram)	Bit Period (eye diagram)
32KHz		
64KHz		
128KHz		

