SSUET/QR/112

Electronic Laboratory Manual

Opto Electronics (EE-471)

8th Semester Electronic Engineering

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OPTO ELECTRONICS (EE-471)

Lab Manual

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Laboratory Exercise 01

Objective

- Study the characteristics of LED.
- Find the relationship between LED voltage and current.
- Find the Wavelength of Light Emitted.

Theory

Like a common diode, the LED (Light Emitting Diode) consists of a P-N contact. When a PN junction is forward biased, current flows within it. This current flow will cause electrons and holes to move is a manner that an electron will move to fill a hole. When this happens, the electron will fall to a lower energy level and this will release an amount of energy in the form of photons. In a larger scale, those photons will produce light.

LEDs are diodes and to light an LED, it must be forward connected. This means that the anode of the LED must be connected to the positive pole of a battery, and the cathode must be connected to the negative pole. This is how to determine the anode and the cathode lead of an LED. Determining the anode and the cathode of a new LED is not very hard. The first way is from the length of its leads. The anode lead is longer than the cathode lead of the led.

The energy radiated is proportional to the energy gap. The higher the energy gap, the greater the frequency of emitted light.

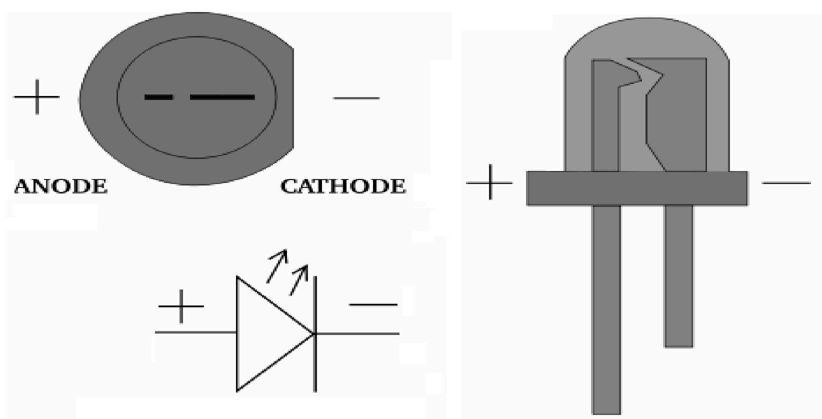


Figure1-1 Light Emitting Diode

Band Gap **Eg=hf**
Since **Eg=hf /λ**

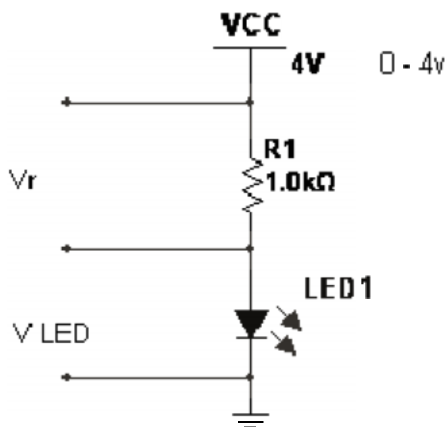
λ = WaveLength
C =Velocity of light
h=Plank's Constant

V_{knee} = Vth = Eg (eV)
λ = WaveLength = 1.24/ Eg

Apparatus

- LED (Red, Green, Yellow)
- Power Supply (10v Variable)
- Resisters (1kΩ, 47kΩ)

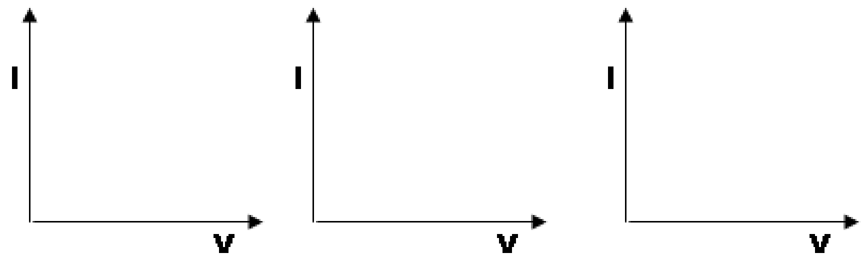
Circuit Diagram



Observation

S. No.	V Applied (V)	Red		Green		Yellow	
		V_{LED} (V)	I_{LED} (mA)	V_{LED} (V)	I_{LED} (mA)	V_{LED} (V)	I_{LED} (mA)

Graph



RED Green Yellow

Result

From the graph the relation between LED's voltage & current is observed.

It is -------------------------- (Linear/ Nonlinear).

a. Vth = Eg =(RED) = ---------------------- V

b. Vth = Eg =(GREEN) = ---------------------- V

c. Vth = Eg =(YELLOW) = ---------------------- V

d. WAVELENGTH (RED LED) = ------------------------------------ μm

e. WAVELENGTH (RED LED) = ------------------------------------ μm

f. WAVELENGTH (RED LED) = ------------------------------------ μm

Laboratory Exercise 02

Objective

- Study the characteristics of LED & Optocoupler.
- Find the relationship between LED voltage and current.
- Find the Current Transfer Ratio (CRT) between Output current and Input current.

Theory

An optocoupler, also called opto-isolator, is an electronic component that transfers an electrical signal or voltage from one part of a circuit to another or from one circuit to another, while electrically isolating the two circuits from each other. It consists of an infrared emitting LED chip that is optically in-line with a light-sensitive silicon semiconductor chip, all enclosed in the same package. The silicon chip could be in the form of a photo diode, photo transistor, photo Darlington, or photo SCR.
The optocoupler application or function in the circuit is to:

- Opto Coupler are used to provide electrical isolation between two circuits.
- Output voltage sampling for regulation.
- System control micro for power on/off.
- Ground isolation.

The energy radiated is proportional to the energy gap. The higher the energy gap, The greater the frequency of emitted light.

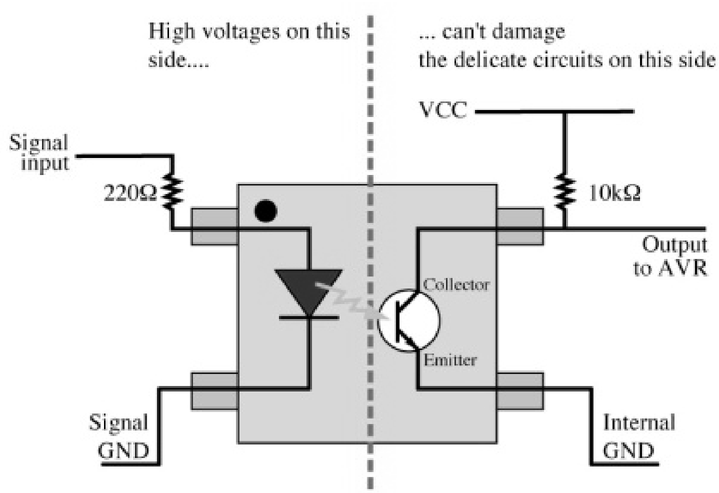


Figure 2-1 Opto Coupler IC

Band Gap **$E_g = hf$**
Since **$E_g = hf/\lambda$**

λ = WaveLength
C =Velocity of light
h=Plank's Constant

V_{knee} = Vth = Eg (eV)
λ = WaveLength = 1.24/ Eg

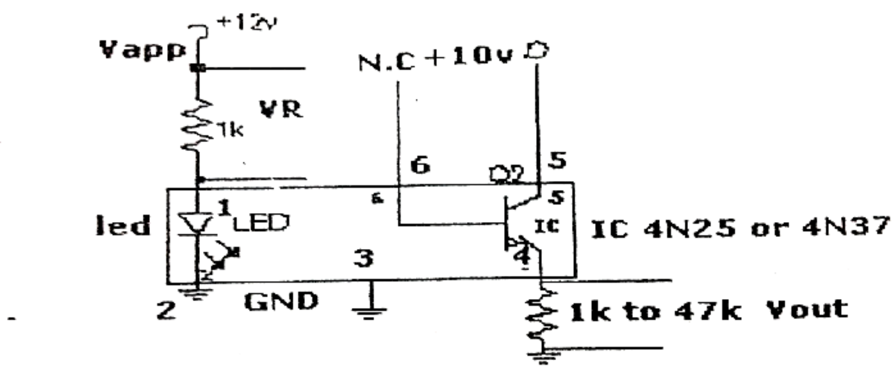
The current transfer ratio,

CTR = I_c / I_{LED}

Apparatus

- IC 4N25 or 4N37
- Power Supply (12v variable & 10v fixed)
- Digital Multimeter (DMM)
- Resisters (1kΩ, 47kΩ)

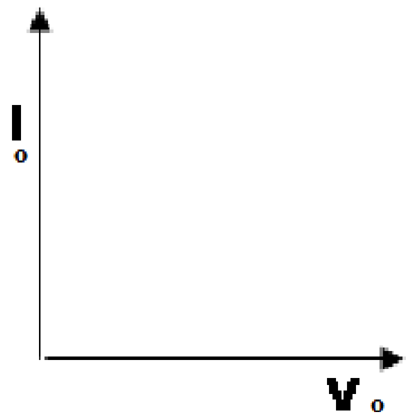
Circuit Diagram



Observation

S. No.	$V_{Applied}$ (V)	V_{LED} (V)	I_{LED} (mA)	V_R (V)	V_{OUT} (V)	$I_O = I_E$ (mA)	I_E / I_{LED}

Graph



Result

From the graph the relation between LED's voltage & current is observed.

- It is -------------------------- (Linear/ Non linear).
- The Current Transfer Ratio is observed.

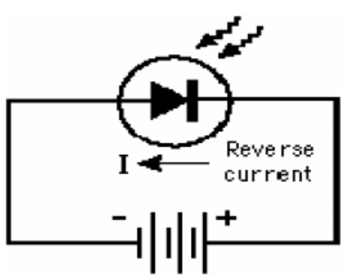
Laboratory Exercise 03

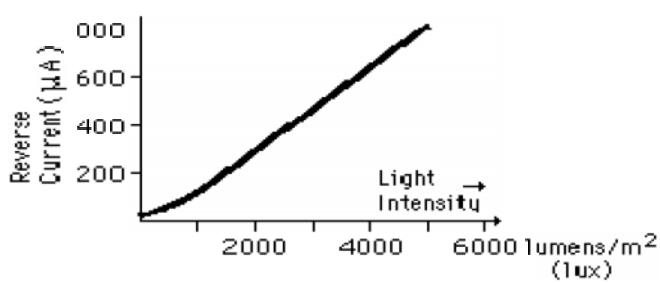
Objective

- Familiarize with the construction and operation of Photo Detectors.
- Using Infrared LED and photo Diode, to couple them and then finding their voltage and current.
- Record and describe how Radiated light affects the current flow in photo Diode.

Theory

A photodiode is a type of photo detector capable of converting light into either current or voltage, depending upon the mode of operation. Photodiodes are similar to regular semiconductor diodes. Many diodes designed for use specifically as a photodiode use a PIN junction rather than a p-n junction, to increase the speed of response. A photodiode consists of an active p-n junction, which is operated in reverse bias. When light falls on the junction, reverse current flows which is proportional to the illuminance. The linear response to light makes it an element in useful photo detectors for some applications. It is also used as the active element in light-activated switches.



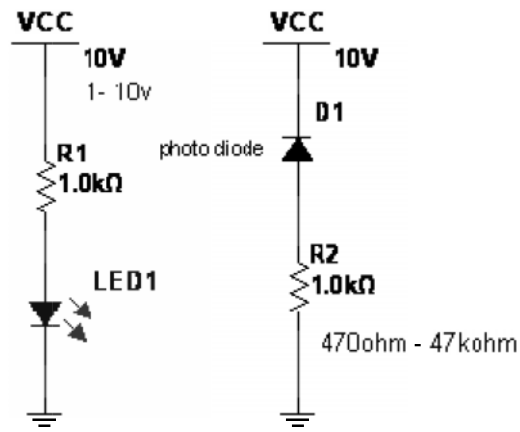


A photodiode is a p-n junction or PIN structure. When a photon of sufficient energy strikes the diode, it excites an electron, thereby creating a free electron (and a positively charged electron hole). This mechanism is also known as the inner photoelectric effect. If the absorption occurs in the junction's depletion region, or one diffusion length away from it, these carriers are swept from the junction by the built-in field of the depletion region. Thus holes move toward the anode, and electrons toward the cathode, and a photocurrent is produced. This photocurrent is the sum of both the dark current (without light) and the light current, so the dark current must be minimized to enhance the sensitivity of the device

Apparatus

- Infrared LED (Tx)
- Photo Diode(Rx)
- Power Supply (10V variable & 10Vor 5V fixed)
- Digital Multimeter (DMM)
- Resisters (1kΩ, 47kΩ)

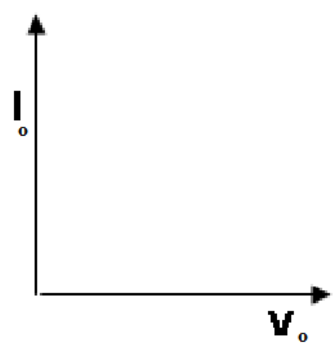
Circuit Diagram



Observation

S. No.	$V_{Applied}$ (V)	V_{LED} (V)	I_{LED} (mA)	V_{OUT} (V)	$I_O = I_E$ (mA)

Graph



Result

From the graph the relation between LED's voltage & current is observed.

- It is ------------------------- (Linear/ Nonlinear).

Laboratory Exercise 04

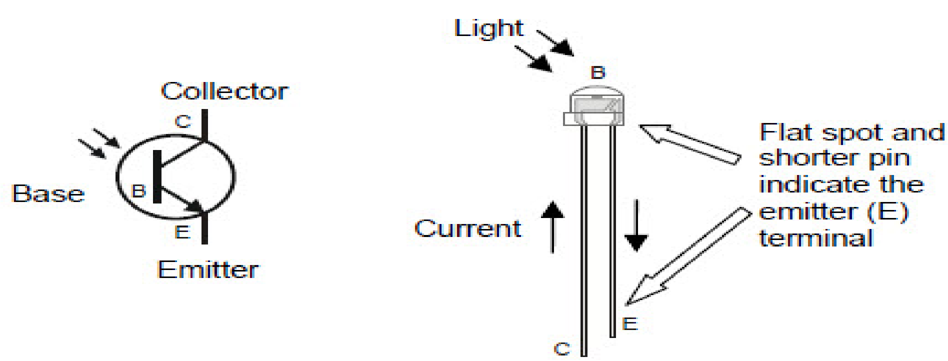
Objective

- Familiarize with the construction and operation of photo Transistors..
- Using Infrared LED and photo Diode, and Transistor, we can make a photo Transistor.
- Finding Voltage and Current relationship.

Theory

A photo transistor can be made to respond to light radiations and work as a sensor. A transistor is like a valve that regulates the amount of electric current that passes through two of its three terminals. The third terminal controls just how much current passes through the other two. Depending on the type of transistor, the current flow can be controlled by voltage, current, or in the case of the phototransistor, by light.

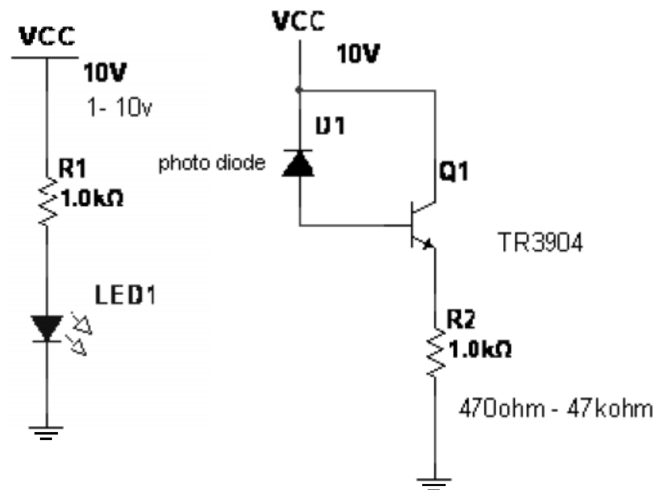
The drawing below shows the schematic and part drawing of the phototransistor in your Robotics Shield Kit. The brightness of the light shining on the phototransistor's base (B) terminal determines how much current it will allow to pass into its collector (C) terminal, and out through its emitter (E) terminal. Brighter light results in more current; less-bright light results in less current.



Apparatus

- Infrared LED (Tx)
- Photo Diode (Rx)
- Transistor (TR 3904)
- Power Supply (10V variable & 10Vor 5V fixed)
- Digital Multimeter (DMM)
- Resisters (1kΩ, 47kΩ, 470kΩ)

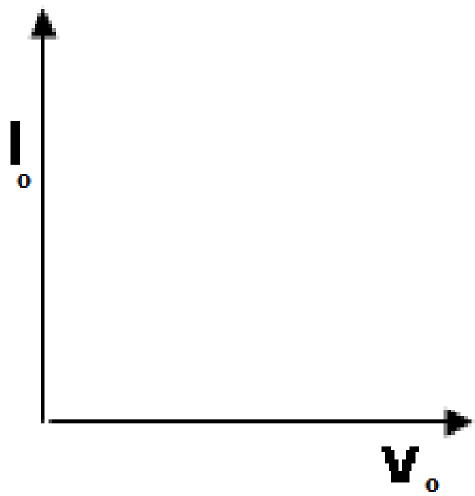
Circuit Diagram



Observation

S. No.	$V_{Applied}$ (V)	V_{LED} (V)	V_{OUT} (V)	I_o (mA)

Graph



Result

From the graph the relation between LED’s voltage & current is observed.

- It is -------------------------- (Linear/ Nonlinear).

Laboratory Exercise 05

Objective

- Familiarize with the construction and operation of Light Dependent Resistors (LDR) or Photo Resistor.
- Use Light Dependent Resistor (LDR) as a Photo Voltaic Detector.
- Finding Out put Voltage and LDR Current relationship.

Theory

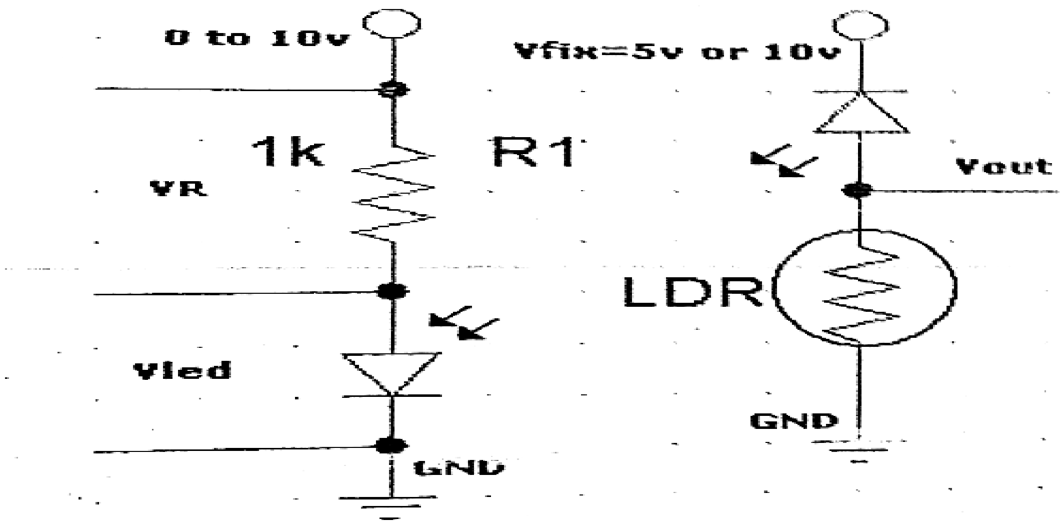
Photoconductive light sensor does not produce electricity but simply changes its physical properties when subjected to light energy. The most common type of photoconductive device is the Photoresistor which changes its electrical resistance in response to changes in the light intensity. Photoresistors are Semiconductor devices that use light energy to control the flow of electrons, and hence the current flowing through them. The commonly used Photoconductive Cell is called the Light Dependent Resistor or LDR

As its name implies, the Light Dependent Resistor (LDR) is made from a piece of exposed semiconductor material such as cadmium sulphide that changes its electrical resistance from several thousand Ohms in the dark to only a few hundred Ohms when light falls upon it by creating hole-electron pairs in the material.

Apparatus

- LED (Red, Green, Yellow, IR LED)
- Photo Diode (Rx)
- Power Supply (10V variable & 10Vor 5V fixed)
- Digital Multimeter (DMM)
- Resisters (1kΩ, 47kΩ)
- LDR

Circuit Diagram



Observation

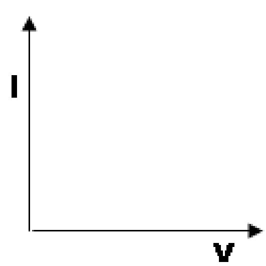
RED				
S. No.	$V_{Applied}$ (V)	V_{LED} (V)	V_{OUT} (V)	I_O (I_{LDR}) (mA)

GREEN				
S. No.	$V_{Applied}$ (V)	V_{LED} (V)	V_{OUT} (V)	I_O (I_{LDR}) (mA)

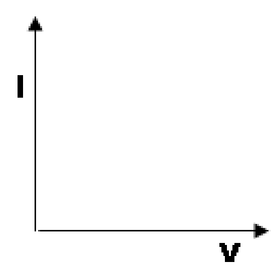
YELLOW				
S. No.	$V_{Applied}$ (V)	V_{LED} (V)	V_{OUT} (V)	I_O (I_{LDR}) (mA)

I.R.				
S. No.	$V_{Applied}$ (V)	V_{LED} (V)	V_{OUT} (V)	I_O (I_{LDR}) (mA)

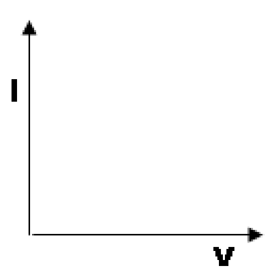
Graph



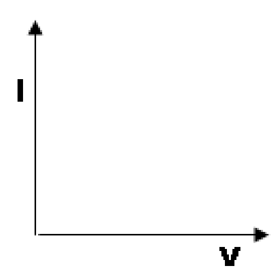
RED



GREEN



YELLOW



I.R.

Result

From the graph the relationship between Output voltage &Output current is observed.

- It is -------------------------- (Linear/ Nonlinear).

Laboratory Exercise 06

Objective

Evaluate the frequency response of IR LED using Opto Coupler IC (4N25), estimating 3db response.

Theory

- Opto Coupler are used to provide electrical isolation between two circuits.
- Opto Coupler has different frequency response depending upon input voltage and Q point setting of transistor.
- **CTR** The point at which current has been transformed is called as CTR (Current Transfer Ratio).

3dB Response BWel = 0.707 * BWopt

- The point at which 0.707 gains is achieved is known as 3db response, In other word appoint where we get half of input energy**.**
- It represents the point at which the output power has applies to 50%. It is useful because the 3db point represent a 45 degree phase shift which a good value to understand what is going in regards to the bode plot**.**

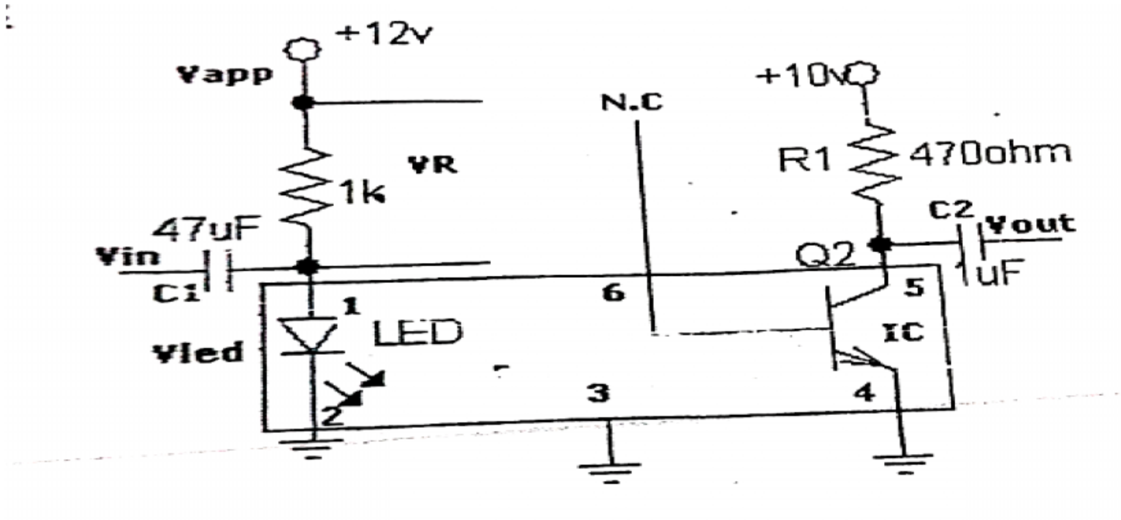
Formulae BWel = 0.707 * BWopt

BW el = Bandwidth electrical
BW opt. = Bandwidth optical

Apparatus

- IC 4N25
- Power Supply (12v variable, 5V & 10v fixed)
- Resisters (1kΩ, 47kΩ,470kΩ)
- Capacitors(1uF, 47uF)
- Function Gerator
- Digital Multimeter
- Oscilloscope

Circuit Diagram



Observation

S. No.	Frequency (Hz)	V_{in} (V)	V_{OUT} (V)	V_{OUT}/V_{IN}	V_{OUT}/V_{IN} (dB)

Result

From the graph the relation between LED's voltage & current is observed.

- It is -------------------------- (Linear/ Nonlinear).
- The current transfer ratio is observed.

Laboratory Exercise 07

Objective

- Study the Characteristics of IR LED and Blue LED.
- Find the relation between voltage and current.
- Find the wavelength and compare it.

Theory

Like a common diode, the LED (Light Emitting Diode) consists of a P-N contact. When a PN junction is forward biased, current flows within it. This current flow will cause electrons and holes to move is a manner that an electron will move to fill a hole. When this happens, the electron will fall to a lower energy level and this will release an amount of energy in the form of photons. In a larger scale, those photons will produce light.

LEDs are diodes and to light an LED, it must be forward connected. This means that the anode of the LED must be connected to the positive pole of a battery, and the cathode must be connected to the negative pole. This is how to determine the anode and the cathode lead of an LED. Determining the anode and the cathode of a new LED is not very hard. The first way is from the length of its leads. The anode lead is longer than the cathode lead of the led.

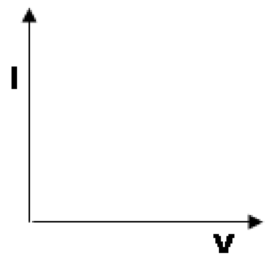
Apparatus

- LED (IR Led, Blue Led)
- Power Supply (10v variable)
- Resisters (1kΩ, 47kΩ)
- Digital Multimeter (DMM)

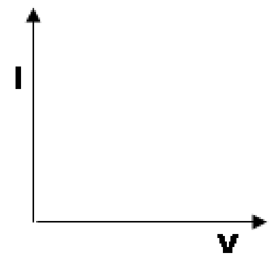
Observation

S. No.	$V_{Applied}$ (V)	Blue		I.R.	
		V_{LED} (V)	I_{LED} (mA)	V_{LED} (V)	I_{LED} (mA)

Graph



Blue



I.R.

Result

From the graph the relation between LED's voltage & current is observed. It is -------------------------- (Linear/ Nonlinear).

a. Vth = Eg =(IR) = ---------------------- V
b. Vth = Eg =(BLUE) = ---------------------- V
c. WAVELENGTH IR LED) = ------------------------------------ um
d. WAVELENGTH (BLUE LED) = ------------------------------------ um

Laboratory Exercise 08

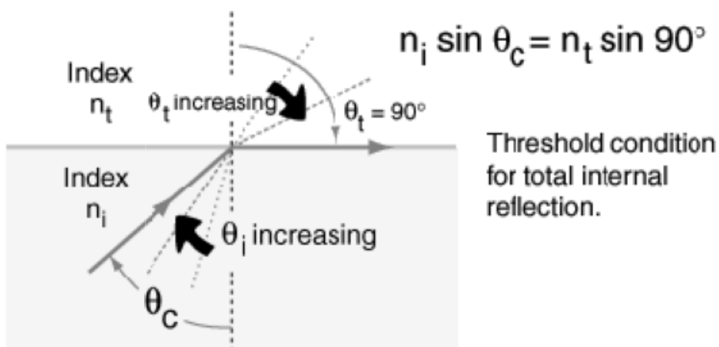
Objective

- Understand principles of light transmission in optical fiber.
- Measure critical angle.
- Calculate Refractive Index (R.I) of the material of optical waveguide provided.

Theory

Total Internal Reflection

When light is incident upon a medium of lesser index refraction, the ray is bent away from the normal, so the exit angle is greater than the incident angle. Such reflection is commonly called "internal reflection" The exit angle will then approach 90° for some critical incident angle θc, and for incident angles greater than the critical angle there will be total internal reflection.



The critical angle can be calculated from Snell's law by setting the refraction angle equal to 90°. Total internal reflection is important in fiber optics.

Apparatus

- Optical Waveguide.
- Laser Light.
- Module (HBE-OPT-202).
- Protractor.

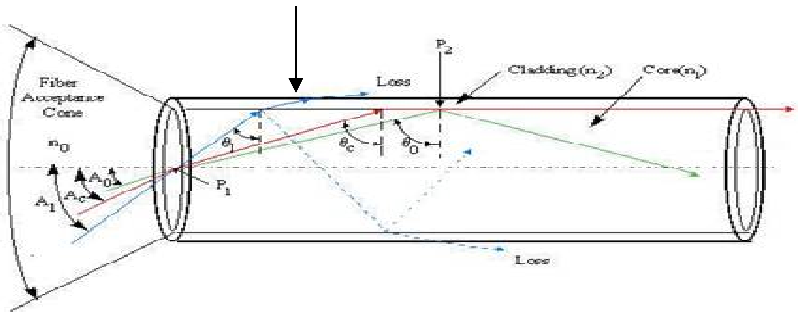
Formula

$\sin\theta c = n2/n_1$

Where;

n_2= R.I of air
n_1= R.I of glass

Diagram



Procedure

- Hold the oblique Line part of optical guide protector.
- Insert the laser pointer into RCA connector.
- Allow ray to enter into four random different points (a, b, c, d).
- Measure critical angle with the help of protractor provided.
- Repeat step for at least four times.

Observation

θ_{c1} =____________ °
θ_{c2} =____________ °
θ_{c3}= ____________ °
θ_{c4}= ____________ °

Calculations

- $\theta_c = (\theta c_1 + \theta c_2 + \theta c_3 + \theta c_4) / 4$
  θ_c = ____________ °.
- $\sin \theta_c = n_2/n_1$
  n_1 = __________.

Result

- Critical Angle found to be θc = _________ °
- Refractive Index of the Material of waveguide (n_1) = ___________

Laboratory Exercise 09

Objective

- Understand the characteristics of Si and Ge diode
- Understand the features of Current and voltage
- Compare the characteristics of Si and Ge diode

Theory

The Diode is two terminals Semi-conductor Element, Displace a low resistance to one polarity regarding the potential difference applied between both ends and if reversing this polarity the resistance will soar high. The junction of P-type semiconductor and N-type Semiconductor is called PN junction

In the balance, narrow spot with the thickness of do, the majority carrier electric charge carries existing on both sides of the joint, for instance, expose minority donor ions and accepter ions in the normal state. This electric charge will generate electric field at the joint, and establish a relevant contact potential. These potential difference woks as a barrier to both diffusing electrons and holes.

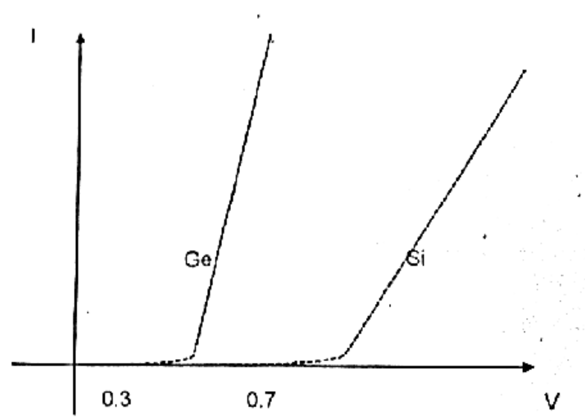


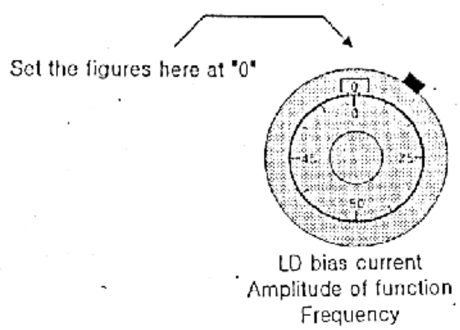
Figure 9-1 Diodes features of forward bias

Apparatus

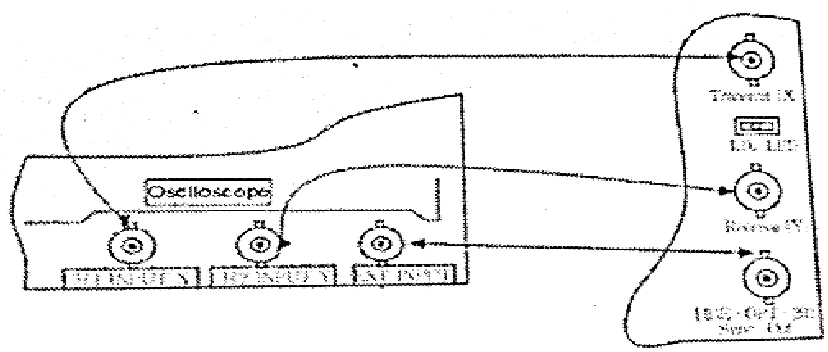
- Opto Training Kit (HBE-OPT-202).
- Oscilloscope.

Procedure

(1) The numerical value of LD bias current control diode, amplitude of function control dial and frequency control dial in the main frame of optical communication experimental board should be set at zero.

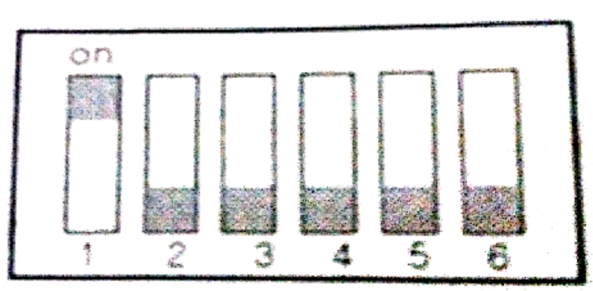


(2) Connect as shown in figure, channel 1, (or X terminal), channel 2 (or y-terminal) or X-trigger input terminal, in the oscilloscope on the left, with" transmitter[x]", receiver[y]" and "sync. out" at the BNC connector on the right.

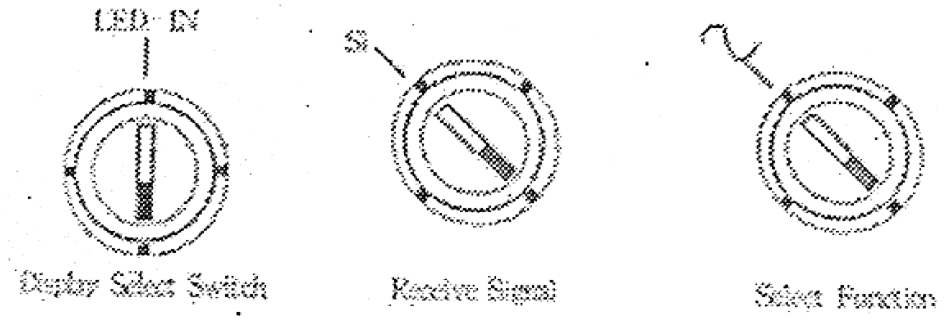


(3) Set trigger source at exterior (EXT) and waveform at dual mode, in the oscilloscope, to be able to simultaneous view both input signals (transmitter) and output signal (receiver).

(4) Turn on number one switch only of "freq. range" DIP switches which are located at the upper centre of "HBE-OPT-202" mainframe.



(5) Set the display select switch to "LED-IN", the receiver signal switch to "PD-LED" and the select – function switch to "~".

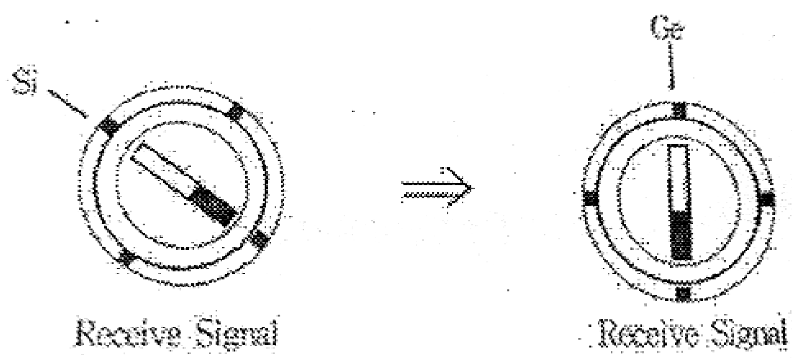


(6) Set the three terminal toggle switch to “LED”. The switch is located at the between” Transmitter” [x] and Receiver [y] BNC connectors in the main frame.

(7) Turn on the power switch in the lower left of the mainframe.

(8) Set “Frequency” control dial at “4-6” and turn “Amplitude of function” control-dial clockwise to set it at “10” .To increase slowly “LD bias Current” control dial without distorting the output as you observe CH1 (input or transmit) waveforms and CH2 (output or receiver) waveforms.

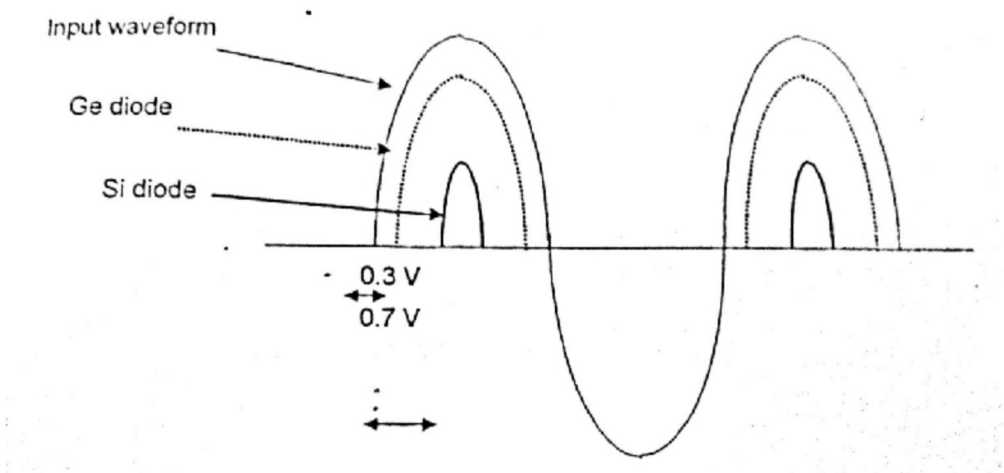
(9) Turn the receiver signal switch to Ge.



(10) Draw the graph of Ge and Si waveform and construct the waveform.

Result

Output waveform corresponding to input waveform of alternating current.



The input voltage of Ge and Si diodes corresponding to the sine wave. Input display Si times of 0.7 and Ge 0.3

Laboratory Exercise 10

Objective

To determine the transmission loss due to bending of fiber cable using Opto Training Kit (HBE-OPT-202).

Apparatus

- Opto Training Kit
- Oscilloscope

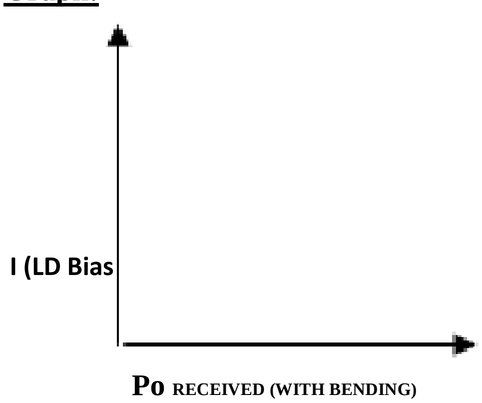
Procedure

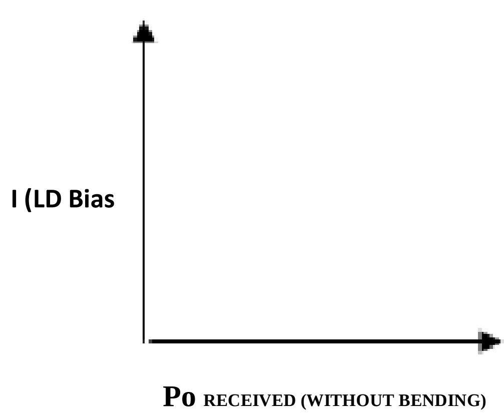
- Set LD bias current Dial to 0.
- Set on position to six frequency range switches.
- Set the toggle switch to LD.
- Set the Display switch to PD-LD.
- Set the receive switch to PD-LD.
- Set the frequent control Dial between 4 & 5.
- Set the amplitude control Dial between 5 & 6.
- Set the signal switch to sine wave throughout the experiment.

Observation

S. No.	LD Bias Current (mA)	Input Current (mA)	Power Recieved (μW)	
			With Bending	Without Bending

Graph:





Result: The transmission loss due to bending of fiber optic cable is observed

Laboratory Exercise 11

Objective

Determine the Transmission loss due to connectors (used) length and area of cross-section of fiber optic cable using Opto Training Kit (HBE-OPT-202).

Apparatus

Opto Training Kit (HBE-OPT-202)

Procedure

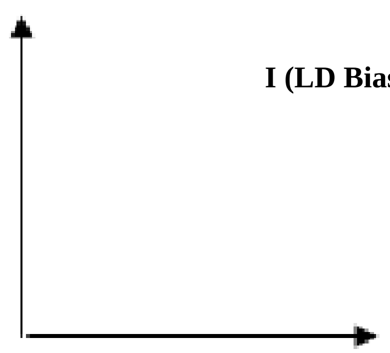
- Set LD bias current Dial to 0.
- Set on position to six frequency range switches.
- Set the tiggle switch to LD.
- Set the Display switch to PD-LD.
- Set the receive switch to PD-LD.
- Set the frequency control Dial between 4 & 5.
- Set the amplitude control Dial between 5 & 6.
- Set the signal switch to sine, Triangular and Square wave.

Observations

S. No.	LD Bias Current (mA)	Input Current (mA)	Power With Connector (μW)	Power Without Connector (μW)

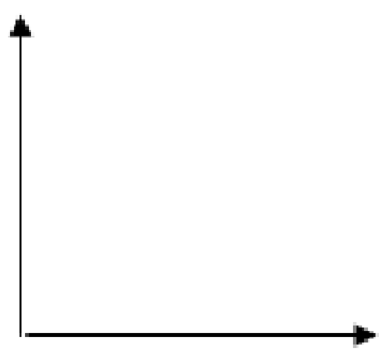
Graph:

I (LD Bias)



Po **RECEIVED (WITH Connector)**

I (LD Bias)



Po **RECEIVED (WITHOUT Connector)**

Result

The Transmission loss due to connector, length and area of cross section of fiber optic cable are observed.

Laboratory Exercise 12

Objective

To transfer data between Modules over optical fiber (KL-900D)

Theory

Application of fiber optics communication Network are widely used in our daily life and its also used many fields such as datacom, cable TV, Telecom and military application.
Early applications of fiber optic transmission links largly under for trunking of telephones lines. Today nearly 70% of the fiber optic used for longe distance under sea co-axial cables are replaced by optical fiber cables.

In some development countries 90% of the backbbone trunks of long distance alnd line telephone networks are instaued with the fiber cables. The installation of the fiber optic networks among the local offices will be completed in 2000.

Apparatus

Opto Training Kit (KL-900D)

Procedure

1. Place the two modules A and B on the work table.
2. Select the data transceiver of each module in 1 position (Transciver).
3. Loosen the inch nut on Tx1 of module A. Insert either end of the 1 meter optical fiber into Tx1 and gernally push in until the fiber tip makes contact with the insulator back wall. Install the other end of the 1-meter optical fiber into Rx1 the module B.
4. Apply 15 Vdc voltage to the power jack of each module through the AC to DC power adopters.
5. Set the character selector button on single position for each module and send numeric, similarlyselect set button into string send alphabets.
6. Apply same procedure to Tx2 end Rx1.

Observation

S. No.	Keyboard	Opposite LCD	Keyboard	Opposite LCD

Result

The data are transmitting from the module A (Tx) receive on a module B (Rx). Hence the transmission is performed accurately and vice versa.

Laboratory Exercise 13

Objective

Splice the Single Mode Fiber (SMF) by using fusion splicer type 39.

Theory

Fiber Optic Cable Splicing

Two optical fiber splicing methods are available for permanent joining of two optical fibers. Both methods provide much lower insertion loss compared to fiber connectors.

1. Fiber optic cable fusion splicing – Insertion loss < 0.1dB
2. Fiber mechanical splicing – Insertion loss < 0.5dB

Fiber optic cable fusion splicing

Fiber optic cable fusion splicing provides the lowest-loss connection. Special equipment called fusion splicer is used to perform the fiber fusion splicing. The fusion splicer performs optical fiber fusion splicing in two steps.

1. Precisely align the two fibers
2. Generate a small electric arc to melt the fibers and weld them together

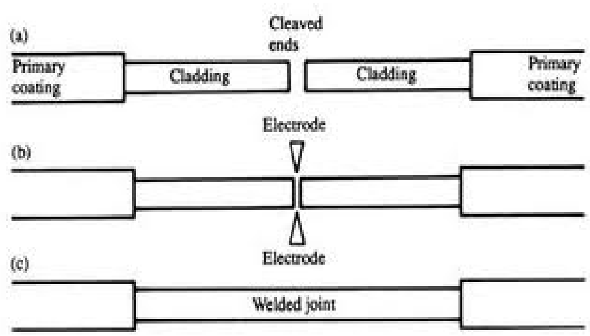


Figure 1 Fiber Splicing

High precision fusion splicers are usually bulky and expensive. With proper training, a fiber splicing technician can routinely achieve less than 0.1dB insertion loss splicing for both single mode and multimode fiber cables.

Apparatus

- Optical Fiber.
- Fusion Splicer.
- Fiber Cleave.
- Power cord.
- Jacket remover (stripping tool).
- Splice protection sleeve.

Fusion Splicer Parts:
Main body, Key board, Monitor, Hood, Heat Shrink Ovan, Power module bay, I/Opanel, V-Qroove, Dispenser, Electrode Cover Plate, Microscope Objective Lens-V groove illumination, Mirror, bare, Fiber Pads, Mirror Projection Glass.

Procedure

The fusion splicing procedure comprises of the following 9 steps:

(1) Fiber Preparation
Feed a splice protection sleeve (strengthened plastic tube) over one of the fibers. The ends of the fibbers should be stripped (as outlined above) and cleaned. Enough of the fiber should be stripped to enable the end (after cleaving) to fit into the fusion splicer mounting.

(2) Fiber Cleaving
The desired low loss splices are hard to achieve without fibers that have been well cleaved leaving square ends. This is even more so with Single Mode fibers (SMF).

(3) Mounting the fibers
The fibers are clamped into place in the fusion splicer. Fusion splicers use two clamps per fiber, one clamp over the coating, the other over the bare fiber.

(4) Coarse Alignment
The ends of the fibers are brought close together and aligned between the splicers electrodes. In the splicer used in this lab is done automatically by the splicer with an image of the fiber ends displayed on a screen; older splicers required manual alignment.

(5) Fibre Cleaning Arc
A short discharge from the splicers electrodes is used to burn off any dust particles or other dirt from the fibre ends.

(6) Fine Alignment
The ends of the fibers are brought together. There are a number of methods for passive and active alignment; the splicer used in the lab do the alignment automatically.

(7) Main Fuse
At this stage an electric arc (from the splicers electrodes) - which can be programmed within the splicer for differing fiber cables - is created across the ends of the fiber to melt them. The fibers are pushed together so that they can fuse together. A number of problems can occur during the main fuse.

(8) Inspection & Test
Visual inspection of the fusion point via the splicer’s owns display will give a good idea as to the success of the splice. The splicer will give an estimation of the splice loss, however it must be remembered this is only estimation. Prior to removing the fibers from the splicer, the machine may put some strain onto the splice to ensure a good physical joint has been made.

(9) Splice Protection

Once the splice has been completed the bare fibers will need protecting, hence the splice protection sleeve in step (1). The splice protection sleeve - which is just a tube of heat shrink with a strengthening member incorporated - is pulled over the splice.

Result

The SMF is successfully spliced.