CHARACTERIZATION OF LED, PHOTODIODE AND LDR

PROJECT REPORT

Submitted by

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In partial fulfilment of the requirement of award of Bachelor Degree of science in Physics.

ST. TERESA'S COLLEGE (AUTONOMOUS)
ERNAKULAM
2025-26

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CERTIFICATE

This is to certify that the project report entitled "**CHARACTERIZATION OF LED, PHOTODIODE AND LDR**" is an authentic work done by GOPIKA G, St Teresa's College, Ernakulam, under my supervision at Department of Physics and Centre for Research, St. Teresa's College, Ernakulam, for the partial requirements for the award of Degree of Bachelor of Science in Physics during the academic year 2025-26. The work presented in this dissertation has not been submitted for any other degree in this or any other university.

Santhi

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B.Sc. PHYSICS
PROJECT REPORT

NAME : GOPIKA G

REGISTER NUMBER : AB23PHY007

YEAR OF WORK : 2025-26

This is to certify that this project work entitled,"CHARACTERIZATION OF LED, PHOTODIODE AND LDR" is an authentic work done by GOPIKA G.

Staff member in-charge
Dr. SANTHI A

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Submitted for the University examination held at St. Teresa's College, Ernakulam.

DATE: 16.04.26

EXAMINER:

1. ATHIRA PRAKASH

2.

DECLARATION

I, GOPIKA G final B.Sc. Physics student, Department of Physics and Centre for Research, St. Teresa's College (Autonomous), Ernakulam, do hereby declare that the project work entitled "**CHARACTERIZATION OF LED,PHOTODIODE AND LDR** " has been originally carried out under the guidance and supervision of **Smt. Dr. SANTHI A**, Associate Professor, Department of Physics and Centre for Research, St. Teresa's College (Autonomous), Ernakulam, in partial fulfilment for the award of the Degree of Bachelor of Physics. I further declare that this project is not partially or wholly submitted for any other purpose and the data included in the project is collected from various sources and is true to the best of my knowledge.

PLACE: Ernakulam

DATE: 30-03-2026

NAME: GOPIKA G

Gopika G

ACKNOWLEDGEMENT

First and foremost, I would like to thank God almighty for showering his blessings on me in this endeavor.

I wish to express my sincere gratitude to Dr. Santhi A, Department of Physics and Centre for Research, St. Teresa's College (Autonomous), Ernakulam, for her guidance, timely help, expert advice, support and persistent encouragement given to me throughout the duration of my project work.

I express my deep sense of gratitude to the Department of Physics and Centre for Research, St. Teresa's College (Autonomous), Ernakulam, for extending the facilities and co-operation required from time to time. I take this opportunity to thank once again Dr. Mary Vinaya, Head of Department of Physics for generous concern and support.

Last but not the least I express my thanks to all teaching and non-Teaching staff of the Department of Physics, for their kind Co-operation.

GOPIKA G

Gopika G

ABSTRACT

Optoelectronic devices play a vital role in modern scientific research and experimental physics. The increasing demand for precise optical sensing and measurements techniques has led to extensive study of semiconductor -based light sensitive components. This project presents a comparative characterization of three optoelectronic devices: Light Emitting Diodes, Photodiode, Light Dependent Resistors. The primary objective is to analyze and compare the V-I characteristics and response behavior of each component under varying environmental and illumination conditions. LEDs are widely used in research laboratories as stable light sources for spectroscopy, optical calibration, and photometric studies. Photodiodes are extensively applied in radiation detection, optical power measurements, biomedical instrumentation, and experimental light intensity measurements due to their high sensitivity. LDRs are commonly utilized in environmental monitoring systems, astronomical light detection studies, and lowcost experimental sensing applications. The findings provide a quantitative understanding of performance of these devices, offering clear understanding of selection of appropriate optoelectronic components for various research-oriented applications such optical absorption study of LED and photodiode and also astronomical light intensity monitoring using LDR etc.

CONTENTS

CHAPTER-1. INTRODUCTION

Optoelectronics is a rapidly advancing field of electronics that deals with the device capable of converting light energy into electrical energy and vice versa. These device forms backbone of numerous scientific instruments and experimental setups used in physics, engineering, environmental studies and biomedical research. Understanding the behaviour and characteristics of optoelectronic components is essential for developing accurate sensing and measurement systems.

Light interacts with solid state materials in many ways. Interaction of light with semiconductor materials are generally classified as Electroluminescence and Photoconductivity.Electroluminescence is the excitation resulting by the application of an electric field, either AC or DC while photoconductivity is phenomenon in which material become electrically conductive due to absorption of electromagnetic radiations such as IR, UV, Gamma radiations, and visible light. In electronic and power generation applications ordinary diodes are utilized which is made of indirect bandgap materials. In these diodes during transitions momentum change is involved. To balance these phonons are also involved resulting the energy to be released as heat. While in Light detection and light emission applications diodes having direct bandgap materials such as Silicon, Germanium are used. The most widely used optoelectronic devices are Light Emitting Diodes, Light Dependent Resistor, and photodiode. The characterization of LED is an example for Electroluminescence study and characterization of photodiode and LDR for photoconductivity in semiconducting materials.

LEDs are now low cost-effective light sources for general lighting and accent lighting. They can replace conventional light source and thus improve flexibility and reduce power consumption. In 1962, the first red LED was created by Nick Holon yak Jr and S.Bevacqua .For several years, researchers have been limited to few colors such as red (1962), yellow and blue (1972) and green. Conventional low power LEDs are an attractive alternative in comparison to conventional products like fluorescent lights, incandescent or discharge. They offer a great advantage in low power consumption, long life time and ability to select a very specific colour among many. Its commonly used as stable and efficient light source in optical calibration setups and spectroscopy studies.

Photodiodes and LDR are photoconductive semiconductor devices that operates opposition to LEDs. They are capable of producing electricity from light energy while diodes transform electricity into light. A photodiode is a light- sensitive semiconductor device that converts incident light into electrical current, making it highly suitable for radiation detection and, optical power measurements, and precision light intensity analysis. An LDR is a passive light sensitive resistor whose resistance varies with intensity of incident light and frequently employed in environmental monitoring, astronomical observations, and basic light sensing applications.

The performance of these devices depends on the parameters such as voltage, current, illumination intensity etc. Studying the V-I Characteristics and response under controlled conditions is crucial for understanding the operational principles and limitations. This project focuses on the experimental investigations and comparative analysis of LED, Photodiode and LDR characteristics. By examining the electrical and optical responses, provides a quantitative understanding of valuable insights for suitability of optoelectronic components for various research-oriented applications and sensor-based experimental systems.

CHAPTER-2. LIGHT EMITTING DIODE -LED

1.1.INTRODUCTION

Electroluminescence is the generation of non-thermal light through the application of an electric field, where high energy electrons interact with luminescent centres in a semiconductor. The commonly used electroluminescent devices in daily life are Light emitting diodes.

There are four main types of electroluminescence devices classified depending on type of drive (a.c or d.c) and character of active layer. The basic structure giving rise to injection luminescence of p-n junction diode operating under forward biased condition. Under forward bias, majority carriers from both sides of the junction cross the depletion layer and enter the material at other side, where there are then the minority carriers and cause the local minority carrier population to be larger than normal. This is described as minority carrier injection. The excess minority carriers diffuse away from the junction recombining with majority carriers. In a Light emitting diode, every injected electrons takes part in a radiative recombination process give rise to an emitted photon.

LIGHT EMITTING DIODE

Light-emitting diode, usually called LED is an opto-semiconductor devices that emits incoherent narrow spectrum of light when electrically biased in the forward direction of p-n junction through doping, as in the common LED circuit. It is a form of electroluminescence. A LED is usually a small area light source, often with optics added to the chip to shape its radiation pattern and assist reflection. The efficiency of the device is described in terms of quantum efficiency, which is defined as ratio of rate of emission of photons to the rate of supply of electrons.in reverse bias, no carrier injection takes place and consequently no light is emitted. The current-voltage (i, v) relationship for a diode can usually expresses as

$$i = i_0 \left[\exp\left(\frac{eV}{\beta kT}\right) - 1\right] \qquad (1.1)$$

Where i_0 is a constant (the reverse saturation current).

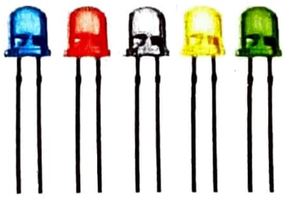


Fig.1.1, coloured 5mm LEDs

WORKING

The LED work like a p-n junction diode. When the diode is forward biased, the current flow through the diode. The flow of current in semiconductors is caused by the both flow of holes in the opposite direction of current and flow of electrons in the direction of current. Hence there will be recombination due to flow of these charge carriers. The number of radiative recombination take place is proportional to carrier injection rate and hence to total current flowing. If the transitions takes place directly between states at the bottom of the conduction band and the top of valence band, the emission wavelength λ_g given by

$$\frac{hc}{\lambda_g} = E_c - E_v = E_g \quad (1.2)$$

Therefore, $\lambda_g = hc/E_g \quad (1.3)$

From the above equation we can say the wavelength of electromagnetic radiation is inversely proportional to the forbidden energygap. Radiative recombination in semiconductors occurs predominantly via three different processes namely interband transitions, recombination via impurity centres and exciton recombination

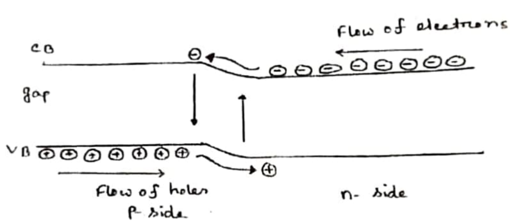


Fig 1.2, Energy level diagram of p-n junction of LED

The emission of photons in an LED explained by energy band theory of solids, which dictates that light emission depends on material's bandgap being direct or indirect. Those semiconductor materials with direct bandgap emits photons. The recombination process is illustrated by an Energy-wavevector diagram for both direct and indirect bandgap materials. In a direct bandgap material, the bottom of the energy level of conduction band lies directly above the valence band in E-k diagram. When electron and hole recombine the energy E=hv corresponding to energy gap Δ(eV) is escaped in form of a photon of frequency v . In indirect bandgap material, the conduction band and valence band are not aligned converting the energy into heat e.g.: Si, Ge etc.

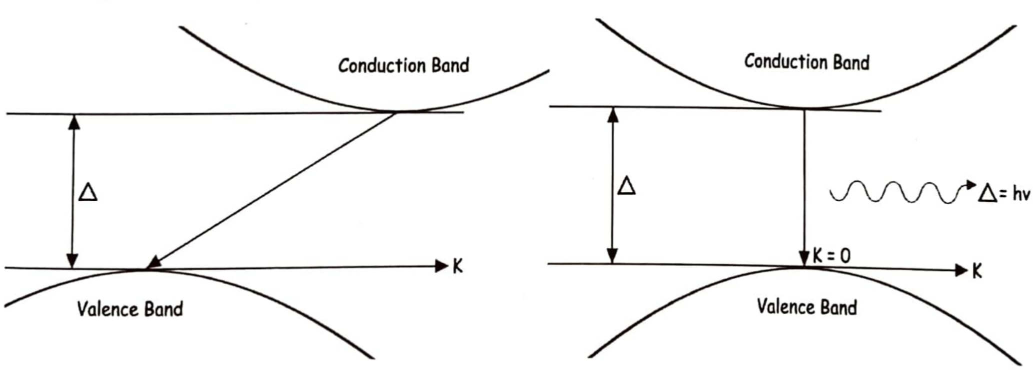


Fig1.3, indirect and direct bandgap materials in semiconductors

LED MATERIALS

Direct bandgap materials are in semiconductor compound form such as Gallium Arsenide (GaAs), Gallium Phosphide (GaP) etc. The dopant atoms added to GaAs to give a wide range of colors. Some of the materials used in LEDs are:

- Gallium Arsenide – Infra red

- Gallium Arsenide Phosphide- red to infrared, orange
- Gallium Phosphide- red, yellow, green
- Gallium Nitride -green, emerald green
- Zinc Selenide -blue
- Gallium Indium Nitride- near UV, bluish green, blue
- Silicon Carbide- blue as substrate
- Aluminium Gallium Nitride – UVs

Gallium Arsenide (GaAS):

GaAs is a III-V compound semiconductor composed of Gallium and Arsenic.It is a direct bandgap semiconductor with energy gap 1.443 eV at room temperatures, corresponding to red or near- infrared light emission. GaAs based LEDs are commonly used in infrared applications such as remote sensing, optical communications and sensing devices. Despite its relatively low bandgap energy compared to other semiconductor materials, GaAs LEDs can still emit visible light when doped with certain impurities or used in heterostructures.

Gallium Nitride (GaN):

GaN is a III-V compound semiconductor composed of Gallium and Nitrogen. It has a wide bandgap energy ranging from approximately 3.4 to 3.5 eV at room temperatures, depending on the specific crystal structure and doping. GaN based LEDs are known for their high efficiency and bright emission across a wide range of wavelengths, including blue, green and UV light. GaN based LEDs are also used in various applications such as displays, automotive lighting, and solid-state lighting.

Overall, Gallium Arsenide, Gallium Nitride and Indium Gallium Nitride are the key semiconductor materials used in LED construction, each offering unique properties and capabilities that enable the production of efficient, bright, and versatile light emitting devices across a wide range of applications.

CONSTRUCTION

Three semiconductor layers deposited on substrate are n-type semiconductor, p-type semiconductor and active region in between them. When forward biased, free electrons from n-type semiconductor and holes from p-type semiconductor pushed to active region. When free electrons and holes recombine with opposite charge carriers a photon is emitted. In LED most of the charge carriers recombine at active region and most of the light emitted by active region. The p-layer is made thin and grown on a n-layer substrate. Metal electrodes are attached on either side of p-n junction serves as external electrical connection. The LED is encased in a dome shaped transparent case so light is emitted uniformly in all directions and minimum internal reflection to take place. Longer leg of LED represents positive electrode or anode. LEDs with more than 2 are also available such as 3,4 and 6 pin configurations to obtain multi-colors in same LED package.

Layered internal structure of LED consist of p-type semiconductor, active region and n-type semiconductor. When a trivalent impurity added to intrinsic semiconductor p-layer is formed, here holes are majority carriers. When a pentavalent impurity added to intrinsic semiconductor n-layer is formed, here electrons are majority carriers. In between a depletion layer with no mobile charge carriers. A voltage greater than the barrier potential is applied and current flows resulting in illumination of LED.

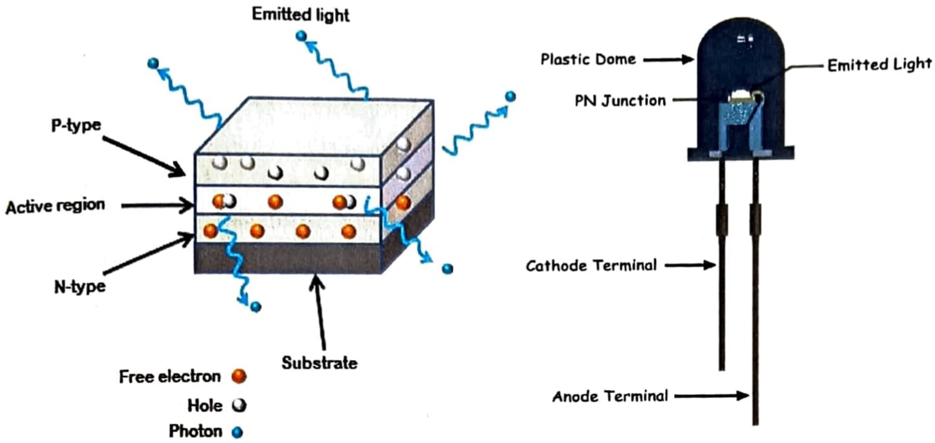


Fig 1.4, Semiconductor layers and structure of LED

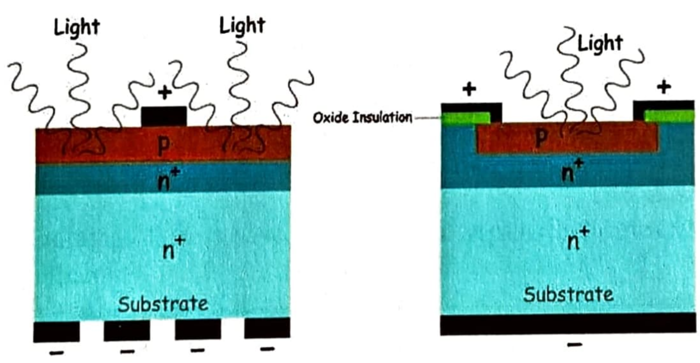


Fig 1.5, Internal structure of LED

ADVANTAGES OF LEDs

1. LEDs produce more light per watt than incandescent bulbs, making them ideal for battery-powered or energy-saving devices resulting high efficiency. They can emit light of an intended color without the use of external color filters, reducing initial costs.
2. The solid package of an LED can be designed to focus light, whereas incandescent and fluorescent sources often require external reflectors. Unlike incandescent lamps which turn yellow when dimmed, LEDs do not change their color tint as current is lowered.
3. They are ideal for applications involving frequent on-off cycling. Unlike fluorescent lamps, they don't burn out quicker when cycled, and unlike HID lamps, they don't require a long restart time.
4. As solid-state components, they are difficult to damage with external shock, whereas traditional bulbs are easily broken if dropped.
5. LEDs have a long useful life (estimated 35,000 to 50,000 hours), significantly outlasting fluorescent tubes (30,000 hours) and incandescent bulbs (1,000–2,000 hours).
6. They typically fail by dimming over time rather than the abrupt burn-out seen in other bulbs. They light up very quickly (in microseconds), which is beneficial for communications devices and brake lights.

7. Their small footprint allows them to be easily populated onto printed circuit boards.
8. LEDs do not contain mercury, unlike compact fluorescent lamps (CFLs).
9. LEDs are very cheap and readily available. They are small, lightweight and available in different colors.

DISADVANTAGES

1. Luminous efficiency is low & LEDs need more power to operate than of p-n junction diodes.
2. On a price-per-lumen basis, LEDs are currently more expensive than conventional lighting technologies.
3. Performance depends heavily on the ambient temperature. Over-driving an LED in high temperatures can lead to overheating and eventual device failure. To maintain a long life, LEDs require adequate heat-sinking, especially in automotive or medical applications.
4. LEDs must be supplied with the correct current, often requiring series resistors or current-regulated power supplies.
5. The spectrum of white LEDs differs from natural sunlight. A spike at 460 nm and a dip at 500 nm can cause objects to be perceived differently (metamerism).
6. They cannot produce the extremely narrow, collimated beams that lasers can (LEDs usually have a divergence of a few degrees).
7. There is an increasing concern that blue and white LEDs may exceed safe limits for "blue-light hazard" as defined in eye safety specifications.

APPLICATIONS

LEDs (Light Emitting Diodes) have revolutionized various industries with their versatility, efficiency and durability.

1. GENERAL LIGHTING:

LEDs are extensively used in general lighting applications, including residential, commercial, and outdoor lighting. LED bulbs and fixtures offer energy efficiency, long lifespan and customizable color options. They are used in homes, streetlights, parking lots and architectural lighting designs.

2.AUTOMOTIVE LIGHTING:

LEDs are increasingly replacing traditional incandescent and halogen bulbs in automotive lighting applications. They are used in headlights, brakeligths, turn signals, interior designing and accent lighting. LEDs provide brighter illumination, faster response time, and improved energy efficiency in vehicles.

3.DISPLAYS:

LED displays are ubiquitous in consumer electronics, advertising and public information systems. They are used in smartphones, tablets, laptops, televisions and digital signage. LED display offers high brightness, vibrant colors, wide viewing angles, and lower power consumption compared to LCD displays.

In summary, LEDs find widespread applications in lighting, displays, indicators and various other sectors due to their efficiency, durability, versatility and aesthetic appeal.

LED CHARACTEISTICS

The current-voltage (I-V) characteristics of LEDs are essential for understanding how these devices behave electrically and optically. The key aspects of LED I-V Charcteristics:

KNEE VOLTAGE OR TURN ON VOLTAGE

When a forward bias voltage is applied to an LED; the positive terminal to connected anode and negative terminal to cathode. Then the current start flowing through the device. Knee voltage or turn on voltage is the minimum voltage requires to turn on the LED. Below this voltage, the LED remains off, and the current through the device is negligible. For LEDs this voltage depends on the material used the color it emits.

FORWARD VOLTAGE DROP

Initially there is a small voltage that must be exceeded to initiate conduction. Once this threshold is surpassed, the LED enters its forward conduction region. The forward voltage drop across an LED is the voltage at which the device starts conducting significantly. It represents the energy barrier that electrons overcome to recombine with holes and emit photons. The voltage drop depends on various factors such as semiconductor materials, bandgap energy and doping concentration. Typically, it ranges from1.5 to 4 eV for most of the LEDs.

FORWARD CURRENT AND LIGHT OUTPUT:

As the LED is in forward bias voltage increases beyond threshold, the current flowing through the LED increases exponentially with increase in voltage. The relationship between forward current and light output in an LED is complex and non-linear. The intensity of emitted light or brightness depends on the forward current in the circuit. At low currents, the light output is minimum and device may emit no visible light. As the current increases the number of electron-hole pars recombining in semiconductor material increases, leading to higher rate of photo emission and increased light output. There is a point at which LED reaches maximum rated, beyond which further increase in current significantly affect the LED and do not increase brightness referred to as saturation region or maximum light output region. To avoid this damage LED circuits generally designed with current limiting resistors.

COLOR CHARACTERISTICS

The colour characteristics of LEDs are primarily determined by the bandgap energy of the semiconductor material used in their construction.

1.BANDGAP ENERGY:

The bandgap energy is the energy difference between the valence band (where electrons are tightly bound to atoms) and the conduction band (where electrons are free to move as charge carriers) in a semiconductor material.In LEDs, electrons are excited from the valence band to the conduction band.When a forward bias voltage is applied, and they recombine with holes in the valence band, releasing energy in the form of photons (light).

2. ENERGY AND WAVELENGTH RELATIONSHIP:

According to Planck's equation ($E = hc/\lambda$), where E is energy, h is Planck's constant, c is the speed of light, and λ is wavelength, there is an inverse relationship between energy and wavelength. Semiconductor materials with larger bandgap energies have shorter wavelengths of emitted light, corresponding to higher-energy photons. Conversely, materials with smaller bandgap energies emit longer wavelengths of light, corresponding to lower-energy photons.

3. LED COLOR EMISSION:

LEDs emit light in a specific color determined by the bandgap energy of the semiconductor material. The wavelength of light emitted by an LED is directly related to the bandgap energy of the material. For example:

- Semiconductors with larger bandgap energies, such as Gallium Nitride (GaN), emit shorter wavelengths of light in the blue and ultraviolet (UV) regions of the spectrum. Semiconductors with intermediate bandgap energies, such as Indium Gallium Nitride (InGaN), emit light in the blue, green, and amber regions of the spectrum.
- Semiconductors with smaller bandgap energies, such as Gallium Arsenide (GaAs), emit longer wavelengths of light in the red and infrared (IR) regions of the spectrum.

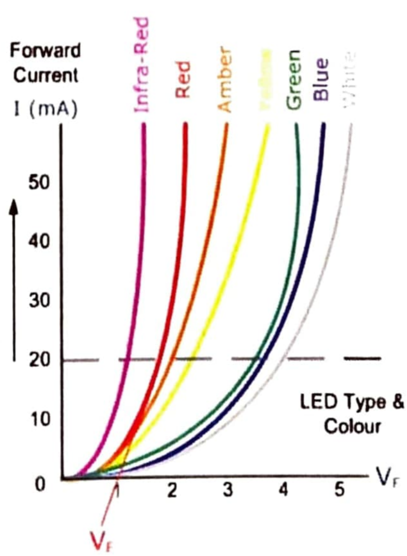


Fig 1.6, V-I curve for colored LEDs

1.1 I-V CHARACTERISTICS OF LIGHT EMITTING DIODES

To study the I-V characteristics of LED a forward biased circuit is used. The I-V characteristics of different coloured LEDs are studied and corresponding wavelength of each color is determined.

APPARATUS:

DC source, LED, voltmeter, milliammeter,microammter, rheostat, resistance box

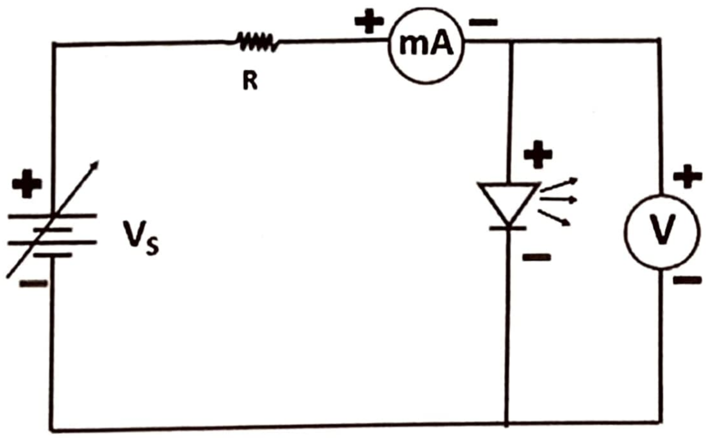
PRINCIPLE:

The current increases with increase in voltage. For each colored LED the Turn-on voltage and the glow start and maximum glow for LED is observed. The wavelength of each colored LED is determined using the equation

$$\lambda = \frac{hc}{eV} \text{ , where } V \text{ is the knee voltage} \qquad (1.4)$$

Where knee voltage is the minimum voltage required to overcome the internal potential barrier.

CIRCUIT DIAGRAM



Forward Biasing condition of LED

Fig 1.7, circuit diagram for V-I Characteristics of LED

PROCEDURE:

The connections are made as shown in circuit diagram. The positive terminal of the battery is connected to lower leg of the rheostat and negative terminal of battery to other and from the upper leg of rheostat is then connected to a resistance box, then to positive electrode of LED (to limit the current to the LED. The LED is connected in series with a milliammeter to measure current and voltage is measured across the terminals of LED. By adjusting the rheostat the current increases and LED starts glow, this voltage is generally very feeble which is of the order of microamperes, so first use a microammeter then replace with a milliammeter. when the voltage increases beyond a threshold value.And the voltage corresponds to maximum luminescence is noted

A graph is plotted by taking voltage in volt along X axis and current in milli amperes along y axis. A exponential increase of current with the increase of voltage is obtained. A tangent drawn on the point at which current increase after threshold voltage gives the knee voltage. The experiment is repeated for different colred LEDs such as Red LED, Blue LED, Green LED, Yellow LED and Pink LED and corresponding wavelength of each colour is determined.

GRAPH

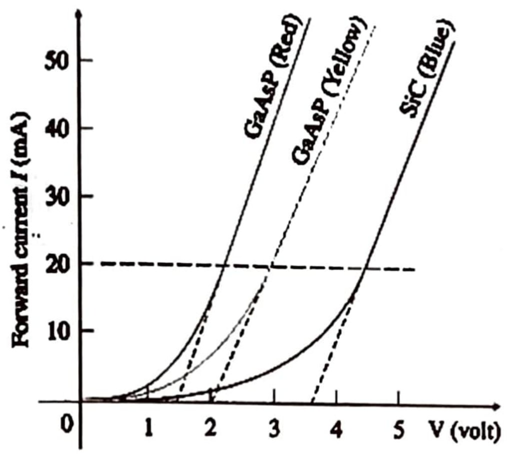


Fig 1.8, Graphical representation of V-I curve

1.1.1 V-I CHARACTERISTICS OF RED LED

The current and voltage values for a red LED in forward biased and the corresponding graph is given by

Sl.no.	VOLTAGE (V)	CURRENT (mA)
1.	0.222	0
2.	0.997	0
3.	1.533	0.01
4.	1.599	0.02
5.	1.635	0.05
6.	1.674	0.11
7.	1.715	0.25
8.	1.837	0.5
9.	1.839	2
10.	1.869	30
11.	1.911	60
12.	1.940	100

GRAPH

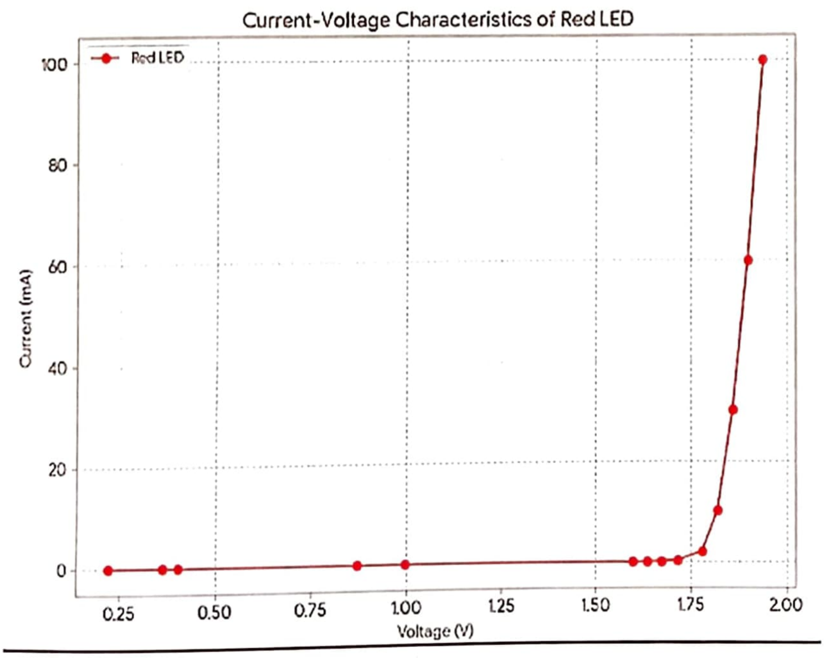


Fig 1.9, V-I characteristics of Red LED

From the graph, the knee voltage = 1.78v

$\lambda = \frac{hc}{eV} = \frac{6.63*10^{-34})*(3*10^{8})}{(1.6*10^{-19})*(1.78)} =$ 698.3nm, is the wavelength obtain

1.1.2 V-I CHARACTERISTICS OF BLUE LED

The current and voltage values for a blue LED in forward biased and the corresponding graph is given by

Sl.no.	VOLTAGE(V)	CURRENT (mA)
1	0.182	0
2	0.777	0
3	1.896	0.005
4	2.04	0.010
5	2.07	0.015
6	2.10	0.025
7	2.13	0.05
8	2.16	0.10
9	2.53	2
10	2.81	10
11	3.01	20
12	3.19	30
13	3.43	50
14	3.51	60
15	3.54	66

GRAPH

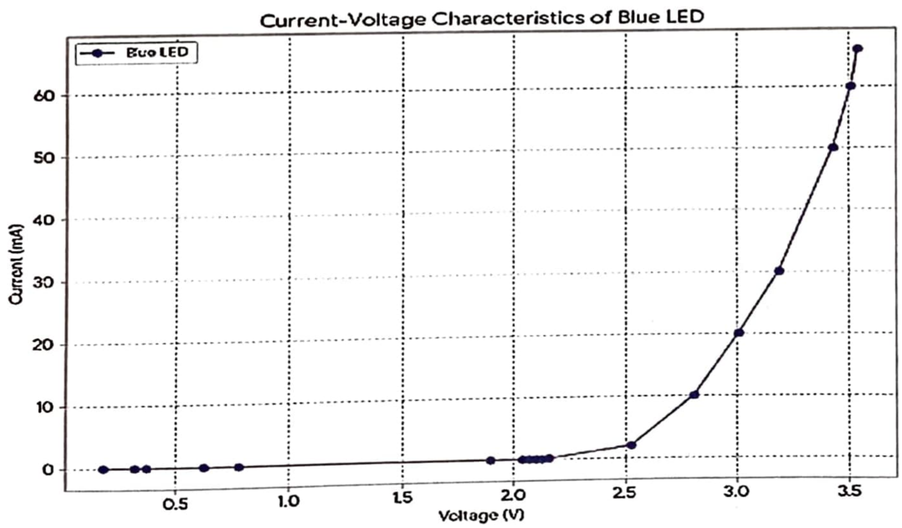


Fig.1.10, V-I characteristics of Blue LED

From the graph, knee voltage = 2.55v

$\lambda = \frac{hc}{eV} = \frac{6.63*10^{-34})*(3*10^{8})}{(1.6*10^{-19})*(2.55)} = 487nm$, is the wavelength obtained

1.1.3 V-I CHARACTERISTICS OF GREEN LED

The current and voltage values for a green LED in forward biased and the corresponding graph is given by

Sl.no.	VOLTAGE(V)	CURRENT (mA)
1	0.183	0
2	1.280	0
3	2.15	0.005
4	2.33	0.010
5	2.37	0.025
6	2.39	0.040
7	2.42	0.060
8	2.46	0.210
9	2.61	2
10	2.64	4
11	2.73	10
12	2.83	20
13	2.93	40
14	3.09	60
15	3.25	100

GRAPH

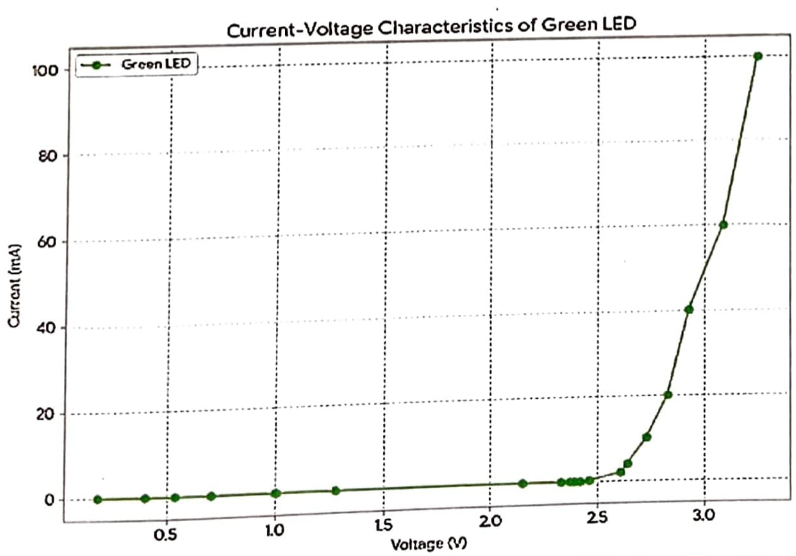


Fig.1.11, V-I characteristics of Green LED

From the graph, knee voltage=2.45v

$\lambda = \frac{hc}{eV} = \frac{6.63*10^{\wedge}-34)*(3*10^{\wedge}8)}{(1.6*10^{\wedge}-19)*(2.45)}$ =506.63nm, is the wavelength obtained.

1.1.4 V-I CHARACTERISTICS OF YELLOW LED

The current and voltage values for a Yellow LED in forward biased and the corresponding graph is given by

SL.NO.	VOLTAGE(V)	CURRENT (mA)
1	0	0
2	1.12	0
3	1.82	1
4	2	10
5	2.05	20
6	2.08	30
7	2.10	40
8	2.11	50
9	2.11	60
10	2.12	70

GRAPH

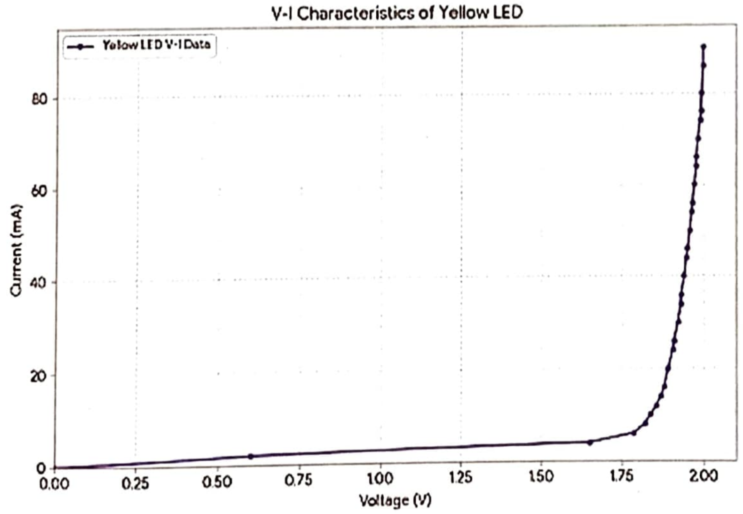


Fig.1.12, V-I characteristics of yellow LED

From the graph, knee voltage= 2.1v

$\lambda = \frac{hc}{eV} = \frac{6.63*10^{-34})*(3*10^{8})}{(1.6*10^{-19})*(2.1)}$ =591.96nm, is the wavelength obtained.

1.1.5 V-I CHARACTERISTICS OF PINK LED

The current and voltage values for a pink LED in forward biased and the corresponding graph is given by

Sl.no.	VOLTAGE(V)	CURRENT (mA)
1	0.225	0
2	0.595	0.020
3	1.450	0.050
4	2.26	0.110
5	2.45	0.180
6	2.49	0.260
7	2.51	0.350
8	2.52	0.460
9	2.63	2
10	2.67	4
11	2.75	10
12	2.84	20
13	2.98	40
14	3.03	50
15	3.13	70
16	3.25	100

GRAPH

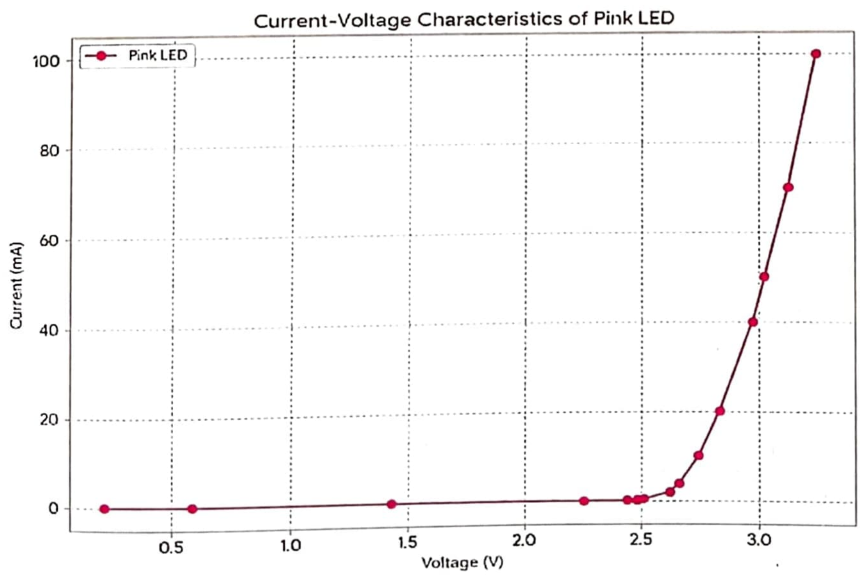


Fig.1.13, V-I characteristics of pink LED

From the graph, knee voltage= 2.675v

$\lambda = \frac{hc}{eV} \frac{6.63*10^{-34})*(3*10^{8})}{(1.6*10^{-19})*(2.675)}$ =464.71nm, is the wavelength obtained

COMBINED GRAPH

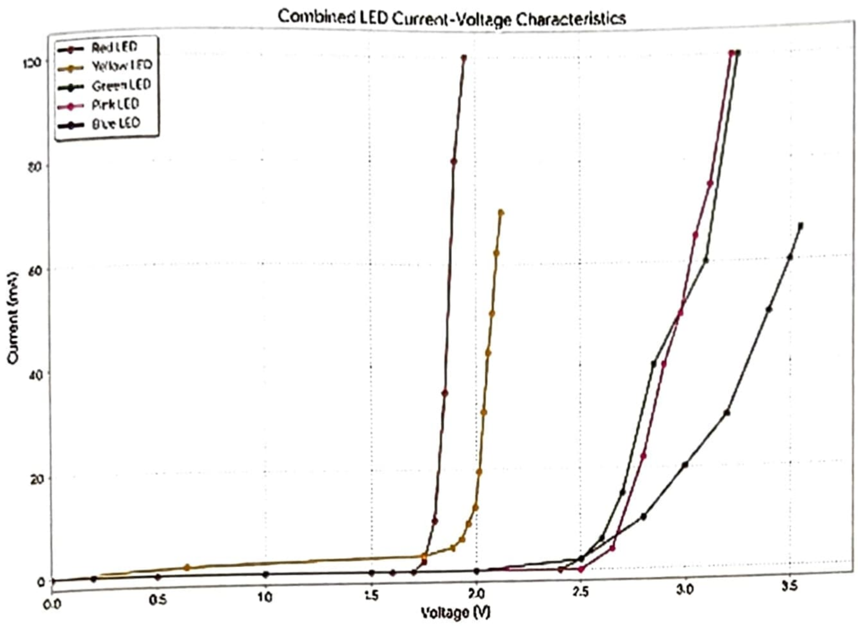


Fig 1.14, combined V-I Characteristics of all LEDs used

INFERENCES:

1. All this V-I graphs current increses with increase in voltage.
2. The wavelength obtained for Red LED, Green LED, Blue LED and Yellow LED are perfectly matches with the standard values of the colored LEDs
3. For pink LED also, unlike red or green LEDs which emit a specific color based on a single material bandgap, pink LED don't exist as a single semiconductor material. Most of the pink LEDs are Indium Gallium Nitride i.e, blue LED at its core. The emission is due to primary emission or phosphor conversion to get pink, by blue chip coated with phosphor layer. The blue light emitted first hits the phosphor some of its absorbed and re-emitted as longer wavelengths usually red. The light escapes the LED is a combination of original blue and converted red. The light escaped a mix of red and blue appear to be pink.

EXPERIMENTAL SETUP

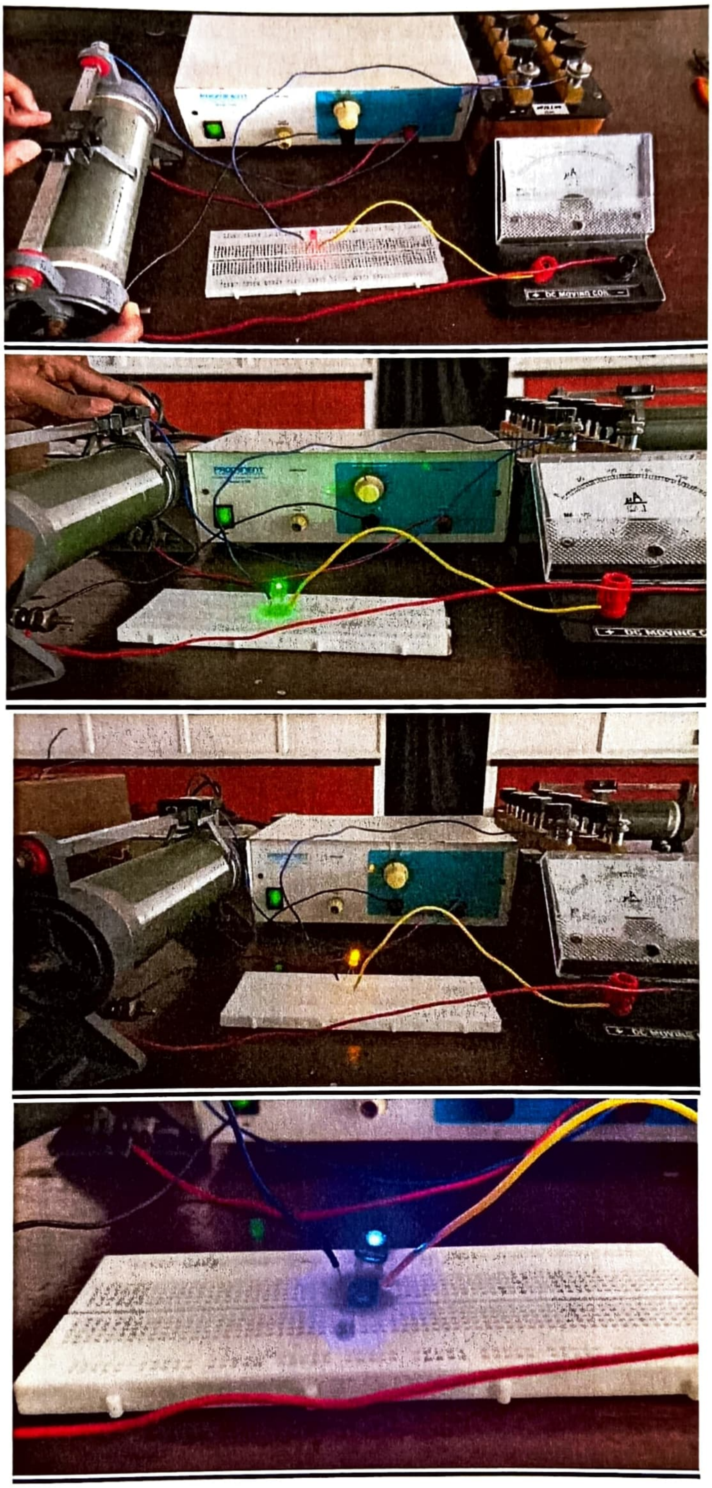


Fig .1.15, Experimental setup for coloured LEDs such as Red LED, Blue LED, Green LED, Yellow LED

1.2 LED DRIVE CIRCUIT USING TRANSISTOR

In order to bias the LED in accordance with the data to transmit, we are using a suitable drive circuit. A drive circuit to drive or bias the LED corresponding to requirements is the LED drive circuit. Here it is a transistor-based drive circuit. In this circuit a single LED is connected in series with a resistor to limit the current through the circuit. The LED is connected to collector of transistor, emitter is grounded and output is obtained from the collector and ground connected to a DSO (Digital storage oscilloscope) . The output is a square wave showing switching between saturation and cut off of the transistor. Then using the LED was biased, it actually is going between on and off continuously. Its frequency is 50 Hz , the ac frequency. Due to persistency of vision of human is 1/20 s. The fast switching between on and off couldn't detect, its assumed to be always on. If we connect the circuit in such a way that instead of ac, a signal is provided, the output will be a data of 1 and 0. Photodiode detector is used but its not efficiently capturing the emission from LED. With additional converging optics, we can improve the detection.

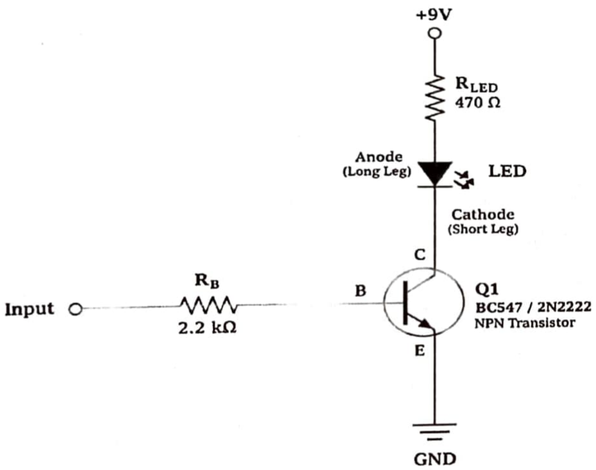


Fig 1.16, circuit diagram of LED drive circuit

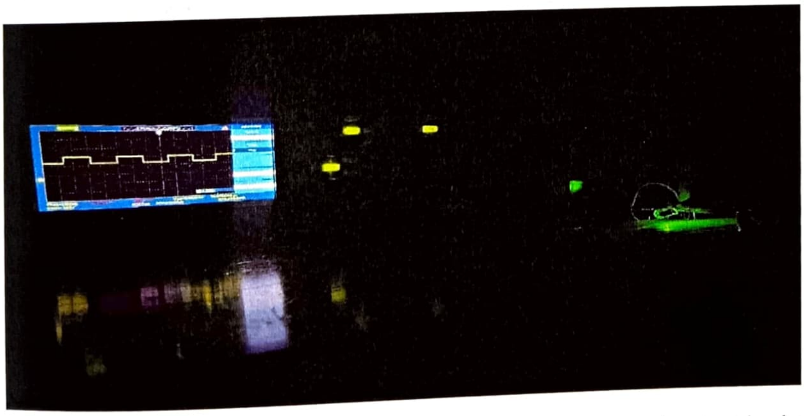


Fig.1.17, Experimental setup of transistor-based LED circuit and output is given to DSO

CHAPTER -3. PHOTODIODE

2.1.INTRODUCTION

Photodiode is an opto-electronic component that works on mainly two modes, namely photovoltaic mode and photoconductive mode. Photovoltaic effect is the process which generates voltage or electric current in a photovoltaic cell when exposed to light. When operating in the zero bias or photovoltaic mode, the device ability to release photocurrent is limited, resulting in the accumulation of voltage. The foundation of solar cells is the photovoltaic effect. A conventional solar cell is just a large area photodiode.

Photoconductivity is an optical and electrical phenomenon in which a material becomes electrically conductive due to absorption of electromagnetic radiation such as visible light, UV, IR or gamma. When light is absorbed by a semiconductor, the number of free electrons and holes increases, resulting high electrical conductivity. To cause excitation, the light strikes with an energy greater than bandgap energy. The diode is reverse biased, this widens the depletion layer and lower junction capacitance and response time reduced. The photocurrent is proportional to illumination.

2.2.PHOTODIODE OR PHOTO EMISSIVE DEVICES

In semiconductors, the electrons are released from valence band, when energy is supplied to such electrons. This energy supplied in form of heat or through an accelerating voltage. Light energy can also be used to produce the current in semiconductors. A junction diode made from light sensitive semiconductor is called a photodiode. Photodiode make use of photovoltaic effect, the generation of a voltage across a p-n junction of a semiconductor when the junction is exposed to light. While the term photodiode can be broadly defined to include even solar batteries, it usually refers to as sensors intended to detect the intensity of light.

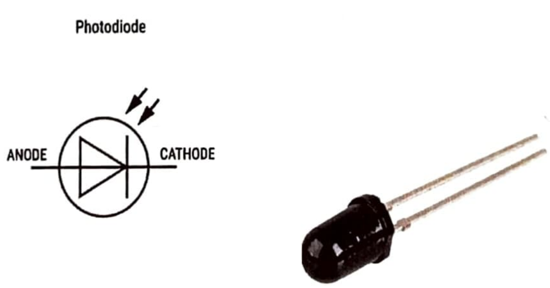


Fig 2.1, symbol and image of photodiode

WORKING

There are four different types of photodiodes. They are PN Photodiode, PIN Photodiode, Avalanche photodiode and Schottky photodiode. They all have same basic principle although some enhanced by other effects. When a photon of sufficient energy enters the depletion region of a semiconductor diode, it may strike an atom with sufficient energy to release the electron from the atomic structure. This creates a hole and free electron. They are oppositely charged. This is inner photoelectric effect. If the absorption occurs in the junction's depletion region, carriers swept from the junction by the electric field of depletion region. Thus, holes move towards to anode and electrons to cathode, and a photocurrent is produced. The total current through photodiode is the sum of dark current and photocurrent. dark current is the current flows without light. The dark current must be minimized to maximize the sensitivity of device. For high-speed operation the depletion region must be kept thin to reduce quantum efficiency the depletion layer must be thick to allow a large fraction of incident light to be absorbed.

Photodiode works on two modes namely photovoltaic mode and photoconductive mode. In photovoltaic mode, the photocurrent from the device is restricted and a voltage develop. The photoconductive mode, when photodiode is reverse biased. The photocurrent is proportional to illumination. Even though the photoconductive mode is faster than photovoltaic electronic noise is high in photoconductive. Silicon based photodiode generate less noise than germanium based.

CONSRUCTION

For photodiode a depletion layer is formed from diffusion of electrons from N layer to the P layer and the diffusion of holes from P layer to N layer. This creates a region between the two layers no free carriers exist. This develops a built-in voltage to create electric field across the depletion region. This allows current to flow in one direction (anode to cathode). The photodiode can be forward biased but current generated will flow in opposite direction, this is the reason for most of the photodiode works on reverse bias.

A photon having enough energy strike an atom within the device and release an electron. If the photon is absorbed in either p or n layer results in electron hole recombination in material as heat. Those absorbed in depletion region will create electron hole pairs move to opposite ends due to electric field. Electrons move to positive potential on cathode and holes move to negative terminal on anode. These moving charge carriers create photocurrent.

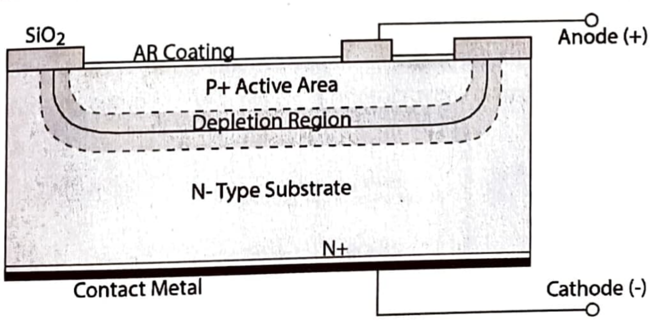


Fig 2.2 internal structure of PN photodiode

APPLICATION

1.They are widely used in various medical applications, such as detectors for computed tomography and pulse oximeters.
2. PIN diodes used for optical communication and lighting regulation.
3. Avalanche photodiode, photomultiplier tubes are used for application such as astronomy, spectroscopy, night vision equipment etc.
4. Alarm systems and counting systems are the two most popular photodiode-based systems.
5. In research and industry, photodiodes are frequently employed to measure light intensity accurately compared to photoconductor

2.3. CHARACTERISTICS OF PHOTODIODE

The photodiode works mainly in two modes, photovoltaic mode and photoconductive mode. For forward biased condition the photodiode experience photovoltaic mode and photocurrent is generated. There is an exponential increase in the current.

REVERSE SATURATION CURRENT

When its reverse biased a small reverse saturation current produced due to the minority carriers. It is related to dark current as:

$$I_D = I_{SAT}\left(e^{\frac{qV_A}{k_BT}} - 1\right) \tag{2.1}$$

Where I_D is the photodiode dark current
I_{SAT} is the reverse saturation current
q is the electron charge
V_A is the applied bias voltage
k_B is the Boltzmann constant
T is the absolute temperature
DARK CURRENT:

When photodiode is kept under dark condition and a sufficient reverse voltage is applied, then an almost constant current, independent of magnitude of reverse bias is obtained. This current corresponds to the reverse saturation current due to thermally generated minority carriers. It is called dark current and its proportional to concentration of minority charge carriers.

PHOTOCURRENT

When the photodiode is exposed to light of sufficient energy will create a free electron and hole pair due to inner photoelectric effect. If the absorption occurs holes move towards anode and electrons to cathode. As a result, a photocurrent is produced.

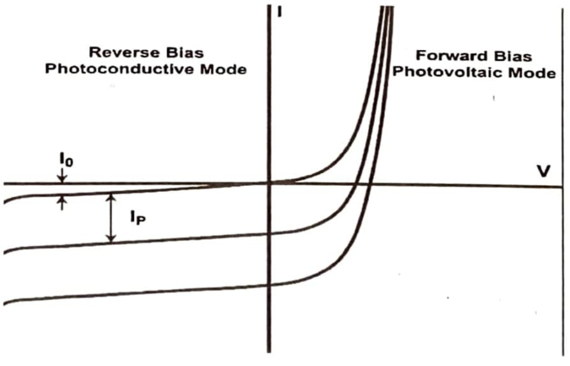


Fig 2.3, characteristic V-I Curve of photodiode for photoconductive and photovoltaic modes of operation

V-I CHARACTERISTICS OF PHOTODIODE

To study the reverse bias characteristics of photo-diode for different intensities of light at a fixed distance of 15cm between photodiode and light source. Forward biased is also observed for verify the exponential growth of current. Reverse bias current increases with intensity of light and saturates.

APPARATUS:variable dc source,photodiode,milliammeter,voltmeter,lightsource

PRINCIPLE

The reverse current in a photodiode depends on the intensity of light falling on it. The application of this diode is in reverse biased condition. the current- voltage equation for a photodiode is given by

$$I_D = I_{SAT}\left(e^{\frac{qV_A}{k_BT}} - 1\right) - I_P \quad \text{,Where } I_P \text{ is the photocurrent (2.2)}$$

CIRCUIT DIAGRAM

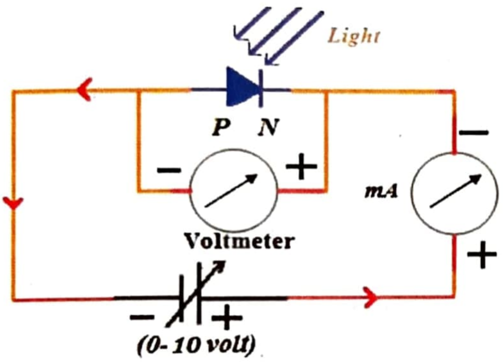


Fig 2.4, circuit diagram of reverse bias for photodiode

PROCEDURE

Connections are made as show in figure. The current is observed by varying the voltage for particular intensity of light. The photodiode must be placed in such a way that the light is exposed completely. Current is noted using a milliampere. The intensity is then varied and corresponding voltage and current is noted. Here a light source which intensity is varied by I=2,4, and 6 corresponding voltage and current is noted for both forward and reverse bias. A graph is plotted by taking voltage along x axis and current in milliamperes along y axis. An exponential growth of current is observed in forward bias and a reverse saturation current is observed in reverse bias.

2.1 V-I CHARACTERISTICS OF PHOTODIODE(REVERSE BIAS)

The V-I characteristics of photodiode for different intensities at a fixed distance of 15 cm between photodiode and light source are observed. Here its reverse biased.

Itensity,I →	I=2 (lux)		I=4 (lux)		I=6 (lux)	
	Voltage(v)	Current(mA)	Voltage(v)	Current(mA)	Voltage(v)	Current(mA)
1	0.2	0	0.2	0	0.2	0
2	0.4	0	0.4	2	0.4	10
3	0.8	0	2	4	0.6	12
4	1	0	3	6	0.8	14
5	2	0	6.8	8	1	16
6	6.2	2	7	8	1.6	18
7	7.2	2	7.2	8	2	20
8	8.2	2	7.4	8	2.8	24
9	9.8	2	7.6	8	3.4	26
10			7.8	8	3.6	26
11			8	8	3.8	26
12			8.6	8	4	26
13			8.8	8	4.2	26

GRAPH

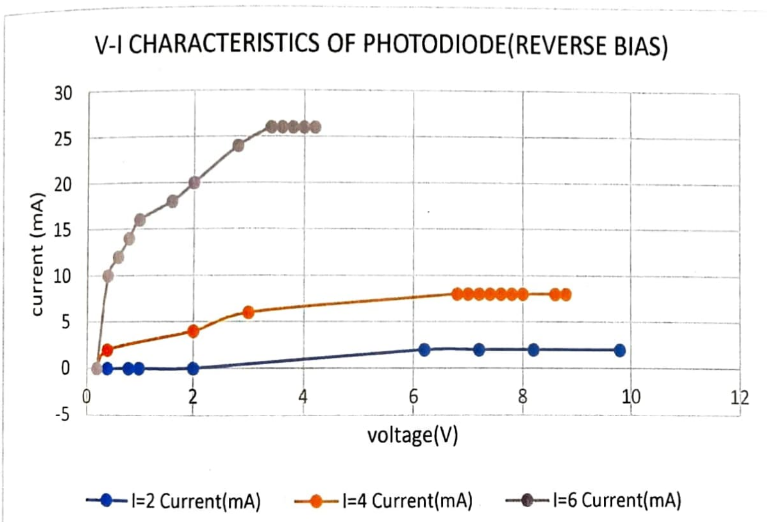


Fig 2.5, V-I characteristics of photodiode of different intensities of a variable light source in reverse bias.

2.2 V-I CHARACTERISTICS OF PHOTODIODE (FORWARD BIAS)

The V-I characteristics of photodiode for different intensities at a fixed distance of 15 cm between photodiode and light source are observed. Here its forward biased.

Intensity, I→	I=2 (lux)		I=4 (lux)		I=6 (lux)	
	Voltage(v)	Current(mA)	Voltage(v)	Current(mA)	Voltage(v)	Current(mA)
1	0.2	0	0.4	0	0.2	0
2	0.4	0.2	0.6	0.2	0.8	2
3	0.6	0.2	0.8	0.4	1	2
4	0.8	0.2	1.4	0.4	1.2	4
5	1	0.2	1.8	0.4	1.4	10
6	1.2	0.4	2	0.6	1.6	14
7	1.8	0.6	2.4	0.6	1.8	20
8	2	0.6	2.6	0.6	2	32
9	2.4	0.6	3.2	0.8	2.2	48
10	2.6	0.6	3.4	0.8	2.4	72
11	3	0.8	3.6	1	2.8	100
12	4	1	4.4	1.2		
13	5	1.2	5.6	1.4		

GRAPH

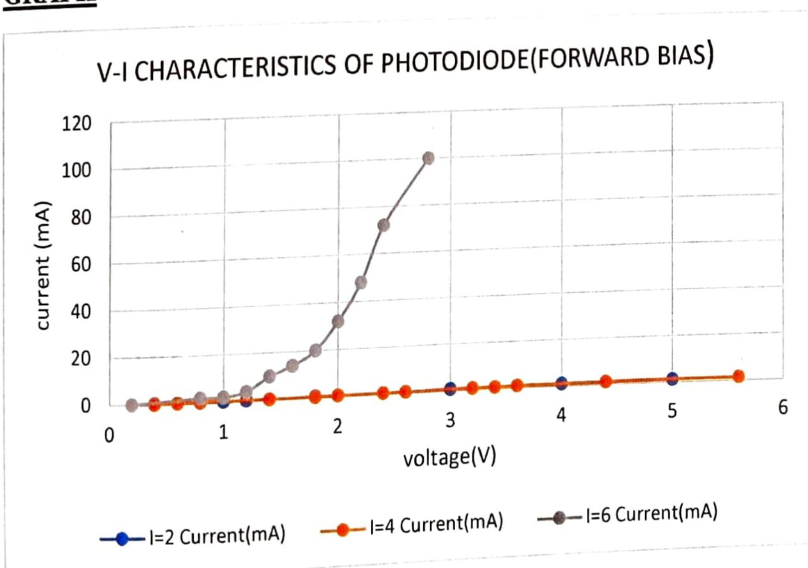


Fig .2.6, V-I characteristics of photodiode of different intensities of a variable light source in forward bias

COMBINED GRAPH

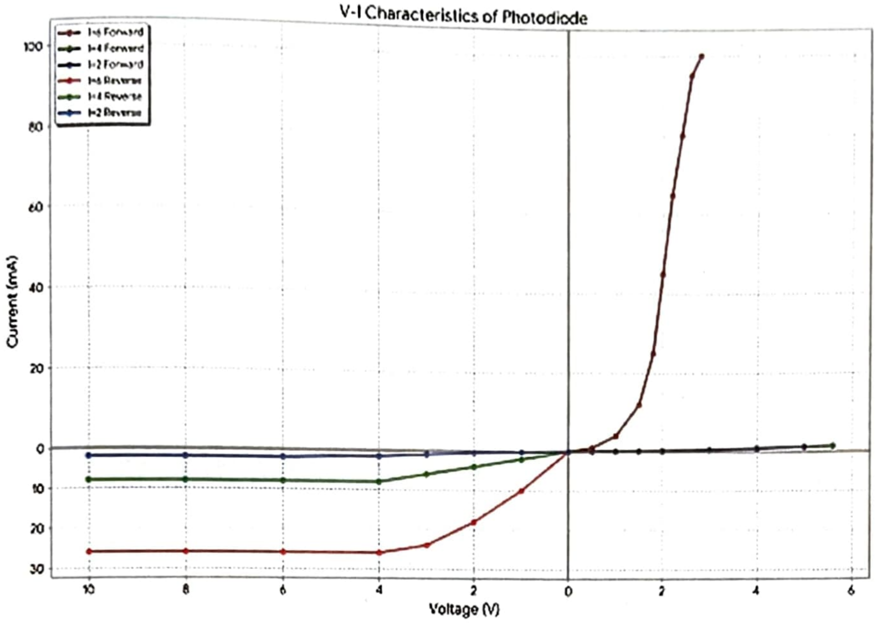


Fig 2.7, V-I characteristics of photodiode for different intensities using a variable light source in both forward and reverse bias

Here the photodiode showing the results for forward and reverse biased photodiode for different intensities namely I=2,4,6. In reverse bias the current saturates after a specific value for each intensity. In forward bias the intensity 6 showing more current for small voltages itself. The first quadrant shows V-I characteristics for forward bias and the third quadrant for reverse bias.

2.3 DARK CURRENT IN PHOTODIODE

The dark current in photodiode is observed by keeping the photodiode under zero illumination.

Sl.no.	Voltage (V)	Current (mA)
1	0.8	0.070
2	1.2	0.100
3	1.4	0.120
4	1.6	0.2
5	1.8	0.2
6	2	0.2
7	2.2	0.2
8	2.6	0.2
9	2.8	0.2
10	3	0.2
11	3.4	0.2
12	3.8	0.2
13	4	0.2
14	4.4	0.2

GRAPH

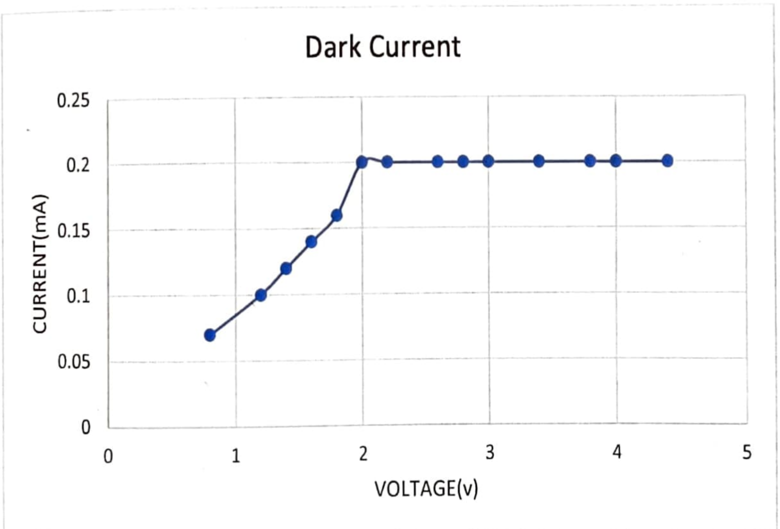
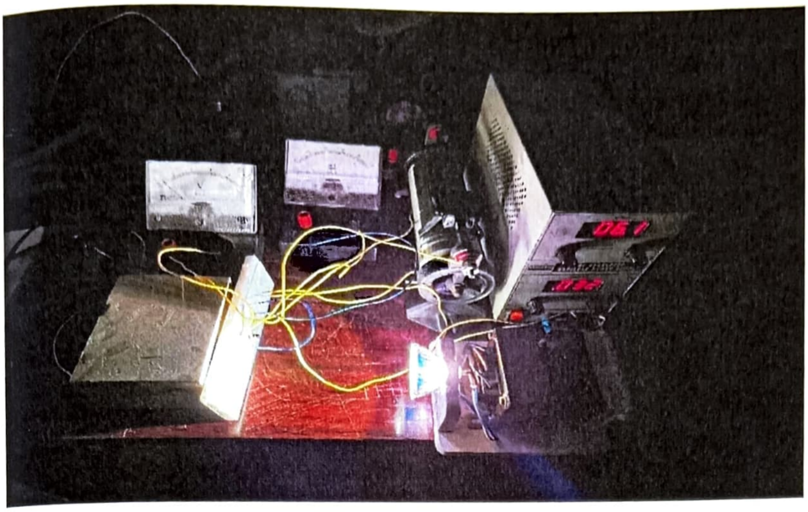


Fig 2.8, V-I Characteristics of Dark current observed in photodiode with zero illumination

EXPERIMENTAL SETUP



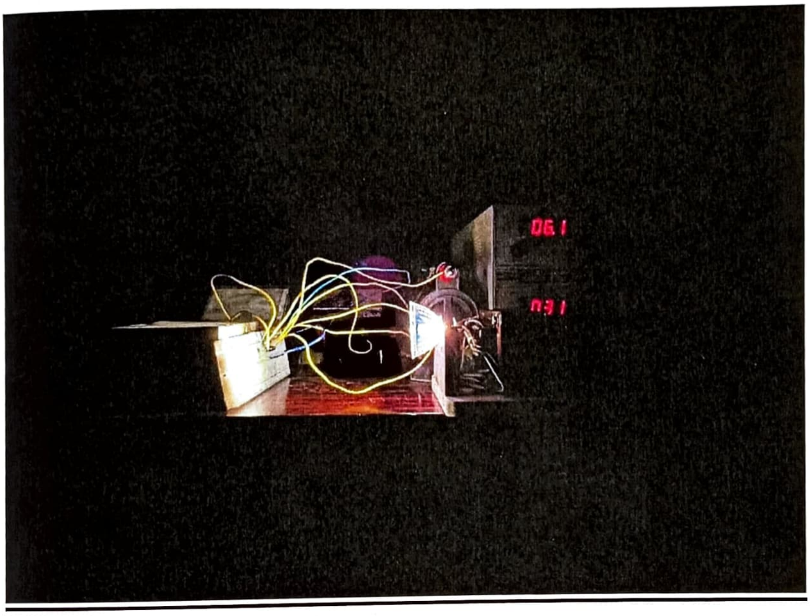


Fig 2.9, experimental setup for V-I characteristics of photodiode using variable light source.

INFERENCES

1. A small change in voltage shows massive change in current. Its highly current sensitive in forward bias.
2. The reverse bias current increases with increase in intensity of light source. Due to the increase in intensity of light, the number of photons incident per unit area per unit time increases, therefore photo-generation of charge carriers increases, hence the current increases.
3. At a fixed intensity the reverse bias current increases initially but after a few volts it saturates. The number of charge carriers generated at fixed intensity of light is fixed. Initially , the number of charge carriers crossing the junction increases with increase in reverse bias voltage and current increases. When all the carriers able to cross the junction and are involved for current flow then due to no increase in charge carriers flow per unit time, the current becomes independent of voltage
4. Since the reverse saturation current at zero intensity of light is 0.2mA.The dark current of photodiode is 200μA.

CHAPTER-4. LIGHT DEPENDENT RESISTOR

PHOTOCONDUCTIVITY

Photoconductivity is an optical and electrical phenomenon in which a material becomes more electrically conductive due to absorption of electromagnetic radiation such as visible light,UV,IR and gamma radiations. It's the effect of increasing electrical conductivity in a solid due to light absorption.

Certain crystalline semiconductors such as Germanium, Silicon, Lead Sulphide and Cadmium Sulphide and the related semi-metal Selenium are strongly photoconductive. Normally semiconductors are relatively poor electrical conductors because they have only a small number of electrons that are free to move under a voltage. Most of the electrons are bound to their atomic lattice in the set of energy states called valence band. But if external energy is provided some electrons are raised to the conduction band, where they can move and carry current. When light is absorbed by a material such as a semiconductor, the number of free electrons and electron holes changes and raises its electrical conductivity. To cause excitation, the light that strikes the semiconductor must have enough energy to raise electrons across the bandgap. When a photoconductive material is connected as part of a circuit, it functions as a resistor whose resistance depends on light intensity. Hence the material is called photoresistor.

LIGHT DEPENDENT RESISITOR

Light dependent resistors, also known as photoresisitors or photoconductive cells works on the principle of photoconductivity. Photoconductivity refers to the phenomenon where the electrical conductivity of a material increases upon exposure to light. In materials exhibiting light photoconductivity, incident photons with sufficient energy can generate electron-hole pairs, creating additional charge carriers. These carriers contribute to an increase in the material's conductivity, allowing it to conduct electricity more effectively.

Photoresisitors are made from semiconductor materials whose resistance changes when illuminated with light energy. Such materials (also known as photoconductors) are Cadmium Sulphide(CdS), Cadmium Selenide (CdSe) and Lead Sulphide(PbS).

WORKING

When these materials are exposed to light, the covalent bonds are broken. This produces charge carriers. The amount of illumination on the surface of the material determines the number of electron-hole pairs generated in the material. This in turn determines the resistance of the photo-conductive cells. The greater the amount of light falling on the surface, greater will be the number of electron- hole pairs generated and therefore lower will be the value of resistance of the material. The lower the amount of light falling on the surface, higher will be the valuevalue of resistance of the material. Thus, the resistance of the semiconductor varies inversely with the light intensity.

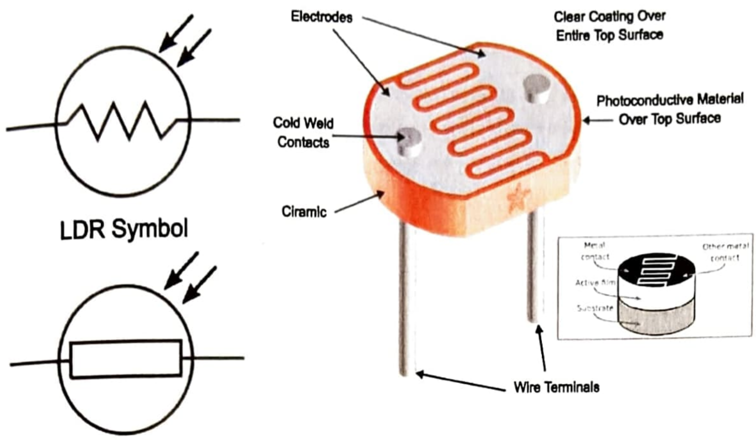


Fig 3.1,Symbol and image of LDR

When the LDR is kept in darkness or zero illumination, its resistance is called dark resistance and the corresponding current is the dark current. It is depending on the intensity of light falling on it.

CONSTUCTION

The construction of an LDR includes a light sensitive material that is placed on an insulating substrate like ceramic. The material is placed in a zigzag shape in order to get the required power rating and resistance. The area of zigzag separates the metal-placed areas into two regions. Where the ohmic contacts are made either on the sides of the area. The resistances of the contacts must be as less as possible to make sure that the resistance, mainly varies due to the light effect only.

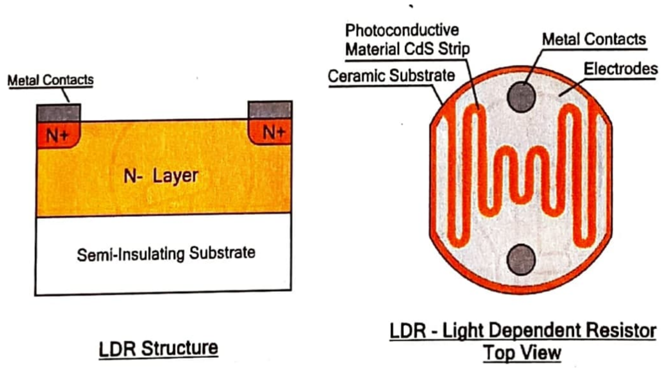


Fig. 3.2, internal structure of LDR

A LDR is made of an N type semiconductor material that sensitive to light and has no free electrons and no light conductions. It has a high resistance in the range of megaohms under no light exposure. A strip of photoconductive material placed on top of an insulating substrate in a zigzag pattern to acquire desired resistance. the whole structure is encapsulated inside a transparent resin that protects the photoconductive material contamination and allow light through it. Different material shows different sensitivity depending on light wavelength.

APPLICATIONS

1. LDRs are frequently used in research environments as cost effective alternative to expensive sensors for specific optical measurements.
2. LDR is used to analyse the response of materials to pulsed light and in chemical research LDR based systems can measure the opacity or concentration of a solution by detecting how much light is absorbed.
3. Used in solar tracking optimization, adaptive lighting in smart cities and in industrial safety and smoke detectors

V-I LDR CHARACTERISTICS IN LDR

In LDR the V-I Characteristics shows a linear relationship means it follows ohms law. LDRs are designed to be highly sensitive to light. they can detect and respond to changes in light intensity across a wide range, from low light levels to bright illumination

DARK RESISTANCE

The slope of the V-I curve with zero illumination is called dark resistance .For LDR its of the order of megaohms. A small current is generated even without a light is due to the thermal generation resulting energy to electron to overcome the bandgap.

SPECTRAL RESPONSE

The spectral response refers to the sensitivity of optical devices to different wavelength of light. For LDR, it defines its sensitivity to different wavelength across the electromagnetic spectrum. LDRs are most sensitive to specific wavelengths. The spectral response is primarily determined by energy bandgap of the semiconductor material used. For standard CdS (cadmium sulphide) LDRs the peak response usually between 500 nm &600 nm . This matches with greenish yellow light .For red laser will trigger a response, but the LDR will be less efficient than with a green laser.CdS and PbS are used for IR sensitivity.

RESPONSE TIME

LDRs have slower response time compared to photodiodes. Response time is describes as how quickly the resistance changes when the light is exposed or removed. There are two part for LDR, rise time and decay time . rise time is the time taken for resistance to drop when light is turned on. And decay time is the time takes for resistance to return to its dark condition that is light turned off. It is slower because it depends on recombination of electrons and holes. Rise time is faster because photons are actively creating charge carriers.

DARK CURRENT

It's the current observed with zero illumination. This current is of the order of microamperes.

3.1 V-I LDR CHARACTERISTICS

A LDR (light dependent resistor), also known as a photoresistor, is a passive electronic component that exhibits changes in its electrical resistance in response to varying levels of light.

APPARATUS

LDR,DC Variable source, rheostat, voltmeter, microammeter, variable light source,RedLaser

PRINCIPLE

When a diode is reverse biased, the reverse saturation current is constituted by minority carriers. These minority carriers are produced the valence electrons from their orbits, thereby producing free electrons and holes. If the energy is provided to a p-n junction by light of suitable wavelength, it can also produce electron-hole pairs the same way. Stronger the intensity of light falling, more will be the number of charge carriers and hence higher will be the reverse current. The amount of light striking the p-n junction controls the reverse current. This current is of the order of microamperes.

CIRCUIT DIAGRAM

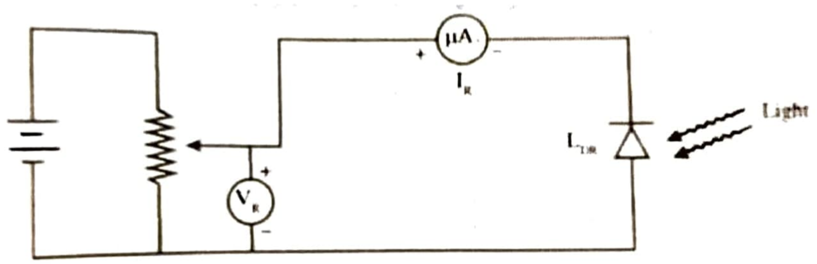


Fig 3.3, Circuit diagram for LDR in reverse bias

PROCEDURE

Make the connections as in the diagram. Note the current by varying voltage using the rheostat. The distance between the LDR and the variable light source are kept at 10cm. The current corresponds to intensities,I=2,4,6 are taken and the dark current also observed at zero illumination. A graph is plotted by taking current in microamperes along y axis and voltage in volts along x axis

V-I CHARACTERISTICS OF LDR

The V-I characteristics of LDR for different intensities at a fixed distance of 10 cm between LDR and light source are observed. Here its reverse biased and current is of the order of microamperes.

Sl.no.	INTENSITY, I=2 (lux)		INTENSITY, I=4 (lux)		INTENSITY, I=6(lux)	
	Voltage(V)	Current(μA)	Voltage(V)	Current(μA)	Voltage(V)	Current(μA)
1	0.05	10	0.05	10	0.05	10
2	0.1	20	0.1	50	0.1	70
3	0.2	50	0.15	80	0.15	120
4	0.25	60	0.2	120	0.2	170
5	0.3	80	0.25	150	0.25	230
6	0.45	130	0.3	190	0.3	280
7	0.5	140	0.35	220	0.35	340
8	0.65	190	0.4	270	0.4	400
9	0.7	200	0.45	320	0.45	460
10	0.85	250	0.5	350	0.5	500
11	0.9	270	0.55	380		
12	1.5	310	0.6	420		
13	2.5	350	0.65	470		
14	3	380	0.7	500		

GRAPH

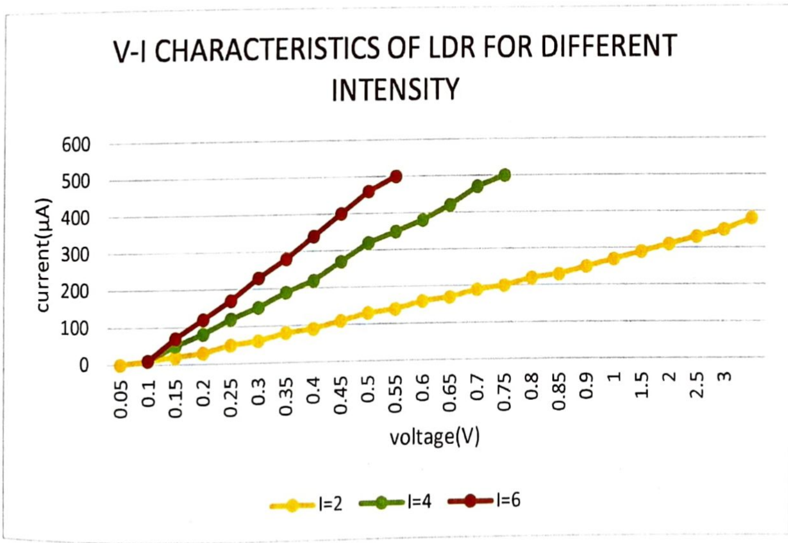


Fig 3.4, V-I Characteristics of LDR for different intensities using a variable light source

RESISTANCE VARIATION OF LDR WITH INTENSITY

The variation of resistance with light intensity for fixed voltages are studied. The resistance and light intensity shows a non- linear relationship. As the intensity of variable light sources increases the corresponding resistance decreases sharply. The resistance of the LDR decreases exponentially with the increase in light intensity. The LDR is highly sensitive at lower light intensities (steep slope) and becomes less sensitive as the intensity increases (the curve flattens). The experiment confirms the negative light coefficient of resistance for the given LDR sample. The resistance is determined from the V-I characteristics data and intensity variation for given voltages are utilized.

Intensity (lux)	Resistance R (Ω)			
	R at V=0.2v	R at V=0.3v	R at V=0.45v	R at V=0.5v
I=2	4000	3750	3461.5	3571.40
I=4	1666.67	1578.98	1406.25	1428.57
I=6	1176.00	1071.40	978.26	1000

GRAPH

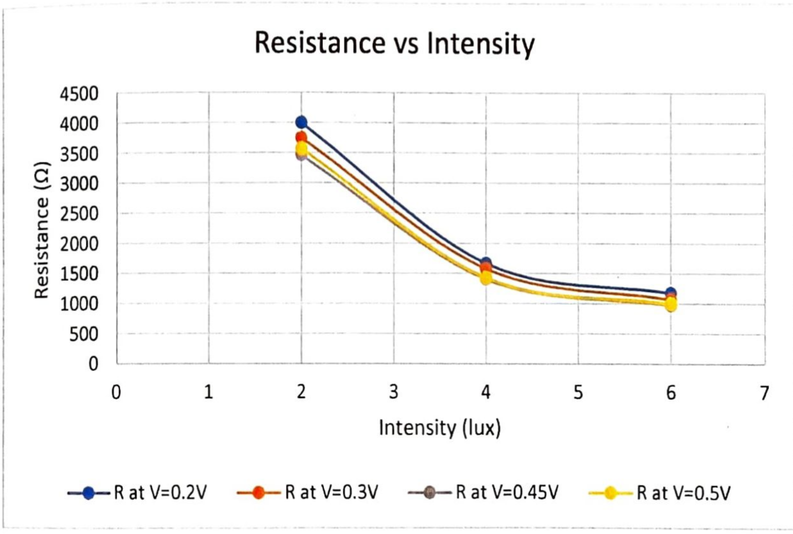


Fig.3.5 resistance variation with light intensity for different fixed voltages

3.2 V-I CHARACTERISTICS OF LDR WITH RED LASER

The V-I Characteristics is studied with replacing the light source with red laser. The V-I characteristics of LDR using Red Laser is observed and vary the intensity of red laser by a polarizer. A polarizer is an optical filter that converts unpolarized light into polarized light by allowing only specific light wave orientations to pass through while blocking others. By the introduction of polarizer, the plane of light transmitted will be altered and thereby intensity varies. The initial light is polarized and corresponding to the relative orientation of the crystal within the polarizer the intensity of the transmitted light varies. Polarizer is used here to change the intensity of red laser even though the polarizer functions to polarize the unpolarized light.

Two experimental setups are involved one with polarizer and the other without polarizer. Here its reverse biased and current is of the order of microamperes.

Sl.no.	Intensity with polarizer		Intensity without polarizer	
	Voltage(V)	Current (μA)	Voltage(V)	Current (μA)
1	0	10	0	10
2	0.2	20	0.05	30
3	0.4	40	0.1	60
4	0.6	60	0.15	100
5	0.8	80	0.2	140
6	1.2	120	0.25	160
7	1.6	160	0.3	200
8	1.8	180	0.35	230
9	2	200	0.4	280
10	2.4	250	0.45	300
11	2.8	290	0.5	360
12	3.2	330	0.55	400
13	3.6	380	0.6	440
14	4.2	450	0.65	470
15	4.6	500	0.7	500

GRAPH

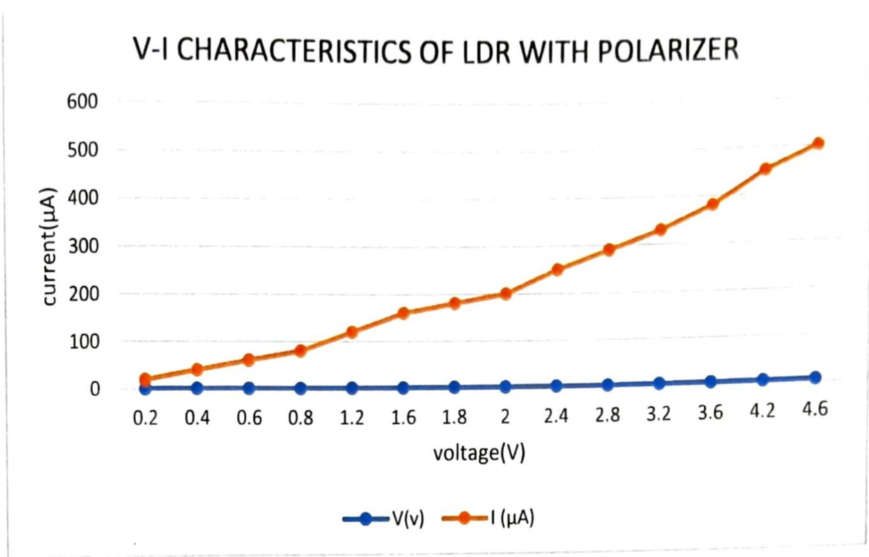


Fig 3.6, V-I Characteristics of LDR using laser with polarizer

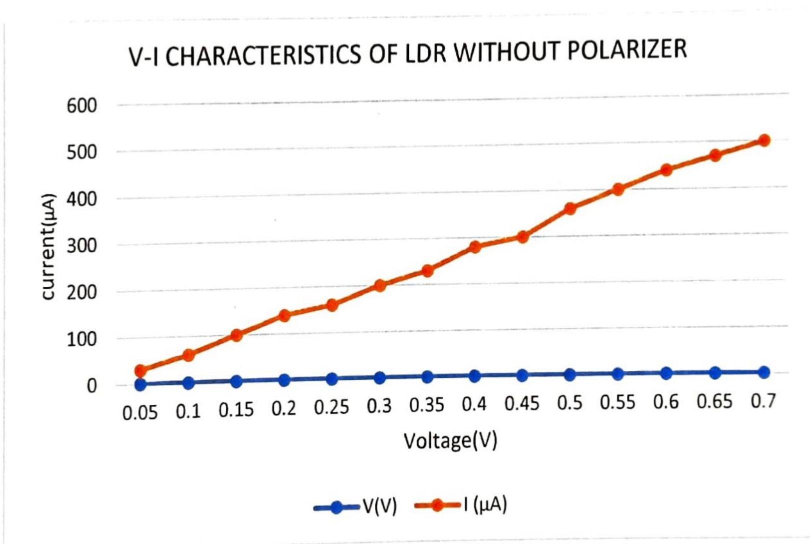


Fig 3.7, V-I Characteristics of LDR using laser without polarizer

3.3 DARK CURRENT

Dark current is observed when the LDR is at zero illumination and voltage of 9v is applied.

Sl.no.	Voltage(V)	Current(μA)
1	1	0.1
2	1.2	0.2
3	2	0.3
4	2.8	0.4
5	3.6	0.5
6	4	0.6
7	4.6	0.7
8	5.4	0.8
9	6	0.9

GRAPH

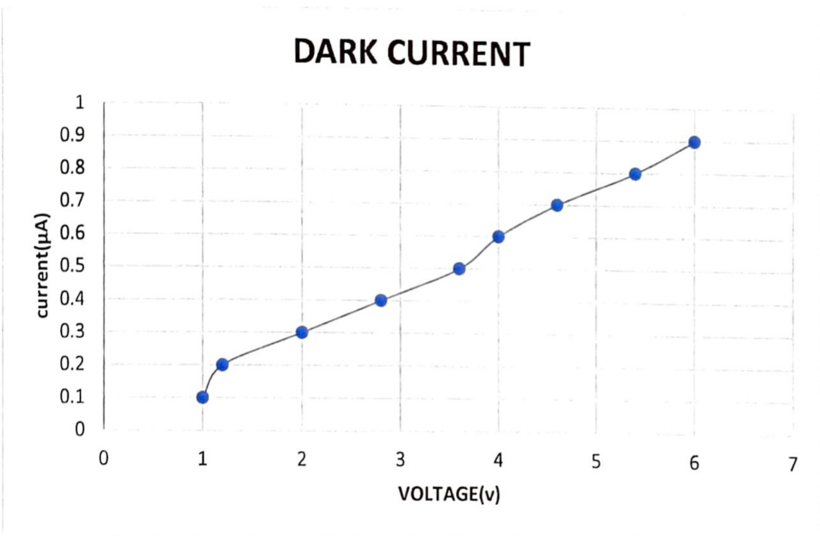


Fig 3.8, V-I Characteristics of Dark current observed in LDR with zero illumination

EXPERIMENTAL SETUP

V-I CHARACTERISTICS OF LDR WITH DIFFERENT INTENSITITES

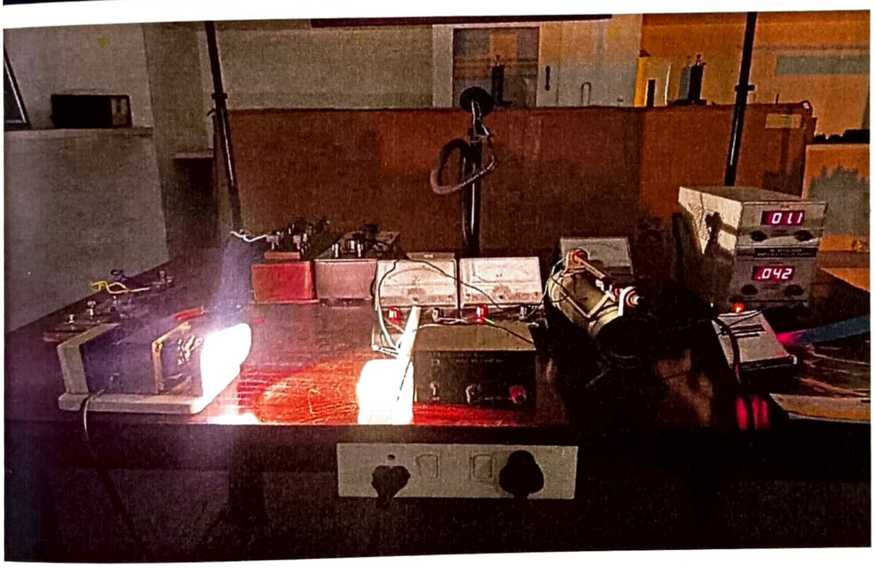


Fig.3.9, experimental setup of LDR in reverse bias with variable light source

INFERENCE

1. For a variable light source for intensities 2,4,6 the current increases with increase in intensity and the resistance drops from several ohms.
2. Dark current is observed with zero illumination of the order of microamperes.
3. For different intensities the current increases with increase in light intensity as it increases from intensity 2 to 6.
4. For fixed voltages resistance and intensity is in non linear relationship

EXPERIMENTAL SETUP

V-I CHARACTERISTICS OF LDR WITH LASER

- **WITHOUT POLARIZER**

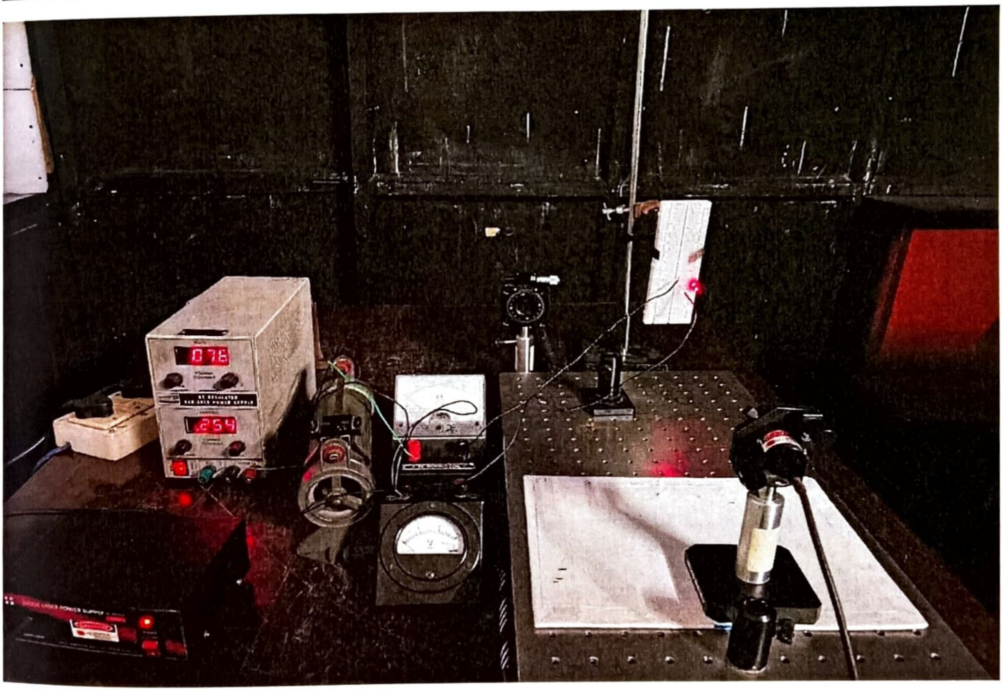


Fig.3.10, experimental setup of LDR in reverse bias with laser and no polarizer

EXPERIMENTAL SETUP

V-I CHARACTERISTICS OF LDR WITH LASER

- **WITH POLARIZER**

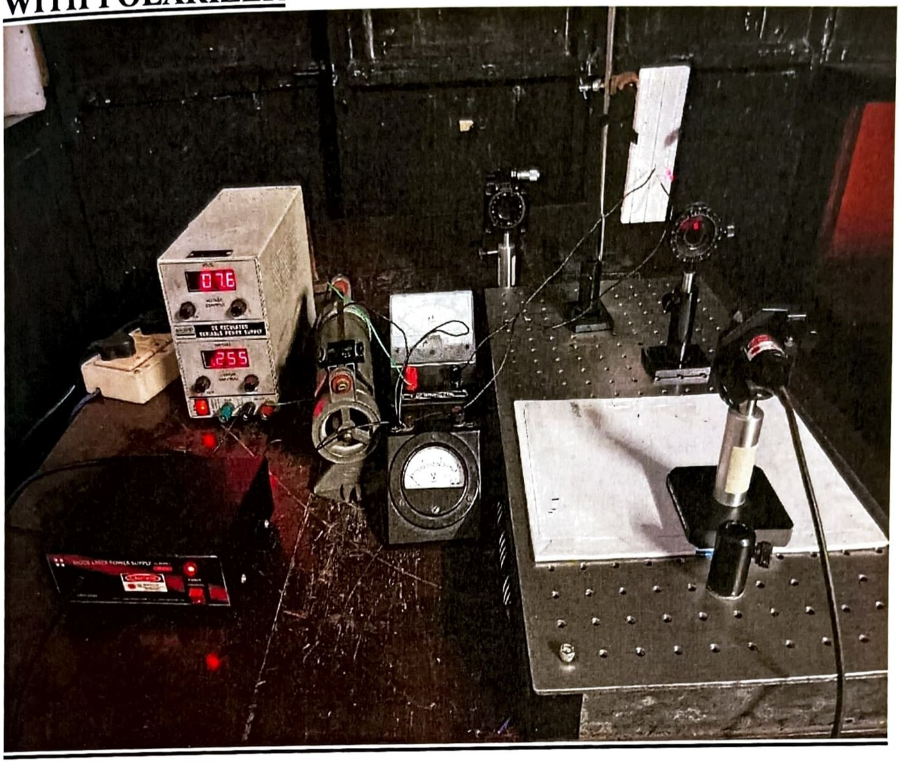


Fig.3.11, experimental setup of LDR in reverse bias using laser and with polarizer

INFERENCE

1. Polarizer is an optical device which converts unpolarized light to polarized. So, polarizer would decrease the intensity. Current increases with increase in intensity.i.e,without polarizer current increases
2. The resistance decreases for LDR with increase in current.
3. In with polarizer setup the intensity is reduced so the current also reduced but still voltage and current show linear relationship.

CHAPTER -5. CONCLUSION

The characterization of LED, photodiode and LDR(photoresistor) has provided a comprehensive understanding of optoelectronic energy conversion and sensing. For light emitting diode exhibited typically non linear semiconductor behaviour requiring a specific knee voltage to overcome the potential barrier and initiate photon emission. In photodiode generated photocurrent was smaller, its high speed and linear relationship between incident light power and current make it the ideal choice for high-frequency applications like optical fibre communication. In LDR shows a linear relationship with current and voltage. The LDR behave ohmically. However the relationship between intensity and resistance is non linear. The project successfully demonstrated that the selection of an optoelectronic component must be based on specific application. For precision and speed photodiode and high sensitivity and cost effective LDR is better choice. LED serves as fundamental reference for understanding how controlled electrical input can generate outputs. And these sensors are designed to detect.

CHAPTER -6. REFERENCES

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