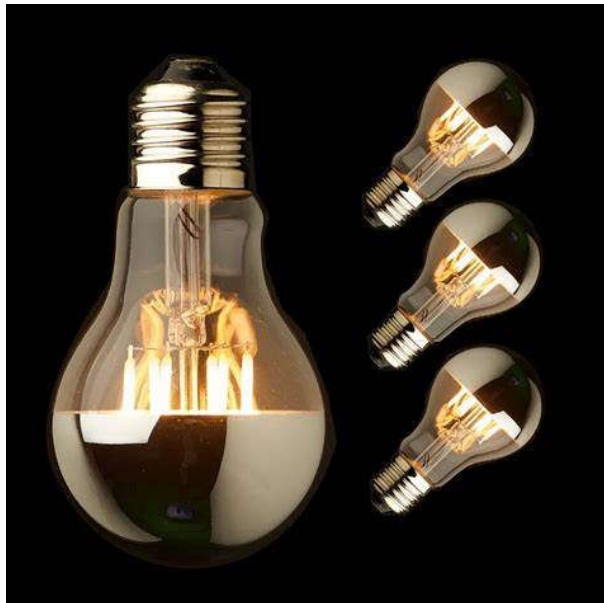




Domestic Application of Electronics



SL.No. 3

Domestic Application of Electronics
Semester-2
Total Credits: 2

Name of course: Domestic Application of Electronics

Semiconductors and Sensors: Insulator, Semiconductor, Metal, elementary semiconductor devices, Sensors and its applications (Diode, Transistor, FET, Photoresistors (LDR), Photodiodes (Photovoltaic and Photo conductive Cells), and Photo Transistors). Metal detector (Conceptually discussed). LCD Displays: Types of Liquid Crystals, Principle of Liquid Crystal Displays, Applications, Advantages over CRT Display. (6 Hrs)

Digital embedded system: Transition of analog to digital system, memory, microprocessor and microcontroller, embedded system, 7seg LED (Elementary Discussion). Introduction to communication, need for modulation, concept of AM and FM (qualitative discussion no derivation) (6 Hrs)

Protection of Electrical lines in House: Concept of RCB and MCB, different types of RCB and MCB, Transmission of electricity: Basic elements: Generator, power transformer, transmission line, main elements of long transmission line, concept of overhead transmission line and underground cable. (6 Hrs)

Electrical machines: Microwave generator, Microwave oven- Principle of microwave cooking, Block diagram, Types. Washing machine: Electronic controller of washing machines. Air conditioners: Air conditioning, Remote controlled air conditioner, Compressor. Loud speakers: Features of Basic loud speaker, Crystal loudspeaker and woofers. (6 Hrs)

Power Supply in Home uses: Regulated Power supply (Rectifier, Filter, Zener Diode, Transistor, IC-78XX, 79XX and LM317). Inverter, Converter, Solar Cell. (6 Hrs)

Common Value Added Course (CVAC-4)

on

Domestic Application of Electronics

Modalities for CVAC-4 course under CCF.

Theory: 2 Credits (50 Marks)

• **Question No. 1 (MCQ) 10x1 = 10**

No of question to be answer = 10 (Out of 12) and each question will carry 1 mark.

• **Question No. 2 (Short Question) 10x2 = 20**

No of question to be answer = 10 (Out of 12) and each question will carry 2 marks.

• **Question No. 3 (Write short notes) 2x5 = 10**

No of question to be answer = 2 (Out of 4) and each question will carry 5 marks.

• **Question No. 4 (Long Question consist of short questions which will not carry more than 5 marks) 1x10 = 10**

No of question to be answer = 1 (Out of 2) and each question will carry 10 marks.

Domestic Application of Electronics

Objectives:

- ❖ Semiconductors and sensors
- ❖ Digital embedded system
- ❖ Protection of electrical lines in house
- ❖ Electrical machines
- ❖ Power Supply in home uses

Semiconductors and sensors

What is a Conductor?

In Electrical & Electronics engineering, a conductor is a type of material that allows the flow of charge otherwise known as electrical current. Most common electrical conductors are made from metals. Such materials allow the current flow due to the presence of free electron or ions which starts moving when voltage is applied.

The conductors have very low electrical resistance i.e. the opposition to the current flow & depend on the length & width of the conductor. It increases with increase in temperature.

What is Insulator?

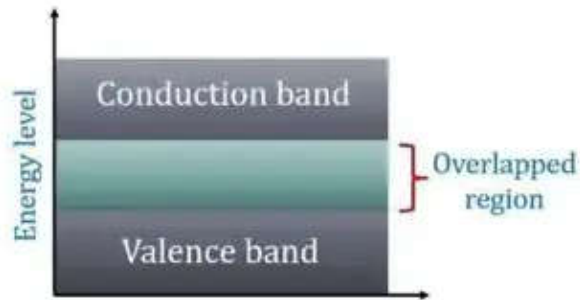
An insulator is a material that has very high electrical resistance & it does not allow the flow of current. There are no free electrons in insulators thus they do not conduct electricity. Thus they are used for protection against shock.

What is Semiconductor?

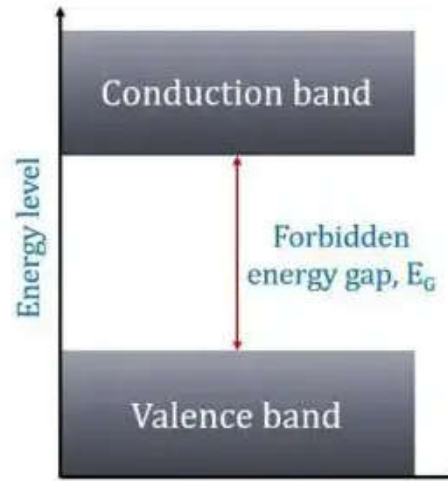
Semiconductors are materials that have conductivity in-between conductors and insulators. They can block or allow the current flow providing total control over it. They are mostly modified by adding impurities called doping. It modifies its properties like unidirectional current flow or amplification or energy conversion etc.

Semiconductors and sensors

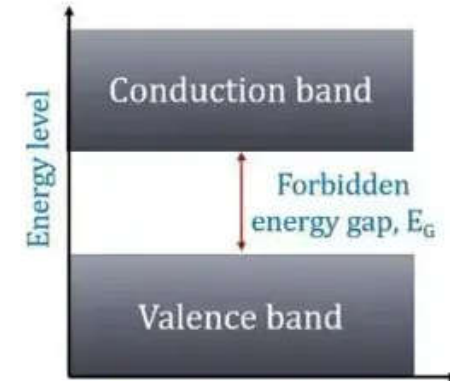
Insulators, Conductors and Semiconductors (with Band Diagram)



Energy band level diagram of conductor



Energy band level diagram of insulator



Energy-band-level-diagram-of-semiconductor

Semiconductors and sensors

Comparison between Conductor, Semiconductor and Insulator

Parameter	Conductor	Semiconductor	Insulator
Forbidden energy gap	Not exist	Small (1 eV)	Large (>5 eV)
Conductivity	High (10^{-7} mho/m)	Medium (10^{-7} to 10^{-13} mho/m)	Very Low (10^{-3} mho/m) Almost negligible.
Resistivity	Low	Moderate	High
Flow of current	Due to movement of free electrons.	Due to movement of electrons and holes.	Almost negligible but only due to free electrons.
Temperature coefficient of resistance	Positive	Negative	Negative
Charge carriers in conduction band	Completely filled	Partially filled	Completely vacant
Charge carriers in valence band	Almost vacant	Partially filled	Completely filled
Example	Copper, Aluminium, graphite etc.	Silicon, Germanium, arsenic etc.	Paper, rubber, glass, plastic etc.
Applications	Conducting wires, Transformers, in electrical cords etc.	Diodes, transistors, optocouplers etc.	Sports equipment, home appliances etc.

Semiconductors and sensors

- Insulators are materials having an electrical conductivity less than 10^{-8} S/cm (like diamond: 10^{-16} S/cm);
- Semiconductors have a conductivity between 10^{-8} S/cm and 10^3 S/cm (for silicon it can range from 10^{-5} S/cm to 10^3 S/cm);
- Conductors are materials with high conductivities, greater than 10^3 S/cm :(like silver: 10^6 S/cm.)

Semiconductors and sensors

Some elementary semiconductor devices:

Types of Semiconductor Devices

We classify these devices on the basis of whether they are **two-terminal** or **three-terminal** devices and sometimes for terminal devices.

- For instance, two-terminal devices include Diode, Zener diode, Phototransistor, Schottky diode, Light-emitting diode (LED), Laser diode, Photocell, Solar cell, and more.
- Some examples of three-terminal semiconductor devices include Bipolar transistor, IGBT, TRIAC, Field-effect transistor, Silicon-controlled rectifier, Thyristor, and more.

Semiconductors and sensors

Diode

A diode is a semiconductor device which consists of a single p-n junction. P-n junctions usually form by joining up of p-type and n-type semiconductor materials. This formation is because the n-type region has a higher number of electron concentrations.

On the other hand, the p-type region has a higher number of hole concentrations. Thus, the electrons diffuse from the n-type region to the p-type region. That's why we use this phenomenon in producing light.

Transistors

Transistors are of two types, bipolar junction transistor and field-effect transistor. The bipolar junction transistor is achieved by the formation of two p-n junctions in two different configurations like n-p-n or p-n-p.

In this kind of transistor, the three regions which form are emitter, collector, and base or the middle region.

FET

The field-effect transistor works on the principle of conductivity and the conductivity can be altered by the presence of an electric field.

Applications of Semiconductor Devices

We use these devices in the designing of logic gates and digital circuits. Moreover, we also use them in microprocessors. Further, we also use them in analogue circuits like oscillators and amplifiers. Finally, we also use them in high voltage applications.

Semiconductors and sensors

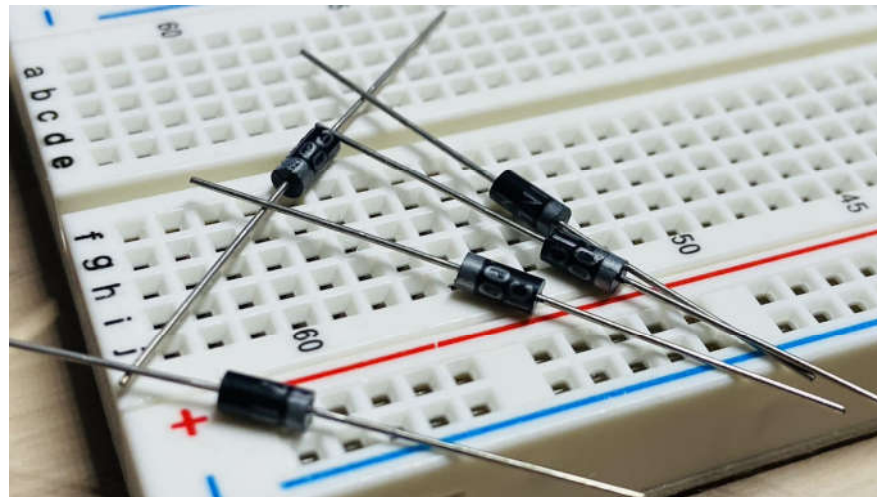
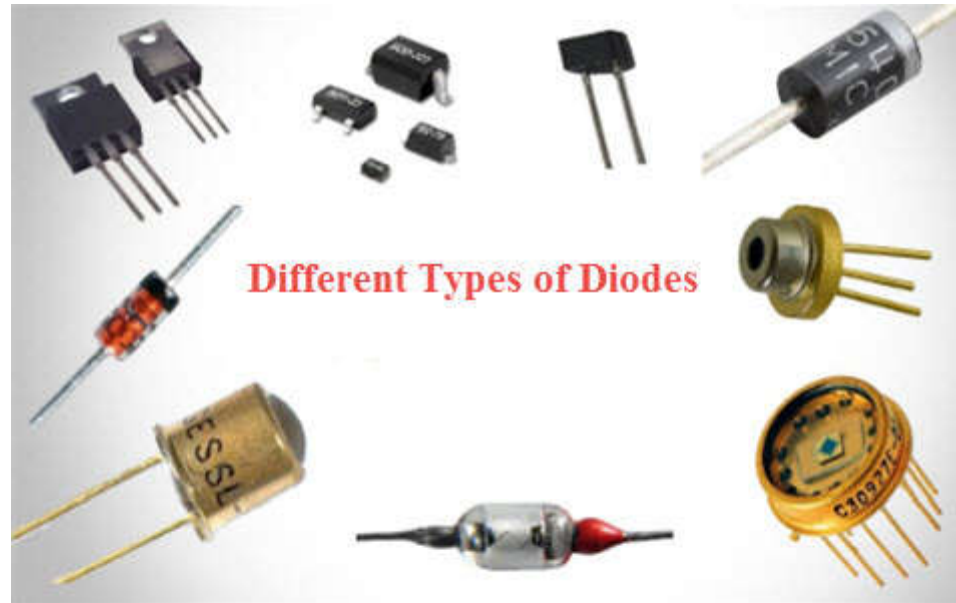
Some Common Applications of Diodes

- Rectifiers
- Clipper Circuits
- Clamping Circuits
- Reverse Current Protection Circuits
- In Logic Gates
- Voltage Multipliers

Diode as a Rectifier

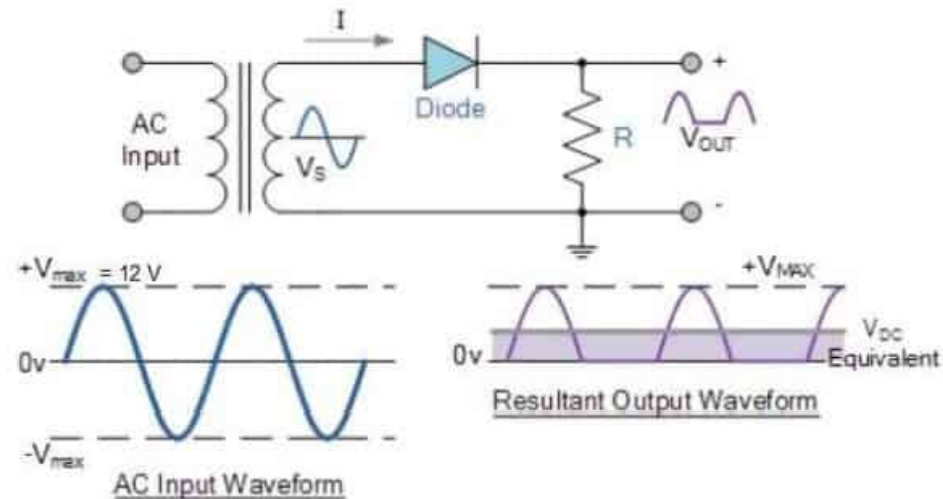
The most common and important application of a diode is the rectification of AC power to DC power. Using diodes, we can construct different types of rectifier circuits. The basic types of these rectifier circuits are half wave, full wave center tapped and full bridge rectifiers. A single or combination of four diodes is used in most of the power conversion applications. Below figure shows diode operation in a rectifier.

Semiconductors and sensors



Semiconductors and sensors

Half Wave Rectifier



- During the positive half cycle of the input supply, anode is made positive with respect to cathode. So, the diode gets forward biased. This results in the current to flow to the load.
- Since the load is resistive, the voltage across the load resistor will be same as the supply voltage i.e., the input sinusoidal voltage will appear at the load (only the positive cycle). And the load current flow is proportional to the voltage applied.
- During the negative half-cycle of the input sinusoidal wave, anode is made negative with respect to cathode. So, the diode gets reverse biased. Hence, no current flows to the load. The circuit becomes open circuit and no voltage appears across the load.
- Both voltage and current at the load side are of one polarity means the output voltage is pulsating DC. Often, this rectification circuit has a capacitor that is connected across the load to produce steady and continuous DC currents without any ripples.

Semiconductors and sensors

Some Common Applications of Transistors

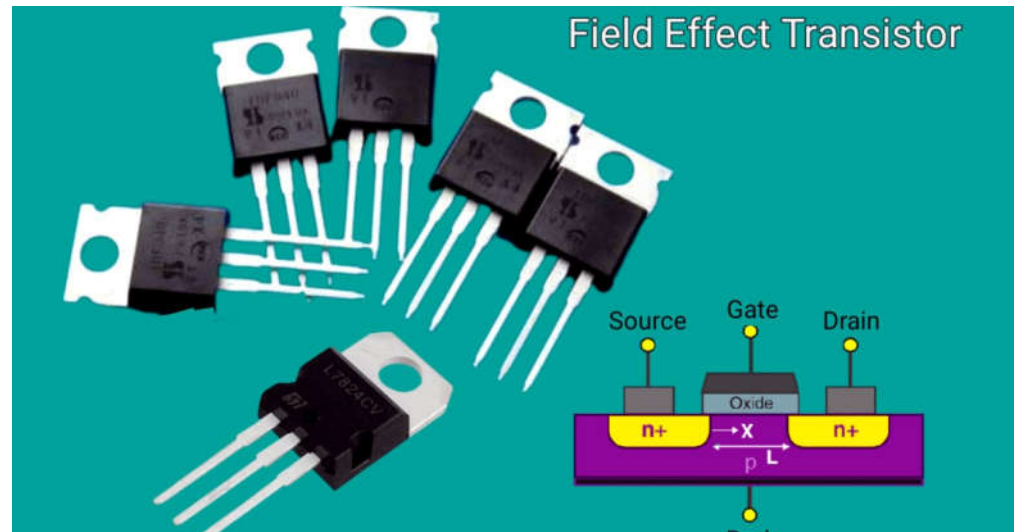


Semiconductors and sensors

Some Common Applications of FET

FET Definition: A Field Effect Transistor (FET) is defined as a type of transistor that uses an electric field to control the flow of current.

- **Analog Switches:** FETs can act as analog switches, switching between conducting and non-conducting states based on gate-source voltage (VGS).
- **Amplifiers:** FETs are used in amplifiers for their high input impedance and low noise, ideal for buffering and RF amplification.
- **Choppers:** FETs function as choppers, converting DC to AC voltage by alternating between cut-off and saturation states.
- **Current Limiters:** FETs can limit current to a fixed level, making them essential in constant-current or current-regulator diodes.



Semiconductors and sensors

What is a Light Dependent Resistor?

An LDR or light dependent resistor is also known as photo resistor, photocell, photoconductor. It is a one type of resistor whose resistance varies depending on the amount of light falling on its surface. When the light falls on the resistor, then the resistance changes. These resistors are often used in many circuits where it is required to sense the presence of light. These resistors have a variety of functions and resistance. For instance, when the LDR is in darkness, then it can be used to turn ON a light or to turn OFF a light when it is in the light.

Semiconductors and sensors

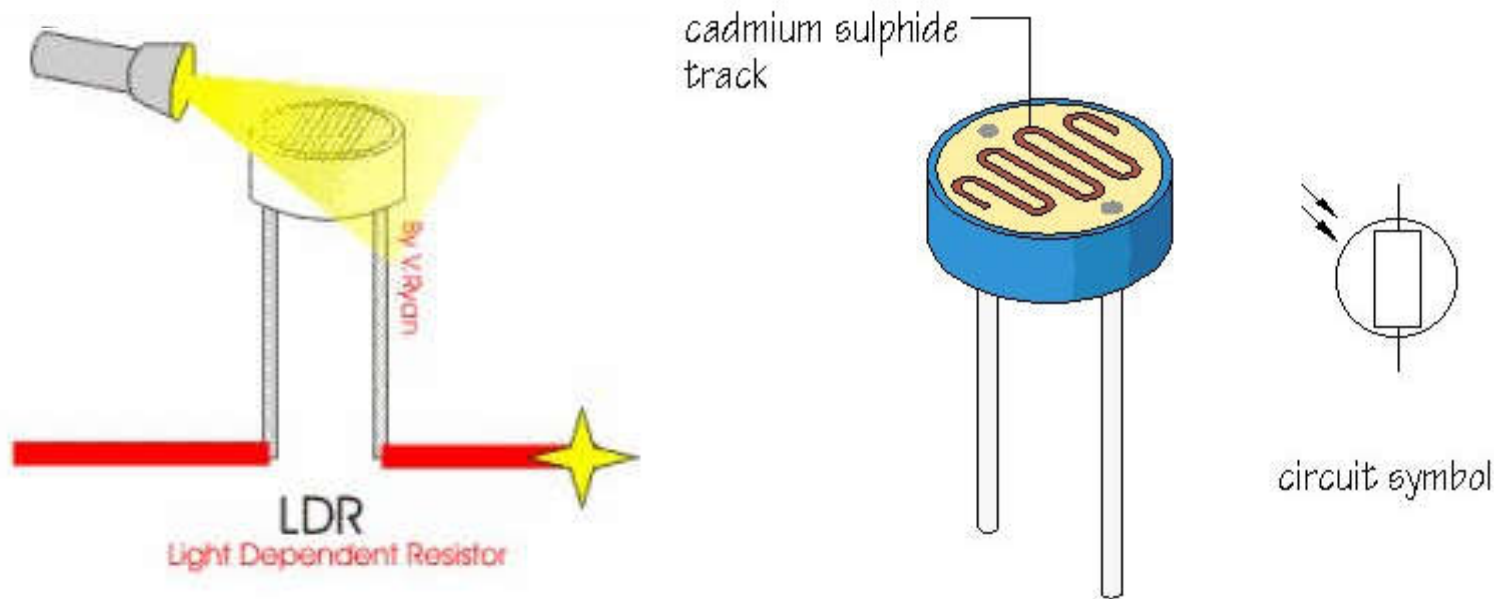
Applications of Light Dependent Resistors (LDRs) include:

- Light-sensitive circuits (e.g., streetlights, photographic light meters)
- Solar cells
- Automatic lighting systems
- Electronic musical instruments (for pitch or volume control)
- Light failure alarm circuits
- Automatic contrast and brightness control in television receivers

Semiconductors and sensors

Working Principle of LDR?

This resistor works on the principle of photo conductivity. It is nothing but, when the light falls on its surface, then the material conductivity reduces and also the electrons in the valence band of the device are excited to the conduction band. These photons in the incident light must have energy greater than the band gap of the semiconductor material. This makes the electrons to jump from the valence band to conduction.

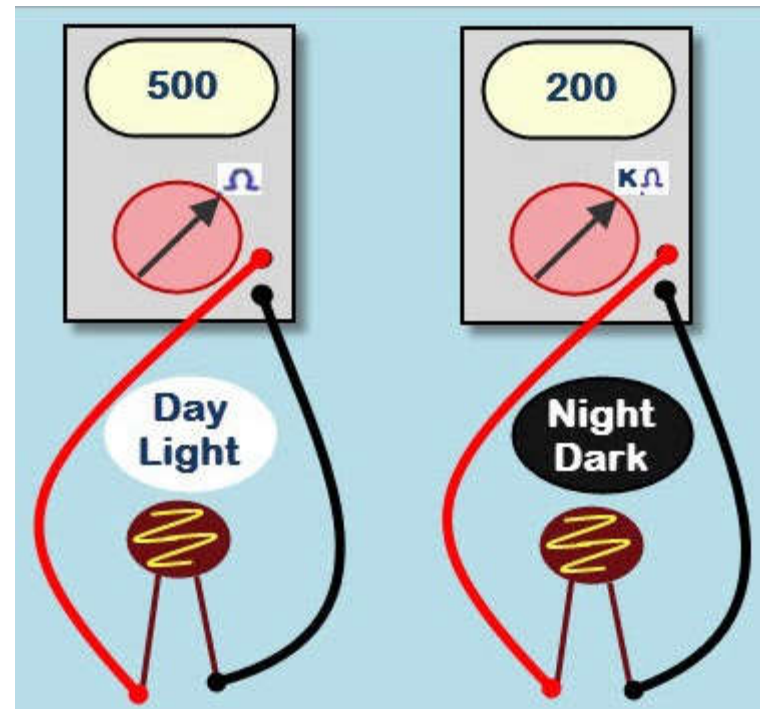
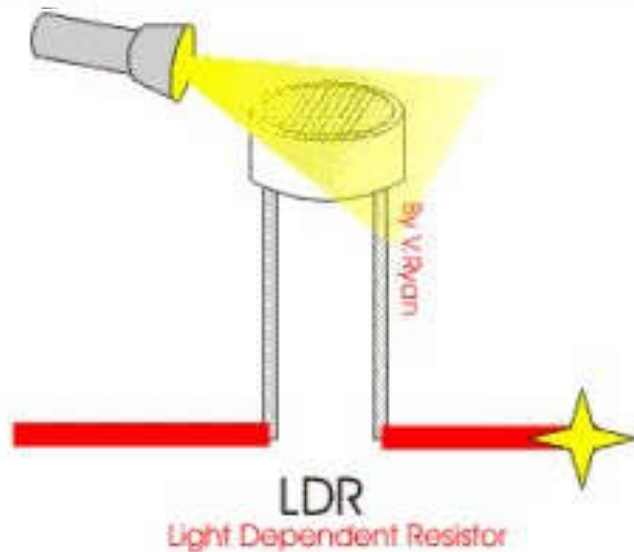


Semiconductors and sensors

Working Principle of LDR?

These devices depend on the light, when light falls on the LDR then the resistance decreases, and increases in the dark. When a LDR is kept in the dark place, its resistance is high and, when the LDR is kept in the light its resistance will decrease.

If a constant "V" is applied to the LDR, the intensity of the light increased and current increases. The figure below shows the curve between resistance Vs illumination curve for a particular light dependent resistor.

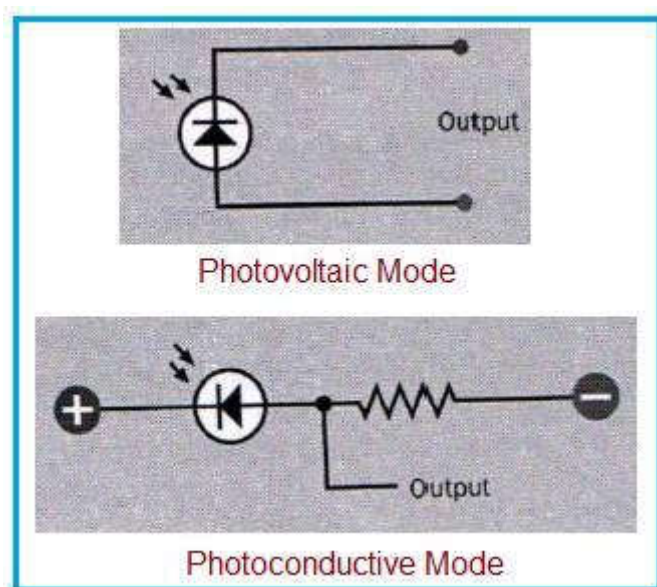


Semiconductors and sensors

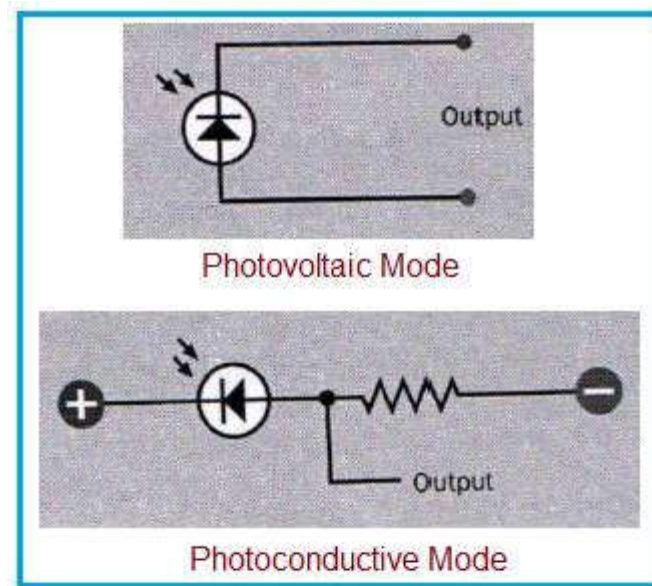
Photodiode Photovoltaic Mode

In photovoltaic mode, when light strikes the photodiode's semiconductor material, it excites electrons to higher energy states. This excitation makes the electrons mobile, leaving behind "holes." The electrons then migrate towards the cathode terminal, and the holes towards the anode. This movement generates a voltage difference between the two terminals, even without external bias.

Even in the absence of visible light, a small current is produced; this is known as the **dark current**. This mode is also sometimes referred to as **zero-bias mode**.



Semiconductors and sensors



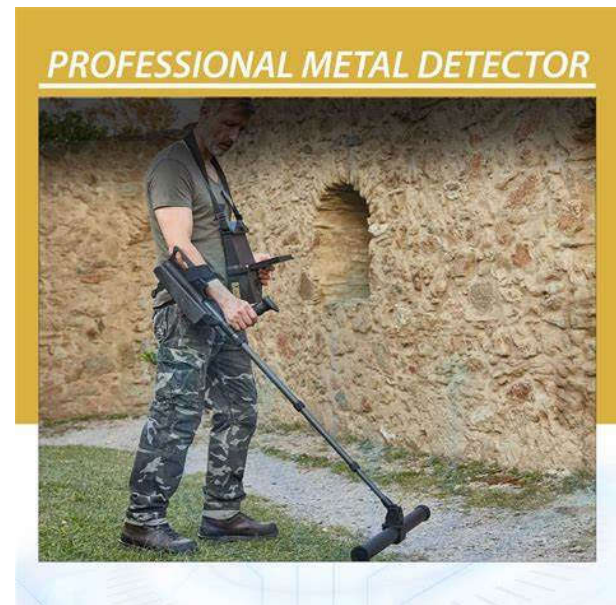
Photodiode Photoconductive Mode

In photoconductive mode, incident light on the photodiode creates electron-hole pairs within the semiconductor material. The application of a reverse bias voltage causes these pairs to move in opposite directions, resulting in a small current flow through the photodiode.

A key advantage of photoconductive mode is its faster response time compared to photovoltaic mode, this mode is also known as **reverse bias mode**.

Semiconductors and sensors

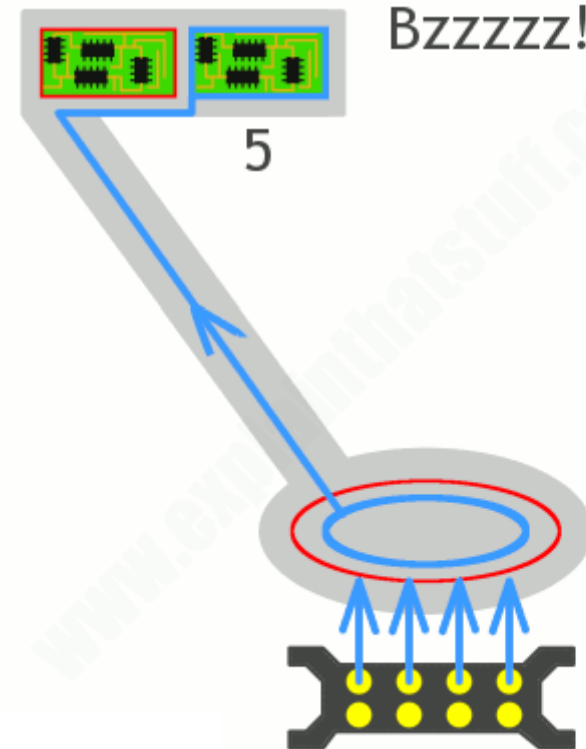
Metal Detector



Semiconductors and sensors

What makes a metal detector buzz when you sweep it over buried treasure? Why is it important to keep the detector moving?

1. A battery in the top of the metal detector activates the **transmitter circuit** (red) that passes electricity down through a cable in the handle to the **transmitter coil** (red) at the bottom.
2. When electricity flows through the transmitter coil, it creates a **magnetic field** all around it.
3. If you sweep the detector above a **metal object** (such as this old gray spanner), the magnetic field penetrates right through it.
4. The magnetic field makes an electric current flow inside the metal object.
5. This flowing electric current creates another magnetic field all around the object. The magnetic field cuts through the **receiver coil** (blue) moving about up above it. The magnetic field makes electricity flow around the receiver coil and up into the receiver circuit (blue) at the top, making a loudspeaker buzz and alerting you you've found something.



Semiconductors and sensors

LCD Display

LCDs are used in a wide range of applications:

- LCD televisions
- Computer monitors
- Instrument panels
- Aircraft cockpit displays etc.
- Small LCD screens are common in LCD projectors and portable consumer devices such as digital cameras, watches, calculators, and mobile telephones, including smartphones.

LCD screens have replaced heavy, bulky and less energy-efficient cathode-ray tube (CRT) displays in nearly all applications since the late 2000s to the early 2010s.

Semiconductors and sensors

How LCDs work

A display is made up of millions of pixels. The quality of a display commonly refers to the number of pixels; for example, a 4K display is made up of 3840 x 2160 or 4096 x 2160 pixels. A pixel is made up of three subpixels; a red, blue and green—commonly called **RGB**. When the subpixels in a pixel change color combinations, a different color can be produced. With all the pixels on a display working together, the display can make millions of different colors. When the pixels are rapidly switched on and off, a picture is created.

The way a pixel is controlled is different in each type of display; CRT, LED, LCD and newer types of displays all control pixels differently. In short, LCDs are lit by a backlight, and pixels are switched on and off electronically while using liquid crystals to rotate polarized light. A polarizing glass filter is placed in front and behind all the pixels, the front filter is placed at 90 degrees. In between both filters are the liquid crystals, which can be electronically switched on and off.

Semiconductors and sensors

Metal Detector

Types of LCDs

- Twisted Nematic (TN) TN displays have low contrast ratios, viewing angles and color contrasts.
- In Panel Switching displays (IPS Panels)- which boast much better contrast ratios, viewing angles and color contrast when compared to TN LCDs.
- Vertical Alignment Panels (VA Panels)- which are seen as a medium quality between TN and IPS displays.
- Advanced Fringe Field Switching (AFFS)- which is a top performer compared IPS displays in color reproduction range.

Semiconductors and sensors

LCD

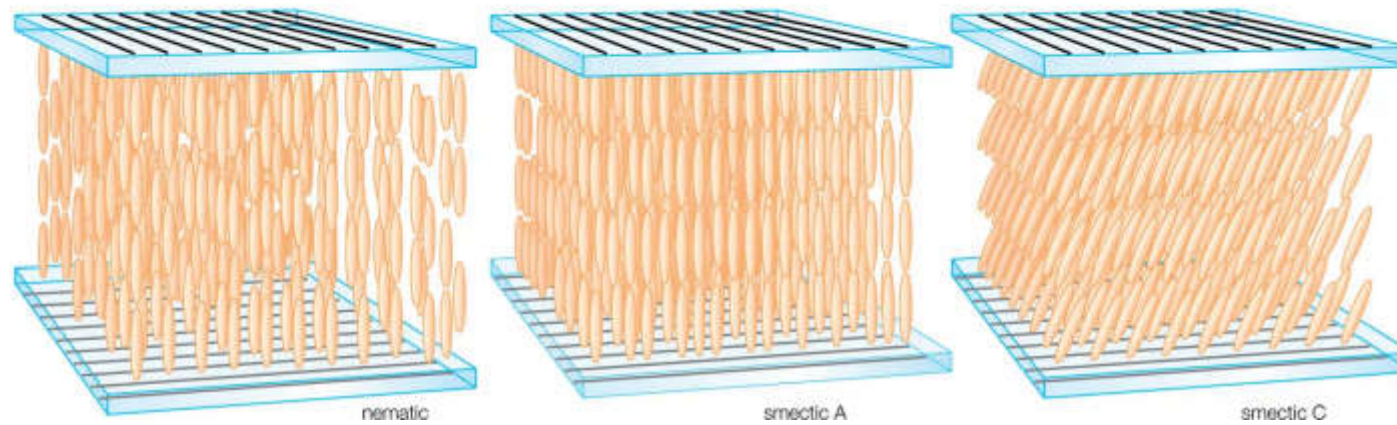
Liquid crystal display (LCD), electronic display device that operates by applying a varying electric voltage to a layer of liquid crystal, thereby inducing changes in its optical properties. LCDs are commonly used for portable electronic games, as viewfinders for digital cameras and camcorders, in video projection systems, for electronic billboards, as monitors for computers, and in flat-panel televisions.

Electro-optical effects in liquid crystals

Liquid crystals are materials with a structure that is intermediate between that of liquids and crystalline solids. As in liquids, the molecules of a liquid crystal can flow past one another. As in solid crystals, however, they arrange themselves in recognizably ordered patterns. In common with solid crystals, liquid crystals can exhibit polymorphism; i.e., they can take on different structural patterns, each with unique properties. LCDs utilize either nematic or smectic liquid crystals. The molecules of nematic liquid crystals align themselves with their axes in parallel, as shown in the figure. Smectic liquid crystals, on the other hand, arrange themselves in layered sheets; within different smectic phases, as shown in the figure, the molecules may take on different alignments relative to the plane of the sheets.

Semiconductors and sensors

LCD



Semiconductors and sensors

LCD

The optical properties of liquid crystals depend on the direction light travels through a layer of the material. An electric field (induced by a small electric voltage) can change the orientation of molecules in a layer of liquid crystal and thus affect its optical properties. Such a process is termed an electro-optical effect, and it forms the basis for LCDs. For nematic LCDs, the change in optical properties results from orienting the molecular axes either along or perpendicular to the applied electric field, the preferred direction being determined by the details of the molecule's chemical structure. Liquid crystal materials that align either parallel or perpendicular to an applied field can be selected to suit particular applications. The small electric voltages necessary to orient liquid crystal molecules have been a key feature of the commercial success of LCDs; other display technologies have rarely matched their low power consumption.