VMOS

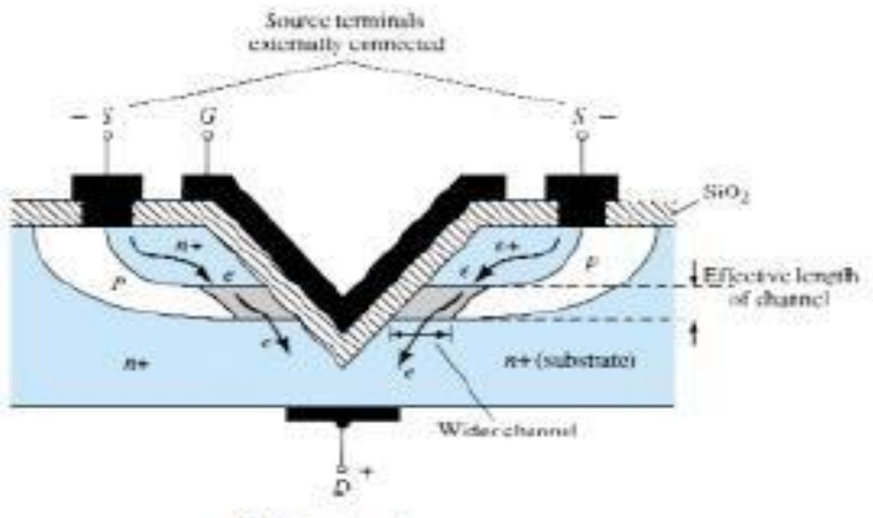
One of the disadvantages of the typical MOSFET is the reduced power-handling levels (typically, less than 1 W) compared to BJT transistors. This shortfall for a device with so many positive characteristics can be softened by changing the construction mode from one of a planar nature to one with a vertical structure as shown in Fig.

All the elements of the planar MOSFET are present in the vertical metal-oxide-silicon FET (VMOS)—the metallic surface connection to the terminals of the device—the SiO2 layer between the gate and the p-type region between the drain and source for the growth of the induced n-channel (enhancement- mode operation). The term vertical is due primarily to the fact that the channel is now formed in the vertical direction rather than the horizontal direction for the planar device.

However, the channel of Fig. also has the appearance of a ―V‖ cut in the semiconductor base, which often stands out as a characteristic for mental memorization of the name of the device. The construction of Fig is somewhat simplistic in nature, leaving out some of the transition levels of doping, but it does permit a description of the most important facets of its operation.

The application of a positive voltage to the drain and a negative voltage to the source with the gate at 0 V or some typical positive ―on‖ level as shown in Fig. will result in the induced n-channel in the narrow p-type region of the device. The length of the channel is now defined by the vertical height of the p-region, which can be made significantly less than that of a channel using planar construction. On a horizontal plane the length of the channel is limited to 1 to 2 µm.

Diffusion layers can be controlled to small fractions of a micrometer. Since decreasing channel lengths result in reduced resistance levels, the power dissipation level of the device (power lost in the form of heat) at operating current levels will be reduced. In addition, the contact area between the channel and the no region is greatly increased by the vertical mode construction, contributing to a further decrease in the resistance level and an increased area for current between the doping layers.



VMOS construction.

There is also the existence of two conduction paths between drain and source, as shown in Fig., to further contribute to a higher current rating. The net result is a device with drain currents that can reach the ampere levels with power levels exceeding 10 W.

Compared with commercially available planar MOSFETs, VMOS FETs have reduced channel resistance levels and higher current and power ratings.

VMOS FETs have a positive temperature coefficient that will combat the possibility of thermal runaway.

The reduced charge storage levels result in faster switching times for VMOS construction compared to those for conventional planar construction**.**

In fact, VMOS devices typically have switching times less than one-half that encountered for the typical BJT transistor.

LIQUID-CRYSTAL DISPLAYS

The liquid-crystal display (LCD) has the distinct advantage of having a lower power requirement than the LED. It is typically in the order of microwatts for the display, as compared to the same order of milliwatts for LEDs. It does, however, require an external or internal light source and is limited to a temperature range of about 0° to 60°C. Lifetime is an area of concern because LCDs can chemically degrade. The types receiving the major interest today are the field-effect and dynamic-scattering units.

A liquid crystal is a material (normally organic for LCDs) that will flow like a liquid but whose molecular structure has some properties normally associated with solids. For the lightscattering units, the greatest interest is in the nematic liquid crystal, having the crystal structure shown in Fig 1.

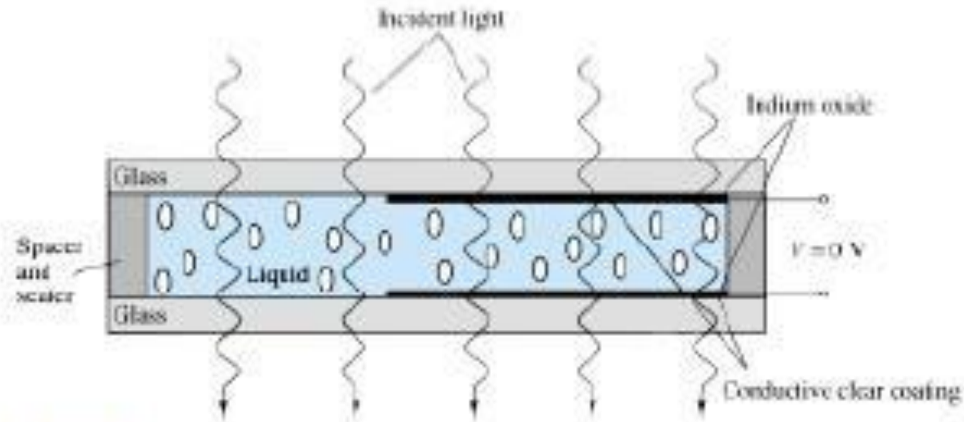


Figure 1 Nematic liquid crystal with no applied bias.

The individual molecules have a rodlike appearance as shown in the figure. The indium oxide conducting surface is transparent, and under the condition shown in the figure, the incident light will simply pass through and the liquid-crystal structure will appear clear. If a voltage (for commercial units the threshold level is usually between 6 and 20 V) is applied across the conducting surfaces, as shown in Fig. 2, the molecular arrangement is disturbed, with the result that regions will be established with different indices of refraction.

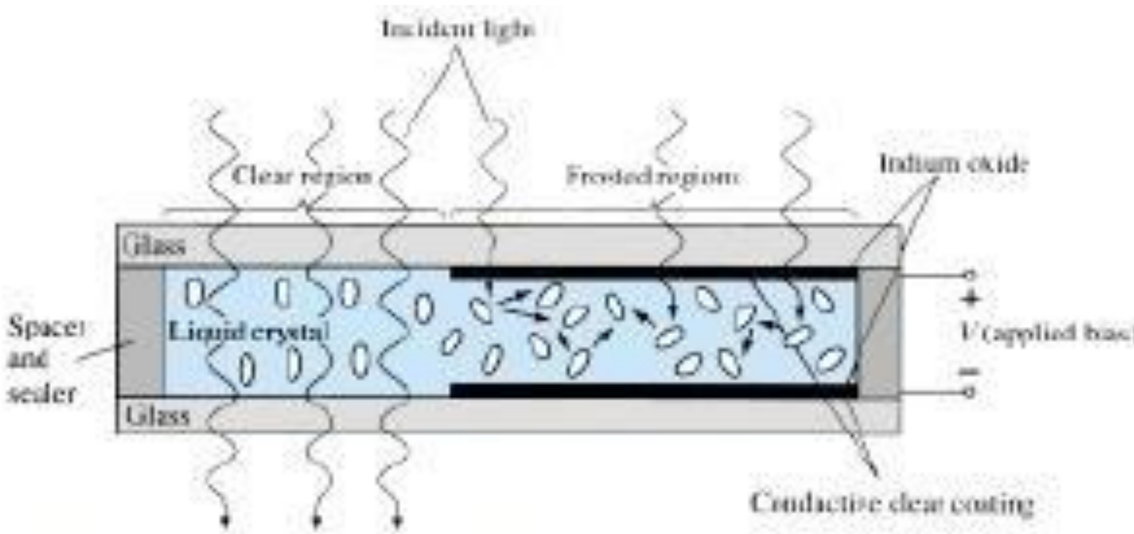


Figure 2 Nematic liquid crystal with applied bias.

A digit on an LCD display may have the segment appearance shown in Fig. 3. The black area is actually a clear conducting surface connected to the terminals below for external control. Two similar masks are placed on opposite sides of a sealed thick layer of liquid-crystal material. If the number 2 were required, the terminals 8, 7, 3, 4, and 5 would be energized, and only those regions would be frosted while the other areas would remain clear.

Figure 3. LCD 8 segment digit display

The field-effect or twisted nematic LCD has the same segment appearance and thin layer of encapsulated liquid crystal, but its mode of operation is very different. Similar to the dynamic-scattering LCD, the field-effect LCD can be operated in the reflective or transmissive mode with an internal source. The transmissive display appears in Fig. 4. The internal light source is on the right, and the viewer is on the left. This figure is most noticeably different from Fig. 20.35 in that there is an addition of a light polarizer. Only the vertical component of the entering light on the right can pass through the vertical-light polarizer on the right.

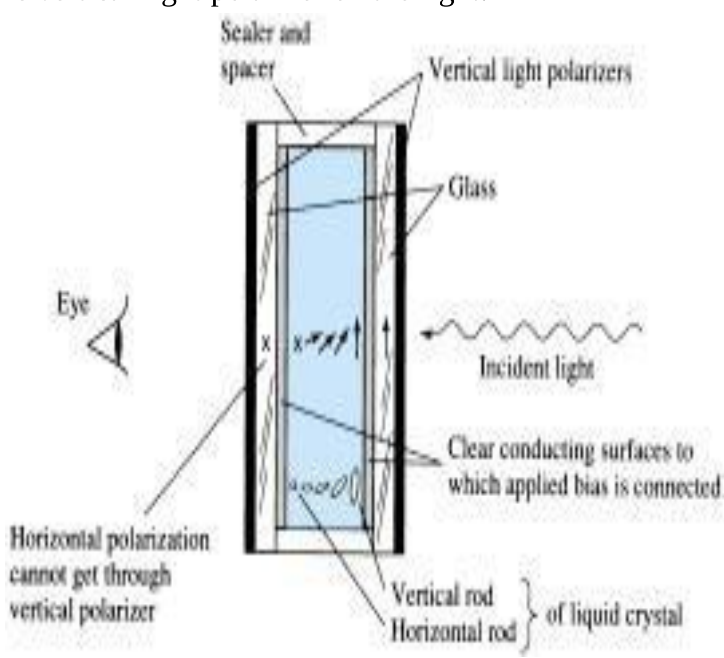


Figure 4. Transmissive field effect LCD with no applied bias

The reflective-type field-effect LCD is shown in Fig. 5. In this case, the horizontally polarized light at the far left encounters a horizontally polarized filter and passes through to the reflector, where it is reflected back into the liquid crystal, bent back to the other vertical polarization, and returned to the observer. If there is no applied voltage, there is a uniformly lit display. The application of a voltage results in a vertically incident light encountering a horizontally polarized filter at the left, which it will not be able to pass through and will be reflected.

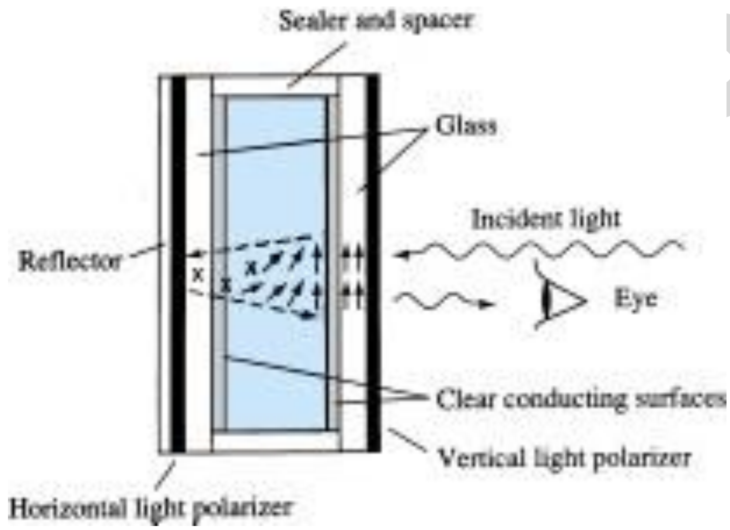


Figure 5. Reflective field effect LCD with no applied bias

Advantages of LCD

- Low power is required
- Good contrast
- Low cost

Disadvantages of LCD

- Speed of operation is slow
- LCD occupy a large area
- LCD life span is quite small, when used on d.c. Therefore, they are used with a.c. suppliers.

Applications of LCD

- Used as numerical counters for counting production items.
- Analog quantities can also be displayed as a number on a suitable device. (e.g.) Digital multimeter.
- Used for solid state video displays.

- Used for image sensing circuits.
- Used for numerical display in pocket calculators.

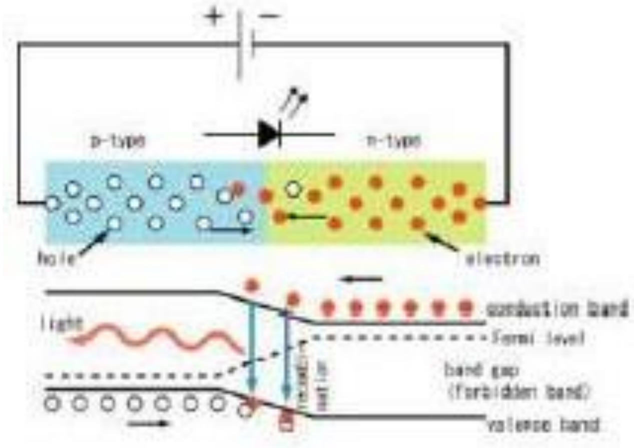
LIGHT EMITTING DIODE (LED)

A light-emitting diode (LED) is a semiconductor light source. LEDs are used as indicator lamps in many devices, and are increasingly used for lighting. Introduced as a practical electronic component in 1962, early LEDs emitted low-intensity red light, but modern versions are available across the visible, ultraviolet and infrared wavelengths, with very high brightness.

When a light-emitting diode is forward biased (switched on), electrons are able to recombine with electron holes within the device, releasing energy in the form of photons. This effect is called electroluminescence and the color of the light (corresponding to the energy of the photon) is determined by the energy gap of the semiconductor. An LED is often small in area (less than 1 mm2), and integrated optical components may be used to shape its radiation pattern.[3] LEDs present many advantages over incandescent light sources including lower energy consumption, longer lifetime, improved robustness, smaller size, faster switching, and greater durability and reliability. LEDs powerful enough for room lighting are relatively expensive and require more precise current and heat management than compact fluorescent lamp sources of comparable output.

Light-emitting diodes are used in applications as diverse as replacements for aviation lighting, automotive lighting (particularly brake lamps, turn signals and indicators) as well as in traffic signals. The compact size, the possibility of narrow bandwidth, switching speed, and extreme reliability of LEDs has allowed new text and video displays and sensors to be developed, while their high switching rates are also useful in advanced communications technology. Infrared LEDs are also used in the remote control units of many commercial products including televisions, DVD players, and other domestic appliances.

SYMBOL OF LED



DIODE I-V CURVE

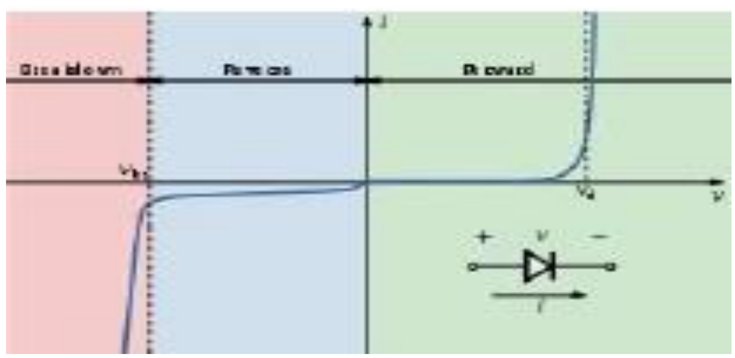


PHOTO TRANSISTORS

Phototransistor, has a photosensitive collector–base p-n junction. The current induced by photoelectric effects is the base current of the transistor. If we assign the notation I for the photoinduced base current, the resulting collector current, on an approximate basis, is

$$I_C = h_{fe} I_\lambda$$

A representative set of characteristics for a phototransistor is provided in Fig. with the symbolic representation of the device. Note the similarities between these curves and those of a typical bipolar transistor.

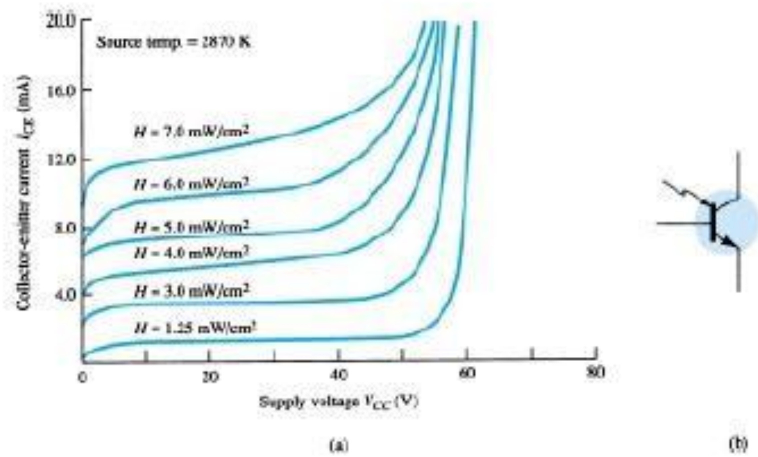
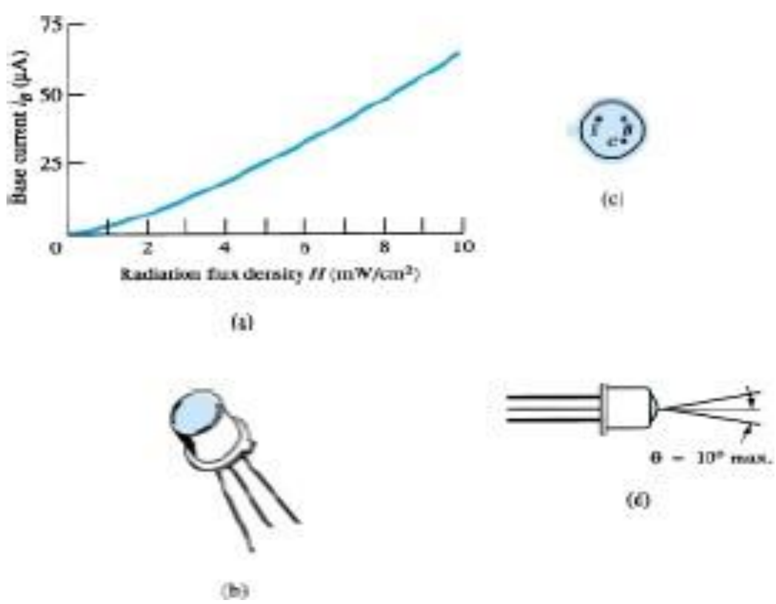


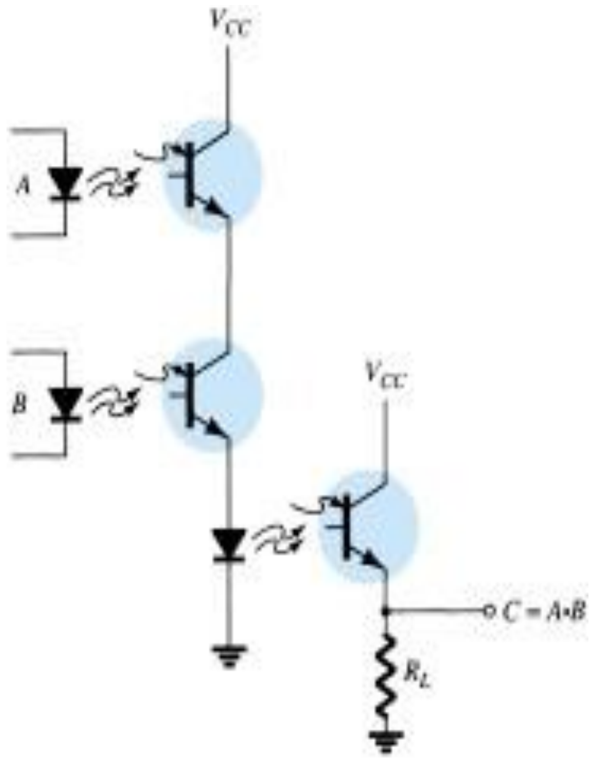
Photo Transistor (a) collector characteristics (b) symbol



Phototransistor (a) base current vs flux density (b) Device
(c) Terminal identification (d) angular alignment

A high-isolation AND gate is shown in Fig using three phototransistors and three LEDs (light-emitting diodes). The LEDs are semiconductor devices that emit light at an intensity determined by the forward current through the device. The terminology high isolation simply refers to the lack of an electrical connection between the input and output circuits.

High isolation AND gate employing phototransistor and LED



Applications

Some of the areas of application for the phototransistor include punch-card readers, computer logic circuitry, lighting control (highways, etc.), level indication, relays, and counting systems.

SOLAR CELLS

In recent years, there has been increasing interest in the solar cell as an alternative source of energy. When we consider that the power density received from the sun at sea level is about 100 mW/cm^2 (1 kW/m2), it is certainly an energy source that requires further research and development to maximize the conversion efficiency from solar to electrical energy.

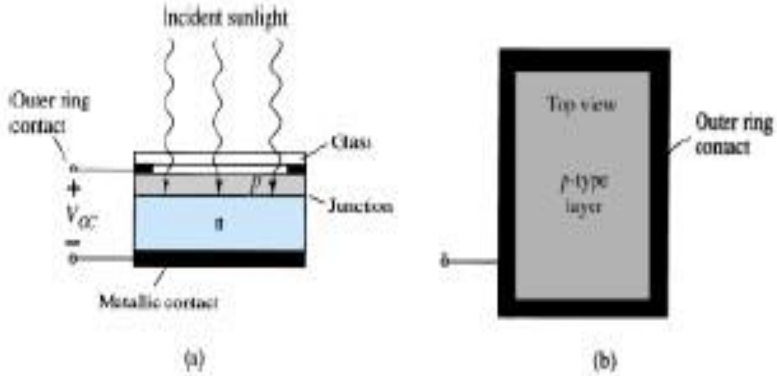


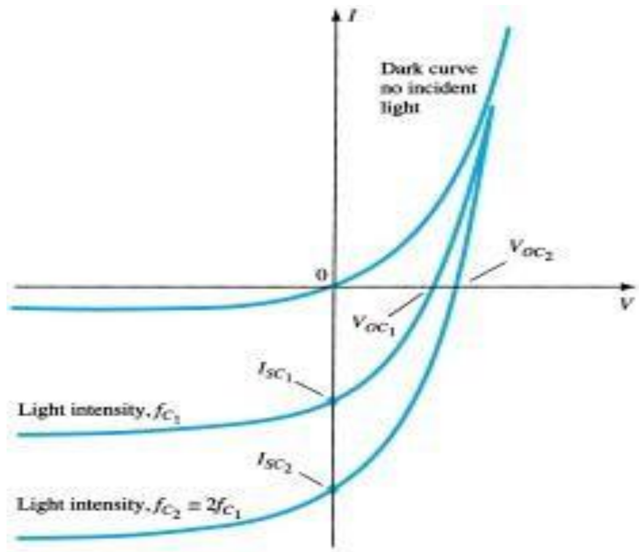
Fig 1. (a) cross section; (b) top view

The basic construction of a silicon p-n junction solar cell appears in Fig. 1. As shown in the top view, every effort is made to ensure that the surface area perpendicular to the sun is a maximum. Also, note that the metallic conductor connected to the p-type material and the thickness of the p-type material are such that they ensure that a maximum number of photons of light energy will reach the junction. A photon of light energy in this region may collide with a valence electron and impart to it sufficient energy to leave the parent atom. The result is a generation of free electrons and holes. This phenomenon will occur on each side of the junction.

In the p-type material, the newly generated electrons are minority carriers and will move rather freely across the junction as explained for the basic p-n junction with no applied bias. A similar discussion is true for the holes generated in the n-type material. The result is an increase in the minority-carrier flow, which is opposite in direction to the conventional forward current of a p-n junction. This increase in reverse current is shown in Fig. 2. Since V= 0 anywhere on the vertical axis and represents a short-circuit condition, the current at this intersection is called the short-circuit current and is represented by the notation I_{SC}.

Under open-circuit conditions (id = 0), the photovoltaic voltage V_{OC} will result. This is a logarithmic function of the illumination, as shown in Fig. 3. V_{OC} is the terminal voltage of a battery under no-load (open-circuit) conditions. Note, however, in the same figure that the short-circuit current is a linear function of the illumination. That is, it will double for the same increase in illumination (f_{C1} and $2f_{C1}$ in Fig. 3) while the change in V_{OC} is less for this region. The major increase in V_{OC} occurs for lower-level increases in illumination. Eventually, a further increase in illumination will have very little effect on V_{OC}, although I_{SC} will increase, causing the power capabilities to increase.

Selenium and silicon are the most widely used materials for solar cells, although gallium arsenide, indium arsenide, and cadmium sulfide, among others, are also used.



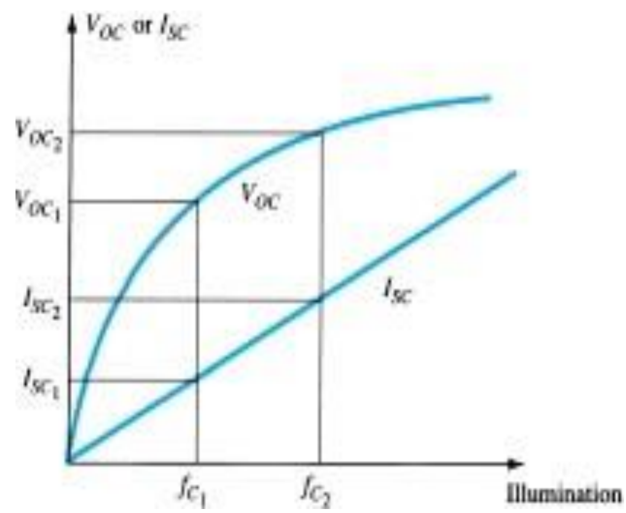
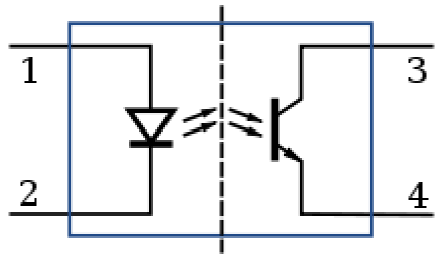


Fig 2. V-I curve for solar cell

Fig 3. Voc and Isc versus illumination for solar cell

OPTO COUPLER:

In electronics, an opto-isolator, also called an optocoupler, photocoupler, or optical isolator, is a component that transfers electrical signals between two isolated circuits by using light. Opto-isolators prevent high voltages from affecting the system receiving the signal. Commercially available opto-isolators withstand input-to-output voltages up to 10 kV and voltage transients with speeds up to 10 kV/μs. A common type of opto-isolator consists of an LED and a phototransistor in the same package. Opto-isolators are usually used for transmission of digital (on/off) signals, but some techniques allow use with analog (proportional) signals.



An opto-isolator contains a source (emitter) of light, almost always a near infrared light-emitting diode (LED), that converts electrical input signal into light, a closed optical channel (also called dielectrical channel), and a photosensor, which detects incoming light and either generates electric energy directly, or modulates electric current flowing from an external power supply. The sensor can be a photoresistor, a photodiode, a phototransistor, a silicon-controlled rectifier (SCR) or a triac. Because LEDs can sense light in addition to emitting it, construction of symmetrical, bidirectional opto-isolators is possible. An optocoupled solid state relay contains a photodiode opto-isolator which drives a power switch, usually a complementary pair of MOSFETs. A slotted optical switch contains a source of light and a sensor, but its optical channel is open, allowing modulation of light by external objects obstructing the path of light or reflecting light into the sensor.

CCD:

A charge-coupled device (CCD) is a device for the movement of electrical charge, usually from within the device to an area where the charge can be manipulated, for example conversion into a digital value. This is achieved by "shifting" the signals between stages within the device one at a time. CCDs move charge between capacitive *bins* in the device, with the shift allowing for the transfer of charge between bins. The CCD is a major piece of technology in digital imaging. In a CCD image sensor, pixels are represented by p-doped MOS capacitors. These capacitors are biased above the threshold for inversion when image acquisition begins, allowing the conversion of incoming photons into electron charges at the semiconductor-oxide interface; the CCD is then used to read out these charges. Although CCDs are not the only technology to allow for light detection, CCD image sensors are widely used in professional, medical, and scientific applications where high-quality image data is required. In applications with less exacting quality demands, such as consumer and professional digital cameras, active pixel sensors (CMOS) are generally used; the large quality advantage CCDs enjoyed early on has narrowed over time.

In a CCD for capturing images, there is a photoactive region (an epitaxial layer of silicon), and a transmission region made out of a shift register (the CCD, properly speaking).An image is projected through a lens onto the capacitor array (the photoactive region), causing each capacitor to accumulate an electric charge proportional to the light intensity at that location. A one-dimensional array, used in line-scan cameras, captures a single slice of the image, while a two-dimensional array, used in video and still cameras, captures a two-dimensional picture corresponding to the scene projected onto the focal plane of the sensor. Once the array has been exposed to the image, a control circuit causes each capacitor to transfer its contents to its neighbor (operating as a shift register). The last capacitor in the array dumps its charge into a charge amplifier, which converts the charge into a voltage. By repeating this process, the controlling circuit converts the entire contents of the array in the semiconductor to a sequence of voltages. In a digital device, these voltages are then sampled, digitized, and usually stored in memory; in an analog device (such as an analog video camera), they are processed into a continuous analog signal (e.g. by feeding the output of the charge amplifier into a low-pass filter) which is then processed and fed out to other circuits for transmission, recording, or other processing.