ROHINI
COLLEGE OF ENGINEERING AND TECHNOLOGY
Approved by AICTE and affiliated to Anna University,(An ISO Certified Institution)
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DEPARTMENT OF BIOMEDICAL ENGINEERING

III Semester

BM3301 SENSORS AND MEASUREMENTS

UNIT – 3

3.4 Photo Voltaic Cell

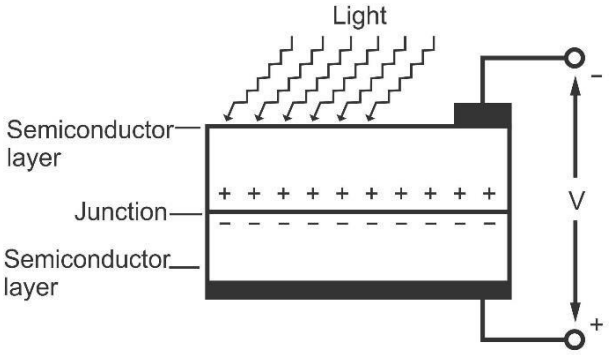
A photovoltaic (PV) cell, commonly called a solar cell, is a nonmechanical device that converts sunlight directly into electricity. Some PV cells can convert artificial light into electricity.

Photovoltaic effect:

The photovoltaic effect is a process that generates voltage or electric current in a photovoltaic cell when it is exposed to sunlight. It is this effect that makes solar panels useful, as it is how the cells within the panel convert sunlight to electrical energy. The photovoltaic effect was first discovered in 1839 by Edmond Becquerel.

Construction of Photovoltaic Cell:

- The cell consists of each a P-type and an N-type material and a PN junction diode sandwiched in between. This layer is responsible for trapping solar energy which converts into electricity.
- The N-type layer is also known as the first layer or the emitter layer. The P-type layer is the base layer and the intermediate layer between the two is the PN junction diode.
- The surface of the cell is covered by an anti-reflective material which traps the light energy and avoids any loss of energy.
- The bottom layer, the last one may completely be covered by the material in which the conductor is made up of.



Solar Cell or Photo Voltaic Cell

- Maximum voltage can be obtained through joining several solar cells in a series or a required current through connecting cells parallel.
- Solar cell's current is directly proportionate to illumination.
- Further, it also depends on the surface size of a cell.
- Moreover, the power output of the cell depends on the level of sunlight.
- The cells are made in the form of flat disks or flat strips in order to increase their surface area.
- Germanium and silicon are mostly used as semiconductor materials in solar cells.
- However, gallium arsenide, indium arsenide, and cadmium arsenide are also used nowadays.
- The construction of a basic solar cell has been elaborated in figure.

Working of Photovoltaic Cell:

- When sunlight (composed of photons) strikes the surface of the PV cell, energy from the photons is transferred to the electrons in the semiconductor material (usually silicon).
- The absorbed energy excites electrons in the semiconductor, allowing them to break free from their normal positions in the crystal lattice. This creates electron-hole pairs, where an electron is free to move, leaving behind a positively charged "hole" in its original position.

- Due to the internal electric field created by the p-n junction (formed by doping the silicon with different materials), the free electrons are pushed towards the n-type (negative) side, while the holes move towards the p-type (positive) side.
- The movement of electrons and holes in opposite directions constitutes an electric current. Metal contacts on the front and back surfaces of the cell allow for the collection of this current.
- The flow of electrons and holes creates a potential difference or voltage across the solar cell. This voltage can be utilized for various applications.
- To make practical use of the generated electrical energy, the solar cell is typically connected to an external circuit. The electricity generated by a single cell is usually low, so multiple cells are connected in series or parallel to form a solar module or panel, providing a higher voltage or current output.
- The electrical energy generated by the PV cells can be used directly to power electronic devices, or it can be stored in batteries for later use when sunlight is not available.

Characteristics of Photo Voltaic cell:

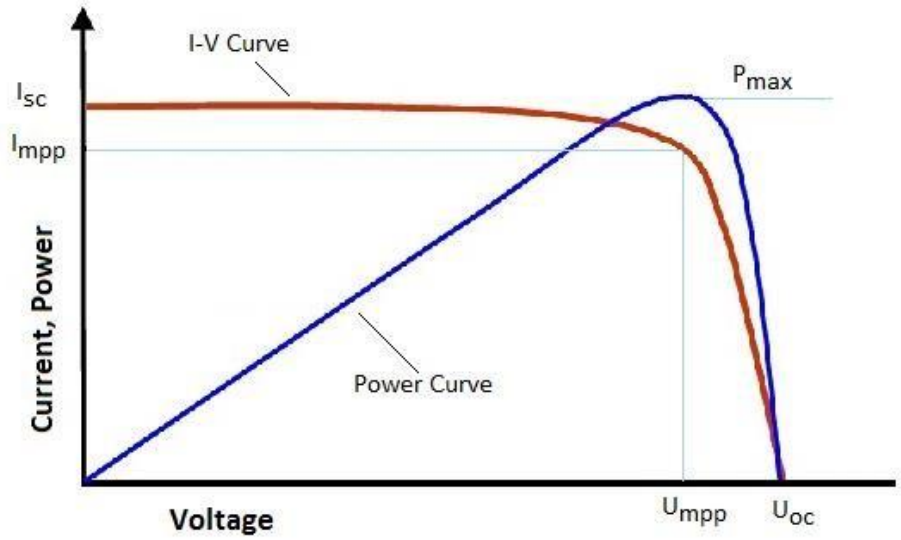


Figure: P-V and I-V Characteristics of Photo Voltaic Cell

I-V curves are obtained by varying an external resistance from zero (short circuit) to infinity (open circuit). Power delivered by the PV cell is the product of voltage (V) and current (*I*). At both open and closed circuit conditions the power delivered is

zero. At some point in between (around the knee point) the delivered power is a maximum.

Note: the maximum amount of current that a PV cell can deliver is the short circuit current. Given the linearity of current in the voltage range from zero to the maximum power voltage, the use of the short circuit current for cable and system dimensioning is reasonable.

The cell will produce the maximum intensity when the resistance between the terminals of the output circuit is minimal;

Another point to consider is the maximum of the PV curve, called maximum power point (MPP), which corresponds to the point on the IV curve, wherein the area of the rectangle formed by the points (V,I) is maximum. This is the point at which the module operates with maximum efficiency and produces the maximum output power. It is the point of maximum power (Vmpp, Impp).

Advantages of Photovoltaic Cell:

i. Clean and Renewable Energy:
ii. Reduced Dependence on Fossil Fuels:
iii. Low Operating Costs:
iv. Solar panels operate ***silently,*** without the noise associated with some other forms of electricity generation
v. Off-Grid Solutions:

Disadvantages of Photovoltaic Cell:

i. Energy Storage Challenges
ii. High Initial Costs
iii. While solar panels have a long lifespan, they do ***degrade*** over time.
iv. Potential for Toxins in Manufacturing:

Applications of Photovoltaic Cell:

Medical Applications:

i. Photovoltaic cells can be used to power implantable medical devices, such as pacemakers, defibrillators
ii. Photovoltaic cells can be integrated into neurostimulation devices used for deep brain stimulation or spinal cord stimulation.
iii. Photovoltaic cells integrated into contact lenses can be used to power electronic components for various biomedical applications.
iv. Photovoltaic cells can be *incorporated i*nto wearable medical devices, such as patches or bands, to power sensors that monitor vital signs.
v. Biomedical Imaging Devices:
vi. Tissue Engineering and Regenerative Medicine

Other Applications of Photovoltaic cell:

i. Residential Solar Power
ii. Commercial and Industrial Solar Installations
iii. Solar-Powered Streetlights
iv. Solar-Powered Water Pumping
v. Solar-Powered Vehicles
vi. Aerospace Applications

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