A CASE STUDY AND ANALYSIS OF HIGH EFFICIENCY PHOTO VOLTAIC CELL

Prajjwal Kumar Bairwa [1], Utkarsh Sharma [2], Shruti Rathi [3], Lalita Kumawat [4], Tushar Agarwal [5]

[1234] B.Tech Student, Department of Electrical Engineering, Arya Institute of Engineering and Technology
[5]Assistant Professor, Department of Electrical Engineering, Arya Institute of Engineering and Technology

ABSTRACT - Photovoltaic cells offer an additional way to get energy. By using the photovoltaic effect, it transforms solar energy into electrical energy. Using semi-conductors, it directly turns sunlight into electricity. Applications on Earth and in space frequently use solar cells. Review of efficient photovoltaic implementation with an emphasis on semiconductor characteristics and overall solar system design.

KEYWORDS : Energy conversion efficiency, photovoltaic, PV, solar cell.

1.INTRODUCTION

Different technologies have been pushed for by energy policies to lower pollutant emissions and slow down climate change. Today It is a renewable alternative to conventional fossil fuel electricity generation that is expanding quickly and becoming more significant. As a renewable, safe, and domestically secure alternative energy source, photovoltaic technology (PV) makes use of sunlight to produce energy. Due to the PV cell's low power output—typically less than three watts—high power jobs need the use of PV modules or solar cells, which are collections of PV cells connected in series and parallel.

PV arrays only generate electricity when they are lit up. It is necessary to use a charge controller and an AC to DC converter to drive AC loads and prevent damaging battery overcharge and over discharge circumstances.

The main goal is to maximise energy storage and PV cells while also improving system efficiency. One needs to have a fundamental knowledge of how PV cells and storage devices work in order to discuss optimisation.

2.FUNCTIONALITY

PV cells rely on light absorption inside a semiconductor material to function. The medium provided by a silicon PN diode allows incident photons to be transformed into energy, typically in the form of heat. If the incident photon energy is greater than the electron's work function, the photon may boost the electron's energy state or even liberate an electron when it is absorbed, transferring energy to the electron in the absorbing material. The electrons are then free to travel about the semiconductor material unrestricted, under the impact of current diffusion, temperature, and electric field phenomena.

All semiconductors have a gap between their valence and conduction bands, according to the quantum theory of semiconductor devices. At absolute zero temperatures, semiconductors are said to be perfect insulators. As temperature rises, a small percentage of electrons receive enough energy to move from the valence band to the conduction band and holes from the conduction band to the valence band. In the case of PV systems, incident photons from illumination, temperature, and electric field are what cause the temperature increase that is directly responsible for this entire process.

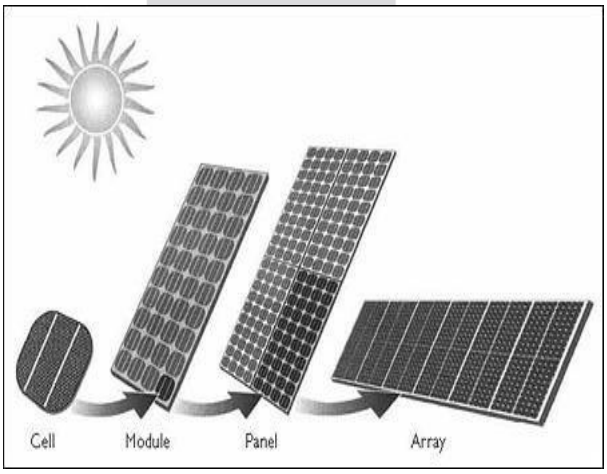

FIG 1: CELL MODULE AND ARAY

An electric potential difference across this junction can be found using the photoelectric effect. Due to the diode's distinctive unidirectional current route, electrons and holes are separated at the n and p regions, respectively, in the absence of illumination. When a PV cell is illuminated, incident photons bombard the cell's electrons, forming electron hole pairs. The electric field produced by the cell junction subsequently causes these electron hole pairs to separate, sending electrons back into the n area and holes into the p region. It is possible to harness energy and construct a bidirectional current path. Now that the fundamentals of PV are understood, a solar cell may be created.

3.A PVC CELL DESIGN

A PV cell is a straightforward pn diode, and the design procedure will take into account the well-known voltage transfer characteristic formulae. These characteristic equations therefore offer a way to establish the ideal PV cell performance limits. The VTC graph shows that the cell has a limiting voltage as well as a limiting current, therefore open circuit and short circuit operation circumstances won't impair its performance. The short circuit current simply changes to the photon induced current at zero applied voltage, and the open circuit voltage may be calculated by setting the cell current to zero.

It should be emphasised that while short circuit current is directly proportional to cell illumination, open circuit voltage only depends on it logarithmically. Maximum power efficiency is sought because PV cells are quite expensive. By applying open circuit and short circuit values to the maximum power equation, or by using differentiation, this maximum point can be found.
$P_m = V_{max} I_{max}$. Once VTC conditions are found, the actual material composition and layout of the cell must be determined.

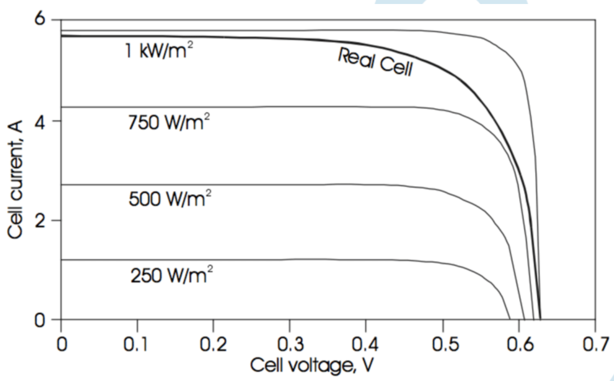

FIG 2-IV CHARACTERISTICS OF REAL AND IDEAL PV CELLSUNDER DIFFERENT ILLUMINATION LEVELS

With a wide variety of energies, photons may or may not be able to overcome the band gap energy and free an electron. However, if a photon has significantly more energy than the necessary band gap energy, the excess energy is lost. Because they reduce the energy conversion efficiency of PV designs by 30% on average. The amount of electricity converted and collected when a solar cell is linked to an electrical circuit is known as energy conversion efficiency. The most common formula for efficiency measurement is $=P_m/(E \times A_c)$, which divides the maximum power by the product of the entire solar module area and irradiance (power for electromagnetic radiation at a surface).

4.PVC ADVANCEMENTS

Although this first-generation semiconductor approach is used in the design of 86% of PV cells, second- and third-generation cells are made of thin film deposits and electron-confined nanoparticle materials. Thin film methods reduce the amount of light-absorbing material used, which lowers manufacturing costs but also reduces the efficiency of energy conversion. Since these thin films have almost no mass, they can be stacked to create multiple layer film cells, which have an average efficiency of 30% compared to the 14% of standard semiconductors. Nano crystalline solar cells increase efficiency by using the same thin-film light absorbing materials, but they are covered with a very thin layer of mesoporous metal oxide whose high surface area helps to increase internal reflections and ultimately light absorption probability and efficiency .This increase of internal reflection helps to boost nanocrystalline PV cell efficiency to over 40%.

5.EXTERNAL DESIGN CONSIDERATION

A designer must take into account the support structures, snow and ice for specific climates, and the load bearing weight of hefty modules. The task of a structural engineer is made more difficult by changes in wind, which cause uneven stress and tension dispersion across the PV system. The orientation of the PV module must be changed to reflect a particular incidence angle that corresponds to the pollution's altered index or refraction. How much energy is needed to carry out the desired auxiliary function must be taken into account when developing a storage system. In order to evaluate a corrected PV system load, it is also crucial to take into account parasitic capacitance and resistance effects caused by storage mechanism-PV cell interconnects. The PV cell's maximum power point may be impacted by this changing load, thus it must be taken into account.

6. APPLICATIONS

- Rooftop residential and commercial systems, outlying water pumping facilities, telecommunications gear, and traffic lights are a few examples of PV devices.
- In the most common configuration, PV cells collect photons and transfer DC electricity through an inverter, which converts the signal to 120 or 240 volts to run AC appliances. The AC power comes into the house through the utility panel and is then distributed to all of the appliances. Unused electricity will be recycled and used again in other facilities.
- Applications for PV cells are countless because they are an alternative energy source. Automobiles, satellites, shuttles, landscape lights, water heaters, stand-alone battery chargers, and utility grid sources are a few typical examples
- This compound could be applied on garments to provide power to cell phone or other wireless devices.

7. ADVANTAGES AND DISADVANTAGES OF PVC CELL

Advantages:

- Solar-generated electricity is pure and silent. PV systems do not emit any hazardous air or water pollution into the environment, deplete natural resources, or jeopardise the health of people or animals because they do not require any fuel other than sunlight.
- Photovoltaic systems are silent and unobtrusive to the eye.
- Small-scale solar power plants can benefit from empty space on existing buildings' rooftops.
- PV cells were first created for use in space, where it is very expensive, if not impossible, to repair anything. Due to its reliability over a long period of time with little maintenance, PV still powers almost all satellites orbiting the earth.
- Solar energy is a locally available renewable resource.

Disadvantages:

- Some hazardous substances, including cadmium and arsenic, are used in the PV manufacturing process.
- Due to the cost of producing PV devices and the equipment's conversion efficiency, solar energy is somewhat more expensive to create than traditional energy sources.

- Solar energy is a changeable energy source because it depends on the sun for energy generation. There may be times when solar power plants produce no electricity at all.

8. PHOTOVOLTAIC SYSTEM APPLICATIONAL VIEW

The PV system is composed of a number of individual PV modules that can be connected either in series (to increase the dc output voltage up to the desired value) to form a string. Then, multiple strings are connected in parallel to increase the output current. The possibility of using multiple strings ensures the PV system modularity, which is one of the most important features of the PV technology. The arrangement of the PV modules in strings also allows for using different solutions for the dc/ac conversion. Available solutions include the centralised inverter, collecting the dc output from the whole array of PV modules, string inverters (with one inverter for each string) or module-integrated inverters (with a mono inverter for each PV module). The centralised inverter is a solution most suitable for PV systems with rated power indicatively above 20kW, connected to the supply system through a three-phase inverter. The other solutions are typical of residential installations, where the power is usually not higher than 5–10kW and the inverters are mono-phase. The adoption of module-integrated inverters requires the installation of a relatively high number of inverters, each one with its protections, directly on the field, paying attention to the fact that the inverters have to withstand different climatic conditions. Yet, the adoption of module-integrated inverters allows for individual and independent control of the mono inverters, with possibility of minimising the losses due to different. Building-integrated photovoltaic (BIPV) systems incorporate photovoltaic properties into building materials such as roofing, siding, and glass and thus offer advantages in cost and appearance as they are substituted for conventional materials in new construction. Moreover the BIPV installations are architecturally more appealing than roof-mounted PV structures. Yoo et al. (2002) proposed a building design to have the PV modules shade the building in summer, so as to reduce cooling loads, while at the same time allowing solar energy to enter the building during the heating season to provide daylight and conducted an analysis of the system performance, evaluation of the system efficiency and the power output. Bakos et al. (2003) described the installation, technical characteristics, operation and economic evaluation of a grid-connected building integrated photovoltaic system (BIPV) and the technical and economic factors were examined using a computerized renewable energy technologies (RETs) assessment tool. Xu et al. (2008) developed and evaluated the performance of an Active Building Envelope (ABE) systems, a new enclosure technology with the ability to regulate their temperature (cooling or heating) by interacting with the sun which integrates photovoltaic (PV) and thermoelectric (TE) Technologies. Chow et al. (2003) described effectiveness of cooling by means of a natural ventilating air stream numerically based on two cooling options with an air gap between the PV panels and the external facade: (I) an open air gap with mixed convective heat transfer, and (ii) a solar chimney with buoyancy induced vertical flow and found that effective cooling of a PV panel can increase the electricity output of the solar cells. Wong et al. (2008) proposed semi-transparent PV top light material for residential application with 50% radiation transmission rate contributing to a maximum of 5.3% reduction in heating and cooling energy consumption when compared with a standard BIPV roof. Cheng et al. (2005) developed an empirical approach for evaluating the annual solar tilted planes irradiation with inclinations from 0 to 90◦ and azimuths from 0 to 90◦ on building envelopes for BIPV applications in Taiwan. Ruther et al. (2008) studied the behavior of grid connected, building integrated photovoltaic (BIPV) solar energy conversion in the urban environment of a metropolitan area in a Brazilian state capital, aiming at maximizing the benefits of the distributed nature of PV generation. Jar dim et al. (2008) studied the behavior of grid-connected, building integrated photovoltaic solar energy conversion in the built environment of metropolitan area in Brazilian state capital, aiming at maximizing the benefits of the distributed nature of PV generation

FIG 4- REAL TIME USE OF PV SYSTERM IN AUTOMATION

9. REVIEW

The world is far more concerned about the depletion of fossil fuels, the harm to the environment, and global warming. Therefore, researchers should constantly consider the generation and use of green and environmentally friendly electrical power. In terms of conversion efficiency, a variety of photovoltaic (PV) materials and systems have made enormous strides in recent years. PV cells use green energy-producing renewable energy technology to produce electricity. In essence, there are two ways to improve the efficiency of PV cells: first, choosing the semi-conducting materials needed to fill the energy gap that corresponds to the solar spectrum and optimizes their optical and electrical properties; and second, inventing new devices that enable better charge collection and solar spectrum utilization through single and multi-junction approaches. The capacity factors of solar photovoltaic arrays are typically under 25%, which is lower than many other industrial sources of electricity.

10. CONCLUSION

Photovoltaic research will continue to advance due to the enticing qualities of PV cells, a proven environmentally friendly power source.Current PV systems are still incredibly inefficient, rare, and mainly utilized in places where there is no other nearby power source because they are still significantly more expensive than fossil fuel-based generators. Thin film and nanocrystal line material developments in photovoltaics will keep advancing, and soon PV efficiency will reach over 50%. PV technology will draw more users as its efficiency rises, which will lower its price. The sun provides ten thousand times more energy than what people use now, thus photovoltaic advancements will eventually replace polluting power plants with a tried-and-true pure energy source.

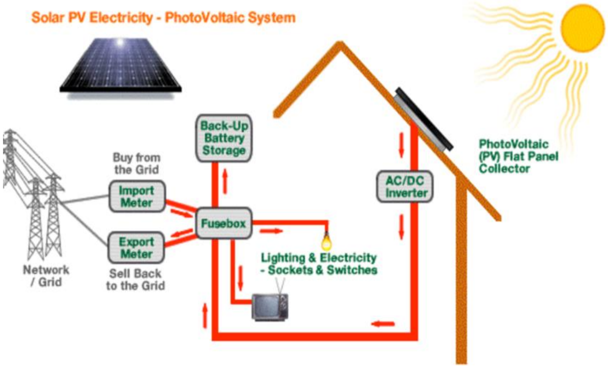

FIG 5-PHOTOVOLTAIC SYSTEM

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