EE6009 POWER ELECTRONICS FOR RENEWABLE ENERGY SYSTEMS

UNIT III-POWER CONVERTERS AND ANALYSISOF SOLAR PV SYSTEMS

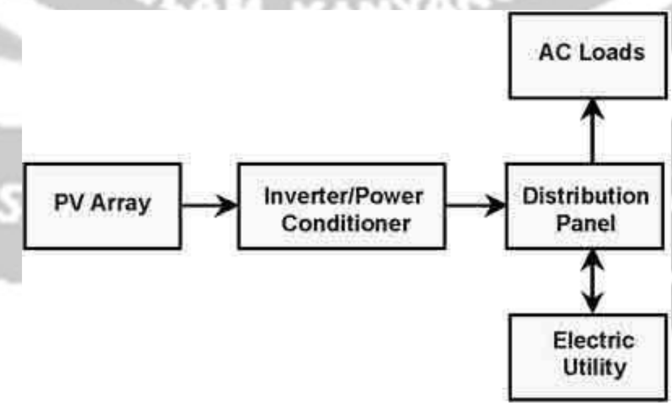
3.4- TYPES OF SOLAR PV SYSTEMS: STAND-ALONE PV SYSTEMS, GRID INTEGRATED SOLAR PV SYSTEMS - GRID CONNECTION ISSUES.

CLASSIFICATION OF PHOTOVOLTAIC POWER SYSTEMS

Photovoltaic (PV) systems are playing an increasingly significant role in electricity grids and there have been changes in system configurations in recent years. Classification of PV systems has become important in understanding the latest developments in improving system

performance in energy harvesting. Photovoltaic power systems are generally classified according to their functional and operational requirements, their component configurations, and how the equipment is connected to other power sources and electrical loads. The two principal classifications are grid-connected or utility-interactive systems and stand-alone systems. In general, grid-connected PV power systems can be categorized into two main groups: centralized MPPT (CMPPT) and distributed MPPT (DMPPT). Photovoltaic systems can be designed to provide DC and/or AC power service, can operate interconnected with or independent of the utility grid, and can be connected with other energy sources and energy storage systems.

Diagram of grid-connected photovoltaic system.



Grid-connected photovoltaic system

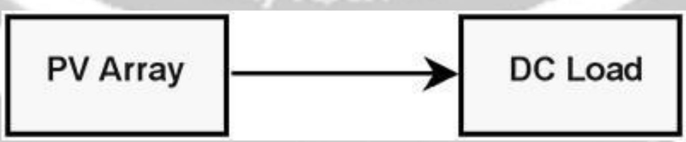
Grid-connected or utility-interactive PV systems are designed to operate in parallel with and interconnected with the electric utility grid. The primary component in grid-connected PV

systems is the inverter, or power conditioning unit (PCU). The PCU converts the DC power produced by the PV array into AC power consistent with the voltage and power quality requirements of the utility grid, and automatically stops supplying power to the grid when the utility grid is not energized. A bi-directional interface is made between the PV system AC output circuits and the electric utility network, typically at an on-site distribution panel or service entrance. This allows the AC power produced by the PV system to either supply on-site electrical loads or to back-feed the grid when the PV system output is greater than the on-site load demand. At night and during other periods when the electrical loads are greater than the PV system output, the balance of power required by the loads is received from the electric utility This safety feature is required in all grid-connected PV systems, and ensures that the PV system will not continue to operate and feed back into the utility grid when the grid is down for serviceor repair.

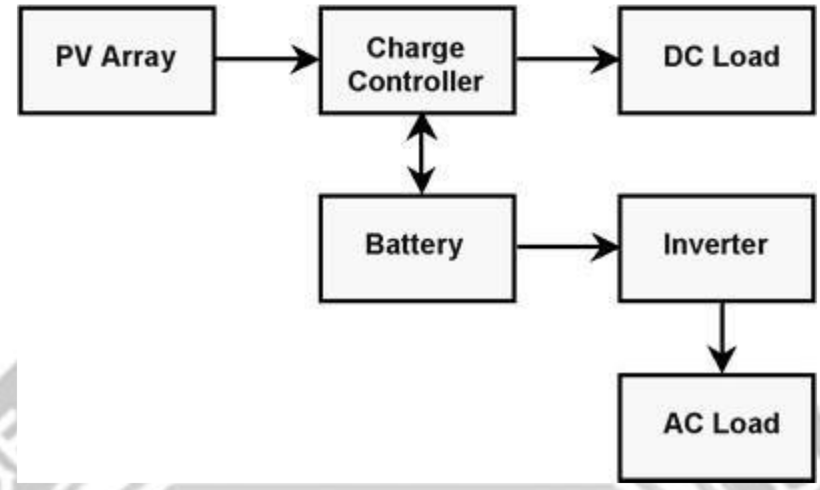
Stand-Alone Photovoltaic Systems

Stand-alone PV systems are designed to operate independent of the electric utility grid, and are generally designed and sized to supply certain DC and/or AC electrical loads. These

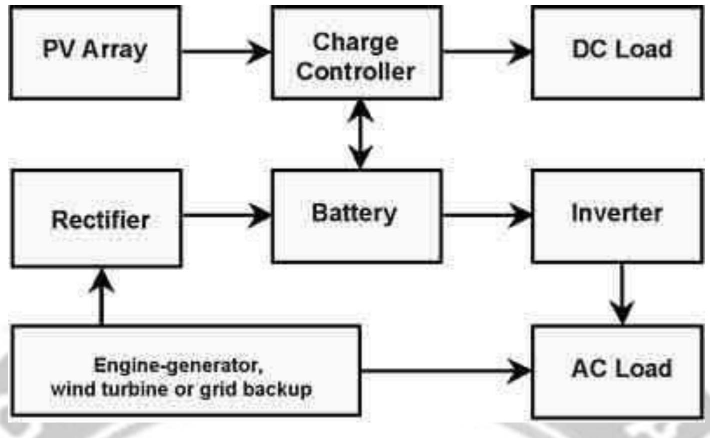
types of systems may be powered by a PV array only, or may use wind, an engine-generator or utility power as an auxiliary power source in what is called a PV-hybrid system. The simplest type of stand-alone PV system is a direct-coupled system, where the DC output of a PV module or array is directly connected to a DC load.



Direct-coupled PV system



Stand-alone PV system with battery storage powering DC and AC loads

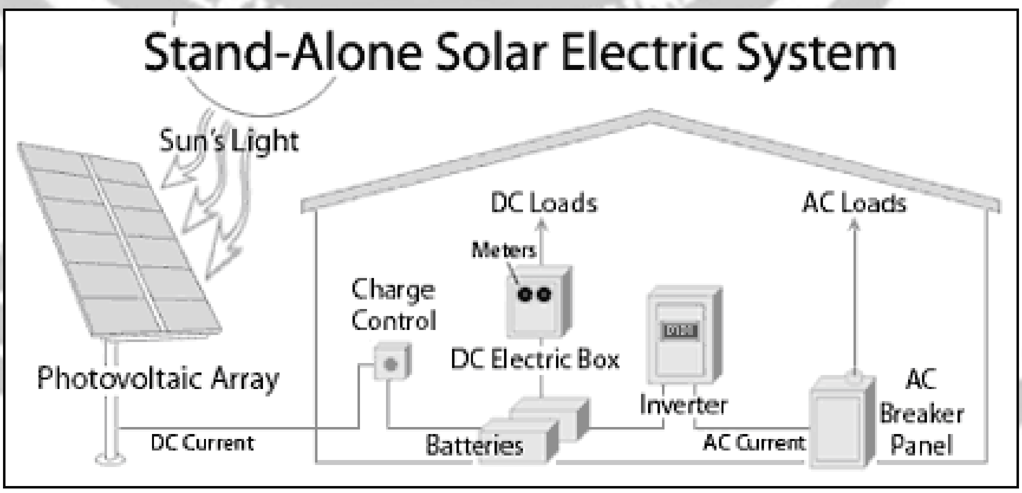


Photovoltaic hybrid system

Since there is no electrical energy storage (batteries) in direct-coupled systems, the load only operates during sunlight hours, making these designs suitable for common applications such as ventilation fans, water pumps, and small circulation pumps for solar thermal water heating systems. Matching the impedance of the electrical load to the maximum power output of the PV array is a critical part of designing well-performing direct-coupled system. For certain loads such as positive-displacement water pumps, a type of electronic DC-DC converter, called

a maximum power point tracker (MPPT), is used between the array and load to help better utilize the available array maximum power output.

A Stand Alone Solar PV System



A free standing or **Stand Alone PV System** is made up of a number of individual photovoltaic modules (or panels) usually of 12 volts with power outputs of between 50 and 100+ watts each. These PV modules are then combined into a single array to give the desired power output. A simple *stand alone PV system* is an automatic solar system that produces electrical power to charge banks of batteries during the day for use at night when the suns energy is unavailable. A stand alone small scale PV system employs rechargeable batteries to store the electrical energy supplied by a PV panels or array. Stand alone PV systems are ideal for remote rural areas and applications where other power sources are either impractical or are unavailable to provide power for lighting, appliances and other uses. In these cases, it is more cost effective to install a single stand alone PV system than pay the costs of having the local electricitycompany extend their power lines and cables directly to the home.

A Stand Alone Solar PV System

While a major component and cost of a standalone PV system is the solar array, severalother components are typically needed. These include:

Batteries:

Batteries are an important element in any stand alone PV system but can be optional depending upon the design. Batteries are used to store the solar-produced electricity for night time or emergency use during the day. Depending upon the solar array configuration, battery banks can be of 12V, 24V or 48V and many hundreds of amperes in total. Deep cycle lead acid batteries are generally used to store the solar power generated by the PV panels, and then discharge the power when energy is required. Deep cycle batteries are not only rechargeable, but they are designed to be repeatedly discharged almost all the way down to a very low charge.

Charge Controller:

A charge controller regulates and controls the output from the solar array to prevent the batteries from being over charged (or over discharged) by dissipating the excess power into a load resistance. Charge controllers within a standalone PV system are optional but it is a good idea to have one for safety reasons. The charge controller ensures that the maximum output ofthe solar panels or array is directed to charge the batteries without over charging or damaging them. They operate automatically, with most commercially available charge controllers having a digital display to show how much power has been created at any time, the state of charge of the batteries and programmable settings to discharge the batteries into a resistive dummy load to minimize the chances of sulphation of the battery cells extending the battery life.

Fuses and Isolation Switches:

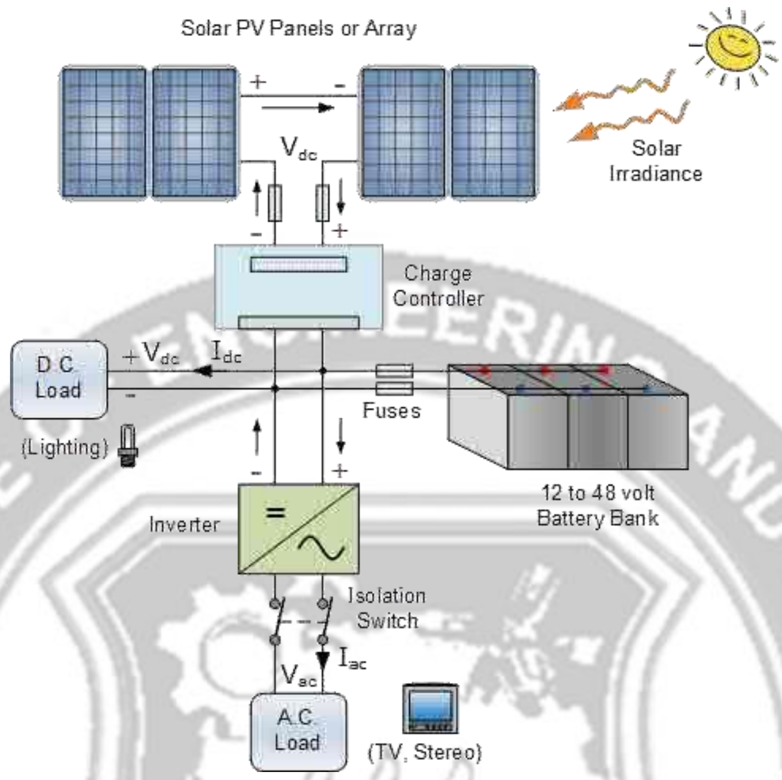
These allow PV installations to be protected from accidental shorting of wires allowing power from the PV modules and system to be turned ―OFF‖ when not required saving energy and improving battery life.

Inverter:

Inverters are used to convert the 12V, 24V or 48 Volts direct current (DC) power fromthe solar array and batteries into an alternating current (AC) electricity and power of either 120 VAC or 240 VAC for use in the home to power AC mains appliances such as TV‘s, washing machines, freezers, etc.

Wiring:

The final component required in and PV solar system is the electrical wiring. Thecables need to be correctly rated for the voltage and power requirements.



Newer low voltage solar technologies have been implemented in a wide variety of lighting applications. Street lights, security lights, solar garden lights and car park lamps can all be designed with small, built-in solar arrays producing a complete stand alone PV system. Exposed to the sun all day, these lights can retain their electrical charge to keep lit all night long. Electric road signs can take advantage of solar panels in the same way, although vital street and traffic signs on major roads and motorway‘s also have alternate sources of power as backup.

Important factors in having a standalone PV system

Solar panels only create electricity while the sun is shining on them so it may be necessary to store enough electricity to get through one or two days of cloudy weather. In this case solar electricity becomes a valuable resource, will not want to live without it, but will not want to waste it, either. Try reducing energy demand through energy efficient measures. Purchasing energy saving appliances and LED lights, for example, will reduce electrical demand and allow purchasing a smaller stand alone PV system to meet actual energy needs.

Energy efficiency allows starting small and then adding on as your energy needs increase. Secondly, while a standalone PV system is not a complicated system to install or run compared with other forms of off grid electrification devices, wind turbines, hydro-electric etc, solar PV systems still require regular maintenance that is not normally associated with standard grid connected mains power.

All the systems components have to be checked and cleaned on a regular basis to make sure that the system is running optimally and like many other off grid systems, PV systems require some basic electrical knowledge in order to be able to install and maintain them in an effective manner and to diagnose any problems so become an expert of system.

There are many advantages of a standalone PV system some include low maintenance, low upkeep cost, no waste or byproducts, and easy expansion by using multiple solar panels and batteries. The disadvantages include high initial investment, especially for the photovoltaicpanels and deep cycle lead acid batteries, reliance on the sun, and the possible danger from battery acid and fumes associated with most forms of renewable energy.