



## Research Paper

# Components of an Off-Grid Solar Power System

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## I. INTRODUCTION

A question that one frequently get is, “What do I need to put together for a SIMPLE Solar Power System?” This is a good question but is quite broad. In market solar electric systems, also known as photovoltaic systems are classified under two main types: **off-grid** or stand-alone and **grid-tie** or interconnected with the power distribution system. The off-grid solar system uses solar panels to charge a battery or a group of batteries. The energy stored in these batteries is further used to power one's lights and appliances. Grid-tie solar systems are the one which interacts with the utility grid and does not require the use of batteries for storage of energy.

In this article, we are writing about off-grid solar systems. More precisely, we are covering small and simple off-grid systems. These systems are not always small but they can get very complex. An example of a complex solar system with batteries is a remote communication tower facility or an island lighthouse.

### Off-Grid Power System

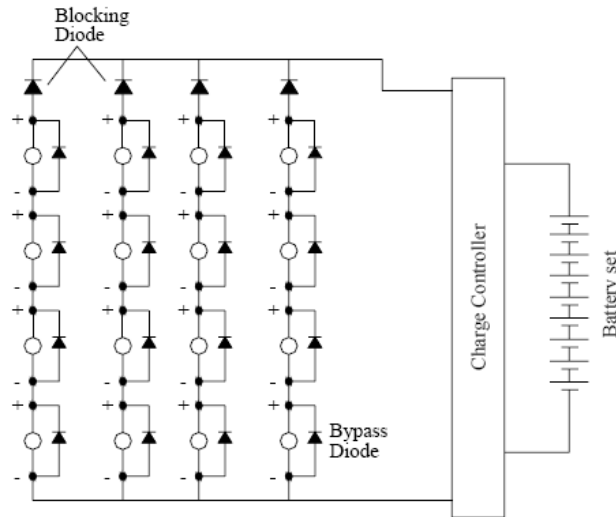
The type of off-grid solar system which we are reviewing here is a type of kit that one might use to illuminate the outdoor home lighting or street RVs. These solar systems operate at 12, 24, or 48 Volts DC and are usually composed of 1-3 solar panels, a charge controller, 1-4 batteries, and an inverter.

Following is how the type, size, and values of these these components are chosen.

Before Proceeding for assembling these components, one should note that It is important that the input and output voltage across the system components are consistent; meaning that if the Solar Power system operates at 12VDC, **all** of its components should be rated at 12V.

### Solar Panels: the source of power

A Solar Panel consists of numbers of Solar modules, connected in series and parallel configuration to provide a specific value of current and voltage. Which is used to charge the battery <sup>(2)</sup>. A Diode is connected at the positive terminals of these strings, called blocking diode. This diode permits the current to flow from solar modules to the battery while charging them (i.e. in the day time) but does not allow the flow of current back from the battery to the module while there is no sunlight falling on the module i.e. during the night or on a cloudy day ( figure 1).

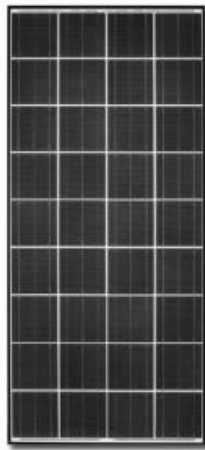


**Figure 1.** Schematic of a Typical Panel

Typically, low wattage solar panels come in 3 W to 130 W range and are rated as 12 or 24 volts. The use of these panels is advisable when one is charging a single battery or a small group of them.

If one is investing in a solar power system, even if it is small; It is recommended to start with a solar panel of about 40W. This recommendation is useful because any panel smaller than that will be able to charge batteries but the power stored will not be sufficient enough to keep the lights and electronics running.

A 60W panel supplies enough power to operate a pair of efficient lights at night and to charge a few electronic devices like mobile phones, electronic video cameras, etc during the day. If one is planning to use a solar power system for charging devices like laptops or running a small DC refrigerator, the suggested panel wattage is 85W onward. In case a single panel is not able to give enough power, additional panel ( in series or parallel depending on requirement) will give enough, for most of the power needs.



**FIGURE 2** KYOCERA 140W 12V SOLAR PANEL

Some Reputable 12V and 24V off-grid solar panel manufacturers in India are Tata Power, Vikram Solar, EMMVE, Moser Bear Solar, etc.

**Charge Controllers: Protecting the batteries**

The charge controller is the most inexpensive but useful component of the solar power system. It protects costly power storage batteries. It also gives an indication about the charging status of the batteries like undercharged, overcharged, or deep discharged; through the LED indicator. Some switches and MCBs may also be present on a high current charger for manual or accidental cut off of charging. It is worth mentioning it here that saving a few rupees on the charge controller is not good because this component is the one that will protect the costly batteries from permanent damage. Typical prices of charge controllers start under Rs 1000/- ( for a Street light system) to few thousand ( depending on capacity).



**Fig 3:** Front view of a typical Charge Controller

To select an appropriate Charge controller, the very first parameter of interest is the system's voltage (12, 24, or 48 Volts). One needs to select a controller as per his requirement of the operating voltage. Some controllers are having a feature called field-configurable voltage. These controllers allow one to select or change the operating voltage.

The next parameter to be careful about is the controller's capacity or the maximum charging current in Amps. For this one have to use the Short Circuit Current of the solar panel. Short Circuit Current, represented as  $I_s$ , is to be multiplied with 1.25 and the result is the maximum current that could come out of the solar panels. For example, if a 50W solar panel has an  $I_{sc}=3.23$ Amps, then multiply it with 1.25 gives a maximum of 4.04Amps. Thus, we have to use a charge controller of 15Amp in this system. If one is unsure about the future expanding requirement of the system, the one can consider another higher i.e. controller having 10Amp as maximum.

Some charge controllers have a feature of Low Voltage Disconnect (LVD), which means the load to the system will get disconnected as soon as the batteries reach a minimum low voltage. The LVD protects the batteries from damage, which may occur due to frequent charging-discharging of battery. The feature is also valuable when the system is accessed by multiple users and it becomes difficult to control the amount of energy drawn from the batteries per day.



**FIG 4** PHOCOS CML SOLID 12/24V CHARGE CONTROLLER

Some reputable manufacturers of small PWM charge controllers in India are Luminous, Microtek, Sukam, Smarten MPPT, etc.

### Energy Storage

12V Deep Cycle Batteries, Batteries or battery maintenance, etc., these are extensive subjects in themselves. For a simple solar system like the one we are describing in this article, one can use commercial 12V deep-cycle batteries or 12 Volts Li-ions / solid-state/dry batteries.

One can even search at places like Flipkart, Amazon, or any local renewable energy supplier. These batteries are of 12 Volts if it is 12 Volts system. In case one needs to increase the capacity of the energy storage, he/she can connect multiple batteries in parallel. A bank of more than four batteries is not advisable for a simple system. If the system requires to be running at 24 or 48 Volts, then one should connect pairs of batteries in series to reach the desired voltage.



**FIGURE 5 TROJAN 27TMX 12V DEEP CYCLE BATTERY**

Some reputable manufacturers of useful batteries in India are Exide, Amar raja, SuKam, HBL, etc. **Power**

#### **Inverter: Charging AC electronics**

Solar panels and batteries deliver energy in Direct Current (DC) mode but conventional outlets provide energy in Alternative Current (AC) mode. The inverter is the device that allows one to use the DC power stored in the batteries to run the conventional electronics, chargers, and appliances which run on AC power. In other words, invert converts DC power to Ac power. Even though one can find lights and appliances that run on DC which can run with Solar Power System directly but there can need to run AC appliances or electronics also.

Depending upon the technique used to design, these inverters are of three types a) Square Wave b) Modified Sine Wave c) Pure Sine Wave. It is advisable to use pure sine wave inverter.

Having a small inverter with a Solar Power system comes very handy. In most instances, a 200-400 Watt inverter can do the job.

Inverters draw power from the batteries even if they are idle. So, one should remember to turn them off after using them. Please note that if one uses motors and other devices that require more power to start ( Start Surge), then he/she shall use an inverter of 3-4 times bigger than the conventional requirement.



**FIGURE 6 SAMLEX PST 300W 12V PURE SINE WAVE INVERTER**

So reputable manufacturers of small DC/AC inverters in India are Microtek, RS Associates, S. R. Electronics, S.S Solar Energy, etc.

## **II. CONCLUSION**

In this article description of components/parts required for a typical off-grid Home Solar System or Street light system is given.

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