International Conference on Recent Trends in Engineering Science and Technology (ICRTEST 2017) ISSN: 2321-8169
Volume: 5 Issue: 1(*Special Issue 21-22 January 2017*) 136 - 138

Management of Energy In Stand-Alone based Solar PV System

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***Abstract*—**In this paper, roof top stand-alone solar photovoltaic system is considered. Solar photovoltaic system has so many components such as solar panel, charge controller, power conditioning unit, battery. Out of all these components solar power conditioning unit is also one important part of this system. In given system solar energy is use as primary source and supply from main line is use as an auxiliary source of energy. Power conditioning unit selects the power supply such as from solar or main smartly according to the different conditions. Therefore, power provided to the home does not get interrupted.

Keywords*—Solar Power Conditioning Unit, Solar Charge Controller, PWM, MPPT, Inverter*

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I. INTRODUCTION

Solar energy is the renewable source of energy and it is freely available on the surface of earth. There are so many energy sources such as coal, petroleum products, etc. but these are non-renewable sources and excessive use of these sources will cause energy crisis. Also, non-renewable energy sources responsible for various types of pollution such as air pollution, water pollution, soil pollution. Therefore, solar energy is better option to avoid all such problems. Power generated by using solar energy can be provided directly to grid which is called as grid connected solar PV power generation system.

Stand-alone solar PV power generation system is the system which is not connected to the grid. This system supply power to the load directly. If more power is require by the load then this system can be connected to the other power sources but PV must be the main source. The other sources in addition to the PV source are diesel generator, wind generator, etc.

PV system are designed and sized to meet a given load requirement. PV system sizing exercise involves the determination of size and capacity of various components, like PV panels, batteries, etc. The decision whether to choose a high quality expensive component or a low quality cheap component lies with the design engineer. In general, there is no unique design to meet a given set of specifications. It is important to think of all possible alternatives to provide the user with the best possible performance at lowest possible cost.

II. STAND-ALONE SOLAR PHOTOVOLTAIC SYSTEM

In stand-alone solar photovoltaic it includes following components:

A. Solar Panel

Parallel connecting solar panels gives higher current. And voltage will remain the same. By connecting Solar Panels in series connection. It will increase Voltage and current will remain the same. Solar panels can also be connected in series-parallel fashion to obtain desired current and voltage level.

For stand-alone solar photovoltaic power generation system, we can mount solar panel on roof top or at ground also. But one thing is very important to remember is deciding the right place for mounting the solar panel because generation of electricity is totally depend upon amount of solar radiation falls on solar module and it is very important that the shadow should not fall over the panel. After calculating the load we can decide the total number of panels required in the system and how much place will be required by the system.

The azimuth angle (β) specifies how many degrees the surface of the module or collector diverges from the exact south-facing direction. The tilt angle (α) specifies the divergence from the horizontal.

For fixed tilt angle throughout the year, the angle of the latitude is preferred. This is one fixed orientation where the panel almost always intercepts the greatest amount of solar radiation during the year. Angle of latitude for mounting solar panel is 19.95^0 N for Chandrapur. We may consider it below up to $(19.95 – 7)^0$ N but not more than 19.95^0 N.

For direction towards North, at 180^0 maximum power is obtain from solar panel for northern hemisphere. Because of lacking of proper place we can consider angle greater than or equal to 180^0 or less than or equal to 210^0 (i.e. South-West).

B. Array Junction Box

Array Junction Box is meant for combining all the incoming lines from the solar panel strings/arrays and deriving one common array output for the multiple array inputs. Array Box is a junction box which allows several photovoltaic strings (from 8 to 32) to be connected in parallel. The total DC power is then distributed to the photovoltaic inverter. It includes photovoltaic string protection, overvoltage protection and a DC output switch disconnector. They are well adapted for Power plants as well as for photovoltaic large buildings.

C. Solar Charge Controller

Solar charge controller is very important part of the solar photovoltaic power generation system. It saves battery from damaging. The electricity produced by the solar panel is in the form of DC and is used to charge batteries via a solar charge controller. Any DC appliances that are connected to the battery will need to be fused. A charge controller, or charge regulator

is basically a voltage and/or current regulator to keep batteries from overcharging. It regulates the voltage and current coming from the solar panels going to the battery. The two types of charge controllers most commonly used in today's solar power generating systems are pulse width modulation (PWM) and maximum power point tracking (MPPT). Both adjust charging rates depending on the battery's charge level to allow charging closer to the battery's maximum capacity as well as monitor battery temperature to prevent overheating.

D. Inverter

Inverter plays crucial role in this system because most of the loads are of AC type. An inverter's basic function is to invert the direct current (DC) output into alternating current (AC).

E. Battery

In stand-alone photovoltaic power systems, the electrical energy produced by the solar PV panels cannot always be used directly. Because, demand from the load does and solar panel capacity may not always equal. Also, electrical power usually needs to be available when the sun is not shining, it usually necessary to store electricity, hence battery banks are used.

III. SOLAR POWER CONDITIONING UNIT

Solar Power Conditioning Unit (PCU) is an integrated system consisting of a solar charge controller, inverter and a Grid charger. It provides the facility to charge the battery bank either through Solar or Grid/DG Set. The PCU continuously monitors the state of Battery Voltage, Solar Power output and the loads. Due to sustained usage of power, when the Battery Voltage falls below a preset level, the PCU will automatically transfer the load to the Grid/DG power and also charge the Batteries through the in-built Grid Charger. Once the Batteries are charged to the pre-set level, the PCU cuts off the Grid / DG power from the system and will restore to feeding the loads from the battery bank & continue to charge the battery bank from the available Solar power.

The PCU always gives preference to the Solar Power and will use Grid/DG power only when the Solar power/ Battery charge is insufficient to meet the load requirement. It's a Power Conditioning Unit (PCU) with special feature like pure sine wave output and more for using in remote areas, where utility line is weak and renewable Energy (RE) sources are available. The PCU is designed to convert energy from RE source as the first priority and to stream energy from grid line when energy from the RE source is lower than the set level.

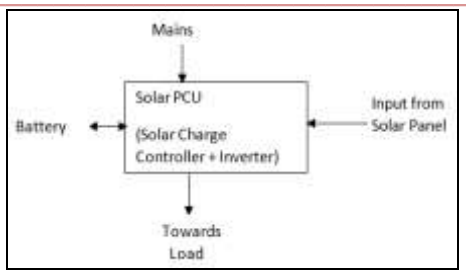

Fig. 1 : Solar PCU

A. Solar charge controller

Solar charge controller is very important part of the solar photovoltaic power generation system. It saves battery from damaging. The electricity produced by the solar panel is in the form of DC and is used to charge batteries via a solar charge controller. Any DC appliances that are connected to the battery will need to be fused. A charge controller, or charge regulator is basically a voltage and/or current regulator to keep batteries from overcharging. It regulates the voltage and current coming from the solar panels going to the battery. The two types of charge controllers most commonly used in today's solar power generating systems are pulse width modulation (PWM) and maximum power point tracking (MPPT). Both adjust charging rates depending on the battery's charge level to allow charging closer to the battery's maximum capacity as well as monitor battery temperature to prevent overheating.

(a) Pulse Width Modulation:

Pulse Width Modulation (PWM) is the most effective means to achieve constant voltage battery charging by switching the solar system controller's power devices. When in PWM regulation, the current from the solar array matches according to the battery's condition and recharging needs. It adjust charging rate depending on the battery's charge level to allow charging closer to the battery's maximum capacity as well as monitor battery temperature to prevent overheating.

(b) Maximum Power Point Tracking

The efficiency of a solar cell is very low and also when solar cells are connected together to form a panel then its efficiency is still not increased. In order to increase the efficiency (η) of solar cell or solar panel we have to use maximum power transfer theorem. The maximum power transfer theorem says that the maximum power is transfer when the output resistance of source matches with the load resistance i.e. solar cell or solar panel impedance. So all MPPT technique's principles are based on maximum power transfer theorem that always trying to matching the impedance of load to source.

The maximum power point tracking (MPPT) is now habitual in grid connected PV power generation system and it is becoming more popular in isolated or stand-alone power

generation systems as well because of the V-I characteristics in PV power generation systems is nonlinear, So it is difficult to supply a constant power to a certain load.

PWM	MPPT
1. Pulse Width Modulation	1. Maximum power point tracking
2. Up to 1.5 kVA PWM is use	2. Above 1.5 kVA MPPT is use
3. Less Cost	3. Costly
4. Efficiency is 80%	4. Efficiency is 98%
5. Mainly use in Polycrystalline solar cell	5. Mainly use in Mono-crystalline solar cell

Table 1: Comparison between PWM and MPPT

B. Inverter

Inverter plays crucial role in this system because most of the loads are of AC type. An inverter's basic function is to invert the direct current (DC) output into alternating current (AC).

In stand-alone photovoltaic power systems, the electrical energy produced by the photovoltaic panels cannot always be used directly. As the demand from the load does not always equal the solar panel capacity, also electrical power usually needs to be available when the sun is not shining, it usually necessary to store electricity, hence battery banks are used.

An electric battery is a device consisting of two or more electrochemical cells that convert stored chemical energy into electrical energy. Each cell has a positive terminal, or cathode, and a negative terminal, or anode. The terminal marked positive is at a higher electrical potential energy than is the terminal marked negative. The normal storage is the Lead-Acid battery. Lead–Acid batteries are widely used.

Operating Conditions of Solar PCU for 5kW power is given in following table:

Sr. No.	Output from Solar Panel (kW)	Battery	5kW Mains	Running Load (kW)	Condition
1.	4.5	Greater than 50%	Connected	4.5	Load run on power obtained from solar panel
2.	3.5	Greater than 50%	Connected	4.5	Load run on power obtained from solar panel + Battery
3.	4.5	Less than 50%	Connected	4.5	Battery get charged by using solar power + Load run on mains
4.	4.5	75%	Connected	3	Load run on power obtained from solar panel + rest solar power is use for battery charging
5.	3	100%	Connected	2	Load run on power obtained from solar panel + 1kW power get waste

Table 2: Operating Conditions of Solar PCU

IV. CONCLUSION

From this paper, energy management system in solar photovoltaic stand-alone power generation system is studied. This shows that if any interruption occurred in the system of solar power generation or if main supply gets interrupted in that situation how solar power conditioning unit will operate smartly. Hence, power will supply to home continuously.

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