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Review on Grid Connected Solar Photovoltaic Power System

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ABSTRACT

Solar power, without a doubt, is the cleanest energy in the world and is being used as a renewable energy since years ago. Residential that uses solar power as their alternative power supply will bring benefits to them. The main objective of this project is to survey and develop a solar system. The system tracks the maximum intensity of light. When the intensity of light is decreasing, this system MPPT tries higher output. This application generates the power only sunny days. Finally, the project is able to generate electrical units and the Sun intensity in order to get maximum power.

Keywords:- Inverters, hybrid topologies, CHB, THD, phase shift pulse width modulation, PWM, sinusoidal pulse width modulation, Solar System, Renewable Energy, Solar power, Boost converter, Solar panel, MPPT.

INTRODUCTION

The use of renewable energy, such as solar energy, experienced a great impulse during the second half of the seventies just after the first big oil crisis. At that time economic issues were the most important factors and the interest in these types of processes decreased when the oil prices fell. There is a renewed interest in the use of renewable energies nowadays driven by the need of reducing the high environmental impact produced by the use of fossil energy systems. The most abundant, sustainable source of energy is the Sun, which provides over 150,000 terawatts of power to the Earth; about half of that energy reaches the Earth surface while the other half gets reflected to outer space by the atmosphere. Only a small fraction of the available solar energy reaching the Earth surface would be enough to satisfy the global expected energy demand. Although most renewable energies derive their energy from the sun, by solar energy we refer to the direct use of solar radiation. One of the greatest scientific and technological opportunities we are facing is to develop efficient ways to collect, convert, store, and utilize solar energy at affordable costs. There are two main drawbacks of solar energy systems:

a) The resulting energy costs are not yet competitive and

b) Solar energy is not always available when needed.

Considerable research efforts are being devoted to techniques which may help to overcome these drawbacks; control is one of those techniques. While in other power generating processes, the main source of energy (the fuel) can be manipulated as it is used as the main control variable, in solar energy systems, the main source of power which is solar radiation cannot be manipulated (Camacho et al. (1997)) and furthermore it changes in a seasonal and on a daily base acting as a disturbance when considering it from a control point of view. Solar plants have all the characteristics needed for using advanced control strategies able to cope with changing dynamics, (nonlinearities and uncertainties). As fixed PID controllers cannot cope with some of the mentioned problems, they have to be detuned with low gain, producing sluggish responses or if they are tightly tuned they may produce high oscillations when the dynamics of the process vary, due to environmental and/or operating conditions changes. The use of more efficient control strategies resulting in better responses would increase the number of operational hours of the solar plants and thus reduce the cost per kw-h produced. This paper describes the main solar energy plants and the control problems involved and how control systems can help in increasing their efficiency.

II SOLAR ENERGY

Solar powered electrical generation can be done either directly, by the use of photovoltaic (PV) cells or indirectly by collecting and concentrating the solar power (CSP) to produced steam which is then used to drive a turbine to provide the electrical power. The direct generation of electricity from solar energy is based on the photovoltaic effect which refers to the fact photons of light knock electrons into a higher state of energy. Although the first application of photovoltaic's was to power spacecrafts, there are many PV power generation for everyday life applications such as grid isolated houses, boats, pumps for water extraction, electric cars, roadside emergency telephones and remote sensing.

Concentrating solar thermal (CST) systems use optical devices (usually mirrors) and sun tracking systems to concentrate a large area of sunlight into a smaller receiving area. The concentrated solar energy is then used as a heat source for a conventional power plant. A wide range of concentrating technologies exist. The main concentrating concepts are: a) parabolic troughs, b) solar dishes, c) linear Fresnels, and d) solar power towers. The main purpose of the concentrating solar energy is to produce high temperatures and therefore high thermodynamic efficiencies.

1. Irradiation – as mentioned, data from different sources has been analyzed and the source identified based on the accuracy perception for the present study.

2. Performance ratio – it is observed that performance ratio depends on the irradiation, the optimum angle of tilt, air temperature, design parameters, quality of modules, efficiency of inverter etc. The results have been obtained based on the above parameters using RETScreen software. The results have been compared with some data available on the recently installed grid connected power plants in India.

3. Degradation – All manufacturers stand a guarantee of performance over a period of 25 years with 90% output for first 12 years and up to 80% after 25 years of operation. Various studies carried out by global renowned institutions on the extent of degradation of output of modules after long term operation in field. These results are analyzed to arrive at the actual field performance.

4. Life expectancy – Trends in the accelerated tests for modules, inverters, supporting structure and cabling have been studied.

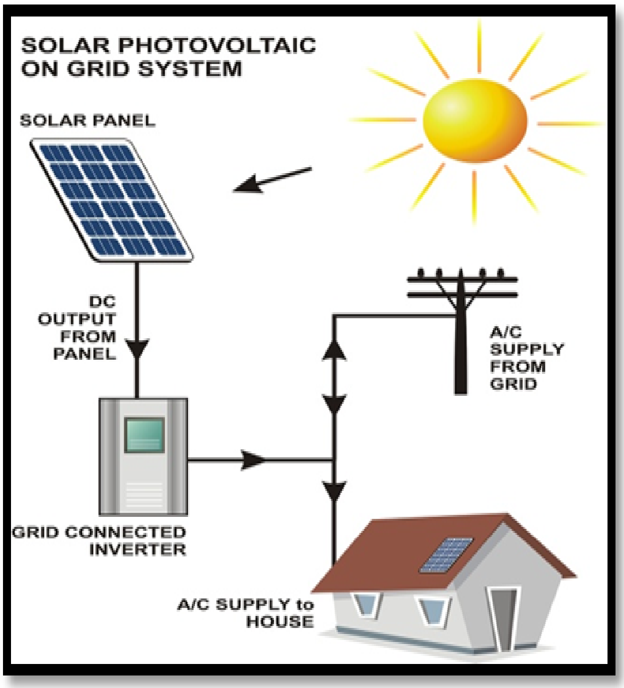

Fig 1: Solar power System.

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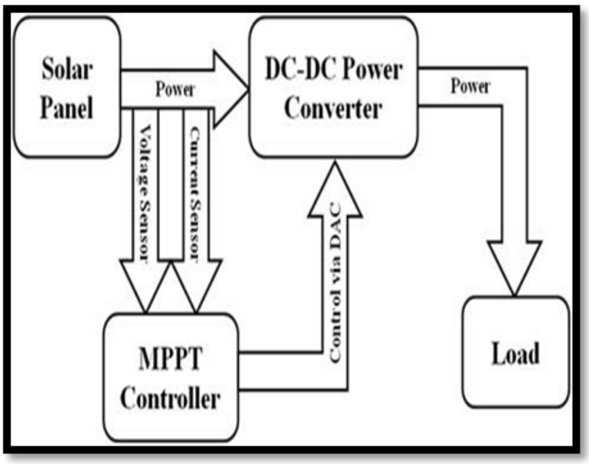

Fig 2: Block of control circuitry

III TECHNOLOGY FOR SOLAR POWER PLANTS

Solar power generation technologies can be broadly classified into two broad categories:

I. Solar Photovoltaic technologies
II. Solar thermal power plants

Solar Photovoltaic (SPV) technologies

Photovoltaic converters are semiconductor devices that convert part of the incident solar radiation directly into electrical energy. The most common PV cells are made from single crystal silicon but there are many variations in cell material, design and methods of manufacture. Solar PV cells are available as crystalline silicon, amorphous silicon cells such as Cadmium Telluride (Cd-Te), Copper Indium diselenide, and copper indium gallium diselenide (CIGS), dye sensitised solar cells DSSC and other newer technologies such as silicon nano particle ink, carbon nanotube CNT and quantum dots.

Table.1.Solar Module effeciency

S.No	Module	Efficiency
1	Thin film	12-14%
2	Polycrystalline	15-16%
3	Monocrystalline	16-18%

I. Performance of solar power plants

The performance of solar power plants is best defined by the Capacity Utilization Factor (CUF) , which is the ratio of the actual electricity output from the plant, to the maximum possible output during the year. The estimated output from the solar power plant depends on the design parameters and can be calculated, using standard software's. But since there are several variables which contribute to the final output from a plant, the CUF varies over a wide range. These could be on account of poor selection /quality of panels, derating of modules at higher temperatures, other design parameters like ohmic loss, atmospheric factors such as prolonged cloud cover and mist. It is essential therefore to list the various factors that contribute to plant output variation. The performance of the power plant however depends on several parameters including the site location, solar insolation levels, climatic conditions specially temperature, technical losses in cabling, module mismatch , soiling losses, MPPT losses, transformer losses and the inverter losses. There could also be losses due to grid unavailability and the module degradation through aging.

Some of these are specified by the manufacturer, such as the dependence of power output on temperature, known as temperature coefficient. The following factors are considered key performance indicators:

a) Radiation at the site
b) Losses in PV systems
c) Temperature and climatic conditions
d) Design parameters of the plant
e) Inverter efficiency
f) Module Degradation due to aging

a) Solar radiation basics and definition

Solar radiation is a primary driver for many physical, chemical and biological processes on the earth's surface, and complete and accurate solar radiation data at a specific region are of considerable significance for such research and application fields as architecture, industry, agriculture, environment, hydrology, agrology, meteorology, limnology, oceanography and ecology. Besides, solar radiation data are a fundamental input for solar energy applications such as photovoltaic systems for electricity

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generation, solar collectors for heating, solar air conditioning climate control in buildings and passive solar devices [3]. Several empirical formulae have been developed to calculate the solar radiation using various parameters. Some works used the sunshine duration others used the sunshine duration, relative humidity and temperature, while others used the number of rainy days, sunshine hours and a factor that depends on latitude and altitude. The primary requirement for the design of any solar power project is accurate solar radiation data. It is essential to know the method used for measuring data for accurate design. Data may be instantaneously measured (irradiance) or integrated over a period of time (irradiation) usually one hour or day. Data maybe for beam, diffuse or total radiation, and for a horizontal or inclined surface. It is also important to know the types of measuring instruments used for this measurements.

b) Losses in PV Solar systems

The estimated system losses are all the losses in the system, which cause the power actually delivered to the electricity grid to be lower than the power produced by the PV modules. There are several causes for this loss, such as losses in cables, power inverters, dirt (sometimes snow) on the modules, ambient temperature, varying insolation levels and so on. While designing a PV system, we have to take into consideration all possible losses.

c) Reflection losses

PV module power ratings are determined at standard test conditions, which require perpendicular incident light. Under field conditions larger incidence angles occur, resulting in higher reflection losses than accounted for in the nominal power rating. Calculations show that for modules faced towards the equator, and with a tilt angle equal to the latitude, yearly reflection losses relative to STC are about 1%.

d) Soiling

Soiling of solar panels can occur as a result of dust and dirt accumulation. In most cases, the material is washed off the panel surface by rainfall; however dirt like bird droppings may stay even after heavy rains. The most critical part of a module is the lower edge. Especially with rather low inclinations, soiling at the edge of the frame occurs. By often repeated water collection in the shallow puddle between frame and glass and consecutive evaporation dirt accumulates. Once it causes shading of the cells, this dirt reduces the available power from a module. The losses are generally 1%, however the power is restored if the modules are cleaned.

e) Mismatch effects

Mismatch losses are caused by the interconnection of solar modules in series and parallel . The modules which do not have identical properties or which experience different conditions from one another. Mismatch losses are a serious problem in PV modules and arrays because the output of the entire PV array under worst case conditions is determined by the solar module with the lowest output. Therefore the selection of modules becomes quite important in overall performance of the plant.

f) Maximum Power Point Tracking (MPPT)

Power output of a Solar PV module changes with change in direction of sun, changes in solar insolation level and with varying temperature. The PV(power vs. voltage) curve of the module there is a single maxima of power. That is there exists a peak power corresponding to a particular voltage and current. Since the module efficiency is low it is desirable to operate the module at the peak power point so that the maximum power can be delivered to the load under varying temperature and insolation conditions. Hence maximization of power improves the utilization of the solar PV module. A maximum power point tracker (MPPT) is used for extracting the maximum power from the solar pv module and transferring that power to the load. A dc/dc converter(step up/step down) serves the purpose of transferring maximum power from the solar PV module to the load. Maximum power point tracking is used to ensure that the panel output is always achieved at the maximum power point. Using MPPT significantly increases the output from the solar power plant. As depicted in the V-I curves for the monocrystalline solar module below, the maximum power point is achieved at the intersection of the current and voltage curves at a particular value of irradiation.

There are losses in the cabling, transformer, inverter and transmission systems, which are easy to determine in most cases.

g) Inverter efficiency

A solar PV inverter is a type of electrical inverter that is made to change the direct current (DC) electricity from a photovoltaic array into alternating current (AC) for use with home appliances or to be fed into the utility grid. These inverters may be stand alone inverters, which are used in isolated systems, or grid tie inverters which are used to connect the power plant to the grid.

The efficiency of an inverter has to do with how well it converts the DC voltage into AC. The currently available grid connected inverters have efficiencies of 96 to 98.5%, and hence choosing the correct inverter is crucial to the design process. There are less efficient inverters below 95% also available. Inverters are also much less efficient when used at the low end of their maximum power. Most inverters are most efficient in the 30% to 90% power range.

IV CONCLUSION

One of the great technological challenges of our times is to produce solar energy at affordable costs. Control is one of the enabling technologies to achieve this objective. This paper has shown what are the main control problems found in controlling solar power systems.

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