A Comparative Analysis of Solar Based MPPT Systems with Various Domestic Applications

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Abstract- Energy, especially alternative source of energy is vital for the development of a country. In future, the world anticipates developing more of its solar resource potential as an alternative energy source to overcome the persistent shortages and unreliability of power supply. In order to maximize the power output the system parts of the electrical phenomenon system ought to be optimized. For the improvement most wall socket following (MPPT) could be a Promising technique that grid tie inverters, solar array chargers and similar devices use to induce the most potential power from one or additional star panels. Among the various strategies accustomed track the most wall socket, Perturb and Observe technique could be a kind of strategy to optimize the ability output of an array. during this technique, the controller adjusts the voltage by alittle quantity from the array and measures power, if the ability will increase, more changes in this direction area unit tried till power now not will increase. during this analysis paper the system performance is optimized by perturbs and observes technique exploitation buck boost device. By varied the duty cycle of the buck boost device, the supply electrical phenomenon may be matched to regulate the load electrical phenomenon to boost the potency of the system. The Performance has been studied by the MATLAB/Simulink.

Keywords- Maximum power point tracking, Photovoltaic system**,** Buck boost converter, Perturb and Observe method, Direct current, Photovoltaic Panel.

I. INTRODUCTION

The extensive use of DC power supplies inside most of electrical and electronic appliances leads to an increasing demand for power supplies that draw current with low harmonic content and also have power factor close to unity. DC power supplies are extensively used in computers, audio sets, televisions and others. The presence of nonlinear loads results in low power factor operation of the power system. The basic block in many power electronic converters are uncontrolled diode bridge rectifiers with capacitive filter. Due to the non-linear nature of bridge rectifiers, non-sinusoidal current is drawn from the utility and harmonics are injected into the utility lines. The bridge rectifiers contribute to high THD, low PF and low efficiency to the power system. These harmonic currents cause several problems such as voltage distortion, heating and noises which result in reduced efficiency of the power system. Due to this fact, there is a need for power supplies that draw current with low harmonic content and also have power factor close to unity [1].

The AC mains utility offer ideally is meant to be free from high voltage spikes and current harmonics. Discontinuous input current that exists on the AC mains thanks to the non-linearity of the rectification method ought to be formed to follow the curving style of the input voltage. the traditional input stage for single section power provides operates by rectifying the ac line voltage and filtering with massive electrolytic capacitors [2].

This process results in a distorted input current waveform with large harmonic content. As a result, the power factor becomes very poor (around 0.6). The reduction of input current harmonics and operation at high power factor (close to unity) are important requirements for good power supplies. Power factor correction techniques are of two types: passive and active power factor correction. While, passive power factor correction techniques are the best choice for low power, cost sensitive applications, the active power factor correction techniques are used in majority of the applications due to their superior performance [3].

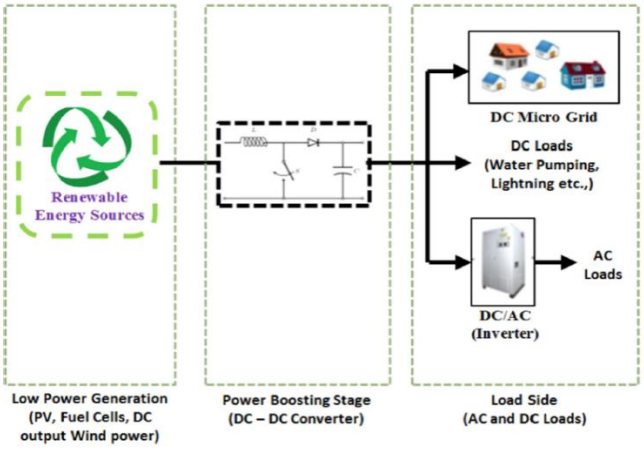

Fig.1: typical renewable energy system with DC–DC converter.

Demand for electric power keeps on increasing nowadays; hence, the world is switching over to the field of renewable energy sources as it is pollution-free, free of cost, and easy to access in remote areas.

A DC/DC convertor is category of power offer that converts a supply of electricity (DC) from one voltage level to a different. There are 2 forms of DC/DC converters: linear and switched. A linear DC/DC convertor uses a resistive free fall to form and regulate a given output voltage, a switched-mode DC/DC converts by storing the input energy sporadically and so emotional that energy to the output at a distinct voltage. The storage will be in either a force field element like associate degree inductance or a electrical device, or in an electrical field element like a condenser. Transformer-based converters give isolation between the input and also the output.

Switch mode converters offer three main advantages:

- The power conversion efficiency is much higher.
- Because the switching frequency is higher, the passive components are smaller and lower losses simplify thermal management.
- The energy stored by an inductor in a switching regulator can be transformed to output voltages that can be smaller than the input (step-down or buck), greater than the input (boost), or buck-boost with reverse polarity (inverter).

Unlike a switching converter, a linear converter can only generate a voltage that is lower than the input voltage. While there are many advantages, there are also some disadvantages with switching DC/DC converters. They are noisy as compared to a linear circuit and require energy management in the form of a control loop. Fortunately, modern switching-mode controller chips make the control task easy.

Utility Interactive Applications: In utility interactive (or grid-connected) PV systems, PV modules are connected to inverters that convert the DC produced by the PV modules to AC. This electricity can then power household appliances or can be sold directly to the grid. As a building receives this energy, it is distributed to appliances and lighting, or other devices where needed. Since PV systems are restricted to function only exposed to the sun, a backup system is frequently required to ensure continuous supply of electricity irrespective of the weather conditions. These systems are most commonly used in houses or commercial buildings to offset electricity cost. A well designed PV system with a proper storage facility can be an attractive prospect for displacing power during the peak hours.

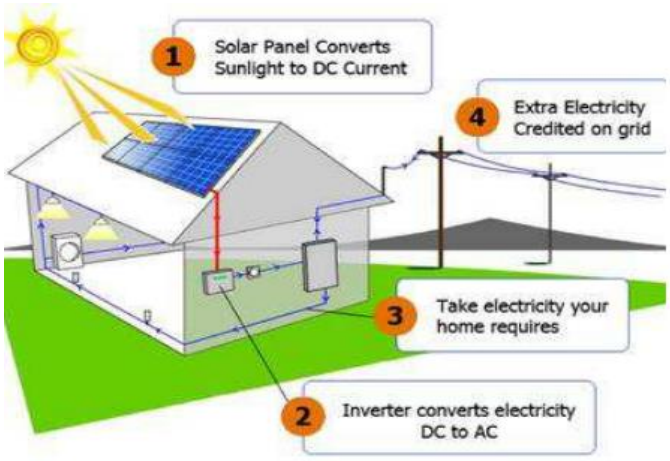

Fig.2: Schematics of utility interactive applications.

II. SOLAR ENERGY DOMESTIC APPLICATIONS

Homeowners are increasingly looking to solar power to make their homes more efficient. Unlike the majority of energy produced in the India. by coal, oil and natural gas, solar power is renewable and nonpolluting energy source. Additionally, it can provide personal and national energy security as it eliminates or cuts down your energy bills and reduces India dependence on imported fuels. Harnessing solar power to light and heat your home isn't just a matter of installing a few solar panels on the roof top it can mean upgrading your hot-water heating system or applying green building design principles to new homes or remodels.

Fig.3: Solar powered refrigerator.

(a) Solar Water Heating:

A solar water heating unit comprises a blackened flat plate metal collector with an associated metal tubing facing the general direction of the sun. The plate collector has a transparent glass cover above and a layer of thermal insulation beneath it.

(b) Solar Heating of Buildings:

Solar energy can be used for space heating of buildings in many ways namely:

(a) Collecting the solar radiation by some element of the building itself i.e. solar energy is admitted directly into the building through large South-facing windows.

(b) Using separate solar collectors which may heat either water or air or storage devices which can accumulate the collected solar energy for use at night and during inclement days.

When the building requires heat then from these collectors or storage devices, the heat is transferred by conventional equipment such as fan, ducts, air outlets, radiators and hot air registers etc. to warm up the living spaces of a building.

(c) Solar-distillation:

In arid semi and or coastal areas there is scarcity of potable water. The abundant sunlight in these areas can be used for converting saline water into potable distilled water by the method of solar distillation. In this method, solar radiation is admitted through a transparent air tight glass cover into a shallow blackened basin containing saline water.

Solar radiation passes through the covers and is absorbed and converted into heat in the blackened surface causing the water to evaporate from the brine (impure saline water). The vapors produced get condensed to form purified water in the cool interior of the roof.

(d) Solar-pumping:

In solar pumping, the power generated by solar-energy is utilized for pumping water for irrigation purposes. The requirement for water pumping is greatest in the hot summer months which coincide with the increased solar radiations during this period and so this method is most appropriate for irrigation purpose. During periods of inclement weather when solar radiations are low then the requirement for water pumping is also relatively less as the transpiration losses from the crops are also low.

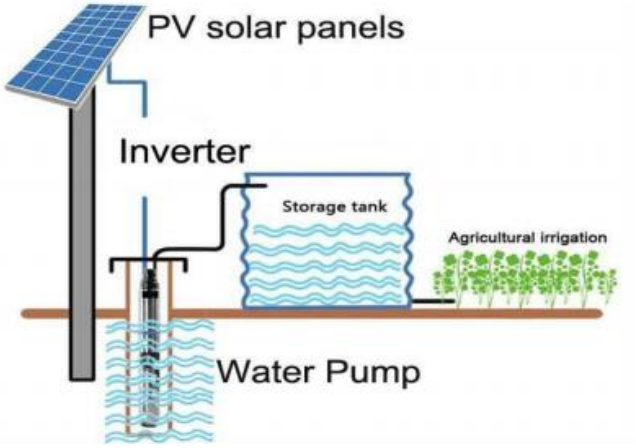

Fig.4: solar water pumps can be very cost effective for remote agricultural activities

(e) Solar Drying of Agricultural and Animal Products:

This is a traditional method of utilising solar energy for drying of agricultural and animal products. Agricultural products are dried in a simple cabinet dryer which consists of a box insulated at the base, painted black on the inner side and covered with an inclined transparent sheet of glass.

(f) Solar Furnaces:

In a Solar furnace, high temperature is obtained by concentrating the solar radiations onto a specimen using a number of heliostats (turn-able mirrors) arranged on a sloping surface. The solar furnace is used for studying the properties of ceramics at extremely high temperatures above the range measurable in laboratories with flames and electric currents.

(g) Solar Cooking:

A variety of fuel like coal, kerosene, cooking gas, firewood, dung cakes and agricultural wastes are used for cooking purposes. Due to the energy crisis, supply of these fuels are either deteriorating (wood, coal, kerosene, cooking gas) or are too precious to be wasted for cooking purposes (cow dung can be better used as manure for improving soil fertility). This necessitated the use of solar energy for cooking purposes and the development of solar cookers. A simple solar cooker is the flat plate box type solar cooke.

(h)Consumer Products:

PV technology is being used for variety of commercially available consumer based products. Small DC appliances such as toys, watches, calculators, radios, televisions, flashlights, fans etc. can operate with PV based energy systems.

Fig.5: Solar powered calculator and radio.

(i) Charging Vehicle Batteries:

Vehicles running on electric power can be charged at PV powered stations. Such vehicles can also maintain their critical battery states using PV powered sources. Boats and other leisure vehicles can be charged directly using PV systems.

Fig.6:Electric vehicles at PV charging station.

III. RESEARCH STRATEGY

This study is carried out in a descriptive, exploratory and explanatory way to provide in-depth insight due to the exploratory nature of the research. It is important to note that this thesis is not focusing on any specific policy tool designed to promote adoption of renewable energy or solar PV system in Nigeria. As Ijeoma-VicentAkpu (2012) noted the shortage of sound government policies as a hindrance to the expansion of renewable energy. Rather this thesis focuses on a large vary of things that affects customers' call to adopt star PV system. These factors might directly, indirectly or not in any respect relate to renewable energy technologies as an example the price of protozoal infection on households might not be directly associated with star PV system, however it economically saps cash away bearing in mind the massive price of feat a solar battery. Examining totally different aspects of the context as an entire is aimed toward enhancing the understanding of this condition of solar power technologies, thereby exposing the loop holes militating against the event of star technologies in Federal Republic of Nigeria and suggests bound actions to encourage growth of star technologies. There exist many literatures bearing on the adoption and barriers of renewable technologies and star PV systems in terms of what the govt. has done or ought to do and in terms of what the purchasers or potential adopters needs the govt. to try and do. However, solely few have incorporated the read or opinion of the importers and suppliers of those star merchandise. Considering this gap, this work will be seen associate exploratory thesis.

In designing a research methodology, a preliminary literature survey was carried out at the outset. Such review provided useful knowledge. However the nature of this thesis requires further investigation and interview to obtain data and proper understanding of diffusion factors within the local context. It was recognized that to comprehensively understand the process of making a decision, the decision-makers has to be engaged. As Painuly (2001) argues that perspective of stakeholders are important because they are directly involved with the studied system and they could help provide better explanation of intricate issues.

Approach	Literature survey	Data collection	Data collection
Source of data	Journals, academic literatures and non-academic literatures	Suppliers/importers of solar PV systems	Organisational consumers and home owners
Method	Literature review	Loosely structured and in-depth interview	Loosely structured interview and in-depth interview
Output	Identification of factors which potentially influences consumers decision to adopt solar PV system	Identification of factors affection importers and suppliers of solar PV system	Identification of factors influencing adoption of solar PV system among home owners and organisations

IV. STRUCTUTRE OF PHOTOVOLTAIC CELL

The principle of the photovoltaic effect is simple: The ray of light, assimilated to photons, passes through the top layer (N doped) of the photovoltaic cell. Then, electrons capture the photons' energy and help them to cross the potential barrier of the PN junction, which generates current. So there is a strong relation between the solar irradiance and the amplitude of the generated current, as in (1). As the solar cells characteristic is close to a semiconductor diode, a classical model can be found in literature [5].

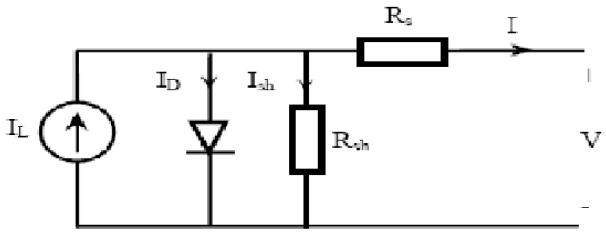

Fig.7: Diode principle circuit.

A or **converter** or **RES inverter**, converts the variable direct current (DC) output of a into a utility frequency alternating current (AC) that can be fed into a commercial electrical grid or used by a local, off-grid electrical network. It is a critical balance of system (BOS)–component in

a photovoltaic system, allowing the use of ordinary AC-powered equipment. Solar power inverters have special functions adapted for use with photovoltaic arrays, including maximum power point tracking and anti-islanding protection.

One of the most important parts in system architecture is the power converters. The reason is that they play an important role in transforming the different types of electricity, to make the electricity convenient to the end users. Since the solar cell produces a DC type of electricity, there's room for various types of power converters. Here, some of the most commonly used power converter types are briefly describe according to their topology, function, efficiency, and the major global manufacturers.

1. **Power optimizer:** Commonly known as a DC-DC power optimizer in solar markets, a power optimizer is a module-level power converter. It takes DC input from the solar module and gives either higher or lower DC output voltage. Such a converter is equipped with an MPPT technology to optimize the power conversion from the solar panel to the DC load or a battery or central inverter. It is also considered one of the most efficient power converters, delivering up to 99.5% efficiency. However, it needs DC cabling from the array. Some of the major players in this power converter market are Solar Edge and Tigo Energy.

2. **Module inverter/micro-inverter:** This is also a module-level power converter. It takes DC input from the solar module and converts it into AC electricity, which is then ready to be connected to the load or single-phase main grid or to a central inverter. It is also equipped with MPPT technology to detect the maximum power point of each module. Even though it doesn't requires any DC cabling, it is more expensive than the power optimizer due to its advanced.

3. **String inverter**: As an extension of a module-level power converter is the string inverter, which is suitable for a string or parallel strings of modules connected in series. Such a power converter is used for small RES systems up to 10 kW in capacity and are usually connected to the main grid. The output of such a power converter is 3 phase lines which are ready to be connected to a low voltage main grid. Even though it is incorporated with MPPT technology, due to the connection of a large RES array, it has a global maximum power point (MPP) which then degrades the efficiency of the RES system.

4. **Central inverter:** In large RES power plants (10 kW and higher), central inverters are used instead of string inverters. However, the central inverters' functionality remains the same (i.e, to produce a 3-phase high voltage output for grid integration), which is why this power converter is considered essential for connecting with the main grid. In many large RES power plants, central inverters are inevitable. But there are many losses within the RES system due to their large and complex configuration. However, to mitigate such losses, some of the manufacturers, like Siemens, have developed a master-slave arrangement, such that at low irradiance the system efficiency will increase.

Maximum power point tracking (**MPPT**) or sometimes just **power point tracking** (**PPT**)) is a technique used commonly with wind turbines and photovoltaic (PV) solar systems to maximize power extraction under all conditions.

Although solar power is mainly covered, the principle applies generally to sources with variable power: for example, optical power transmission and thermophotovoltaics.

PV solar systems exist in many different configurations with regard to their relationship to inverter systems, external grids, battery banks, or other electrical loads.[5] Regardless of the ultimate destination of the solar power, though, the central problem addressed by MPPT is that the efficiency of power transfer from the solar cell depends on both the amount of sunlight falling on the solar panels and the electrical characteristics of the load. As the amount of sunlight varies, the load characteristic that gives the highest power transfer efficiency changes, so that the efficiency of the system is optimized when the load characteristic changes to keep the power transfer at highest efficiency. This load characteristic is called the *maximum power point* (MPP) and MPPT is the process of finding this point and keeping the load characteristic there. Electrical circuits can be designed to present arbitrary loads to the photovoltaic cells and then convert the voltage, current, or frequency to suit other devices or systems, and MPPT solves the problem of choosing the best load to be presented to the cells in order to get the most usable power out.

Solar cells have a complex relationship between temperature and total resistance that produces a non-linear output efficiency which can be analyzed based on the I-V curve. It is the purpose of the MPPT system to sample the output of the PV cells and apply the proper resistance (load) to obtain maximum power for any given environmental conditions. MPPT devices are typically integrated into an electric power converter system that provides voltage or current conversion, filtering, and regulation for driving various loads, including power grids, batteries, or motors.

- Solar inverters convert the DC power to AC power and may incorporate MPPT: such inverters sample the output power (I-V curve) from the solar modules and apply the proper resistance (load) so as to obtain maximum power.
- The power at the MPP (P_{mpp}) is the product of the MPP voltage (V_{mpp}) and MPP current (I_{mpp}).

Perturb and observe

In this method the controller adjusts the voltage by a small amount from the array and measures power; if the power increases, further adjustments in that direction are tried until power no longer increases. This is called the perturb and observe method and is most common, although this method

can result in oscillations of power output. It is referred to as a hill climbing method, because it depends on the rise of the curve of power against voltage below the maximum power point, and the fall above that point.[15] Perturb and observe is the most commonly used MPPT method due to its ease of implementation. Perturb and observe method may result in top-level efficiency, provided that a proper predictive and adaptive hill climbing strategy is adopted.

V. PREVIOS RESULT AND SIMULATION

The PV cell temperature is maintained constant at 25 degree Celsius and the solar intensity is varied in steps up to the rated value of 1200W/meter square. That the current slightly increase with increasing intensity thereby increasing the power output of the solar cell.

VI. CONCLUSION

The huge amount of research that has been carried over the past decade has led to an increased interest in implementing PV systems to satisfy energy needs. PV systems can be mounted directly to the building structure instead of putting on separate support structures, thus reducing space requirements. PV systems are available on flexible modules and can be mounted on almost every surface to harness solar energy. Finally, we should mention that, with the advance of technology, transparent and wearable PV systems are not far.

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