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Original Research Paper

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PERTURB AND OBSERVE ALGORITHM BASED SOLAR TRACKER

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ABSTRACT Energy is absolutely essential for our life and demand has greatly increased worldwide in recent years. The research efforts in moving towards renewable energy can solve these issues. Compared to conventional fossil fuel energy sources, renewable energy sources have the following major advantages they are sustainable, never going to run out, free and non-polluting. Renewable energy is the energy generated from renewable natural resources such as solar irradiation, wind, tides, wave, etc. Amongst them, solar energy is becoming more popular in a variety of applications relating to heat, light and electricity. It is particularly attractive because of its abundance, renewability, cleanliness and its environmentally-friendly nature.

KEYWORDS : cascaded multilevel inverter, switches, total harmonic distortion.

I. INTRODUCTION

Solar energy is one of the most important renewable energy sources that have been gaining increased attention in recent years. Solar energy is plentiful; it has the greatest availability compared to other energy sources. The amount of energy supplied to the earth in one day by the sun is sufficient to power the total energy needs of the earth for one year.

Solar energy is clean and free of emissions, since it does not produce pollutants or by-products harmful to nature. The conversion of solar energy into electrical energy has many application fields. India has tremendous scope of generating solar energy. The geographical location of the country stands to its benefit for generating solar energy.

The reason being India is a tropical country and it receives solar radiation almost throughout the year, which amounts to 3,000 hours of sunshine. This is equal to more than 5,000 trillion kWh.

Almost all parts of India receive 4-7 kWh of solar radiation per sq meters. This is equivalent to 2,300–3,200 sunshine hours per year. States like Andhra Pradesh, Bihar, Gujarat, Haryana, Madhya Pradesh, Maharashtra, Orissa, Punjab, Rajasthan, and West Bengal have great potential for tapping solar energy due to their location. Since majority of the population lives in rural areas, there is much scope for solar energy being promoted in these areas.

One of the important technologies of solar energy is photovoltaic (PV) technology which converts irradiation directly to electricity by the PV effect Solar to electrical energy conversion can be done in two ways: solar thermal and solar photovoltaic. Solar thermal is similar to conventional AC electricity generation by steam turbine excepting that instead of fossil fuel; Heat extracted from concentrated solar ray is used to produce steam and apart is stored in thermally insulated tanks for using during intermittency of sunshine or night time. Solar photovoltaic use cells made of silicon or certain types of semiconductor materials which convert the light energy absorbed from incident sunshine into DC electricity. To make up for intermittency and night time storage of the generated electricity into battery is needed.

Recently, research and development of low cost flat-panel solar panels, thin-film devices, concentrator systems, and many innovative concepts have increased. In the near future, the costs of small solar-power modular units and solar-power plants will be economically feasible for large-scale production and use of solar Energy.

II. Solar Power System

Photo Voltaic Modules

A PV or solar cell is the basic building block of a PV (or solar electric) system. An individual PV cell is usually quite small, typically producing about 1 or 2W of power. To boost the power output of PV cells, they have to be connected together to form larger units called modules. The modules, in turn, can be connected to form larger units called arrays, which can be interconnected to produce more power. By connecting the cells or modules in series, the output voltage can be increased. On the other hand, the output current can reach higher values by connecting the cells or modules in parallel.

MPPT Algorithm:

A maximum power point tracker is an electronic DC-DC converter that optimizes the match between PV arrays and the battery bank or utility grid. MPPT is algorithm that included in charge controller for extracting maximum available power from PV array. Maximum Power Point Tracking (MPPT) is used to obtain the maximum power from these systems. In these applications, the load can demand more power than the PV system can deliver. There are many different approaches to maximizing the power from a PV system, this range from using simple voltage relationships to more complexes multiple sample based analysis.

- Perturb and observe
- Incremental conductance
- Current sweep
- Constant voltage

Perturb And Observe Method:

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 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.

CPV MODULES

The optics in CPV modules accept the direct component of the incoming light and therefore must be oriented appropriately to maximize the energy collected. In low concentration applications a portion of the diffuse light from the sky can also be captured. The tracking functionality in CPV modules is used to orient the optics such that the incoming light is focused to a photovoltaic collector.CPV modules that concentrate in one dimension must be tracked normal to the Sun in one axis. CPV modules that concentrate in two dimensions must be tracked normal to the Sun in two axes.

Accuracy requirements

The physics behind CPV optics requires that tracking accuracy increase as the systems concentration ratio increases. However, for a given concentration, no imaging optics provides the widest possible acceptance angles, which may be used to reduce tracking accuracy. In typical high concentration systems tracking accuracy must be in the ± 0.1° range to deliver approximately 90% of the rated power output. In low concentration systems, tracking accuracy must be in the ± 2.0° range to deliver 90% of the rated power output. As a result, high accuracy tracking systems are typical.

Technologies supported

Concentrated photovoltaic trackers are used with refractive and reflective based concentrator systems. There is a range of emerging photovoltaic cell technologies used in these systems. These range from conventional, crystalline silicon-based photovoltaic receivers togermanium-based triple junction receivers.

Single axis trackers

Single axis trackers have one degree of freedom that acts as an axis of rotation. The axis of rotation of single axis trackers is typically aligned along a true North meridian. It is possible to align them in any cardinal direction with advanced tracking algorithms. There are several common implementations of single axis trackers.

These include horizontal single axis trackers (HSAT), horizontal single axis tracker with tilted modules (HTSAT), vertical single axis trackers (VSAT), tilted single axis trackers (TSAT) and polar aligned single axis trackers (PSAT).

Horizontal single axis tracker (HSAT)

The axis of rotation for horizontal single axis tracker is horizontal with respect to the ground. The posts at either end of the axis of rotation of a horizontal single axis tracker can be shared between trackers to lower the installation cost. Field layouts with horizontal single axis trackers are very flexible.

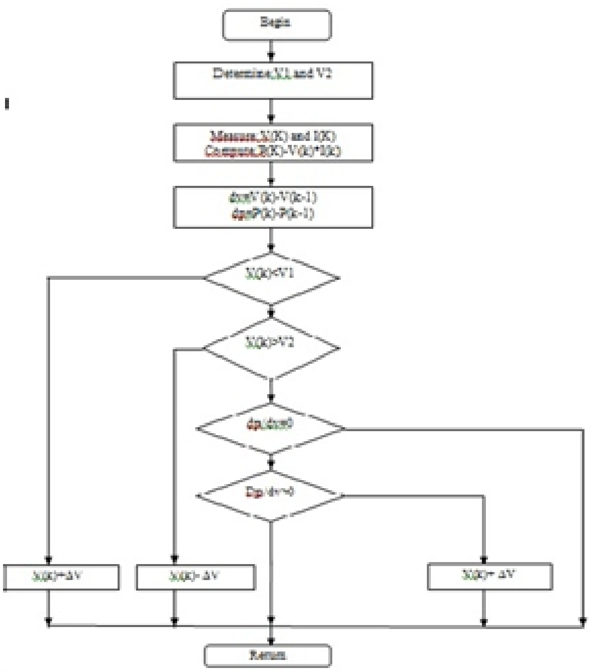


Fig 1. Incremental Conductance Flow Chart

The hybrid gray-wolf assisted perturb and observe algorithm is proposed.P&O SMPPT tracks the MPP by perturbing the operating point and then observing the change in power before and after perturbations. This P&O is considered as the reference for any new MPPT to compare, as it is one of the best MPPTs popularly used. The P&O based MPPT algorithm first calculates the power (P) of the PV array by measuring its voltage and current.Proposed Hybrid-MPPT The fusion of GWO and P&O based MPPT technique which we call as GWO-PO hybrid MPPT is an intelligent computational algorithm which avoids the confusion that may appear during transformation of homogenous to non-homogenous and vice-versa i.e. during uniform insulation, P&O MPPT comes into act to track the MPP but during non-uniform insulation, Hybrid MPPT tracks the GP with initialization of the GWO first followed by the action of P&O, when the grey wolves reach closer to each other, the P&O MPPT gets started at the location of the best wolf in GWO process. The proposed GWO-PO hybrid-MPPT is applied to the PV system operating under PSCs. In the proposed MPPT algorithm, the position of a wolf refers to duty ratio of the dc-dc converter used for implementation of MPPT which eliminates the PI control loop. This makes the controller more simplified and reduces the computational burden in tuning the controller gain.

More number of wolves results in higher MPP accuracy but also increases the computational burden. Therefore, number of grey wolves may be considered as 3 to reduce the computational time. Fig.4 shows the flowchart of the proposed Hybrid-MPPT technique. The following steps are adopted to implement the proposed MPPT algorithm.

Procedure

Step 1: Initialize the position of the wolves on fixed positions with equal space to lie between 10% and 90% of the duty ratio.

Step 2: To maximize the PV array output power 'P' at each wolf position, activate the converter and evaluate output power: P V I pvpvpv*=(11)

Step 3: Adjust the position of grey wolf as follows:-=+ 1) ( ) . D k D k a e í i (12) where D is current grey wolf, k is number of iterations, i is number of current grey wolves and ae, are coefficient vectors

Step 4: Repeat steps 3 and 4 until all the wolves converge towards the MPP.

Step 5: After locating the MPP begin the P&O loop for tracking the maximum power (GP). Choose a small step size to obtain reduced oscillations in PV output power and higher tracking efficiency.

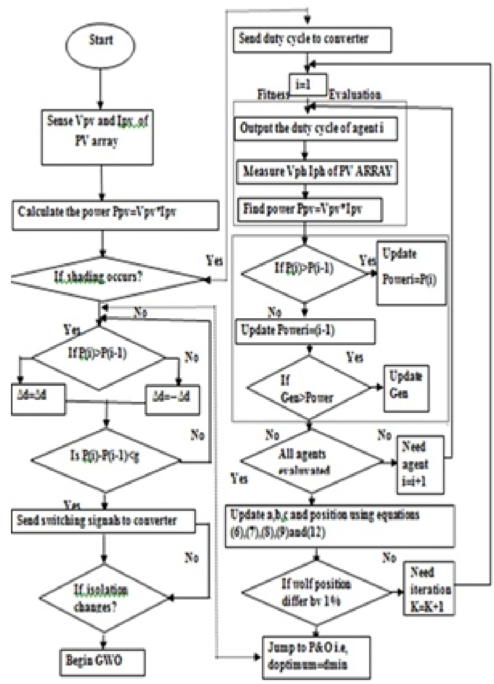


Fig2.Grey Wolf Assisted Perturb and Observe Flow Chart

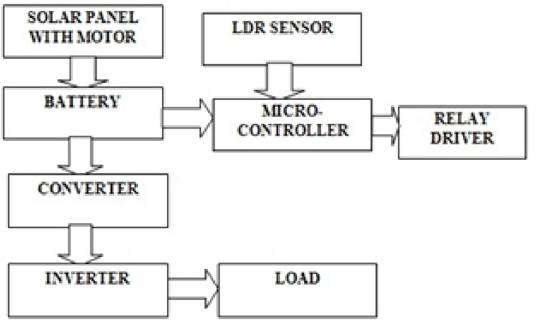


Fig3. Block Diagram

Power Supply Circuit

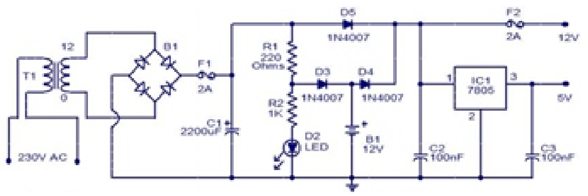


Fig4. Power Circuit

Brushed DC motors

DC motor design generates an oscillating current in a wound rotor, or armature, with a split ring commutator, and either a wound or permanent magnet stator. A rotor consists of one or more coils of wire wound around a core on a shaft; an electrical power source is connected to the rotor coil through the commutator and its brushes, causing current to flow in it, producing electromagnetism. The commutator causes the current in the coils to be switched as the rotor turns, keeping the magnetic poles of the rotor from ever fully aligning with the magnetic poles of the stator field, so that the rotor never stops but rather keeps rotating indefinitely. Many of the limitations of the classic commutator DC motor are due to the need for brushes to press against the commutator.

Efficiencies

Depending on construction, photovoltaic panels can produce electricity from a range of frequencies of light, but usually cannot cover the entire solar range (specifically, ultraviolet, infrared and low or diffused light). Hence much of the incident sunlight energy is wasted by solar panels, and they can give far higher efficiencies if illuminated with monochromatic light.

Therefore, another design concept is to split the light into different wavelength ranges and direct the beams onto different cells tuned to those ranges. This has been papered to be capable of raising efficiency by 50%.

Currently the best achieved sunlight conversion rate (solar panel efficiency) is around 17.4% in new commercial products typically lower than the efficiencies of their cells in isolation. The energy density of a solar panel is the efficiency described in terms of peak power output per unit of surface area, commonly expressed in units of watts per square foot (W/ft2).

The most efficient mass-produced solar panels have energy density values of up to 16.22 W/ft2 (175 W/m2)

Thin- film modules

Third generation solar cells are advanced thin-film cells. They produce high-efficiency conversion at low cost.

Rigid thin-film modules

In rigid thin film modules, the cell and the module are manufactured in the same production line.The cell is created on a glass substrate or superstrate, and the electrical connections are created in situ, a so-called "monolithic integration". The substrate or superstrate is laminated with an encapsulates to a front or back sheet, usually another sheet of glass. The main cell technologies in this category are CdTe, or a-Si, or a-Si+uc-Si tandem, or CIGS (or variant). Amorphous silicon has a sunlight conversion rate of 6-12%.

Flexible thin-film modules

Flexible thin film cells and modules are created on the same production line by depositing the photoactive layer and other necessary layers on a flexible substrate.

If the substrate is an insulator (e.g. polyester or polyimide film) then monolithic integration can be used. If it is a conductor then another technique for electrical connection must be used.

The cells are assembled into modules by laminating them to a transparent colorless fluoropolymer on the front side (typically ETFE or FEP) and a polymer suitable for bonding to the final substrate on the other side. The only commercially available (in MW quantities) flexible module uses amorphous silicontriple junction

III. Keil-C51 Compiler

The C programming language is a general-purpose programming language that provides code efficiency, elements of structured programming, and a rich set of operators. C is not a biglanguage and is not designed for any one particular area of application. Its generality combined with its absence of restrictions, makes C a convenient and effective programming solution for a wide variety of software tasks. Many applications can be solved more easily and efficiently with C than with other more specialized languages.

The Cx51 Optimizing C Compiler is a complete implementation of the American National Standards Institute (ANSI) standard for the C language. Cx51 is not a universal C compiler adapted for the 8051 target. It is a ground-up implementation dedicated to generating extremely fast and compact code for the 8051 microprocessor. Cx51 provides you with the flexibility of programming in C and the code efficiency and speed of assembly language.

The C language on its own is not capable of performing operations (such as input and output) that would normally require intervention from the operating system. Instead, these capabilities are provided as part of the standard library. Because these functions are separate from the language itself, C is especially suited for producing code that is portable across a wide number of platforms

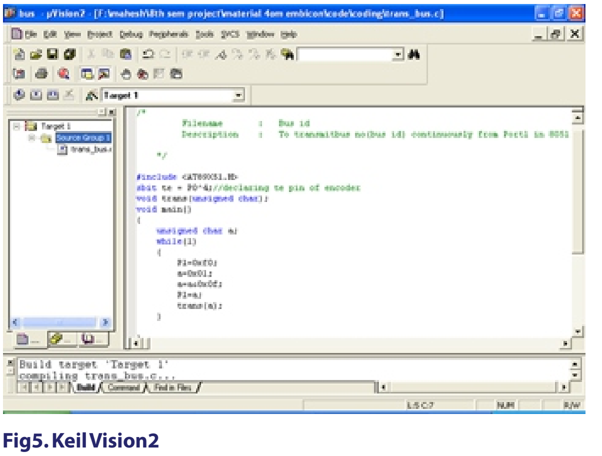


Fig5. Keil Vision2

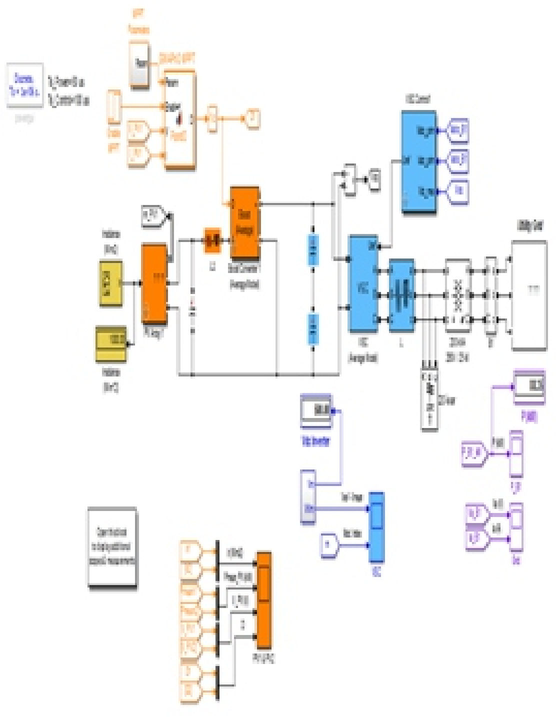


Fig6. Simulink Model

The above Simulink model shows the connection of PV arrays connected with the Boost Converter. The Boost converter ensures the operation of the solar panels at Maximum Power Point with the help of the Grey Wolf Assisted Perturb and Observe Algorithm in the 8051 microcontroller.

The DC Power output from the Boost Converter is fed to the Voltage Source converter for AC conversion and the power output is fed to the utility grid. If the utility grid consists of the any type of three phase load with this rating below 88.35 KW.

A 12v panel consists of 36 cells to produce the 16 to 18v at maximum solar irradiation condition, but if the solar irradiation is low then produce the 14.5v with the implementation of MPPT.

This is automated system which will automatically control the operation of street lights using LDR and timers; it will control the light ON and OFF sequences. Here we using microcontroller for controlling street light operation.

The heart of the embedded system is the microcontroller. Atmel architecture based Atmel microcontroller from NxP is used to implement this paper. Microcontroller acts as the heart of the paper, which controls the whole system.

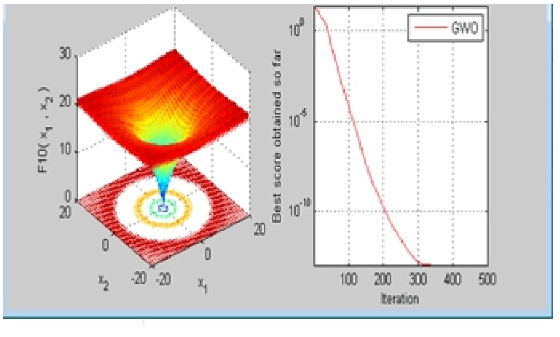
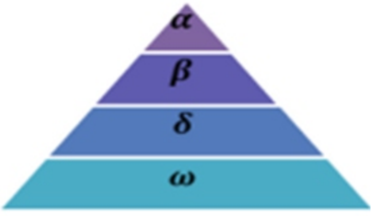


Fig7. GWO

The above fig shows the convergence of the search values using the Grey Wolf Assisted Algorithm. The search values converge at a point of iteration of the Maximum Power Point. This iteration based on the following search agents,

- α is the leader and decision maker
- ß and δ assist α in decision making.

Rests of the wolves (ω) are followers.



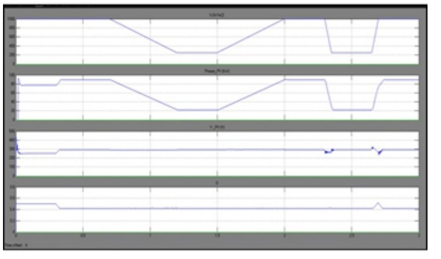
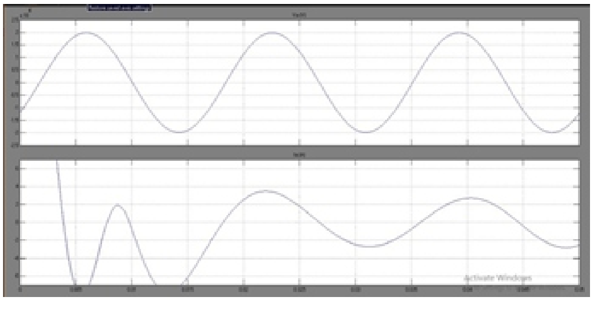


Fig8. Solar Output Waveform

This figure shows the voltage, current, power and duty cycle of the PV array. If the solar radiation increases output of power from the PV array also increases. If the radiation varies the obtained power also varies. Because solar panel consists of a photovoltaic cell it absorbs the solar radiation (photons) that converts DC current.

Fig9. Voltage and Current Waveform from VSC



Obtained Power:

Fig10. Output Power

The above figure shows the maximum power obtained at the point of maximum solar radiation. The output of a single solar PV cell is 0.5 V. Each panel contains 36 Cells. The output of 0.5V from each panel is available at the maximum point of solar irradiation. In order to achieve the above voltage 8 such panels are cascaded to get the output of 88.35 kW.

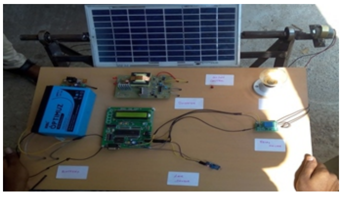


Fig11. Hardware Module

The above figure shows the prototype model of our designed tracking device. It is the one which follows the sun's movement throughout the day and provides uninterrupted reflection to the solar panel.

The sun rays will fall on the solar panel in two ways, which is, they will fall directly on the solar panel and also the reflector will reflect the incident rays on the solar panel. Suppose at the time of sun rise the sun is in extreme east the reflector will align itself in some position by which the incident rays will fall on the solar panel. Now when the earth rotates and the sun gets shifted from its earlier position the reflection of the incident rays will also change. Thus as a result the light will fall on the light dependent sensors kept on each side of the solar panel.

The tracking circuit is so designed that when reflection falls on say the light dependent sensor attached to the right of the panel, the tracker will move towards the left, and visa-versa. Similar in the case when the reflection falls on the sensor attached at the top of the panel, circuit will make the tracker to move downwards. We here have tried to bring two simple principles together.One being, the normal principle of incidence and reflection on which our tracker works. And the other is the principle on which the solar panel works, which is on the incidence of the solar rays the photovoltaic cells, will produce electricity. This both principles are combined there and as a result of which we are able to fetch nearly double the output which the panel gives normally

I. CONCLUSION

This paper is based on the combination of the ST and MPPT in order to ensure that the solar PV panel is capable of harnessing the maximum solar energy following the sun's trajectory from dawn until dusk and is always operated at the MPPs with the gray wolf assisted perturb and absorb algorithm This Paper has presented development of a new GWO-PO Hybrid-MPPT for maximum power from a PV system with different possible patterns. The effectiveness of the proposed GWO-PO Hybrid MPPT algorithm was evaluated through both simulation studies followed by experimental studies on a prototype hardware system. The study of the Hybrid-MPPT with other fast converging technique envisage that the proposed GWO-PO Hybrid-MPPT exhibits superior performance such as higher tracking speed and faster convergence towards the GP.

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