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MPPT & Solar Photovoltaic (PV) Incremental Conductance Algorithm Maximum Power Point (MPP) Electrical Power Thermal Energy using DSP

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Abstract: A maximum power point tracking (MPPT) scheme is obligatory to ameliorate the efficiency of a solar photovoltaic (PV) panel. This paper proposes an ameliorated incremental conductance algorithm (InC) for tracking the maximum power point (MPP) of a solar PV panel. Solar PV cells have a non-linear V-I characteristic with a distinct MPP which depends on environmental factors such as temperature and irradiation. Solar energy systems have emerged as a viable source of renewable energy over the past two or three decades, and are now widely utilized for a variety of industrial and domestic applications. Such systems are predicated on a solar collector, designed to amass the sun's energy and to convert it into either electrical power or thermal energy. In general, the puissance developed in such applications depends fundamentally upon the amount of solar energy captured by the collector, and thus the quandary of developing tracking schemes capable of following the trajectory of the sun throughout the course of the day on a year. The obtained simulation results are compared with MPPs achieved utilizing the conventional InC algorithm under sundry atmospheric conditions. The results show that the ameliorated InC algorithm is better than the conventional InC algorithms for tracking MPPs of solar PV panels. Adscititiously, it is simple and can be facilely implemented in digital signal processor (DSP).

Keywords: Maximum Power Point Tracking (MPPT), Solar Photovoltaic (PV), Incremental Conductance Algorithm (Inc), Maximum Power Point (MPP), Electrical Power**,** Thermal Energy, Digital Signal Processor (DSP).

I. INTRODUCTION

Energy is absolutely essential for our life. Recently, energy demand has greatly incremented all over the world. This has resulted in an energy crisis and climate change. The research moving towards renewable energy can solve these quandaries. Compared to conventional fossil fuel energy sources, renewable energy sources have the following major advantages: they are sustainable, never going to run out and are non-polluting. Renewable energy is energy engendered from renewable natural resources such as solar radiation, wind, tides, wave, etc. Amongst these sources, solar energy is one of the most paramount renewable sources and is widely utilized. The sun radiates an amount of energy onto the earth's surface everyday which is enough to provide the energy injuctive authorization of humans. Supplementally, most of the renewable energy sources such as wind energy, tidal energy, wave energy, etc. originate from solar energy. The applications for solar energy are incremented, and that need to ameliorate the materials and methods used to harness this puissance source [1].

The solar cell has an optimum operating point to be able to get the maximum puissance. To obtain maximum power from photovoltaic array, photovoltaic power system customarily requires maximum power point tracking controller [2] and [3]. There are three major approaches for maximizing power extraction in solar systems. They are sun tracking, maximum power point tracking or both [4]. These methods need perspicacious controllers such as fuzzy logic controller or conventional controller such as PID controller. In the literature, many maximum power point tracking systems have been proposed and implemented [5] and [6]. The fuzzy theory predicated on fuzzy sets and fuzzy algorithms provides a general method of expressing linguistic rules so that they may be processed expeditiously. The advantage of the fuzzy logic control is that it does not stringently need any mathematical model of the plant. Incrementing of Energy demand and the depletion of fossil fuel has made compulsory to look back into renewable energy predicated generation of electricity. Particularly solar energy predicated photo voltaic (SPV) has gained more consequentiality predicated on availability and feasibility.

The surplus amount of puissance engendered, apart from giving to the consumer load can be alimented to the grid utility with IEEE standards and policy [1]. In the interest of expanding the number of PV predicated GTI installations and providing maximum benefit, it is compulsory to consider in more detail of the potency loss from a partially shaded PV system discussed in [2]. In most of the analysis [3-5], Shading factors and shade time of PV engenderers envisages the engenderment of output potency. Solar panels have a nonlinear voltage-current characteristic, with a distinct maximum power point (MPP), which depends on the environmental factors, such as temperature and irradiation. In order to perpetually harvest maximum power from the solar panels, they have to operate at their MPP despite the ineluctably foreordained vicissitudes in the environment. This is why the controllers of all solar power electronic converters employ some method for maximum power point tracking (MPPT). Over the past decades many MPPT techniques have been published. The algorithms that where found most opportune for sizably voluminous and medium size photovoltaic (PV) applications is incremental conductance. The transmutation in sun's position is monitored, and the system always keeps that the plane of the panel is mundane to the direction of the sun. By doing so, maximum irradiation and thermal energy would be taken from the sun.

II. RELATED WORK

A. Existing System

The relative position of the sun and earth is conveniently represented by designates of the celestial sphere around the earth. The equatorial plane intersects the celestial sphere in the celestial equator, and the polar axis in the celestial poles. The earth kineticism round the sun is then pictured by ostensible kineticism of the sun in the elliptic which is tilted at 23.45° with veneration to the celestial equator. The angle between the lines joining the centers of the sun and the earth and its projection on the equatorial plane is called the solar declination angle.

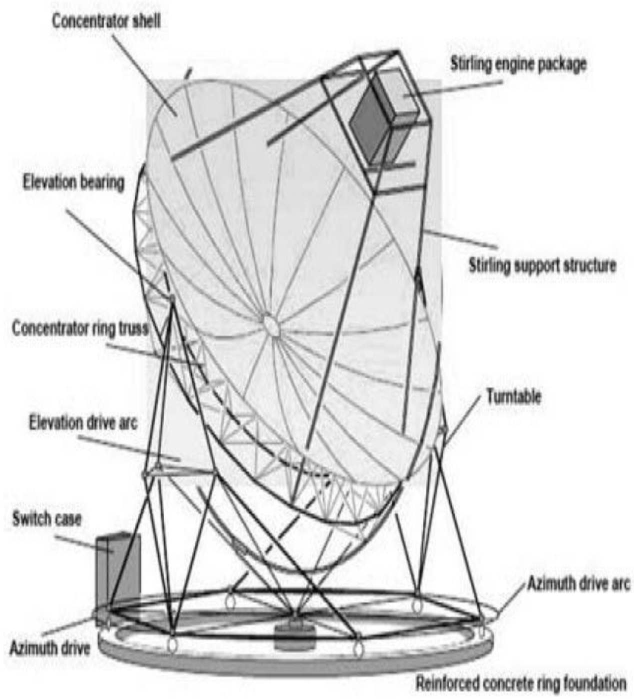

Fig1. Schematic representation of the solar angles.

The earth itself rotates at the rate of one revolution per day around the polar axis. The circadian rotation of the earth is depicted by the rotation of the celestial sphere about the polar axis, and the instantaneous position of the sun is described by the hour angle, the angle between the meridian passing through the sun and the meridian of the site. The hour angle is zero at solar noon and increases toward the east. To get an efficient solar tracker system, a diminutive solar panel is utilized in lieu of a sizably voluminous one to obtain a graphical position data of the sun when it is detected and send this data to the sizably voluminous panels. This system can be installed anywhere in the world without kenning the sun directions and seasons.

B. Proposed System

Solar tracking system utilizes a stepper motor as the drive source to rotate the solar panel as shown in Fig. 1. The position of the sun is resolute by utilizing a tracking sensor, the sensor reading is converted from analog to digital signal, and then it passed to a fuzzy logic controller implemented on FPGA. The controller output is connected to the driver of

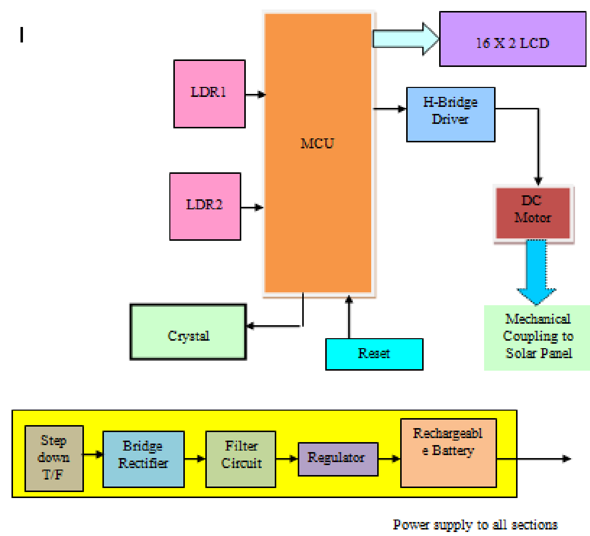

Fig2. Proposed System Black Diagram.

A solar tracker is an electro-mechanical contrivance for orienting a solar photovoltaic panel toward the sun trackers, especially in solar cell applications require a high degree of precision to ascertain that the concentrated sunlight is directed precisely to the powered contrivance. Solar trackers can be active or passive and maybe single axis or dual axis. Single axis trackers mundanely utilize a polar mount for maximum solar efficiency and employ manual elevation (axis tilt) adjustment on a second axis, which can be adjusted conventionally during the year. Trackers can be relatively inexpensive for photovoltaic. This makes them especially efficacious for photovoltaic systems utilizing high-efficiency panels. Solar trackers customarily need inspection and lubrication on a conventional substructure.

III. IMPLEMENTATION

A. Geographical Location with Meteorological Data

A PV system's geographical location were considered for Vellore, Tamilnadu, India with the longitude of 790 9 ′ 32″ E & Latitude of 120 58′ 26″ N & with solar insolation of

930 W/m2 as amassed from [11].Positional changes of sun path determine the volume of feasible sunshine that falls on the modules. The location decides the possible sunshine that is blocked afore reaching the array and it shows capability of the system in displaying the modules to the sunlight. Astronomical land with solar isolation has made the landowner to design a solar park to engender sizably voluminous amount of peak potency.

B. Factors Affecting Shading in Photovoltaic Cell

SPV array is assembled by series/parallel connection of SPV modules to obtain desired voltage and current. In a more sizably voluminous SPVA occurrence of partial shade is prevalent due impact of trees, falling of leaves, nearby buildings or other solar obstructions. The shading of solar panel makes the internal cell to get heated, and hotspot quandary [12] is engendered and makes the entire system to get damaged. The shading and partial shading affects SPV in their energy yield. To harness received solar radiation into thermal or electrical energy it should be installed in a congruous orientation as examined in [13, 14].

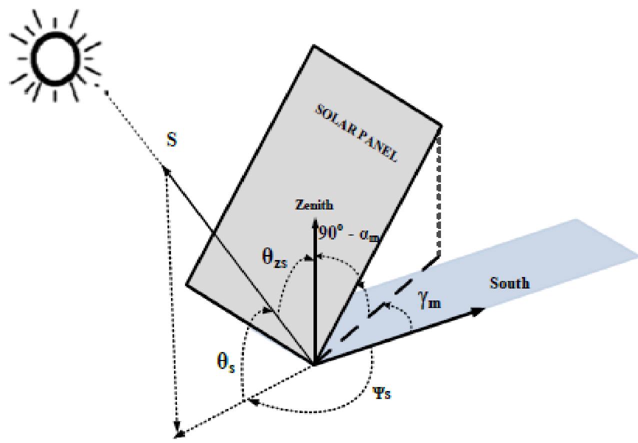

Fig3. Relationship between the angles at a tilted photovoltaic generator plane.

In [15,16] several Maximum Power Point Tracking (MPPT) techniques are discussed for extracting potency. The SPV has the nonlinear relationship between four variables: current, voltage, irradiance and temperature. For the sizably voluminous requisite of puissance it is desired to connect a higher number of solar panels together in an array, the shade on one module affects the entire array dealing with its many configurations like series -parallel (SP),Total Cross-Tied (TCT), Bridge-linked (BL) and Honeycomb (HC) performances are evaluated in [13] by connecting the bypass diodes. It has been noted that shading factors play a major role in consideration. The method utilized for manipulating the irradiance on shaded planes is described in [17].

C. Consideration of SITE Construction

To maximize the PV potential of a building, solar PV system design should be ideally considered and coordinated with the architectural design of a project [15] by kenning the zoning laws [13].However, grid-connected systems are conventionally found in urban and suburban areas and the modules are customarily installed on roofs, where some shading is sometimes inevitably ineluctable. Factors influencing the relative impact of shadow effects are site-concrete and include differences in terrain elevation between involved properties, the height and bulk of structures, the time of year, the duration of shading ina day, and the sensitivity of adjacent land causes loss of sunlight.

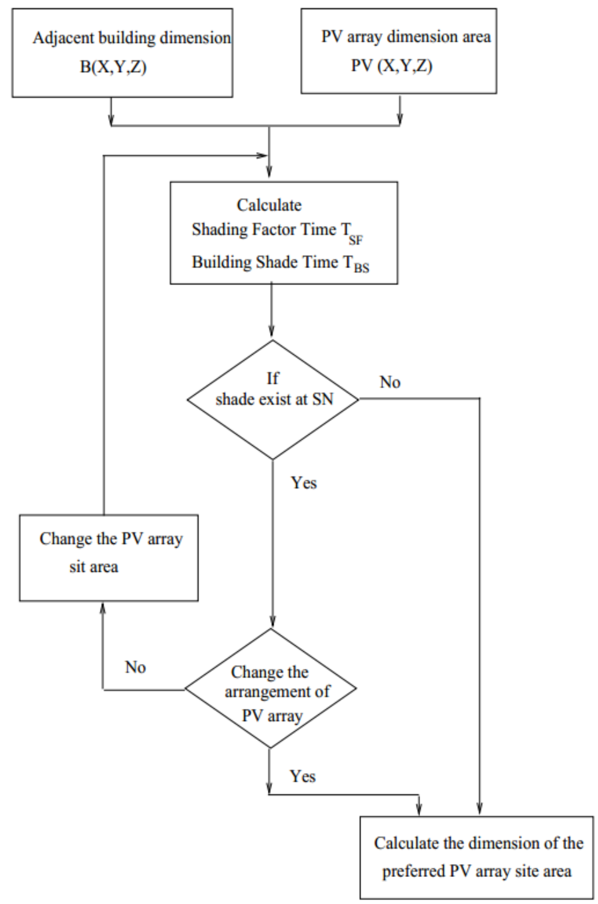

Fig4. Estimation of PV site area.

Shadows cast by structures vary in length and direction throughout the day and from season to season. Of the total amount of the sun's energy available during a daylight period, approximately 85 % of it reaches the earth between 9:00a.m. and 3:00p.m. Therefore energy harvest is indispensable to obtain maximum energy from the sun. Voltage and current predicated MPPT techniques, and enhanced PV output utilizing optical sensors is visually perceived in and load voltage of the illuminated portion of the array is derived in. Due to different shading effects, V-I characteristics are withal mismatched as examined in. By kenning the dimensions of the adjacent building and SPVA, shade time can be prognosticated and the preferred site can be culled. If shade subsists at peak hours the arrangement of SPVA can be transmuted with steps as shown in the flowchart in Fig. 4.

IV. EXPERIMENTAL RESULT

The result of shade analysis is exhibited in Table 1 with six arrangements. The arrangements A1 to A6 with number of rows and columns demonstrates different placement of direction, covered within the area, starting from the shady time & Pmax with shade and without shade. And it is pellucid that the arrangement and placement of SPVA engender different shade time obtaining maximum power (Pmax). Arrangement, A1 (8x5) solar panel is placed left to right and it is within the 300 square foot area with starting of shade time 14.10 with maximum power 3193.99W with shade and 2167.62W without shade. Correlating with other arrangements,A1 (8x5) and A3 (20x2) is feasible by giving an optimal solution of 2506.26W and 2167.62W. Since, the shade time commences at 14.10 and 14.30 while other arrangement commences early in 13.20with the shade profile for a day. Further, some of the arrangement is not within the 300 square foot area.With starting of shade time 14.10 with maximum power 3193.99W with shade and 2167.62W without shade. Correlating with other arrangements, A1 (8x5) and A3 (20x2) is feasible by giving an optimal solution of 2506.26W and 2167.62W. Since, the shade time commences at 14.10 and 14.30 while other arrangement commences early in 13.20 with the shade profile for a day. Further, some of the arrangement is not 300.

Table 1: Summary of the performance of SPVA in gabled roof

Arrangement of panel array panel in south direction	Placement of direction	Area within 300 square feet	Starting of Shade time, (T_{sh})[HH:MM]	P_{max}(W)	
				Without shade	Shade
A1 (8x5)	Left-Right	Applicable	14.10	3193.39	2167.62
	Top-Bottom	Applicable	13.26		
A2 (5x8)	Left-Right	Applicable	13.30	3193.48	1127.6
	Top-Bottom	Not Applicable	13.32		
A3 (20x2)	Left-Right	Not Applicable	14.30	3194.23	2506.26
	Top-Bottom	Applicable	14.00		
A4 (2x20)	Left-Right	Not Applicable	13.20	3194.23	1508.94
	Top-Bottom	Not Applicable	13.28		
A5 (4x10)	Left-Right	Applicable	13.28	3194.28	1509.12
	Top-Bottom	Applicable	13.32		
A6 (10x4)	Left-Right	Applicable	14.07	3193.62	1716.14
	Top-Bottom	Applicable	13.31		

V. CONCLUSION

A congruous method for finding shading factor and novel prognostication of the site consideration is proposed. This evaluates the optimal arrangement of PV array dimension in the roof by eschewing the peak shade timings. The dimension of the site area and SPVA is considered, and the arrangement decides the output power with reverence to shade timings. The output characteristic under sundry arrangements shows different peak powers with the shadetimings. The x- coordinate position with the timing graph prognosticates shade time of sundry sites. By soothsaying the PV site area with the shade analysis, feasible solution of energy yield of maximum power can be made reliable.

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