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AN ADAPTIVE EXTREMUM SEEKING CONTROL FOR REAL TIME OPTIMIZATION IN PHOTOVOLTAIC SYSTEM

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Abstract - Extremum seeking control approach is a theory building a feedback system in such a way that oscillation around the MPPT will boost the PV System efficiency .An alternative ESC approach is to introduce a small amount of perturbation into the control system. Maximum Power Point Tracker (MPPT) using extremum seeking control algorithm with emphasis in solar photovoltaic (PV) system. The ESC is better because of its low cost ,high efficiency and good power factor . Ripple Correlation Control**(**RCC) is used in first stage high pass filter along with the relational operator to develop the system .The reason for choose RCC is due to its high voltage gain and a low input current ripple which minimizes the oscillation at the module operation point .A major advantage of ESC is that it is capable of improving the system performance .The variable phase MPPT power ripple feedback signal developed by sensing and multiplying together PV array .The entire system is simulated using Matlab simulink environment .The system is expected to be operated with high efficiency and low cost long life time .

Keywords - Extremum seeking control, real-time optimization, ripple correlation control, ripple-based control, ripple-based optimization, switching power converters

I. INTRODUCTION

Photovoltaic's (PV) is a method of generating electrical power by converting sunlight into direct current electricity using semiconducting materials that exhibit the photovoltaic effect. A photovoltaic system employs solar panels composed of a number of solar cells to supply usable solar power. Photovoltaic are best known as a method for generating electric power by using solar cells to convert energy from the sun into a flow of electrons[6]. The photovoltaic effect refers to photons of light exciting electrons into a higher state of energy, allowing them to act as charge carriers for an electric current. Photovoltaic are best known as a method for generating electric power by using solar cells to convert energy from the sun into a flow of electrons. The solar cells for produce electricity is shown in the figure 1. The photovoltaic effect refers to photons of light exciting electrons into a higher state of energy, allowing them to act as charge carriers for an electric current.

Figure 1 Solar cells produce electricity directly from sunlight

II. RELATED WORK

The San Jose-based company Sun power produces cells that have an energy conversion ratio of 19.5%, well above the market average of 12–18%. The most efficient solar cell so far is a multi-junction concentrator solar cell with an efficiency of 43.5% produced by Solar Junction in April 2011. The highest efficiencies achieved without concentration include Sharp Corporation at 35.8% using a proprietary triple-junction manufacturing technology in 2009, and Boeing Spectrolab (40.7% also using a triple-layer design).Several companies have begun embedding power optimizers into PV modules called "smart modules". These modules perform maximum power point tracking (MPPT) for each module individually, measure performance data for monitoring, and provide additional safety. Such modules can also compensate for shading effects, wherein a shadow falling across a section of a module causes the electrical output of one or more strings of cells in the module to fall to zero, but not having the output of the entire module fall to zero. At the end of September 2013, IKEA announced that solar panel packages for houses will be sold at 17 United Kingdom IKEA stores by the end of July 2014. The decision followed a successful pilot project at the Lakeside IKEA store, whereby one photovoltaic (PV) system was sold almost every day. The panels are manufactured by a Chinese company named Hanergy Holding Group Ltd.

2.1 Overview of Extremum Seeking Control

The ESC is an adaptive control target via filtered and driving signals with uncertain (or) unknown in formations in some aspects. A major advantage of ESC is that it does not require a system model, and is capable of improving the system performance Application of ESC might be found in non linear control issues, and non linear local minimum and maximum localizations[3]. There might exist a local extremum for a non linear output P-v characteristics curve in the case of shaded solar cell. Block diagram is composed of an integrator, a differentiator, a logic circuit and an amplifier. ESC is then applied to track the MPP which is to locate the maximum power point[9].

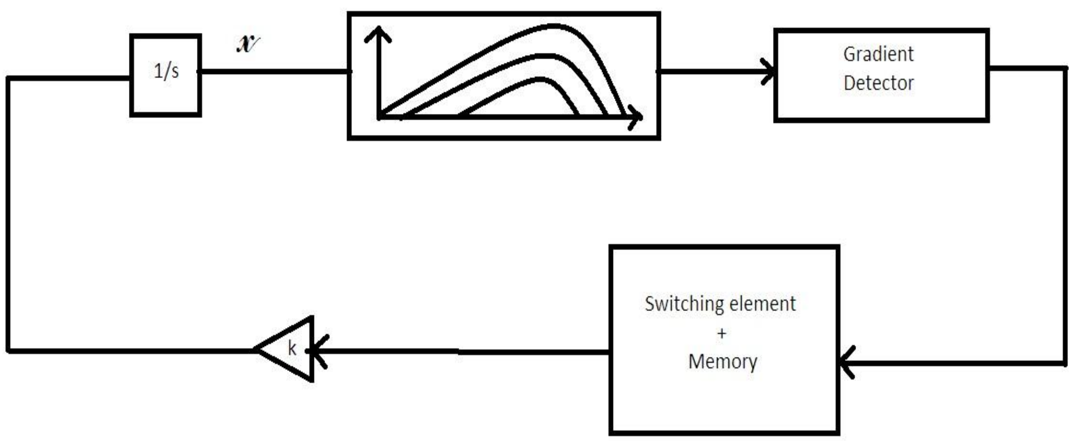

Figure 2 . A Block diagram of an ESC system

ESC system shows the simplest way to find the maximum point by ESC method on the MPP on the solar cell P-V curve. The current balance point is identified by a gradient detector, subsequent to which modification toward the next instant is determine and the current signal , is stored into memory is assessed for alteration at the next instant a switching element, as shown in the figure 2.

2.2 Ripple Correlation Control

Maximum power point tracking by the ripple correlation method uses the naturally existing 0% to 200% 120Hz the naturally existing 120HZ perturbations of sourced power into the ac line (as filtered through the large energy storage capacitor) to dynamically detect and track the zero slope point of the power output curve of the photovoltaic panel. A 120 Hz, fixed phase, ac reference signal for slope detection is developed high- pass filtering the ripple, voltage that is present on the energy storage capacitor[1]. The variable phase MPPT power ripple feedback signal developed by sensing and multiplying together PV array .The block diagram of RCC is shown in the figure 3.

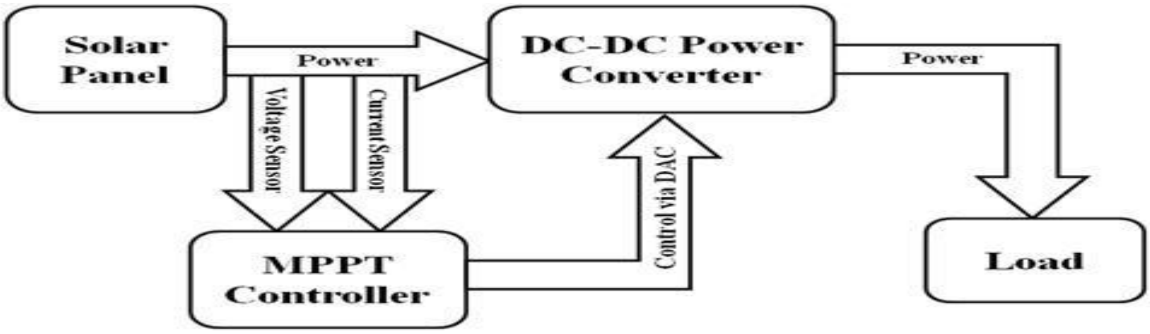

Figure 3. Block diagram of a ripple correlation control

Current and voltage and high-pass filtering the together these two 120Hz ac wave forms (the error output is zero at the MPPT) error signal strength is directly proportional to delivered power, so error gain must be divided by the output power command in to keep over all loop- gain by cause of the switching power converter, the power command to the line current selling control section[5]. A periodic can be set to within a few percent of measured PV array power. The small remaining error in command level is eliminated by summing this PV power feed forward signal together with the MPPT error feed back signal [4].

III. PROPOSED SYSTEM

MPPT is algorithm that included in charge controllers used for extracting maximum available power from PV module under certain conditions. The voltage at which PV module can produce maximum power is called ‘maximum power point’ (or peak power voltage). Maximum power varies with solar radiation, ambient temperature and solar cell temperature[8]. Typical PV module produces power with maximum power voltage of around 17 V when measured at a cell temperature of 25°C, it can drop to around 15 V on a very hot day and it can also rise to 18 V on a very cold day . The major principle of MPPT is to extract the maximum available power from PV module by making them operate at the most efficient voltage (maximum power point)[8]. That is to say : MPPT checks output of PV module, compares it to battery voltage then fixes what is the best power that PV module can produce to charge the battery and converts it to the best voltage to get maximum current into battery. It can also supply power to a DC load, which is connected directly to the battery.

MPPT is most effective under these conditions:

Cold weather, cloudy or hazy days: Normally, PV module works better at cold temperatures and MPPT is utilized to extract maximum power available from them.

When battery is deeply discharged: MPPT can extract more current and

3.1 MPPT Controller

Maximum power point tracking (MPPT) for PV arrays is the newest feature being integrated into many whole house charge controllers. PV modules’ voltage and current vary throughout the day depending primarily on temperature. MPPT uses a mathematical algorithm to "track" the optimal point of production of a PV array to maximize annual energy generation. In most locations and applications, an MPPT controller will increase the annual output of your PV array by about 15 percent. Hot climates (like Palm Springs, California) will see a smaller increase in energy gain compared to colder places (like Denver, Colorado) because PV voltage decreases as the module temperature increases. Here's an example of why MPPT controllers are beneficial. It's a cold winter day and your batteries are at a relatively low state of charge and voltage (12.3 VDC). Let's assume that the array is rated for 34 amps at 17.5 volts. Because it's cold, the array's maximum power point is actually 19.5 volts. A non-MPPT controller will operate the array at the battery voltage, in this case about 12.3 VDC. The array amperage may be a little higher at the lower voltage, say 36 amps. So in this example, the total wattage charging the batteries is 443 watts (36 A x 12.3 V).

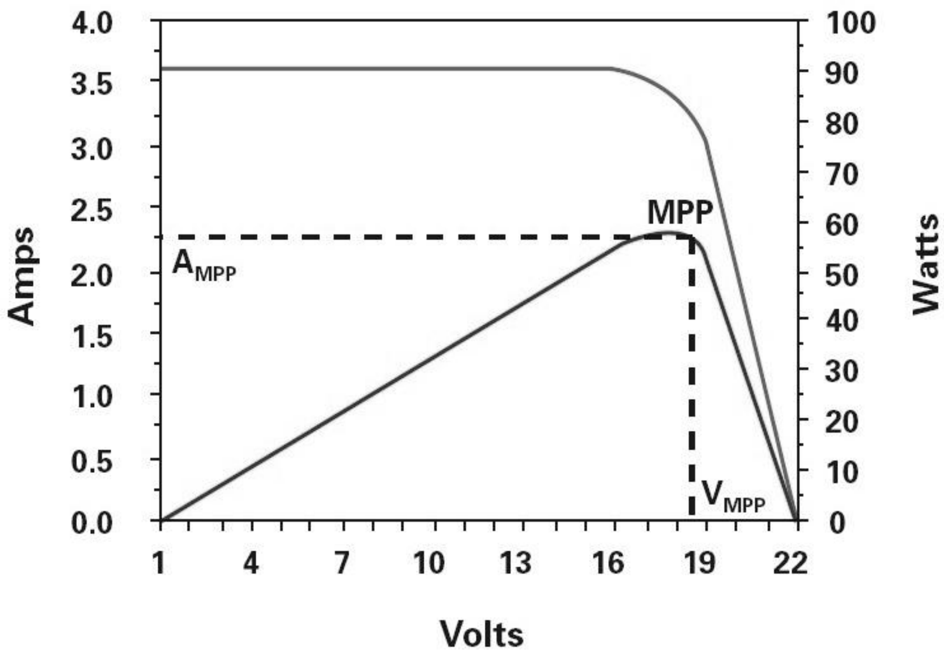

Figure 4. PV panel IV curve

MPPT controller, the array will operate at its maximum power point, producing 663 W (34 A x 19.5 V). Even if the charge controller is only 95 percent efficient, it will still deliver 630 watts to the batteries, an increase of 187 W compared to a non-MPPT controller as shown in the figure 4.As the array heats up, and the battery voltage rises during the daily charging cycle, the additional energy harvested by the MPPT controller will decrease. In the summertime, the array will be operating at a high temperature and its voltage will be relatively low. In addition, the batteries will typically be at a higher state of charge due to long sunny days[10]. Under these conditions, the performance of an MPPT controller and non-MPPT controller may be about the same. But the bottom line is that MPPT controllers will increase your PV array's annual production, especially during the short sun days of winter. The MPPT controller may cost $600 instead of $200, but that additional $400 gets you increased energy harvest when you need it most, year after year, and can often be offset right out of the gate by decreased wire and installation costs. Another reason to use an MPPT controller is that nonstandard PV modules are becoming more common. Many modules designed for grid-tied PV systems are no longer being made with the industry standard of 36 or 72 cells. Panels with 40, 42, 60, or other numbers of cells are becoming more common, and some new technologies produce higher voltage per cell. An MPPT charge controller can easily convert an odd voltage array into a usable array for battery charging.

IV. SIMULATION RESULTS

MATLAB was written originally to provide easy access to matrix software developed by the LINPACK (linear system package) and EISPACK (Eigen system package) projects.MAT LAB is high performance language for technical computing. It integrates computation, visualization, and programming environment. Furthermore, MAT LAB is a modern programming language environment it has sophisticated data structures, contains built-in editing and debugging tools and supports object oriented programming. These factors make MAT LAB an excellent tool for teaching and research.MAT LAB has many advantages compared to conventional computer languages .(e.g., C FORTRAN) for solving technical problems .

MAT LAB is a interactive system whose basic data element is an array that does not require dimensioning. The software package has been commercially available since 1984 and is now considered as a standard tool at most universities and industries world wide. It has powerful built-in routines that enable a very wide variety of computations. It also has easy to use graphic comments that make the visualization of result immediately available. Special applications are collected in packages referred to as tool box. There are tool boxes for signal processing, symbolic computations, control theory simulation, optimization and several other fields of applied science and engineering. Uses of MAT LAB in a wide range of applications, including signal and image processing, communication, control design, test and measurements, financial modeling and analysis, and computational biology. Add-on tool boxes extend the MAT LAB environment to solve particular classes of problems in these application areas.

4.1 Block diagram of proposed system

The block diagram of proposed system modeled with extremum seeking control method is designed below in Figure 5. The block consists of PV model subsystem connected as a variable irradiance. Voltage and current is brought into the notch filter and peak filter. The signal generator and gain is also connected to the duty cycle.

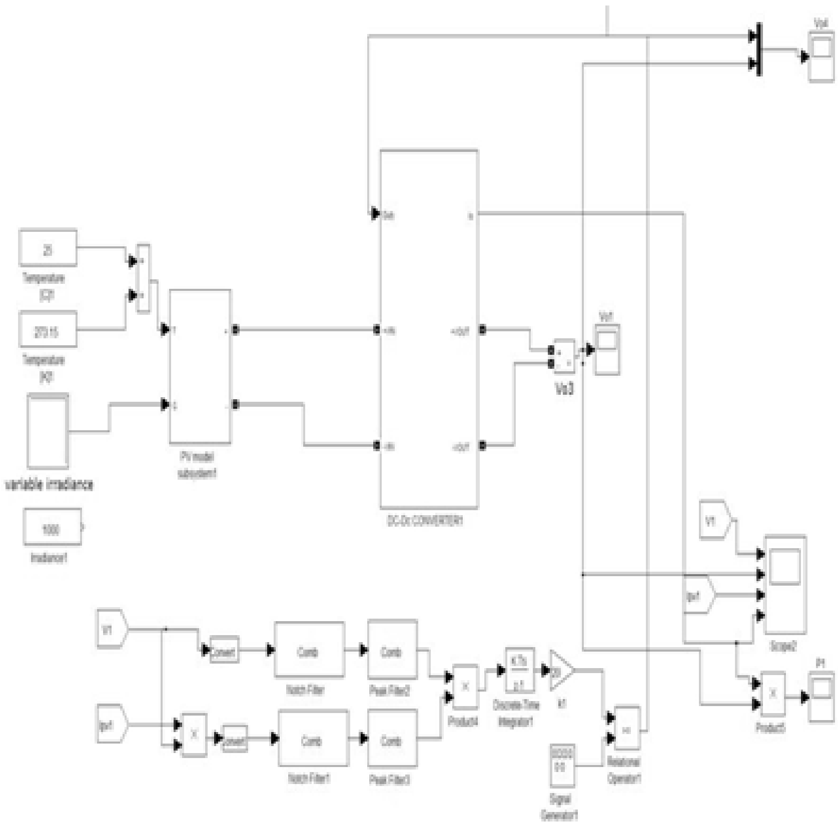

Figure 5. MATLAB Block Diagram Proposed Method

The figure 6 shows, the wave form output. The use of the extremum seeking control method reduces the voltage. The settling time of oscillation becomes constant soon.

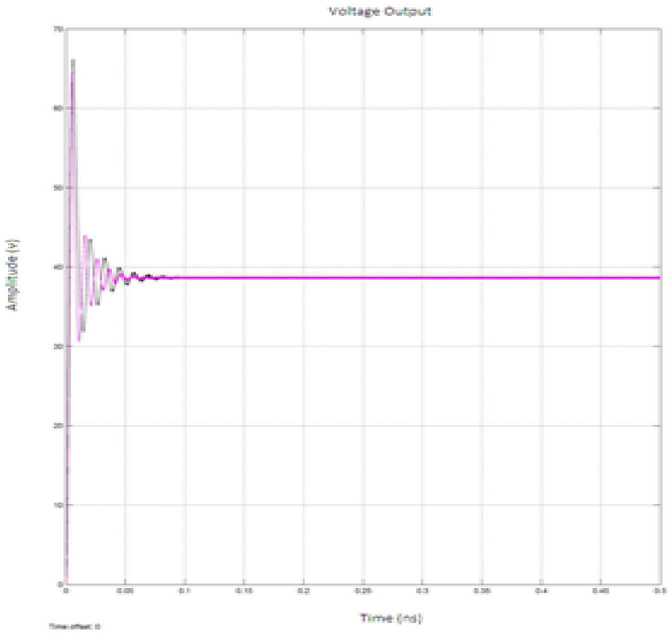

Figure 6. Wave form of Output Voltage

The overall output for the PV fed through Extremum Seeking Control is shown n the figure 7. This fig consists of four graphs. The first graph states the input voltage. The second graph is output voltage and the third graph states the input current. The last graph gives the output current.

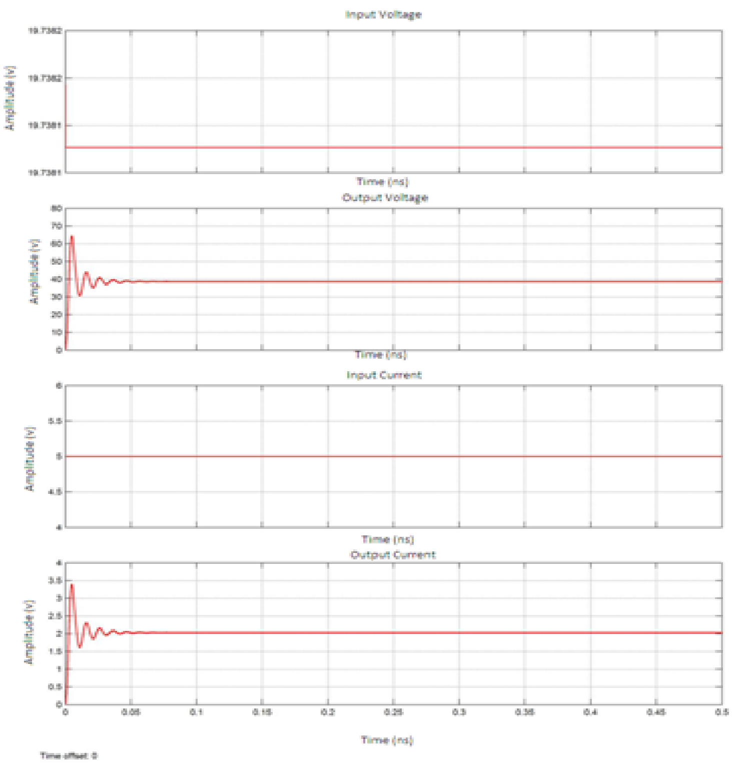

Figure 7. Simulation Results of Overall Output Waveform

V. CONCLUSION

Solar energy is very large, inexhaustible source of energy. In principle, solar energy could supply for all the present and future energy needs of the world on a continuing basis. Extremum seeking control has mainly developed in the automatic control literature with recent applications to energy systems.ESC optimizes a uni model time- varying objective function in real- time using perturbations. ESC utilizes injected perturbations. Application of ESC might be found in non linear control issues and non linear control minimum and maximum localizations. The main contribution of the proposed system is given as follows Ripple correlation control provides high voltage gain and will also reduce the input current ripple. ESC improves the system performance uSing Matlab simulink model verified. Thus through the proposed system we get higher efficiency than by the existing system

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