

# An Implementation of Maximum Power Point Tracking Algorithms for Photovoltaic Systems using Matlab & Arduino based RTOS System

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## Abstract

This paper have an implementation of solar MPPT measurement system to daily record analysis. In this paper, we presents the utilization of a RTOS (real time operating system) for control of photovoltaic power using Maximum Power Point Tracking (MPPT) control mechanism. We already discussed in our previous paper .First we analyzed the photovoltaic module using Matlab platform and Arduino platform. Our main aim of the paper for the boost converter of PV is to be used along with a Maximum Power Point Tracking control mechanism for solar plates. The MPPT control mechanism is responsible for extracting the maximum possible power from the photovoltaic system and which is feed it to the load via the boost converter, which steps up the voltage to required magnitude. The main purpose of this system will be to track the sun and analysis the maximum power point of the photovoltaic module. So In this way we can be check the maximum possible power from the photovoltaic. The algorithms is utilized for MPPT mechanism. Which are generalized in algorithms and this are easy to model or use as a code. The algorithms are written in m files of MATLAB platform and utilized in simulation purpose using GUI unit and control the solar plates using Arduino. In this system we can save the energy and use the maximum renewal energy from the sun. We implement the system in gui layout and Arduino real-time controlling system.

**Keywords:** Arduino, Maximum Power Point Tracking, MATLAB, simulation, photovoltaic

## I. INTRODUCTION

As we know that a non-renewable energy resource is a resource that does not renew itself at a sufficient rate of energy. The energy which is taken from these resources are available on the earth in limited quantity and will vanish fifty-sixty years from now. Non-renewable resources are not environmental friendly and can have serious effect on our health. Non-renewable sources exist in the form of fossil fuels (natural gas, oil and coal). We know that fossil fuels materials are continually produced by the decay of the plant and animal matters, but rate of the production is very slow and takes many of years, very much slower than the rate of at which we use them. Any non-renewable energy in this resources that we use are not replaced in the reasonable amount of the time and are thus we considered "used up", not be available to us again. In the industry, domestic areas we use the inverter for the appliances power supply units. Their Inverter efficiencies typically are declared is calculated as a fraction of AC output which divided by DC input power. Inverter manufacturers and system installers are assume that the inverters are normally working at the condition of maximum power point (MPP) of the I-V curve of the PV array. In practice, there are a number of factors which cause the actual operating point to vary from the true MPP. For example, devices that use search algorithms to find the MPP have to move constantly around this optimal point thus operating the array off of MPP for some period of time. Search algorithms use finite time and voltage or current steps that may cause some error. These maximum power point tracking the inaccuracies conspire to reduce the conversion efficiency of the Photovoltaic array and therefore, in the entire system. MPPT performance is the important to system designers who are guaranteeing a certain system of performance and need to know all of the system losses as well as to system operators, who want to ensure that their solar system is operating per its specifications. Thus an inverter MPPT validation should include the MPPT performance. When pressed, inverter manufacturers may claim an MPPT accuracy or the efficiency, but this value is likely based on the resolution of the MPPT search algorithm, which is not on a measured performance. Appropriate methods of the calculation of the Maximum power point tracking performance - both for validation purposes and for field of verification - Its need to be defined, and, along with them, the terms and calculations to be used.

### A. Objective

The main objective of this paper is to develop a system based on Matlab GUI (Graphical User Interface) and Arduino control system, which can be used for MPPT tracking. In the Arduino platform we used to control the solar plates position and after tracking the sun with perfect position, we can be analysis the power gain generated during the tracking the sun. The Matlab based gui model helps to this analysis process. We can find the perfect angle and time of High gain MPPT.

## II. LITERATURE REVIEW

Many MPPT algorithms have been developed by the researchers and the industry delegates all over the world. They use the voltage feedback method, observation and perturbation method, linear-approximation method, the incremental conductance method, the hill climbing method, an actual measurement method, the fuzzy control method etc [3]-[8]. In the literature review by the [5], they use DSP chips to implement the function of the MPPT in order that the output of solar modules can approach its maximum power point by continuously perturbing the solar power and observing that. In the research of [6], the response in speed and applicability of perturbation and observation of maximum power and hill climbing methods are compared to the PV grid connected system. Moreover, [7] and [9] improve the calculation efficiency of the perturbation and the observation and the hill climbing methods in their researches. The requirements of the implementing of the maximum performance of a photovoltaic solar system are not only good weather conditions but also with an appropriate MPPT methods [10]-[11]. The aim of this paper is to study and compare the advantages, shortcomings and an execution of efficiency for three power-feedback type MPPT methods, in this paper including the perturbation & observation (P&O), an incremental conductance (INC) [12] and the hill climbing (HC) methods. Matlab and Simulink platform is used to implement the modeling and simulations tasks, and to compare the execution efficiency and the accuracy of the selected MPPT methods.

## III. MPPT ALGORITHMS

Maximum power point tracking (MPPT) is performed by some battery charge controllers and by most grid connected PV inverters. The principle is to adjust the actual operating voltage  $V$  (or current  $I$ ) of the PV array so that the actual power  $P$  approaches the optimum value  $P_{MAX}$  as closely as possible (see figure 1)

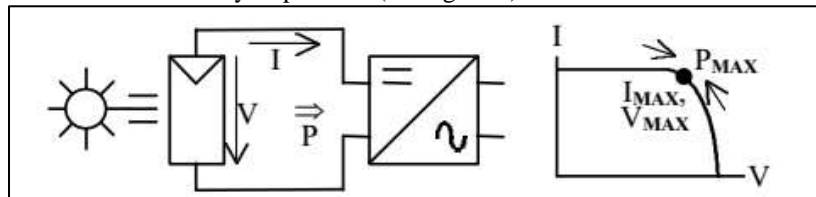


Figure 1: Maximum Power Point Tracking Principle

Many different ways exist to track the MPP which can be classified as either direct or indirect methods. Direct methods include algorithms that use measured DC input current and voltage or AC output power values, and, by varying the PV array operational points, determine the actual MPP. Adjustment of MPP may occur continuously or intermittent, and algorithms may well or not include artificial MPP search movements.

Indirect methods are those which use an outside signal to estimate the MPP. Such outside signals may be given by measuring the irradiance, the module temperature, the short circuit current, or the open circuit voltage of a reference solar cell. A set of physical parameters has to be given, and the MPP set point is derived from the monitored signal.

### A. MPPT Accuracy, Error, and Efficiency

Static and dynamic factors influencing MPPT behavior include:

- 1) Power (irradiance level),
- 2) Voltage (temperature; layout including well- or mismatched PV and MPPT voltage ranges),
- 3) Fluctuations (clouds),
- 4) PV technology (I-V curve shape)
- 5) Need (battery state of charge, in case of charge controller with MPPT).

Three terms can be used to describe how well an MPPT performs. They are functions of time (even under static conditions, due to MPPT search movements) and of additional parameters.

Accuracy (static and dynamic) indicates how close to MPP the MPPT operates the PV array and can be defined as a percentage of  $I_{MAX}$ ,  $V_{MAX}$ , or  $P_{MAX}$ :  $MPPT.X = X/X_{MAX}$  With  $X = I, V, \text{ or } P$

Efficiency indicates the ratio of actual to available PV array power (a particular case of accuracy) or energy [1]:

$$MPPT.P = P / P_{MAX}$$

$$MPPT.E = E / E_{MAX}$$

Error (static and dynamic) indicates the absolute or relative difference between actual and MPP values of voltage, current or power:  $MPPT.X = X - X_{MAX}$  (absolute) or  $X / X_{MAX} - 1$  (relative) with  $X = I, V, \text{ or } P$

Accuracy and efficiency are essentially the same, however, efficiency,  $MPPT.P$ , can be used to 'correct' the inverter's conversion efficiency as shown in figure 2. Since the MPPT operates the PV array as a constant voltage or constant current source, voltage or current error better describes what the MPPT is doing. Also, voltage or current error for a given MPPT varies only as a function of  $I_{MAX}$  and  $V_{MAX}$  whereas efficiency is additionally a function of the PV array I-V curve shape (fill factor).

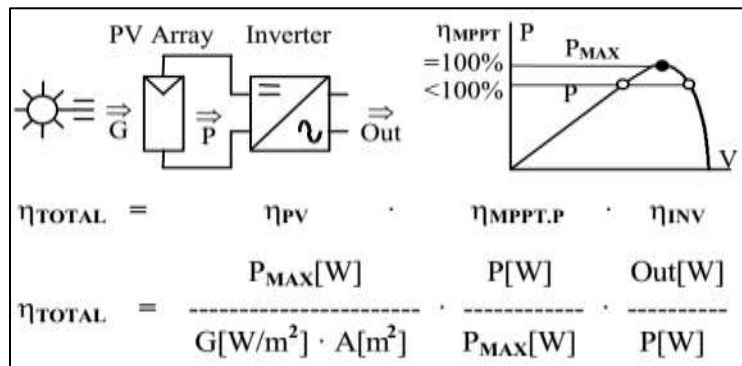


Figure 2: Efficiencies of MPPT and Power Conversion

#### IV. MPPT SOLAR TRACKING SYSTEM

In this paper we also used the hardware section which is based on Arduino platform. Four Light Dependent Resistors (LDR) as a light sensor have been used. It is named as LDR-1, LDR-2, LDR-3, LDR-4. LDR-1 for measuring the day light intensity, LDR-2 and LDR-3 for comparison purpose and movement of mirror, LDR-4 for solar panel movement. The LDR-4, light sensors is separated by divider which will create shadow on one side of the light sensor if the solar panel is not perpendicular to the sun. The light intensity falling on LDRs 2 and 3 should be greater than the light falling on LDR-1. For the controlling circuit, Arduino acts as a brain that controls the movement of the motor via relay. Data received from the sensors is processed by the Arduino. The microcontroller will send data to the two Bidirectional Johnson motors via relay to ensure solar panel is perpendicular towards the Sun. Relay controls the rotation of the motors either to rotate clockwise or anticlockwise. The solar panel that is attached to the motors will react according to the direction of the motor. If the LDR-4 value is high compared with reference at comparator ic lm324, the Johnson will rotate in forward direction. A reference value is set which is equal to the sum of the values of ldr 1 and half the value of voltage drop across rheostat RV1. If LDR-2 and ldr 3 values is low when compared with Reference, the mirror will rotate in forward direction until there is a shade in ldr2 or 3. Then the mirror moves in the reverse direction, until values of either 2 or 3 is greater than reference. Thus the solar panel and the mirror will automatically track towards the sun's maximum intensity throughout the day.

#### V. IMPLEMENTATION

We design a software gui model using Matlab platform. This model helps to handles for analysis purpose. We can be control the direction of Solar panel and measure the voltage, current and power rating using this system.

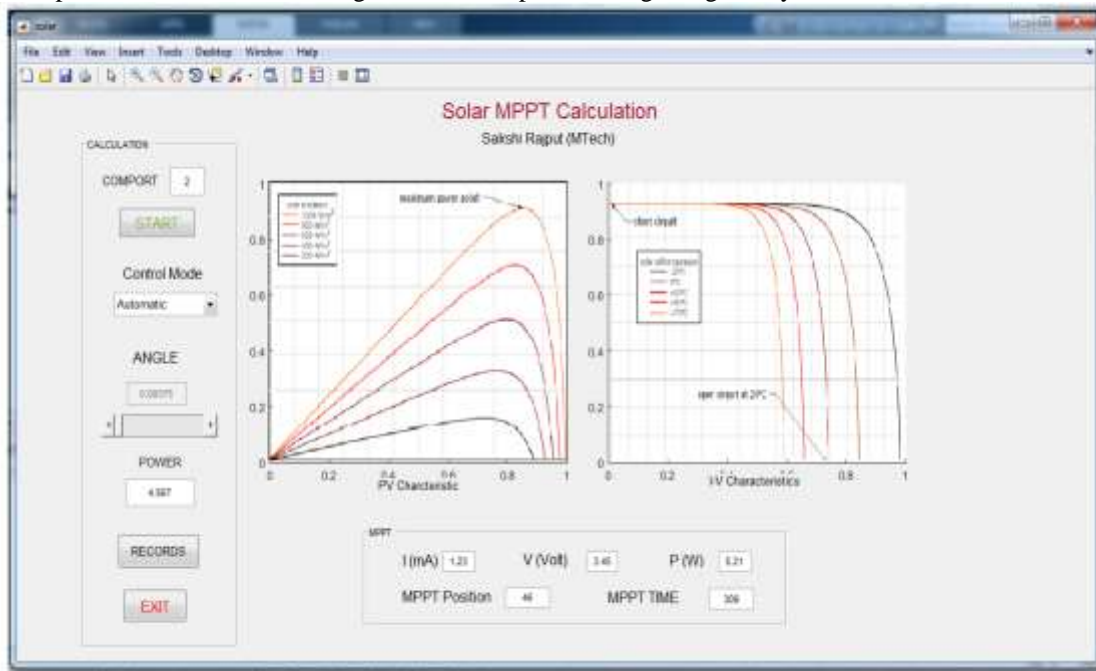


Fig. 3: A gui layout for solar MPPT System

We attached arduino with this system to control the solar plate. We use LDR as a sensor to check the sun light intensity level and the servo motor rotate the solar panle 180 degree. In using of voltage sensor we can be record the solar voltage and current.

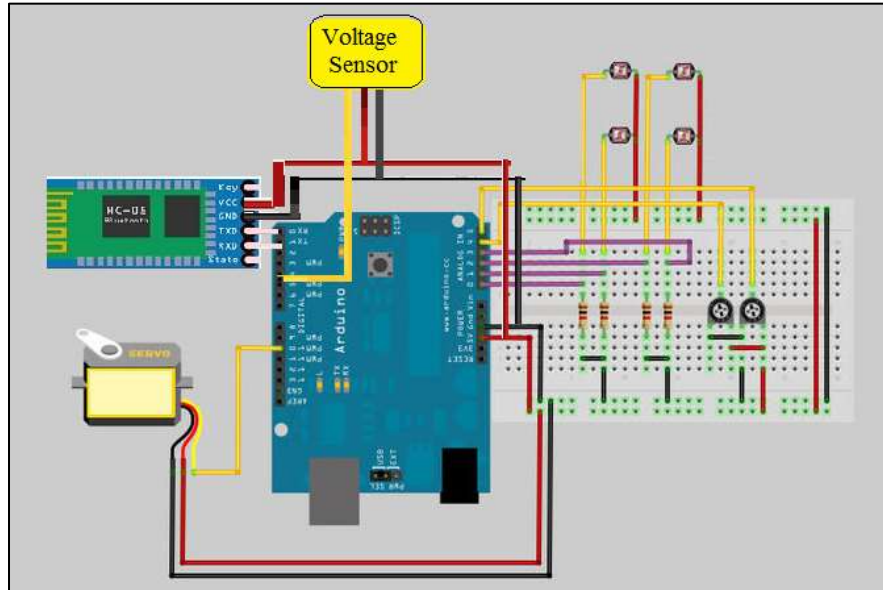


Fig. 4: A hardware implementation for solar MPPT system

## VI. EXPERIMENTAL RESULTS

We achieve different voltage and current rating in different angle and time. As shown in result we select the MMPT time in 1:00 pm to 1:30 pm. In this time we have maximum voltage in our solar panel.

Table – 1

Results respect with angle of plate and time

Angle	Time	Power(W)	Voltage(V)	Current (mA)
30°	9:30 am	17.542	3.5	50.12
45°	11:00 am	19.054	3.8	50.14
60°	12:30 pm	25.10	5	50.20
75°	1:00 pm	60.03	12	50.25
90°	1:30 pm	60.02	12	50.25
105°	3:00 pm	20.8	4	50.12
120°	4:00 pm	10.02	2	50.01

## VII.LIMITATIONS OF THIS SYSTEM

We have some of limitations in this system, In this system PV array change their direction according to the Sun direction but sometimes sun is covered with cloud in cloudy days. In this cloudy days this system cannot be work well. It reset the initial point of angle in PV array.

## VIII. DISCUSSIONS

The output power of the solar photovoltaic plate module varies according to the regular variation in the direction and position of the sun, variation in the solar insolation level. Also there is a single maximum power point in the photovoltaic characteristics of the PV module for a each operating condition. It is desired that because the PV module operates in close to this maximum power point. The process of the operating PV module at the MPP is called as maximum power point tracking (MPPT). Maximization of the PV power improves for the utilization of the solar PV module and which offers the main advantage of providing the high efficiency under the rapidly changing atmospheric conditions.

## IX. CONCLUSION

It can be concluded in this paper, that the proposed system will help to the calculation of P-V and I-V curves on MATLAB GUI platform by using the mathematical modelling of the Photovoltaic array. The PV array will operate with near to its maximum power point by using MPPT algorithm, which are used to track continuously the maximum power point. Thus in this way we can increase the efficiency of PV array. This system user can easily handle and control the measurement of solar MPPT.

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