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Maximum Power Point Tracking for PV System

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Abstract: This paper presents the design and practical implementation of Maximum Power Point Tracking (MPPT) for Photovoltaic (PV) system based on Perturb and Observe algorithm. A DC-DC converter is used to regulate battery charging. The system is controlled by using an Arduino based AVR Microcontroller (ATMEGA 16), sensing the solar panel voltage and generating the Pulse Width Modulation (PWM) signal to control duty cycle of the DC-DC converter. The ATMEGA16 microcontroller was chosen because it has the necessary features for our project such as built-in Analog-to-Digital Converter (ADC), PWM outputs, low power consumption and low cost. Additionally, we have also included "real time single axis solar tracking system" to our solar panel using LDR sensors, which improves energy extraction and efficiency. Implemented hardware demonstrate the effectiveness and validity of the proposed system in order to attain satisfactory results from the method. This paper mainly focuses on the successful use of ATMEGA16 controller in the execution of the MPPT calculation and its constructional highlights which help pick up the fitting and precise outcomes.
Keywords: Photovoltaic system, Analog-to-Digital Converter, AVR Controller (ATMEGA 16), Maximum Power Point Tracking, Pulse Width Modulation, DC-DC converter, Duty Cycle.

I. INTRODUCTION

In the modern era of electrical energy adaptation to the renewable energy is necessary due to the environmental aspects and dependence to coal. Renewable energy is a practical, affordable solution to our electricity needs. The main disappointment to renewable energy is the low utilization factor. The utilization factor can be improved with the help of modern technology.

Our work is on the analysis and implementation of the concept and algorithm of "Maximum Power Point Tracking" on a Photo Voltaic Array. Solar photovoltaic (PV) panels are a great source of renewable energy generation. The biggest problem with solar systems is relatively low efficiency and high cost. This work hopes to alleviate this problem by using novel electronic converter and control. An electronic DC/DC converter is designed for a Solar PV system. A Maximum Power Point Tracking (MPPT) algorithm is implemented through this converter by "using Arduino based Microcontroller (ATMEGA 16)". The algorithm used for MPPT is Perturb and Observe (P & O). This algorithm allows the PV system to work at its highest efficiency. Different current sensing and voltage sensing technologies used with the converter for the MPPT algorithm are offered and tested. Results from experiments will be presented. These results will show that the proposed converter and MPPT control algorithm improves overall PV system efficiency without adding much additional cost.

Additionally, we have also included "real time single axis solar tracking" system to our photovoltaic array, which improves energy extraction and efficiency. The basic aim is to charge the battery of 12V. Though there are some MPPTs already on the market, our team has decided to make our own MPPT using a converter and microcontroller. The following paper illustrates our thought process during the design of our MPPT, along with results of our working product. If MPPT is not used then the power received by the battery will be only 60-70% of the total value and the rest 30% will remain un-utilized and in order to fix this problem Pulse Width Modulation is used so that no portion of energy remains un-used or un-utilized. By which utilization factor of the system improves, the increase in utilization factor is the basic aim of our project.

A. About Photovoltaic Panel

PV panels generate electricity through what is called the "Photovoltaic Effect". In the least difficult frame the Photovoltaic Effect can be portrayed as takes after: Light particles called photons are always produced from the Sun. This can be seen by the brightness on a sunny day when many of these particles make it to earth's surface. The effect comes into play when these particles hit a PV material, such as a solar cell. When the photons impact this material it excites the atoms within the material, which causes an electron-hole pair to form. A band gap incorporated with the material makes the electron move along a specific predefined way. This electron-gap match creation happens many circumstances over, all through the panel. All of these flowing electrons generate a current that is directed out of the panel to some type of load. In this way, the photovoltaic impact changes over light into the more helpful type of energy, power. Sunlight based cells yield control in what is called an I-V curve. A typical I-V and P-V curve of a solar cell can be seen in Figure 1. This curve represents what the current output by the solar cell would be as the output voltage is varied and vice versa. This curve can be easily obtained from the I-V curve through the equation P = V x I.

There are three other important aspects of a solar cell also shown in Figure 1. The first two are the open circuit voltage (Voc) and the short circuit current (Isc) of the cell. The open circuit voltage is the voltage that is respect the cell terminals when the cell is exhibited to light and there is no current spilling between the terminals. This is also the maximum voltage that can be produced by the cell, which makes knowing this number useful when designing a circuit or load to connect to the cell terminals.

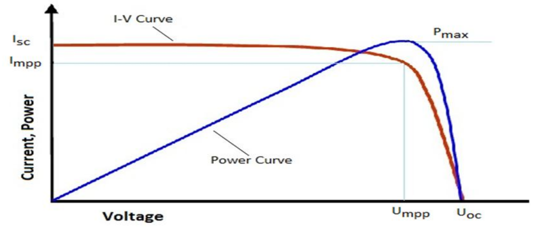

Fig- 1: I-V & P-V curve for a solar cell

The short circuit current is the current that will flow when the cell is under light and the terminals are shorted together. This is the maximum current that can be yield by the particular sunlight based cell. The third imperative part of a sun based cell is the MPP. This is the point where the cell is operating at maximum efficiency and outputting the highest power available. The MPP additionally has voltage at maximum power (Vmp) and current at greatest power (Imp) focuses related with it. Each individual cell is relatively little in size and can only produce a small amount of power. The Voc of an individual solar cell is usually approximately 0.6 V. The cells turn out to be considerably more valuable when consolidated in an exhibit to make a PV panel. When connected together the cells properties add together to create an I-V curve that has the same appearance as that of an individual cell but is larger in magnitude. The cells in a cluster are generally associated in arrangement to acquire a higher and more proper terminal voltage. The PV panel used in our project work has the following rating: -

V_{oc} = 21.5V I_{sc} = 0.7A
V_m = 17.5V I_m = 0.6A
P_m = 10W.

B. Maximum Power Point Tracking

A MPPT system works similarly as it sounds it would. The system tracks the MPP under fluctuating conditions and after that executes a type of calculation to modify the converter so it will hold the boards control yield at the most noteworthy point for that given time. By and large, the following system finishes this assignment utilizing current and voltage estimations to discover the power yield of the PV panel at the present time. The particular calculation at that point takes this data and ascertains the changes that should be made to the circuit with a specific end goal to enable the panel to create more power from outside the system, by utilizing outer information streams which are perused from the outside world. The alterations made to the converter are more often than not as an adjustment in the obligation cycle controlling the converter. The impact is that an adjustment in obligation cycle changes the yield voltage. In a converter not associated with a PV panel this expansion in yield voltage would be caused by the converter enabling more info current to go through it. The qualities of a PV panel combined with this impact are what enable MPPT to happen.

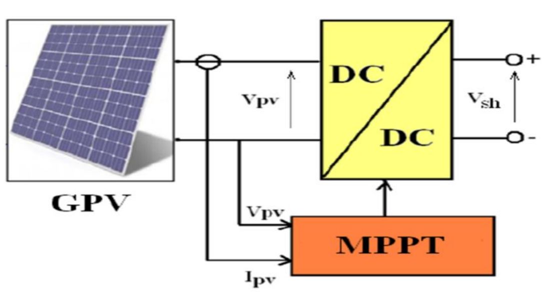

Fig- 2: I-V & P-V curve for a solar cell

At the point when the current of a PV panel expands the voltage will inevitably start to diminish, and when the voltage builds the present will in the long run diminish. At the point when the obligation cycle of the converter is expanded the current permitted to go from the PV panel to the converter is expanded. This causes the PV panel to move from the point it is at present working at on the I-V bend to the following point with a higher current yield, moving left. This thus diminishes the voltage yield by the PV panel. Once the working purpose of the panel can be changed a calculation can be actualized to control this change, subsequently framing a MPPT system. Every calculation may act distinctively yet this is the reason for most all MPPT systems. In the wake of considering in the qualities and lacks of every calculation, the P&O strategy is utilized as a part of this task.

There are 3 different ways to implement MPPT: -

Perturb and Observe (P&O).

Incremental Conductance.

Fuzzy Logic.

In our project, we have implemented the first one, that is, the P&O algorithm of implementing MPPT.

C. Perturb and Observe (P&O) Algorithm

The P&O algorithm is a relatively simple yet powerful method for MPPT. The algorithm is an iteration based approach to MPPT. A flowchart of the method can be seen in Figure 3.

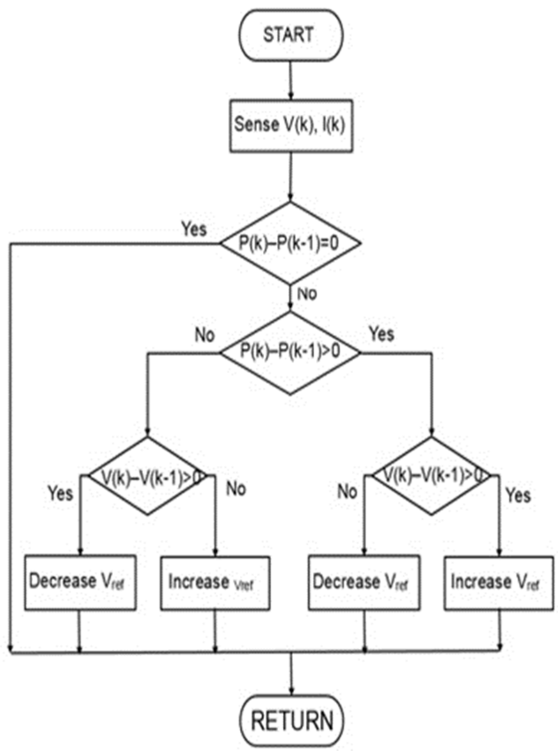

Fig- 3: Perturb and Observe Algorithm

The initial phase in the P&O calculation is to detect the current and voltage by and by being yield by the PV panel and utilize these qualities to figure the power being yield by the panel. The calculation at that point looks at the present power against the power from the past cycle that has been put away in memory. On the off chance that the calculation is simply in the main cycle the present power will be looked at against some steady put in the calculation amid programming. The system thinks about the distinction amongst present and past forces against a predefined consistent. This consistent is put inside the calculation to guarantee that when the technique has discovered the MPP of the PV panel, the obligation cycle will stay steady until the point when the conditions change enough to change the area of the MPP.

D. ATMEGA16 AVR Controller

AVR is a group of microcontrollers created by Atmel starting in 1996. These are altered Harvard engineering 8-bit RISC single-chip microcontrollers. AVR was one of the principal microcontroller families to use on-chip streak memory for program stockpiling, rather than one-time programmable ROM, EPROM, or EEPROM utilized by different microcontrollers at the time.

bit superior microcontroller from the Atmel's Mega AVR family. Atmega16 is a 40 stick microcontroller in view of improved RISC (Reduced Instruction Set Computing) engineering with 131 intense directions. It has a 16 KB programmable blaze memory, static RAM of 1 KB and EEPROM of 512 Bytes. The continuance cycle of blaze memory and EEPROM is 10,000 and 100,000, individually. The vast majority of the guidelines execute in one machine cycle. It can take a shot at a maximum recurrence of 16MHz. ATmega16 stick graph ought to illuminate things a bit

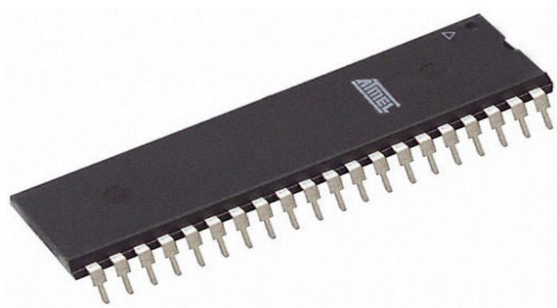

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Fig- 4: ATMEL'S ATMEGA16 Controller

There are 32 I/O (input/yield) lines which are separated into four 8-bit ports assigned as PA, PB, PC and PD. ATmega16 has different in-manufactured peripherals like USART, ADC, Analog Comparator, SPI, JTAG and so forth. Every I/O stick has an elective errand identified with in-fabricated peripherals.

AVR controller is used in our application in order to get smooth aftereffects of maximum power from irritate and watch system calculation.

1) Pin Diagram of ATMEGA16

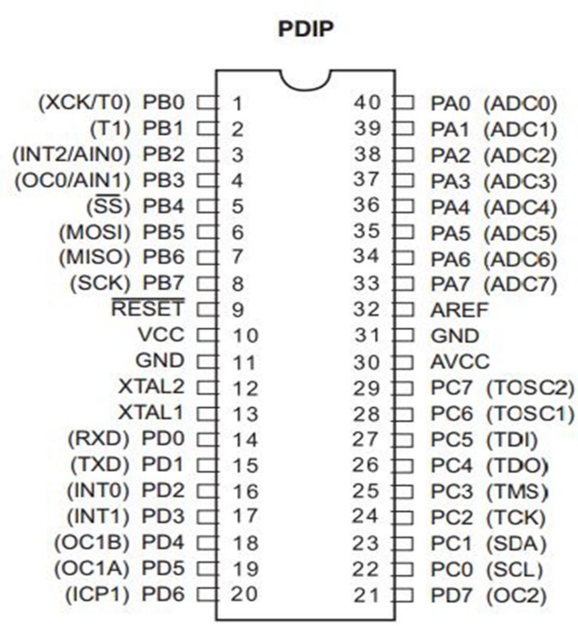

Fig- 4: Pin diagram of ATMEGA16 controller

Fig.4 given above gives us the fundamental thought regarding the AVR controller circuit which contains 40 pins to which different info and yield ports can be associated. This microcontroller is utilized as a part of the usage of bother and watch calculation so as to accomplish stable maximum power purpose of the sun powered panel in a brief timeframe term. AVR controller due to its multi-operational parameters and simple execution in the circuit enhances the fluctuating idea of energy v/s voltage bend of the 10W sun oriented panel.

II. HARDWARE IMPLEMENTATION

For our undertaking, a microcontroller expected to perform three particular capacities and those were as per the following:

A. Give the right recurrence of the PWM square wave,
B. Figure the power utilizing the current and voltage perusing got from the DC/DC converter without fail,
C. Actualize 'Perturb and Observe' calculation that contrasted the past power with new power and changed the obligation cycle of PWM to track the maximum power point effectively.

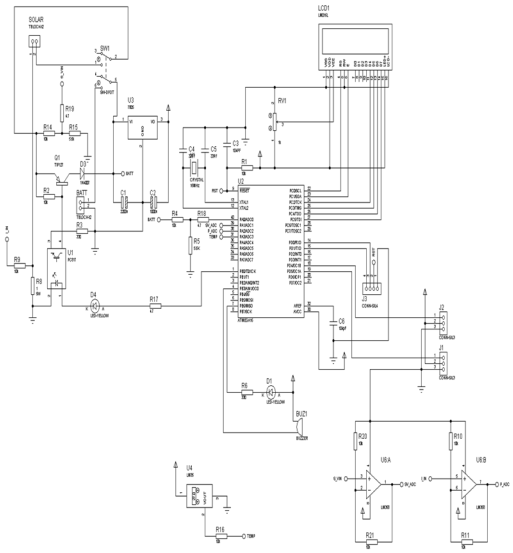

Fig- 10: Circuit for hardware implementation

We used a current sensor along with a voltage sensor to implement the algorithm, we were able to get the change in duty cycle.

Fig- 11: Hardware Implementation of MPPT

The LCD display of 2*16 demonstrates the yield estimations of voltage and current from which we can assess the estimations of maximum power.
The estimation of maximum power is gotten after the controller plays out various motions around the pinnacle point.

III. RESULTS

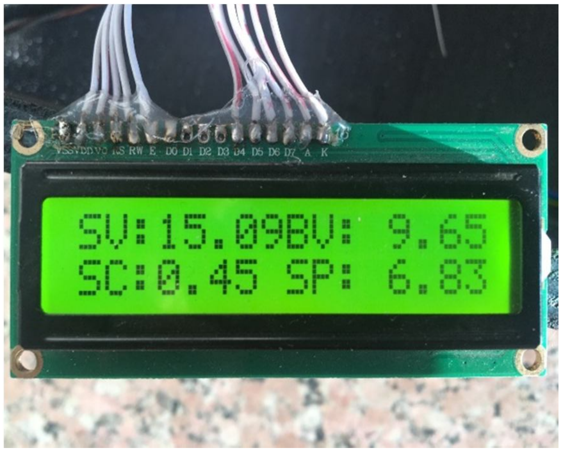

Fig- 11: Project Output

The value of solar voltage (SV) here is 15.09V, whereas the value of solar current (SC) is 450mA and the Solar power (SP) is 6.83W.

Fig- 11: Project Output

Similarly, the value of solar voltage (SV) here is 14.65V, whereas the value of solar current (SC) is 440mA and the Solar power (SP) is 6.44W.

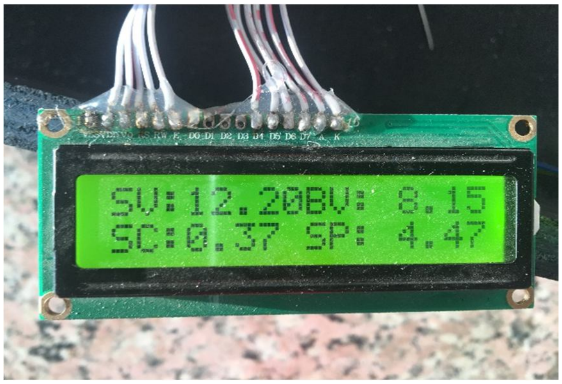

Fig- 11: Project Output

Similarly, the value of solar voltage (SV) here is 12.20V, whereas the value of solar current (SC) is 370mA and the Solar power (SP) is 4.47W.

The observations shown above signifies with the help of perturb and observe technique we can obtain the required value of maximum power of the panel.

IV. CONCLUSION

From the above execution of Perturb and Observe calculation obviously the MPPT control acquired after the lift converter shifts the voltage level, will bring about the power almost as same as the power which is gotten from the PV panel. This implies by controlling the PWM of the lift converter, we have acquired the greatest power. By utilizing the AVR controller, the maximum power is conveyed by the panel and 12V battery is charged individually and results are gotten easily and precisely.

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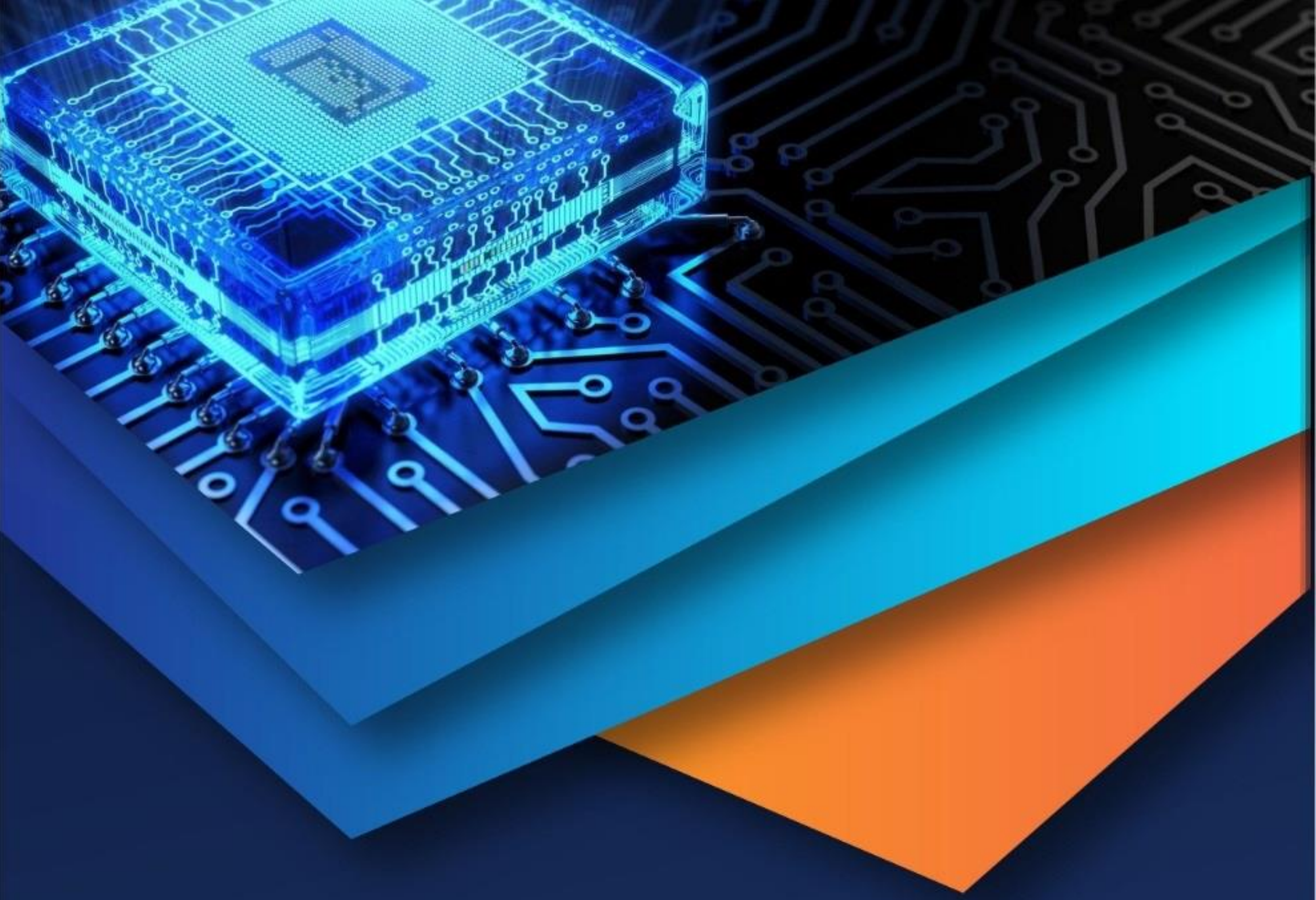

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