



## Design and Implementation of MPPT Algorithm for Solar Energy System

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**Abstract**— Renewable energy sources such as solar energy are acquiring more significance, due to shortage and environmental impacts of conventional fuels. The photovoltaic (PV) system for converting solar energy into electricity is in general costly and is a vital way of electricity generation only if it can produce the maximum possible output for all weather conditions. This paper presents the design and practical implementation of the real-time P & O algorithm for maximum power point tracking (MPPT) control in a photovoltaic (PV) system. The PV system usually consists of a PV array that converts solar energy to electrical energy, a DC/DC converter that converts low dc voltages produced by the PV array to a high dc voltage (Buck boost converter), which is directly connected to load or battery. A DSP that controls the total system and implement the MPPT algorithm by controlling the current and voltage of the PV array. The MPPT algorithm is vital in increasing the efficiency of the system. A 100 W prototyping PV system was implemented with a buck boost dc-dc converter using a DSP controller to execute the proposed MPPT algorithm. An MPPT algorithm was tested for fast changing environmental conditions, and the test results are analysed. These are very useful to design low power residential application.

**Keywords**— MPPT Algorithm, modelling of solar system, buck boost converter, solar characteristics,

### I. INTRODUCTION

Because of combustion of fossil fuels global warming caused by environmental problems, the raising prices of crude oils and natural gases. They promote continuous effort to improve energy system and its efficiency. There is a need to search for abundant and clean energy sources due to the depleted and increasing prices of oil. Solar energy acts as an alternative renewable energy source. Photovoltaic cells are used as renewable energy system. Photovoltaic (PV) cells can be used to generate dc voltages and given to Buck boost converter. The buck boost converter output is given to battery. Buck boost converter gives constant output which will control by PWM controller and feedback control system.

### II. Modeling Of Solar Pv Cell

The working condition of the solar cell depends mainly on the load and solar isolation. They operate in the open circuit mode and short circuit mode. Based these characteristics, the output voltage, current and power can be computed.[1]

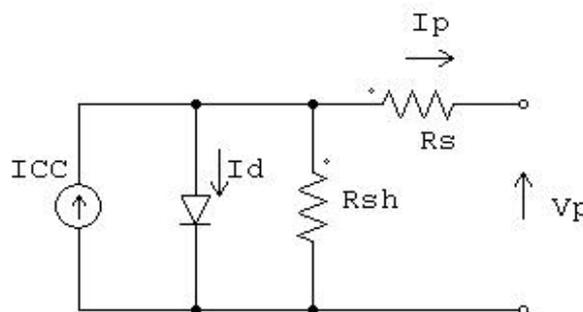


Fig.1 Equivalent Solar cell model

$I_{ph}$  – Photodiode current

$V_d$  – Diode voltage

$I_d$  – Diode current

$n$  - Diode factor (1 for ideal and  $>2$  for real conditions)

$I_o$  - Reverse saturation current

$T$  - Temperature for the solar arrays panel in kelvin

$K$  – Boltzmann's constant =  $1.38 \times 10^{-23}$  J/K

$Q$  – Electron charge =  $1.6 \times 10^{-19}$  C

$R_s$  – Intrinsic series resistance usually in milli-ohms  $R_{sh}$  – Shunt resistance usually in kilo-ohms

The I-V characteristics of a solar cell while neglecting the internal shunt resistance is given by

$$I_{out} = I_{ph} - I_o \left[ \exp \left( \frac{q}{nKT \ln(V + I_{out}R_s)} \right) - 1 \right] \quad (1)$$

In the event that the circuit is shorted indicating that the output voltage is =0. The current through the diode is being omitted. The short-circuit current,  $I_{sc} = I$  can be represent by

$$I = I_{ph} - \frac{R_{sf}}{R_{sh}} \quad (2)$$

Generally with the relationship that exists between  $I_{sc}$  and  $I_{ph}$ , the output current is given below. From the relationship, output current is approximately the almost the same as the photocurrent.

$$I = I_{sc} = \frac{I_{ph}}{\left( \frac{1+R_{sf}}{R_{sh}} \right)}$$

When the circuit is in open-circuit mode, the output current  $I$  is =0. At this point, the open-circuit voltage,  $V_{oc}$  is calculated.

$$V_{oc} = V_{max} = \left( \frac{(nKT)}{q \cdot \ln \left( \frac{I_{ph}}{I_o} \right)} \right)$$

The output power can be expressed based on the open circuit voltage and short circuit current.

$$P = IV = \left( \frac{I_{ph} - I_d - V_d}{R_{sh}} \right) = V \quad (3)$$

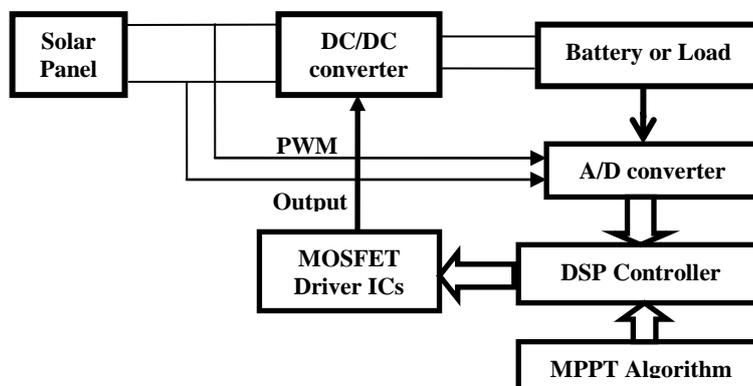
The  $P_{max}$  relationship is also represented in terms of  $V_{mppt}$ . The  $P_{max}$  is the maximum output power and  $V_{mppt}$  is the optimal output voltage.[2]

$$P_{max} = I_{ph} \left\{ \begin{array}{l} V_{oc} - \left( \frac{nKT}{q} \right) \ln \left( \frac{1 + qV_{mppt}}{nKT} \right) - \left( \frac{V_{oc}}{qV_{mppt} + nKT} \right) + \\ nKT \left( \frac{1}{V_{mppt}} \right) \ln \left( 1 + \frac{qV_{mppt}}{nKT} \right) \end{array} \right\}$$

$I_{ph}$  – Photodiode current

$V_d$  – Diode voltage .

### III. BLOCK DIAGRAM OF PROPOSED WORK



### IV. DC-DC CONVERTER

Switch mode DC-to-DC converter are normally use to convert the unregulated Direct Current (DC ) input sources into controlled DC output at certain or required voltage level. Buck-Boost converter is combination of a buck and boost converter. It can be an non inverting topology where the output voltage is of opposite polarity as the input. It can also act as a buck converter follow by the boost converter function. From figure 2, when the switch is in the “on state”, the inductor stored the energy in the magnetic field as it is connected with the source voltage where currents

will flow through. The diode is reversed biased and hence no current can flow to the load through the diode. The capacitance will provide current in this “Ton” situation. When the switch is off, inductance is disconnected from the source and there will be no current drop which the inductance will reverse it EMF. A voltage is generated as the diode at this time is forward biased; current will flow in the load and charged up the capacitance.

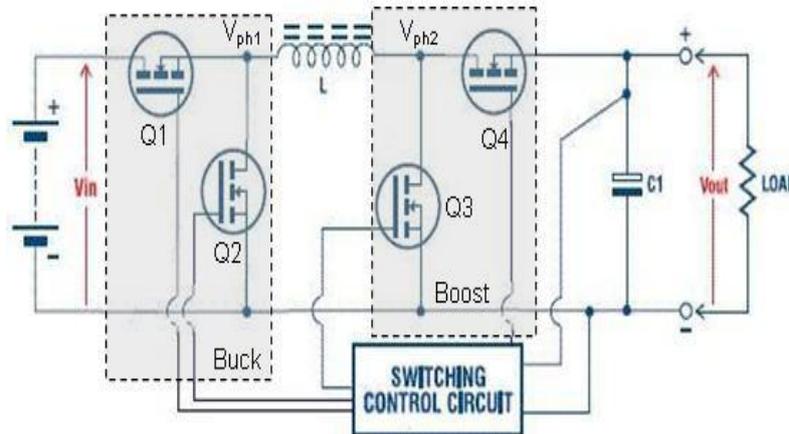


Fig.2 Buck Boost Converter

The converter is made up of an input source voltage, an inductor, a switch, capacitor and the output load. This type of configuration is used to boost up the output voltage with a lower input source. Most of the designs usually specified they require value of input voltage, output voltage and the load current whereas the inductor and ripple current are free parameters. To reduce a ripple, a larger value of inductor should be able to reduce it since it is inversely proportional to the ripple current. Likewise when choosing the inductor, it should ensure the saturation current is greater than the inductor peak current and able to cope with the rms current. It should be noted a light load for the circuit can go in discontinuous mode. By choosing a large value inductor, the ripple current is two times larger than the minimum load current, the inductor will always operate in continuous mode. [5]

When the switch is close or on state, the voltage across the inductor is represented by equation .

$$V_L = L \frac{di}{dt} = I_{LPK} / t_{on}$$

The current across the inductor is expressed by.

$$I_{Lon} = [V_{in} - V_{sat} / L] t_{on}$$

When the switch is open or on state, the voltage across the inductor is given by

$$V_L = L \frac{di}{dt} = [I_{Lmin} - I_{LPK} / t_{off}]$$

The current across the inductor is given by

$$I_{Loff} = I_{LPK} - [V_{out} + V_F - V_{in} / L] t_{off}$$

The duty cycle is given as:

$$D = t_{on} / t_{on} + t_{off}$$

The ratio of the on-time and off-time can be represented by equation

$$t_{on} / t_{off} = V_{out} + V_F - V_{in} / V_{in} - V_{sat}$$

The required minimum inductance value can be expressed as

$$L = (V_{out} - V_{in} + V_F) (1 - D) / \min(i_{load}) f$$

The capacitor value can be calculated when the ripple voltage is present at the output as follows

$$C_{out} = (I_{out} / V_{ripple}) t_{on}$$

$$V_{out} = V_{in} / (1 - D)$$

The value of D is varies in the range of  $0 < D < 1$ . The lowest output voltage value is when  $D = 0$ , which the output voltage equals  $V_{in}$  and when D approaches unity, the output voltage tends to infinity.

### B .Buck Converter

Buck converter components elements are the same as the Boost converter, except the arrangement of the power switch, Inductor and diode are slightly different. Again the operation consists of varying the switching duty cycle of the power switch to obtain desire output voltage. However, this time is to step down from a higher voltage to a lower voltage.

$$V_{out} = V_{in} D$$

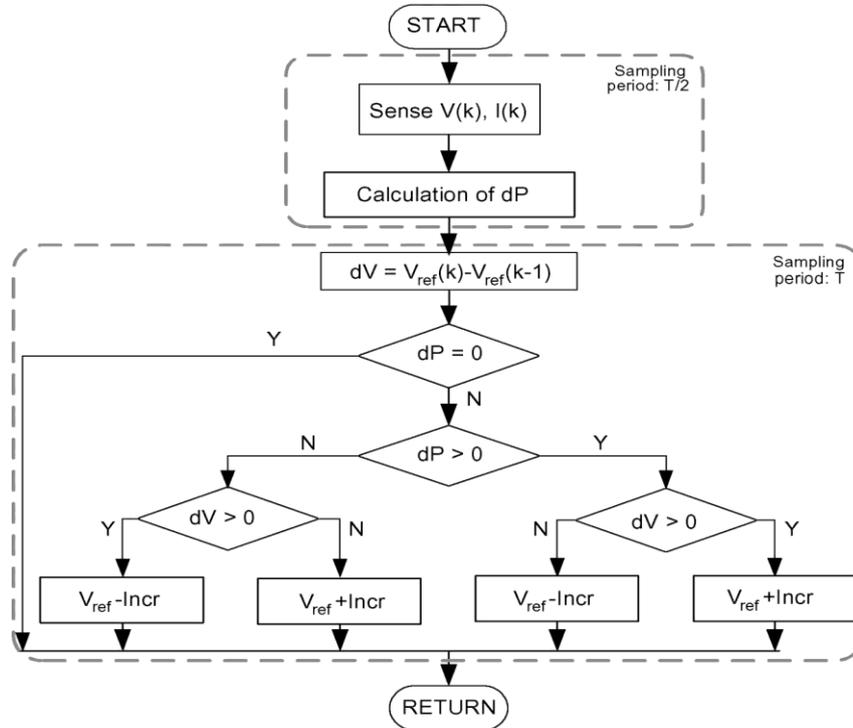
It is clear that the output voltage depends directly on the duty cycle. If the duty cycle is 50%, output voltage will be one half of the input voltage.

#### IV. Mppt Alorighm

The MPPT controller circuit helps to determine the maximum output power of a PV cell that can be fully utilized efficiently. Using a voltage or current sensor at the output of the PV cell stimulator circuit, with the appropriate detector circuit, the voltage and current value could be monitor. by looking at the drop in current, that is where the peak voltage value can be obtained.[2]

Perturb and Observe method

In a hill-climbing method based system, gradient of the output power is calculated by the means of varying the operating current till a point where the curve will look like the peak of a hill until the gradient reaches almost zero. This method actually takes references from the actual output power detection of the photovoltaic and thus the Maximum Power Point Tracking can be obtained even if the optimum operating points fluctuate due to irradiance and temperature problems. [3] The hill climbing method is one way to be implemented on tracking the power. The algorithm flowchart is as shown



#### V. Implementation

To test the performance of this MPPT algorithms, as per above block diagram, The setup consists of 1) a DC/DC converter, 2) a solar array simulator, 3) a DSP control board, 4) battery.

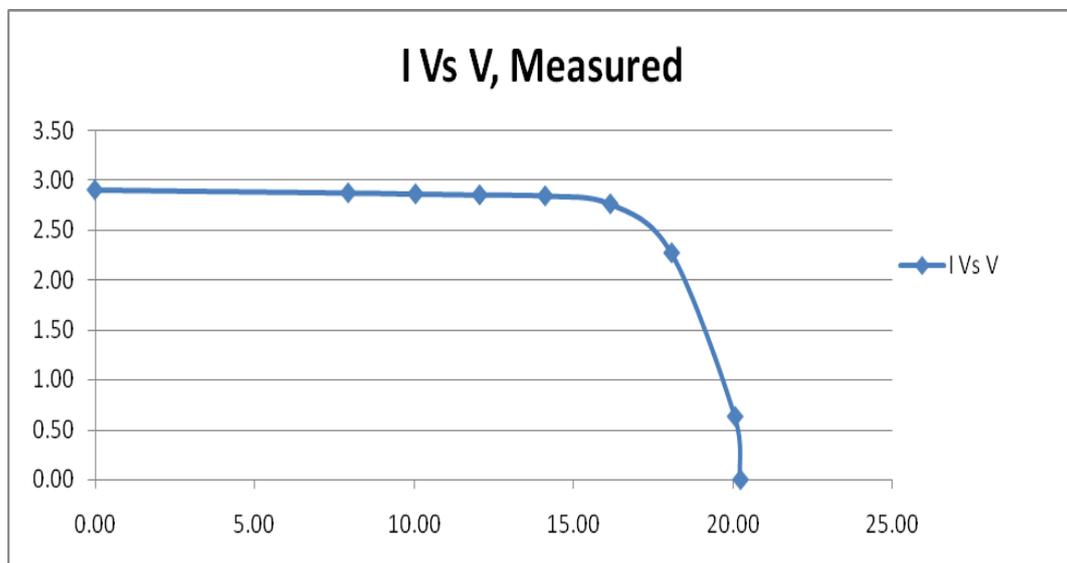
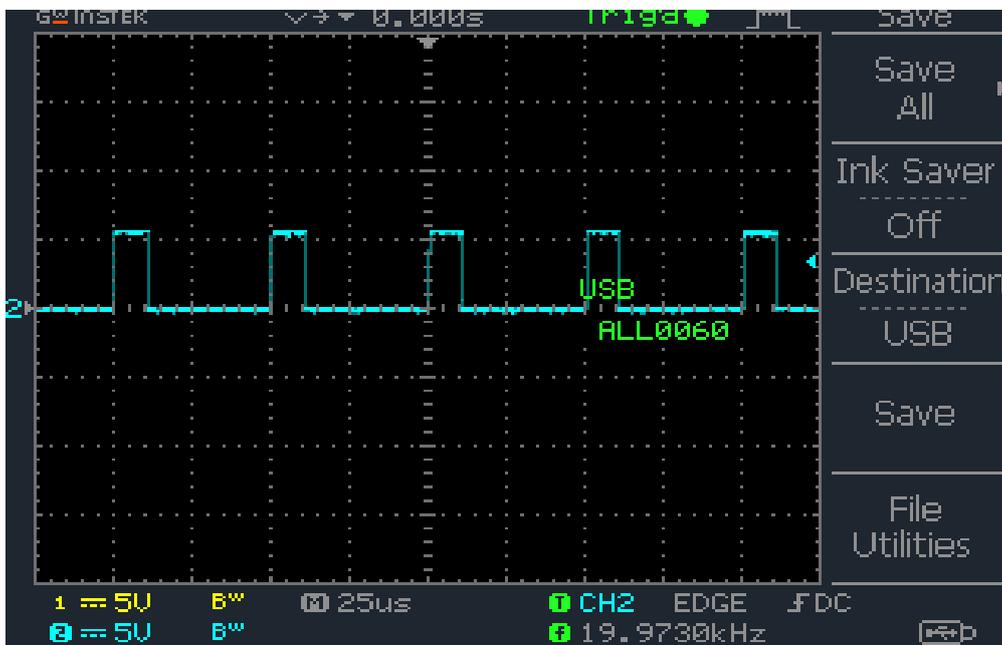
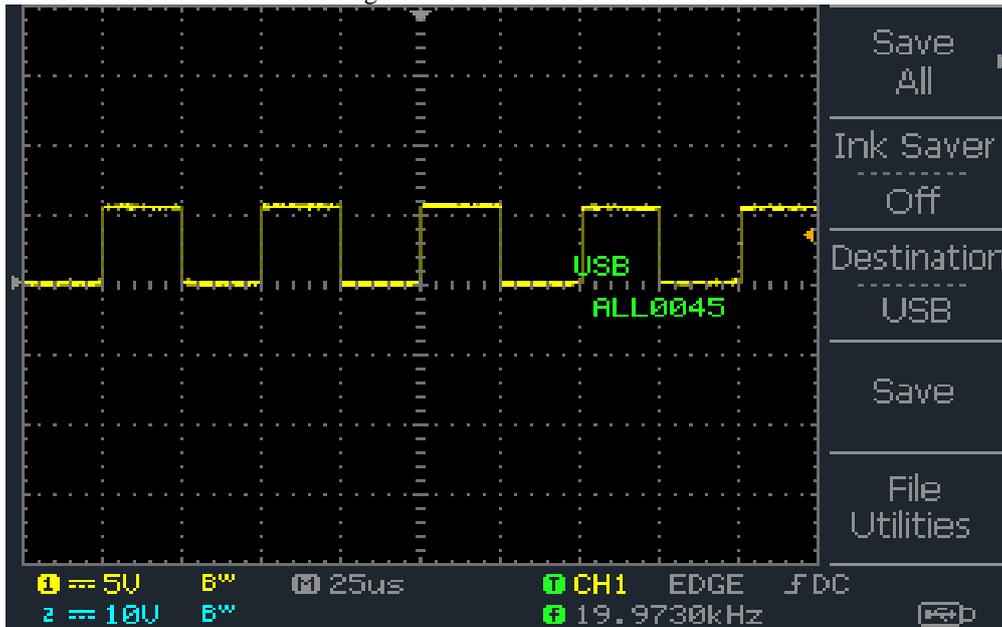
The MPPT algorithm and the control of the DC/DC converter were implemented of TI TMS320F2812 DSP. The DSP measured the input current and input voltage though the A/D module and calculated the power obtained from the SAS. The DC/DC converter is a working at a switching frequency of 100 KHz. The different values of parameters are as below

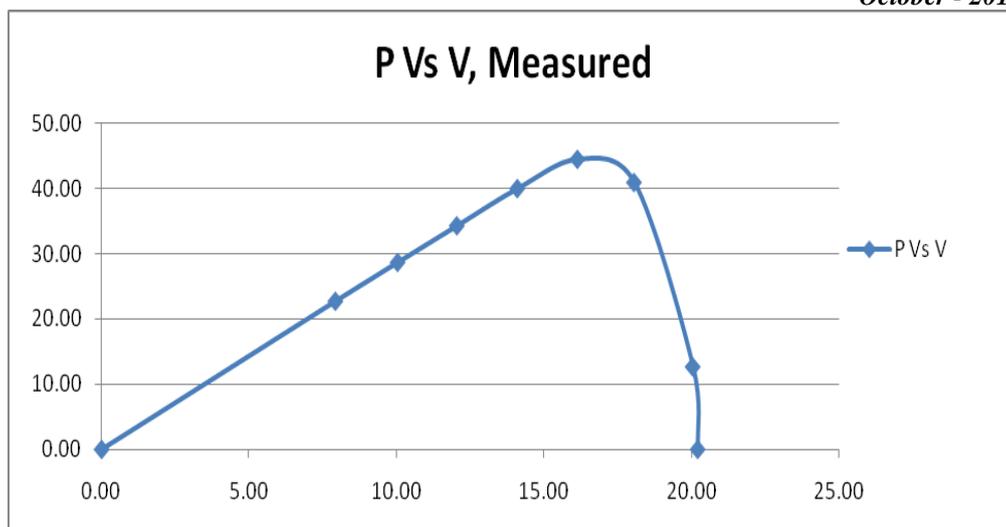
Parameter	Value
Inductor	210 H
Capacitor	10μF
MOSFET	10A,400V

#### VI. Experimental Results

PV Side			Battery			% Eff
V	I	P	V	I	P	
0.00	2.90	0.00	24.12	0.00	0.00	0.00
7.93	2.87	22.76	24.12	0.83	20.02	87.96
10.04	2.86	28.71	24.14	1.07	25.83	89.95
12.05	2.85	34.34	24.14	1.28	30.90	89.97
14.10	2.84	40.04	24.18	1.51	36.51	91.18
16.14	2.76	44.55	24.18	1.61	38.93	87.39
18.06	2.27	41.00	24.22	1.48	35.85	87.44
20.05	0.63	12.68	24.16	0.43	10.39	81.91

PWM Signals for Buck and Boost converter





## VII. Conclusion

In this paper, the development of maximum tracking algorithm is presented and implemented by using DSP processor which gives the maximum efficiency of solar system. In this we have developed DC-DC Buck boost converter which gives constant output voltage and system becomes more efficient and stable. Also different parameters of the circuit calculation is carried out. Solar system characteristics are verified. Different methods of PWM control is studied by using this algorithm.

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