Microcontroller based Constant Voltage Maximum Power Point Tracking for Solar inverter applications

M. N. Islam[1], A. Rahman[2], H. Akhter[3], M. Begum[4], Y. Mawla[5], K. Asaduzzaman[6], M. Hoq[7]

[1,2,3,4,5] Electronics Division, Atomic Energy Centre, Bangladesh Atomic Energy Commission, P.O. Box No. 164, Dhaka, Bangladesh.
[6,7]Institute of Electronics, Atomic Energy Research Establishment, Bangladesh Atomic Energy Commission, G.P.O Box 3787, Savar, Dhaka, Bangladesh.

Abstract— *Microcontroller based maximum power point tracking (MPPT) has been presented for single phase stand alone or grid connected solar inverter applications. The PV array consists of only 12V cell arrangement, thereafter, Discrete Comparator Circuit, The PIC microcontroller P16F676 controls the high power switching devices in the proposed MPPT scheme. The Constant Voltage (CV) algorithm continuously searches for the PV voltages in the rapidly changing weather conditions. The less pin and housing microcontroller does it all for the proposed Constant Voltage (CV) MPPT algorithm. The MPAB Simulation proves a very good agreement with the discrete comparator and switching devices for grid voltage, back-up battery charging and temporary load shedding operation. Therefore, until and unless MPPT voltages are in the operating region, the scheme allows grid voltage and back-up battery charging.*
Keywords— *Microcontroller, MPPT, Comparator, CV Algorithm and Solar Inverter.*

I. INTRODUCTION

Maximum power point tracking (MPPT) is a widely used control technique to extract maximum power available from the solar cells in a photovoltaic system [1]. The maximum power generated by the PV panel changes with the intensity of the solar radiation and the operating temperature. To increase the ratio output power/cost of the installation it is important that PV panel operates in the maximum output power point (MPPT) [2]. In this regard, A constant voltage maximum power point tracking (MPPT) algorithm that automatically adjusts the reference voltage to account for varying environmental conditions is presented. This simple, analog feedforward PWM controller was simulated by MATLAB/Simulink [3]. A New Technique for Tracking the Global Maximum Power Point of PV Arrays Operating Under Partial-Shading Conditions based on controlling a dc/dc converter connected at the PV array output .This technique can be applied both standalone or grid connected PV systems with unknown electrical characteristics and does not require knowledge about PV modules configuration [4]. In [5], analyses the improved modelling of solar PV module and proposes a genetic algorithm (GA) based maximum power point tracking. The GA optimized values are used to train the artificial neural network (ANN). The MPPT is simulated and studied by using MATLAB software.The MPPT uses an inexpensive micro-controller to perform all of its functions. This includes maximum power point tracking, series battery voltage regulation, sensorless short circuit protection of the MPPT's converter and intelligent shutdown and wakeup at dusk and dawn [6]. An integrated MPPT has been proposed by using a simple soft-switched topology for better efficiency and lower cost than external MPPT [7]. In the present research, a Constant Voltage (CV) or Open Circuit Voltage Ratio method Maximum Power Point Tracking (MPPT) has been proposed to control the efficiency of the PV array. Microcontroller based control algorithm has been employed with the MPPT scheme for single phase stand alone or grid connected solar inverter applications.

II. METHODOLOGY

2.1. Arrangement of PV Array

There is a wide flexibility for the arrangement of PV array starting from 12V to upper. In this prototype simulation 12V PV array gives the grid voltage of 500V (Peak) shown in fig.5.

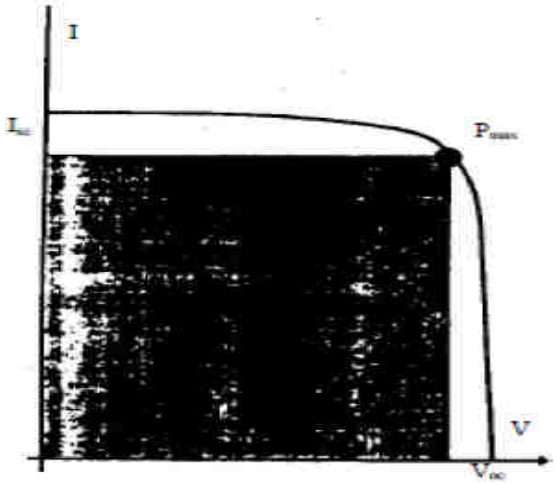

Fig.1: I-V characteristics of a solar cell with Maximum Power Point

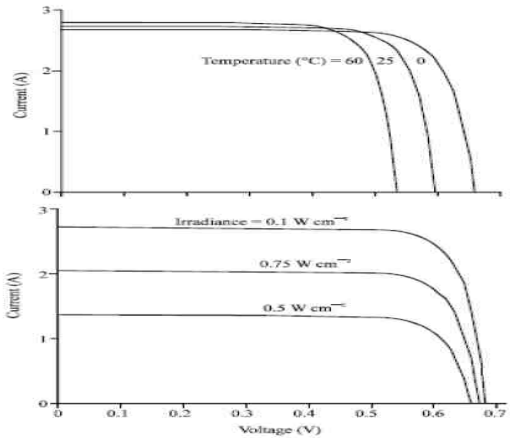

Fig.2: Temperature and Irradiance dependence on the I-V characteristics of a Solar Cell.

$$P_{\max} = V_m \times I_m = FF * V_{oc} I_{sc} \quad (1)$$

The maximum power P_{max} is produced by the device when the product of IV is maximum as shown in fig.1 where FF is the Fill Factor, open circuit voltage (V_{oc}) and the short circuit current (I_{sc}).

$$\eta = \frac{P_m}{E_c \times A_c} \quad (2)$$

The solar cell energy conversion efficiency (η) is the percentage of power converted and collected when a cell is connected to an electrical circuit. This term is calculated using the ratio of P_m divided by the input light irradiance under standard test conditions (E_c in Wcm^{-2}) as shown in fig.2 and the surface area of the solar cell (A_c in cm^2)

$$FF = \frac{P_m}{V_{oc} \times I_{sc}} = \frac{\eta \times A_c \times E_c}{V_{oc} \times I_{sc}} \quad (3)$$

Another defining term in the over all behaviour of a solar cell is the Fill Factor (FF). This is the ratio of the maximum power point (P_m) divided by the open circuit voltage (V_{oc}) and the short circuit current (I_{sc}). [8].

2.2. Block Diagram of the Proposed Scheme

The block diagram shown in fig.1 below comprises of PV Array, Discrete Comparator Circuit (lower comparator and upper comparator) Microcontroller Circuit and high power and high speed switching devices for grid voltage, charging battery back-up and optional load shedding operation.

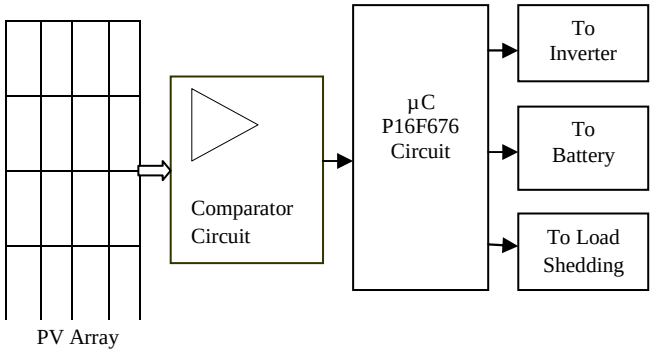

Fig.1: The Block Shows Elements of the Proposed

2.3. Schematic Diagram of the Proposed Scheme MPPT Scheme

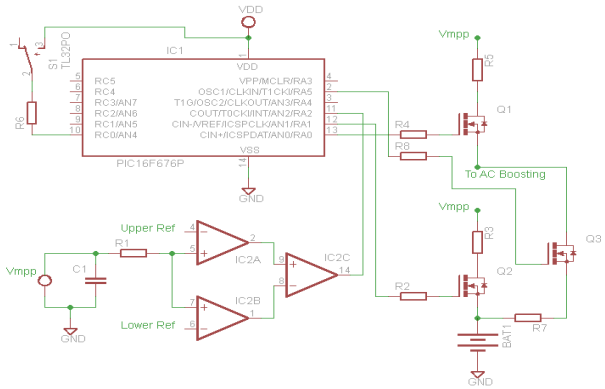

Fig.2: Schematic of the Proposed Maximum Power Point Tracking (MPPT)

On a clear day, if the solar irradiance is sufficient then the PV array gives proper DC voltage to Constant Voltage (CV) method microcontroller (P16f676) employed algorithm MPPT scheme. This scheme always checks for the proper DC voltage from PV array whether it would present or not. On a cloudy day or at night, when the solar irradiance is insufficient the scheme maintains off or performs temporary load shedding operation depending on the stoage battery.

The Constant Voltage Algorithm Voc is the open circuit voltage of the PV panel. Voc depends on the property of the solar cells. A commonly used Voc/Vmpp value is 76% [1, 9]. This relationship can be described by equation II.d.1 below:

$$V_{mpp} = K * V_{oc} \text{ Where k= 0.76 to} \leq 1 \quad (4)$$

2.4. Results and Discussion

Inverter, DC to AC, is very essential for most of the precise and sophisticated instruments and electrical and electronic systems to prevent a shutdown or damage or operation in case of power failure [10]. Therefore, a single phase Grid Connected/Standalone solar inverter topology has been proposed. The main goals of present study are as follows:

The chosen Maximum Power Point Tracking (MPPT) scheme comprises of PV Array, Discrete Comparator Circuit (lower comparator and upper comparator) Microcontroller Circuit and high power and high speed switching devices. The PV array generates the MPPT voltage for actuation in the comparator circuit. At initial stage, both lower and upper comparator gives logic low level output which yielded the final comparator to a logic low. Therefore, no interrupt has occurred in the microcontroller consequently no grid voltage and battery charging.

During solar hour when the solar irradiance is enough then the PV array voltage increased sufficiently the lower comparator went logic high that pushed final comparator to a logic high. Simultaneously, the microcontroller received an interrupt and as long as this state available the MPPT scheme gave grid voltage and battery charging. If this trend continued then the upper comparator went high and the both lower and upper comparator high the final comparator output became low. Consequently, the MPPT scheme operation is same as initial stage. The same thing goes for the dusk, dawn, cloudy day or at night. Therefore, until and unless MPPT voltages are in the operating region, the scheme allows grid voltage and battery charging.

Introduction of less pin and housing microcontroller for the proposed Constant Voltage (CV) MPPT algorithm. In this MPLAB simulation, the scheme maintains promising utilization of the available PV voltage. The proposed MPPT scheme would be suitable for Grid Connected/Standalone Solar System, IPS (Instant Power Supply) or UPS (Uninterrupted Power Supply). Constant Voltage Method based Maximum Power Point Tracking (MPPT) with Microcontroller employed control algorithm In the scheme, there is a Discrete Comparator (LM339) Circuit. The LM339 consists of four independent precision voltage comparators, with an offset voltage specification as low as 20mV max for each comparator, which were designed specifically to operate from a single supply over a wide range of voltages [11].

Then with a less pin and housing microcontroller followed by high power and high speed switching devices for grid voltage and back-up battery charging which would be used with when needed load shedding operation. In Lower Comparator with a 9.12V (76% of Voc) reference and Upper Comparator coupled with open circuit voltage (Voc) reference.

Thereafter, these pulses are then applied to external interrupt pin of the microcontroller (P16F676). The microcontroller controls the switching devices (IGBT-D) for grid voltage, back-up battery charging and temporary load shedding operation. Performing MPLAB Integrated Development Environment (IDE) Simulation. The complete design contains discrete electronics and programmable part. The MPAB Simulation proves a very good agreement with the discrete comparator and switching devices.

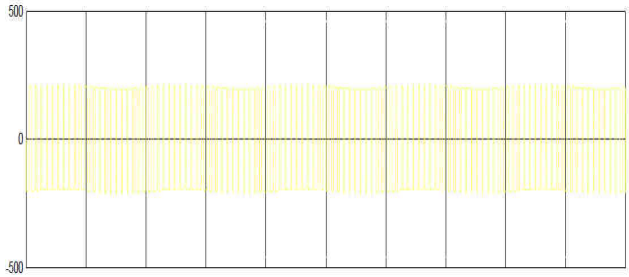

Fig.5: Shows the Grid Voltage 500V (peak) for 12V input in Matlab Simulation.

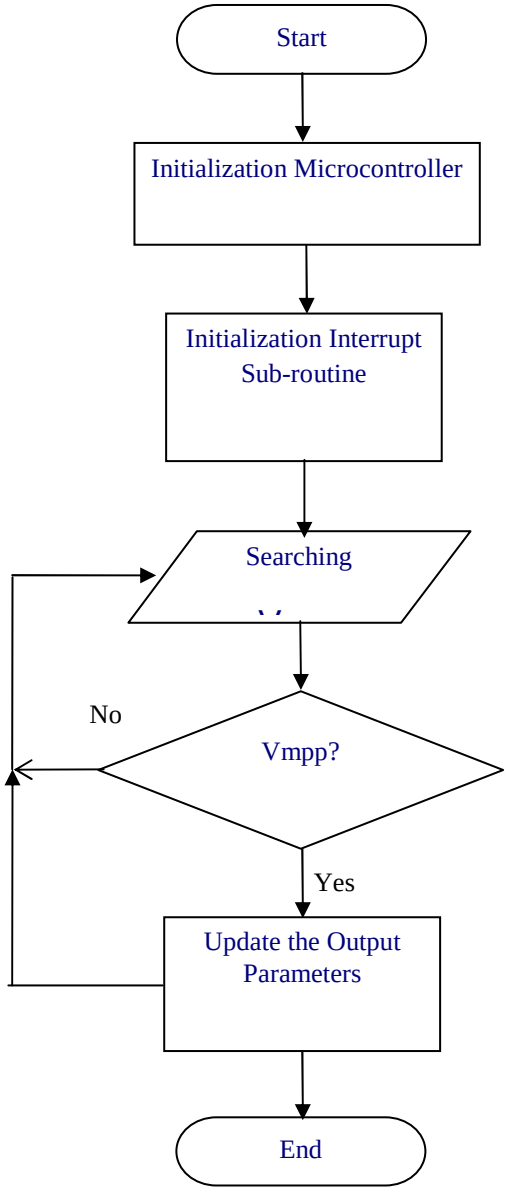

Fig.6: Shows the Program Flow Chart for the proposed MPPT Scheme.

III. CONCLUSION

Now a day, Inverter Topology is a very important research area in Power Electronics. In this context, Microcontroller based Constant Voltage Maximum Power Point Tracking for a solar inverter application has been proposed. In this research,

- The design process was analytical and simulation based on MPLAB Integrated Development Environment (IDE).
- Microcontroller (PIC 16f676) based control algorithm has been employed with the Constant Voltage (CV) or Open Circuit Voltage Ratio method Maximum Power Point Tracking (MPPT).
- The proposed MPPT scheme would be suitable for Grid Connected/Standalone Solar System, IPS (Instant Power Supply) or UPS (Uninterrupted Power Supply).

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