

Design and Implementation of Maximum Power Point Tracking in Photovoltaic Systems

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ABSTRACT: *This paper presents an algorithm for maximum power point tracking to optimize photovoltaic systems. Beta algorithm is a type of MPPT algorithm. It is having fast tracking ability. The algorithm has been verified on a photovoltaic system modeled in Lab VIEW environment. This algorithm significantly improves the efficiency during the tracking.*

KEYWORDS - *Photovoltaic cell, maximum power point tracking (MPPT), Beta method, LabVIEW.*

I. INTRODUCTION

The world population is increasing day by day and the demand for energy is increasing accordingly. Oil and coal as the main source of energy nowadays, is expected to end up from the world during the recent century which explores a serious problem in providing the humanity with an affordable and reliable source of energy. Renewable energy is derived from natural processes that are replenished constantly. Renewable energies are inexhaustible and clean. The energy comes from natural resources such as sun, wind, tides, waves, and geothermal heat. Solar energy is quite simply the energy produced directly by the sun. Solar energy is radiant light and heat from the sun harnessed using a range of technologies such as photovoltaic, thermal electricity and etc. A solar cell (also called a photovoltaic cell) is an electrical device that converts the energy of light directly into electricity by the photovoltaic effect.

A solar panel is a set of solar photovoltaic modules electrically connected and mounted on a supporting structure. The majority of modules use wafer based crystalline silicon cells or thin-film cells based on cadmium telluride or silicon. The structural member of a module can either be the top layer or the back layer. Electrical connections are made in series to achieve a desired output voltage and in parallel to provide a desired current capability. Several types of solar cells are available. Mono crystalline Solar Cells, Polycrystalline Solar Cells, Amorphous Silicon (a-Si) Solar Cells, Cadmium Telluride (CdTe) Solar Cells [1].

In general there is only one point on P-V and V-I curve called the maximum power point. At this point only PV system operates with maximum efficiency and produces maximum output power. A number of MPPT methods have been developed and employed in recent years, such as the Constant Voltage method, Perturb and Observe (P&O) method, Incremental Conductance (INC) method, Short-circuit Current method, Fuzzy Logic Control (FLC) and Genetic Algorithm (GA) etc [2-5]. The major drawback of P&O method a sudden change in the climatic condition, doesn't affect the duty cycle. The major drawback of P&O method a sudden change in the climatic condition, doesn't affect the duty cycle. The drawback in INC algorithm, after tracking the maximum power point that point is fixed for the duty cycle calculation. The advantage of the fuzzy logic control is that it does not strictly need any mathematical model of the plant. It is based on plant operator experience [6-8].

LabVIEW (short for Laboratory Virtual Instrument Engineering Workbench) is a system-design platform and development environment for a visual programming language from National Instruments. The software is perhaps the most important component of the system. The main routine, or VI, provides a front panel interface that allows the operator to control and monitor the system. It calls to perform functions that gather analog input, send analog output. The front panel is what allows the operator to control and monitor the process [9-11].

II. SYSTEM DESCRIPTION

The block diagram of general MPPT Photo Voltaic system is shown in the following figure. The photovoltaic Output voltage and current are given to MPPT algorithm and DC/DC converter. The algorithm used is to calculate the duty cycle for the converter in different irradiation level.

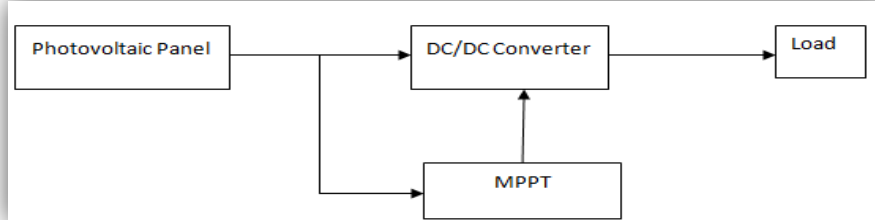


Fig - 1 Block Diagram of General MPPT System

III. MPPT ALGORITHM

Beta is a variable used to find the intermediate value between current and voltage. Beta is calculated by using the following equation.

$$\ln(I_{pv}/V_{pv}) - C \cdot V_{pv} = \ln(I_0 \cdot C) = \beta$$

Where I_{pv} denotes panel output current, V_{pv} denotes panel output voltage. C denotes conductance, is calculated by using

$$C = q / (\eta K T N_s)$$

Where q denotes the electron charge (charge carried out by single electron or photon $1.602176565 \times 10^{-19}$ coulombs), η denotes the quality factor of the junction panel, K denotes the Boltzmann constant ($1.380648813 \times 10^{-23}$ J/K), T represent the temperature, and N_s represent number of cells in series. It may be noted that β is independent of insolation but depends on temperature [12].

The initial step of the algorithm is to reading the output voltage (V_{pv}) and current (I_{pv}) measured from Photovoltaic panel. After getting the value V_{pv} and I_{pv} the β value is calculated. Check β value is in steady state or not. If β is in the steady state, then β is checked whether it is within range of steady state or not. if β in that range then it is switched to Hill climbing or other methods. After that same process repeated again from the initial state. If the β is not in steady state, it starts processing from initial steps. If the β is not in the steady state range and then error value is calculated. β_g , the value of β corresponding to the most probable array temperature is used as the guiding value.

$$\text{error} = \beta_g - \beta_a$$

The steady state value is calculated by a fixed temperature, the difference in the magnitude value of β at maximum power point lies smaller, from that β_{Min} and β_{Max} ranges are fixed. Smaller changes irradiation level made changes in wide range. β_{Max} is taken from maximum irradiation in maximum temperature. β_{Min} is taken in minimum irradiation and in minimum temperature. Both values β_{Min} and β_{Max} calculated at maximum power point. Error values are calculated from the difference between β_g and β_a . From that new duty is calculated, by summing the old duty cycle with the product of error and Boltzmann constant.

$$d_{new} = d_{old} + \text{error} \times k$$

d_{old} is the previous duty cycle, d_{new} is new duty cycle and K is a constant corresponding to the β plot. After that new duty cycle is checked whether the new duty cycle is lies between the d_{Min} and d_{Max} . From that duty cycle is calculated for DC-DC converter [13, 14].

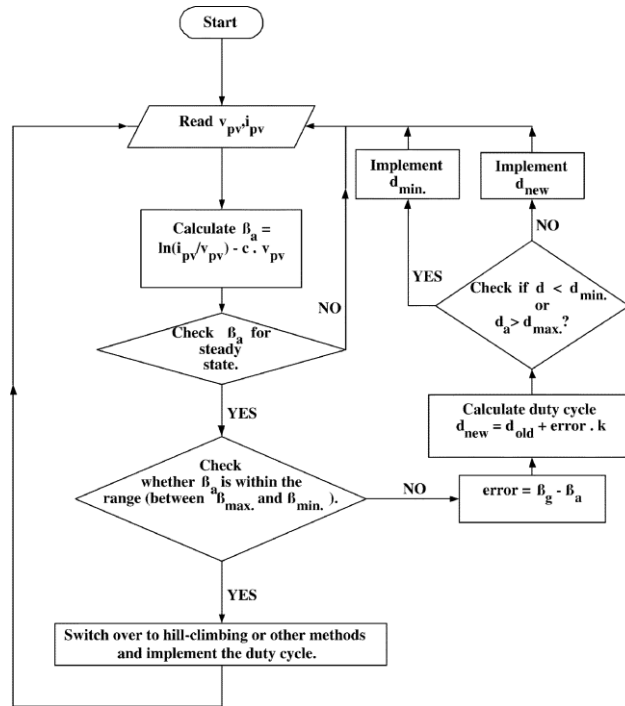


Fig – 2. Flowchart of the Beta Method

IV. SIMULATION OF THE PROPOSED ALGORITHM

The entire solar array converter system has been simulated in LabVIEW with a provision to feed the insolation, temperature, and output array voltage as input parameters and calculate the corresponding output array current and voltage.

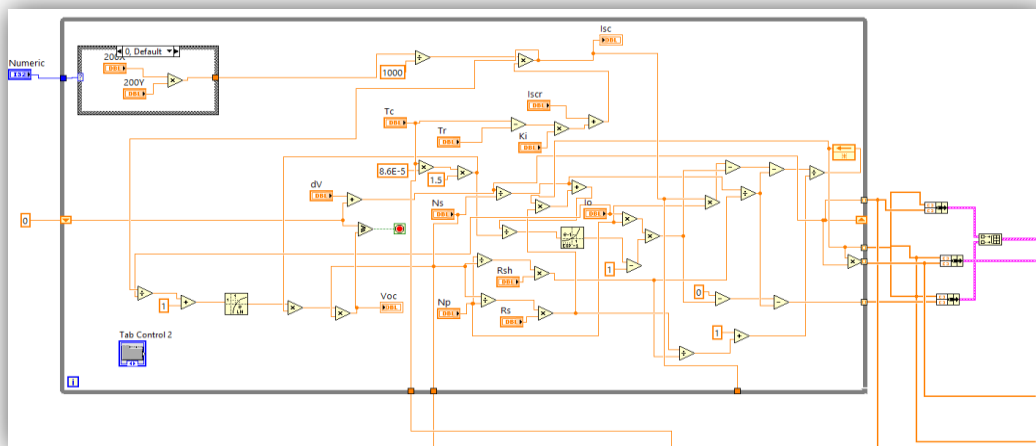


Fig- 3. Block diagram of Photovoltaic panel

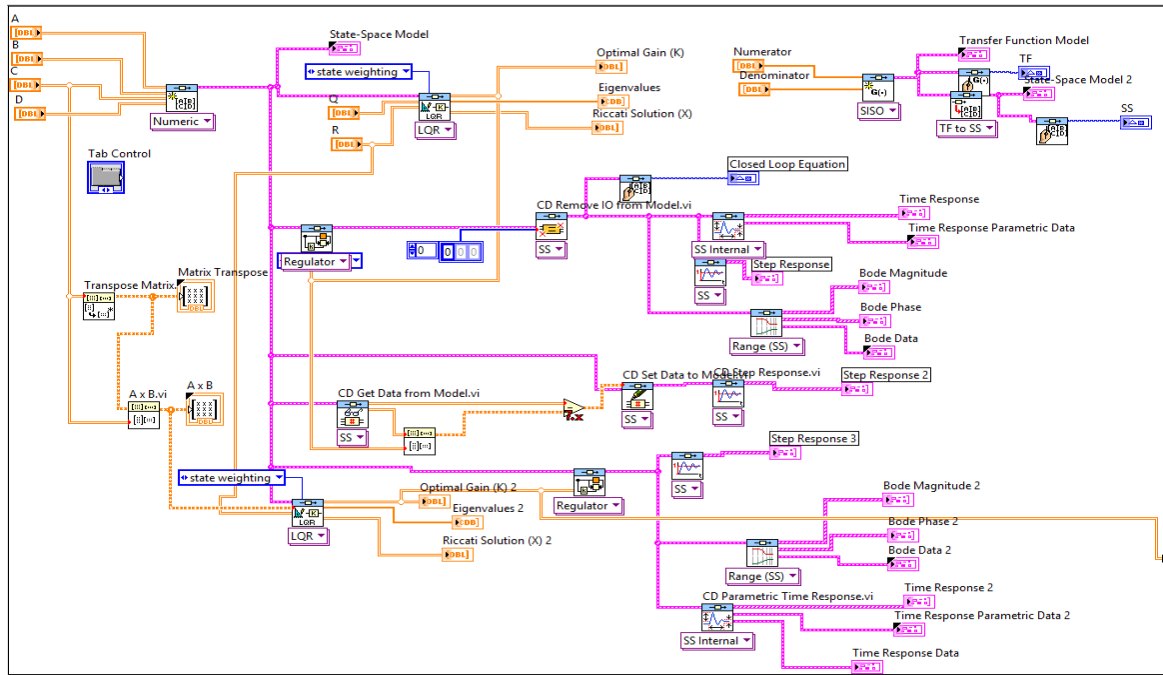


Fig-4. Block diagram of the LQR controller

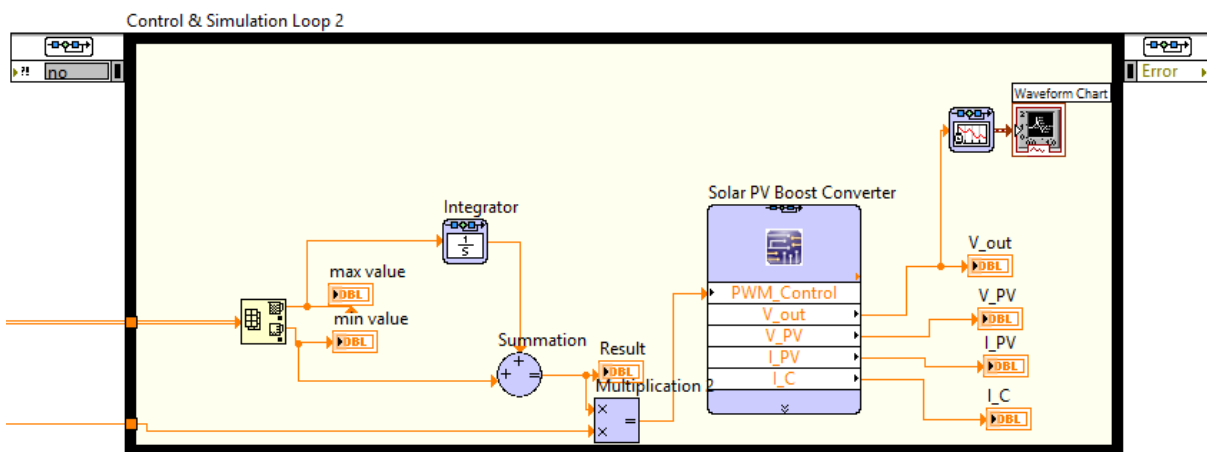


Fig – 5. Simulation of Boost converter

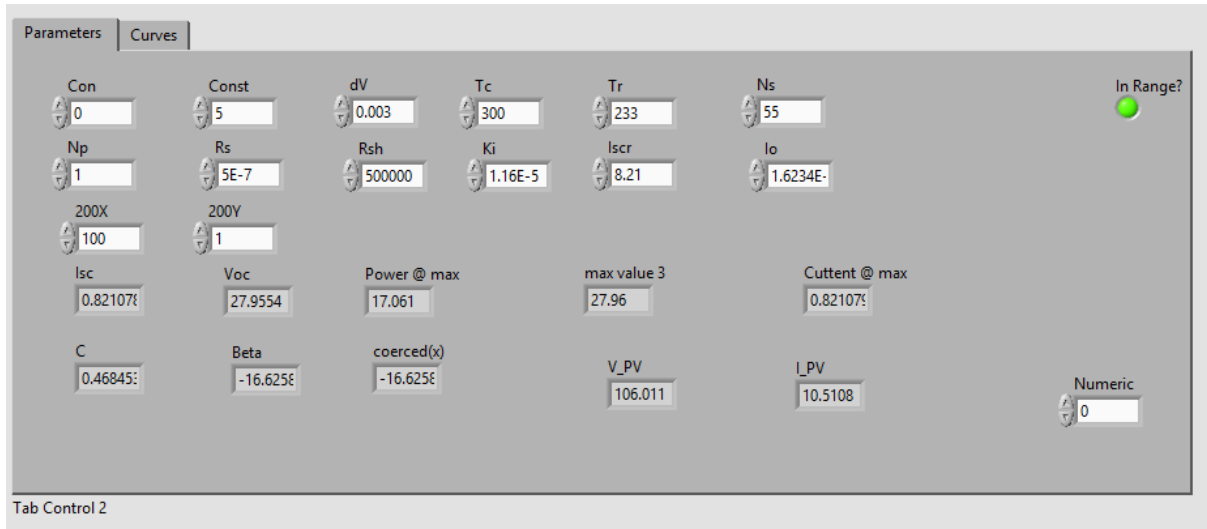


Fig -6. Front panel of Parameters

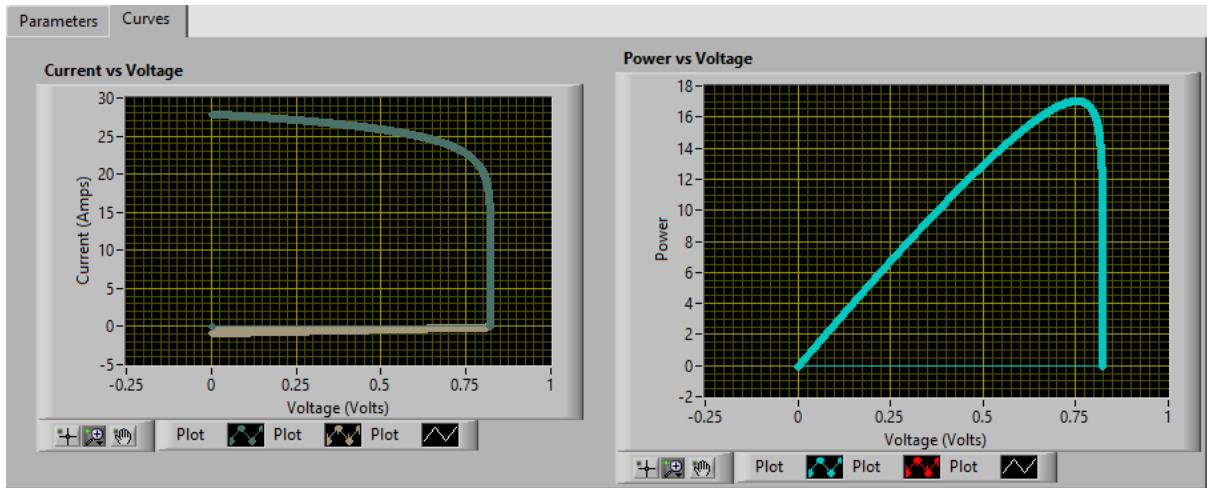


Fig – 7. Front panel of I-V and P-V curves

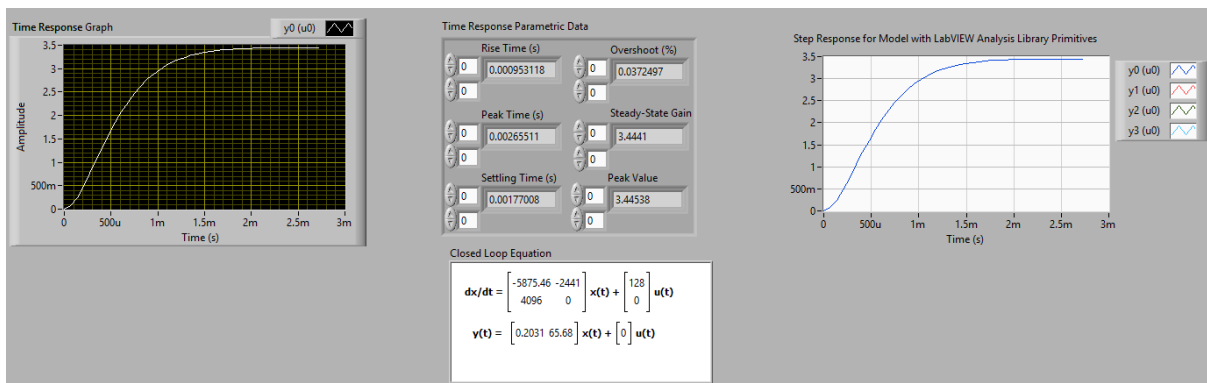


Fig- 8. Step response of the closed loop system

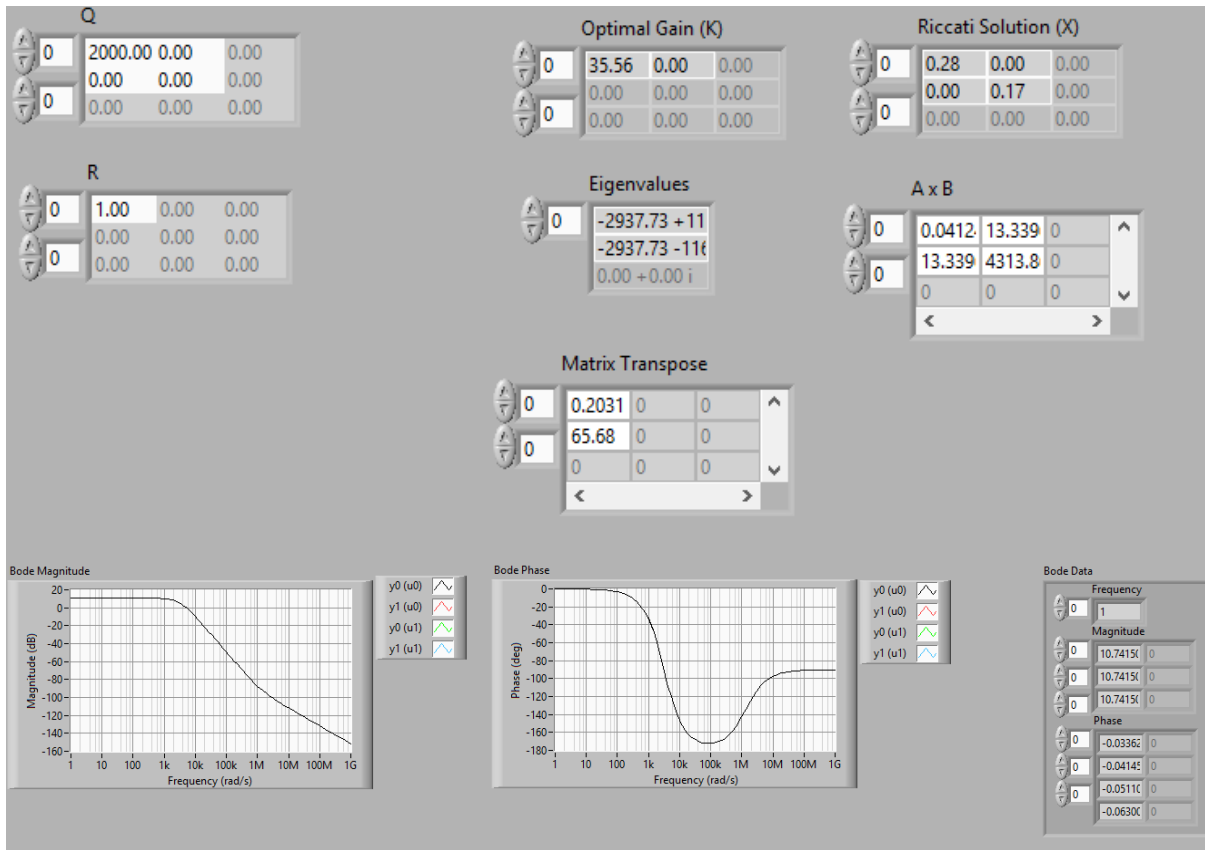


Fig-9. Bode plot of the closed loop system

TABLE 1. Output of boost converter in different irradianations with different MPPT algorithms

MPPT	Irradiation(W/M ²)	Output(W)
Incremental Conductance	500	98.22
	1000	207.6
	1500	321.22
Beta	500	103.85
	1000	210.52
	1500	328.33

Table 1 shows the boosted output voltage in Incremental Conductance algorithms, at different irradiation levels. From this table it says that the beta method is giving high output power compare to other method.

V. CONCLUSION

From the above simulated results we conclude that the beta (β) method is best method among various MPPT algorithm methods. It has smaller ripple voltage in steady state, good transient performance and simplicity of implementation.

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