"Enhancement of MPPT Based PV Boost Converter Response Using PID Controller"

Bhawana Deshmukh[1], Ritesh Diwan[2]
[1]Student of M.E. (Power Electronics), [2]Associate Professor (ET & T)
Raipur Institute of Technology, NH-6 Mandir Hasoud, Chhatauna, Raipur (Chhattisgarh), India-492001

Abstract- In this paper, the enhancement of MPPT based PV boost converter response using PID controller is proposed and implemented. The methodology is based on connecting a pulse width modulated (PWM) DC/DC boost converter between PV panel and inverter to feed power to grid. A proportional –integral-derivative (PID) controller is used to enhance the response of dc-dc boost converter by controlling the duty cycle efficiently as well as to keep the current injected into the grid sinusoidal. As PID controller is suitable for reduction of uncertain effects in the nonlinear system control. Perturb and observe (P&O) MPPT method is used to track the maximum power. The proposed system is implemented using MATLAB/SIMULINK 2014 for varying irradiance and temperature of PV panel and simulation results has been compared and verified.

I. INTODUCTION

Renewable energy is a type of energy that is derived from enduring natural processes and energy of natural processes changed into available forms. Renewable energy sources are sunlight, wind, flowing water, biological processes, and geothermal. The use of renewable energy sources is rising rapidly because of the fact that fossil fuels are inadequate, being speedily depleted, pollute the environment and reason climate change. In addition, another issue that increases the use of renewable energy sources is that they can be installed all over the place, and can be developed using various technologies.

The most frequent sources of renewable energy are solar and wind energy. The wind turbines must ensure maximum exposure to wind in order to achieve wind energy. Also, PV turbines must be built far from residential areas, due to the fact that the sound of wind turbines greatly inconveniences people. In the rural location of wind turbines is generally on the migration route of birds. Research shows that birds often change their migration routes or that birds die by hitting operational turbines due to the PVs (Akkaya et al. 2002). Accordingly, it is observed that solar farms, as a source of renewable energy, are more widespread than PVs.

II. PV APPLICATION POWER FLOW CONTROL AND CONVENTIONAL CONTROLLERS

A PV application is a renewal energy source power generation which is guided by computer or electronic programming. PV applications have replaced slaves in the assistance of performing those repetitive and dangerous tasks which humans prefer not to do or unable to do due to size limitations or even those such as in external space or at the bottom of the sea where humans could not survive the extreme environments. The word PV application can refer to both physical PV applications and virtual software agents, but the latter are usually referred to as bots.

PV system is an emerging field of modern technology. The science of PV system has grown tremendously over the past few decades, fueled by rapid advances in computer and sensor technology as well as theoretical advances in control and computer vision .PV system involves many technical and scientific disciplines, for example, sensor and vision technologies, computer architecture, drive systems and motor technologies, real time systems, automatic control, modeling, mechanical design, applied mathematics, man-power generation interaction, system communication, and computer languages.

PV applications are often classified into assembly and non-assembly PV applications. Assembly PV applications tend to be small, electrically driven and either revolute in design. The main non-assembly application areas have been in welding, spray painting, material handling, and power generation loading and unloading.

PV application manipulators are composed of links connected by joints to form a kinematic chain. They are typically rotary (revolute) or linear (prismatic). A revolute joint is like a hinge and allows relative rotation between two links. A prismatic joint allows a linear relative motion between two links. Joints are driven by actuators. Actuators are connected through either direct drive or gear train. Mainly three actuators are presented: 1) Pneumatic 2) Hydraulic type and 3) Electric motors. Different actuators have different dynamics. Electric motors are more famous because of their light weight and high Voltage. Moreover controlling of electric motors are much easier than other two actuators [2, 23 of dt]. Therefore, for high speed applications usually electric actuators like direct current (DC) motors, induction motors, and brushless DC motors are used. Moreover, the dynamics of most motors remains non-linear and hence popular in PV application applications.

Control in path tracking means "how do we get the output of the system to follow the input?". The basic problem in power flow control of manipulator is to determine the control inputs necessary to follow, or track a desired pre-planned trajectory. Main challenges in PV application power flow control problem is the complexity in dynamics and presence of uncertainties especially in high speed operations or while controlling direct-drive PV applications, for which no gear reduction is available to mask effective inertia variations. A general design for power flow control of manipulator has been represented.

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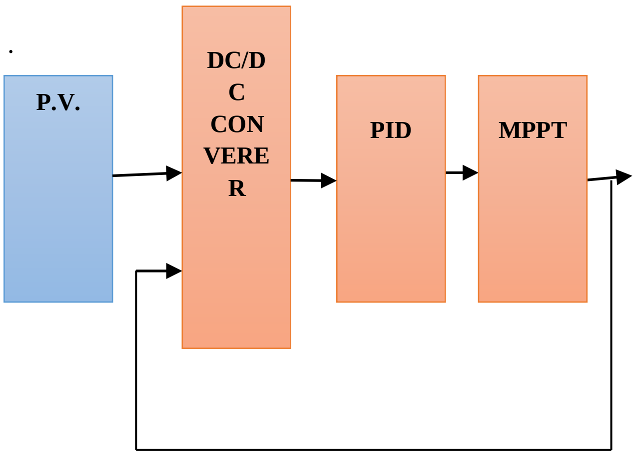

Fig.1: General Design for Power flow control of PV application Manipulator.

Power flow control scheme of a PV application manipulator can be explained in the terms of following sections.

1. Pre-planned trajectory.
2. Control mechanism.

In preplanned trajectory section, it is required to generate a suitable trajectory for a particular motion purpose like handling some object from one place to other by manipulator end-effectors. In this section firstly, a suitable path is planned to keep in view that manipulator can move from one place to other to fulfill the task without hitting an obstacle. In almost all the industrial applications this work is done offline on a system separate from the control mechanism of the manipulator. This is performed by the operator or by a computer program e.g. CAD/CAM tool. In an autonomous PV system, online motion planning is performed depending on the task objective and availability of sensor information about the position of the PV application with respect to the neighboring objects. After getting a planned path, the next step is to give a mathematical formulation to the path generated. This can be done by generating the position, velocity, and acceleration as the functions of time. These trajectories are restricted to motion primitives obtained while planning the path. Set of positions and orientations of manipulator end-effectors of a trajectory is relative to the base coordinate frame. This trajectory obtained is then translated to the joint space to determine the reference motion compatible with the PV application control system. The **main objective** of the control mechanism is to make manipulator to track the path generated in pre-planned trajectory section. The Control mechanism in power flow control scheme represented in Fig. 2.1 is the work to be emphasized in this thesis. This part of control design is of great importance. By appropriate control mechanism, motions of the joints are steered along the joint references, causing the end -effectors to follow the trajectory calculated by the trajectory generator. The control scheme proposed for the power flow control of manipulator should be capable to make manipulator to track the pre-planned trajectory even in presence of uncertainties.

In real life applications or computer simulations, disturbances from many sources can contribute to worse theoretical performance result. Although computer should have much fewer disturbances compared to real experiments, factors such as integration estimation and sampling rate can cause the controllers to behave differently than mathematical predictions. Hence, the computer simulation is the first step to verify the performance of all the controllers.

This chapter contains the dynamic model and properties of a general PV application manipulator. Actuated dynamics (of a widely used dc motor) are also briefed as they are very important for the analysis of the PV application system and the design of controllers. Various disturbances disturbing in the power flow control of a PV application manipulator has been discussed and explained. Simulink Modeling is one of the most dynamic and effecting uncertainties present in the manipulator system. In order to have a good tracking performance of the manipulator, it is required to compensate the influence of the Simulink Modeling forces. Simulink Modeling models are needed to describe the Simulink Modeling behavior well and can be incorporated in control algorithms. Thus, a review of various Simulink Modeling models has been covered in this chapter. This chapter also contains a review and implementation of various classical controllers present in literature. This is followed up by comparative analysis of these methods for power flow control of a manipulator.

III. DYNAMIC MODEL OF PV APPLICATION MANIPULATOR

The creation of the dynamic equations of motion of a PV application manipulator may be done for various reasons including:

- Computer simulation of PV application arm motion
- Analysis of manipulator design and performance
- Evaluation of controller design

- Constituent part of controller algorithm.

IV. PROBLEM STATEMENT

In the base paper design the simple PV cell is using to get power output. When we don't apply any controller then the power output is 190 W. For the voltage graph output voltage is 208 V when we don't apply any controller. Output current is near about 1.2 A. We can further improve the performance of the system. The power is too low as compare to PID controller power.

V. PROPOSED METHODOLOGY

A proportional– integral– derivative controller (PID controller) is a control loop feedback mechanism (controller) commonly used in industrial control systems. A PID controller continuously calculates an error value as the difference between a measured process variable and a desired set point. We are using PID controller for improve the performance of the peak power and peak voltage. As the PID controller gain change the value of the output graph will increase .But after a fix gain the value cannot be change.

MPPT Algorithms ;the MPPT (maximum Power point) is a larger frequency DC/DC converters .They take the DC input from solar panels change to higher frequency AC & convert it back down to different DC current & voltage to exactly match to system of the batteries. MPPT' operating at higher audio frequencies generally used in 30- 80 KHz range. The advantage of greater frequency circuits that we can be designed with higher efficiency. The conventional controller is charging discharge battery , it simply linked the modules directly to the battery. This modules to operate at battery voltage, typically is not the ideal. The main principle of incremental conductance technique is that the derivative of the output power (P), in terms of voltage (V), at the peak power points equal to zero (dP/dV = 0).

PID controller A proportional–integral–derivative controller (PID controller or three-term controller) is a control loop feedback mechanism widely used in industrial control systems and a variety of other applications requiring continuously modulated **control** . The PID controller attempts to correct the error between a desired set point & a measured process variable by calculating & then output of a corrective action that can adjust the process according. As the PID controller involves calculation three different (separate) parameters, Proportional (P), Derivative (D) and the Integral (I) values. values. The Proportional (P) value is determine the reaction to current error, the Derivative (D) value is determine reaction based on the rate at which the error has been changed and the Integral (I) value determine the reaction based on the sum of the current errors. This three actions are used to adjusting the process via a control elements. We are using PID controller for develop the performance of the voltage and peak power. PID controller gain alter the value of the output will alter but after a fixed gain the value cannot be alter.

Proportional-integral-derivative (PID) controllers are broadly used in industrial control systems because of the reduced number of parameters to be tuned. The most popular design method is the Ziegler–Nichols method, which relies solely on parameters find from the plant step response. However, besides being proper only for systems with monotonic step response, the compensated systems whose controllers are tuned in accordance with the Ziegler–Nichols method have usually a step response with a high-percent overshoot. In this paper, tuning methods for proportional-integral (PI) and PID controllers are planned that like the Ziegler–Nichols method, need only parameters obtained from the plant step response. The methodology also encompasses the design of PID controllers for plants with under damped step response and provides the means for a systematic adjustment of the controller gain in order to meet transient performance specifications. In addition, since all the growth of the methodology relies solely on concepts introduced in a frequency-domain-based control path, the paper has also a didactic contribution.

As the capacity of PV systems is growing significantly, the impact of PV modules on utility grids cannot be ignored. Grid-connected PV systems can cause problems on the grid, such as injecting more harmonics or reducing the stability level or margin by exciting the resonant mode of the power system [15]. This problem can be severe when a large scale PV module is connected to the grid. Current harmonics produce voltage distortions, current distortions, and cause unsatisfactory operation of power systems.

Therefore, harmonic mitigation plays an important role in grid-connected PV system. To both increase the capacity of PV arrays and continue power quality, it is necessary to comply with some requirements such as harmonic compensation [16].

The IEEE Standard [17], which was introduced in 1981 and revised in 2003, provides direction on dealing with harmonics produced by static power converters and nonlinear loads. This standard helps to prevent harmonics from negatively affecting the utility grid.

PV panels can be used either offline or online. In offline applications, PV panels supply local loads which can be residential or commercial used. In online applications, these modules not only supply local loads, but also are connected to the utility grid. In this case, the system would be called “grid-connected PV system.” Recently, grid-connected PV system installation is increasing tremendously in many countries. Around 75% of the total PV systems installed in the world are grid-connected [5]. In the future, this penetration rate will become larger because of the economic advantages of these types of renewable energy systems.

Generally, one of the challenges of grid-connected renewable energy systems, including solar grid-connected systems, is their compatibility with grid utility because of their different

output frequencies. This fact brings up the question of how to incorporate them into a standard utility grid. To solve this issue, these systems have to employ some sort of interface which makes them able to convert their output frequency and inject synchronized power into the grid.
Since the output of PV panels are direct current (in the case of grid-connected PV systems), the interface is typically a DC-AC converter (inverter) which inverts the DC.

VI. RESULT AND SIMULATION

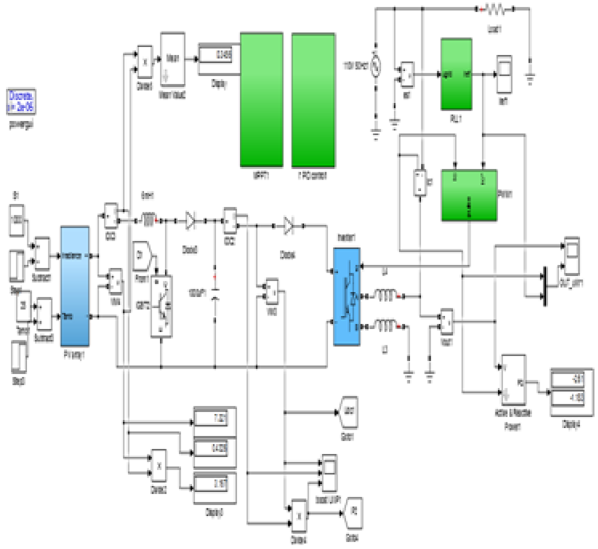

Fig.1: PID based Modeling.

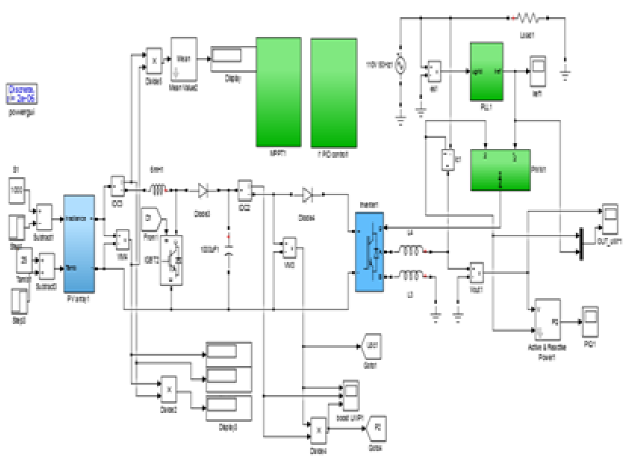

Fig.2: PID based Modelling.

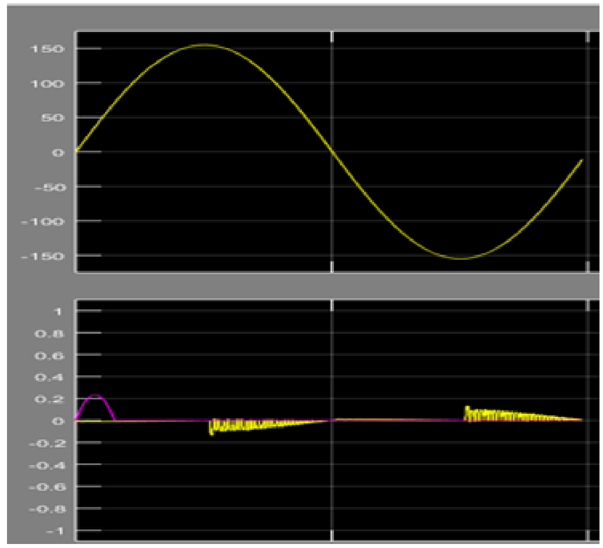

Fig.3: Output PID based Modelling.

VII. CONCLUSION

This paper concludes that the Internal Model Controller tuned Proportional Integral Derivative Controller gave the best response in terms of stability and speed of response (rise time and fall time) when compared with CHR, ZN and TL tuned PID for a dual axis solar tracker. The internal model control provides a transparent frame work for control system design and tuning. The internal model control based proportional integral derivative controller design is simple and robust to handle the model uncertainties and disturbances and less sensitive to noise than proportional integral derivative controller for an actual process in industries. Modeling of a dual axis solar tracker. An IMC-PID controller was developed for a dual axis solar tracker. The result of this work showed that the IMC-PID controller provided an efficient and commendable improvement in the relative stability, disturbance attenuation, set point tracking and an improved speed of response for the system.

VIII. REFERENCES

[1]. D. L. Chandler, "What can make a dent?" MIT News, Oct. 2011.
[2]. Wikipedia, "Solar energy," March 2014. [Online]. Available: http://en.wikipedia. org/wiki/Solar energy
[3]. G. Carr, "Alternative energy will no longer be alternative," The Economist, Nov. 2012. [Online]. Available: http://www.economist.com/news/ 21566414-alternative-energy-will-no-longer-be-alternative-sunny-uplands
[4]. NREL, "Best research photovoltaic cell efficiencies," Dec. 2013.
[5]. X. Yuan and Y. Zhang, "Status and opportunities of photovoltaic inverters in grid-tied and micro-grid systems," Proceedings of CES/IEEE 5th International Power Electron-ics and Motion Control Conference (IPEMC), vol. 1, pp. 1–4, Aug. 2006.

[6]. D. C. Martins, “Analysis of a three-phase grid-connected PV power system using a modified dual-stage inverter,” International Scholarly Research Notices (ISRN) Re-newable Energy, vol. 2013, pp. 1–18, 2013.
[7]. A. Khalifa and E. El-Saadany, “Control of three-phase grid-connected photovoltaic arrays with open loop maximum power point tracking,” Proceedings of IEEE Power and Energy Society General Meeting, pp. 1–8, 2011.
[8]. M. Calais, J. Myrzik, T. Spooner, and V. Agelidis, “Inverters for single-phase grid-connected photovoltaic systems-an overview,” Proceedings of 33rd IEEE Annual Power Electronics Specialists Conference (PESC 02), vol. 4, pp. 1995–2000, 2002.
[9]. B. Verhoeven, “Utility aspects of grid connected photovoltaic power systems,” Inter-national Energy Agency Implementing Agreement on Photovoltaic Power Systems, Report IEA PVPS T5-01, 1998.
[10]. M. Meinhardt and G. Cramer, “Past, present and future of grid connected photovoltaic- and hybrid-power-systems,” Proceedings of IEEE Power Engineering Society Summer Meeting, vol. 2, pp. 1283–1288, 2000.
[11]. International Energy Agency, “Innovative electrical concepts,” International Energy Agency (IEA), Report IEA PVPS T7-7, 2001.
[12]. J. Riatsch, H. Stemmler, and R. Schmidt, “Single cell module integrated converter system for photovoltaic energy generation,” Proceedings of Conference on European Power Electronics(EPE97), pp. 71–77, 1997.