Closed Loop Fractional Order P-I-D Controlled PV Based Buck Boost Converter System under Partial Shading

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Abstract
This work is planned to improve the reaction of the PV-system utilizing FOPID- controller during partial-shading. This paper manages examination amongst PI and FOPID-controlled PV fed Buck Boost-Converter with inverter (PVBBCI) systems. Open-loop-PVBBCI-system, closed-loop-PI-controlled-PVBBCI and FOPID-based-PVBBCI-system are composed; displayed and recreated utilizing Simulink and their outcomes are introduced. The examinations demonstrate the unrivaled execution of FOPID-controlled PVBBCI-system. The proposed-system has preferences like diminished equipment count, upgraded dynamic reaction and enhanced stability.

Index-Terms: 'Photo-voltaic-system '(P-V), 'Fractional-Order-PID-Controller' (FOPID), 'Maximum-power-point-tracking' (MPPT).

NOMENCLATURE:

'PI' - 'Proportional-Integral'
'FOPID' -Fractional-order-PID
'SGS' - Smart-Grid-System
'PISGS' - PI-controlled-Smart-grid-system
'FOPIDSGS' -'FOPID-Controlled-smart-grid-system'
'THD' - Total-Harmonic-Distortion
'PV' - Photo-voltaic
'R.E.S' - 'Renewable-energy source'

I.INTRODUCTION

Environmental problems like heating and therefore the constant increase of fossil-fuel costs have drawn a lot of attention towards renewable energy sources, notably on electrical phenomenon (PV) energy.

Photovoltaic systems are a critical component in achieving energy independence and reducing the harmful environmental effects caused by increased carbon emissions. Due to variations in solar insolation and environmental temperature, photovoltaic systems do not continually deliver their theoretical optimal power unless a maximum power point tracking (MPPT) algorithm is used.

MPPT technologies are employed in electrical phenomenon systems to deliver the utmost on the market power to the load below changes of the star insolation and close temperature.

Typically, MPPT algorithm are integrated into power electronic converter systems, where the duty cycle of the converter is controlled to deliver maximum available power to the load.
Several MPPT algorithms have been reported in the literature. The most common of these algorithms is the perturb and observe (P&O) method .This control strategy requires external circuitry to repeatedly perturb the array voltage and afterward live the ensuing amendment within the output power.While P&O is inexpensive and relatively simple, the algorithm is inefficient in the steady state because it forces the system to oscillate around the maximum power point (MPP) instead of continually tracking it which introducing dynamic power losses to the system. Furthermore, the P&O algorithm fails under rapidly changing environmental conditions, because it cannot discern the difference between changes in power due to environmental effects versus changes in power due to the inherent perturbation of the

rule.“Execution checking and examination of middle scale grid-connected PV system is exhibited by therefore. This paper presents execution consequences of middle scale grid-connected PV system for checking periods. The execution and misfortunes of PV system is quantitatively assessed and broke down utilizing figuring model with observed information so different PV system innovations are improved. The goal of this paper is to create reliable and substantial assessment strategy for Photovoltaic (PV) system execution so greatest yield is accomplished over the system lifetime with execution change. Execution observing and examination of middle scale grid-connected PV system [1] 2007.Correlation of PV(photovoltaic)-array MPPT(maximum-power-point-tracking)-techniques is proposed by Esram. The wide ranges of methods for maximum power point following of photovoltaic (PV) exhibits are examined. . It is demonstrated that no less than 19 particular techniques have been presented in the writing, with n many variations on implementation. This paper should fill in as an advantageous reference for future work in PV power generation [2] May 2007.

Versatile control technique to upgrade infiltration of PV power generations in weak grid is given by Liu. Low short circuit limit and high grid impedance are the fundamental electrical attributes of weak-grid, and there are some stability and power quality issues with a substantial number of PV power generation systems consolidated into weak grid. The expanding infiltration of PV power generation effectively prompt voltage ascend toward the end of grid, and it influences the capacity of weak grid to acknowledge PV power capacity[3]-Feb 2015.

Plan and execution an adaptive-control for MPPT-frameworks utilizing ‘model-reference adaptive-controller’ is introduced by Omari. A versatile control is to remove the greatest power from the photovoltaic-generator. Another calculation is created in view of the MMRAC (modified-model reference-adaptive-control) joined with IC (incremental-conductance-calculation), and Lyapunov-technique to get the control law to accomplish the MPP (maximum-power-point) under the variety of temperature and the irradiance. This framework contains a DC/DC boost-converter, the photovoltaic-panel (PV), and the versatile MPPT (maximum-powerpoint-tracker) calculation (MPPT) [4]-Jul-2017.

Sensor-less versatile control of full Snubber-inverter for photovoltaic-applications is recommended by Faraci. This proposes another versatile control system of the auxiliary-branch of the resonant-Snubber-inverter for photovoltaic(PV)-applications. By differing the turn-on time of the auxiliary-branch in light of the load current, the auxiliary-resonant-current is lessened without the requirement for any extra segments, diminishing the circling misfortunes and enhancing framework proficiency. An investigation of the full-Snubber-inverter task is talked about. Distinctive control techniques of the auxiliary branch are compared[5]-Feb-2015.

Versatile control of grid-associated photovoltaic-inverter for most extreme VA use is given by Sant. A versatile-control for grid-associated-photovoltaic (PV) framework that considers the API (active-power-injection) & APF(active-power-filtering) usefulness. This-PV-system –operates-in-3modes: (1) ‘API-only’, (2) ‘API&APF’ with the full-usage of PV-inverter VA-limit, & (3) ‘API&APF’ with particular-THD (total-harmonic-distortion) restrict for the infused-streams. The maximum-power-point -tracking (MPPT) is accomplished with perturb& observe-method [6]-Jan-2014.

II. PHOTOVOLTAIC - ENERGY CONVERSION-SYSTEM

A PV-system (is a system which) converts electricity using sunlight and transfer this electricity to the load when needed. Figure 1.1 depicts a block diagram resembling a typical PV conversion system. The PV conversion system necessarily consists of PV modules, DC-DC converters, DC-AC inverters and MPPT controllers etc.

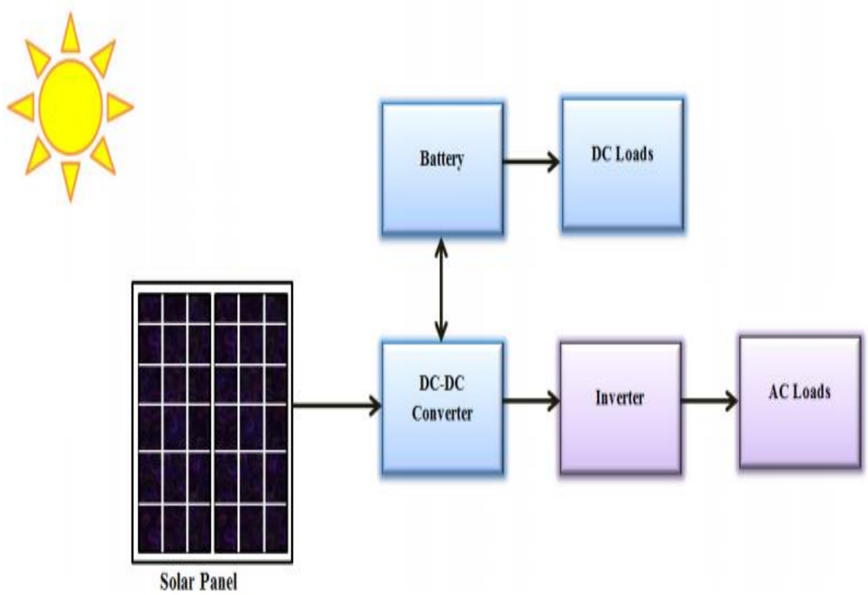

Figure-1.1 'PV-conversion-system'

"An adaptive-control-system for 3-phase-PV (photovoltaic)-inverters-working in a polluted and variable frequency-electric-grid" is introduced by Garcera. The proportional-resonant (PR) controller has been proposed in the past as a reasonable technique to control the current created by the grid-associated-photovoltaic-V.S.I. Because of the way that data in regards to the frequency of the framework is expected to utilize this control system, the synchronous-reference-frame-phase-locked-loop (SRF-PLL) is customary-exploited. To guarantee that the THD(total-harmonic-distortion) of the injected current (THD) meets the suitable norms, regardless of whether the grid voltage is contaminated and its frequency changes, a versatile control system is exhibited here[7]-Marc-2012. 'Late advances& control-techniques in grid-connected PV-system' is recommended by Arulkumar. As of late, grid-associated photovoltaic-framework has risen with its straightforwardness, dependability and bearableness.

The scopes of grid-tie-inverters (GTI) are named little scale as a few several kilowatts and huge scale as many megawatts. In like manner, the standard of interconnecting to the grid is made higher degree in enhancing its power system reliability, effectiveness &cost. Besides, the working of grid associated inverter essentially relies upon robustness in control procedure, notwithstanding working in unusual grid conditions, for-example, 'deviation of voltage & recurrence'. This audit centers around updating grid standard codes and directions, likewise review of late control systems and direct power control [8]-2016.

'A relative investigation of control systems for PWM-rectifiers in AC-flexible-speed-drives' is given by Malinowski. 'Control-procedures for PWM-rectifiers in AC-customizable-speed-drives' are introduced [9]-Aug-2003.

'Utilization of FOPID-control-system in anti-windup-scheme' is displayed by Gupta. An anti-windup-plan for corresponding integral-derivative-controllers is exhibited. The approach depends on the joined utilization of Fractional-order-PID-control and back-calculation anti-windup-strategy. Along these lines, the impediments' that can hinder previously proposed systems are survived. In particular, the technique can ensure an acceptable execution for forms with various standardized dead occasions, without the tuning of extra parameters being required [10]-Apr-2013.

Plan of a single-phase-rectifier with improved power-factor and low THD utilizing boost-converter-technique is proposed by Ismail. The reason for having low PF and high-THD for a diode-capacitor kind of rectifiers is identified with non-linearity of the input current. Technique for re-molding the input-current waveform to be comparative example as the sinusoidal input voltage is finished by the boost-converter and the related controls that go about as a power-factor-correction (PFC) circuit. The consequences of the composed system were contrasted against and without PFC control [11].

'A novel regular power factor remedy conspires for homes & workplaces' are given by Basu. This investigates the approach of having a typical PFC (power-factor-correction) circuit for local and business loads. This prompts bring down harmonic-distortion without the need to introduce (costly) dynamic rectifiers in each end-client gadget. The requirement for power-factor correction and in addition various outline choices is talked about here. The plan & cost estimation of a typical PFC (power-factor-correction) plan and some unwavering quality issues are discussed [12]-Mar-2003.

'Single-phase-PFC (power—factor-correction): a review' is demonstrated by 'Garcia'. New suggestions and future-gauges have expanded the enthusiasm for power-factor-correction circuits. There are various arrangements in which line current is sinusoidal. A survey of the most-intriguing answers for single-phase and low-power-applications is conveyed out [13] May 2003.

III.RESEARCH-GAP

The literature [1] to [13] do not deal with comparison of PI & FOPID-based PVBBCI-systems to improve the dynamic response. This work proposes FOPID to improve dynamic response and maintain constant voltage of PVBBCI system during partial shading.

IV.SYSTEM DESCRIPTION

Block diagram of proposed system is shown in Fig.1.2. AC output of PV is applied to a dual buck boost converter. The output of BBC is applied to the AC load. The output voltage is sensed and it is compared with the reference voltage. The error is applied to a FOPID controller. The output of FOPID controller is used to generate the updated pulses.

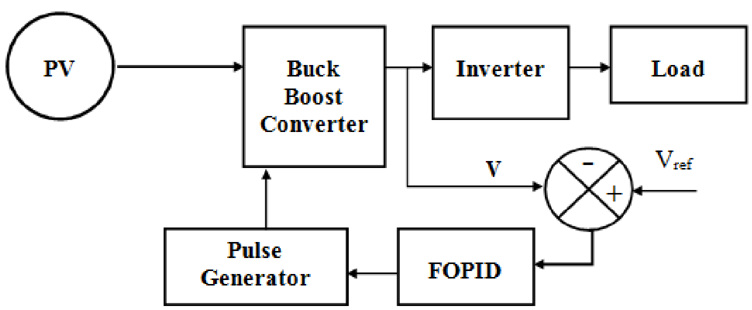

Figure 1.2 Block Diagram of proposed system

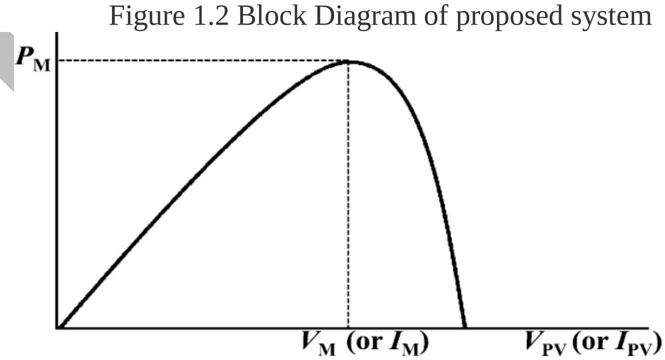

Figure 1.3 Power–voltage characteristics of photovoltaic systems

V.SIMULATION-RESULTS

Closed-loop-PVBBCI-system with PI-controller is appeared in Fig-3.1. First when the PV system is on the voltage is stored in the capacitor.Then, the output of the PV system is fed to the Buck boost converter where the voltage may be stepped up to maintain the constant voltage at the output..The output of the buck boost converter is compared with the reference voltage which is the maximum power point tracking voltage.The error signal is fed to PI controller and the output of the PI controller is fed to PWM to change the duty cycle of the system. Thus PI controller is used to regulate the voltage.

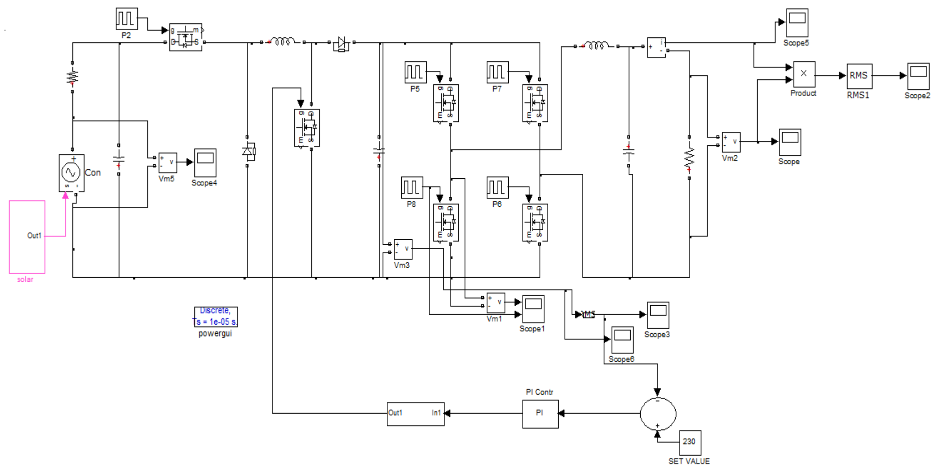

Figure-3.1 'Closed-loop-PVBBCI-system with PI-controller'

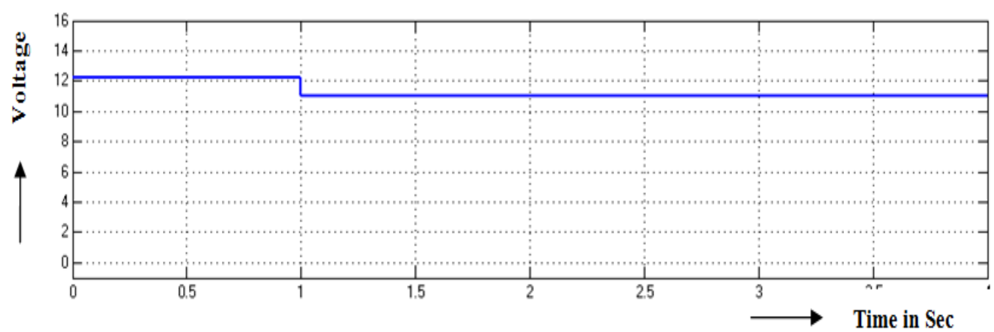

Figure 3.2 'Input-voltage'

The output of the PV system is 12 V. Under partial shading , the voltage is decreased from 12V to 11V. This is the input voltage of the Buck boost converter which is appeared in Fig-3.2. The reduction in voltage is due to the partial shading.

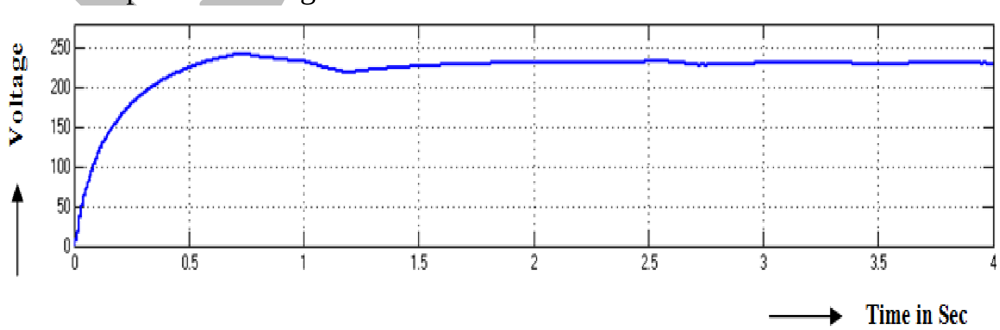

Figure-3.3 'Output-voltage of buck-boost-converter'

The output voltage of the Buck boost converter is shown in Fig.3.3 and it is approximately 245V. The output voltage decreases at t = 1 sec and then reaches normal value. The output voltage of BBC is regulated by using PI controller.

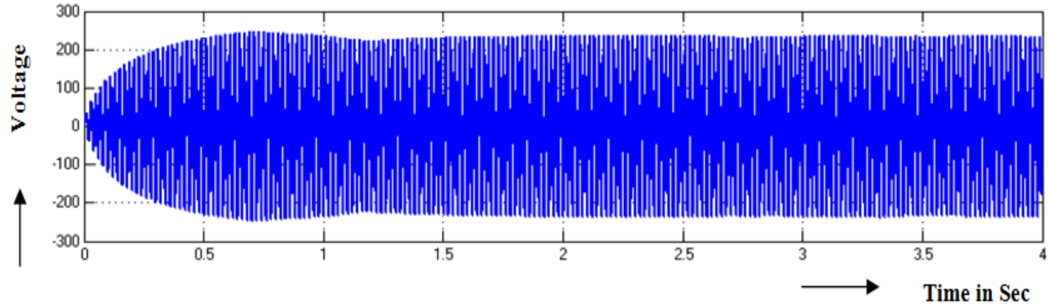

Figure-3.4 'Output-voltage of inverter'

The output voltage of the Inverter is shown in Fig.3.4 and it is approximately 245V. The output voltage of inverter decreases at t = 1 sec and then reaches normal value. Thus the output voltage of inverter is regulated by using PI controller.

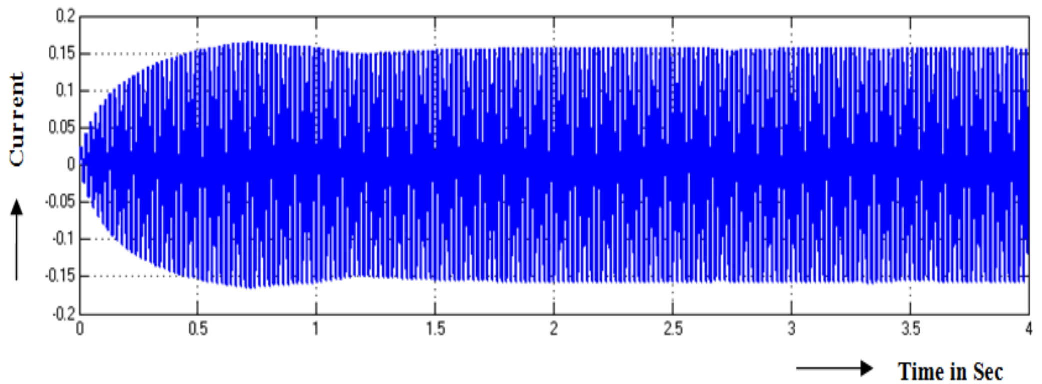

Figure-3.5 'Output-current of inverter'

The output current of the Inverter is shown in Fig.3.5. Which is approximately 0.16A. The output current of inverter decreases at t = 1 sec and then reaches normal value. Thus the output current of inverter is regulated by using PI controller.

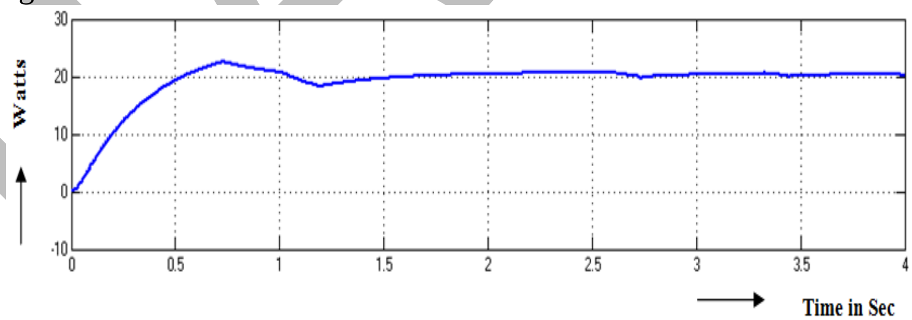

Figure-3.6 'Output-power'

The output power of Inverter is shown in Fig.3.6 which is 20 watts, RMS value of power. RMS value of the power = RMS value of the voltage x RMS value of the current.
P rms = (245*0.707) x (0.16*0.707)= 20 watts.
Here, the output power settling time is 1.7s and the steady state error is 2.6V

Closed-loop-PVBBCI-system with FOPID-controller is appeared in Fig-3.1. First when the PV system is on, the voltage is stored in the capacitor.Then, the output of the PV system is fed to the Buck boost converter where the voltage may be stepped up to maintain the constant voltage at the output..The output of the buck boost converter is compared with the reference voltage which is the maximum power point tracking voltage.The error signal is fed to FOPID controller and the output of the FOPID controller is fed to PWM to change the duty cycle of the system. Thus FOPID controller is used to regulate the voltage.

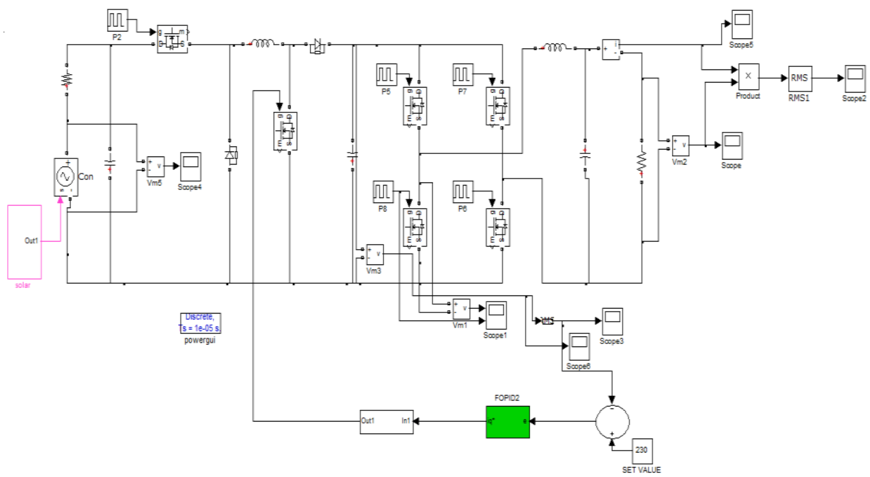

Figure-3.7 Closed-loop-PVBBCI-system with FOPID-controller

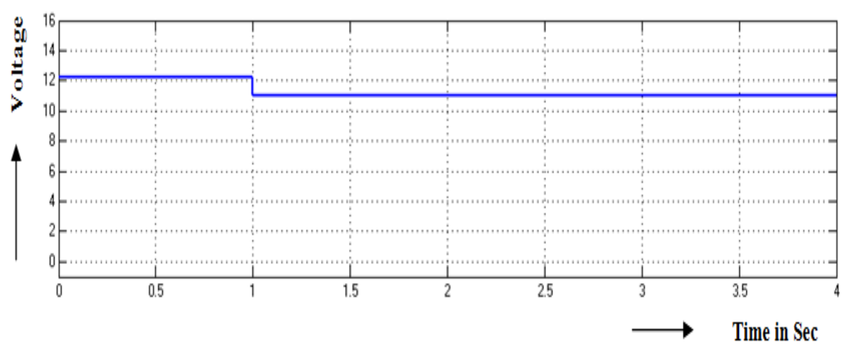

Figure-3.8 ‘Input-voltage’

The output of the PV system is 12 V. Under partial shading , the voltage is decreased from 12V to 11V. This is the input voltage of the Buck boost converter which is appeared in Fig-3.8.

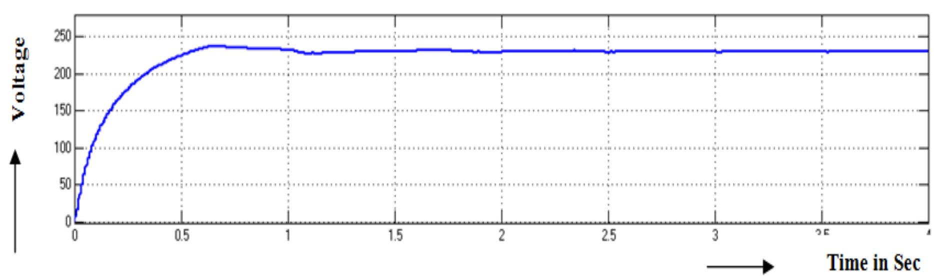

Figure-3.9 ‘Output-voltage of buck-boost-converter’

The output voltage of the Buck boost converter is shown in Fig.3.3. Which is approximately 245V. The output voltage of BBC decreases at t = 1 sec and then reaches normal value. The output voltage of BBC is regulated by using FOPID controller.

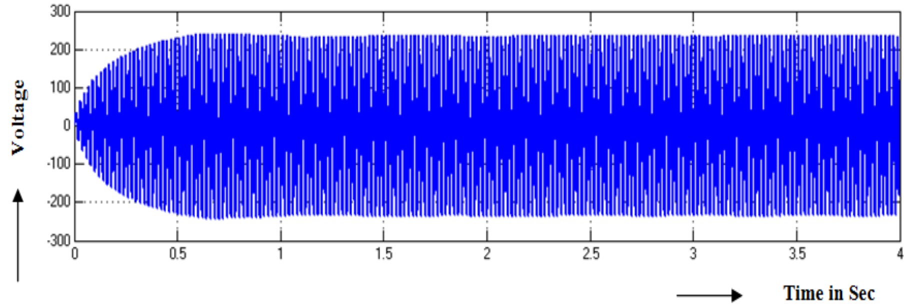

Figure-3.10 'Output-voltage of inverter'

The output voltage of the Inverter is shown in Fig.3.10 which is approximately 245V. The output voltage of inverter decreases at t = 1 sec and then reaches normal value. The output voltage of inverter is regulated by using FOPID controller.

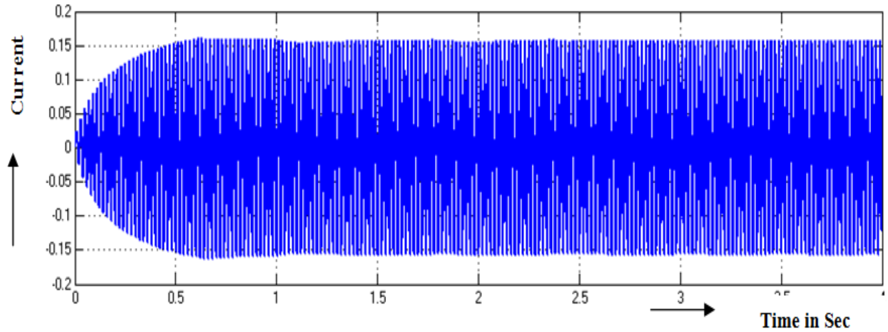

Figure-3.11 'Output-current of inverter'

The output current of the Inverter is shown in Fig.3.11. which is approximately 0.16A. The output--current of inverter decreases at t = 1 sec and then reaches normal value. The output--current of inverter is regulated by using FOPID controller.

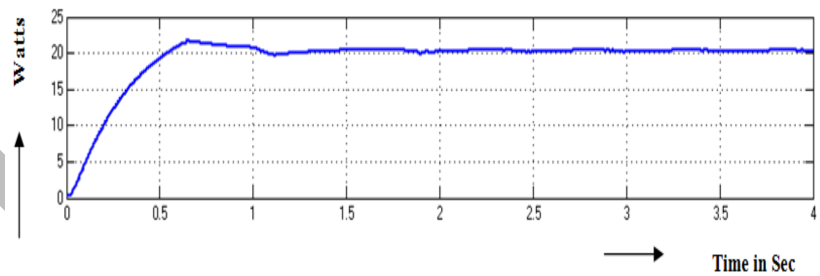

Figure-3.12 'Output-power'

The output power of Inverter is shown in Fig.3.12 which is 20 watts, RMS value of power. The output power of inverter decreases at t = 1 sec and then reaches normal value. The output power of inverter is regulated by using FOPID controller. RMS value of the power = RMS value of the voltage x RMS value of the current.

P rms = (245*0.707) x (0.16*0.707) = 20 watts.

Here, the output power settling time is 1.4s and the steady state error is 1.5V

The comparison of time-domain-parameters is given in Table 1. The rise-time is reduced from 1.2 sec to 1.1 sec; the peak-time is reduced from 1.4 to 1.3 sec; the Settling-time is reduced from 1.7 to 1.4 sec and steady-state-error is reduced from 2.6 to 1.5 volts by replacing P-I controller with FOPID-controller. Dynamic-response is also improved by using FOPID-controller.

Table -1 Comparison of time domain parameters

Types of controller	T_r	T_p	T_s	E_{ss}
PI	1.2	1.4	1.7	2.6
FOPID	1.1	1.3	1.4	1.5

VI.CONCLUSION

PV-based BBCI-system is investigated with fall in input voltage due to partial shading. The output -voltage is regulated using PI & FOPID-controllers. The reactions are evaluated in terms of 'rise-time', 'peak-time', 'settling-time' &'steady-state-error' in output-voltage. By using FOPID-controller, the 'settling-time' is reduced to 1.4 sec &steady-state-error is reduced to 1.5V. Therefore-FOPID based-PVBBCI-system is superior to PI-based-PVBBCI system. The scope of the present-work is to compare PI-controlled-PVBBCI with FOPID-controlled PVBBCI-system.

The comparison with adaptive-controlled-PVBBCI-system will be done in near-future. The PVBBCI can be extended to handle-high-power.

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