Analysis of Grid-Connected Solar PV System in Composite Environment

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Abstract -- **Grid connected Solar PV (GCSPV) systems are being increasingly used to maintain the current balance between demand and supply around the globe. In this paper, the Modeling-Simulation of a 40kWp GCSPV system has been carried out. The SPV system is installed at Ghaziabad. This GCSPV consists of an SPV module, DC-to-DC converter, DC-to-AC inverter and filters. The SPV system takes into account both external ambient temperature and solar irradiance. Finally, a DC-to-AC converter is used to regulate and synchronize the DC-to-DC converter's output voltage with the grid. The MPPT controller extracts the power from the solar PV arrays. The proposed model appears to be capable of attaining the objectives based on simulation results of GCSPV systems in northern region of India.**

Keywords: DC-to-DC converters, SPV module, DC-to-AC inverters, Energy yield, MPPT algorithm

I. INTRODUCTION

ROOF-TOP Grid Connected Solar PV system have received increased attention to combat global energy demand and supply differences. Solar Photovoltaics scores over others since it does not involve moving parts and there is now a growing optimism that the solar power supplies will be the solution for crippling shortages facing the world. Environmental-friendly power is progressively viewed as fundamental resource. For the large scale, the use of roof-top systems, Grid interconnection of PV framework is required. PV system is connected to utility grids as they provide the energy at the time of black-outs [1]. PV is undeniably more relevant than other resources. Hence generating energy with solar PV is the most common application utilizing RESs across the world. Among environmental-friendly power, the PV frameworks assume a fundamental part in this progress for PV applications [2-4].

PV power [5] delivering to the utility grid has been the quickest developing sustainable power innovation by a long shot since it pulled in the consideration of strategy producers. It is more acknowledged in mainstream to the researchers that human actions are influencing environmental changes and that a greater part of this effect comes from non-renewable energy sources ignition brought about by the electric utility industry [6]. Distributed Generator (DG), Photovoltaic (PV) frameworks give a method for moderating these difficulties by generating power straightforwardly from daylight. Dissimilar to off-grid PV frameworks, Grid-Connected Solar Photovoltaic Systems (GCPVS) work along with the electric utility network and therefore they require no capacitive additional frameworks [7]. GCPVS supply power back to the matrix while delivering abundance power. GCPVS assist with counter- balancing ozone depleting emanations by uprooting the power required by the associated (neighborhood) load and giving extra power to the grid [8-10]. The primary objective of the current analysis is to decide the exhibitions of a network associated PV framework in the composite climate locations during one year of consistent activity [11]. In this paper, we consider a PV framework and converters' topologies that consolidates modules which have been working throughout the previous 23 years which makes this concentrate much more intriguing since debasement impact [12].

Within the last eight decades nearly six hundred models of DC/DC power converters were employed in different fields of power system application as well as the renewable energy production. PV solar systems are non-linear systems and too sensitive to the variations of climatic conditions, the characteristics of the magnitudes delivered by this method (current, voltage) have the purpose. Generally it's troublesome in the operational purpose between the loads so PVG is that the best purpose of the system, during this case it becomes necessary to introduce the Maximum Power Point Tracker (MPPT) [13]. This method is employed because the controller of a DC/DC power device through its switch that acts as resistivity adapter. In the literature, there are many techniques of MPPT analysis, which posses benefits and limitations [14]. In this work, we have used P&O approach to show the classification and performance of MPPT techniques applied in partial shading conditions.

The DC/DC power device is a necessary part in PV solar system's improvement , because it acts as an interface between the PVG and load. This DC/DC power device is controlled through its switch by a symptom generated by the MPPT technique termed as the duty cycle [15]. One among various convert styles of device is employed within the literature Buck, Boost and Buck Boost power device [15].

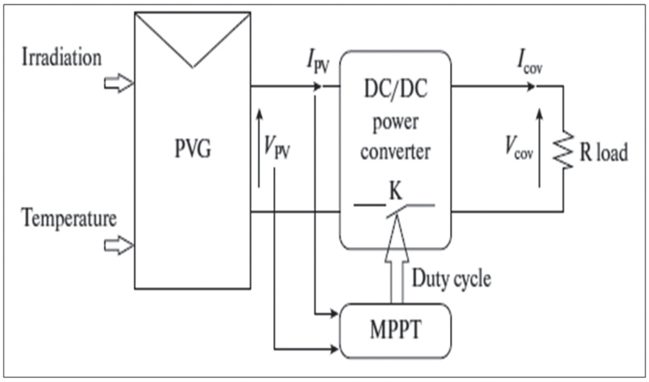

Figure 1. Description of the optimized SPV system.

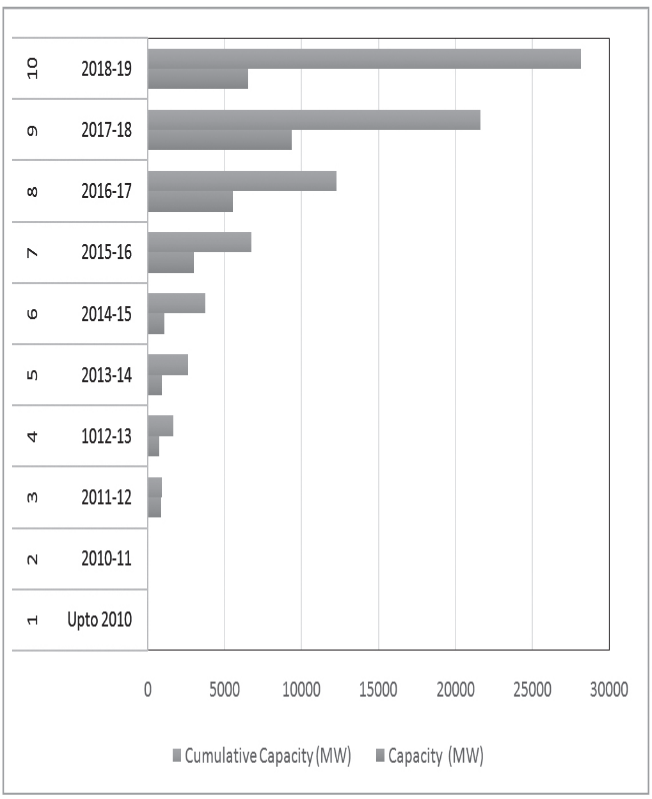

Figure 2. Growth trends of GCSPV system.

II. PHOTOVOLTAIC SYSTEM

An SPV system is created with solar PV modules that converts sunlight into electricity. GCSPV associated system with MPPT techniques, reached to MPP, which will turn out the foremost electricity, from the PV array. We have the purpose that initially to increase the magnitude of the voltage, which is able to be set through the utilization of a DC/DC(BOOST) convertor, As far as the output of the DC\DC converter are going to be inverted into AC for grid association with inverters [16]. The subsequent could be a breakdown of the Photovoltaic cell modeling, various MPPT algorithmic rules, DC to DC convertors & DC to AC convertors for grid association for electrical supply.

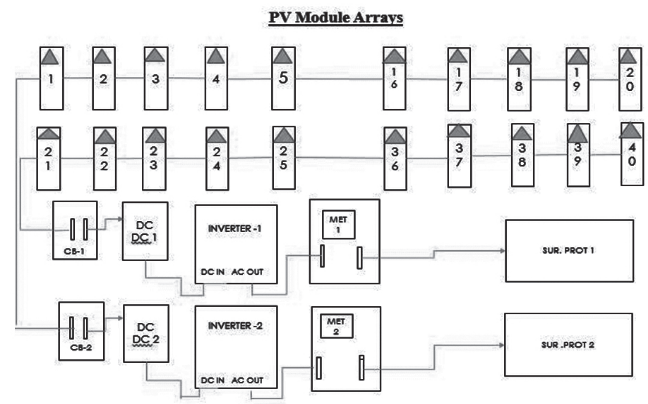

Figure 3. Schematic layout of 40 kWpGCSPV system.

III. SOLAR PV CELL

A Solar photovoltaic cell also called as (PV cell) is basically a semiconductor device that captures photon energy from sunshine and transforms it to electricity. ILG, IOS, R_{sh}, and R_s are difficult to determine in the ideal solar photovoltaic cell (PV Cell) model since they are tied to the temperature and radiation intensity of the cells. Engineering applications have become much more difficult as a result of this. Manufacturers of PV arrays supply several experimental technical parameters as open-circuit voltage (V_{OC}), max. Power point current (I_m), short-circuit current (I_{SC}), and max. Power point power (P_m), max. Power point voltage (V_m). Figure 4 depicts the equivalent circuit of a perfect photovoltaic cell.

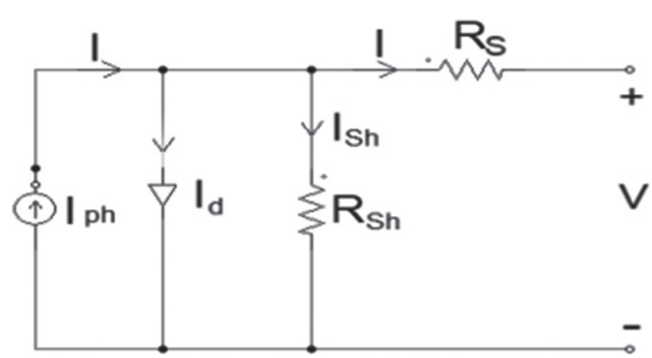

Figure 4. Solar cell equivalent circuit.

$$I_{pv} = I_{ph} - I_0\left(e^{(V_{pv} + R_s I_{pv})/V_T} - 1\right) - \frac{V_{pv} + R_s I_{pv}}{R_{sh}}$$

where,
'I_{pv}' is the current of PV outputs,
'I_{ph}' is the photogenes current,
$q = 1.6x10^{-19}$ Coulomb,
I_d is the diode reverse saturation current,
The voltage is Vpv,
R_s is series resistance,
R_{sh} is the shunt resistance,

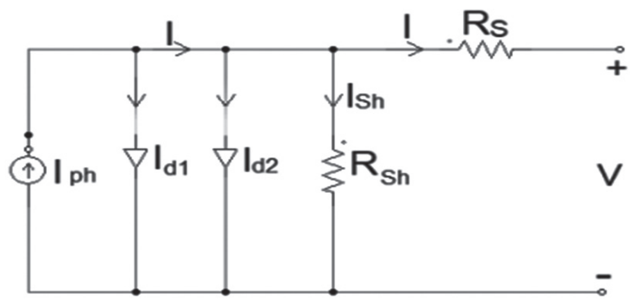

Figure 5. PV array model.

The single diode model is supposed to be negligible for recombinant losses in the depletion region. A major loss, especially on low voltages, is the combination in a genuine solar cell. It cannot be modelled appropriately with a single diode. The fact that this loss is taken into account results in the model of two diodes being more accurate [17].

The double diode model shown in Fig. 5, gives:

$$I_{pv} = I_{ph} - I_{d1}\left(e^{\frac{q(V+IR_s)}{kT}} - 1\right) - I_{d2}\left(e^{\frac{q(V+IR_s)}{2kT}} - 1\right) - \frac{V + IR_s}{R_{sh}}$$

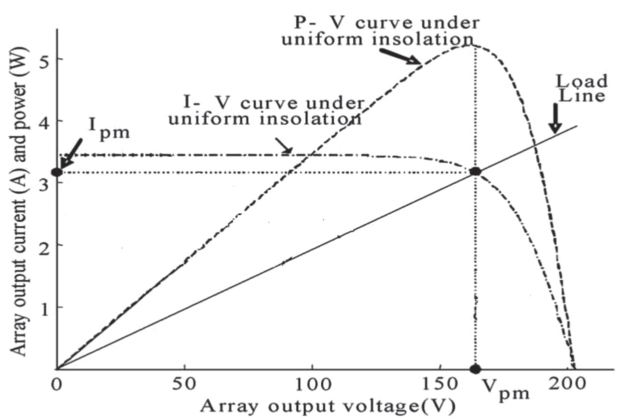

Figure 6. I-V & P-V characteristics of solar PV array.

TABLE 1-- VARIOUS PARAMETERS & THEIR SYMBOLIC REPRESENTATION

Symbol	*Meaning*
V	Solar Photovoltaic Cell Output Voltage
I	Solar Photovoltaic Cell Output current
I_{LG}	Current of photons
I_{OS}	Rev. Sat. current of SPV
T	Nominal Opt. Temp
Q	Electron Charge
K	Boltzmann Constant
K_I	Temp. Coeff
I_{SC}	S. C. Current
S	SPV Radiations
E_{GO}	Energy Band Gap
A, B	Identity Constant
Tr	Absolute Temp.
I_{OR}	Rev. Sat. current of SPV at Tr
R_{SH}	Parallel Resistance
R_S	Series Resistance

TABLE 2 -- SYSTEM PARAMETER & THEIR SPECIFICATIONS

Parameter	*Symbol*	*Values*
Max. power voltage	V_m	35.93 V
Max. power current	I_m	8.35 A
O. C. Voltage	V_{oc}	44.46 V
S.C. Current	I_{sc}	8.75 A
Max. Power	P_{max}	300Wp
Fill Factor	F_n	0.76

TABLE 3 -- MONTHLY AMBIENT TEMP & SOLAR IRRADIANCE

Date	*Ambient Temp,*°C	*Irradiance,* kWh/m^2
April	28.97	5.62
May	29.9	4.84
June	29	4.94
July	26.86	4.36
August	26.64	4.32
September	26.48	4.57
October	26.06	4.69
November	19.89	3.05
December	17.01	3.28
January	14.76	3.3
Feb	18.79	4.21
March	24.07	4.59

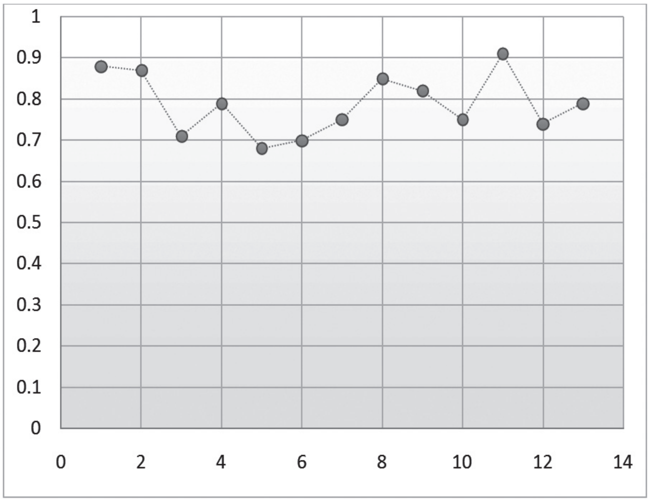

Figure 7. Results for annual-performance ratio parameter.

IV. FLY-BACK CONVERTER

Figure 8. Depicts the standard layout of a fly-back device. System has low-inductance isolated buck-boost device with a smaller device split. The gate drive circuit's primary is connected to the MOSFET switch that ensures that the desired output voltage is maintained during operation. A transformer's polarity is used to segregate the input and output voltages. The fly-back device receives the unregulated dc voltage from the PV arrays. The secondary side winding voltage of the device is corrected and filtered by employing a diode and a condenser [17].

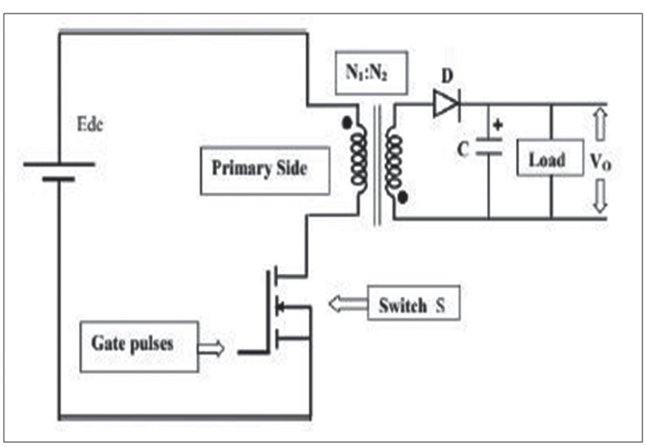

Figure 8. Basic circuit of fly-back converter.

V. CONTROL STRATEGIES

The following control strategies are used for the proposed grid connected PV system:

(1) MPPT Algorithmic Approaches
(2) Grid Synchronization Controller
(3) SPV Inverter Controller

There is a point in each solar cell where it generate the maximum power and MPPT utilizes various methods. To evaluate and observe that MPP point in our study, we used the perturbation and observation (P&O) approach. Figure 9 represents the MATLAB/ SIMULINK model for the P&O method. Figure 11 shows the Simulink model of Perturbation and Observation algorithm.

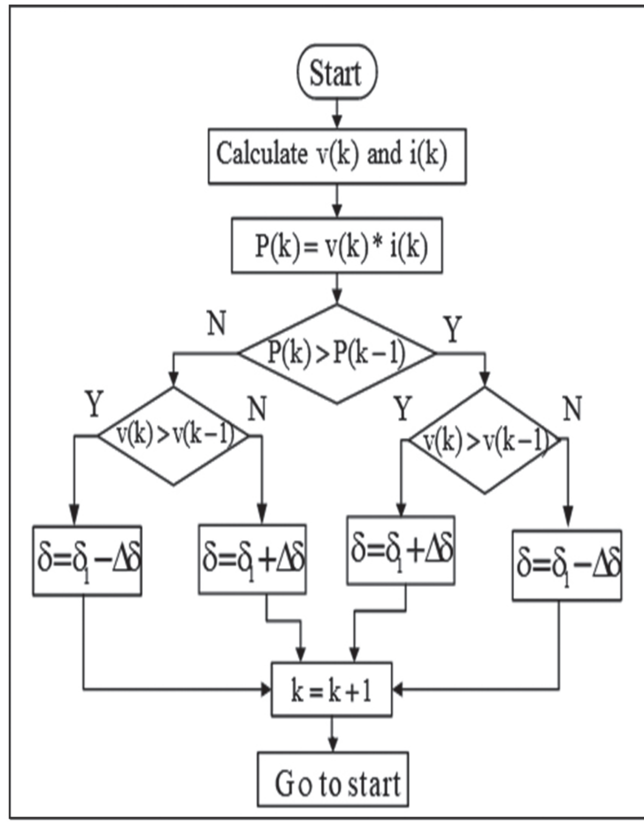

Figure 9. Flowchart of MPPT P&O Algorithm.

VI. SIMULATION RESULTS & OUTPUT

Simulation has been carried out to demonstrate the proposed system's performance. Figure 11 shows the MATLAB simulation of the planned arrangement.

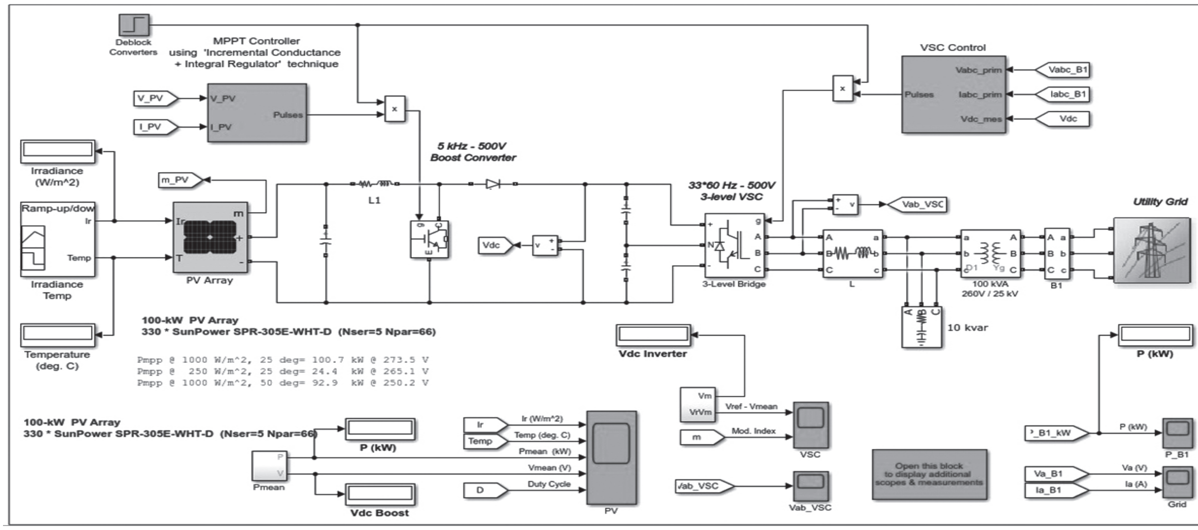

Figure 10. Complete model of proposed system.

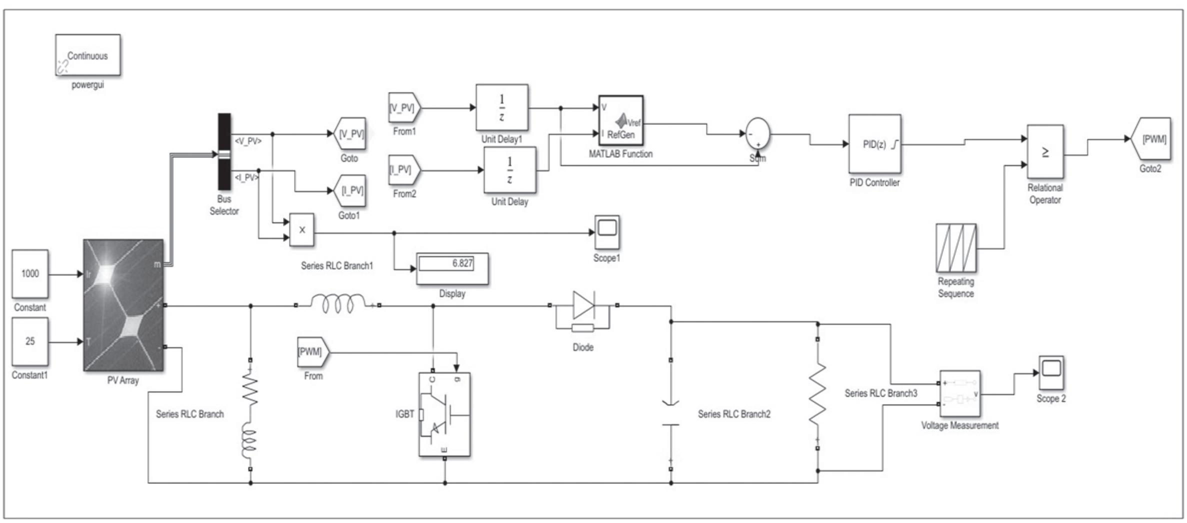

Figure 11. Model of photovoltaic system with MPPT.

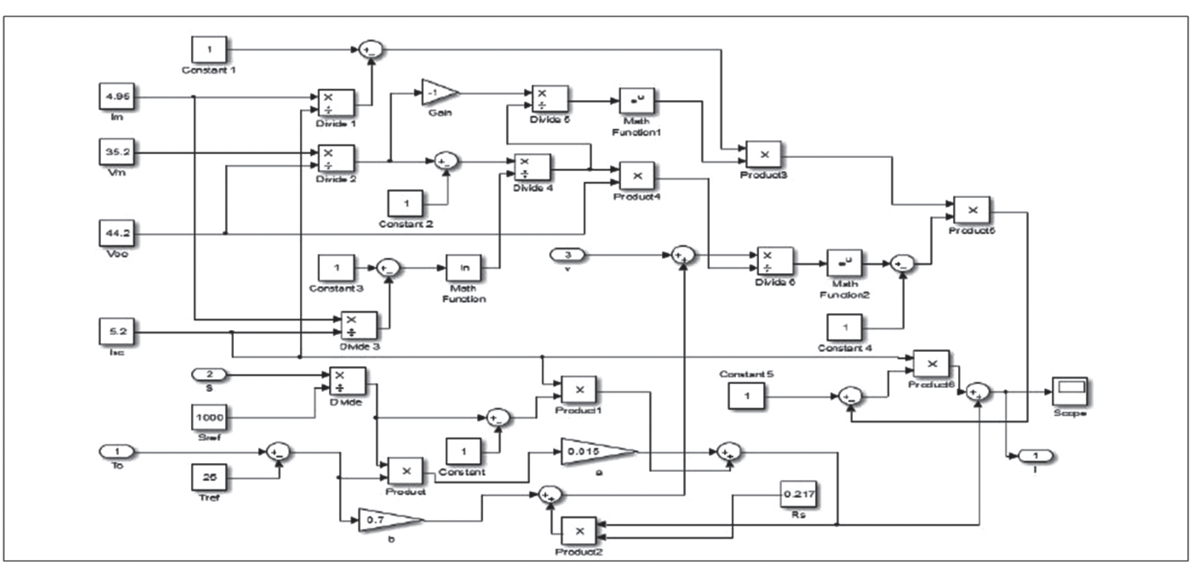

Figure 12. Model of photovoltaic system without MPPT.

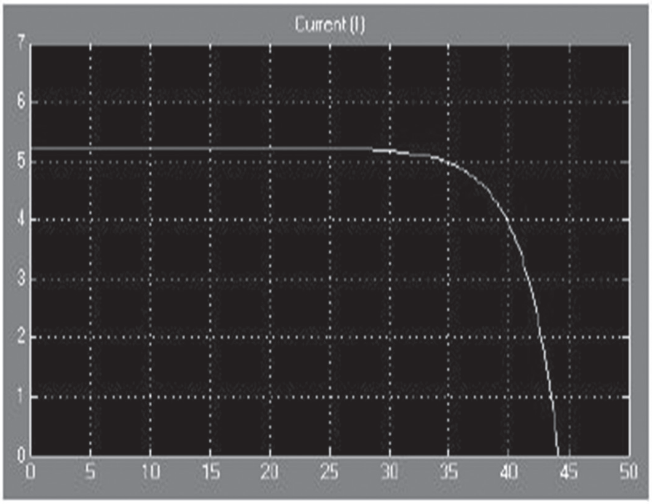

Fig.13. I-V characteristic curve for solar PV array.

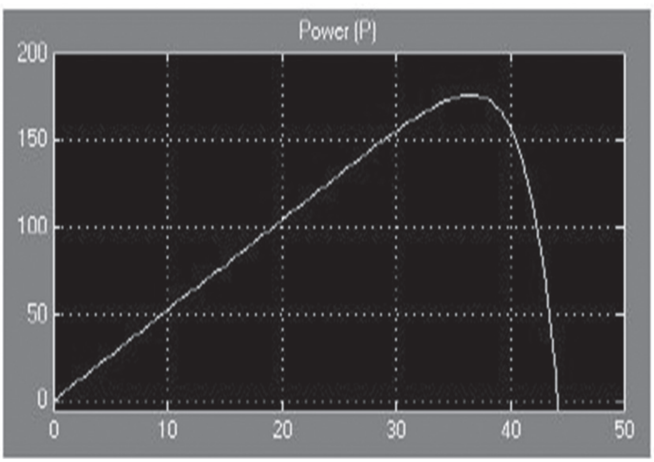

Figure 14. PV characteristic curve for solar PV array.

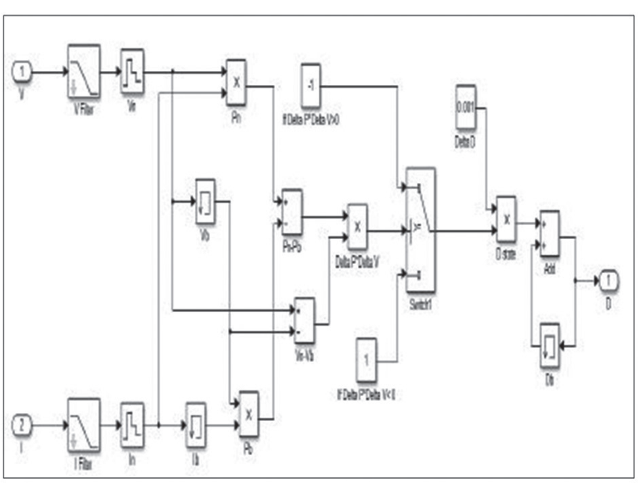

Figure 15. MATLAB-SIMULINK model for P&O approach.

The P&O rule generates a pulse for the high voltage output of the fly-back boost device that is afterwards fed into the DC/AC electrical converter. With the inverter circuit, a PWM wave generator is employed to get four pulses for four semiconductor switches.

The voltage (V) and frequency (f) synchronous output voltage is as indicated with the help of electrical converter circuit and PWM generator, conjointly as PLL.The AC output potential wave kind might be a continual single-phase ac with a 230 V potential and a 50 Hertz frequency. The AC current output wave kind might be a single-phase output with a 4.75 Amp.

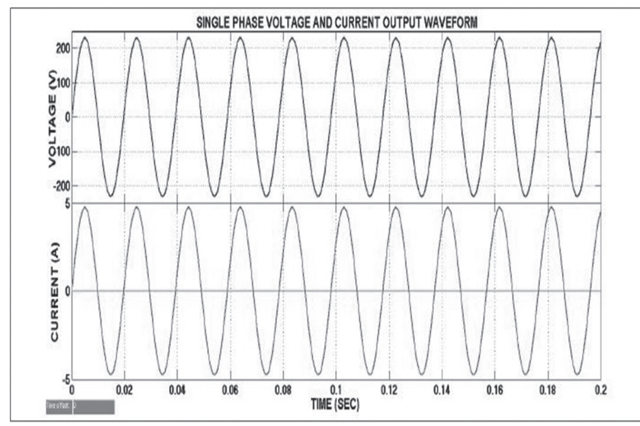

Figure 16. Single-phase voltage and current output waveforms.

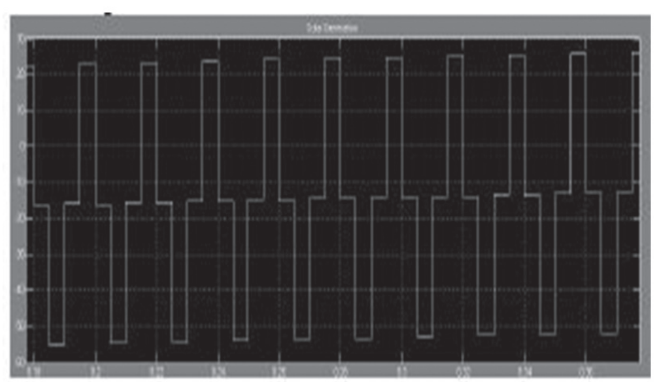

Figure 17. I-T SPV generated output level.

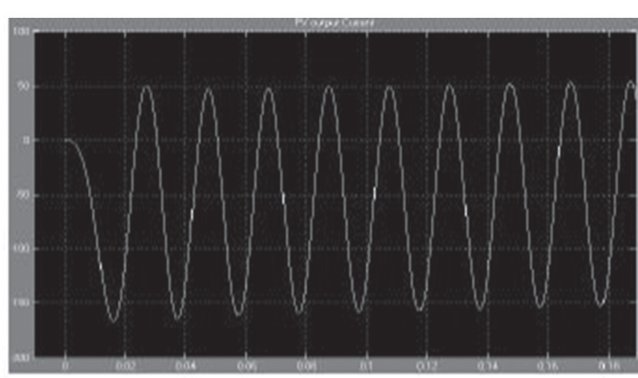

Figure 18. Modified I-TSPV generated output level.

VII. CONCLUSION

The experimental investigation, mathematical analysis and modelling of a 40kWp grid connected solar PV (photovoltaic) system that can execute its needed task under a variety of temperature and irradiance (around the year) conditions are described. This output current and thus power, both were out of phase with the voltage of the grid for a brief period of time, approx. 0.06s, it returned back in phase with the local grid and persisted. The mean performance ratio factor is obtained to be 0.79 which is very much closed to 0.80 (80%). The simulation results support the projected management technique, that regulates the Fly back convertor's output voltage and provides a much better output with lower ripple voltage than the Boost convertor. Due to several advantages, it's a reliable solution for installing in remote locations across the globe.

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With a distinguished track record, Arun has amassed invaluable experience through notable successes in competitions such as the Smart India Hackathon, KPIT Sparkle, and various University Innovation initiatives. Beyond these accomplishments, he has exhibited unwavering dedication to both technical and non-technical pursuits, a ctively participating in events at zonal, university, national and international levels.