Adaptive Dc Link Voltage for Cpi Voltage Variations For A Three Phase Grid Tied Spv System

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ABSTRACT: This proposed model manages a three- stage two-organize grid tied SPV (sunlight based photograph voltaic) framework. The main stage is a help converter, which fills the need of MPPT (most extreme power point following) and sustaining the removed sunlight based vitality to the DC connection of the PV inverter, while the second stage is a two-level VSC (voltage source converter) serving as PV inverter which bolsters control from a support converter into the matrix. The point of this controller is to accomplish an ideal MPP operation without the need of barometrical conditions estimations and to improve the productivity of the PV control framework. This model likewise utilizes a versatile DC connect voltage which is made versatile by modifying reference DC interface voltage as per CPI (regular purpose of interconnection) voltage. The versatile DC connect voltage control helps in the decrease of exchanging force misfortunes. A sustain forward term for sun oriented commitment is utilized to enhance the dynamic reaction. A photovoltaic (PV) framework can create wide scopes of voltage and current at terminal yield. Be that as it may, a PV cell is required to practically keep up a consistent direct present (DC) voltage at a craved level amid constant varieties . To get this objective, a DC/DC converter together with control plot topology is utilized. A versatile PI control plan is proposed to settle the yield voltage of the DC/DC converter, with a specific end goal to keep up and balance out the Adaptive DC-connect voltage in like manner to the progressions of voltage at the Common Point of Interconnection before the framework. The Point of Common Coupling is a point in the electrical framework where various clients or numerous electrical burdens might be associated. This ought to be a guide which is open toward both the utility and the client for direct estimation. Extensive quantities of little scale sunlight based photovoltaic (PV) frameworks are being associated with the appropriation level of the power lattice PV frameworks are incorporated to the power network by means of force electronic converters. The model is tried considering reasonable matrix voltage varieties for under voltage varieties. This model is profitable not just in instances of incessant and managed under voltage (as in the instances of far outspread closures of Indian framework) additionally in the event of ordinary voltages at CPI. The THD (add up to music bending) of lattice current has been discovered well under the farthest point of an IEEE-519 standard. The approval of the proposed MPPT controller is appeared by MATLAB/SIMULINK reproduction.

Keywords: Inverters, Sliding Mode Control (SMC), Photovoltaic (PV) systems, Power quality

INTRODUCTION The electrical energy has a vital role in development of human race in the last century. The diminishing conventional primary sources for electricity production have posed an energy scarcity condition in front of the world. The renewable energy sources such as solar, wind, tidal etc are few of such options which solve the problem of energy scarcity. The cost effectiveness of any technology is prime factor for its commercial success. The SPV (Solar Photovoltaic) systems have been proposed long back but the costs of solar panels have hindered the technology for long time, however the SPV systems are reaching grid parity [1], [2]. The solar energy based systems can be classified into standalone and grid interfaced systems. The energy storage (conventionally batteries) management is the key component of standalone system. Various problems related to battery energy storage standalone solar energy conversion systems are discussed in [3]–[6]. Considering the problems associated with energy storage systems, the grid interfaced systems are more preferable, in case the grid is present. The grid acts as an energy buffer, and all the generated power can be fed into the grid. Several grid interfaced SPV systems are proposed in past addressing various issues related to islanding, intermittency, modeling etc [7]–[9]. With growing power system, the attention is moving from centralized generation and radial distribution to distributed generation. The distributed generation can bring in several advantages such as reduction in losses, better utilization of distribution resources, load profile flattering etc [10]–[12]. The SPV systems provide a good choice for distributed generation system considering small scale generation from rooftop solar, modularity of power converter and static energy conversion process. The initial investment in SPV systems is high because of high cost of solar panels [13]. Therefore, considering the initial investments for any installed plant, the aim is to extract maximum energy output from the given capacity. To accomplish the objective of extraction of maximum energy from an installed PV array several techniques are proposed in the literature [14]–[18]. A review of MPPT (Maximum Power Point Tracking) techniques is shown in [14]. An incremental conductance (InC) based MPPT technique is shown in [15]. An ANN based MPPT algorithm is shown in [16]. The application of sliding mode controller to MPPT algorithm is shown in [17]. A combination of fractional open circuit voltage and fuzzy based MPPT technique is shown in [18] wherein a constant offset is added at the output of fuzzy controller to improve the MPPT performance. The incremental conductance based MPPT is fast, accurate and easy to implement. In this paper, a composite InC based MPPT method is used. The composite InC method is a combination of fractional Voc and InC based method. The proposed MPPT technique limits the area of search for MPP point hence improves the MPPT performance. The tripping of the plant causes generation loss in case of grid tied PV generation system. In general, grid tied VSCs have under voltage and overvoltage protection. The nominal range of set point for under voltage and over voltage is around 0.9 pu and 1.1 pu [19]. This range is very narrow because of reasons such as converter may lose control, increase in converter rating, and converter losses at low voltage etc. In case of weak distribution system, a wide voltage variation is observed. During peak loading condition, a sustained voltage dip or under voltage is observed commonly. The practical range of voltage variation is about ±15% of the nominal voltage. Normally in such wide variation of distribution system the shunt connected

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converter trips frequently. However, in case of tripping of converter the PV generation is lost even when PV power is available. Therefore, minimizing converter trips indirectly increases energy yield from the installed plant. The proposed system is capable of working with wide range of voltage variation hence avoids the generation loss. The use of two stage SPV generation system has been proposed by several researchers [20]–[23]. Conventionally a DC-DC converter is used as first stage which serves the purpose of MPPT. The duty ratio of DC-DC converter is so adjusted that PV array operates at MPP point. The second stage is a grid tied VSC (Voltage Source Converter) which feeds the power into the distribution system. A single phase two stage grid tied PV generation system with constant DC link voltage is shown in [20]. Moreover, the three phase grid tied PV generation system with constant DC link voltage control is also shown in [21], [22]. The concept of loss reduction by adaptive DC link voltage for VSC in hybrid filters is shown in [23], [24] wherein, the DC link voltage is adjusted according to reactive power requirement of filter. However, in the proposed system the DC link voltage of VSC is made adaptive with respect to CPI voltage variation. Moreover, the circuit topologies in both the systems are different. Therefore, the work presented in [23], [24] is very different from the proposed work. For proper control of VSC currents, the DC link voltage reference is set more than peak of three phase line voltages. The limitation for current control in single-phase grid connected converter is shown in [25]. Considering the variation of CPI (Common Point of Interconnection) voltage, the reference DC link voltage is kept above the maximum allowable CPI voltage. Therefore in case of fixed DC link voltage control for VSC, the system always operates at a DC link voltage corresponding to worst case condition. The system configuration for the proposed system is shown in Fig. 1. A two stage system is proposed for grid tied SPV system. The first stage is a DC- DC boost converter serving for MPPT and the second stage is a two-level three phase VSC. The PV array is connected at the input of the boost converter and its input voltage is controlled such that PV array delivers the maximum power at its output terminals. The output of boost converter is connected to DC link of VSC. The DC link voltage of VSC is dynamically adjusted by grid tied VSC on the basis of CPI voltage. The three phase VSC consists of three IGBT legs. The output terminals of VSC are connected to interfacing inductors and the other end of interfacing inductors are connected to CPI. A ripple filter is also connected at CPI to absorb high frequency switching ripples generated by the VSC

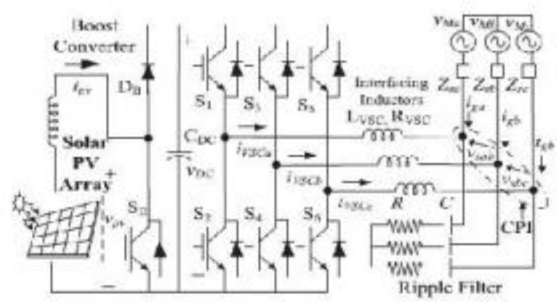


Fig. 1 System Configuration

In solar power system the power delivered to the load is highly dependent on solar radiation and PV array temperature. I-V and P-V curves of a solar cell with constant module temperature and solar radiation have been shown in figure 2. At the intersection of Imp and Vmp, array generates maximum electrical power [1]

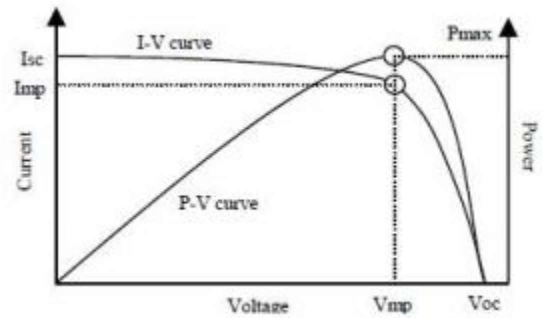


Fig. 2 Current-voltage and power-voltage characteristics of a solar cell

As per maximum power transfer theorem, the circuit delivers maximum power to the load when source impedance matches the load impedance. In case of stand-alone solar system dc-dc converter is connected in between PV array and the dc load. Maximum power point tracking (MPPT) system varies the duty cycle of the dc-dc converter in order to match source and load impedance and to deliver maximum power to the load. Various MPPT methods have been reported in the literature. These methods can be classified as: i) methods based on load line adjustment of I-V curve and ii) method based on artificial intelligence (fuzzy logic or neural network based MPPT methods). The MPPT methods viz. perturb and observe (P & O), incremental conductance (INC), voltage feedback (VF) are based on load line adjustment of I-V curve. These methods have been found less suitable under uncertainties due to varying atmospheric and load conditions. The MPPT system based on artificial intelligence (fuzzy logic or neural network) has robust capabilities in regard to uncertainties [2, 3]. Real time simulation and comparative analysis of five mostly referred MPPT techniques viz. perturb and observe, incremental conductance, fuzzy logic, neural network and adaptive neuro-fuzzy inference system (ANFIS) based MPPT techniques have been presented in this paper. The paper is organized as follows. In section two a brief introduction of various MPPT techniques has been presented. Section three describes the modeling of solar PV system. Modeling and real time simulation of MPPT algorithms has been given in section four. In section five, comparative analysis of five MPPT techniques and experimentation results have been presented, followed by conclusions.

BOOST CONVERTER:

A Boost Converter i.e. Step-up Converter is a DC-to-DC power converter with an output voltage greater than its input voltage. It is a class of switched mode power supply containing at least two semiconductor switches i.e., a diode and a transistor and at least one energy storage element i.e., a capacitor, inductor or the two in combination. Filters made of capacitors sometimes in combination with inductors are normally added to the output of the converter to reduce output voltage ripple.

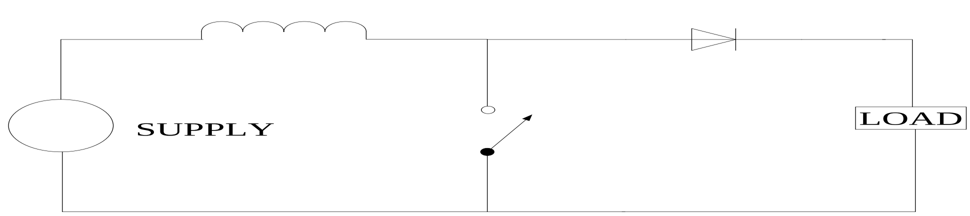


Figure 3: Basic schematic of a Boost Converter

Overview of Boost Converter:

Power for the Boost Converter can come from any suitable DC sources, such as batteries, solar panels, rectifiers and DC generators. A process that changes one DC voltage to a different DC voltage is called DC to DC conversion. A boost converter is a DC-to-DC converter with an output voltage greater than the source voltage. A boost converter is sometimes called a step-up converter since it "steps up" the source voltage. Since power P=VI must be conversed, the output current is lower than the source current.

MAXIMUM POWER POINT TRACKING

A composite InC based MPPT algorithm is used. A range of voltage for peak power is known with the knowledge from fractional Voc MPPT, which is 0.7Vocmax to 0.9Vocmax, where Voc is open circuit voltage and Vocmax is maximum open circuit voltage. The voltage for peak power is always searched in this range for fast search of Vmpp. The InC algorithm works in order to minimize the difference between the incremental conductance and the conductance offered by the PV array. At first, the reference PV array voltage is estimated based on the In C principle then that reference voltage is used to estimate the duty ratio of the boost converter. For calculation of an incremental conductance ΔIPV and ΔVPV are estimated as,

$$\Delta IPV = IPV\ (k) - IPV\ (k-1) \qquad (1a)$$

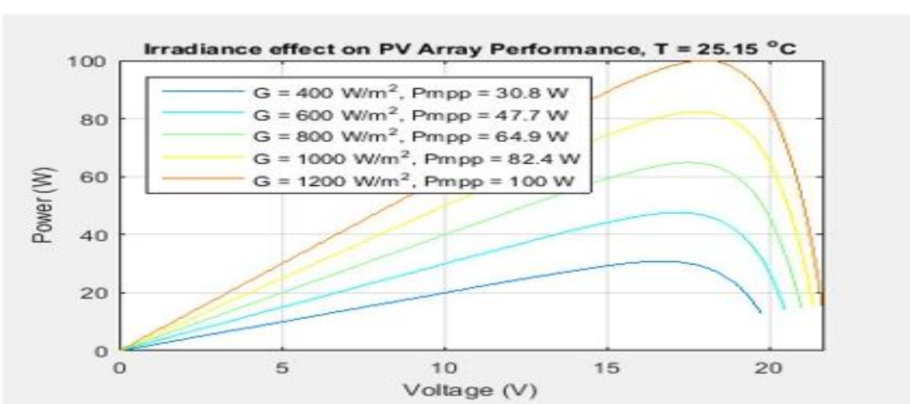
$$\Delta VPV = VPV\ (k) - VPV\ (k-1) \qquad (1b)$$

where IPV(k) and VPV(k) are the instantaneous sampled current and voltage of the solar array. The governing equations for InC based MPPT algorithm is as,

MPPT ALGORITHUM:

Maximum power point tracking (MPPT) is an algorithm implemented in photovoltaic (PV) inverters to continuously adjust the impedance seen by the solar array to keep the PV system operating at, or close to, the peak power point of the PV panel under varying conditions, like changing solar irradiance, temperature, and load. Engineers developing solar inverters implement MPPT algorithms to maximize the power generated by PV systems. The algorithms control the voltage to ensure that the system operates at "maximum power point" (or peak voltage) on the power voltage curve, as shown below.

MPPT algorithms are typically used in the controller designs for PV systems. The algorithms account for factors such as variable irradiance (sunlight) and temperature to ensure that the PV system generates maximum power at all times.

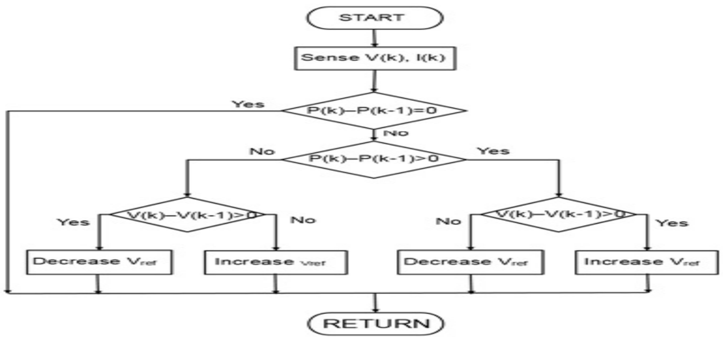


Implement Maximum Power Point Tracking 1

Power voltage curve with I-V and P-V characteristics of a photovoltaic system.

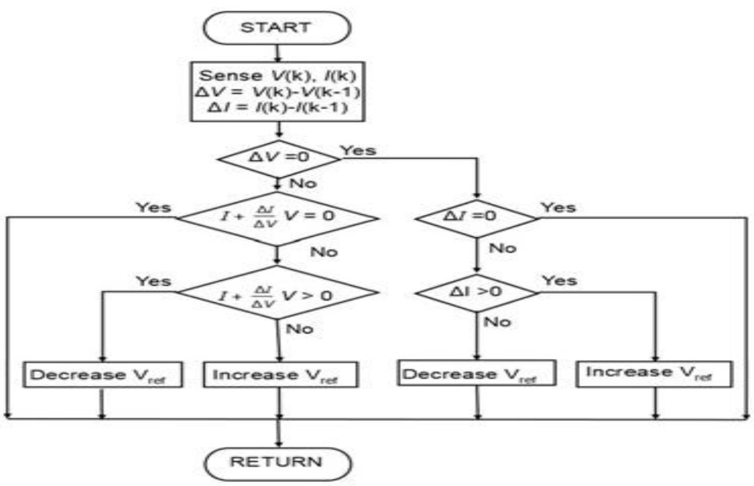
The three most common MPPT algorithms are:

Perturbation and observation (P&O): This algorithm perturbs the operating voltage to ensure maximum power. While there are several advanced and more optimized variants of this algorithm, a basic P&O MPPT algorithm is shown below.



Basic P&O algorithm.

Incremental conductance: This algorithm, shown below, compares the incremental conductance to the instantaneous conductance in a PV system. Depending on the result, it increases or decreases the voltage until the maximum power point (MPP) is reached. Unlike with the P&O algorithm, the voltage remains constant once MPP is reached.



Incremental conductance algorithm.

Fractional open-circuit voltage: This algorithm is based on the principle that the maximum power point voltage is always a constant fraction of the open circuit voltage. The open circuit voltage of the cells in the photovoltaic array is measured and used as in input to the controller.

PROPOSED SYSTEM:

The basic control approach for the SPV system is shown in Fig. 2. The control of the system can be divided into two main parts, which are control of the boost converter and control of a grid tied VSC. The input voltage of a boost converter is adjusted according to MPPT algorithm and the output voltage of boost converter, which is also the DC link voltage of VSC is also kept adaptive according to CPI voltage condition. In overall, the proposed system is operated such that both the input and output voltages of boost converter are adjusted according to sensed variables of the circuit. The boost converter feeds the power to the DC link of VSC, which then feeds that power into the three-phase grid at unity power factor with respect to CPI. A composite InC based MPPT technique is used to estimate the reference PV array voltage and a PLL-less control is proposed for the control of the VSC. The amplitude of the refrence grid currents is estimated using a PV feedforward (PVFF) term and a PI controller DC link voltage error. A set of unit vectors is estimated from grid voltages to synchronize output currents of VSC. The estimated reference grid currents are compared with sensed grid currents and a hysteresis current controller is used to generate switching logic for VSC. The detailed formulation for control algorithm is presented in the later half of this section.

CONSTRUCTION:

A PI controller is used to maintain the DC link voltage to reference DC link voltage. The sensed DC link voltage is passed through a low pass filter to suppress the switching noise. The output of low pass filter is designated as VDC. The difference between VDCref and VDC is the input to the PI controller. The amplitude of grid currents consists of two main parts which are the loss component and the contribution from the PV array. The output of PI controller can considered as loss component in steady state condition. The loss component is estimated as,

Iloss (k) = Iloss (k−1) + Kp {ve (k)−ve (k−1)} + Kive (k) (7)

A PV feed forward (PVFF) term for PV array contribution to grid current is also estimated to provide fast dynamic response for changes in solar insolation and grid voltages. The PV feedforward term is estimated as,

IPV g = (2PPV)/ (3VZ) (8)

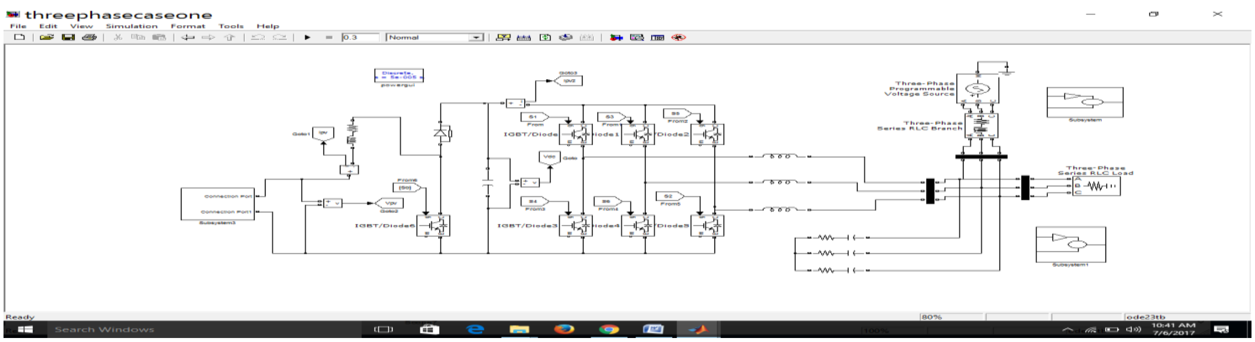
It can be observed from the above equation that in case of insolation variation, the PV power (PPV = VPV ∗ IPV) changes and the instantaneous effect can be observed on PV contribution term. Moreover, the in case of voltage variation at CPI, the grid currents need to be adjusted to feed same solar power, which eventually is adjusted due to term Vz in the PV contribution term. The grid currents are assumed coming out of CPI terminals and considering the direction of grid currents, the losses are drawn from the grid whereas the PVFF is fed into the grid. Therefore, net amplitude of grid current is estimated as,

Irg = Iloss − IPV g (9)

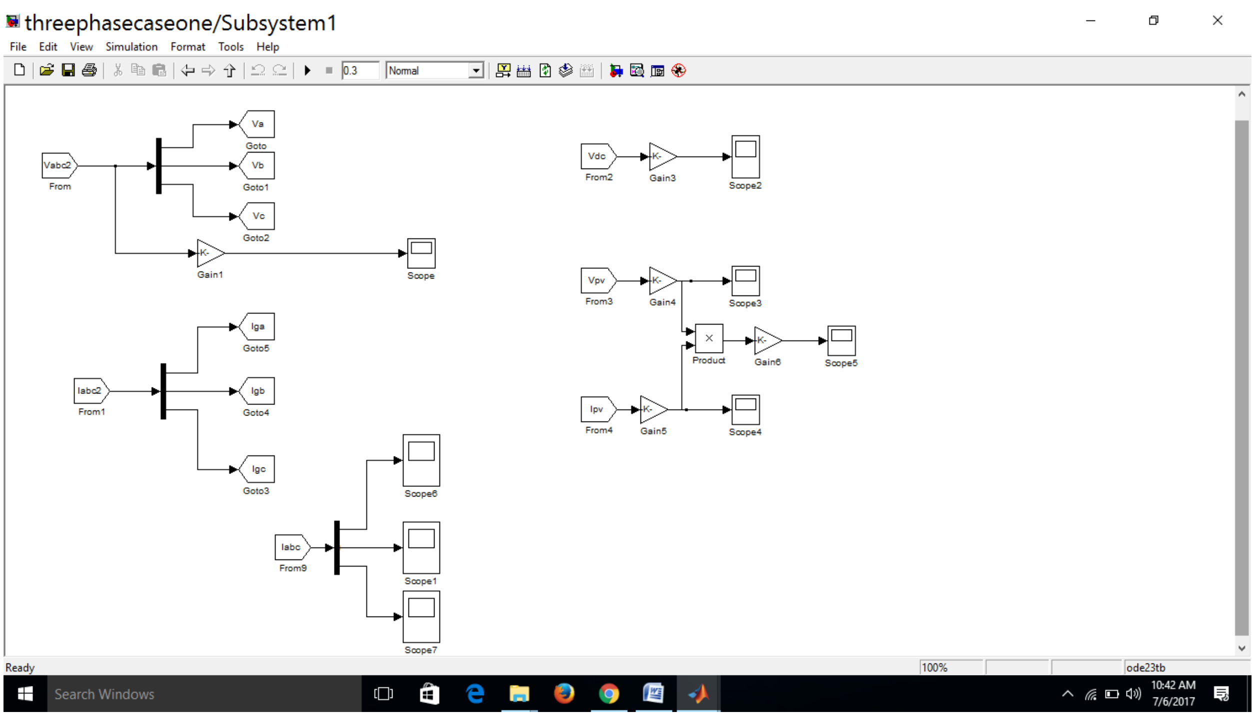
The estimated amplitude of grid current Irg is then multiplied with unit vectors of corresponding phases to estimate reference grid currents. The reference and sensed grid currents are then given to current controller. The output of current controller is the switching pulses to the VSC.

SIMULATION RESULTS:

show performance of proposed system under sudden change in insolation from 1000W/m2 to 500W/m2 with and without feed forward compensation respectively. Before time t = 0.3 s, the system is working under steady state condition with SPV insolation at 1000W/m2. The grid currents are balanced and sinusoidal. At time t = 0.3 s, the insolation is decreased from 1000W/m2 to 500W/m2. The PV array current decreases due to decrease in insolation and so is the PV array power. It can be easily observed that the dynamic response for sudden change in insolation level is better for proposed system. The DC link voltage for only PI controller based system shows more deviation and longer time to settle as compared to proposed system with feed forward compensation based control approach. The system with proposed control approach soon reaches the next state and it feeds the reduced power into the grid. No appreciable effect is observed on the DC link voltage of VSC.



Internal sub system:



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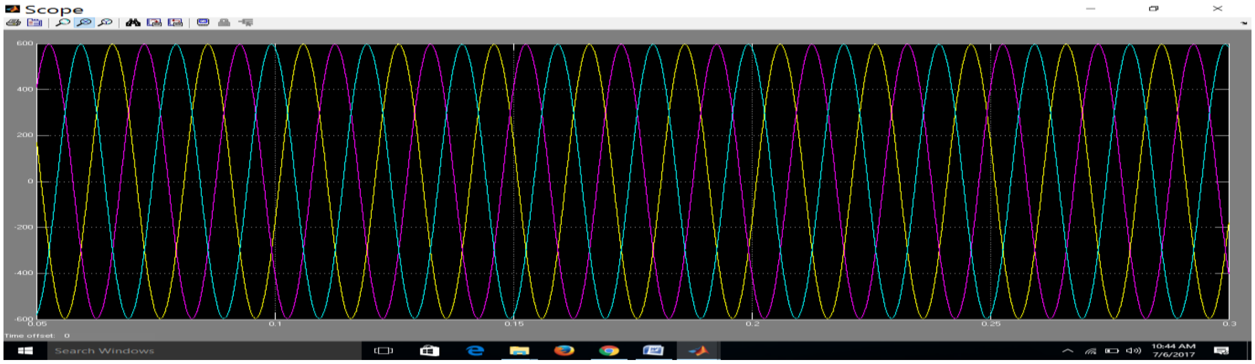

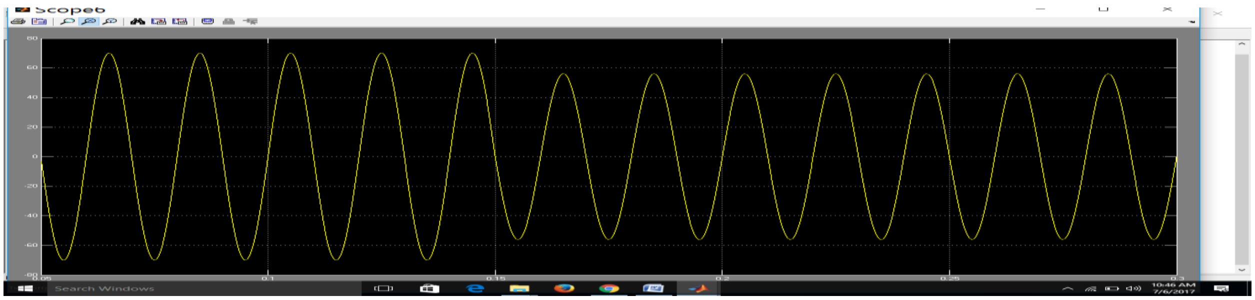

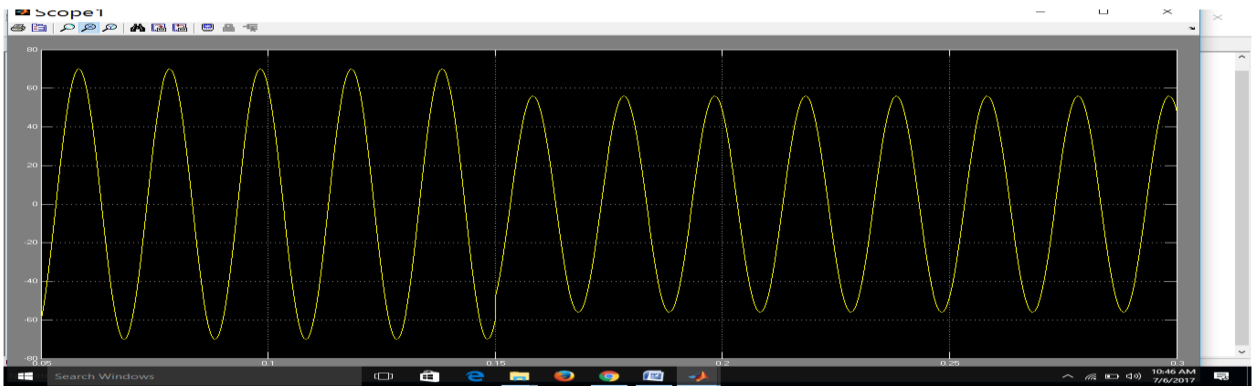

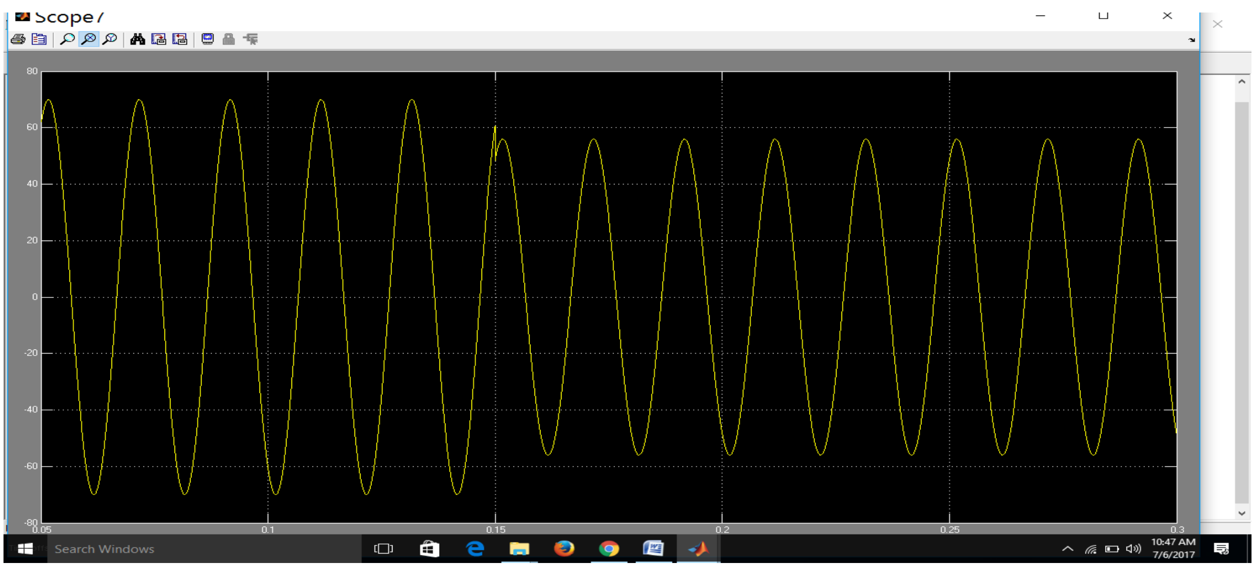

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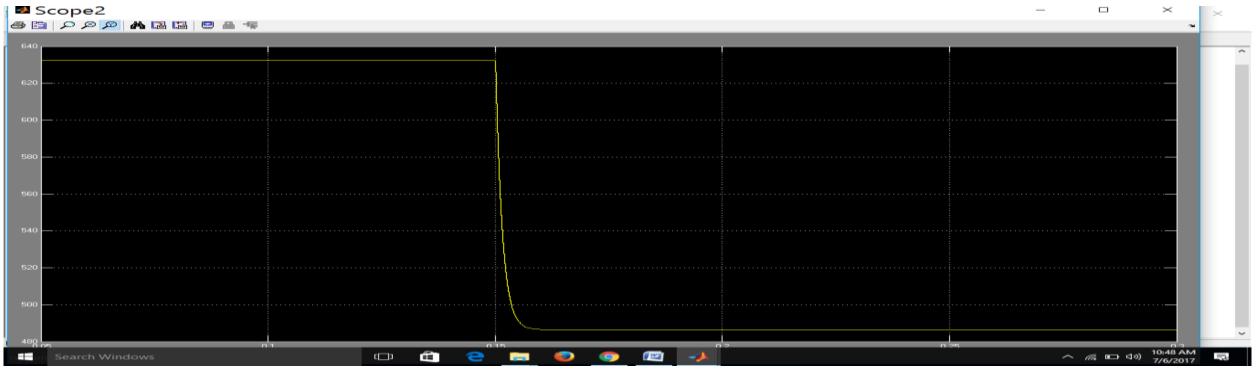

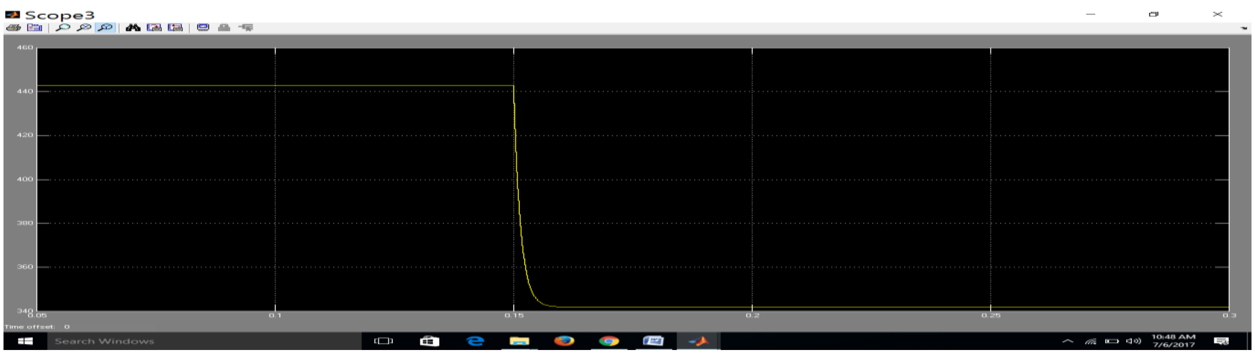

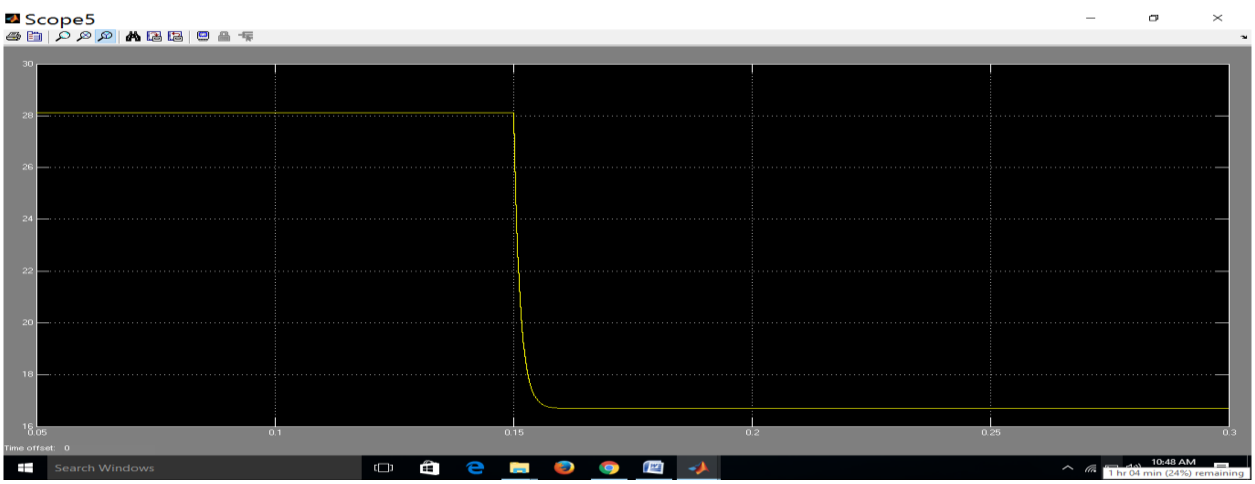

CONCLUSION

A two-stage system has been proposed for three-phase grid connected solar PV generation. Earlier, works have been done in this area using Incremental based MPP Technique to control the boost converter and adaptive DC link voltage control approach for control of grid tied VSC. In this proposed model, a Fuzzy Logic based MPPT algorithm is used for control of the boost converter and Sliding Mode control approach has been proposed for control of grid tied VSC.. The performance of the system has been demonstrated for wide range of CPI voltage variation. The DC link voltage is made adaptive with respect to CPI voltage which helps in reduction of losses in the system. The fuzzy logic and sliding mode control approaches not only enchances the speed and accuracy of the model , but also improves performance of the system upto 20 % of CPI variation

REFERENCES

[1] M. Pavan and V. Lughi, "Grid parity in the Italian commercial and industrial electricity market," in Proc. Int. Conf. Clean Elect. Power (ICCEP'13), 2013, pp. 332–335.

[2] M. Delfanti, V. Olivieri, B. Erkut, and G. A. Turturro, "Reaching PV grid parity: LCOE analysis for the Italian framework," in Proc. 22nd Int. Conf. Exhib. Elect. Distrib. (CIRED'13), 2013, pp. 1–4.

[3] H.Wang and D. Zhang, "The stand-alone PV generation system with parallel battery charger," in Proc. Int. Conf. Elect. Control Eng. (ICECE'10), 2010, pp. 4450–4453.

[4] M. Kolhe, "Techno-economic optimum sizing of a stand-alone solar photovoltaic system," IEEE Trans. Energy Convers., vol. 24, no. 2, pp. 511–519, Jun. 2009.

[5] D. Debnath and K. Chatterjee, "A two stage solar photovoltaic based stand alone scheme having battery as energy storage element for rural deployment," IEEE Trans. Ind. Electron., vol. 62, no. 7, pp. 4148–4157, Jul. 2015.

[6] S. Krithiga and N. G. Ammasai Gounden, "Power electronic configuration for the operation of PV system in combined grid-connected and stand-alone modes," IET Power Electron., vol. 7, no. 3, pp. 640–647, 2014.

[7] I. J. Balaguer-Álvarez and E. I. Ortiz-Rivera, "Survey of distributed generation islanding detection methods," IEEE Latin Amer. Trans., vol. 8, no. 5, pp. 565–570, Sep. 2010.

[8] C. A. Hill, M. C. Such, D. Chen, J. Gonzalez, and W. M. Grady, "Battery energy storage for enabling integration of distributed solar power generation," IEEE Trans. Smart Grid, vol. 3, no. 2, pp. 850–857, Jun. 2012.

[9] W. Xiao, F. F. Edwin, G. Spagnuolo, and J. Jatskevich, "Efficient approaches for modeling and simulating photovoltaic power systems," IEEE J. Photovoltaics, vol. 3, no. 1, pp. 500–508, Jan. 2013.

[10] P. Chiradeja, "Benefit of distributed generation: A line loss reduction analysis," in Proc. IEEE/PES Transmiss. Distrib. Conf. Exhib.: Asia Pac., 2005, pp. 1–5.

[11] A. Yadav and L. Srivastava, "Optimal placement of distributed generation: An overview and key issues," in Proc. Int. Conf. Power Signals Control Comput. (EPSCICON'14), 2014, pp. 1–6.

[12] K. A. Joshi and N. M. Pindoriya, "Impact investigation of rooftop Solar PV system: A case study in India," in Proc. 3rd IEEE PES Int. Conf. Exhib. Innovative Smart Grid Technol. (ISGT Europe), 2012, pp. 1–8.

13] E. Drury, T. Jenkin, D. Jordan, and R. Margolis, "Photovoltaic investment risk and uncertainty for residential customers," IEEE J. Photovoltaics, vol. 4, no. 1, pp. 278–284, Jan. 2014.