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Solar Photovoltaic System with Pi Controller for Maintaing Constant Cpi Voltages

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ABSTRACT

Solar photo Voltaic (SPV) systems based grid interfacing systems involve two stage power conversions. This conversion requires Maximum Power Point Tracking (MPPT) based boost converter that can supply a constant DC link voltage with a SPV as its input as the first stage. The second stage conversion involves a three-level Voltage Source Converter (VSC) that serving as PV inverter which feed power from the boost converter to the grid. To meet the grid requirements the voltage at the Common Point of Interconnection (CPI), the voltage of the inverter must be made equal to the voltage of CPI. This can be done adjusting DC link voltage of stage one of the converter. This can be achieved by using anadaptive feed forward Proportional and integral Controller (PI). The advantage of this controller is that it improves dynamic response, reduces the switching losses and provides robust response under grid voltage variations. The performance of the system is verified with the help of MATLAB based simulation studies and the case studies are presented.

Keywords:*Adaptive DC link, MPPT, solar PVArray, VSC, CPI ,* PI Controller

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

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 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. With growing power system, the attention is moving from centralized generation and radial distribution to distributed generation. The distributed generation can bring in several

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Advantages such as reduction in losses, better utilization of distribution resources, load profile flattering etc. 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. Therefore, considering the initial investments for any installed plant, the aim is to extract maximum energy output from the given capacity In solar energy system inverter is the main part which converts DC power obtained from solar cells in to AC power to fed in to the Grid.

GENERAL SPV SYSTEMS

There are two main system configurations – stand-alone and grid-connected. As its name implies, the stand-alone PV system operates independently of any other power supply and it usually supplies electricity to a dedicated load or loads. It may include a storage facility (e.g. battery bank) to allow electricity to be provided during the night or at times of poor sunlight levels. Stand-alone systems are also often referred to as autonomous systems since their operation is independent of other power sources. By contrast, the grid-connected PV system operates in parallel with the conventional electricity distribution system. It can be used to feed electricity into the grid distribution system or to power loads which can also be fed from the grid.

It is also possible to add one or more alternative power supplies (e.g. diesel generator, wind turbine) to the system to meet some of the load requirements. These systems are then known as 'hybrid' systems.

Hybrid systems can be used in both stand-alone and grid-connected applications but are more common in the former because, provided the power supplies have been chosen to be complementary, they allow reduction of the storage requirement without increased loss of load probability. Figures below illustrate the Schematic diagrams of the three main system types are show in fig 1

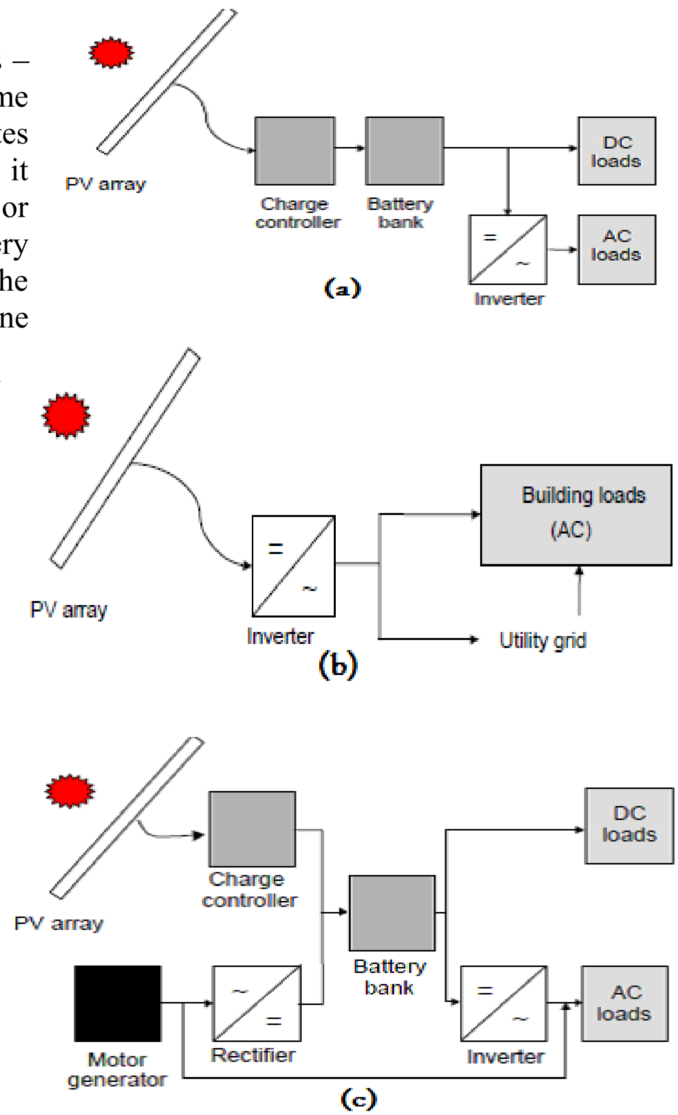

Fig1 Schematic diagram (a) stand-alone photovoltaic system(b).Grid-Connected photovoltaic

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system. (C). hybrid system incorporating a photovoltaic array and a motor generator

SYSTEMCONFIGURATION

The use of two stage SPV generation system has beenproposed by several researchers.Conventionally aDC-DC converter is used as first stage which serves the purposeof MPPT. The duty ratio of DC-DC converter is so adjusted thatPV array operates at Maximum Power Point. The second stage is a grid tiedVSC (Voltage Source Converter) which feeds the power intothe distribution system. A two stage grid tied PVgeneration system with constant DC link voltage is system is shown in fig 1. Moreover, the three phase grid tied PV generation systemwith constant DC link voltage control is also shown in fig 2. 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 bythe VSC.The concept of loss reduction by adaptive DC link voltage for VSC in hybrid filters and 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 is very differentfrom the proposed work.For proper control of VSC currents, the DC link voltage reference is set more than peak of three phase line voltagesConsidering the variation of CPI(Common Point of Interconnection) voltage, the reference DClink voltage is kept above the maximum allowable CPI voltage.

Therefore in case of fixed DC link voltage control for VSC, thesystem always operates at a DC link voltage corresponding toworst case condition.

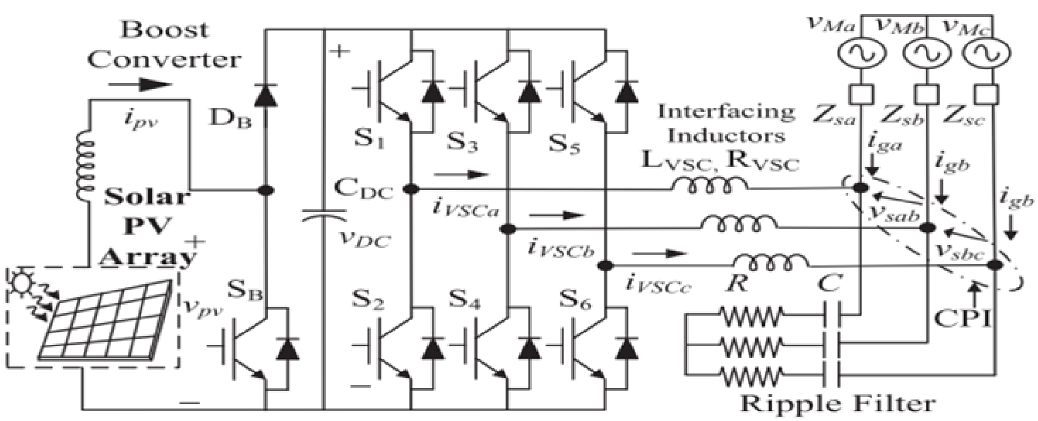

Figure2 **:**System Configuration under consideration

CONTROL APPROACH

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The basic control approach for the SPV system is 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 reference grid currents is estimated using a PV feed forward (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.

MODEL SIMULATION With the available stability conditions the simulation model for the system configuration shown in fig 2 is presented in figure 3. The System parameters are presented in below

Figure 3:MATLAB based schematic Of Solar Photovoltaic System With Pi Controller For MaintaingConstantCPI Voltages

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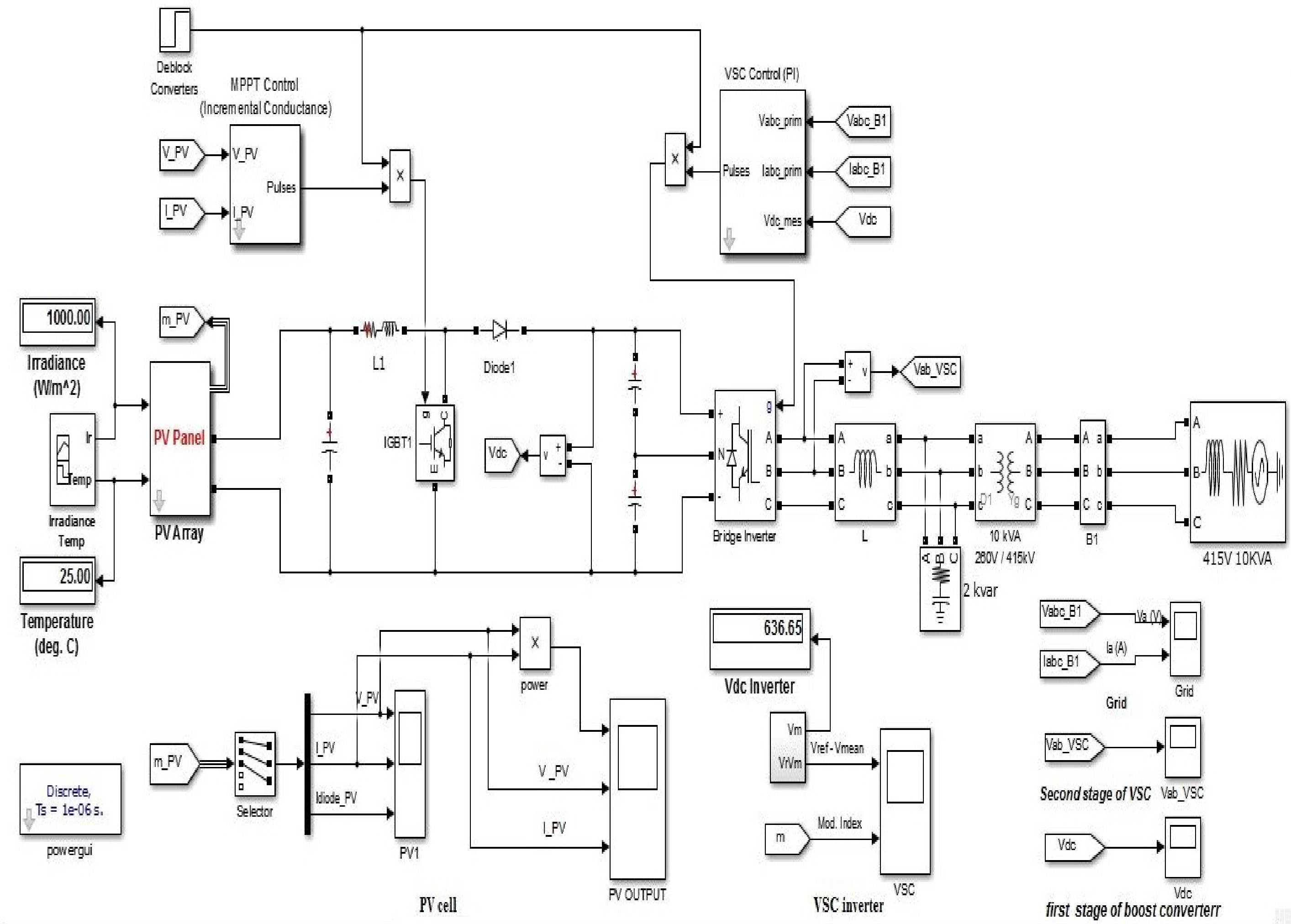

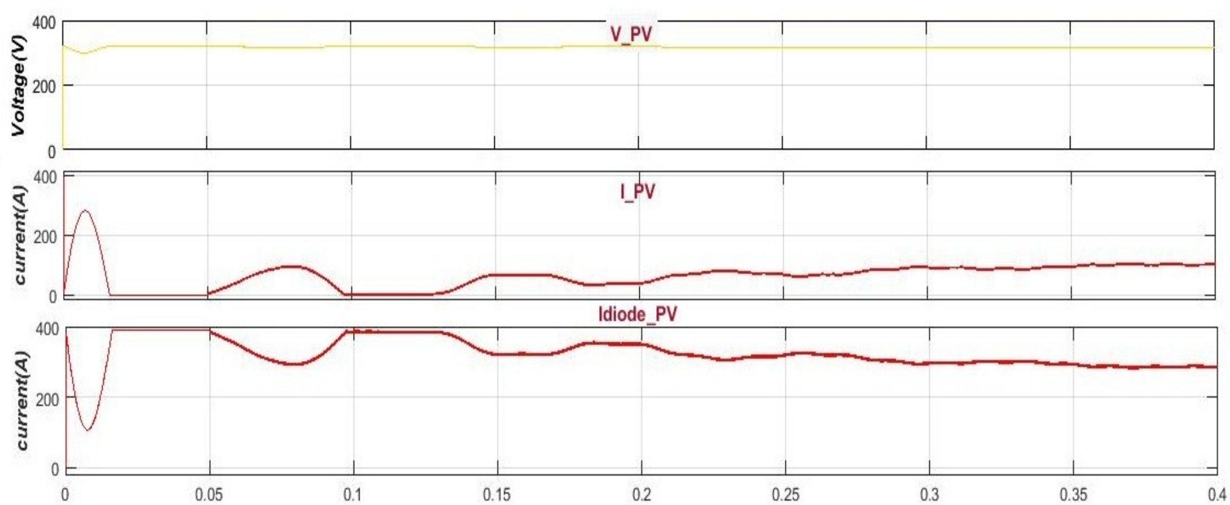

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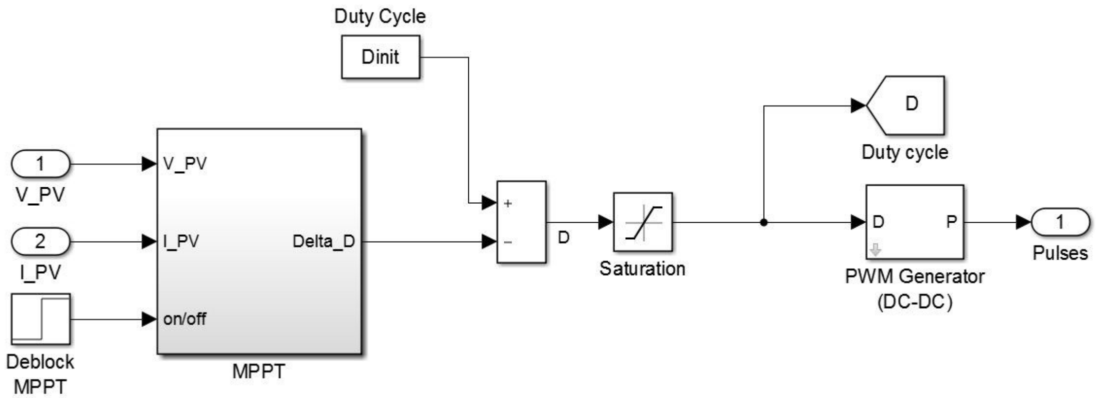
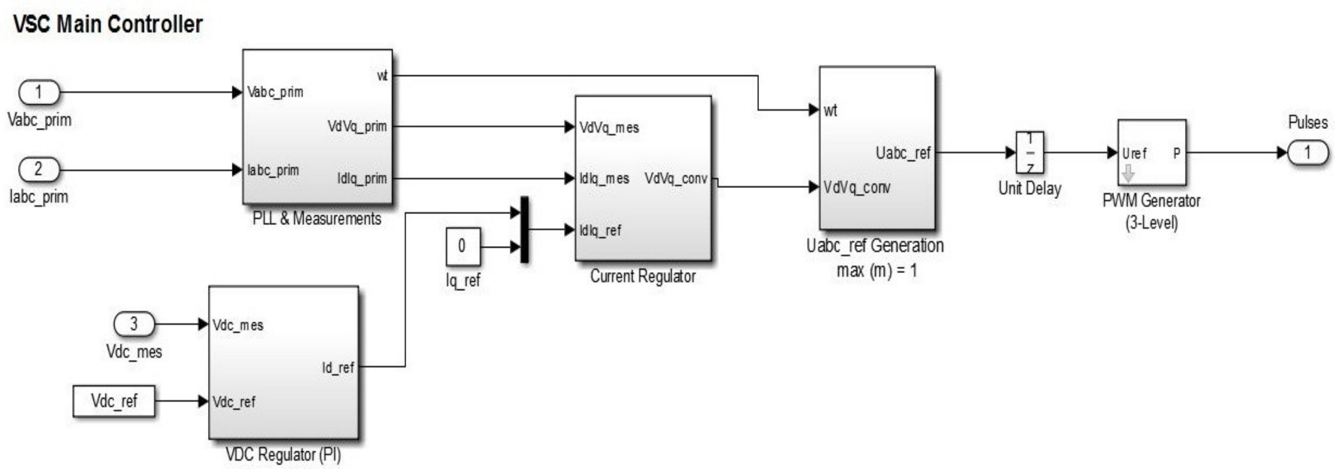
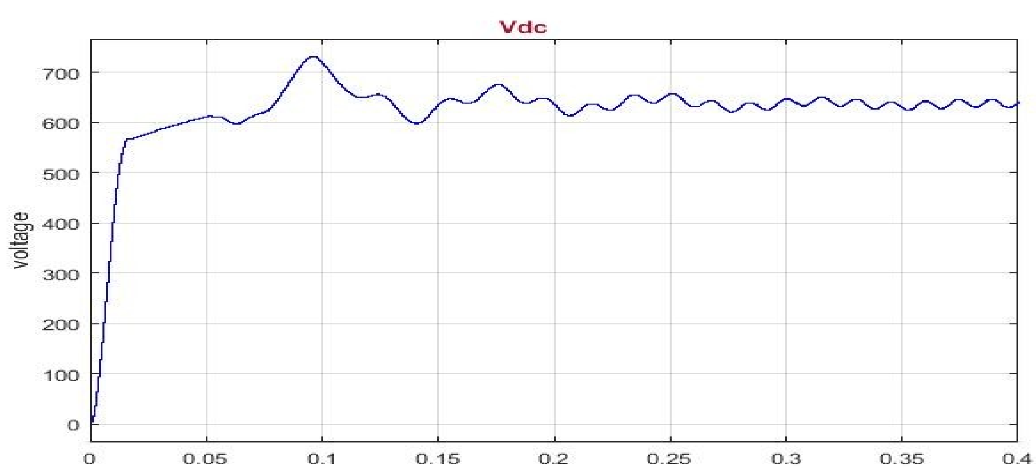


Figure 4: MPPT Controller used for generation trigger pulses to DC – DC converter

Figure 5: Voltages and currents of MPPT based PV Array

Figure 6 : Output Voltages of MPPT based boost converter





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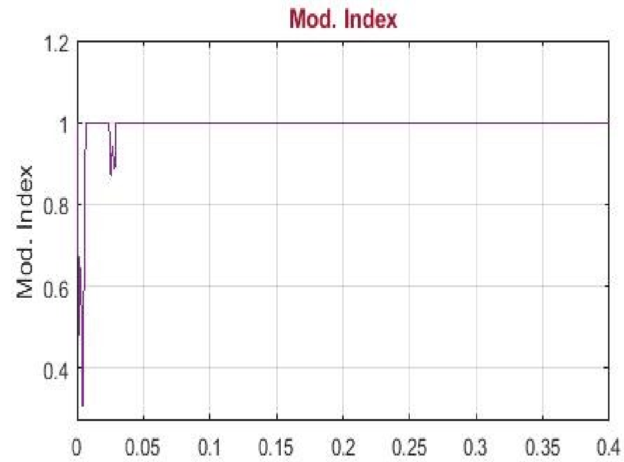

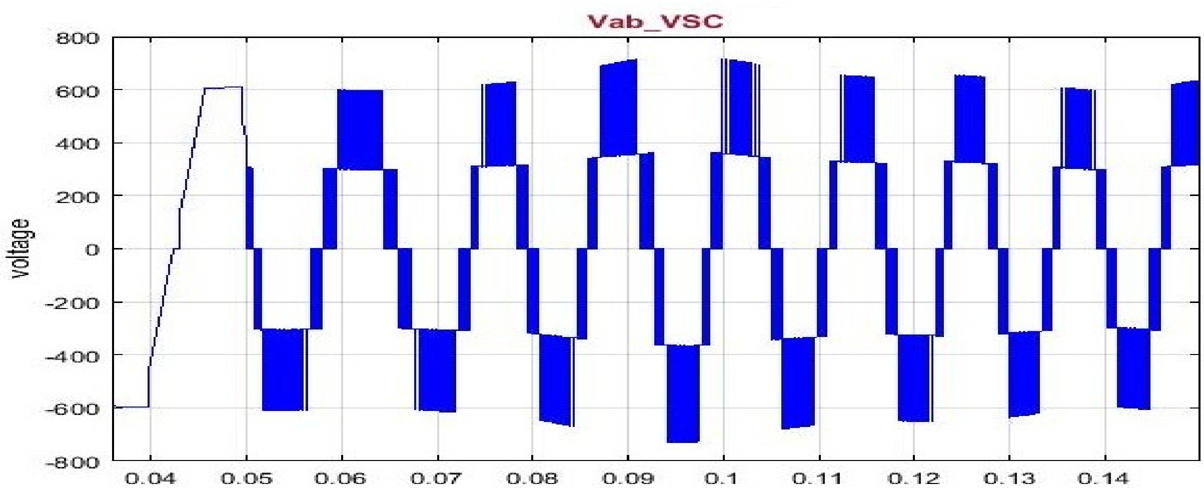

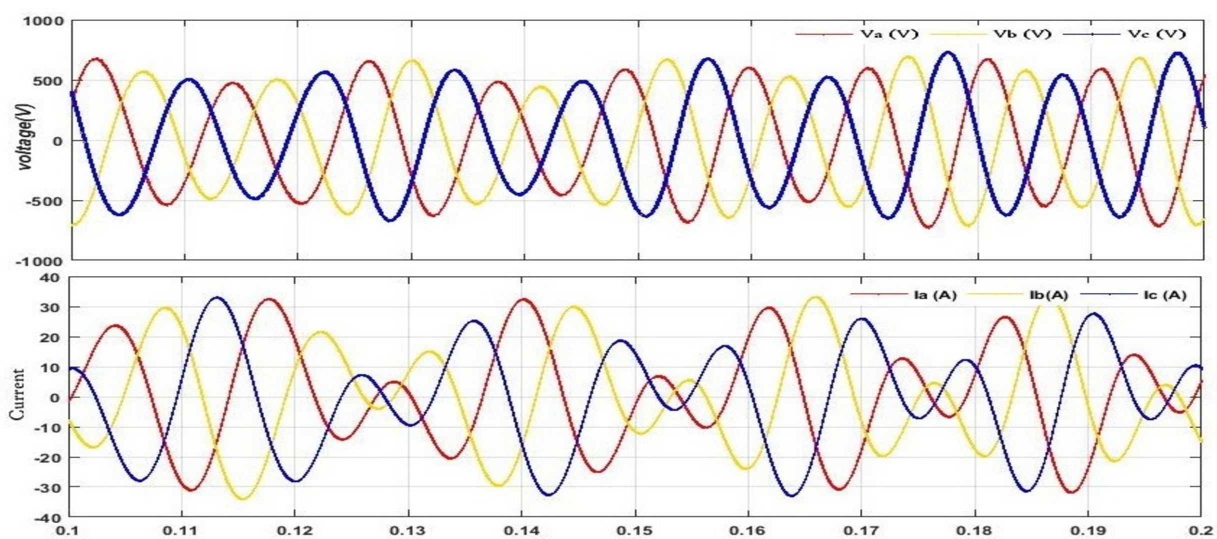

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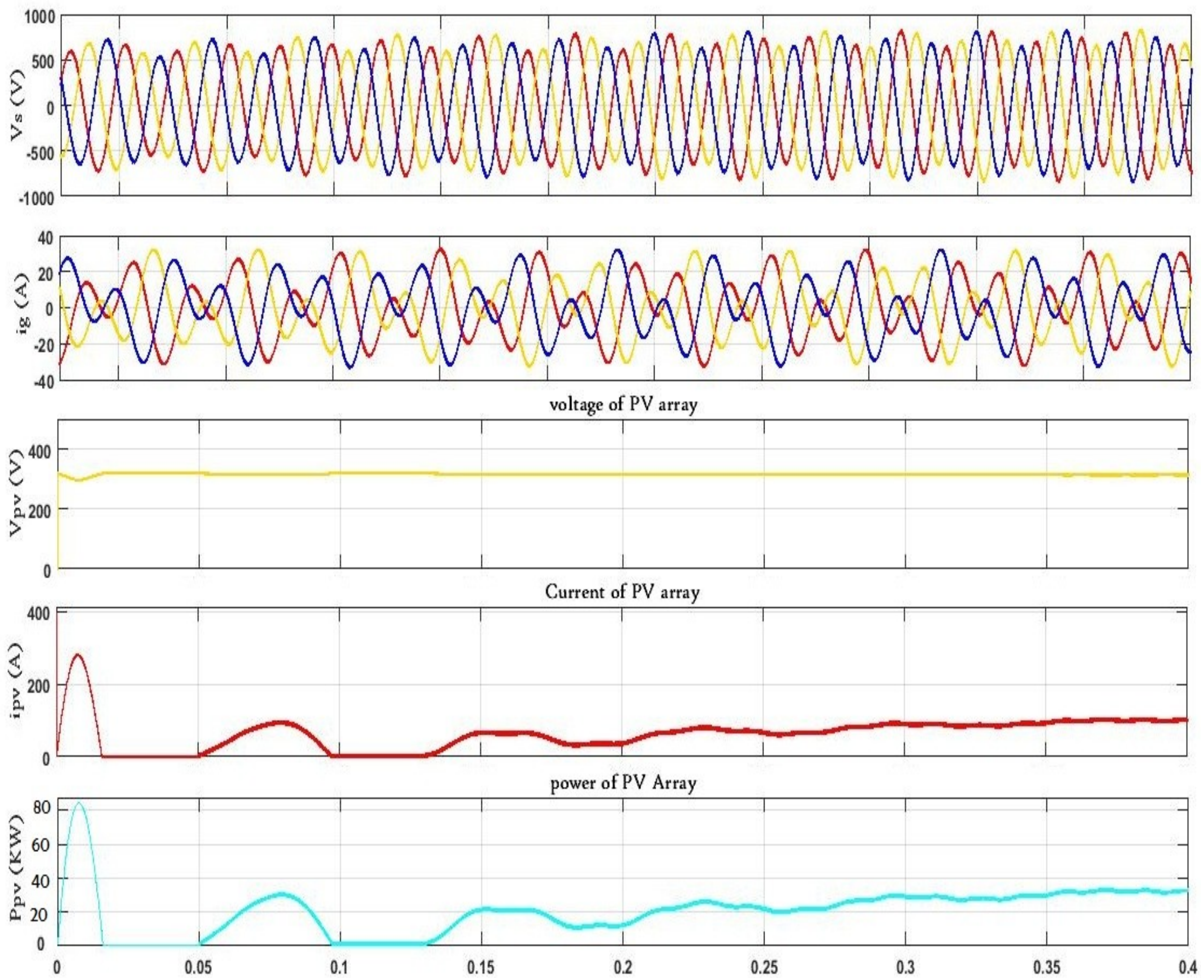
Figure 10: dynamic response of the system

Figure 11: Simulated performance for change in solar insolation without feedforward for PV



contribution

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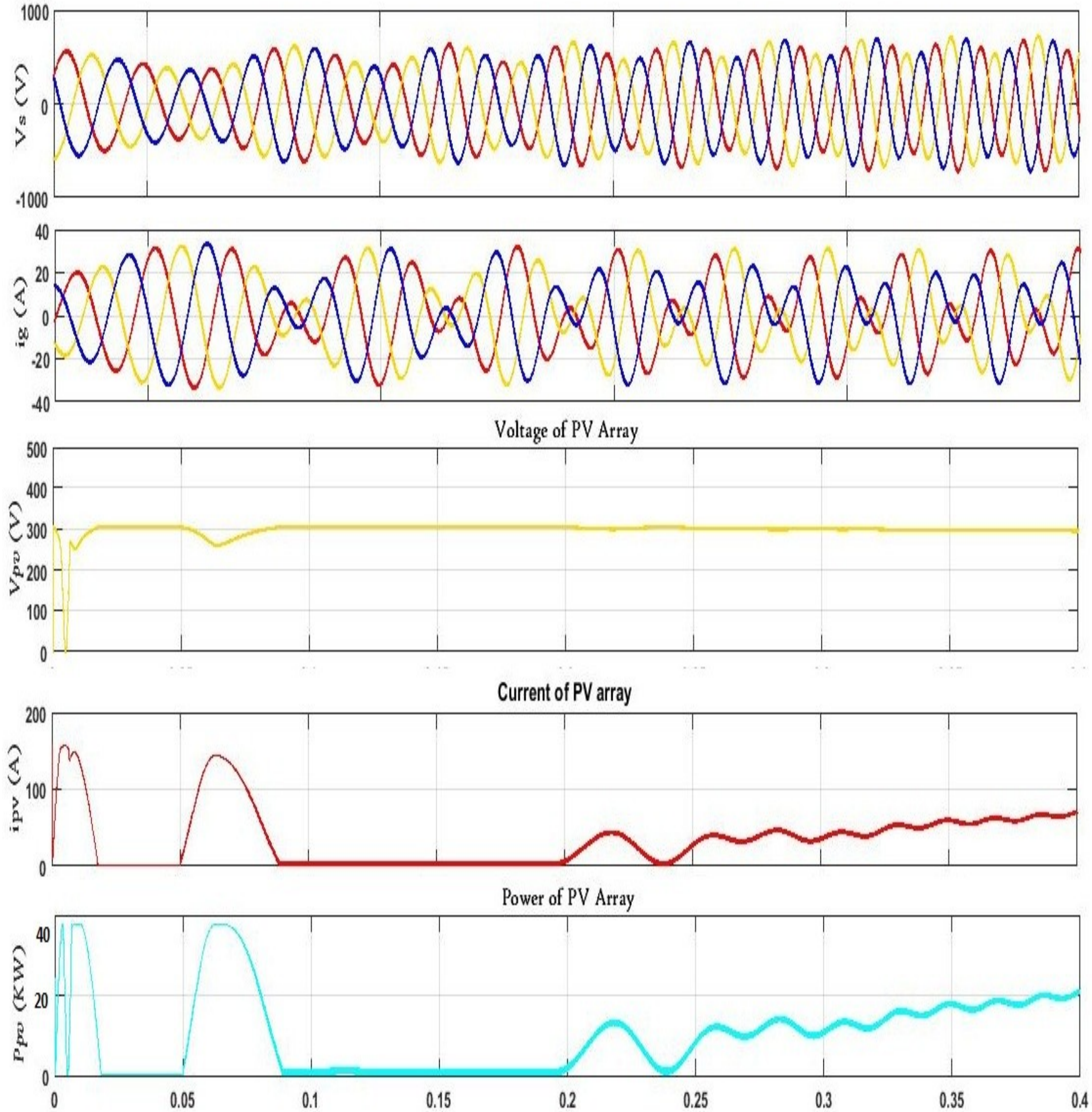

Figure 12: Simulated performance for change in solar insolation with feedforward for PV Contribution

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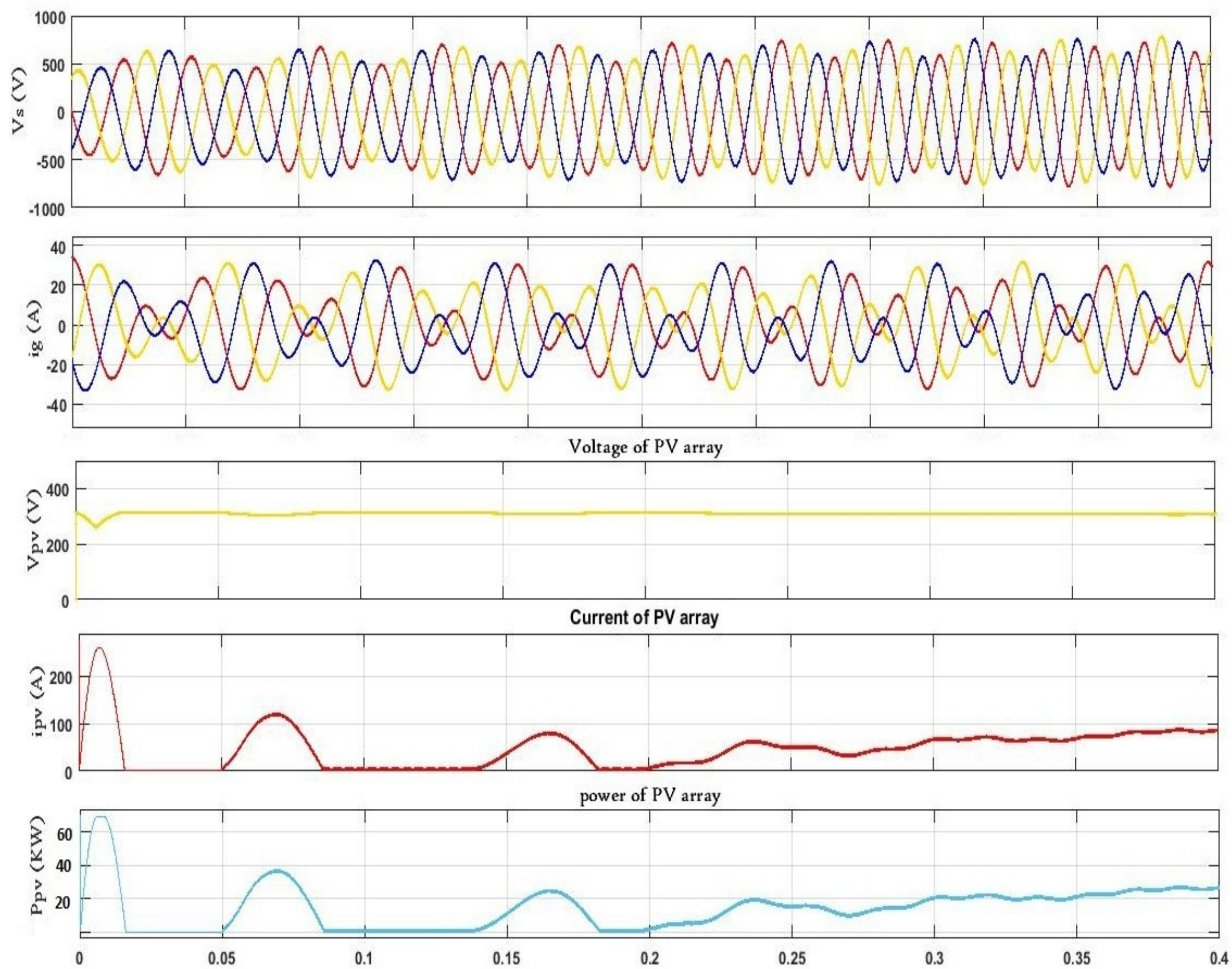

Figure 13: Simulated performance fornormal to under voltage (415 V to 350 V),

CONCLUSION

A two-stage system has been modeled for three-phase gridconnected solar PV generation. A composite InC based MPPTalgorithm is used for control of the boost converter. The performance of proposed system has been demonstrated for widerange of CPI voltage variation. A simple adaptiveDC link voltage control approach has been proposed for control of grid tied VSC. The DC link voltage is made adaptivewith respect to CPI voltage which helps in reduction of lossesin the system. Moreover, a PV array feed forward term is usedwhich helps in fast dynamic response. An approximate linearmodel of DC link voltage control loop has been developed andanalyzed considering feed forward compensation. The PV arrayfeed forward term is so selected that it is to accommodate forchange in PV power as well as for CPI voltage variation. Afull voltage and considerable power level prototype has verifiedthe proposed concept. The concept of adaptive DC link voltagehas been proposed for grid tied VSC for PV application however, the same concept can

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be extended for all shunt connectedgrid interfaced devices such as, STATCOM, D-STATCOM etc.This system yields increased energy output using thesame model just by virtue of difference in DC linkvoltage control structure.

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