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POWER QUALITY AND MAXIMUM POWER POINT TRACKING IN A GRID SYNCHRONISED PHOTO-VOLTAIC SYSTEM

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Abstract — *This paper presents an application of MPPT control for the integration of single phase single stage solar photovoltaic (SPV) system to a multifunctional grid. The main aim of this integration of single-phase SPV system with the grid comprises of harmonics elimination, reactive power compensation and PFC (Power Factor Correction). A VSC is connected to the PV array.To maintain PV string voltage to the reference value PI controller is used. To estimate reference PV voltage MPPT controller is used. To obtain fast dynamic response load components are utilized along with the feed forward terms for SPV array. Simulation results are recorded performed on MATLAB-based environment for the given system.*

Keywords- *MPPT, PFC,SPV and VSC*

I. INTRODUCTION

The rapid increase of energy along with the price of coal, natural gas etc and as well as environmental pollution are causing the attention of the people towards the renewable energy systems i.e. solar, wind etc. For sustainable energy, the integration of solar photovoltaic (SPV) energy to the grid is required with fast control and good technology. Accordingly, circuit topology and control algorithms are shown [1-5] to incorporate challenges such as cost and efficiency. Conventionally, two stage interfaced SPV energy systems are used in which first stage performs MPPT(Maximum Power Point Tracking) and second stage is used to feed extracted energy into the grid. These two stage systems have drawbacks of full rating of two power converters. Various configurations of grid interfaced PV systems are proposed in [6] . However, single stage SPV systems are introduced in the distribution systems. These systems locally inject active power into the grid and help in reduction of losses in the distribution line and transformer. The increasing power converters in the distribution systems are causing serious PQ problems. Shunt Active Power Filters and DSTATCOM(Distributed Static Synchronous Compensator) are dealt with such power quality issues[7-11].

This paper mainly focusses with a multifunctional single-phase single-stage VSC-based SPV system working under a wide range of grid voltage variations. It not only feeds solar energy into the grid but also performs all features of the shunt active power filter simultaneously. The proposed single-stage single VSC-based SECS serves the purpose of harmonics mitigation, reactive power compensation and MPPT along with feeding extracted energy at unity power factor. The proposed system acts as a distributed generation system feeding active power for the local loads which helps in the reduction of losses in distribution system.

For the implementation a simple PLL (Phase Locked Loop) control is used in the system. The proposed control algorithm uses the load and PV feed-forward terms for the fast dynamic response. An adjustable DC-link voltage is used for MPPT control. An intuitive and simple control algorithm is presented for control of VSC of the SPV system. Moreover, the proposed control algorithm is robust to take care for abnormalities in the grid voltages such as sudden sag and swell in the grid voltage. Simulation results are shown for a wide range of grid voltage variations. The dynamic response of the system with proposed control algorithm is found satisfactory.

II. PROPOSED SYSTEM AND CONTROL SCHEME

The schematic diagram of proposed system is shown in Fig. 1. It consists of a SPV array with a single phase VSI (Voltage Source Inverter), an interfacing inductor, a ripple filter, AC grid and mixed loads. The PV string which consists of a series parallel combination of small rating panels is connected across the DC link of the VSC. A single-phase H bridge inverter consists of two insulated gate bipolar transistor legs is used as a power converter module to interface PV power to the grid. The interfacing inductor is connected in series of VSC and the grid. The interfacing inductor absorbs the instantaneous voltage difference between the PWM voltage of VSC and the grid voltage. A ripple filter is connected in parallel to the grid to absorb switching harmonic ripples in the PCC voltage. The loads are combinations of linear or non-linear elements. A lagging linear load is considered for emulating a linear load and a diode bridge rectifier with RL load is considered for emulating a non-linear load. Overall, the loads are connected at the single-phase grid and VSC is connected at the PCC via interfacing inductor. the grid experiences the combination of VSC and load as an equivalent resistance with the operation of VSC.

MPPT Control Approach

The control algorithm of the proposed VSC is the heart of the SPV system. For simplicity, a hill climbing MPPT technique is used in the proposed work. In this MPPT algorithm, the operating point is perturbed in one direction and a change in the power is observed. In case, when the power output of string is increased then the operating point is perturbed in the same direction else the direction of perturbation is reversed. The MPP is achieved by keeping the SPV string voltage to V_{mpp} (voltage corresponding to peak power on power against voltage curve of PV string). The output of MPPT controller is the reference PV string voltage. The PV string voltage is set to reference value with the help of a PI (proportional integral) controller. The PV string is directly connected across the DC link of VSC as shown in Fig. 1, hence the reference PV string voltage is also the reference DC-link voltage. The reference DC-link voltage is continuously adjusted according to ambient conditions. The reference DC-link voltage in steady-state conditions is approximately equal to V_{mpp}, where V_{mpp} is voltage corresponding to peak power on power against voltage curve of PV string. The MPPT controller estimates the reference PV string voltage (or DC-link voltage), which is then given to control algorithm for grid interfacing part of VSC.

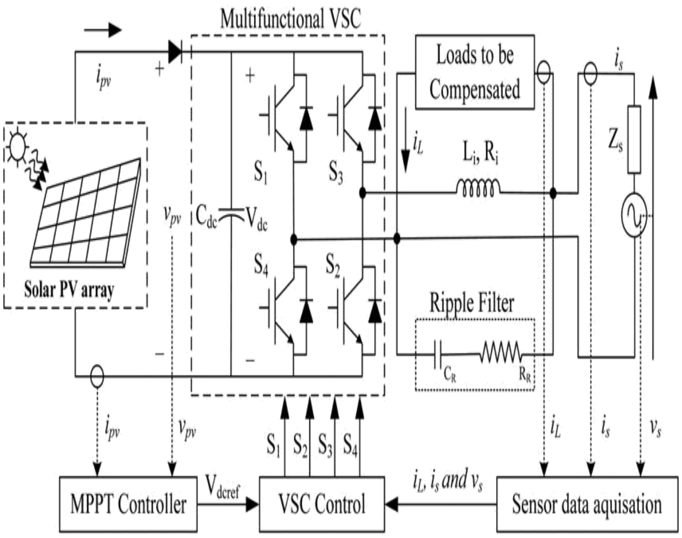


Fig 1. Proposed system topology

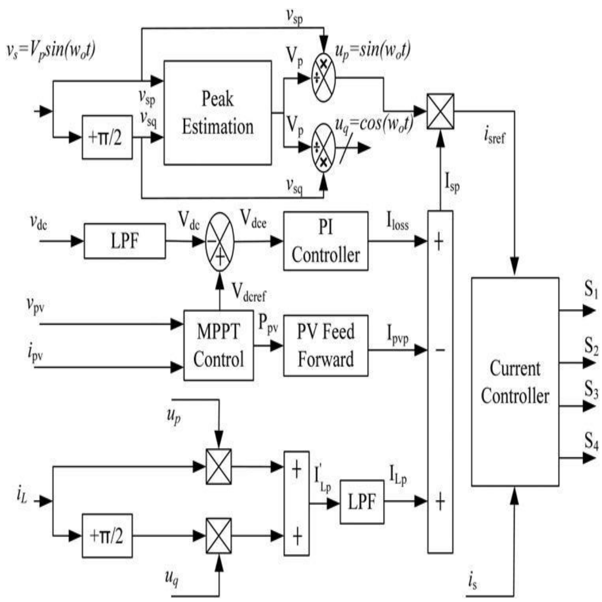
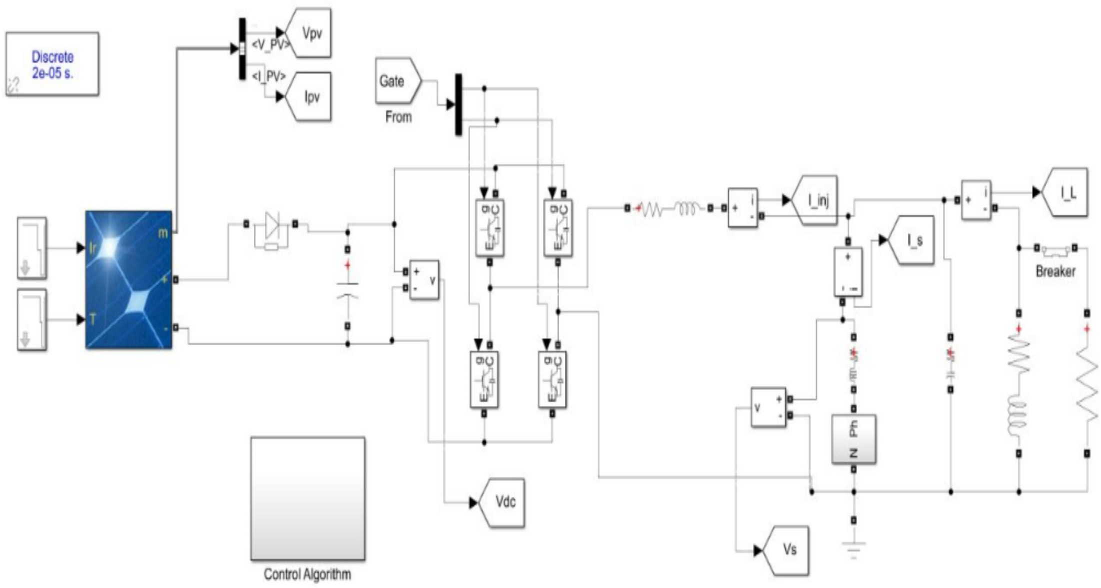
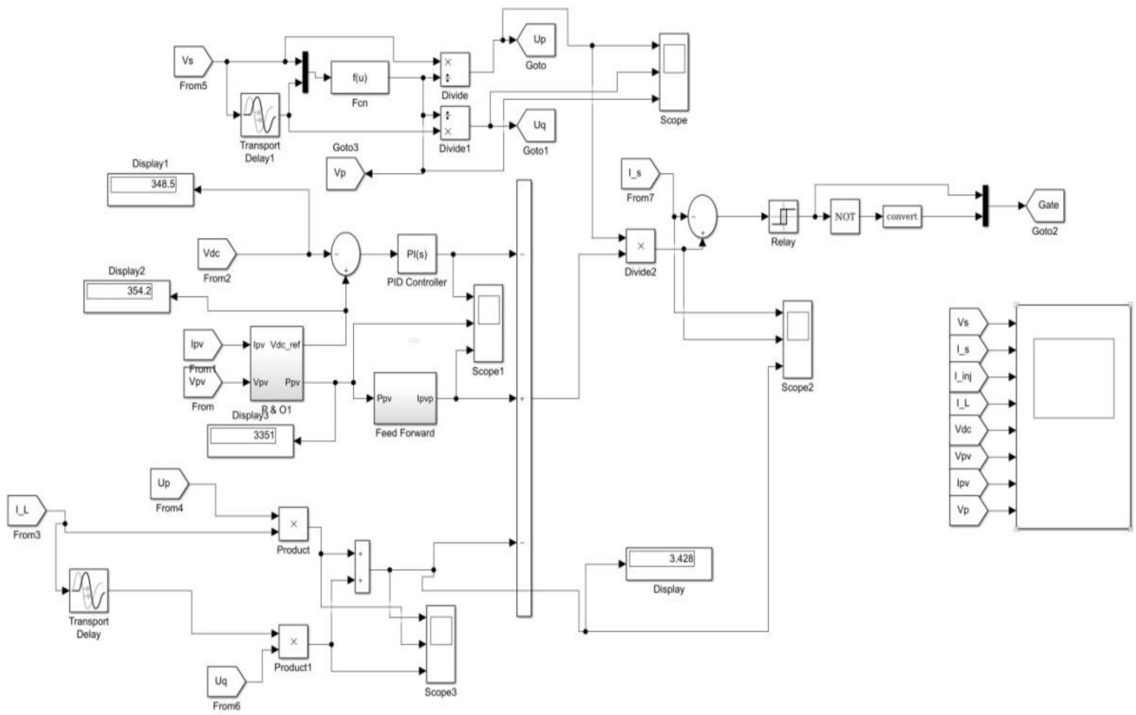


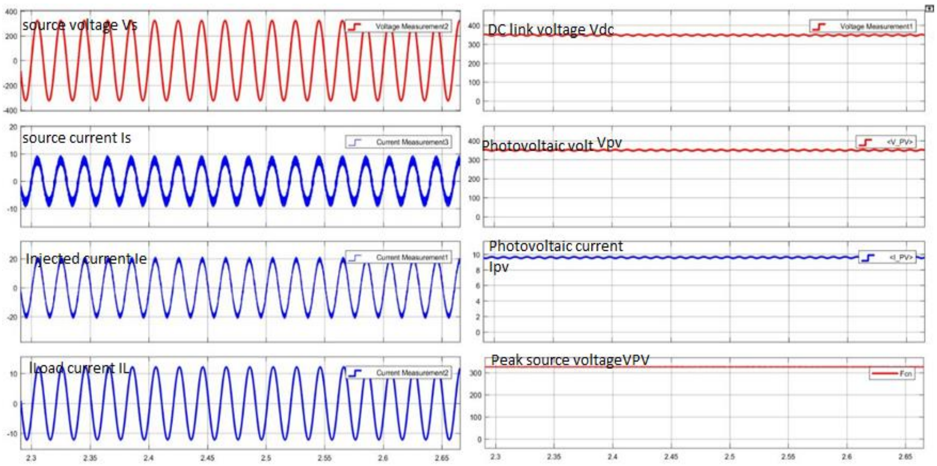
Fig. 2 Control structure for grid interfacing VSC

III . SIMULATION RESULTS



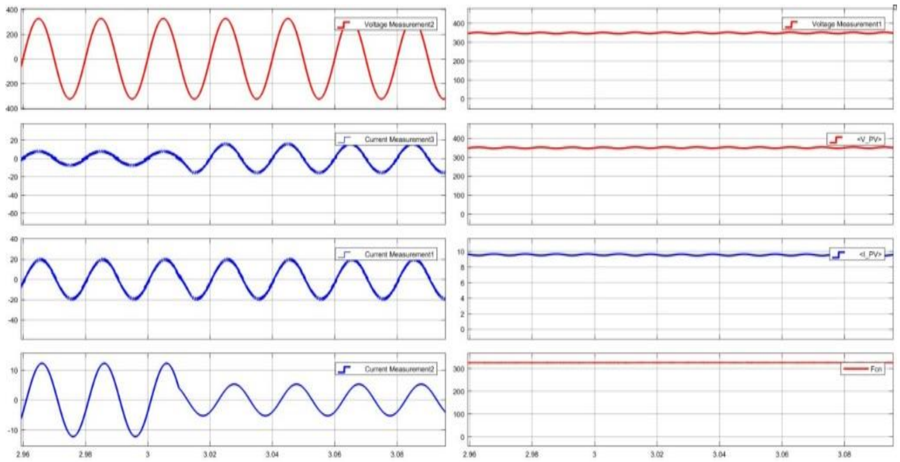


3.1. PERFORMANCE OF STEADY STATE

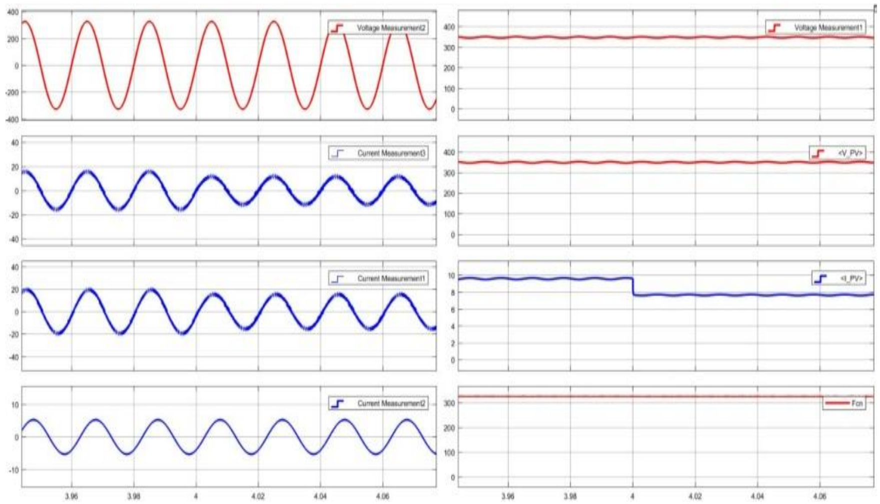


Case1: Steady state t=2.5 to 2.7s

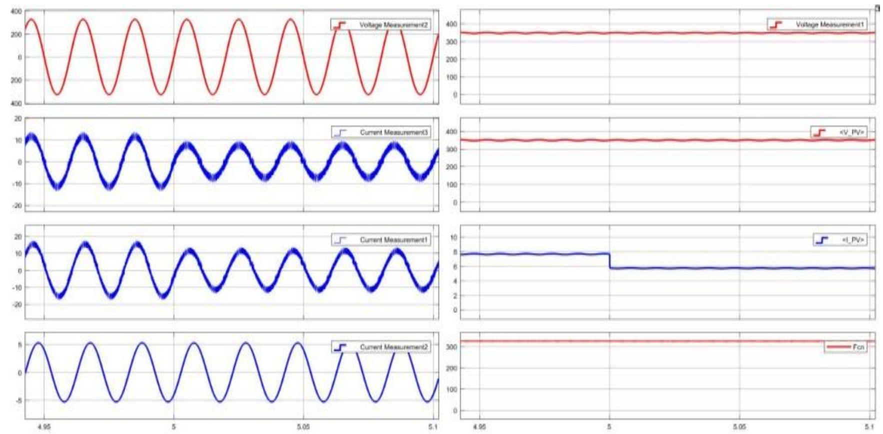
3.2. PERFORMANCE OF SYSTEM DECREASE IN LOAD



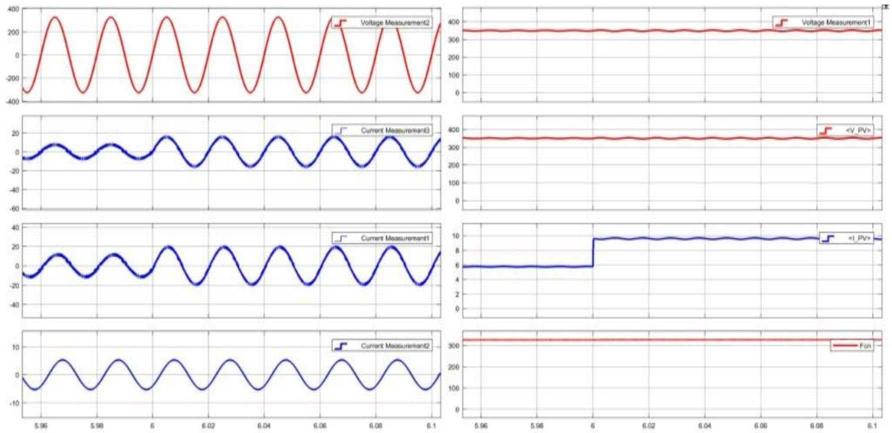
3.3. PERFORMANCE OF SYSTEM CHANGE IN IRRADIATION



Case3(a): Change in irradiation t=4s at 1000 to 800

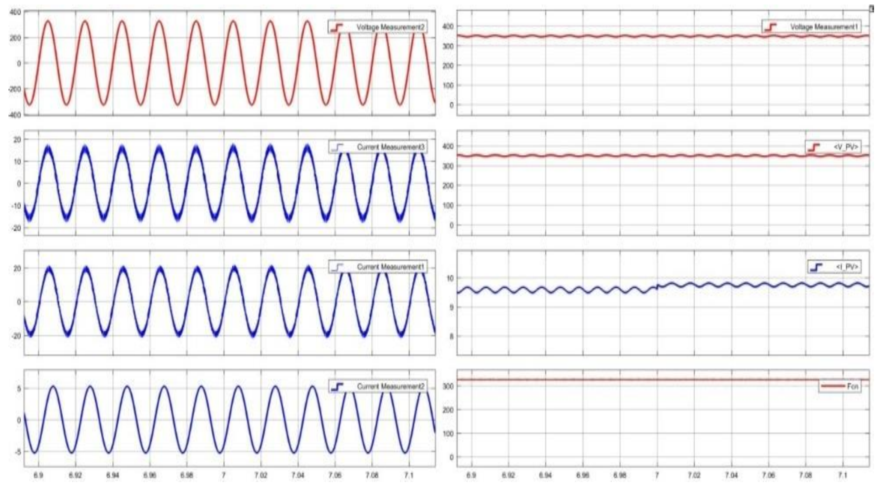


Case3(b): Change in irradiation t=5s at 800 to 600

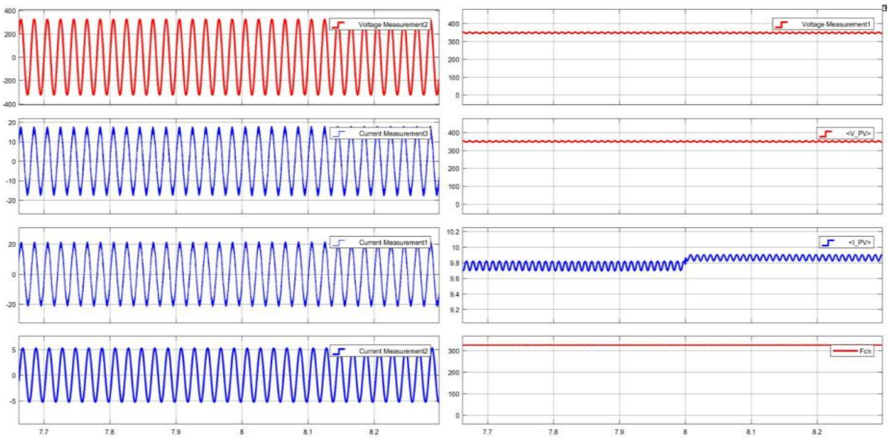


Case3(c): Change in irradiation t=6s at 600 to 1000

3.4. PERFORMANCE OF SYSTEM CHANGE IN TEMPERATURE



Case4(a): Change in temperature t=7s at 35deg to 30deg



Case4(b): Change in temperature t=8s at 30deg to 25deg

IV CONCLUSION

A single stage SPV grid integrated system has been proposed for feeding solar PV energy into the distribution network and power quality improvement simultaneously . The proposed system compensates for the reactive power and harmonics, which further reduces losses in distribution line and transformer. Moreover, it locally feeds the power to loads which helps in reducing the distribution line losses. A robust PLL-less control has been proposed for control of multifunctional VSC which has been tested under abnormal grid conditions (voltage sag/swell). The performance of the proposed control algorithm has been found to be good even under abnormal grid conditions. Moreover, the performance of the proposed control algorithm has been observed to be quite satisfactory under load transients and steady-state conditions. A wide variety of simulation results have demonstrated all features of the proposed system. The grid current THD has been observed below 5% even with nonlinear loads at PCC. The simulations results have shown the feasibility of the proposed system.

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