# Minimization of V&I Sensors Multifunctioning in Solar Based Grid Connected System

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***Abstract*: Accuracy of sensors measuring Photovoltaic (PV) array output voltage, current and the ac currents flowing between VSC and grid plays an indispensable role in efficient operation of a grid connected PV system. Erroneous measurements due to malfunctioning of aforementioned sensors can cause significant disruptions in the operation of a PV system, as the impact of erroneous measurements propagate through the controllers in aPV system. In this paper, malfunctioning of PV system sensors are regarded as sensor faults. This paper presents an approach for diagnosis and mitigation of sensor faults in a PV system. The fault diagnosis approach is based on the sliding mode observer (SMO) based fault detection and identification theory, which is capable of accurately estimating faults in sensor measurements. Estimated faults are used by the fault mitigation technique in the proposed approach to rectify the sensor measurements. The rectified sensor measurements are used by the controllers in PV system, instead of possibly erroneous sensor measurements, which ensure fault resilient operation of the PV system. The efficacy of the proposed approach has been validated through rigorous simulation.**

## 1. INTRODUCTION

Fig. 1 shows a complete schematic diagram of the proposed system in which a grid is interfaced with a solar PV generating system using a three-leg VSC. The configuration consists of SPV panels, a DC-DC boost converter, interfacing inductors,a ripple filter and a VSC with a two stage control system MPPT control and inverter control.

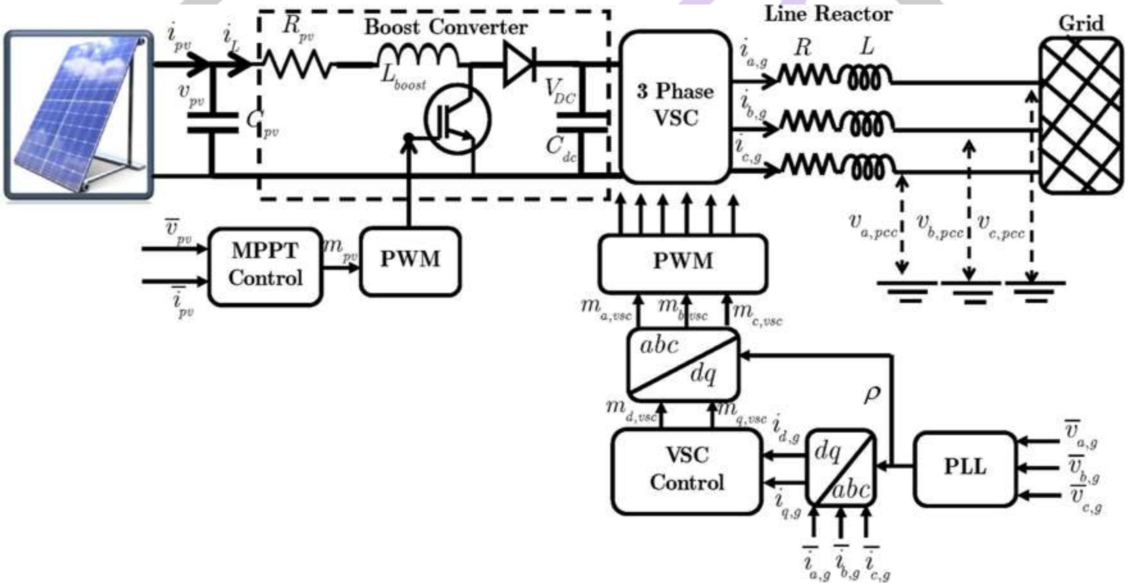



Fig. 1 Schematic of grid interfaced SPV energy system

## 2 CONTROL ALGORITHM

Two stage control algorithms are used in the proposed system as shown in Fig.

1. First stage is maximum PowerPoint tracking (MPPT) which is used to control DC- DC boost converter whereas the second stage is to control VSC switching. For VSC control, a new control algorithm called adaptive noise reduction (ANR) has been used in this work as shown in Fig. 2. Detailed control systems are presented in the following section.

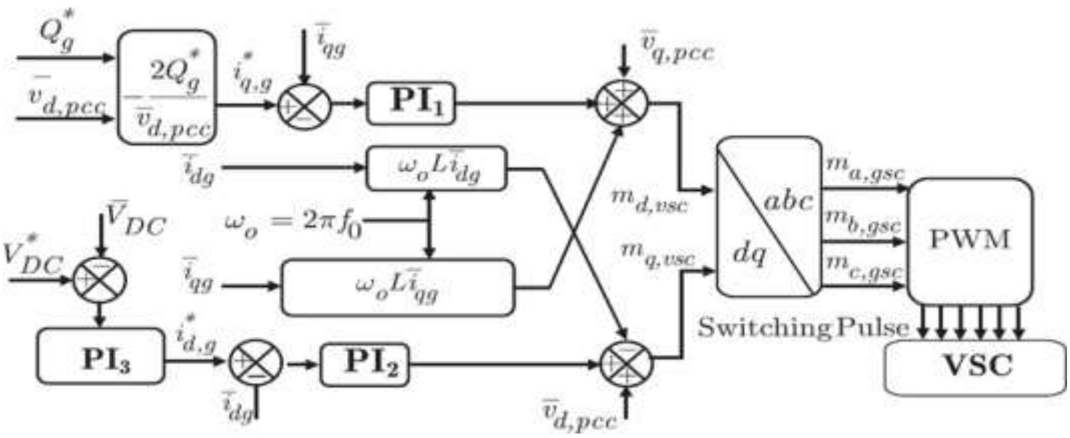



Fig. 2 General block diagram of VSC control algorithm

**Stage 1- Control of DC-DC boost converter (MPPT)**

Several MPPT algorithms have been presented and analyzed in the literature [8]. The Inc Cond method, which is popular among them, has been used here. The IncCond control is based on the fact that the slope of the PV array power curve is zero at the maximum power point (MPP). In this method, PV array voltage (*Vpv*) and current (*Ipv*) are sensed and fed to the MPPT controller to track the MPP where change in voltage and current is estimated as,

Instantaneous conductance (I/V) and the incremental conductance (Δ*I*/Δ*V)* are madeequal by adjusting reference voltage (*Vref)* and subsequently control signal for DC- DC boost converter is generated using the *Vref*at MPP.

**B. Stage 2 - Control of Three Phase VSC**

This control algorithm consists of three main blocks as shown in Fig. 2. The first and most important block is for extracting

$$dV_{pv} = V_{pv}(k) - V_{pv}(k-1) \quad (1)$$

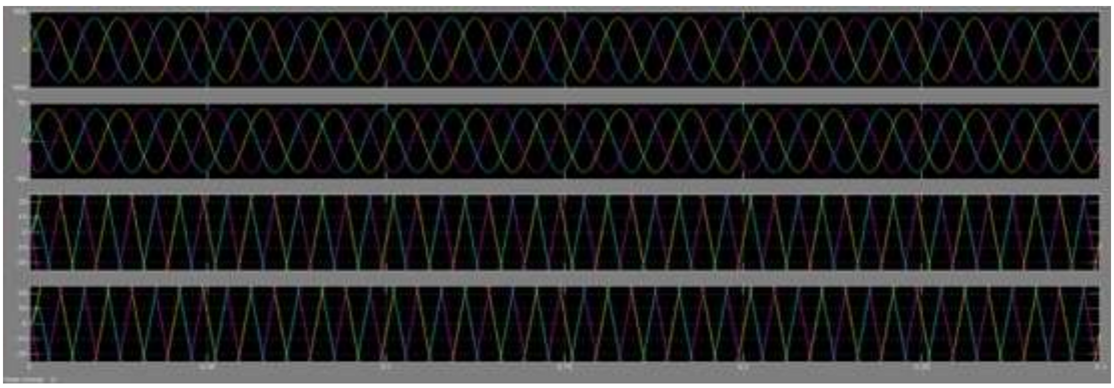
$$dI_{pv} = I_{pv}(k) - I_{pv}(k-1) \quad (2)$$

fundamental load current quickly and accurately i.e. harmonic detection, the second one is for estimating active component of load currents and whereas the last one is for estimating source reference current signals.

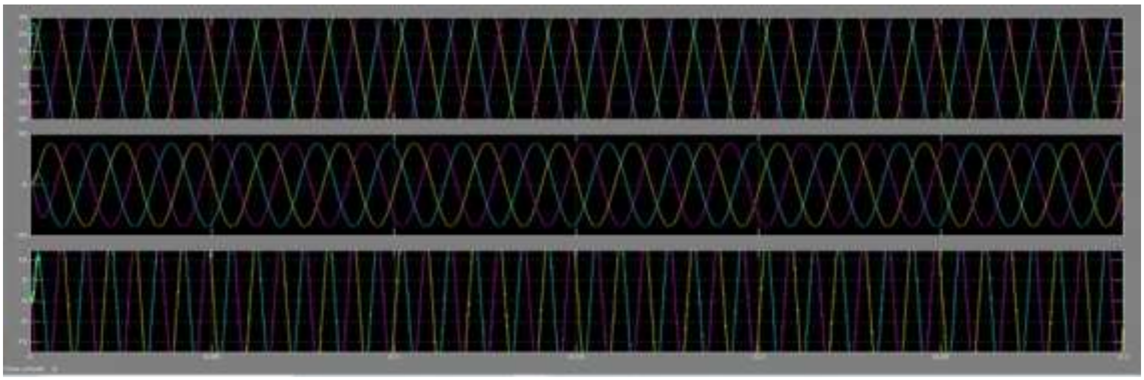
**3. PROPOSED FAULT DIAGNOSIS AND MITIGATION**

The schematic diagram of the proposed fault diagnosis and mitigation approach which ensures sensor fault resilient operation of PV systems is shown in Fig. 4. In the following sections, the detailed description of the proposed fault diagnosis and mitigation scheme is presented. 4.1. Design of proposed fault diagnosis system To design and implement the SMO, a fault-dependent mathematical model describing the dynamics of the measured quantities will be required. The model willbe used to design the proposed SMO for fault diagnosis. In the following, first a sensor fault dependent model, which describes the dynamics of v iipvpv d g , , , and iqg, under both healthy and sensor fault conditions. This is followed by the development of SMO and fault estimation procedure. 4.1.1. Sensor fault dependent state space model This subsection presents a sensor fault dependent model which describes the dynamics of the PV output voltage (vpv) and d q coordinate currents flowing between VSC and the grid ( ii d g q g , , , ). The equations that describe v ipvd g , , and iq g, have already been presented in Eqs. (2) and (3). Combining (1)–(4), ignoring series resistance ( Rs) of the PV array and considering the fact that the operation of phase locked loop (PLL) ensures v V d pccpcc , = and vqpcc , = 0 , the following state Eq. (7) results, which represents the dynamics of v iipvpv d g , , , and iq g,.

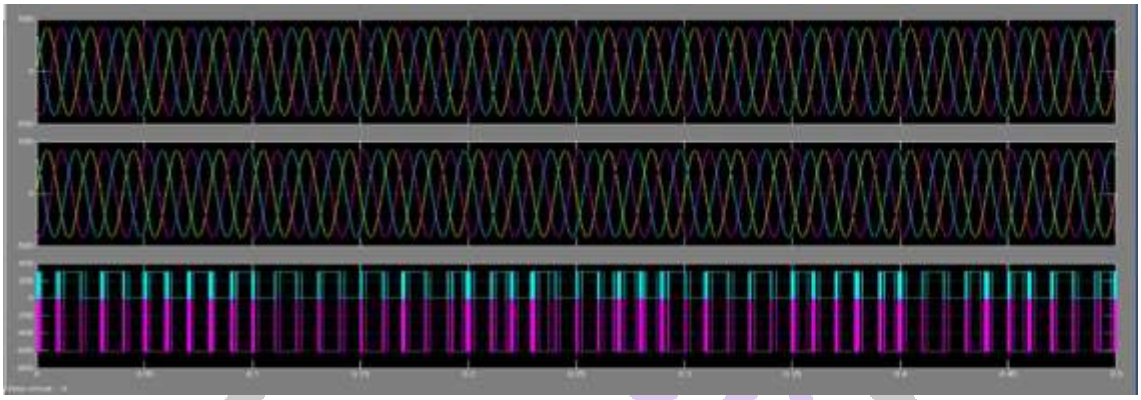
**4. SIMULATION RESULTS:**



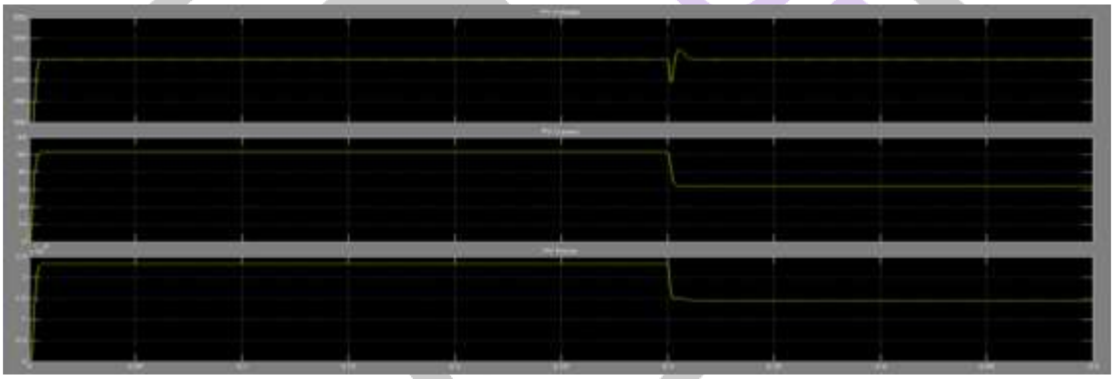
PV VOLTAGE:



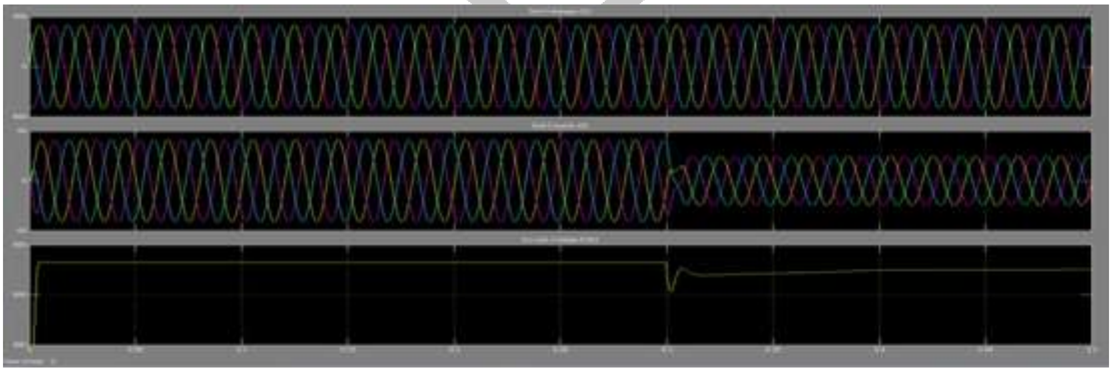
PV CURRENT:



PV POWER:



GRID VOLTAGE:



PV VOLTAGE, CURRENT, POWER:

**5. CONCLUSION:**

This paper presents an approach for diagnosis and mitigation of malfunctioning of sensors measuring PV array output DC voltage and current as well as the sensor measuring the ac current flowing to the grid in grid connected PV systems. The proposed approach diagnoses malfunctioning in the aforementioned sensors using SMO based fault detection and identification technique, which estimates the errors in the measurements due to malfunctioning in the corresponding sensors. The estimated errors are used by the proposed mitigation approach to rectify the erroneous measurements. The rectified measurements are fed to the PV system controllers (MPPT and VSC controller) to ensure reliable operation of the PV system. Rigorous simulation and experimental studies are carried out to demonstrate theadverse impact of sensor malfunctioning, as well as the effectiveness of the proposed approach in diagnosing and mitigating the sensor faults and ensuring reliable operation of a grid connected PV system under sensor malfunctioning.

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