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Impedance Insertion Islanding Detection for Safe Operation of Distributed Generation System

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Abstract: Whenever the utility system undergoes any disturbance and the probability of catastrophic failure, increases there is an immidiate need for control actions to be taken to limit the extent of the disturbance on the critical customers. Properly designed islanding detection scheme is an efficient way to secure power supply for the most important customers in the distribution system during a utility outage. The ultimate goal when such scheme is implemented is maintaining the voltage and frequency during islanded operation within the standard limits. This paper presents a impedance insertion based islanding control strategy to safe gaurd the grid connected distribution system against the faulty one. The distribution system forms an island in a way to continue supplying the local load without any interruption.

I. INTRODUCTION

As the distributed generation (DG) expanding for rapid growth and to meet the increasing demand also to reduce carbon traces, integrated power and energy networks are emerging as a fundamental enabling technology. With the increasing penetration of the integration of DG networks, the control and stability of the utility system has become essential [1]. The integration of DG systems with conventional power networks has primarily been increased by providing significant relief in the technical and commercial development. DG networks offer the benefits of reducing carbon emission and producing reliable electricity on site, thereby reducing the need to build new transmission lines hence avoiding the transmission losses [2]. DG units offer significant assistance in a present day deregulated power system consumers while adding flexibility to an electric grid based on the traditional centralized model [3]. Its applicability ranges from residential to small commercial, extended to industrial users. Due to the environmental, economic and strategically benefits offered by DGs, the current energy market is significantly developed and moving towards decentralization [4].

In deregulated structure the increasing competition amongst energy supply companies to secure more consumers and more profits, the utilities are need to maintain power quality with a high degree of un-interrupted power service. Therefore, current protection practices of disconnecting the DGs following a disturbance to prevent islanding will is a practical or reliable solution in a deregulated market environment. With the high DG penetration, compared to local load and system capacity, the unintentional islanding must be prevented to aggravate local disturbances. If DG penetration becomes widespread, the anti-islanding methods may also impact bulk power system voltage and frequency. Hence the elimination of unintentional islanding, while minimizing DG impact on system performance are conflicting objectives using the current protective functions [5]. This paper presents a high speed islanding detection method based on impedance insertion to meet the above objective

II. CLASSIFICATION OF ISLANDING DETECTION METHODS

Formation of the island, caused by the disconnection from the main grid without stopping the energy generation from the DG sources is termed as islanding [6]. Islanding can be either intentional or unintentional.
The purpose of intentional islanding is to construct a power "island" during system disturbances [7]. The standard approach in detecting an islanding situation is to measure the DG output parameters and from these parameters a decision is taken to decide whether or not an islanding situation has occurred. The schematic islanding detection system is presented in figure 1. The basic classification of these techniques is presented in figure 2.

Active methods converse directly with the system operation, contrary, passive methods recognize the problem based on the parameters measured. By measuring deviations in the output power and system frequency active methods detect islanding. On the other hand, passive methods monitor parameter changes in the power system like changes in the rate of output power, phase displacement and system fault level monitoring. In nearly every case, a loss of utility disrupts the normal system voltage, current and/or frequency. Passive technique utilizes these changes to detect unusual operation of the DG (unintentional islanding).

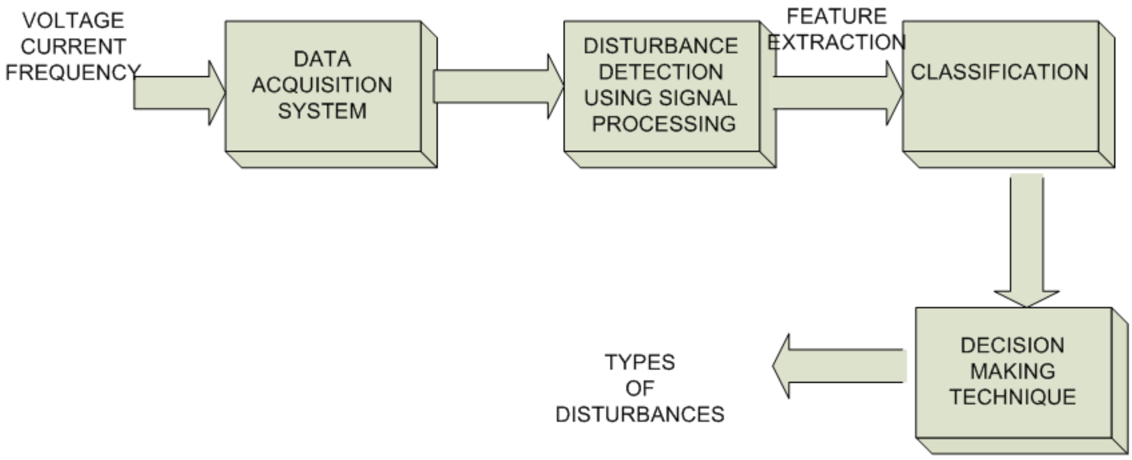

Figure-1 Schematic of Islanding detection technique

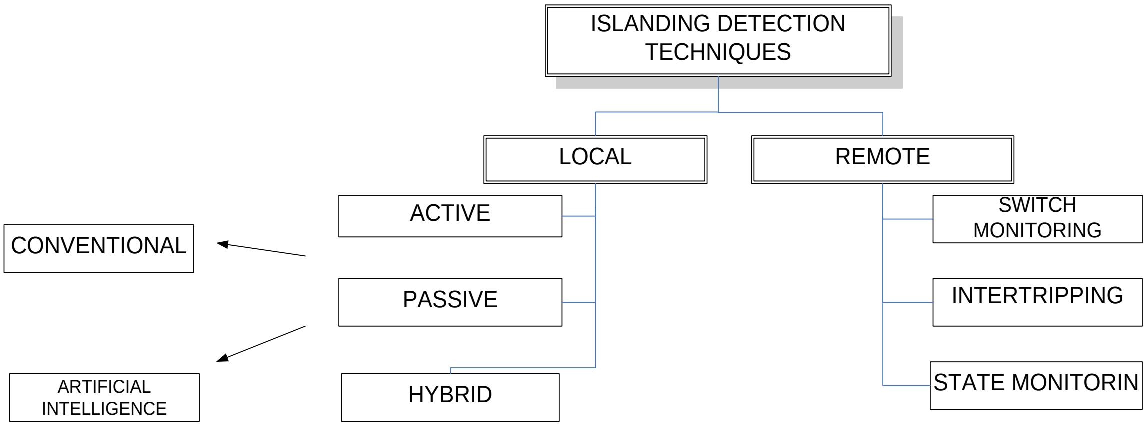

Figure-2 Classifications of islanding techniques.

III. IMPEDANCE INSERTION ISLANDING TECHNIQUE

There may be a question to as why so much research and efforts are required to develop the logic or algorithm for detect islanding, is it important to contemplate whether or not the problem really requires the amount of effort being depleted. Generally speaking, the reasons for anti-islanding are given as (in no particular order) [8,9];

- Safety reasons: in case of islanding, the repairing crews must be aware to avoid any hazardous situation against live wires
- Protection of equipment of end-user: sensitive equipments could theoretically be damaged if operating parameters vary remarkably from the nominal values. In this case, the utility is liable for the damage.
- Termination of failure: Reclosure of circuit onto an active-island may cause problems with the utility's equipment, or cause automatic reclosing systems to fail to notice the problem.
- Inverter confusion: Reclosing onto an active-island may create confusion to the inverters. They are all implemented in different suitable occasions. Generally, small-capacity-scale grid-connected DG systems are more like to use anti-islanding features due to their flexible feature. However, a big-capacity-scale system mainly uses for maintaining their high efficiency and reliability.

Variable impedance when inserted to deliberately force a section of the grid into a condition that will assure the DG systems disconnection. This method uses active systems parameters at the head-end of the utility, as opposed to relying on the network topology.

A simple example is a big capacitor bank that are inserted to a branch, left charged up and normally disconnected by using a switch. In case of system failure, the capacitors are switched into the branch by the utility after a short delay. This can be easily skilled through automatic means at the point of distribution. The capacitors can only supply current for a small period to ensure the start or end of the pulse they deliver will cause enough of a change to trip the inverters [12].

There appears to be no NDZ for this method of anti-islanding. The only disadvantage it possesses is its high cost; the capacitor-bank has to be large enough to cause changes in voltage that would be detected, and this is a function of the amount of load on the branch. In theory, very large banks would be required; an expense the utility is unlikely to look on favorably.

IV. PROPOSED WORK

In this work a variable-impedance insertion based active islanding detection technique has been proposed, which is capable of detecting islanding in 3m seconds. The technique proposed monitors system parameters, such as voltage and/or frequency, at the point of common coupling (PCC) between the grid and the DG source. An impedance circuit working as a filter for high ripple voltage is designed to block a high peak pulse such that islanding can be detected. The circuit designed is shown in Fig-3.

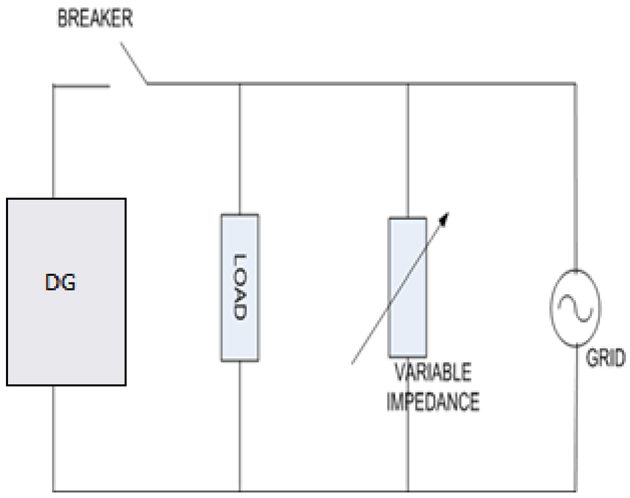

Figure 3 Schematic diagram of the proposed variable impedance insertion islanding method.

A DG system is designed using wind and solar hybrid system having system combine power of 20 KW.
At steady state, the RLC load is matched closely with the DG power and the power flow between the grid and the DG is very small. At 0.1 s the Grid Breaker opens and the proposed IDM detects the islanding. The current via the inserted impedance is quite low and within the range of measurement. In this study, this current is comparable to the DG output due to the small test system considered and the low insolation at the time of the islanding. As soon as the islanding detected the circuit breaker contacts are open and DG continues to supply the local load. The system designed is capable of maintain constant voltage and frequency after few cycles until system is restores. In DG system designed is of 1 kW/400 V RMS voltage under nominal insolation levels.

V. RESULTAND DISCUSSION

The system is designed in MATLAB SIMULINK. The DG is designed using wind and solar hybrid system. The DC input voltage is 370 V at the output of DC rectifier; the PO MPPT is used to design the PWM for DC rectifier. The output power of DG is 1 KW. The design consideration is given in Table 1.

Table-1 Component and rating used in the PI controller.

Components	**Ratings**
System nominal voltage	415 V RMS
Frequency	50 Hz
RLC load	3.28 KΩ, 10.45 mH, 0.98μF
Inserted impedance	44-735 Ω

DG input power	1KW
LC filter	4.41mH and 5.7µF
Switching frequency	40 KHz
Grid power	5MW
DC input voltage	370 V
Active and reactive power flow at PCC	90 KW and .17 MW

The system has been analysed for static conditions both at grid connected and islanded mode. For grid connected DG operation a constant load of 500 w and dynamic load of RLC as shown in Table is connected and circuit breaker copntacts are remain closed in normal operation. Figure 4 and 5 shows the output voltage and current waveform at PCC and grid side respectively. From the figure it can be observed that system take few cycles to stablize and after synchronization it remains constant at syncronous frame. Figure 6 presents the active and reactive power flow in the proposed system. Figure 7 gives the current flow across the impedance connected for islanding. From the figure it can be observed that since the system is in normal mode of operation the current is very low and constant.

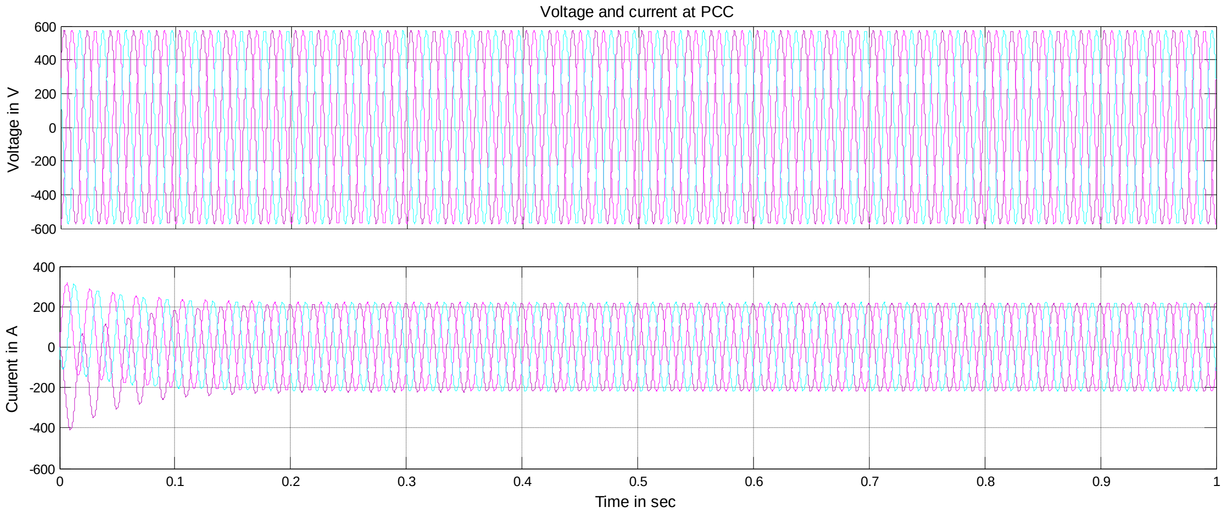

Figure 4 Output voltage and current at the PCC

A three phase fault is connected to operate the circuit breaker in a way to form an island. The circuit breaker opens its contact at 0.1 sec and system restores voltage at 0.2 sec. it takes a time of 0.1 sec to stabilize the system in the condition of islanding and system remains operable and the DG supplies the load with same voltage and frequency. System takes few cycles to stabilize under such condition. Figure 8 and 9 shows the output voltage and current waveform at PCC and grid side respectively for islanded mode. Figure 10 presents the active and reactive power flow in the proposed system. From the results it can be observed that at the time of islanding grid voltage only suffers some fluctuations but the system remains synchronize maintaining it voltage constant even in the duration of islanding. Also at PCC though current ins zero but some voltage is present across the resistance inserted. Hence the designed islanding detection technique is efficient in maintaining the system performance.

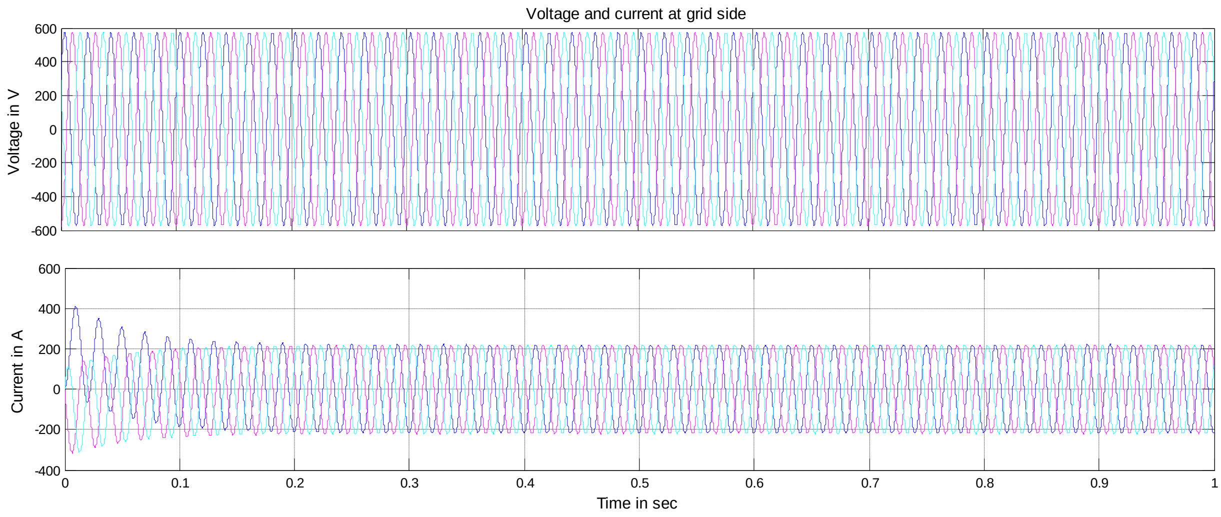

Figure 5 Output voltage and current at grid side

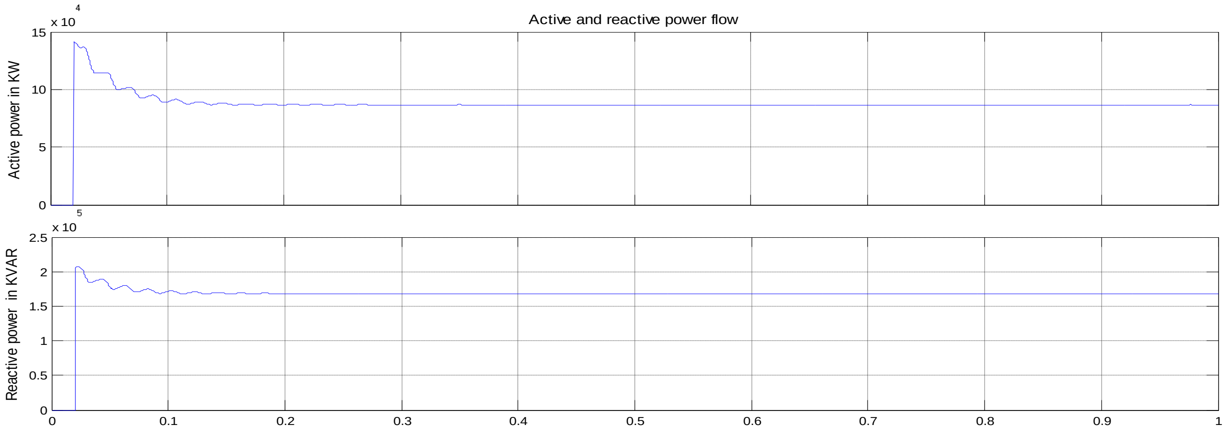

Figure 6 Output active and reactive power at PCC

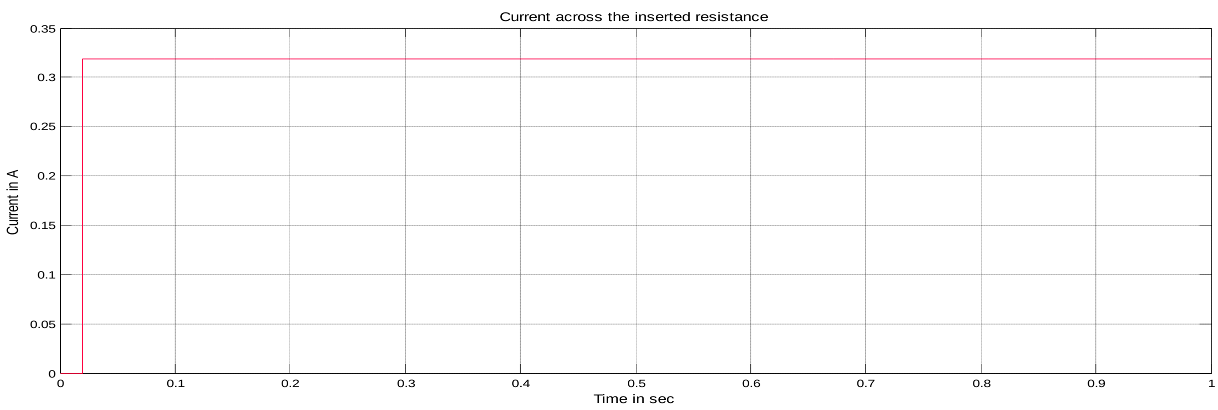

Figure 7 Output Current across the impedance inserted.

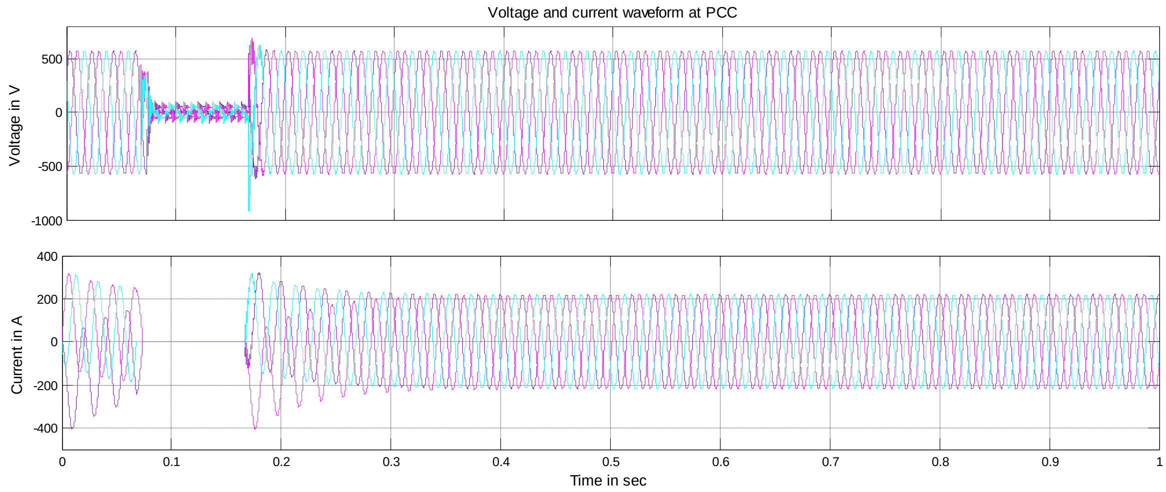

Figure 8 Output voltage and current at PCC

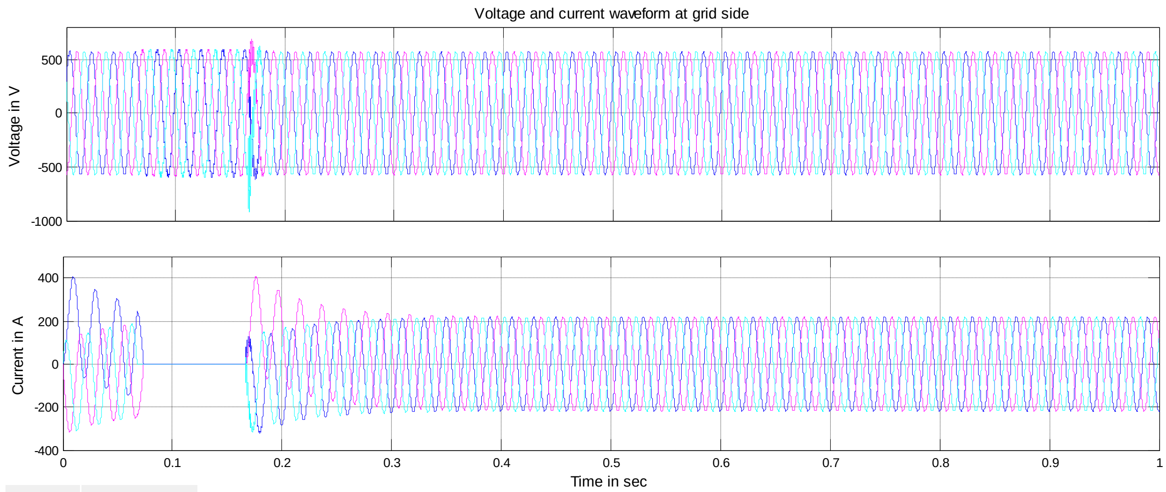

Figure 9 Output voltage and current grid side.

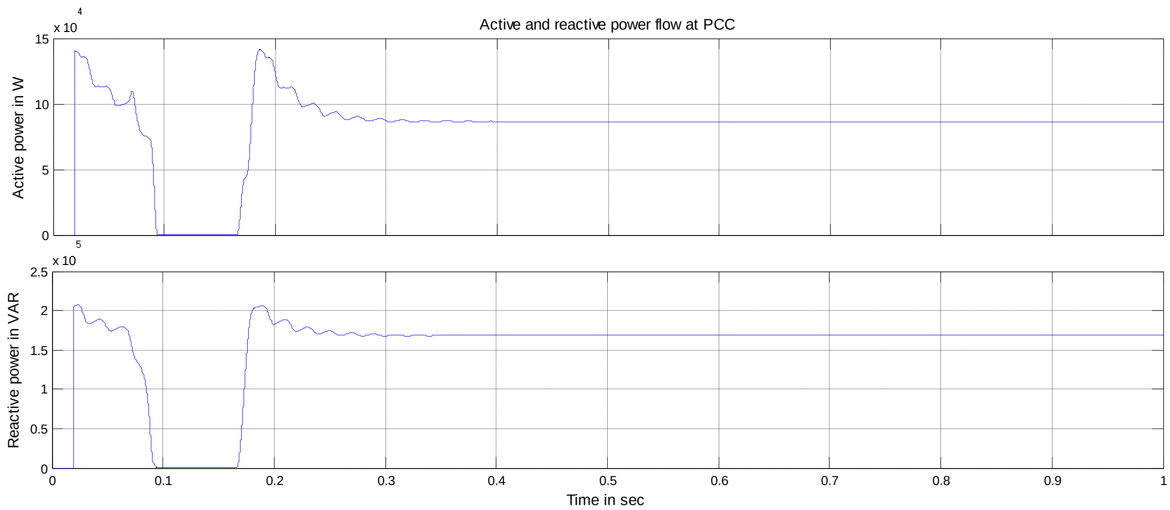

Figure 10 Output current of Solar system converter side at balanced non-linear load with proposed topology

IV. CONCLUSION

An impedance insertion based active islanding detection technique for grid connected DG system has been proposed in this paper. The proposed technique monitors, in time domain, the ripple content of the RMS value of the PCC voltage and detects islanding when the current across the inserted impedance is higher than a predefined threshold for a certain period of time. The proposed control technique utilizes the DG interface in improving the utility voltage during islanded operation by controlling the amount of injected reactive power from the VSI. During

Islanded operation, the control scheme is modified such that the grid voltage undergoes few fluctuation but is capable of maintaining stability and voltage magnitude.

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