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Smart Solar Grid integrated PV System with Faulty Permanence Enhancement: For Better Rural Electrification in India

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ABSTRACT

The rapid installation of solar power projects producing hundreds of MWs is a corroboration of solar power feasibility. But, this large grid connected power generation can have a significant influence on the entire power system and has led to violation of the standard grid codes. Compared to conventional generation solar power plant lacks of inertia and faster dynamics. Therefore, any disturbances causes' voltage collapse leads to voltage instability condition. This reflects harmonics, flicker and stability problems. The planned system considered for this project consists of a two parallel connected solar modules (SPM) interfaced to AC host system. There is Central Supervisory Controller (CSC) unit, having main objectives of grid synchronization of all SPMs and proposed Dynamic reference control algorithm of each SPM for controlling the active and reactive supply conditions. Each SPM also consists of its own Individual Inverter Controller (IIC) unit, having objectives of maximum power calculation and controlled pulse generation. This research article is designed with efficient control system having primary objective of Fault stability behavior (FSB) by implementing the proposed DRP control algorithm at CSC. The proposed control system of project is studied under steady state and fault conditions. The designed system is also considering realistic considerations as partial shading of PV array effect and circulating current effect to estimate the performance of the system.

Key words : Grid integration, power Electronics, Smart grid

1.INTRODUCTION

The rapid growth in the green energy in the scenario of digital India creating more opportunities to research on renewable energy sources. As the availability of green energy in the nature is abundant its operation cost is very less and the resultant pollution effects are zero [1-4].

scheme. The considered solar system serving the active power to the distribution system, facilitating an effective use of solar array and reducing load harmonic components. Rahul Agrawal had also developed [6] integrated solar generation scheme to three phase utility with green and continuous power flow at faulted and max load conditions. This system is implemented with PLL less fast characteristics of triangular function (CTF) control technique. The functions of this control technique are the extraction of fundamental components of load current, estimation of in-phase and quadrature components, estimation of AC and DC loss components and calculation of reference currents. Various configurations and control schemes [7] have been implemented in the literature for mitigation of PQ issues caused by non-linear loads.

In [8] author has proposed control scheme which allows a grid connected single phase inverter to mimic the behavior of a synchronous generator. A. B. Shitoleet. al [9] has presented a utility current response based altereddq-current control system for integrating inverter impacts fixed loading on the utility, transient free operation. The presented technique does not require separate calculation of reference reactive components and harmonic components; hence the control circuit complexity is reducing.

Kumar et. al. [10] have developed the DSTATCOM system which works in dual mode of current control mode (CCM) and Voltage control mode (VCM) thereby mitigating the current and voltage based PQ issues, respectively making the system interactive to loads and grid supply. In [11] the author has explored the sensitivity of real and reactive power of voltage profile of Low voltage under voltage disturbances of grid.

In [12] the PI has proposed dynamic reference point (DRP) control algorithm for low and medium level DG inverters for AC grid applications. The DRP based control algorithm exhibits several specific advantages such as increased reliability of grid interfaced inverter and more active and reactive injection capacities. The DRP control algorithm enhances the standards of power grid. But, the PI has considered aforementioned control algorithm with grid ideal condition and only one inverter is handling entire power, whereas in the proposed project grid fault conditions are considered to improvise the stability behavior of the grid. Another realistic consideration to be considered for this project is the modular solar inverter operated in parallel to grid.

2.ANALYSIS OF FAULT CONDITIONS

The basic block diagram shown in Figure 1. It consists solar power generation unit is connected to grid interfaced unit. The grid interfaced unit converts DC energy to AC supply which is connected to grid. To synchronize output energy to source an PLL is used. The controller plays an important role of control of grid interfaced inverter.

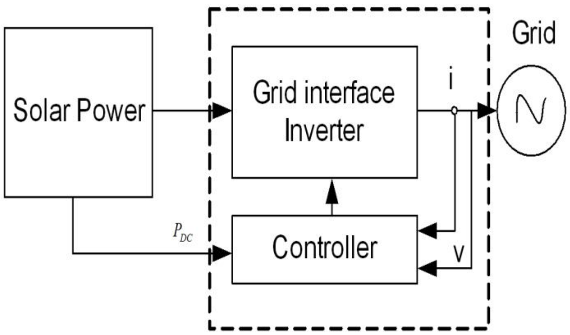

Figure 1: Basic Block diagram

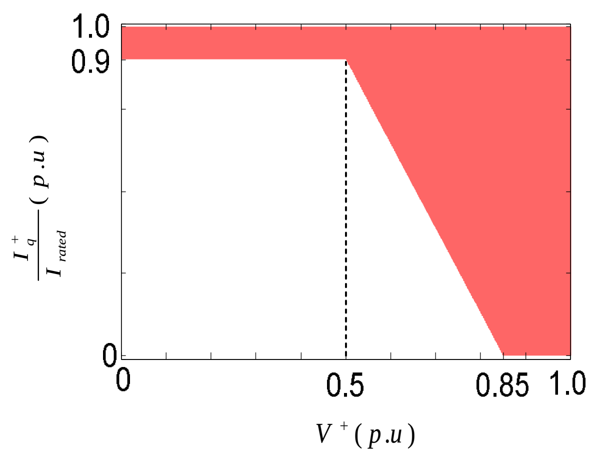

Figure 2: Voltage profile characterstics of fault current

As in steady state condition grid interfaced inverter suplies majority of active power generated by reneable energy source where as in abnormal faulted conditions there is more concentration on transient conditions and stability of the system.

There are different types of faults can appear at the utility side this may cause several effects at utility side. The effects are depends on the types of the faults. The major effects hich can be considered as variation on the voltage profile at PCC and the second effect is enarmous increse in current dran by the source. In traditional grid condition hen fault transients are high then the source of energy is isolated from the utility. But, this may cause unstabilty situation on connected grid. Figure 2. Shows the voltage profile characterstics with reactive current component. This indicates the quantity of the reactive power suppoert required to the grid under faulted conditions voltage variations.

3. PROPOSED CONTROL ALGORITHM

The Dynamic reference control algorithm is proposed to imrove the faulted condition of the smart grid inverter. Figure 3 shows the control algorithm of the proposed method. The algorithm consistes following operational procedure as,

- Basic mesarable quantities are collected from the grid connected system by using different transeducers like PCC voltage, current and phase angle
- Considering the generated active power as reference power.
- Calculation of the direct axis component of the inverter current.
- Verifying positive component of the PCC voltage is less tha 0.85 pu. This will indicates the faulted condition.
- *Case-1: Supply only active power with in the limit of generated power:* This condition is implemented when the voltage profile of the PCC is normal. In this condition the total active power required by the load is supplied by the Green energy. The reference reactive component of the grid inverters set as zero.
- *Case-2: Supply only active power over load limit of generated power:* This condition is implemented when the voltage profile of the PCC is normal. In this condition maximum amount of green energy is supplied which not sufficient to balance load. Therefore remaining balance power is supplied by grid.The reference reactive component of the grid inverters set as zero.
- *Case-3: Combination of active and reactive power with in green energy limit:* This condition is implemented when the voltage profile of the PCC is abnormal i.e hen the voltage profile reduction os less than 0.85 pu. In this condition the total active and reactive power required by the load is supplied by the Green energy. The reference coponents active and reactive are recalculated as per the requirement of the load.
- *Case-4: Combination of active and reactive power over load limt of green energy limit:*This condition is implemented when the voltage profile of the PCC is abnormal i.e hen the voltage profile reduction os less than 0.85 pu.In this condition the partial active and reactive power required by the load is supplied by the Green energy.
- *Case-5 & 6: Supply only reactive within and over limt of the green energy:*This condition is implemented when the voltage profile of the PCC is very abnormal i.e hen the voltage profile reduction os less than 0.85 pu.

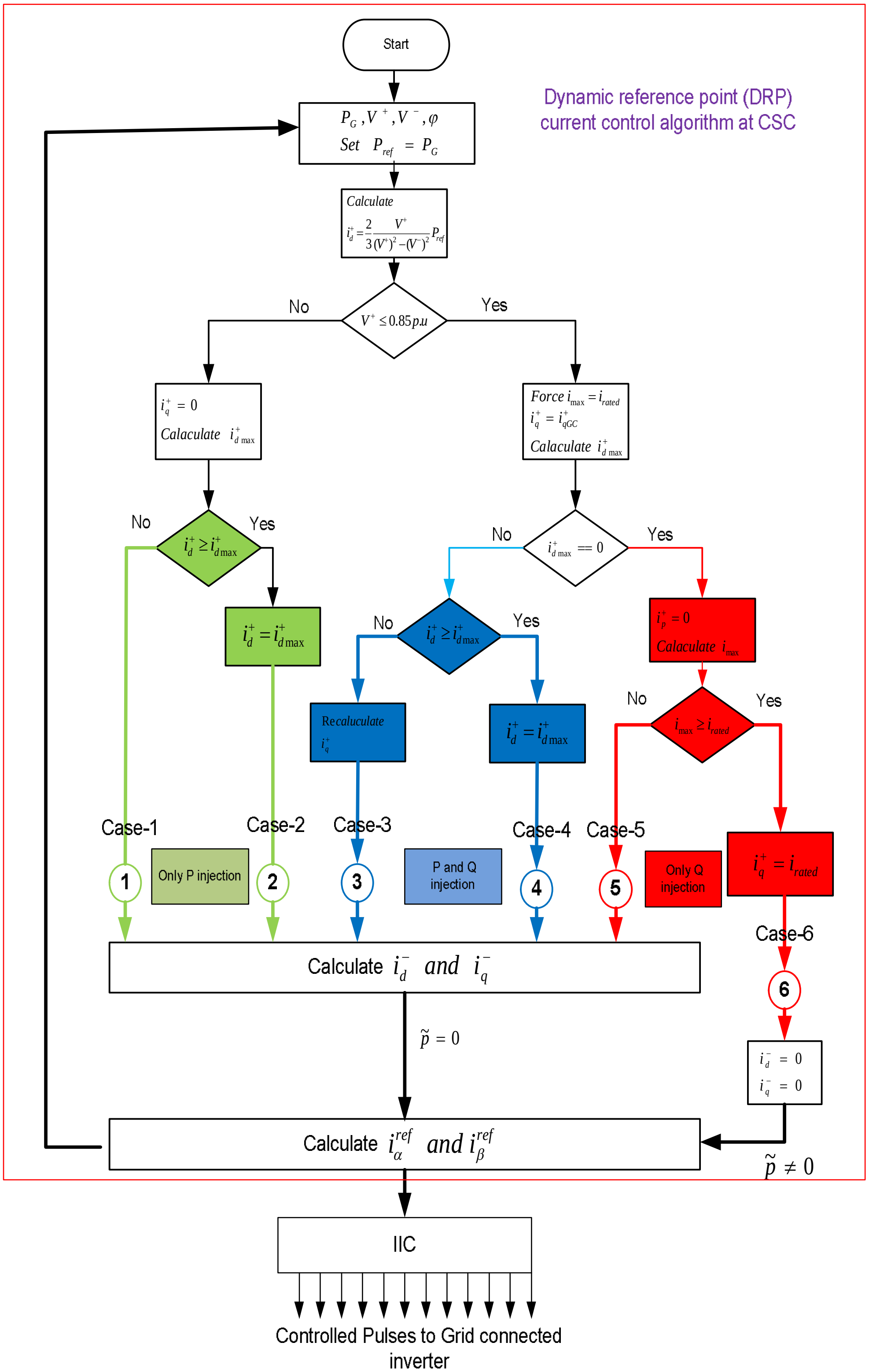

Figure 3: Flow chart of proposed DRC algorithm

4.SIMULATION RESULTS

Figure 4 to Figure 6 shows the simulations results of three phase to ground faults with grid integrated system. There is a fast recovery of current with considerable transient time. Figure 7 to Figure 10 shows the results of single line to ground fault condition. This shows more transient oscillations in the current component.

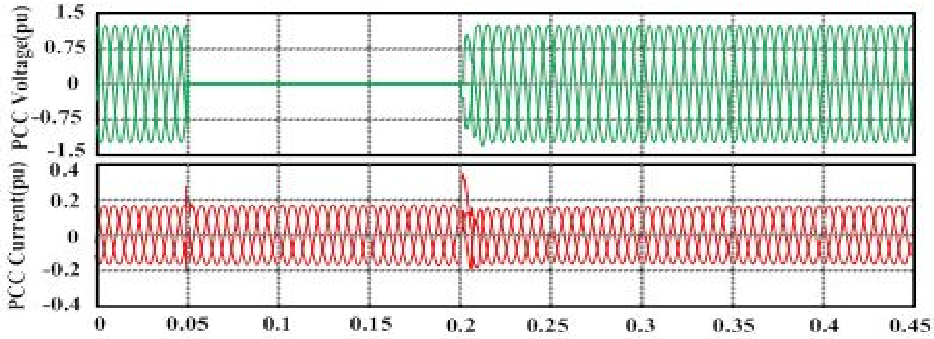

Figure 4:PCC Voltage and Current (Three Phase to Ground Fault)

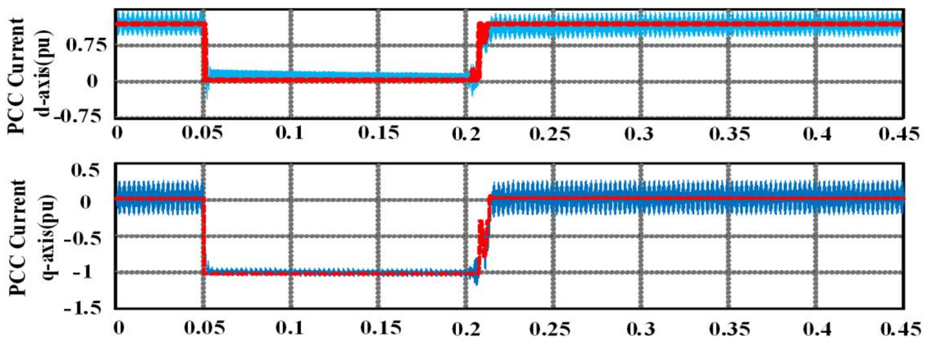

Figure 5: Pq axis PCC Current components(Three Phase to Ground Fault)

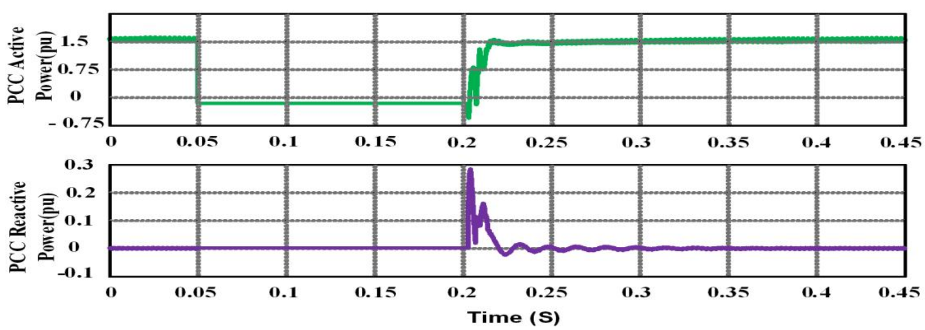

Figure 6: Active and Reactive Power component (Three Phase to Ground Fault)

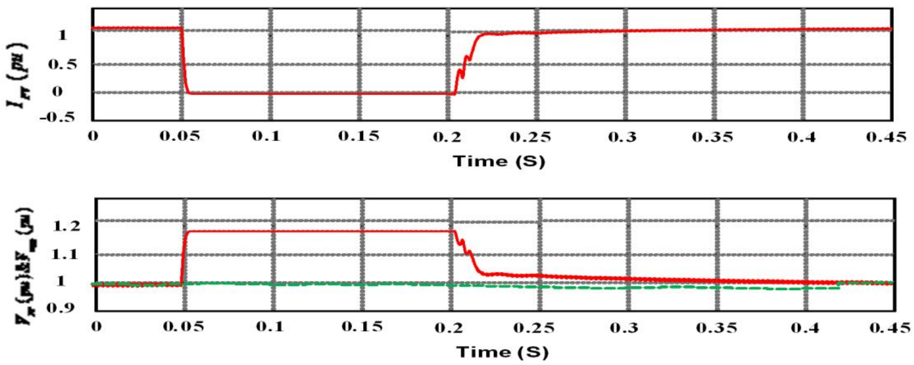

Figure 7:PCC Voltage and Current (Single line to Ground Fault)

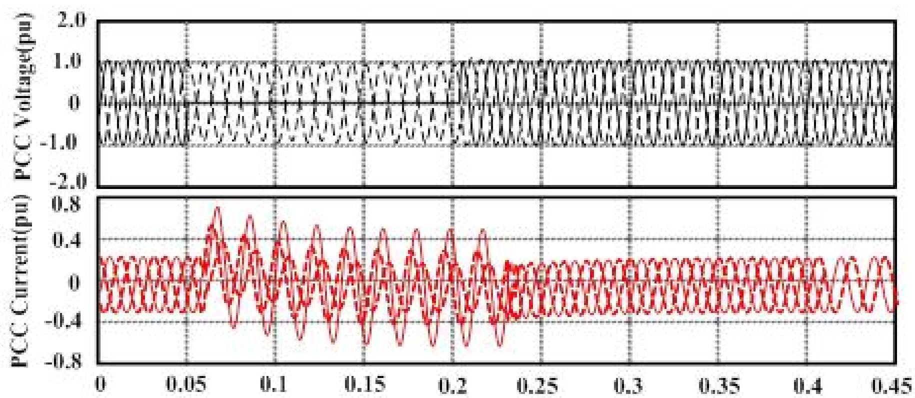

Figure 8:PCC Voltage and Current (Single line to Ground Fault)

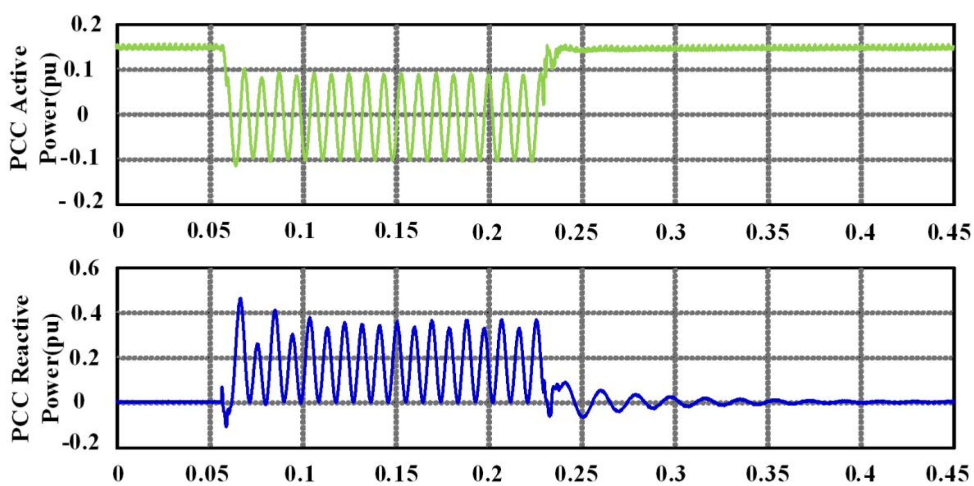

Figure 9: Active and Reactive Power component (Single line to Ground Fault)

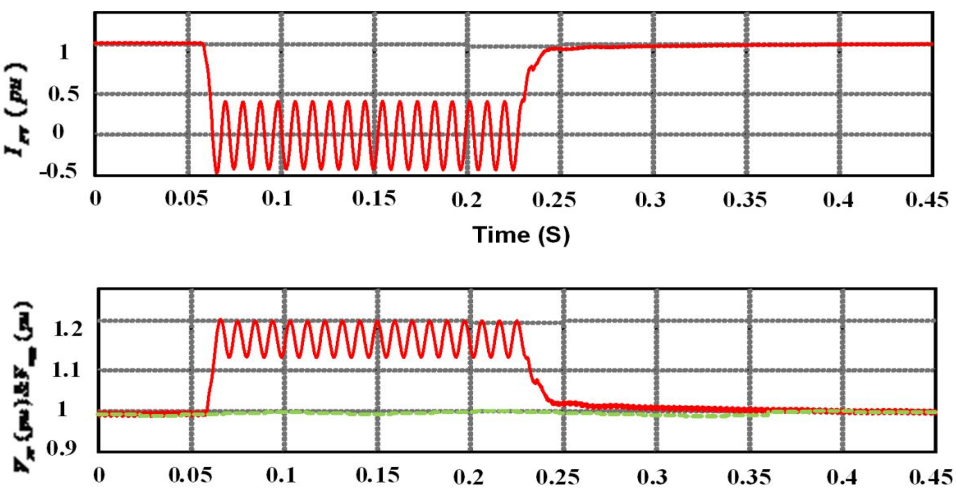

Figure 10: Pq axis components of reference and actual Components

5. CONCLUSION

The research article presented a smart PV inverter integrated to grid with different fault conditions like LLLG and LG faults. The intensity of the any type of the fault is very high in case grid tied condition due to less stability inertia. From the results it can be observed that fault conditions are generating high transient conditions. The triple line to ground fault have high transient time and single line to ground fault is observed to be negative sequence components.

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