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Analysis of Fault Ride Through Capability of Single-Phase Solar Fed Inverter

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Abstract - *Today effective solar power generation is necessary for smart grid implementation. Also, reliable and protected solar inverter is necessary for effective smart grid. As contrary to traditional two stage system, a single-stage solar energy conversion system is implemented, resulting in increased efficiency and reduction of weight and size. Now-a-days maximum power point tracking (MPPT), phase locked loop (PLL), closed loop current and voltage controller are combined in single stage. At the time of L-G fault occur near grid side, were high magnitude of grid current causes high switching of inverter current and voltage imbalance. This problem can be removed by using fast current error controlled SDBR switch. Also the solar inverter needs not to be disconnected from the grid during the fault conditions. Comparative results are obtained by simulation in MATLAB software.*

Key Words: Fault ride through, PV, Inverter control, Protection, SDBR, etc.

1. INTRODUCTION

Solar inverter is a power electronics device that converts the variable direct current output of a solar PV panel into an alternating current that can be supply into an electrical grid or to an off-grid local system. Conventional inverters have double loop control which is a complex process. Fig. 1 shows basic single stage photovoltaic energy conversion system diagram.

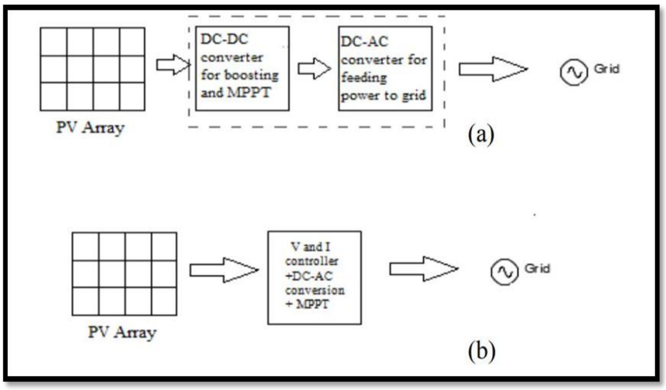

Fig -1: Grid connected solar inverter topologies: (a) Traditional two-stage and (b) Alternative single-stage system

Among them cost effective single stage topology having highest factor of comparison but consist of complex one cycle controller. To overcome this problem simple closed loop current and voltage controller with some modification has been implemented.

1.1Fault Ride Through Capability

At the time of connecting PV plants to grids, it is essential to provide them with dynamic support for the grid voltages. This dynamic support is referred to fault ride through (FRT) capability in which the PV plant should stay connected in the case of grid faults depending on the fault time duration [6]. They have also to provide support to the grid voltages by injecting reactive power. Considering the FRT capability, there are four major reasons for inverter disconnection during grid faults, which are the following ones: (i) over current at the ac side, (ii) excessive dc-link voltage, (iii) loss of grid voltage synchronization, (iv) the reactive current injection imbalance. If system remains connected during these abnormalities, it indicates improved FRT capability of system. The single stage single phase solar inverter with improved fault ride through capability [12]. MATLAB model has developed while keeping first two conditions in focus and achieved better results in simulation.

Table -1 Comparative study of various single-stage single-phase solar inverter topologies.

S. No.	Name Of Topology	Power Output from Inverter in watt	Efficiency in % (a)	No. of devices without filter (b)	Factor of Comparison (a) / (b)	T.H.D [Io]	Inverter Type
1	MPPT with capacitor identifier for PV power system.	500	78	8	0.0975	-	Buck Boost
2	Novel maximum power point tracking controller for PV energy conversion system	-	>90	6	0.15	3.09	H bridge PWM
3	A cost-effective single Stage inverter with MPPT	573.6	95.6	5	0.1912	5.769	H bridge

4	Single Stage full bridge buck boost inverter	500	90	8	0.1125	5-8	Buck Boost
5	Single Stage inverter direct ac connection of a PV cell module	-	83.5	7	0.1192	-	fly back
6	Control of single stage single phase PV inverter	-	-	5	-	5.8	H bridge PWM
7	Single Stage grid connected inverter topology for solar PV system with MPPT	-	83	9	0.0922	9.13	Two Buck boost
8	Integrated inverter for a single-phase single stage grid connected PV system based on Z source	250	83.33	11	0.0757	3.8	Z source
9	Mppt in a one cycle controlled single stage PV inverter	-	89	6	0.1483	8.31	H bridge
10	A novel single phase single stage inverter for solar application	-	-	10	-	-	Buck Boost

1.2 Simulation Model and Results

In this work, the simulation has been performed through MATLAB/Simulink software 2013a. Simulation model of solar inverter with fault is shown in Fig. 2.

Here PV panel consists of series connection of 11 modules which produce around 660 W power, which is fed to the inverter and controlled by closed loop voltage and current controller.

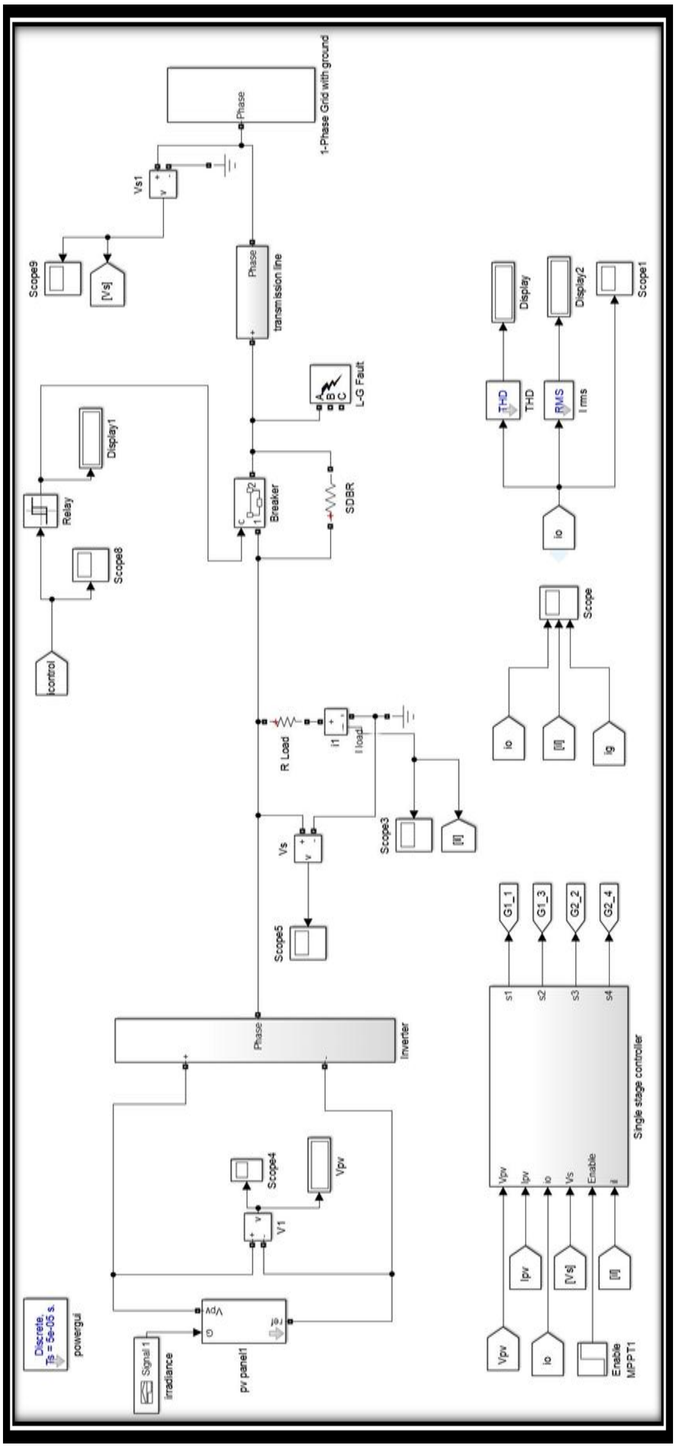

Fig - 2: Simulation model of single-stage single-phase solar inverter with SDBR controller

Here grid has 230 V and 60Hz frequency. Total number of components are seven including LC filter. Fig. 3 shows various currents in normal condition from which it is clear that inverter is able to supply 550 W local load and also fed current to the grid.

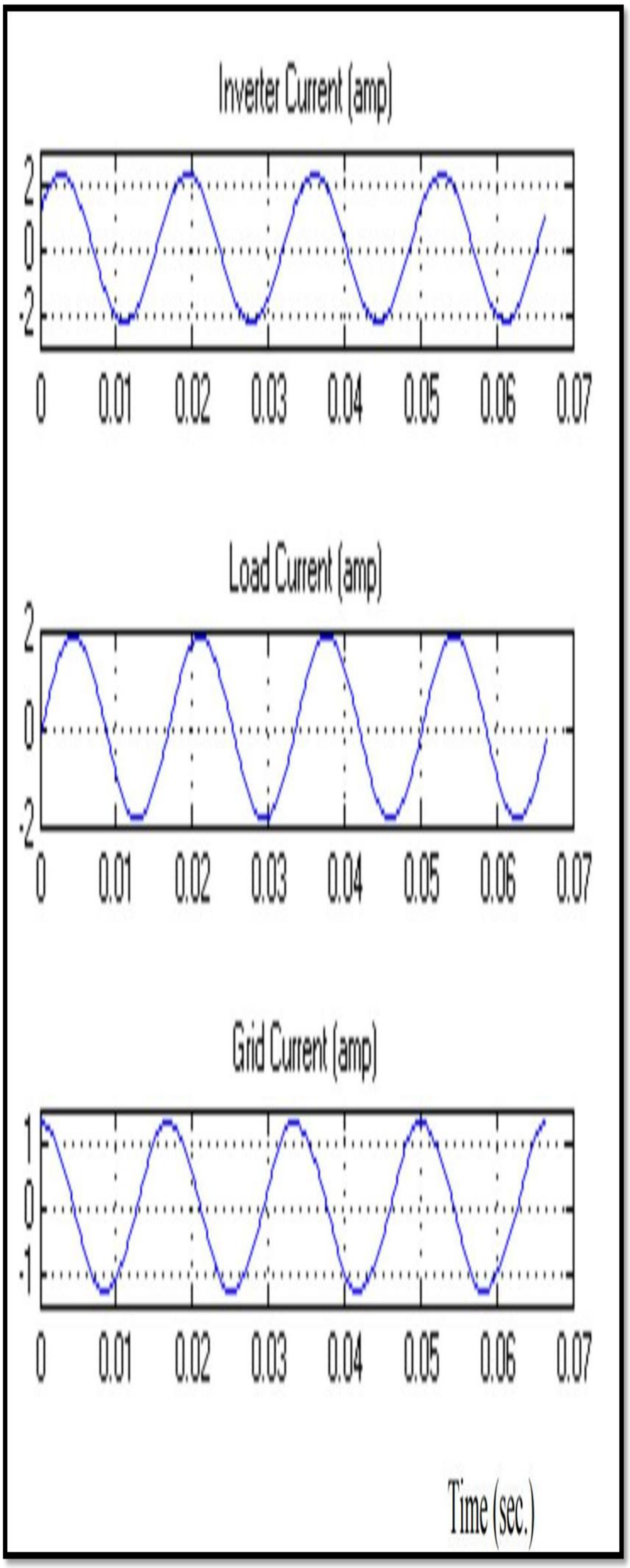

Fig -3: Various currents in normal condition

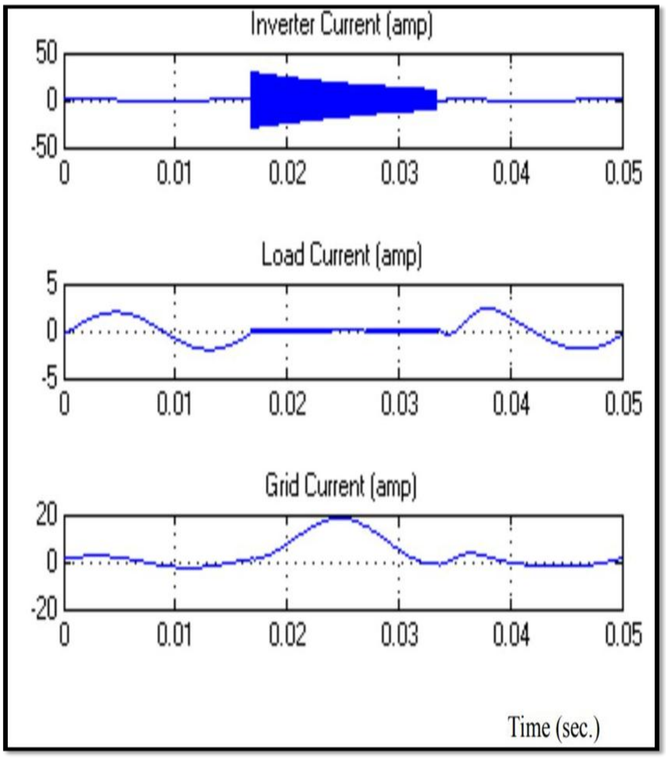

Fig -4: Various currents at the time of fault occurs

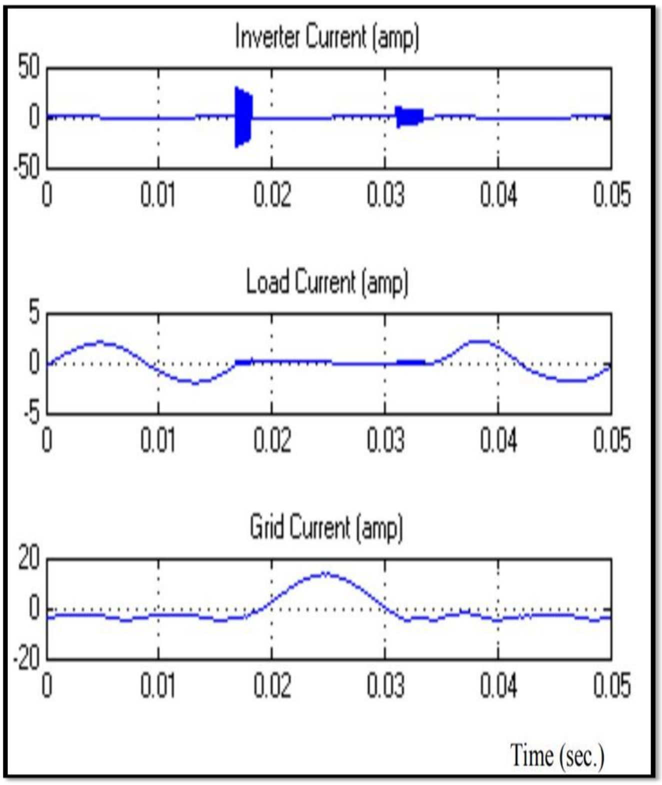

Fig -5: Various currents after SDBR control action

3. CONCLUSIONS

Inverter current T.H.D is 6.849% and having R.M.S value of 0.91. Efficiency of solar inverter is 94.09%. Further Fig. 4 shows various currents at the time of L-G fault occur near grid side, were high magnitude of grid current causes high switching of inverter current and voltage imbalance. This problem can be removed by using fast current error controlled SDBR switch as shown in Fig. 5. Also, there is no need to disconnect the solar inverter during the fault which is proved in Fig. 6.6. Fault time is for 0.0167 sec. in which switching spikes remain only for 0.0009 sec. thus fault ride through capability of solar inverter has been improved with SDBR technique.

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