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RENEWABLE ENERGY SOURCE INTEGRATION WITH DISTRIBUTION GRID USING SIMPLIFIED CONTROL STRATEGY FOR INDUCTION MOTOR DRIVE

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Abstract-Now a days, induction motor applications are been increased. For the speed control of induction motor drive we need inverter. Conventional three-level inverter can drive the induction motor for its speed control. Out of various configurations of MLI, Diode clamped MLI is popular. It has the advantages of simple configuration and requires less number of individual DC sources. But the basic knowledge of faults in the inverter circuit can be very handy for the effective design of induction motor drive system. Knowing the types of faults that might occur in the inverter, fault mitigation techniques can be known and corresponding algorithm for fault mitigation can be prepared. Prior information regarding different types of faults in inverter is to be known to identify and to mitigate the faults. In this paper different types of faults in inverter were discussed. Basic three-level inverter was taken up for analysis driving induction motor. Faults like diode open, diode shot, gate open, gate short fault, IGBT open and IGBT short faults were discussed in detail along with their results. Models were developed using Matlab/Simulink.

Keywords: Distributed generation, Renewable Energy Source (RES), hysteresis current control. Interfacing, Induction motor.

I. INTRODUCTION

Access to quality, reliable and reasonable energy is essential for promoting economic and social development in rural areas. As a result of exaggerated standard of living, growing population, rapid industrialization etc., the energy demand has increased and thence the gap between generation and demand area unit increasing significantly [1]. Distributed Generation (DG) is that the power generation from regionally obtainable sources; typically renewable energy sources [2]. DG is on the increase since distributed energy systems with renewable sources have nice potential in providing reliable power to the agricultural areas wherever grid extension is troublesome and uneconomical [3]. The increasing demand for power and also the focus on environmental protection drive the efforts to focus on developing renewable energy sources. The energy demand for electric power is increasing day by day. End users and electric utilities are concerned about meeting the growing energy demand. Distributed generation (DG) systems are presented as a suitable form to offer high reliable electrical power supply. Renewable energy supply (RES) integrated at distribution level is termed as distributed generation (DG). The utility is concerned as a result of the high penetration level of intermittent RES in distribution systems because it might pose a threat to network in terms of stability, voltage regulation and power-quality (PQ) problems [4]. Therefore, the metric weight unit systems area unit needed to follow with strict technical and regulative frameworks to ensure safe, reliable and economical operation of overall network. With the advancement in power electronics and digital management technology, the DG systems will currently be actively controlled to reinforce the system operation. A simple hysteresis controller [5] is used to control the interfacing converter. This controller is very simple in operation and design and can effectively control the switches in interfacing converter. This interfacing converter transfers the active power from the RES to the grid. Reference current plays an important role in control strategy [6]. In this paper, fixed and variable reference currents are given to validate the performance of the system.Electricity generation using renewable resources is often taking place in small scale due to disperse nature of the recourses. The size of these generators typically varies from a few hundreds of kilowatts to several megawatts. The types of grid interfaces used with Photovoltaic's are Power electronics converter & Induction generator/ Power electronics converter. In this paper, recent ongoing trends in grid integration of solar energy system are presented, the power quality improvement by using hysteresis current control [7]. Most suitable energy sources supply energy in the form of electrical power Distributed Generation (DG) systems are often connected to the utility grid through power electronic converters for induction motor drive. A grid-connected inverter provides the necessary interface of the DG to the phase, frequency and amplitude of the grid voltage, and disconnects the system from the grid when islanding.

II. INTERCONNECTION OF RES TO MAIN UTILITY DISTRIBUTION GRID

The planned system consists of RES connected to the dc-link of a grid-interfacing inverter as shown in Fig.1. The voltage supply inverter may be a key part of a weight unit system because it interfaces the renewable energy supply to the grid and delivers the generated power.

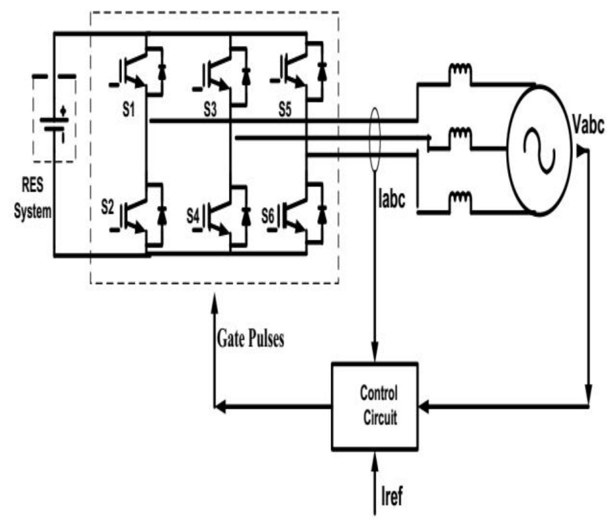

Fig.1: Interconnection of RES to main Utility Distribution Grid

The RES is also a DC supply or associate degree AC supply with rectifier coupled to dc-link. Usually, the photo-voltaic system generates power at variable low dc voltage, whereas the variable speed wind turbines generate power at variable ac voltage. Thus, the power generated from these renewable sources needs power learning (i.e., dc/dc or ac/dc) before connecting on dc-link. The DC capacitor decouples the RES from grid and conjointly allows freelance management of converters on either side of dc-link. Due to the intermittent nature of RES, the generated power is of variable nature. The dc-link plays a very important role in transferring this variable power from renewable energy supply to the grid RES area unit described as current sources connected to the dc-link of a grid-interfacing electrical converter. A voltage source converter (VSC) could be a power device that connected in shunt or parallel to the system. It will generate a curving voltage with any needed magnitude, frequency and point in time. It additionally converts the DC voltage across storage devices into a group of 3 part AC output voltages. it's additionally capable to get or absorbs reactive power. If the output voltage of the VSC is larger than AC terminus voltages, is alleged to be in electrical phenomenon mode. So, it'll compensate the reactive power through AC system. The sort of power switch used is ANIGBT in anti-parallel with a diode. The 3 part four leg VSI is sculpturesque in Stimulant by exploitation IGBT.

III. SIMPLIFIED HYSTERESIS CONTROL STRATEGY

Low cost with easy implementation and its excellent dynamic response makes hysteresis control a prior option as control strategy. One of the simplest current control PWM techniques is the hysteresis band (HB) control shown in this figure 2. The obtained current reference signal, while converted from dq/abc transformation, is split into each phase reference currents and is measured with the actual phase currents of individual grid phases. The error signal thus generated fed to relay producing pulses. This method contains hysteresis band (HB) to obtain pulses to the switches of grid interfacing converter. Pulse generation is explained in figure 3. Basically, it is an instantaneous feedback current control method in which the actual current continuously tracks the command current within a pre assigned hysteresis band. As indicated in the figure 3, if the actual current exceeds the HB, the upper device of the half-bridge is turned off and the lower device is turned on. As the current decays and crosses the lower band, the lower device is turned off and the upper device is turned-on. If the HB is reduced, the harmonic quality of the wave will improve, but the switching frequency will increase, which will in turn cause higher switching losses.The physical phenomenon of current management (HCC) is that the best management methodology to implement; it had been developed by Brod and Novotny in 1985. The shunt APF is enforced with three sections current controlled VSI and is connected to the ac mains for compensating the present harmonics. The VSI gate signals area unit brought out from physical phenomenon current controller. A Hysteresis current controller is enforced with a closed-loop system and waveforms area unit shown in Fig.3.3. An error signal is employed to manage the switches during voltage supply electrical converter. This error is that the distinction between the specified current and the current be inginjected by the electrical converter. If the error exceeds the higher limit of the physical phenomenon band, the higher switch of the inverter arm is turned off and also the lower switch is turned on. As a result, the present starts decaying.

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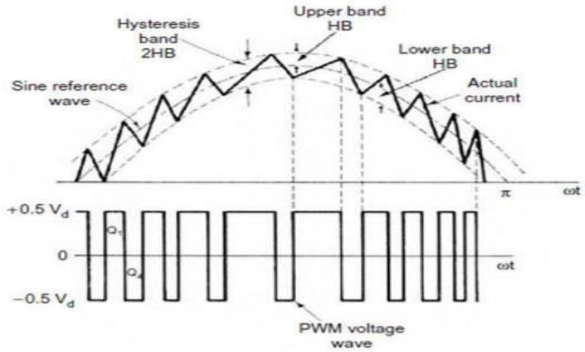

Fig.2: Hysteresis Band Current control

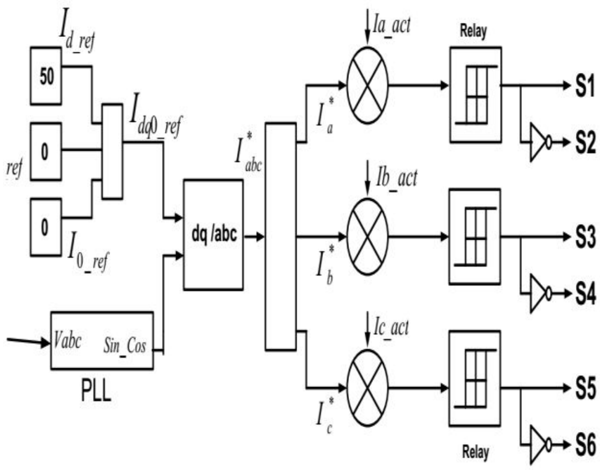

Fig.3: Hysteresis Current Controller

IV. INDUCTION MOTOR

An asynchronous motor type of an induction motor is an AC electric motor in which the electric current in the rotor needed to produce torque is obtained by electromagnetic induction from the magnetic field of the stator winding. An induction motor can therefore be made without electrical connections to the rotor as are found in universal, DC and synchronous motors. An asynchronous motor's rotor can be either wound type or squirrel-cage type.Three-phase squirrel-cage asynchronous motors are widely used in industrial drives because they are rugged, reliable and economical. Single-phase induction motors are used extensively for smaller loads, such as household appliances like fans. Although traditionally used in fixed-speed service, induction motors are increasingly being used with variable-frequency drives (VFDs) in variable-speed service. VFDs offer especially important energy savings opportunities for existing and prospective induction motors in variable-torque centrifugal fan, pump and compressor load applications. Squirrel cage induction motors are very widely used in both fixed-speed and variable-frequency drive (VFD) applications. Variable voltage and variable frequency drives are also used in variable-speed service.In both induction and synchronous motors, the AC power supplied to the motor's stator creates a magnetic field that rotates in time with the AC oscillations. Whereas a synchronous motor's rotor turns at the same rate as the stator field, an induction motor's rotor rotates at a slower speed than the stator field. The induction motor stator's magnetic field is therefore changing or rotating relative to the rotor. This induces an opposing current in the induction motor's rotor, in effect the motor's secondary winding, when the latter is short-circuited or closed through external impedance. The rotating magnetic flux induces currents in the windings of the rotor; in a manner similar to currents induced in a transformer's secondary winding(s). The currents in the rotor windings in turn create magnetic fields in the rotor that react against the stator field. Due to Lenz's Law, the direction of the magnetic field created will be such as to oppose the change in current through the rotor windings. The cause of induced current in the rotor windings is the rotating stator magnetic field, so to oppose the change in rotor-winding currents the rotor will start to rotate in the direction of the rotating stator magnetic field. The rotor accelerates until the magnitude of induced rotor current and torque balances the

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applied load. Since rotation at synchronous speed would result in no induced rotor current, an induction motor always operates slower than synchronous speed. The difference, or "slip," between actual and synchronous speed varies from about 0.5 to 5.0% for standard Design B torque curve induction motors. The induction machine's essential character is that it is created solely by induction instead of being separately excited as in synchronous or DC machines or being self-magnetized as in permanent magnet motors.For rotor currents to be induced the speed of the physical rotor must be lower than that of the stator's rotating magnetic field (n_s); otherwise the magnetic field would not be moving relative to the rotor conductors and no currents would be induced. As the speed of the rotor drops below synchronous speed, the rotation rate of the magnetic field in the rotor increases, inducing more current in the windings and creating more torque. The ratio between the rotation rate of the magnetic field induced in the rotor and the rotation rate of the stator's rotating field is called slip. Under load, the speed drops and the slip increases enough to create sufficient torque to turn the load. For this reason, induction motors are sometimes referred to as asynchronous motors. An induction motor can be used as an induction generator, or it can be unrolled to form a linear induction motor which can directly generate linear motion.

Synchronous Speed:

The rotational speed of the rotating magnetic field is called as synchronous speed.

$$Ns = \frac{120 \text{ x } f}{P} \quad \text{(RPM)} \tag{1}$$

Where, f = frequency of the supply

P = number of poles

Slip:

Rotor tries to catch up the synchronous speed of the stator field, and hence it rotates. But in practice, rotor never succeeds in catching up. If rotor catches up the stator speed, there won't be any relative speed between the stator flux and the rotor, hence no induced rotor current and no torque production to maintain the rotation. However, this won't stop the motor, the rotor will slow down due to lost of torque, and the torque will again be exerted due to relative speed. That is why the rotor rotates at speed which is always less the synchronous speed.

The difference between the synchronous speed (Ns) and actual speed (N) of the rotor is called as slip.

$$\% \text{ slip} \quad s = \frac{Ns - N}{Ns} \text{ x } 100 \tag{2}$$

V. MATLAB/SIMULINK RESULTS

Case 1: Control with fixed reference current signal

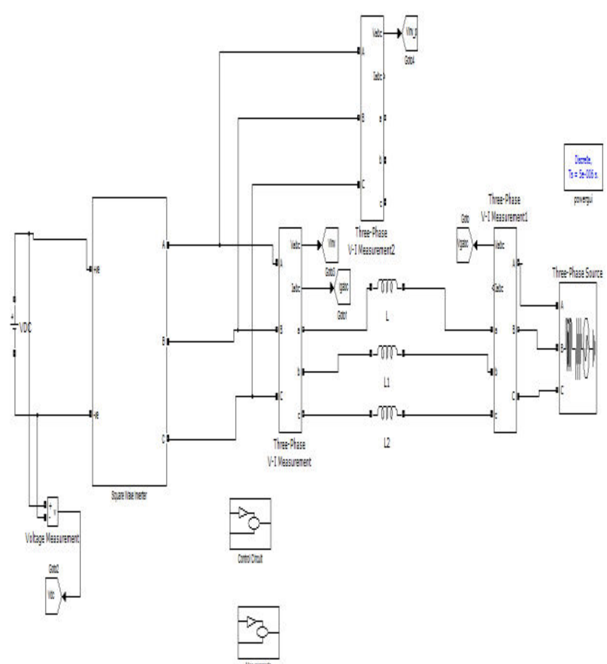

Fig.4. Matlab/Simulink model of Interconnection of RES to main Utility

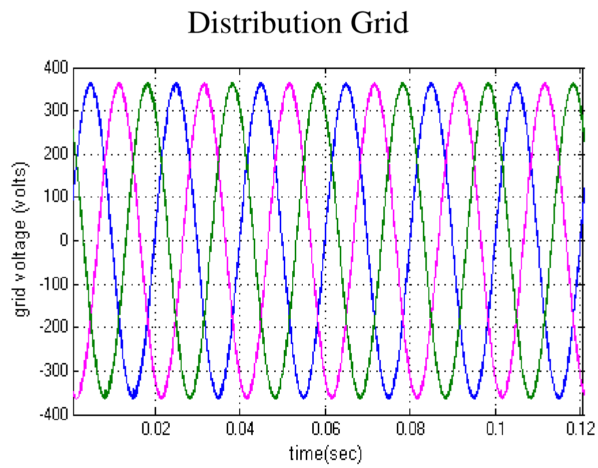

Fig.5 Grid voltages with fixed reference current signal

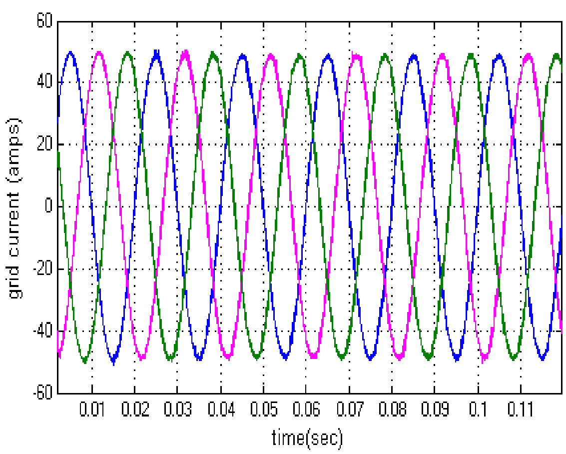

Fig.6 Grid currents with fixed reference current signal

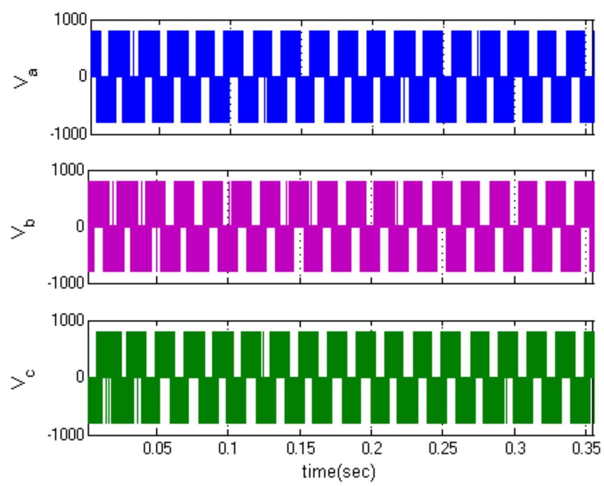

Fig.7 Inverter line Voltages with fixed reference current signal

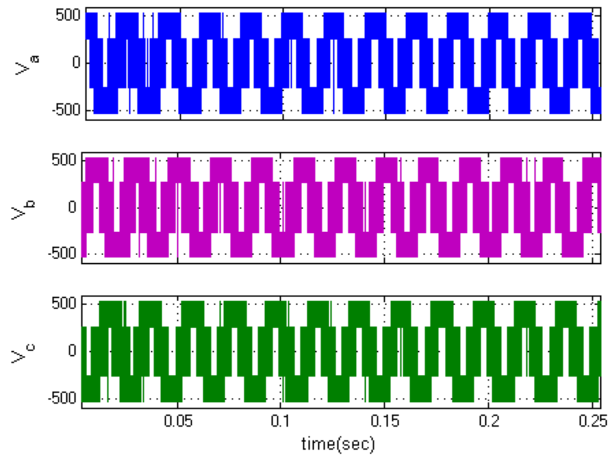

Fig.8 Inverter Phase Voltages with fixed reference current signal

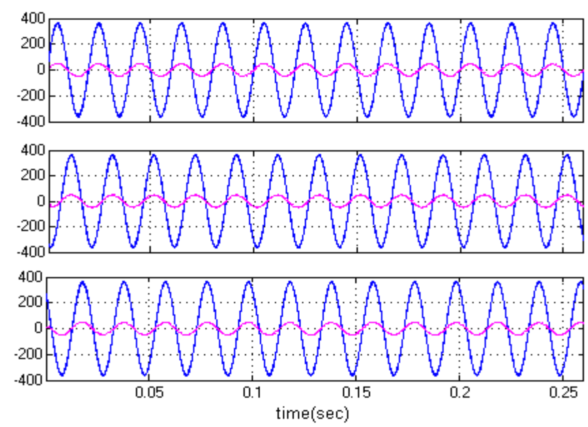

Fig.9 Inverter three phases relation between Voltages and currents with fixed reference current signal

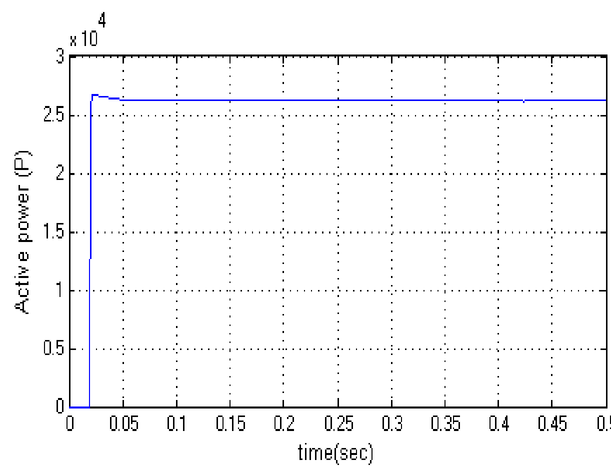

Fig.10 Active power with fixed reference current signal

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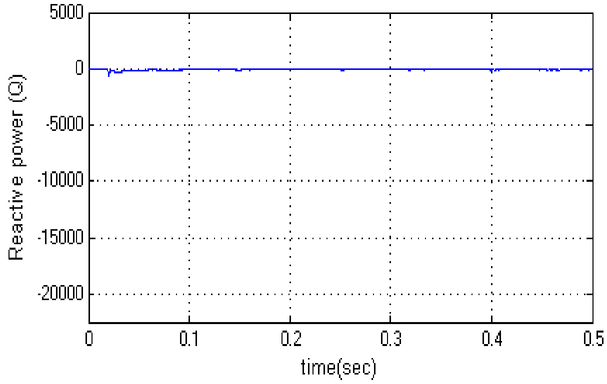

Fig.11 Reactive power with fixed reference current signal

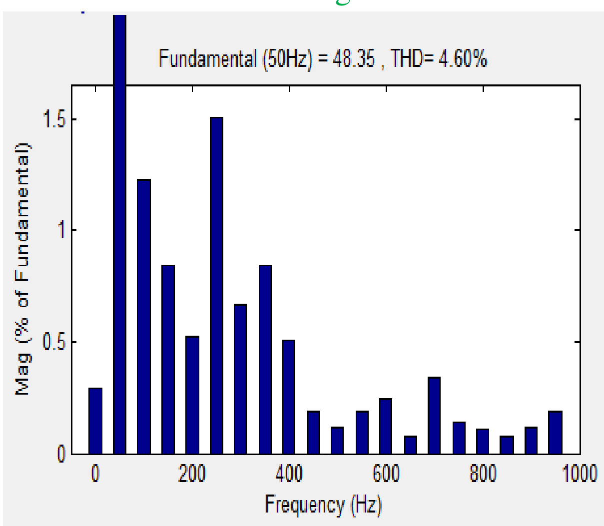

Fig.12. THD in source current with fixed reference current signal

Case 2: Control with variable reference current signal

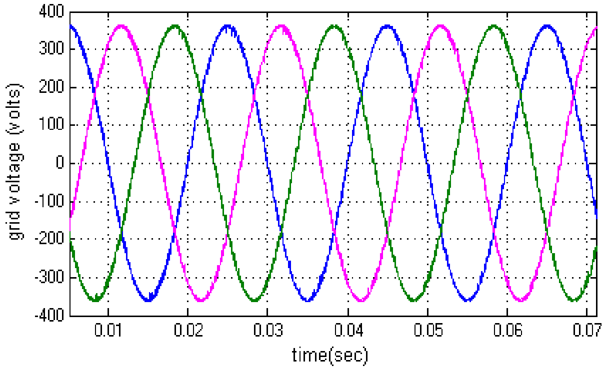

Fig.13 Grid voltages with Variable reference current signal

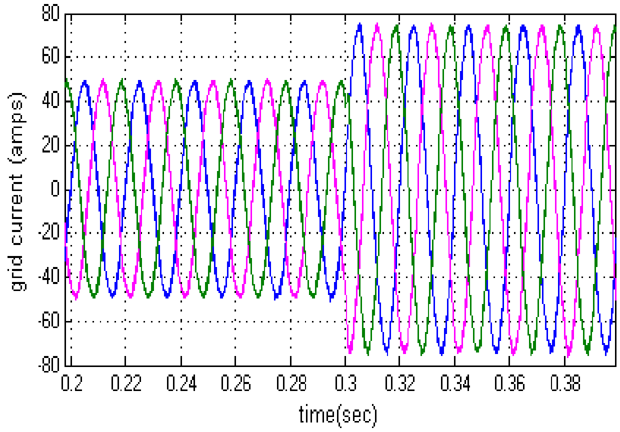

Fig.14 Grid currents with variable reference current signal

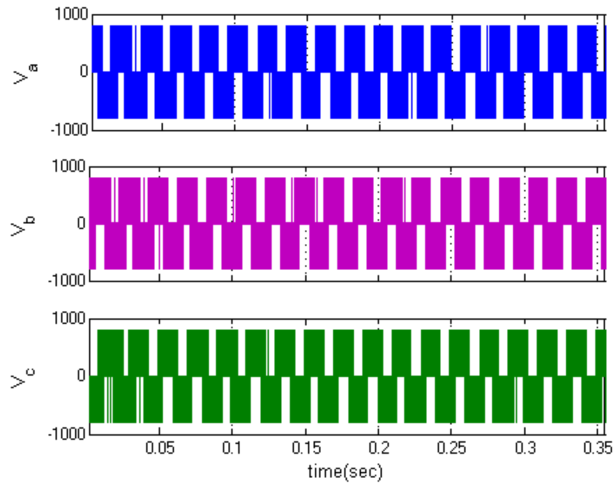

Fig.15 Inverter line Voltages with variable reference current signal

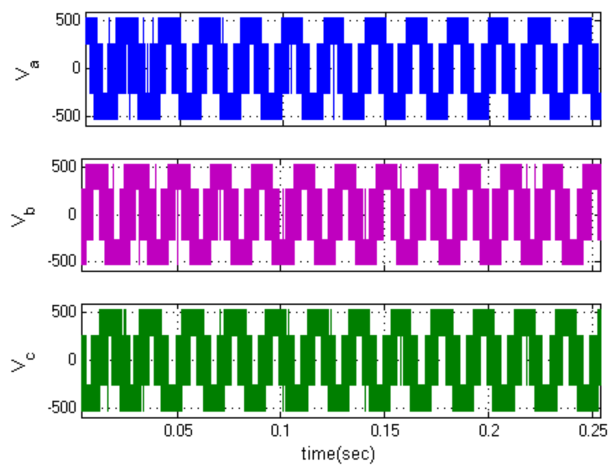

Fig.16 Inverter Phase Voltages with variable reference current signal

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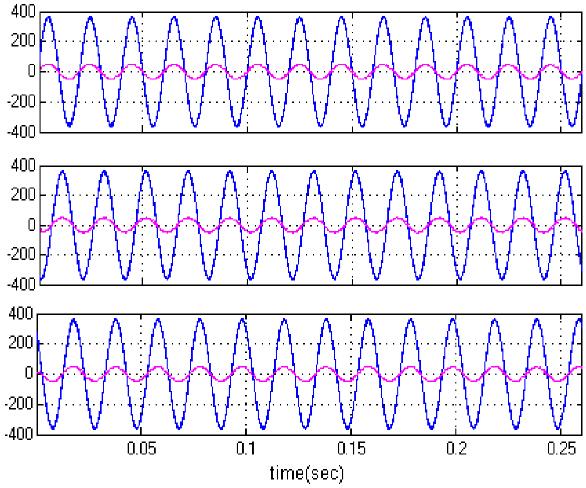


Fig.17 Inverter three phases relation between Voltages and currents with variable reference current signal

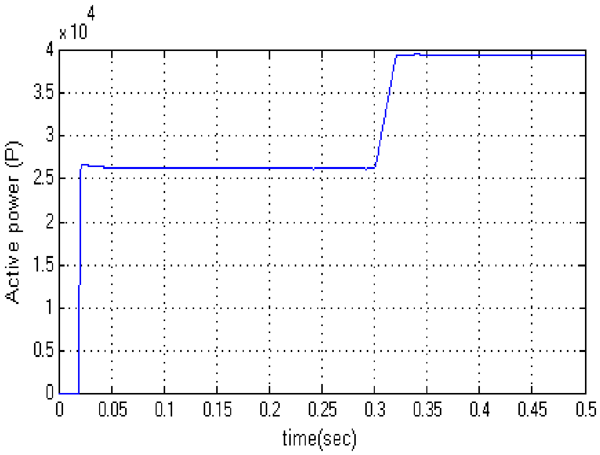


Fig.18 Active power with variable reference current signal

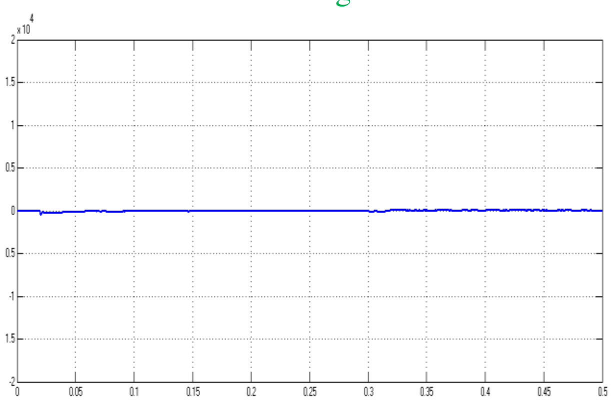


Fig.19 Reactive power with variable reference current signal

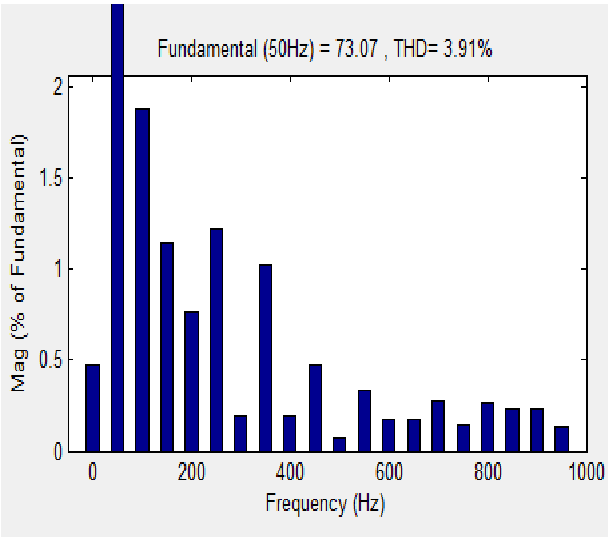


Fig.20 THD in source current with variable reference current signal

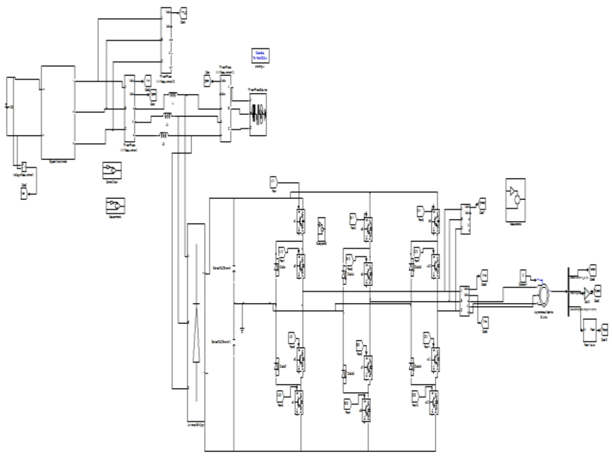
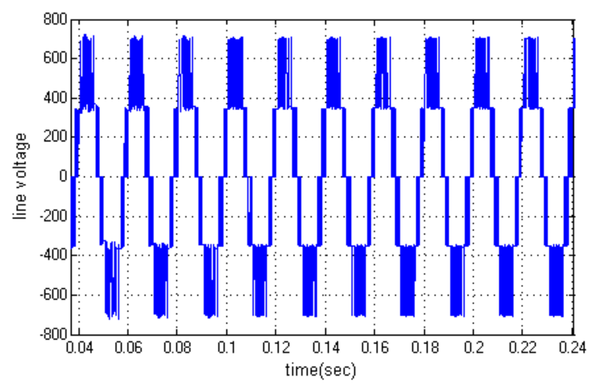


Fig.21 Matlab/Simulink model of Interconnection of RES connected to 3 phase induction motor drive



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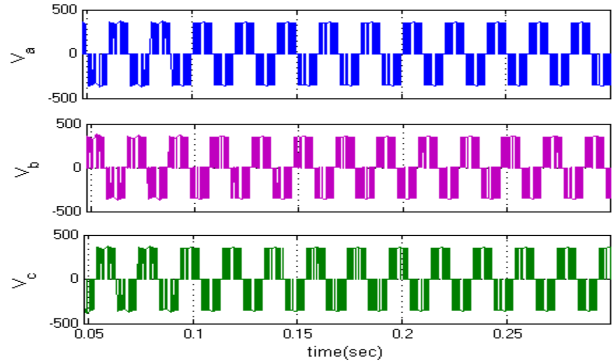

Fig.22 Simulation waveforms for (a) line voltages (b) Phase voltages

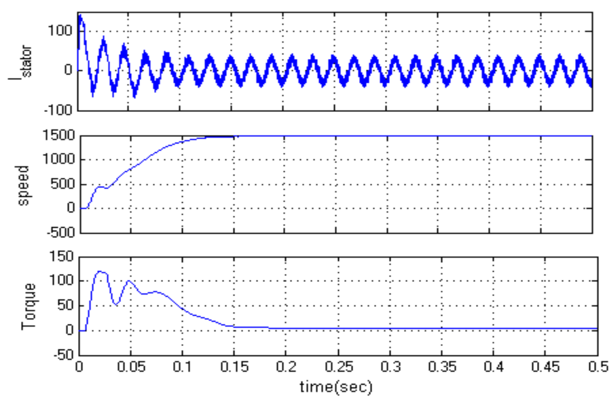

Fig.23 Simulation waveforms for stator current, speed and Torque of induction motor

VI. CONCLUSION

Distributed generation (DG) is one of the emerging trends in power system these days. Incorporation of DG can be made at distribution level. The power generated by Renewable Energy Source (RES) is fed to the distribution grid through an interfacing converter. This interfacing converter is controlled using a hysteresis current control which is simple in operation. Active power transfer from RES was discussed. Hysteresis current control strategy was discussed in detail. System was validated by giving fixed and variable reference current signals to the controller. Results shows that the active power when fed from the RES to the grid maintains less THD (within standards) in grid currents when reference current signal was kept constant and also when varied. Results regarding to active power, grid voltages and currents along with THD was discussed and the results validate the function of control scheme for grid interfacing scheme of RES with induction motor.

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