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Three Phase Voltage Source Inverter for Front End Rectifier Fed to Ac-Motor Drive Using Matlab

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Abstract*— A 6-switch three phase inverter is widely used in industrial application using AC-drives. This model mainly demonstrates the use of 3-leg IGBT switches for three phase inverter. The switching operation of a three phase inverter is controlled so that output is achieved at every 60 degree angle. A PWM generator is used to generate PWM signals at required phase. The designed inverter model can be used to demonstrate the relationship of input DC, modulation index, switching frequency and total harmonic distortion (THD).The simulation results have been carried out using MATLAB/Simulink.

***Index Terms*— Voltage Source Inverter (VSI), Front End Rectifier (FER), DC-AC converter, LC filter**

I. INTRODUCTION

Inverters are used in a large number of power applications. A Voltage Source Inverter (VSI) is one which takes a fixed dc voltage and converts it into independently controlled ac output. VSI are divided into three categories PWM inverter, Square wave inverter and single phase inverter with voltage cancellation, PWM technique is used to model the VSI. A fixed dc input voltage is given to the inverter and a controlled ac output voltage is obtained by adjusting the ON and OFF periods of the inverter components. PWM techniques are characterized by constant amplitude pulses. The width of these pulses is however modulated to obtain inverter output voltage control and to reduce its harmonic content. Single phase VSI is used for low power applications and three phase VSI is used for medium to high power applications. The main purpose of these topologies is to provide a three phase voltage source where the amplitude, phase and frequency of the voltage should always be controllable. Most of the applications require sinusoidal voltage waveform (eg:- UPS, FACTS, VAR compensator), arbitrary voltages are also required in some applications (eg:-active filters, voltage compensator). In inverters the power semiconductors devices always remains forward-biased due to the supply voltage, and therefore, self controlled forward device such as IGBTs and MOSFETs are suitable[1].

II. PROPOSED SYSTEM

Front End Rectifier (FER) is typically connected to line side of the motor drive, so called Front end rectifier or Line side converter. The dc output voltage of the FER can be regulated and the input power factor is adjustable. Power can flow in either direction which can be used in many motor drive applications. Another advantage of FER is the regeneration capability, especially for drive applications. The proposed system schematic diagram is shown in Fig 1. The proposed model consists of a Front End Converter, Dc-link, VSI and AC motor Drive. The AC supply is given as the input to the FER [1]. The FER converts the AC supply to DC which is connected to the grid. This DC is converted to desirable AC voltage by the VSI and fed to the AC-motor drive.

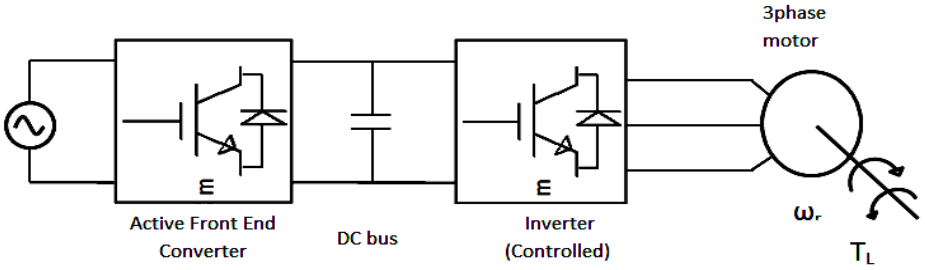

Fig 1 Schematic Diagram of Proposed System

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In this paper the Voltage Source Inverter is designed in MATLAB/Simulink.

III. THREE PHASE VOLTAGE SOURCE INVERTER

The three phase voltage source inverter generates less harmonic distortion in the output voltage utilized in the phase to phase AC load. The circuit model of three phase VSI is shown in Fig 2 and the six valid switch states are given in Table 1[1]. In three phase VSI the switches of any leg of the inverter (T_{A+} and T_{A-} , T_{B+} and T_{B-} , or T_{C+} and T_{C-}) cannot be switched on simultaneously because this would result in a short circuit across the dc link voltage supply. Similarly, in order to avoid undefined states in the VSI, the switches of any leg of the inverter cannot be switched off simultaneously as this will result in voltages that will depend upon the respective line current polarity. The states (1 to 6 in Table 3) produce ac output voltages [2]. In order to generate a given voltage waveform, the inverter moves from one state to another. The selection of the states in order to generate the given waveform is done by the modulating technique that should ensure the use of only the valid states.

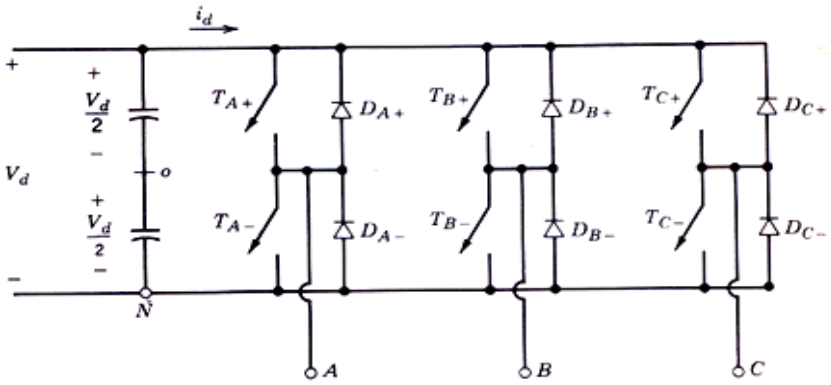

Fig 2 Three phase inverter

STATES		Phase to Phase Voltage		
ON	OFF	V_{ab}	V_{bc}	V_{ca}
T_{A+} T_{B-} T_{C-}	T_{A-} T_{C+} T_{B+}	V	0	-V
T_{C-} T_{B+} T_{A+}	T_{C+} T_{B-} T_{A-}	0	V	-V
T_{B+} T_{A-} T_{C-}	T_{B-} T_{A+} T_{C+}	-V	V	0
T_{A-} T_{C+} T_{B+}	T_{A+} T_{C-} T_{B-}	-V	0	V
T_{C+} T_{B-} T_{A-}	T_{C-} T_{B+} T_{A+}	0	-V	V
T_{B-} T_{A+} T_{C+}	T_{B+} T_{A-} T_{C-}	V	-V	0

Table 1 Switches states for three phase VSI

Many applications that require an inverter use three phase power. Two main examples are AC-motor drive and uninterruptible power supplies [3]. This can be obtained by three legs, one of each phase. Output voltage from an inverter can also be adjusted by exercising a control within the inverter itself. The most efficient method of doing this is by pulse width modulation control used within an inverter. The advantages of PWM techniques are mentioned as:

a. The output voltage control with this method can be obtained without any additional components.

b. With the controlling of the output voltage, lower order harmonics can be erased or minimized.

PWM inverters are very much suitable in industrial applications [4].

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IV. THREE PHASE INVERTER MODULE

The module of three phase inverter is designed by using MATLAB software tool. Based on design and simulation results are shown. It is developed by line to line voltage of 415V rms. The simulation model is shown in Fig 3.

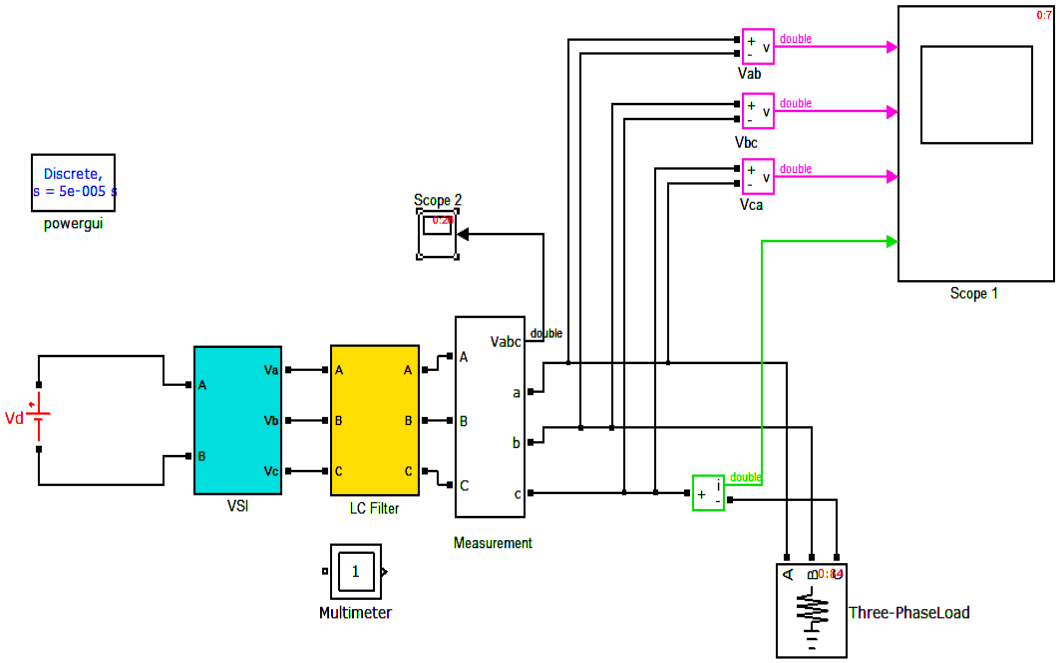

Fig 3 Three Phase Voltage Source Inverter

The module is designed by taking voltage source which remains constant connected to the three phase bridge converter. If we are taking the constant input voltage Vdc is 646 V then Vab L-L is 415 Vrms is the phase to phase voltage. The equation is given below;

$$Vab(L\text{-}L) = 2*\sqrt{(2/3)}* Vd \qquad (1)$$

The frequency is taken as 50 Hz. The three phase bridge converter consists of three leg IGBT of internal diode resistance Ron= 0.001 Ω, Snubber resistance Rs=$1e^5\Omega$. It allows simulation of converters using both naturally commutated (and line-commutated) power electronic devices (diodes or thyristors) and forced-commutated devices (GTO, IGBT, and MOSFET).

The Fig.4 shown below. PWM gate pulses is connected to the 3 phase bridge converter the control signal frequency (fc) is taken as 50, carrier frequency as 1080 Hz and modulation index is 1.

LC filter is connected to filter the unwanted harmonics. The output LC filter is connected to remove high switching frequency components from output current of inverter [5] [6]. The simulation design of LC filter is shown in Fig.5 where L= $15e^{-3}$, C= $10e^3$. The filter is designed taking into account the following parameters for the grid and inverter as shown in Table 2. The value of L is design based on current ripple. Smaller ripple results in lower switching and conduction losses. Typically the ripple current can be chosen as 10% - 15% of rated current. Considering 10% ripple at the rated current the designed value of inductor (L) in the system is given by

$$\Delta iLmax = 1/8 * Vdc / L* fs \qquad `(2)$$

The capacitor C is designed based on reactive power supplied by the capacitor at fundamental frequency. In this design reactive power can be chosen as 15% of the rated power is given by

$$C = 15\%* Prated / 3*2\,\pi\, f * V^2 rated \qquad (3)$$

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DC source voltage	646
Line voltage	415
Frequency	50
Modulation Index	1

Table 2

The three phase load parallel RLC load block the parameters taken nominal phase to phase voltage Vn (Vrms) is 415, nominal frequency (fn) is 50 Hz, active power (P) is $5e^3$ W.

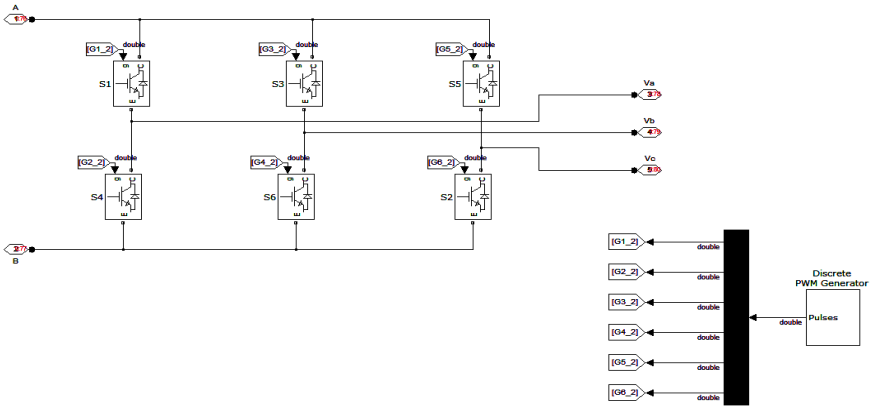

Fig 4 Three phase bridge converter-IGBT switches

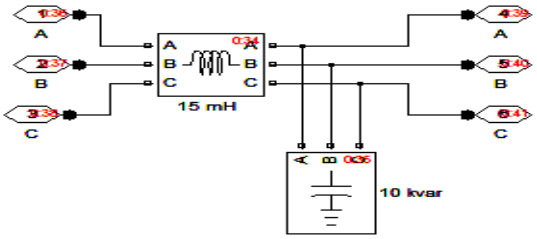

Fig 5 LC filter

V. SIMULATION RESULTS

The simulation of entire system is done by MATLAB simulation results are shown below. The input voltage constant with respect to time is shown in Fig 6.

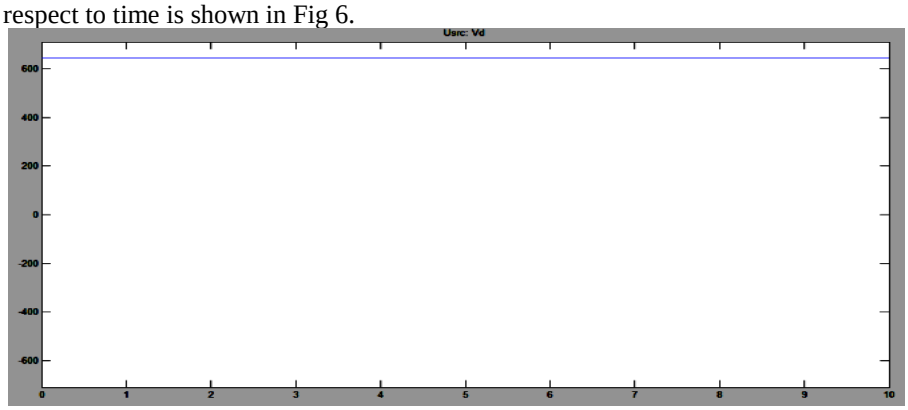

Fig 6 Input voltage

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The output voltages of the three phase voltage source inverter i.e., phase to phase of ab, bc, and ca of each phase with respect to time the waveform is shown in Fig 7.

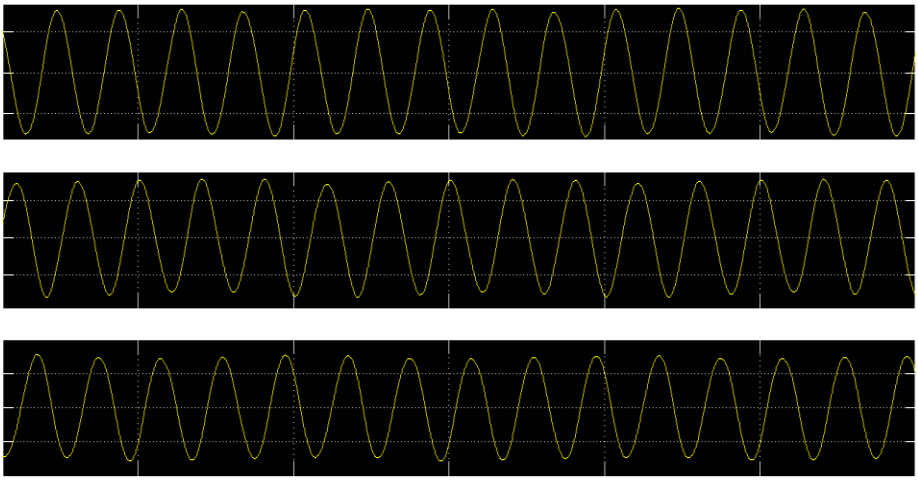

Fig 7 Phase to Phase output voltage of Scope-1

The three phase voltage with the three phase load the output voltage waveform is sinusoidal is shown in Fig 8.

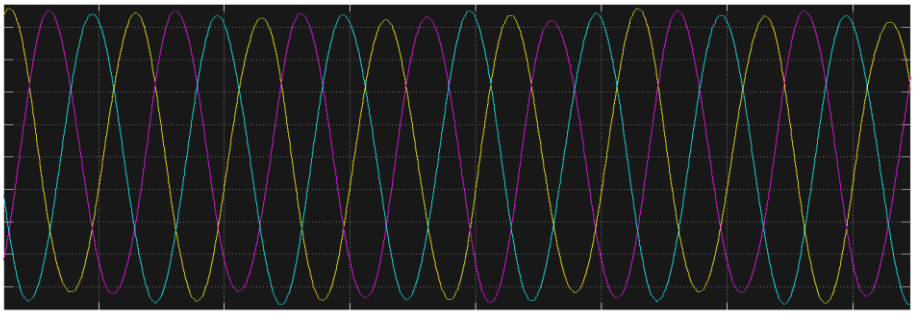

Fig 8 Three Phase voltage waveform of Scope-2

The Total Harmonic Distortion (THD) is obtained by conducting the FFT analysis. THD obtained is 3.79% which is relatively small.

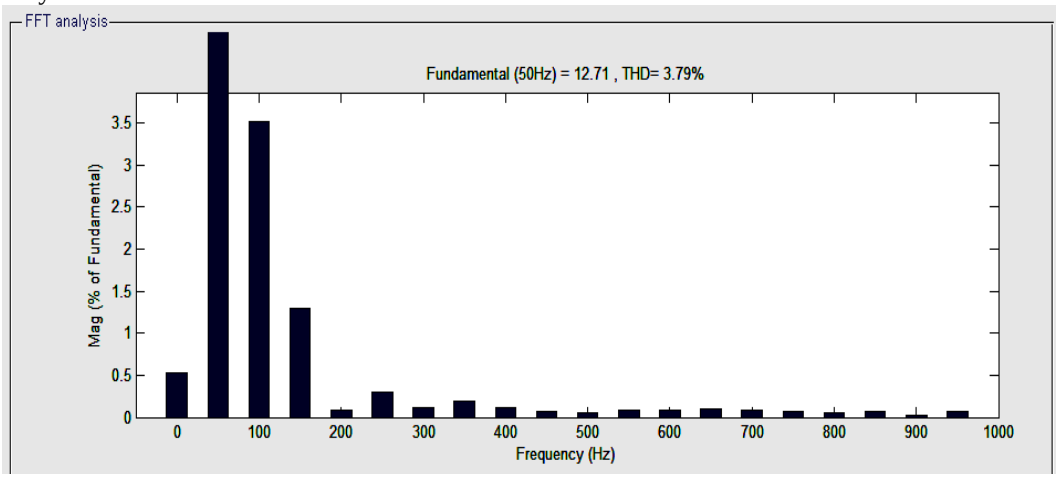

Fig 9 THD display

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VI. CONCLUSION

This model demonstrates a DC-AC converter. The VSI is designed using 6-IGBT switches. It can be used to demonstrate the relationship of input DC, Modulation index, filter selection and Total harmonic features. The simulation result has been carried out by MATLAB/ simulink. It is a Discrete PWM pulse generator is used to provide gating pulses for IGBT switches. LC filter is fed with the converter output to smoothening of the output waveform. The studied inverter topology offer advantages such as improved output waveform, smaller filter design and lower THD (3.79%). Simulation and experimental results shows the effectiveness of the proposed system.

VII. FUTURE WORK

The designed VSI is used in the Front End Rectifier topology as shown in Fig 1.The output of the Front End Rectifier is fed to AC motor drive .Improved power factor and total harmonic distortion (THD) of ac input line current of front-end rectifier for ac motor drive is achieved using this topology.

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