SINGLE PHASE SUPPLY FED THREE PHASE INDUCTION MOTOR USING SPWM INVERTER

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Abstract: This paper presents a simple single phase to three phase conversion technique. Sinusoidal pulse width modulation (SPWM) technique is used to generate the gate pulses which are used to fire the switches. A three phase load or motor is connected with this generated three phase supply to test the output and to control the speed of three phase induction motor. As we know electric drives have a vast application in industries. This is because the three phase motors are more controllable than any other motor or drive and is also easily available. We it necessary to test the three phase induction motor by feeding this obtained supply.

Keywords-SPWM inverter, Single-Phase to Three-Phase conversion technique, Voltage Source Inverter

1. INTRODUCTION

As we know that power electronics deals with conversion and control of electrical powerfor various applications. Often a conversion system is a hybrid type that mixes more than one basic conversionprocess. The switchingtype of conversion can introduce distortion andgenerate harmonics on source line and load; suchproblems can be eliminated by introducing filter at the input.

Motor drives constitute a predominant load for the agricultural sector. As most rural communities in the India are supplied with single-phase ac power, these drives have to be realized with single-phase motors, or with three phase motors (Induction Motors) driven by phase converters. Autotransformer capacitor phase converters and rotary phase converters have been used for several decades.Both have the advantages of simple structure and reasonably low cost. Autotransformer capacitor phase converters, however, cannot easily obtain balanced output voltage with reasonable cost, and rotary converters are heavy and have significant no-load losses, also both topologies have high inrush current during motor startup. The three-phase induction motors have some advantages in the machine efficiency, power factor, and torque ripples compared to their single-phase counterparts The non-ideal character of the input current drawnby these rectifiers creates number of problems like increase in reactive power, high input current harmonics,low input power factor, lower rectifier efficiency, largeinput voltage distortion etc. An induction motor is essentially a constant-speed motor when connected to a constant voltage and constant-frequency power supply. The operating speed is very close to the synchronous speed. If the load torque increases, the speed drops by a very small amount. It is therefore suitable for use in

substantially constant-speed drive systems. Many industrial applications, however, require several speeds or a continuously adjustable range of speeds. Traditionally, dc motors have been used in such adjustable-speed drive systems. However, dc motors are expensive, require frequent maintenance of commutators and brushes, and are prohibitive in hazardous atmospheres. Squirrel-cage induction motors, on the other hand, are cheap, rugged, have no commutators, and are suitable for high-speed applications. The availability of solid-state controllers, although more complex than those used for dc motors, has made it possible to use induction motors in variable-speed drive systems. Here we are using a simple diode rectifier and a thyristor based inverter which will fed and control the speed of three phase induction motor. We are also employing a LC filter which is necessary for reducing the harmonics produced by these converters.

2. IMPLEMENTATION OF PROPOSED TECHNIQUE

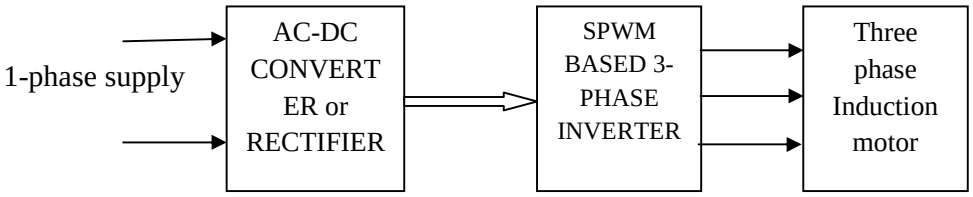


Fig 1: The Block Diagram of Proposed Scheme

In figure 1, the ac-dc converter or rectifier converts the single phase supply into a dc supply which will be then converted into three phase supply by using a three phase inverter whose firing angle will control the output voltage and hence the speed of induction motor.

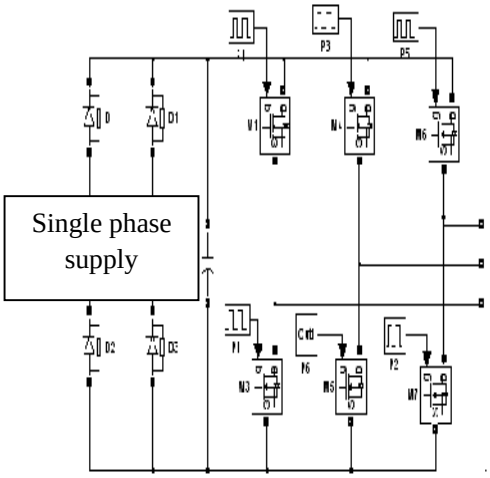


Fig 2: The Schematic Diagram of the Proposed Scheme

It can be observed from shown figure 2 that the drive system consists of a single phase AC supply, single phaseDiode bridge Rectifier, three phase four switch Inverter, three phase Induction Motor and controlled circuits. The standard ACpower supply is converted to a DC by using a single-phase diode bridge rectifier. Then this dc is converted back into three phase

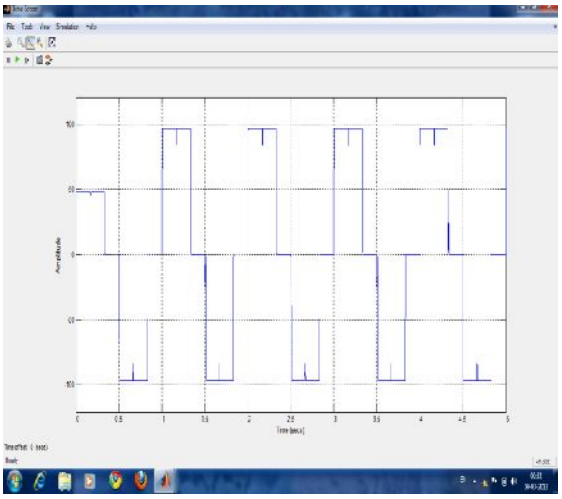
ac by using a three phase inverter especially Voltage Source Inverter(VSI).

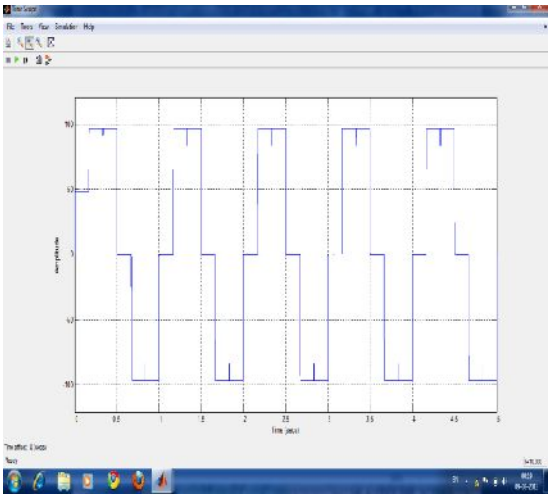
The working of proposed scheme and the output in different modes has been shown in table 1:

Table 1: Output of Voltage Source Inverter (VSI)

S No.	MOSFET	Mode	V_{an}	V_{bn}	V_{cn}
1	6,1	1	+V/2	-V/2	0
2	1,2	2	+V/2	0	-V/2
3	2,3	3	0	+V/2	-V/2
4	3,4	4	-V/2	+V/2	0
5	4,5	5	-V/2	0	+V/2
6	5,6	6	0	-V/2	+V/2

Fig 3(a), (b) and (c) show the response of the output voltages between phase a-b (V_{ab}), b-c (V_{bc}) and c-a (V_{ca}) which is symmetrical.





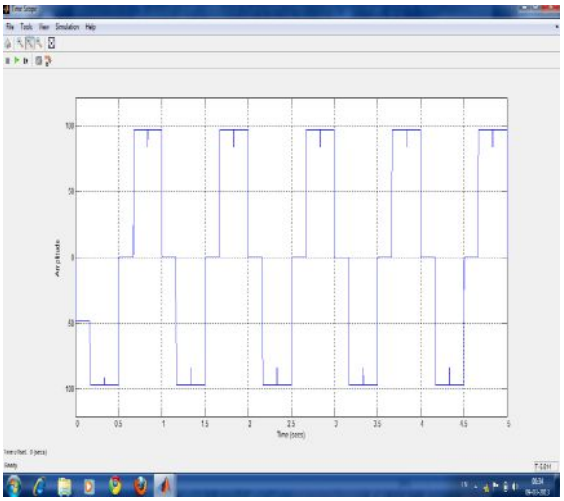


Fig. 3(a): Output Voltage(V_{ab}) Fig. 3(b): Output Voltage(V_{bc}) Fig. 3(c): Output Voltage(V_{ca})

Fig 3: Output Voltages between Phases a, b and c

3. SINUSOIDAL PULSE WIDTH MODULATION (SPWM)

This is a pulse width modulation technique in which a reference sine wave is compared with a high frequency carrier wave and the output pulses are generated. These pulses are further used for firing of the switches used in the inverter. And hence, the output voltage of the inverter is obtained by these switching. The pulses are generated by the rule as:

- $V_c > V_r$ then pulse is 1
- $V_c < V_r$ then pulse is 0

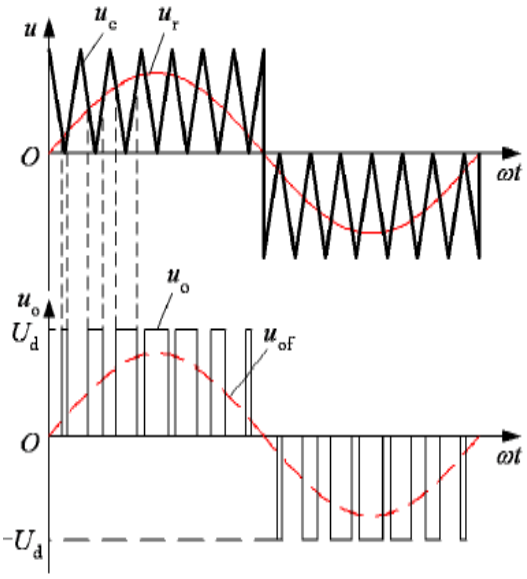


Fig. 4: Generation of Pulses by Comparing Carrier and Reference Wave

4. RESULTS AND DISCUSSIONS

In the present work, an Asynchronous Machine block is used in motor mode. It consists of an asynchronous machine inan open-loop speed control system. The performance of a 5HP three phase induction motor under the proposed scheme was experimentally studied at 400 V under different loads. The machine's rotor is short-circuited, and the stator is fed by a SPWM inverter, built with Simulinkblocks. The inverter uses sinusoidal pulse-width modulation.Use of SPWM control has the advantage of reduction in harmonics in the output voltagewaveform, hence the reduction in heating of motorcompared to the 6-step square wave inverter. The SPWMtechnique also reduces pulsating torque of the motor.Motor line current is nearly sinusoidal in nature, which fully satisfies the design requirement. With the increase ofswitching frequency the motor line current can be made more sinusoidal. At an increased load a small distortion isobserved in the PWM output voltage waveform. Thisdistortion can be filtered out using appropriate filter. The output response at 8 Nm load torque has been shown in figure 4, figure 6 and figure 7.Speed can be seen increasing up to a level of 1500 rpm. After steady state the speed is constant at 1500 rpm. Figure 5 shows the output response of induction motor at 0 Nm. It can be observed that the speed of the motor does not have any significant change. Torque, rotor current and stator current are almost sinusoidal.
SPWM output voltage and current can also be seen are almost sinusoidal.

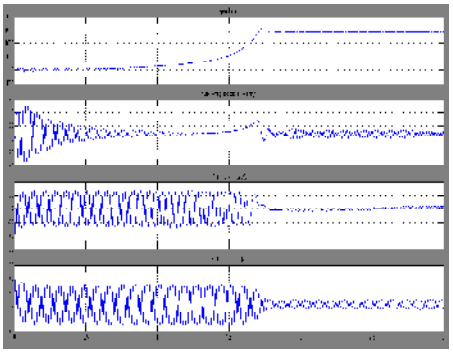


Fig. 5: Response at 8 Nm Load Torque

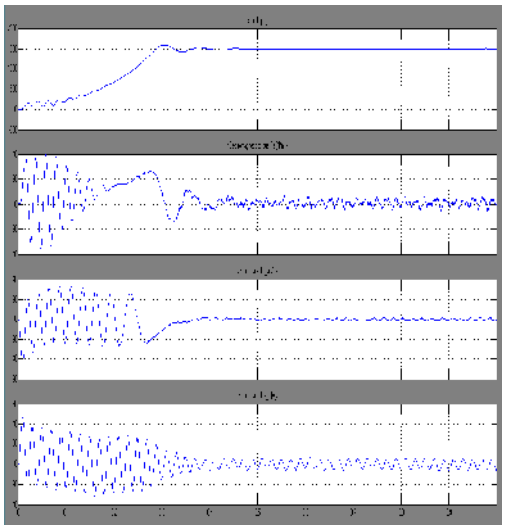


Fig. 6: Response at 0 Nm Load Torque

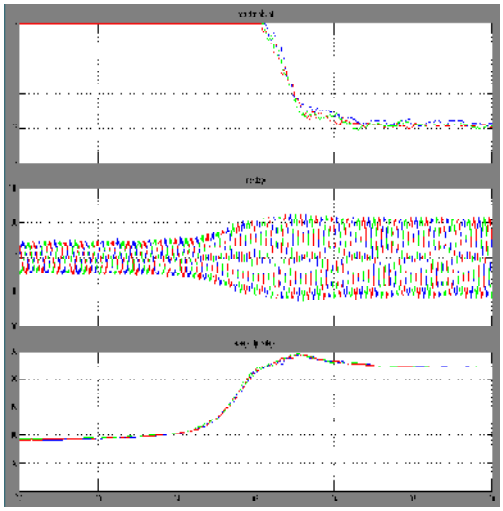


Fig.6: (a) Modulation Index, (b) Motor Input Voltage, (c) Average Output Voltage

Figure 7 shows three phase output voltage and current waveforms. The colored waveforms are the three phases of the output voltage. The output voltage and current can be seen approximately sinusoidal. Due to high leakage inductance of induction motor the higher harmonics are filtered out due to high reactance as the frequency is high. Due to this the current waveform is more sinusoidal in nature than voltage waveform.

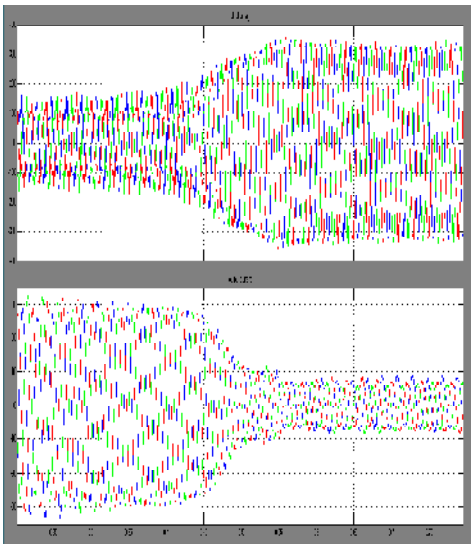


Fig. 7: Three Phase Output Voltage and Current of SPWM Inverter

Any simulation is not complete without checking the harmonic content in the output voltage obtained from the inverter. Hence the THD analyses has been done by using MATLAB Simulink. The THD of the output voltage and current has been shown in figure 8 and 9.The harmonic contents or the THD in output voltage and current are 16.19% and 17.25% respectively.

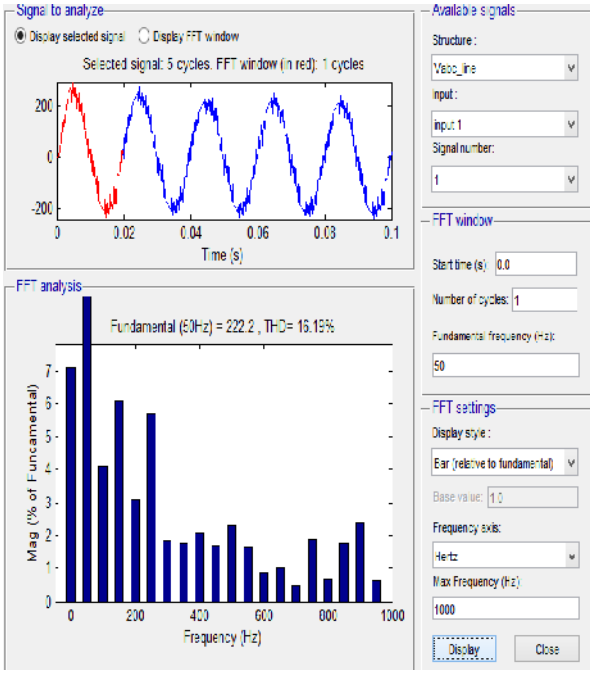


Fig 8: THD in SPWM Inverter Output Voltage

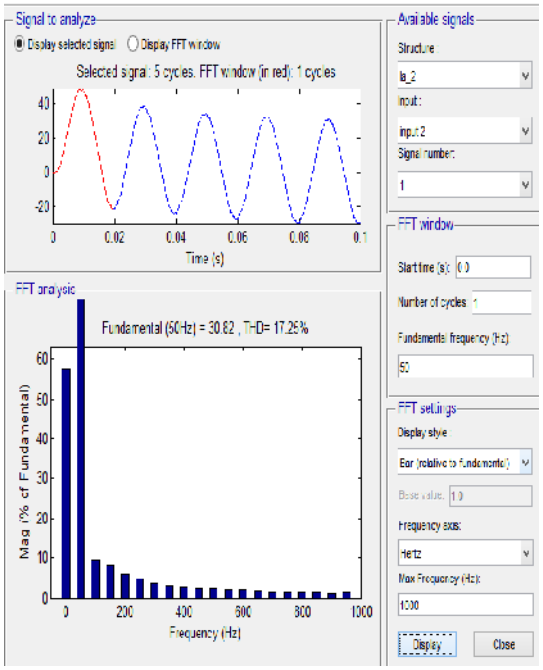


Fig 9: THD in SPWM Inverter Output Current

5. CONCLUSIONS

From the presented work it may be concluded that a three phase induction motor can be run by using single phase supply economically and efficiently. The proposed technique also shows that speed control of the motor can be done within the scheme of phase conversion i.e. it does not require any extra speed controlling component. The SPWM technique may be efficiently implemented for speed control of three phase induction motor.

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