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# Simulation And Implementation of Single Phase to Three Phase Converter

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*Abstract:* **This paper presents a single phase to three phase conversion technique. The purpose is to develop electronic converters suitable to supply consumers in rural or remote areas. In this paper, explain how three phase inductive load is run by a single phase supply by using rectifier, boost converter and three phase inverter. Sinusoidal pulse width modulation technique is used to generate the gate pulses which are used to fire the switches of inverter. Simulation is carried out using SIMULATION SOFTWARE.**

*Keywords:--* **Single-Phase to Three-Phase conversion technique, rectifier, DC-DC converter, three phase inverter.**

## I. INTRODUCTION

In many instances, the cost of supplying three phase service in remote rural areas is prohibitive due to the higher utility tariff and the higher infrastructure cost of three phase extension. Over the last several years the increase in automation in farming techniques and in small rural industries has led to the widespread use of three phase induction motors for fans, pumps, compactors, hammermills, a variety of farming equipment, crop dryers, irrigation and air-conditioners, which requires three phase supply. Due to the unavailability of the three phase supply some provision for single phase to three phase power conversion is necessary to allow the use of these three phase motors supplied with single phase power. In such situations, single phase to three phase converters are an excellent choice, whose cost is often a small fraction of that of a full three phase service. Other factors that influence the choice of a static converter and a three-phase motor combination are listed as follows:

1) Three-phase motors are significantly more efficient and economical than their single-phase counterparts.
2) Starting and inrush currents in a three-phase motor are less severe than in a single-phase motor.

The foregoing discussion emphasizes a strong need for efficient, cost effective, and high-quality single-phase to three phase converters. Presently, available phase converters for such applications are classified into three categories 1) rotary phase converter 2) autotransformer with switched capacitors phase converter and 3)static phase converter.

Rotary phase converters and autotransformer with switched capacitors phase converters have been used for several decades. Both have the advantages of simple structure and reasonably low cost. Autotransformer with capacitor phase converter, however,cannot easily obtain balanced output voltage with reasonable cost and rotary converters are heavy and have significant no-load losses,also both categories have high inrush current during motor startup.

Static phase converters are therefore an excellent choice and have been recently developed with varying performance and circuit complexities**.** Further, the wide spread availability of higher power semiconductor devices and their control logic make the static converters more suitable for single phase to three phase power conversionis the subject of this paper.

This paper, therefore, presents a new single phase to three phase converter topology to generate high quality fixed frequency and fixed voltage balanced three phase output using bridge rectifier, dc-dc converter and three phase inverter. Sinusoidal pulse width modulation technique is used to generate the gate pulses which are used to fire the switches of inverter. Selection of suitable PWM strategy has been explained in order to maintain balanced aswell as high quality output voltage. Analysis and simulation results illustrate the superiority of the proposed topologies.

 

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## II. IMPLEMENTATION OF PROPOSED TECHNIQUE

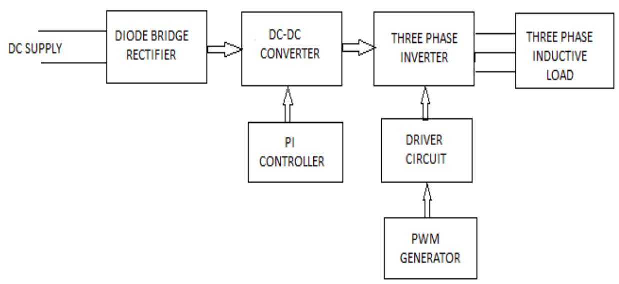


***Figure 1. The block Diagram of proposed scheme***

In figure1 **.** The single phase bridge rectifier converts the single phase supply into a dc. It is boosted to the required value using the dc -dc converter or bulk boost converter. DC is converted to AC using three phase voltage source inverter(VSI). The output of PWM inverter is fed to the three phase inductive load.

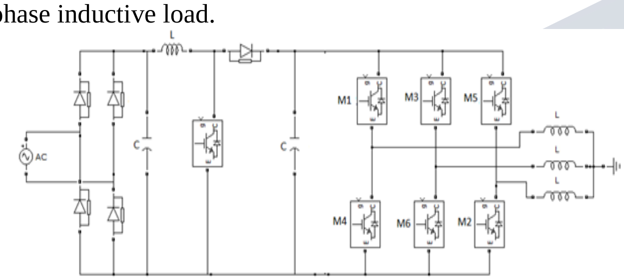


***Fig2. Circuit diagram of proposed scheme***

The circuit model of single phase rectifier with boost converter and three-phase inverter system is shown in Figure 2. The output is connected to three phase inductive load. The power devices are assumed to be ideal, when they are conducting, the voltage across them is zero, they present an open circuit in their blocking mode. The phase voltages are derived from the line voltages in the following manner by assuming a balanced three-phase system .

The line voltages in terms of the phase voltages in a three-phase system with phase sequence abc are

$$V_{ab} = V_{as} - V_{bs} \text{---------------(1)}$$

$$V_{bc} = V_{bs} - V_{cs} \text{---------------(2)}$$

$$V_{ca} = V_{cs} - V_{as} \text{----------------(3)}$$

where $V_{ab}$, $V_{bc}$, and $V_{ca}$ are the various line voltages and $V_{as}$, $V_{bs}$, and $V_{cs}$ are the phase voltages.

Subtracting equation (3) from equation (1) gives

$$V_{ab} - V_{ca} = 2V_{as} - (V_{bs} + V_{cs}) \text{---------(4)}$$

In a balanced three-phase system, the sum of the three phase voltages is zero

$$V_{as} + V_{bs} + V_{cs} = 0 \text{-------------(5)}$$

Using equation (5) in (4) shows that the difference between line voltages Vab and $V_{ca}$ is

$$V_{ab} - V_{ca} = 3V_{as} \text{---------------(6)}$$

from which the phase a voltage is given by

$$V_{as} = \frac{Vab - Vca}{3} \text{---------------(7)}$$

Similarly, the b and c phase voltage are

$$V_{bs} = \frac{Vbc - Vab}{3} \text{-----------------(8)}$$

$$V_{cs} = \frac{Vca - Vbc}{3} \text{----------------(9)}$$

The phase voltages derived from line voltages and the line-to-line voltages are 120 electrical degrees in duration, the phase voltages are six-stepped and of quasi-sine waveforms. These periodic voltage waveforms, when resolved into Fourier components, have the following form

$$V_{ab}(t) = \frac{2\sqrt{3}}{\pi} Vdc\ (\sin w_s t - \frac{1}{5}\sin 5w_s t + \frac{1}{7}\sin 7w_s t)$$

$$V_{bc}(t) = \frac{2\sqrt{3}}{\pi} Vdc\ \{\sin(w_s t - 120) - \frac{1}{5}\sin(5w_s t - 120) + \frac{1}{7}\sin(7w_s t - 120)\}$$

$$V_{bc}(t) = \frac{2\sqrt{3}}{\pi} Vdc\ \{\sin(w_s t - 240) - \frac{1}{5}\sin(5w_s t - 240) + \frac{1}{7}\sin(7w_s t - 240)\}$$

The phase voltages are shifted from the line voltages by 30 degrees, and their magnitudes are $V_{dc}$. Only the fundamental produces useful torque, and hence only it needs

 

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to be considered for the steady-state performance evaluation of inverter-fed inductive load. In this regard, the fundamental rms phase voltage for the six-stepped waveform is

$$V_{ph}=\frac{Vas}{\sqrt{2}}=\frac{2}{\pi}\frac{Vdc}{\sqrt{2}}=0.045V_{dc}$$

***Principle of operation of dc-dc converter***

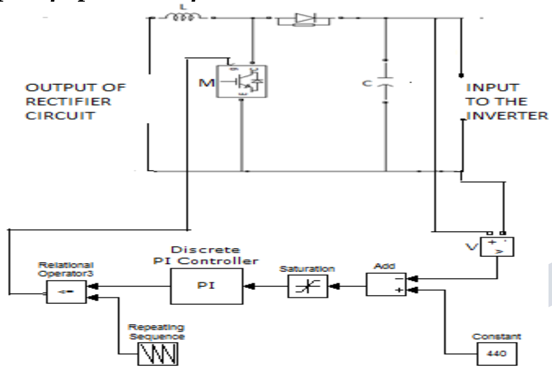


***Figure3.Circuit diagram of dc-dc converter***

The operating principle of dc-dc converter is that when switch M is ON in that time inductor stores some energy. When the switch is OFF that time, the storage energy of inductor and output voltage of rectifier circuit combine with and go to the inverter circuit.

The switch M is controlled by PI controller. PI controller to improve the performance of this converter. Therefore, the value of $K_p$ and $K_i$ can be found by Ziegler-Nichols method which is $K_p$ = 0.5 and $K_i$= 1

***Principle of operation of three phase inverter***

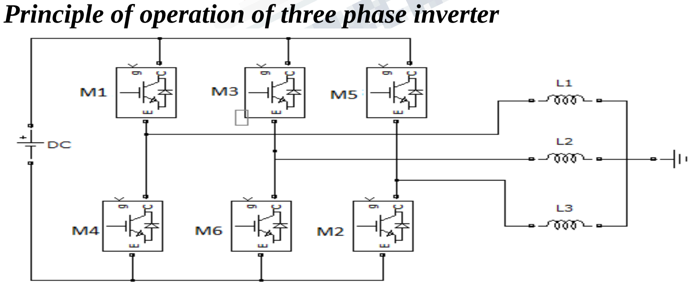


***Figure4:The circuit diagram of inverter fed three phase inductive load***

The power circuit diagram of inverter fed three phase inductive load is shown in figure 4.The inverter has six switches namely, M1,M2,M3,M4,M5,M6. The switches are controlled in order to generate an AC output from the DC input. The switching pattern of three phase inverter is shown in table 1.

***Table-1: Switching pattern for 120° mode three phase Voltage Source Inverter***

| Angle | ON Switches | OFF Switches | Vas | Vbs | Vcs |
|---|---|---|---|---|---|
| $0^0$-$60^0$ | M1 M6 | M2 M3 M4 M5 | $+\frac{V}{2}$ | $-\frac{V}{2}$ | 0 |
| $60^0$-$120^0$ | M1 M2 | M3 M4 M5 M6 | $+\frac{V}{2}$ | 0 | $-\frac{V}{2}$ |
| $120^0$-$180^0$ | M2 M3 | M1 M4 M5 M6 | 0 | $+\frac{V}{2}$ | $-\frac{V}{2}$ |
| $180^0$-$240^0$ | M3 M4 | M1 M2 M5 M6 | $\frac{V}{2}$ | $+\frac{V}{2}$ | 0 |
| $240^0$-$300^0$ | M4 M5 | M1 M2 M3 M6 | $\frac{V}{2}$ | 0 | $+\frac{V}{2}$ |
| $300^0$-$360^0$ | M5 M6 | M1 M2 M3 M4 | 0 | $-\frac{V}{2}$ | $+\frac{V}{2}$ |

## III. SIMULATION AND RESULT

The simulation model has been developed to convert single phase to three phase by using Simulation software. Fig. 5 shows the PWM generation block. The PWM block provides the required PWM pulses for the 6-switches of Inverter. Fig. 6 shows the complete simulation circuit diagram of the system. The 3-phase output voltage is shown in Fig. 7. A balanced 3-phase output current is shown in Fig.8

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 harmonic contents or the THD in output voltage and current are 0.26 and 0.17respectively.

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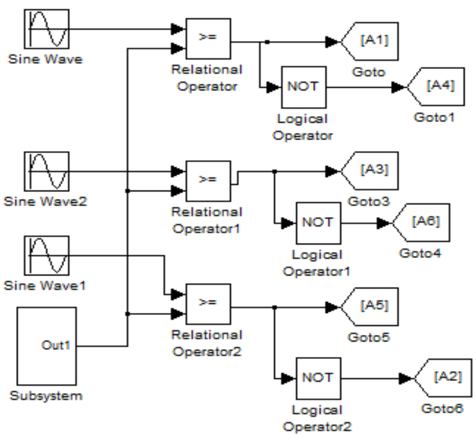


*Figure. 5 The PWM generation block.*

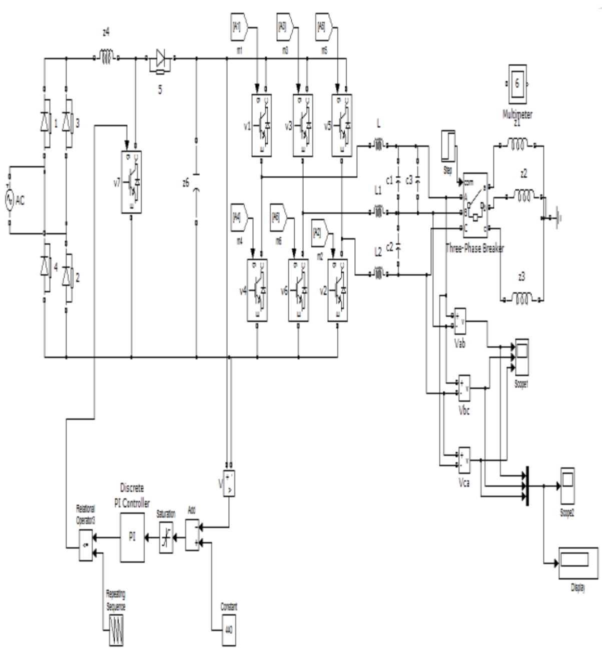


*Figure 6.The complete simulation model*

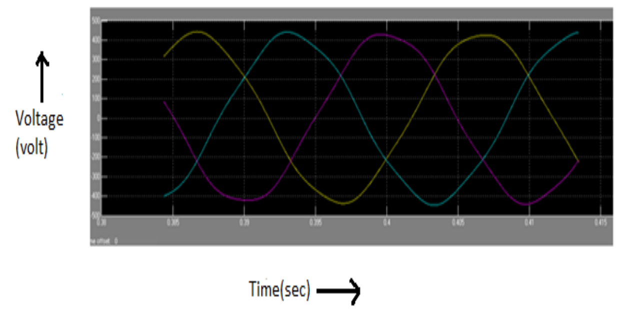


*Figure 7.Output phase voltage waveform*

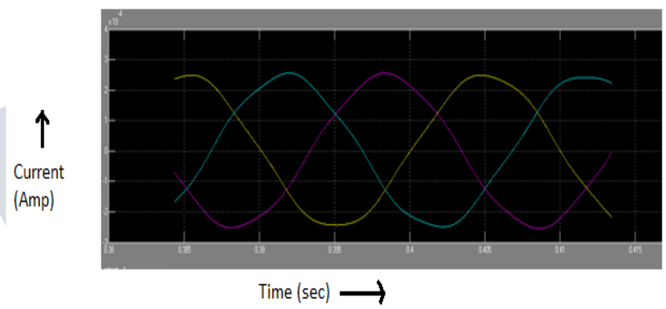


*Figure 8. Output current waveform*

## IV. CONCLUSION

A significant amount of the world's population lives in rural and remote areas of developing countries. The procedures to implement electric utility systems in these localities have still been full of challenges. Very often these areas are less densely populated, and sometimes too poor to afford energy systems. Due to the need for three phase electricity in today's remote areas for agriculture work where three phase power is not available easily, in those areas these single phase to three phase converters are useful.

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