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Modeling and Simulation of Single Phase to Three Phase Cycloconverter for Low Cost AC Motor Drives

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Abstract:
This paper presents Matlab modeling and simulation of Single phase to three phases Cycloconverter for driving three phase induction motor and analysis of torque for various frequencies. The proposed converter employs only six naturally communicated thyristor, so the resulting Cycloconverter-motor drive system is cheap and compact, however this single phase to three phase modulation strategy is proposed on the basis of variable frequency technique.

Key words: *Thyristor,Induction motor, Matlab/Simulation*

1. Introduction

The three-phase induction motors have some advantages in the machine efficiency, power factor, and torque ripples compared to their single-phase counterparts. Therefore, it is desirable to replace the single-phase induction motor drives by the three-phase induction motor drives in some low-power industrial applications. However, in some rural areas where only a single-phase utility is available, we should convert a single-phase to a three-phase supply. As we know that the rating of the machine increase with the increase in number of phase .eg.output of three phase motor is 1.5 times the output of a single phase motor of same size.

The conventional method for conversion of a single phase to three phase voltage is the utilization of rotator, capacitor or autotransformer converters. Most of these converters remain balanced only at one specified load. There are also many converter topologies that can transform a single phase AC Voltage into variable into variable voltage, variable frequency three phase voltage supply. In this paper a A new simple single-phase to three-phase Cycloconverter based on discrete variable frequency technique is proposed The configuration, shown is Fig.1, only consists of six thyristors, and its output frequency can be up to 25Hz. The discrete variable frequency modulation strategy is explained in sections II. Simulation based on Matlab/Simulink is given in sections III.

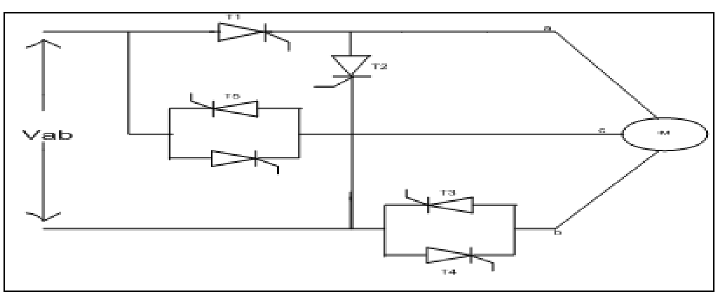

Figure 1

2. Control Scheme

Under the control of power Supply frequency, reducing frequency will improve the electromagnetic torque of induction at starting. Through controlling the triggering angle of thyristors, discreet variable frequency voltage and current can be obtained. Furthermore, these discreet variable frequencies are the sub-harmonic of the ac power supply frequency, which is obtained by triggering the thyristor so as to include or omit partial half cycle of the power supply voltage. This can be illustrated in the following figure.

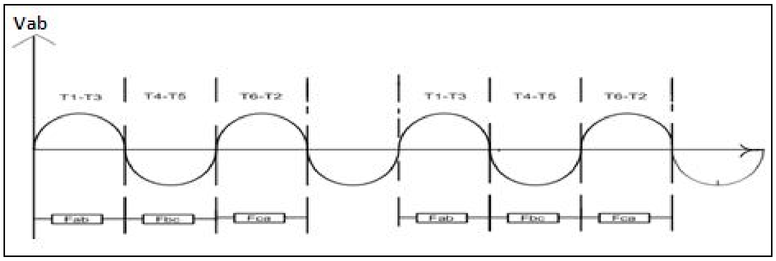

Figure 2

The above fig2. Shows the corresponding switching sequence with respect to input voltage Vab.

- T1-T3 are fired at t1.then current Iab is obtained, as a result Iab produces the mmf vector Fab
- Similarly T4-T5 and T2-T6 are fired at t2, t3 respectively, then mmf vector Fbc, Fca are formed by Ibc, Ica.

On the basis of the above scheme following are the resultant frequency as seen in fig3 and fig4.however by controlling the firing angle of the thyristor we are obtaining 25 Hz and 12.5 Hz frequency as seen in following fig.

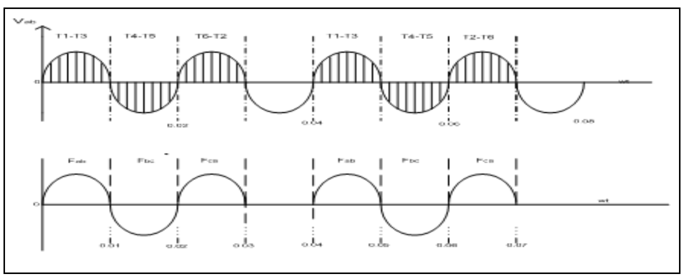

Figure 3

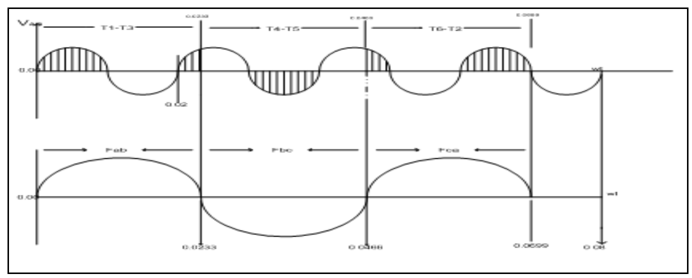

Figure 4

The figure3 and Figure4 show the partial half cycles used for generation of 25Hz and 12.5Hz, assuming the power supply frequency is 50Hz. The wave profile under new frequency is not sinusoidal. In effect, the meaning of new frequency implies the one of fundamental component of the generated voltage. Some other discrete frequencies generated from a50Hz power supply are 10Hz, 16.67Hz, 6.25Hz, 4.55Hzand 3.57Hz.

3. Simulation

In order to investigate the proposed single-phase to three-phase Cycloconverter and the discrete variable frequency modulation strategy, simulations were performed using SIMULINK with post processing of data in Matlab

The simulation has been carried out with a 400V, 50Hz single-phase supply. The motor selected for the test is an industrial 1430 rev/min, 400V, 50Hz star connected four-pole three phase motor. The stator resistance $r_s = 1.405\Omega$. The stator inductance is $L_{ls} = 0.005839H$. The rotor inductance referred to stator side is $r'_r = 1.395\Omega$. The mutual inductance is $L_m = 15.1mH$. This is a precondition for satisfactory performance of the three-phase motor.

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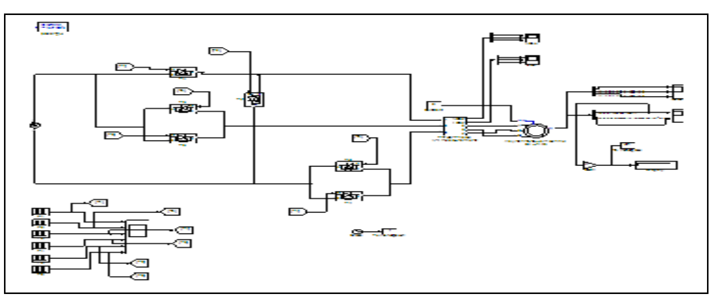

Figure 5: Simulink model for 25 Hz frequency

3.1. Simulation Results for Freq.25hz

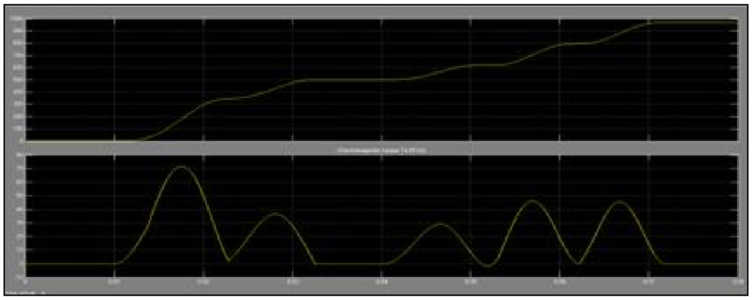

Figure 6: Rotor Speed and Electromagnetic torque

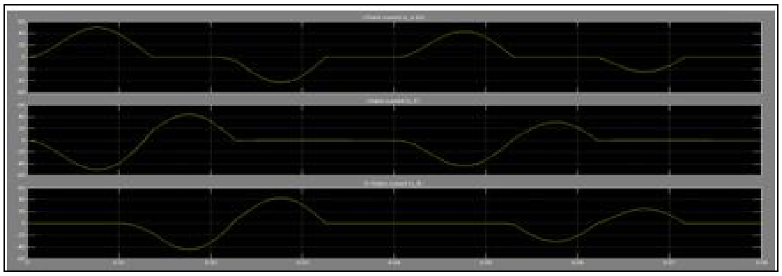

Figure 7: Three phase stator current

3.2. Simulation Results for Frequency 12.5 Hz

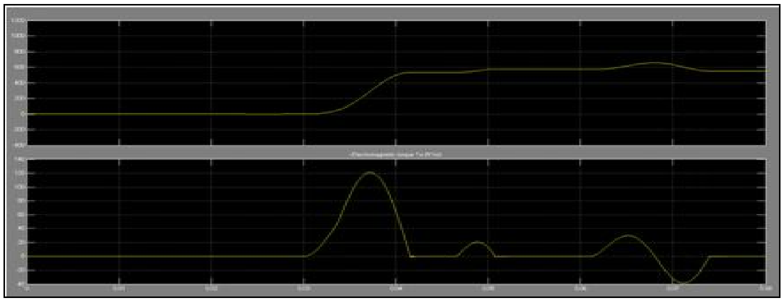

Figure 8: Rotor Speed and Electromagnetic torque

4. Conclusion and Future Scope

This paper has proposed a new single-phase to three-phase Cycloconverter for a three-phase induction motor drive fed from a single-phase supply. The configuration consisting of six thyristor is simple and compact. The main Advantages of the topology include:

- The thyristor can sustain high inrush currents for a short time, the rating of the drive may not need to be upgraded for higher starting torque requirement.
- There must be two thyristor fired at any time.
- This system is easy to implement in a small size for lacking of energy storage element.
- New discrete variable frequency control strategy is applied to improve electromagnetic torque at starting and its output frequency can be up to half of the input frequency. Simulation results show the good performance of the Cycloconverter and induction motor.

5. References

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