

Speed Control of Induction Motor using Cycloconverter

B. SAI SINDURA ^{#1}, B. N . KARTHEEK ^{*2},

[#]Department of Electrical and Electronics Engineering, K L University
Vaddeswaram, Guntur, AP, India

^{*}Asst Professor
Department of Electrical and Electronics Engineering, K L University
Vaddeswaram, Guntur, AP, India

Abstract— This method is used to control the speed of the induction motor .The speed control by this method is simple and can be made economical by using different methods to control the operation of cycloconverter which in turn controls the performance of motor. The formula for speed for induction motor is $N_s=120f/p$. from this formula we can conclude that the speed of the motor can be varied in two ways, one is by changing the number of poles and the second method is by changing the frequency. The speed control through the first method is uneconomical and the number of poles can't be varied under running conditions and the size of the machine also becomes bulky. These problems can be overcome by the second method. In this method the frequency can be varied under running conditions also and there is no change in the size of the motor. In this method the frequency changing device is cycloconverter. A cycloconverter is a power electronic device used to convert constant voltage constant Frequency AC power to adjustable voltage adjustable frequency AC power without a DC link. In among all the methods this method is simple, reliable and economical. The various speed of induction motor is obtained by varying the supply frequency by using cycloconverter.

Keywords- Cycloconverter, Split Phase Induction Motor

I. INTRODUCTION

Speed control of induction motor is necessary in industrial applications. There are several methods for the speed control of induction motor. Cyclo-converters are used in very large variable frequency drives with ratings from few megawatts up to many tens of megawatts. A cycloconverter is controlled through the timing of its firing pulses, so that it produces an alternating output voltage. It can also be considered as a static frequency changer and typically contains silicon-controlled rectifiers. The development of the

semiconductor devices has made it possible to control the frequency of the cycloconverter according to the requirement and deliver a large amount of controlled power with the help of semiconductor switching devices like Thyristors, MOSFET's in order to get alternating output of variable frequency. The quality of the output waveform improves if more switching devices are used. Split-phase induction motors are widely used in many applications due to their energy efficient characteristics. Improvements in its performance mean a great saving in electrical energy consumption. Thus, a cycloconverter has the facility for continuous and independent control over both its output frequency and voltage. Cycloconverter eliminates the use of flywheel because the presence of flywheel in machine increases torsional vibration and fatigue in the component of power transmission system.

II. SINGLE- PHASE TO SINGLE-PHASE CYCLO-CONVERTER

The single-phase to single-phase cycloconverter with mid-tap transformer type converter is shown in Fig.1.

As shown in fig.1. in this type of arrangement midpoint tap transformer is use to obtain variable voltage and variable frequency. Waveforms shown are obtained by varying the number of cycle covered by positive and the negative converters and firing angle.

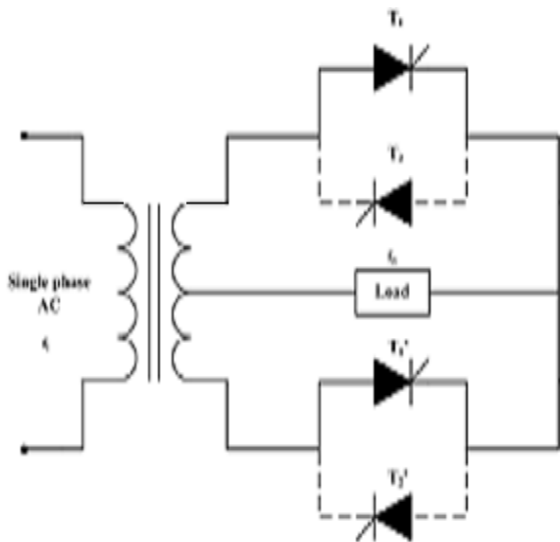


Fig.1 Single Phase Mid-tap Transformer Type Cycloconverter

III. WORKING

The frequency can be varied by varying the conduction period for each mosfet. The gate pulse for SCR can be provided by either by using firing circuit. Here for positive half cycle of input or supply. T1, T2' are forward biased, T1 is given pulse. For negative half cycle of input or supply T1', T2 are forward biased. T1' is given pulse. For another positive half cycle T2' is given pulse. For another negative half cycle T2 is given pulse. By using cycloconverters we can vary voltage and frequency. As AC motor characteristics require the applied voltage to be proportionally adjusted whenever the frequency is changed in order to deliver the rated torque this method is also called volts/hertz.. For optimum performance, some further voltage adjustment may be necessary especially at low speeds, but constant volts per hertz are the general rule. This ratio can be changed in order to change the torque delivered by the motor.

The input voltage, V_s is an ac voltage at a frequency, f_i , as shown in Fig.2 (A). All the thyristors are fired at $\alpha=0^\circ$ firing angle, i.e. thyristors act like diodes. Note that the firing angles are named as α_p for the positive converter and α_n for the negative converter. The frequency of V_o can

be changed by varying the number of cycles the positive and the negative converters work. It can only change as integer multiples of input frequency in Single Phase to Single Phase Cycloconverter. For example, to obtain the input frequency four times the output frequency as shown in fig.2 (B) fired positive group and negative group converter alternately.

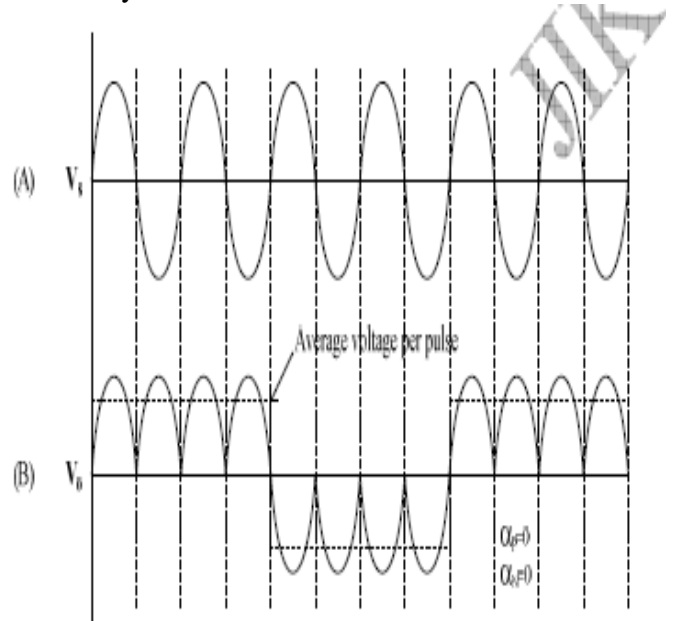


Fig.2 (A) Input Voltage Waveform of Single Phase to Single Phase Cycloconverter

Fig.2 (B) Output Voltage Waveform for Zero Firing Angle of Single Phase to Single Phase Cycloconverter (Input Frequency is Four Times Output Frequency)

IV: MODELING OF SPLIT PHASE INDUCTION MOTOR

Split phase induction motors are usually constructed with two windings on the stator side and squirrel cage winding in the rotor side. The auxiliary winding is used to produce a rotating field to start the motor. The axis of the auxiliary winding is placed 90° electrical ahead of the main winding as shown in Fig.3. The simulation of the motor is presented in the stationary d-q frame to facilitate the application of the inverter. Since the axis of the main and auxiliary windings are already orthogonal, the stationary d-q axes are chosen aligned with the

orthogonal axes of the physical windings. The squirrel cage rotor is represented by equivalent two coils transformed to the stationary d-q axis as shown in Fig.3.

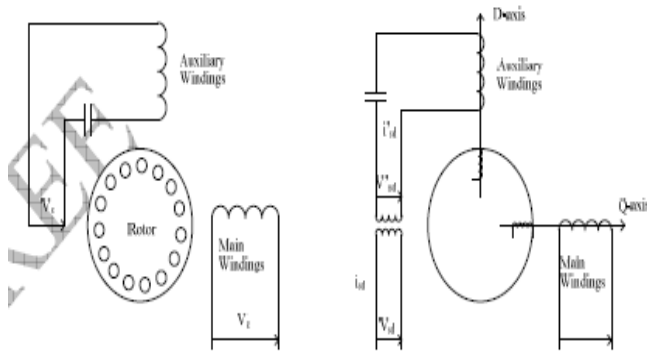


Fig.3 Modeling of Split Phase Induction Motor

Stator windings covers two windings namely the main and auxiliary coils have different number of turns and different mutual reactance. Therefore, a transformation is made to transfer the auxiliary winding to an equivalent winding with the same number of turns as that of the main coil. The new variables referred to the equivalent coil are given as follows:-

$$\begin{aligned}\psi_{s\alpha} &= L_{s\alpha}i_{s\alpha} + L_{m\alpha}i_{r\alpha} \\ \psi_{s\beta} &= L_{s\beta}i_{s\beta} + L_{m\beta}i_{r\beta} \\ \psi_{r\alpha} &= L_{m\alpha}i_{s\alpha} + L_{r\alpha}i_{r\alpha} \\ \psi_{r\beta} &= L_{m\beta}i_{s\beta} + L_{r\beta}i_{r\beta}\end{aligned}$$

The current equation of the motor can be written in the d-q stationary frame as follows:

$$i_{s\alpha} = \frac{L_{r\alpha}\psi_{s\alpha} - L_{m\alpha}\psi_{r\alpha}}{L_{s\alpha}L_{r\alpha} - L_{m\alpha}^2}$$

$$i_{s\beta} = \frac{L_{r\beta}\psi_{s\beta} - L_{m\beta}\psi_{r\beta}}{L_{s\beta}L_{r\beta} - L_{m\beta}^2}$$

$$i_{r\alpha} = \frac{L_{s\alpha}\psi_{r\alpha} - L_{m\alpha}\psi_{s\alpha}}{L_{s\alpha}L_{r\alpha} - L_{m\alpha}^2}$$

$$i_{r\beta} = \frac{L_{s\beta}\psi_{r\beta} - L_{m\beta}\psi_{s\beta}}{L_{s\beta}L_{r\beta} - L_{m\beta}^2}$$

The equations of motion are given by:

$$T_e = P_p(L_{m\beta}i_{s\beta}i_{r\alpha} - L_{m\alpha}i_{s\alpha}i_{r\beta})$$

$$J \frac{d}{dt} \omega_r = T_e - T_L$$

Where;

$\psi_{s\alpha}, \psi_{s\beta}, \psi_{r\alpha}, \psi_{r\beta}$ are the d-q stator and rotor flux linkage, respectively, $i_{s\alpha}, i_{s\beta}, i_{r\alpha}, i_{r\beta}$ are the stator and rotor currents, $L_{s\alpha}, L_{s\beta}, L_{r\alpha}, L_{r\beta}$ are the stator and rotor inductances, $L_{m\alpha}, L_{m\beta}$ are the magnetizing inductances,

ω_r =Rotor speed, electric rad/sec,

T_e =Developed torque,

T_L =Load torque,

J =Rotor moment of inertia,

V: SIMULATION RESULT

Simulink model of split phase induction motor and single phase to single phase cycloconverter is shown in Fig.3. The objective of this paper is to analyse the speed of induction motor performance. The stator of a split phase induction motor has two windings, the main winding and

auxiliary winding. Since, the d-q axis model of an induction motor is only valid for sinusoidal input voltage. Fig4 and Fig5 shows output phase voltages and currents for input frequency is 2 times the output frequency of the single-phase Cycloconverter.

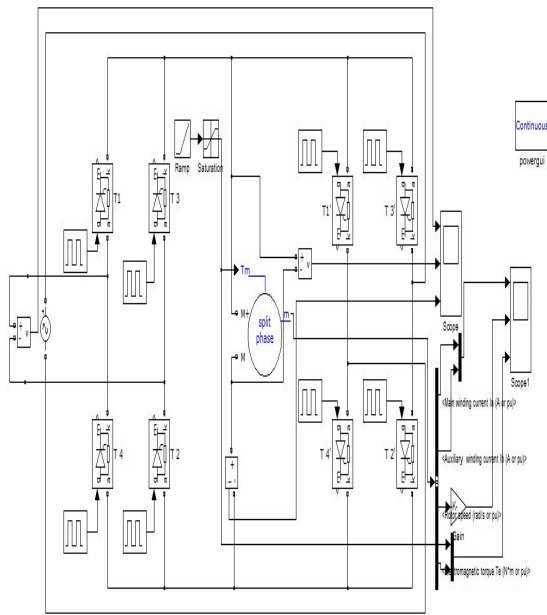


Fig.3. Cycloconverter Fed Split Phase Induction Motor

Fig.4 (a) Source Voltage (b) Output Voltage (c) Output current Waveform of Single Phase to Single Phase Cycloconverter When Input Frequency is Two Times Output Frequency.

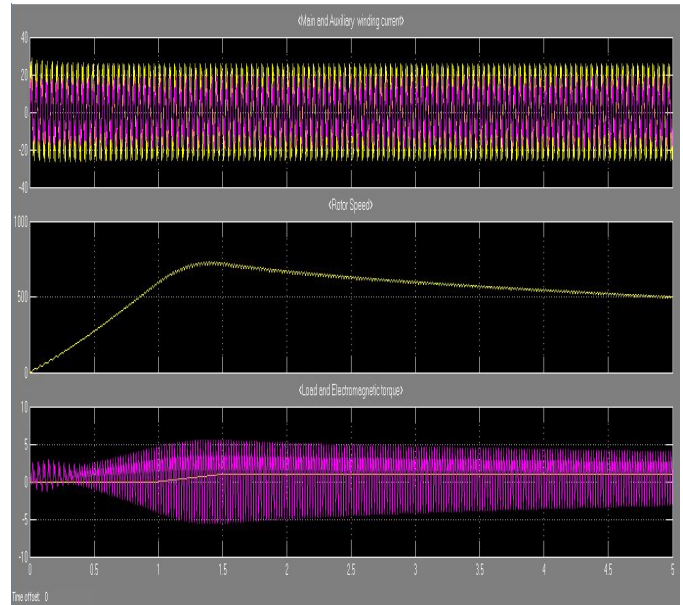


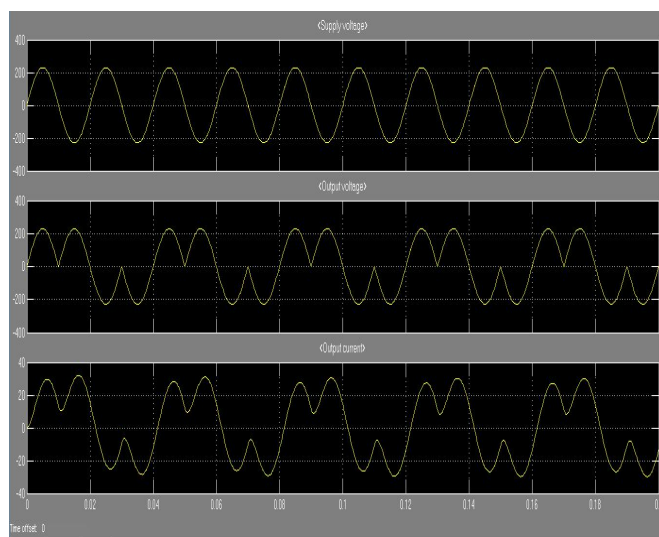
Fig.5 (a) Main winding and auxiliary winding current (b) Rotor Speed (c) Load and Electromagnetic Torque Waveform of Single Phase Induction Motor, When Input Frequency to the Cycloconverter is Two Times Output Frequency

VI: CONCLUSION

From this work and result analysis, it is observed that speed of an induction motor can be efficiently controlled by using Cycloconverter. The role of Cycloconverter in speed control of induction motor is to vary the supply frequency which in turn, changes the speed of motor. In the present work, the Simulation of speed control of motor at different frequencies by using Cycloconverter is simulated and waveforms are discussed.

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