

## **Simulation of Step-down Cycloconverter For Speed Control of Single Phase Induction Motor**

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**Abstract**— This paper describes new techniques for controlling naturally commutated, circulating current free cycloconverter when used to drive induction motors. Simulation of step-down cycloconverter for speed control of split phase capacitor start induction motor is shown in this paper. The cycloconverter is device that converts ac supply of one frequency into ac supply of different frequency without any dc stage in between. It can be also consider as a static frequency changer and typically contains silicon-controlled rectifiers. A.C. motors have the great advantages of being relatively inexpensive and very reliable. Induction motors in particular are very robust and therefore used in many domestic appliances such as washing machines, vacuum cleaners, water pumps, and used in industries as well. The induction motor is known as a constant-speed machine, the difficulty of varying its speed by a cost effective device is one of its main disadvantages. As the AC supply frequency cannot be changed, so the use of a thyristor controlled cycloconverter which enables the control of speed in steps for an induction motor is solution for this problem.

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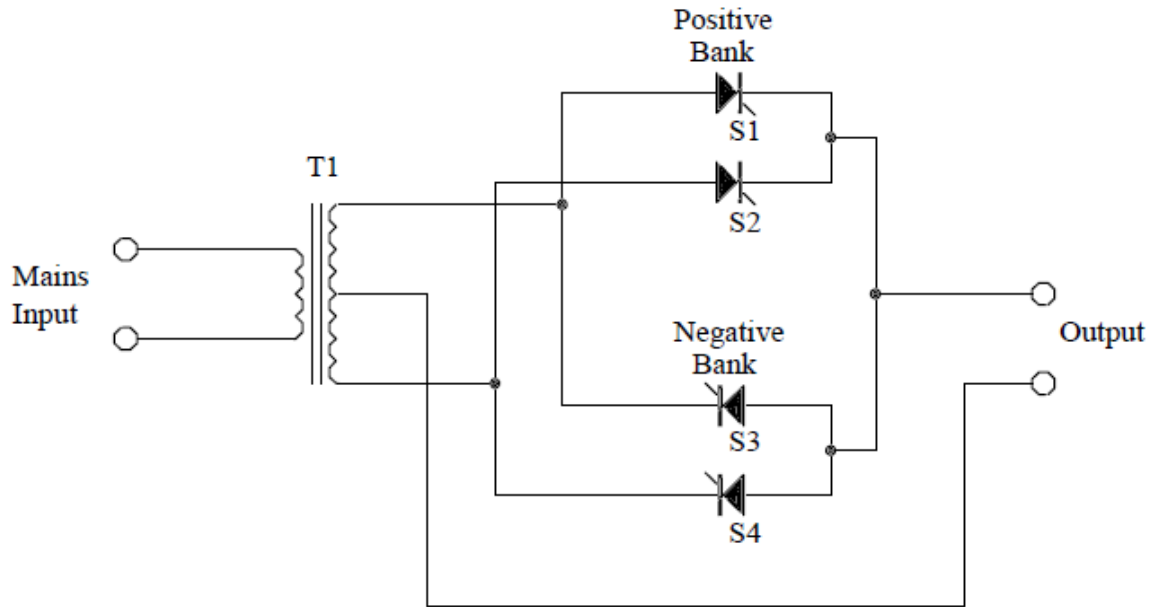
**Keywords** - Speed control, induction motor, cycloconverter, Simulink, Split phase, MATLAB.

### **I. INTRODUCTION**

In this paper cycloconverter is introduced as a type of power controller, where an alternating voltage at supply frequency is converted directly to an alternating voltage at load frequency (normally lower), without any intermediate dc stage. These new approaches need a simple method of control for ac motors [1]. Control of ac motors become very popular because it is possible to obtain the characteristics of dc motors by improving control techniques. Initially, the basic principle of operation used in a cycloconverter is discussed. Then the circuit of a single phase to single cycloconverter of a single-phase to using thyristors is presented [2]. This is followed by describing the operation of the cycloconverter circuit, along with waveform.

### **II. BLOCK DIAGRAM OF PROPOSED SCHEME**

Figure 1 shows a basic schematic block diagram of the proposed scheme. The circuit of a single phase input to single phase output cycloconverter is shown in Figure 1. It is perhaps the simplest type of cycloconverter and will be used in this thesis as the basis for the investigations into the operation of the cycloconverter and for developing techniques for improving its performance.

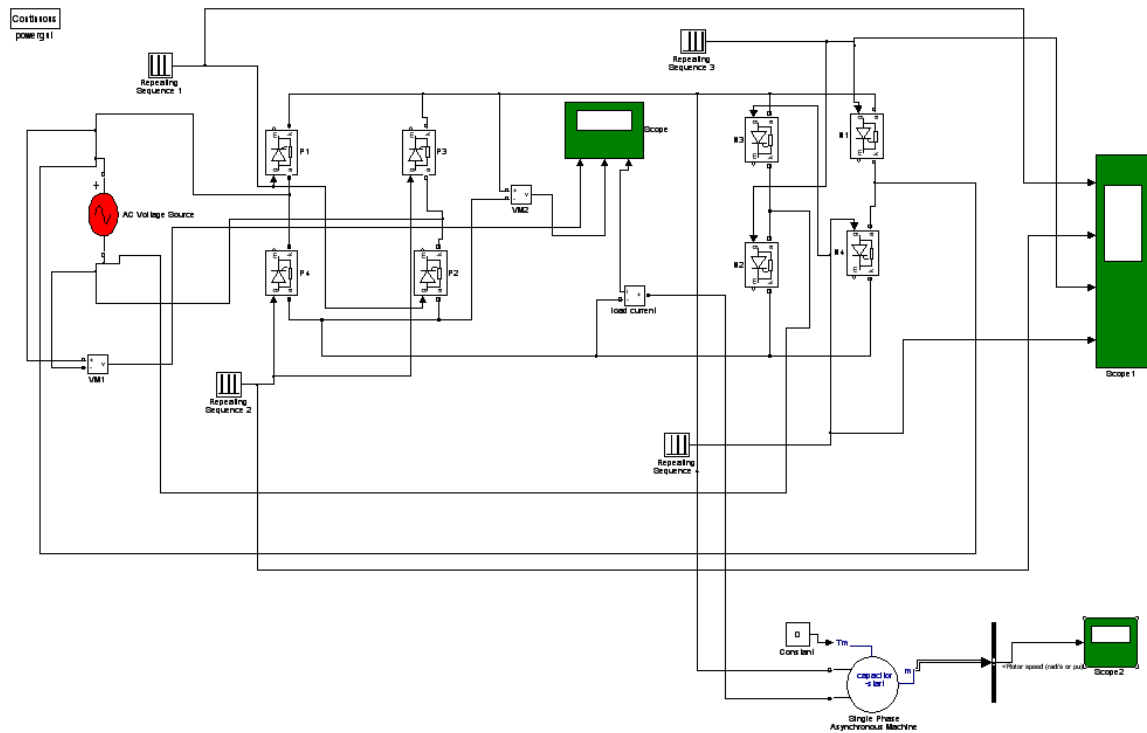


**Figure 1** Circuit diagram of cycloconverter

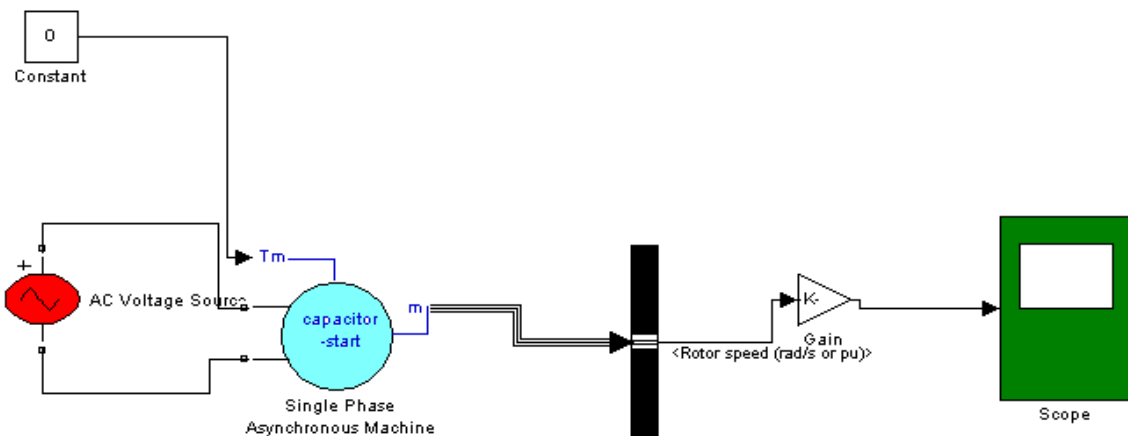
The cycloconverter has been traditionally used only in very high power drives, usually above one megawatt, where no other type of drive can be used. Examples are cement tube mill drives above 5 MW [3,4], the 13 MW German-Dutch wind tunnel fan drive [5], reversible rolling mill drives [6,9] and ship propulsion drives [7,8]

### **III. SIMULATION OF OPEN LOOP CYCLOCONVERTER**

SIMULINK model of single phase to single phase cycloconverter and single phase induction motor is shown in Fig 4 and 5, respectively. The objective of this work is to analyse the speed of single phase induction motor performance for various output frequency of the 1-phase cycloconverter [7].

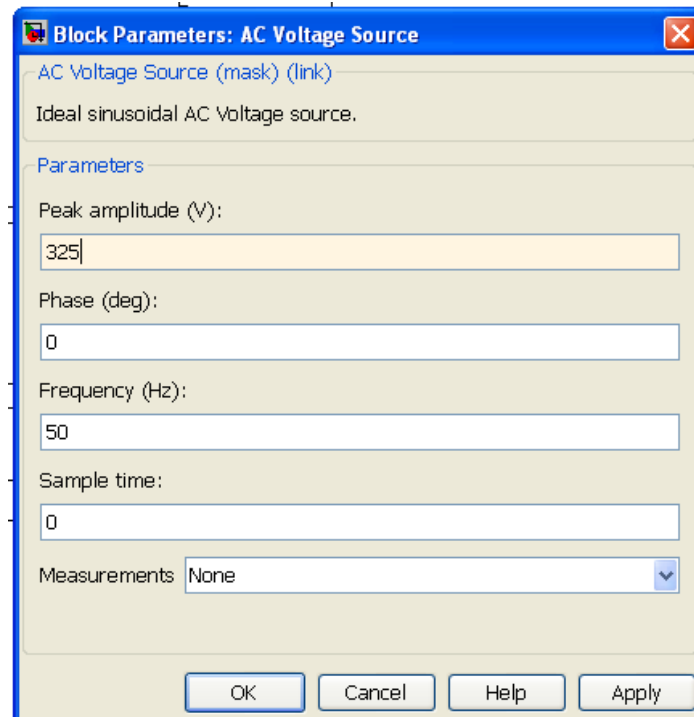


**Figure 2 MATLAB model of open loop cycloconverter**

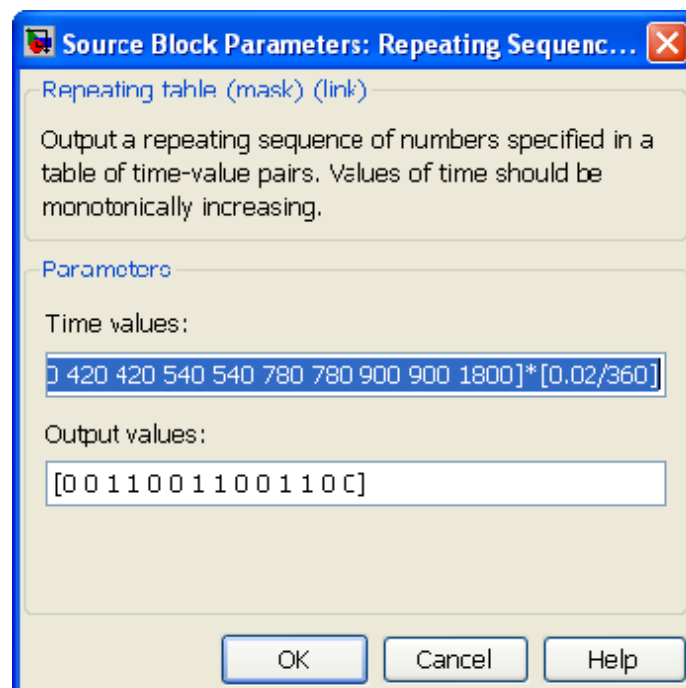


**Figure 3 SIMULINK model of a Single phase Induction motor model (capacitor start)**

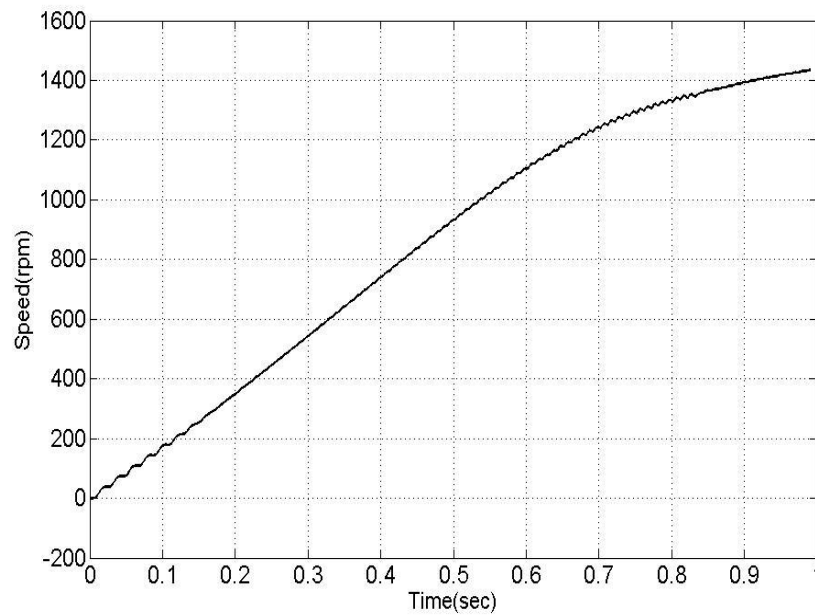
Figure 3 shows the output voltage & current for variable input voltage. The same result along with the values of different parameter is tabulated in table 2.



**Figure 4 Block parameters of AC voltage source**

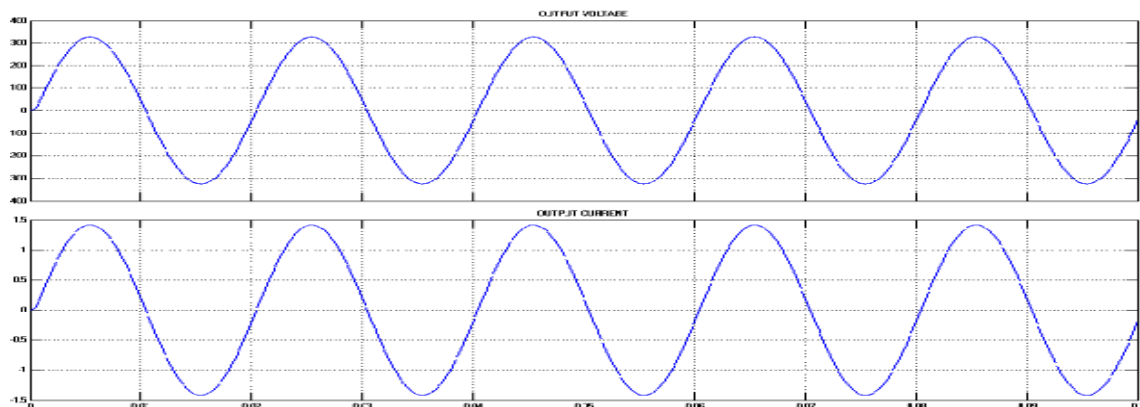


**Figure 5 Block parameters of repeating sequence1of cycloconverter circuit**

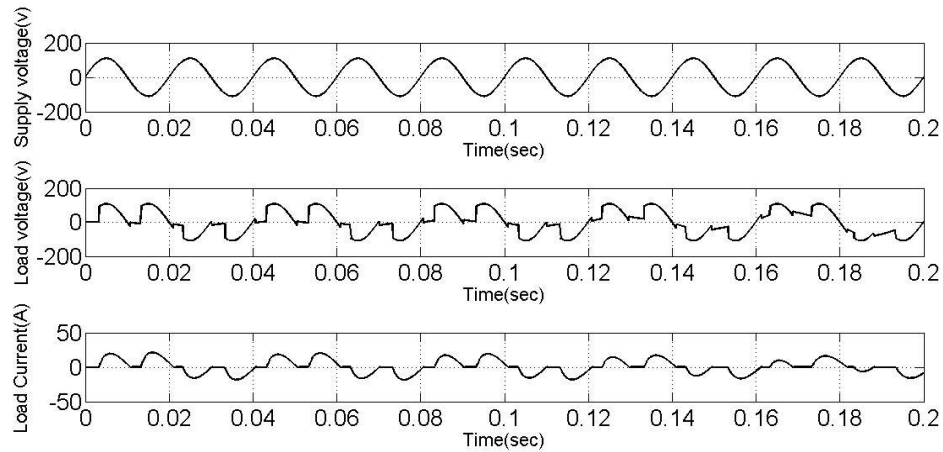


**Figure 6 Speed Vs time output of single phase induction motor at  $f=50$  Hz**

In order to get a better understanding of the control system and to verify the control techniques, Fig 7, Fig 8 and Fig 9 shows output waveform of cycloconverter for input frequency, which is 2,3 and 5 times the output frequency of the 1-phase cycloconverter.

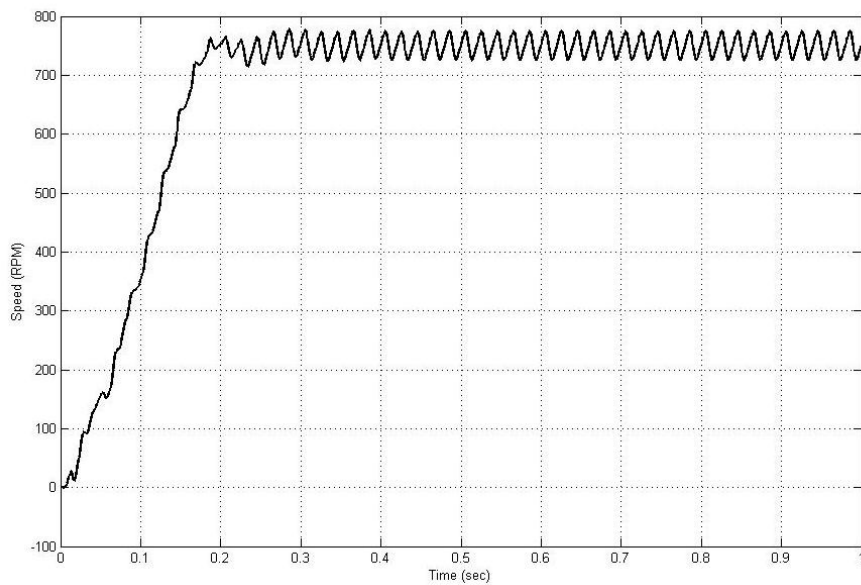


**Figure 7 Output of cycloconverter at  $f=50$  Hz**

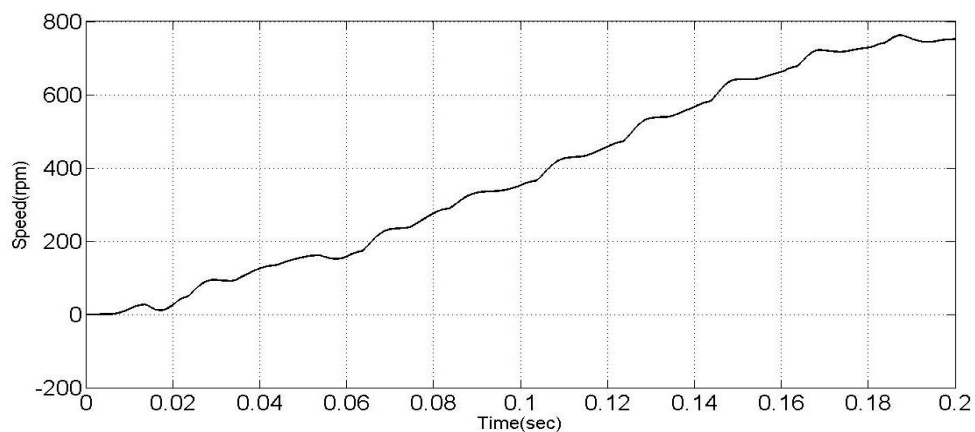


**Figure 8 Output of cycloconverter at  $f=25\text{Hz}$**

The input and output waveforms are shown in above figure. It is clearly indicates that the input frequency 50 Hz is reduced to 25 Hz ( $1/2$ ) at the output.

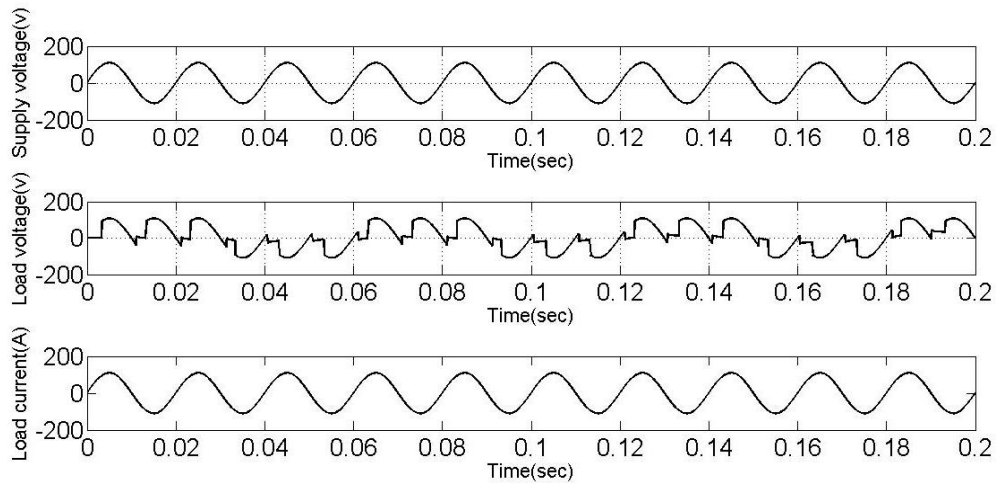


**Figure 9 s speed Vs time output at  $f=25\text{Hz}$**



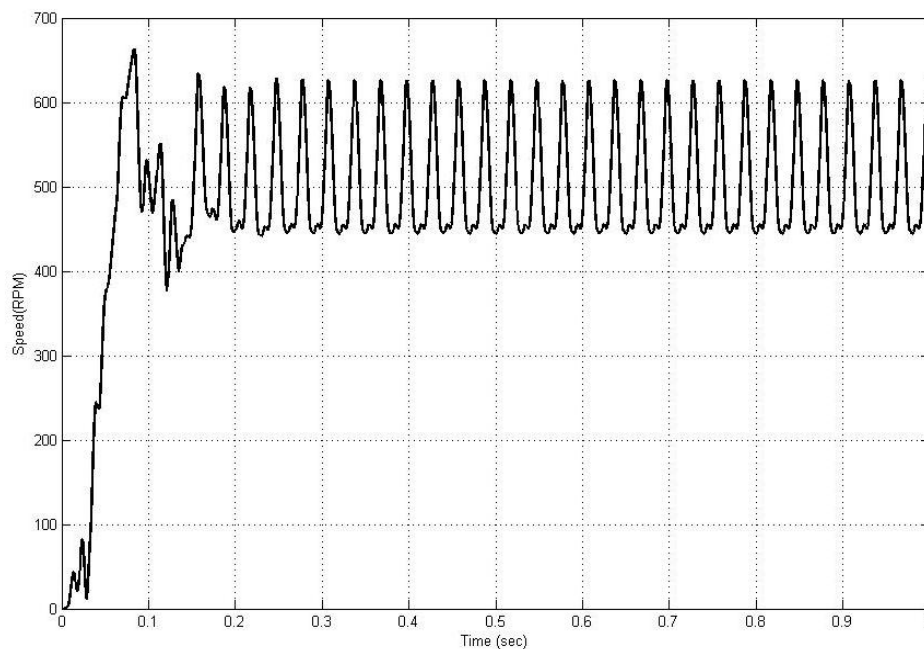
**Figure 10 Speed Vs time output at  $f=25\text{Hz}$**

As shown in above figure 10 while frequency is reduced to 25Hz speed of the single phase induction motor is also reduced.



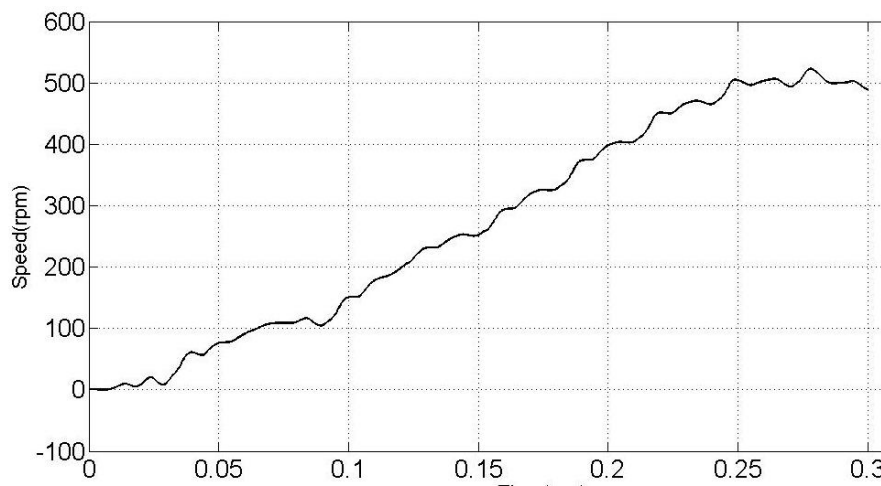
**Figure 11 Output of cycloconverter at  $f=16.66\text{Hz}$**

The input and output waves are shown in above figure. It is clearly indicates that the input frequency 50 Hz is reduced to 16.66 Hz ( $1/3$ ) at the output.



**Figure 12 Speed Vs time output at  $f=16.66\text{Hz}$**

As shown in above figure 12 while frequency is reduced to 16.66 Hz speed of the single phase induction motor is also reduced.

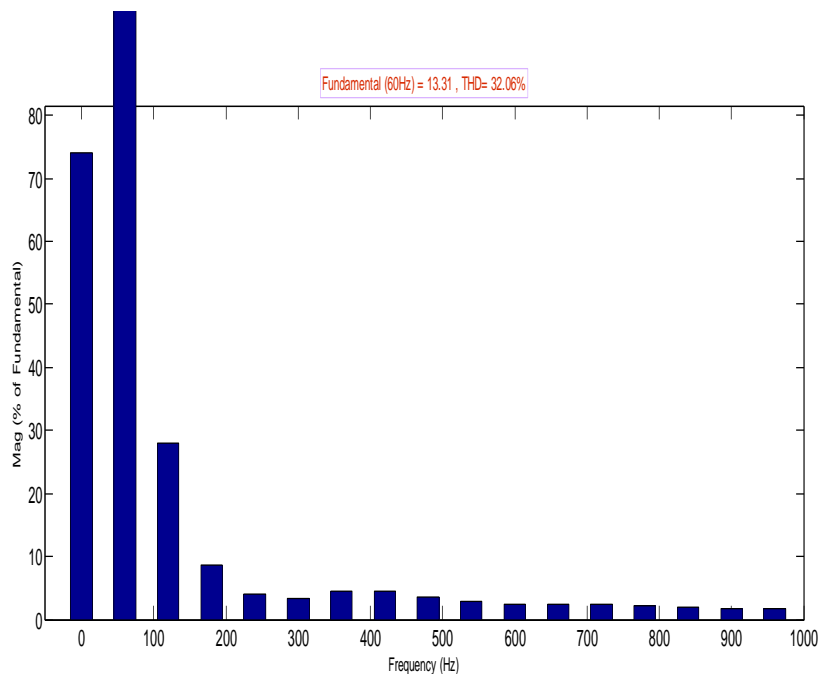


**Figure 13 Speed Vs time output at  $f=16.66\text{Hz}$**

#### **IV HARMONIC ANALYSIS OF CYCLOCONVERTER FED INDUCTION MOTOR**

In general, harmonic behavior affected by many factors, such as the motor speed, motor load, cycloconverter configuration and control algorithm, coupling transformer inductances, magnetizing characteristics, and to some extent, the connection mode.

Harmonic Spectrum of this system is shown in below figure14; it shows higher values of harmonics are present in the system due to cycloconverter.



**Figure 14 % THD analysis of the system**



**Table 1 Result table**

Supply frequency (Hz)	Output Frequency (Hz)	Speed of induction motor (rpm)
50	50	1434
50	25	762
50	16.66	500

### V RECTIFIER MODE

In this mode, during each positive half cycle SCR1 is fired and during each negative half cycle SCR2 is fired. Due to conduction of these SCRs current is flowing through the load in the same directions. The result of this mode for 0.25 HP AC motor are given in table 2. In this mode instead of keeping firing angle of SCR, different firing angle can be used as shown in below table 2.

**Table 2 Rectifier mode observation table**

Sr.No.	Firing Angle	Speed(rpm)
1	16°	1050
2	33°	850
3	44°	770
4	54°	600

### VI CONCLUSION

The cycloconverter circuit is simulated and finally desired results are obtained for different frequency. So by changing the supply frequency speed variation of induction motor can be obtained. Gate pulse for bridge 1 (positive cycle) and bridge 2 (negative cycle) can be obtained from repeating sequence by programming for 50 Hz, 25Hz and 16.66Hz frequency. Harmonic analysis is done also this scheme can be used as rectifier mode or voltage controller.

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