MATLAB Simulation of Single Phase Mid – Point Step Up and Step Down Cycloconverter

M. Narayanan

Department of EEE, Info Institute of Engineering, Coimbatore, Tamil Nadu, India

ABSTRACT

Use of power electronic converters has increased due to its main objective of saving electrical energy largely. Variable frequency drives plays a major role in energy savings in AC motor drives. So the study of converter is necessary to change frequency and hence the speed of the drive. In this paper step up and step down mid – point cycloconverter for varying supply frequency is presented with simulation in MATLAB simulink software.
Keywords: Step Up Cycloconverter, Step Down Cycloconverter, MATLAB Simulink

I. INTRODUCTION

With the increasing motor loads for industrial applications the concept of energy saving has become vital. About 70% of the electrical loads are motor loads. Hence, the requirement of energy savings in electric drives is achieved through power electronic converters.

Variable frequency drives are mostly used for controlling either the torque or the speed of the AC motor. Applications such as pumps, centrifugal fan use the technique of variable frequency to achieve variable speed and variable torque. Variable frequency in ac drives can be achieved by inverter fed or cycloconverter fed drives. The advantage of cycloconverter over inverter fed drive is its single stage conversion.

Cycloconverter is a power electronic circuit that converts fixed voltage fixed frequency input ac voltage to variable voltage variable frequency output ac. The output frequency may be greater than input frequency (step up cycloconverter) or the output frequency may be less than the input frequency (step down cycloconverter).

The variation in frequency in single phase mid – point step up and step down cycloconverter is simulated using MATLAB software and the results are discussed.
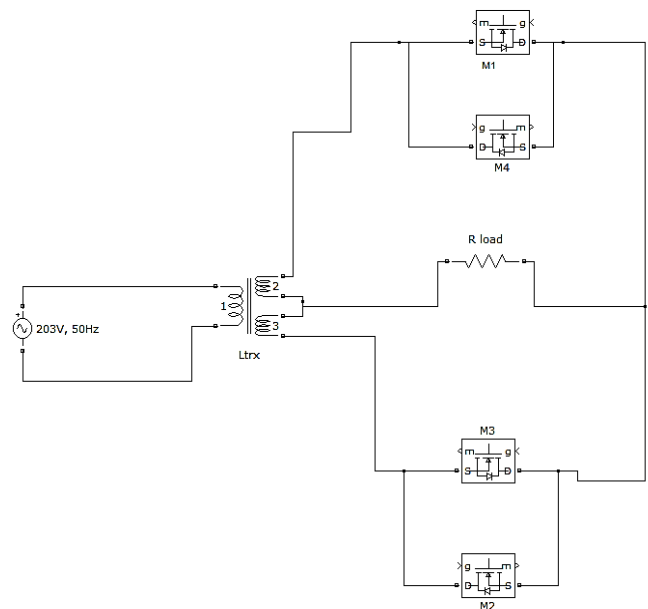
II. MID POINT CYCLOCONVERTER

Figure 1: Mid – Point Cycloconverter

The circuit diagram shown above is mid – point cycloconverter which can be used to produce output frequency both greater than and less than the supply frequency. Thus, it acts as step up or step down cycloconverter. However, it requires triggering suitable MOSFET on and turning off conducting MOSFET. In this circuit, only one MOSFET is made to conduct at a time.

III. STEP UP CYCLOCONVERTER

The simulation is carried by using MATLAB simulink 7.10.0 (R2010a). The power electronic components and other necessary items are taken from Sim Power Systems in Simulink library browser.

The simulation diagram of mid - point cycloconverter using MATLAB simulink software is shown in Figure 2. The main components of the circuit are: mid – point transformer, four MOSFET switches, resistive load, scope to view the output waveform, voltmeter to measure the input and output voltage.
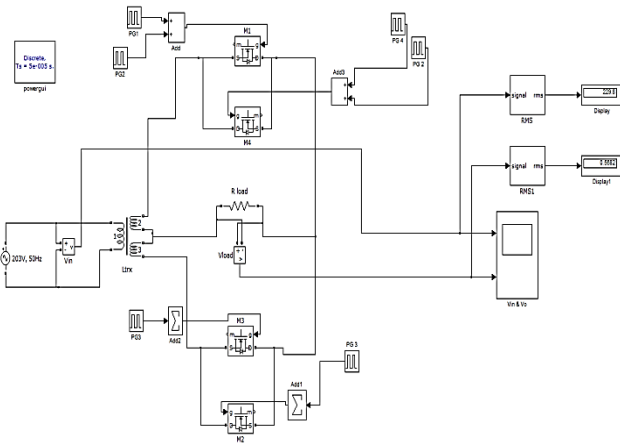
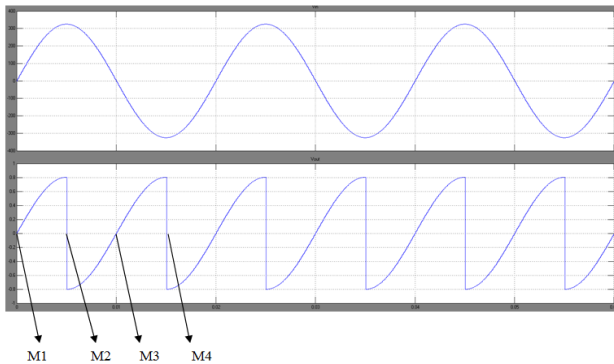**Figure 2:** Simulation circuit for step up cycloconverter

Figure 3: Output frequency of 100 Hz

The Time period of the input waveform = 0.02 sec
Hence the input frequency = 1 / T = 1/ 0.02 = 50Hz
The Time period of the output waveform = 0.01 sec
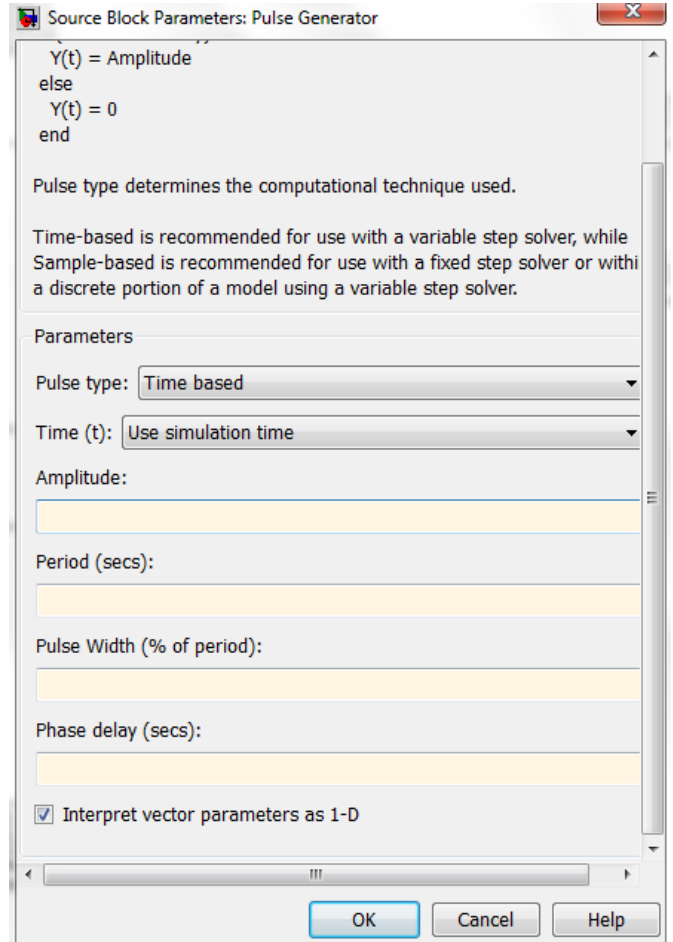Hence the output frequency = 1 / T = 1/ 0.01 = 100Hz

Figure 4: Pulse Generator Block

The pulse generator is used in MATLAB to generate the required pulse width and phase delay. The important parameters that have to be calculated are Period (secs), Pulse Width (% of period) and Phase delay (secs). The amplitude can be fixed as 1V. After analysing the required output and choosing a correct period, the pulse width and phase delay can be calculated.

The formula to calculate pulse width (% of period) and phase delay (secs) are given as follows:

$$\text{Pulse width} = \frac{\text{Conduction angle}}{360} \times 100$$

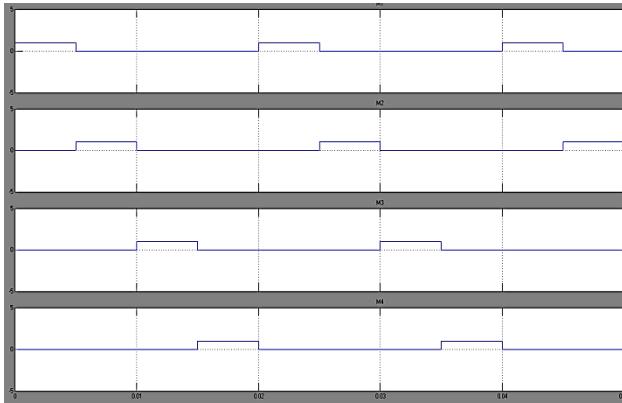$$\text{Phase delay} = \frac{0.02 \times \text{Firing angle}}{360}$$

Figure 5: Pulse width for MOSFETs M1 to M4

The pulse waveform generated to produce output frequency of 100Hz is shown above. During the positive half cycle of the input waveform M1 and M2 should conduct for 90 degrees each and during the negative half cycle M3 and M4 should conduct for 90 degrees.

We know that the time period of input waveform equals 0.02 secs. Therefore to produce a pulse of width 90 degrees, the pulse width formula can be used:

$$\text{Pulse width} = \frac{\text{Conduction angle}}{360} \times 100$$

$$= \frac{90 * 100}{360}$$

$$= 25\%$$

Similarly the phase delay required to produce pulse for M2 is 90 degrees. Hence, to calculate in secs phase delay is given by:

$$\text{Phase delay} = \frac{0.02 \times \text{Firing angle}}{360}$$
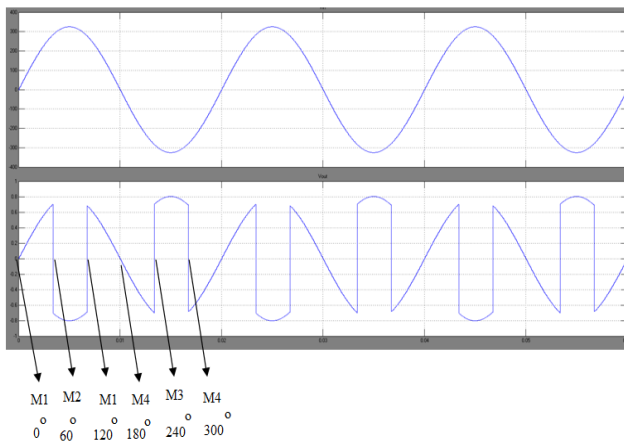
$$= \frac{0.02 * 90}{360}$$

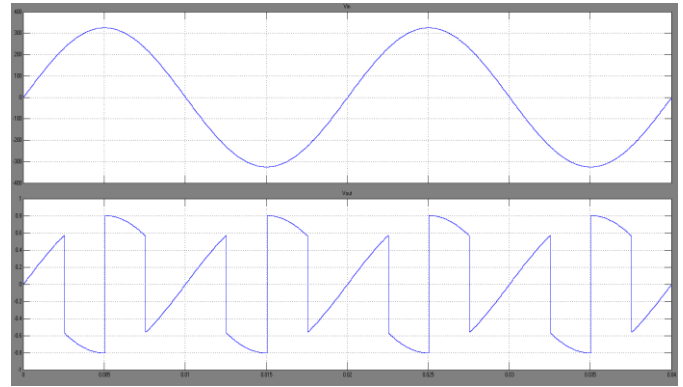$$= 0.05 \text{ secs}$$

Figure 6: Output frequency of 150 Hz
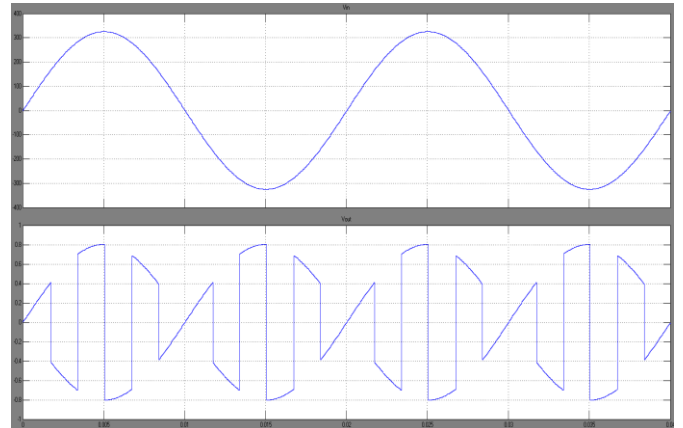

Figure 7: Output frequency of 200 Hz

Figure 8 : Output frequency of 303 Hz

For any frequency step up, the operation of the circuit should follow the table shown below:

TABLE I

S. No	Switch turned on	Period (degrees)
1	M1 & M2	0<wt<180
2	M3 & M4	180<wt<360

The frequency can be increased by increasing the number of turn on and turn off of the respective MOSFET. The use of SCR is not recommended since it requires external commutation circuit and hence MOSFET is used as switching device.

IV. STEP DOWN CYCLOCONVERTER

The circuit uses AC supply of 230Vrms, 50Hz frequency, four thyristors, three winding transformer (230V – 12-0-12V), pulse generator to produce phase delay with required pulse width to turn on thyristor, resistive load of 1 ohms, signal rms block to generate rms value of input and output voltage, voltmeter to measure voltage, scope to view waveform and display to view rms value.
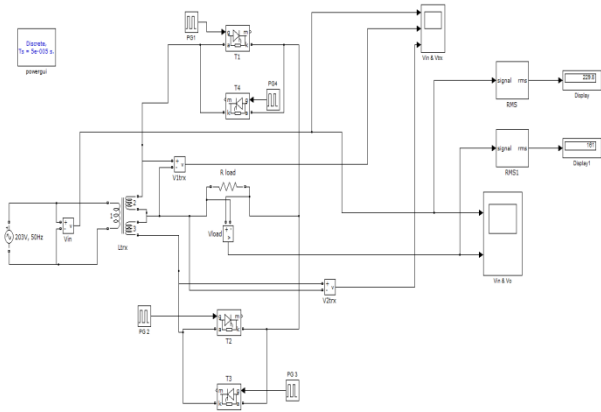
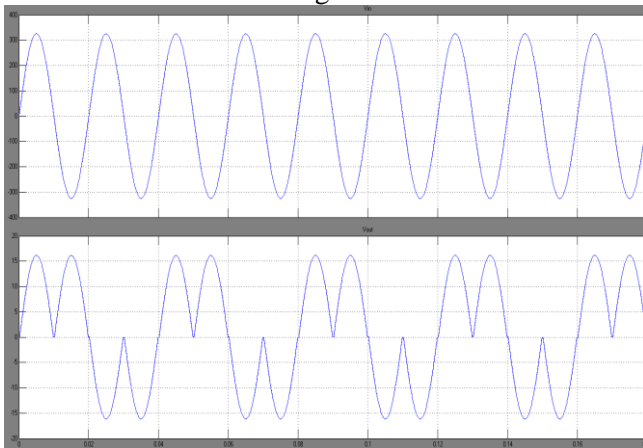**Figure 9:** Mid – point cycloconverter Simulation diagram

Figure 10. Input and output voltage waveform (f = 25Hz and firing angle = 0 deg)

The circuit uses SCR's as power electronic switch. The thyristor can be turned off using natural or line commutation method. The firing angle can be varied to vary the output voltage.

V. CONCLUSION

This paper presents MATLAB simulation of mid – point step up and step down cycloconverter. Only frequency variation is presented for both cycloconverters. Voltage variation is possible by varying the firing angle of the power electronic switch used. Thus, variable voltage and variable frequency is possible in single stage by using cycloconverter.

VI. REFERENCES

[1]. Suganthi Vinodhini, Samual Rajesh Babu and Aran Glenn (2016). Single phase to Single phase step-down cycloconverter for Electric traction applications. International Conference on Electrical, Electronics, and Optimization Techniques.

[2]. Shweta Sethi and G.K. Jindal (2015). Software Design and Hardware Realisation of Single Phase to Single Phase Step Down Cycloconverter. International Journal of Innovations in Engineering and Technology (IJIET), Vol. 5, issue 1.

[3]. Y. Prudvi Sai Krishna Gowda, Guttula Hema, Seepana Durga Prasad and Vattikuti Vilasitha (2016). Performance and Speed Control of Cycloconverter fed Split Phase Induction Motor. International Research Journal of Engineering and Technology (IRJET), Vol. 3, issue 9.

[4]. Kaushal S. Pandya and Niraj B. Danidhariya (2014). Simulation of Speed Control of Single Phase Induction Motor Using Cycloconverter. National Conference on Emerging Trends in Computer & Electrical Engineering, pp – 343 - 347.

[5]. K.S.Pandya and N. B. Danidhariya (2014). Simulation of Step-down Cycloconverter for Speed Control of Single Phase Induction Motor. International Journal of Advance Engineering and Research Development, Vol. 1, issue 5.

[6]. Ravi Prakash, Senetsolu Nyekha, Prateek Sahu and Prof. Devendra Tiwari (2016). SPMC as Single Phase to Single Phase Cycloconverter vwith SPWM using MATLAB/Simulink. International Journal of Scientific Development and Research.(Oct 2016), Vol. 1, issue 10.