MATLAB SIMULATION OF SINGLE PHASE MID – POINT AND BRIDGE TYPE STEP DOWN CYCLOCONVERTER

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Abstract

With the introduction of variable speed drives the term energy efficiency is achieved through power electronic converter. Energy conversion in required format can be obtained using suitable power electronic converter circuit. AC – DC, AC – AC, DC – AC and DC – DC is possible as required by our application with significant energy savings. In this paper step down Cycloconverter which converts AC – AC is simulated using MATLAB simulink software and the output voltage for various firing angles in mid – point and bridge type step down Cycloconverter is studied.

Keywords: Step – down Cycloconverter, Mid – point cycloconverter topology, Bridge type Cycloconverter topology, MATLAB simulink

INTRODUCTION

Electrical Energy conversion is the process by which electrical energy in one form is converted to other. The process of conversion is done based on the load requirement. Earlier rotary converter is used for the purpose of conversion of AC – DC or DC – AC. But the advent of power electronic switches made energy conversion using rotary converter obsolete. The reduced losses, less maintenance, compact, cost effectiveness, greater efficiency and flexible control are few advantages which power electronic converter had over rotary converter.

Based on the energy conversion the circuit may be a rectifier (AC – DC), chopper (DC – DC), AC voltage regulator or Cycloconverters (AC – AC) and inverter (DC – AC).

The various conversions using power electronic switches that can be obtained are summarized and shown in Fig (1).

The term variable here means the output voltage can be varied higher or lower than the input voltage or frequency when supply is ac. It can be viewed that both inverter and cycloconverter circuit produces variable voltage and variable frequency (VVVF) as output. But for the purpose of variable voltage and variable frequency mostly cycloconverter is used as it involves single stage conversion.
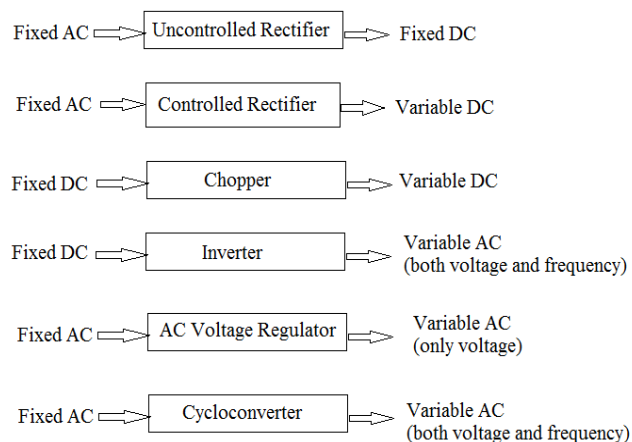

Fig (1) Power Electronic Converters

Cycloconverter is a power electronic circuit which converts fixed AC input to variable voltage, variable frequency output. It is said to be step down cycloconverter when the output frequency is less than the input frequency. The basic topology used for this purpose is:
 a) Mid – point cycloconverter topology
b) Bridge type cycloconverter topology. Some applications of cycloconverters are
- o Cement mill drives
- o Ship propulsion drives
- o Rolling mill drives
- o Scherbius drives

o   Ore grinding mills

MID – POINT CYCLOCONVERTER
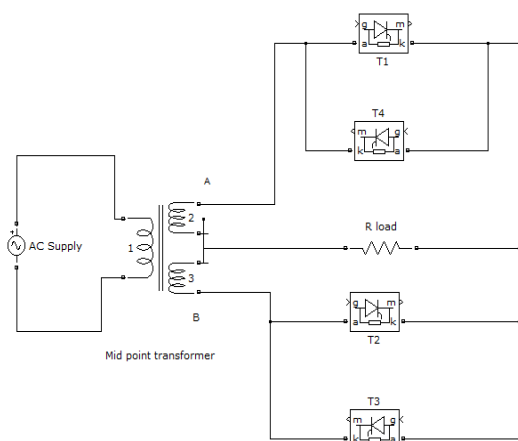
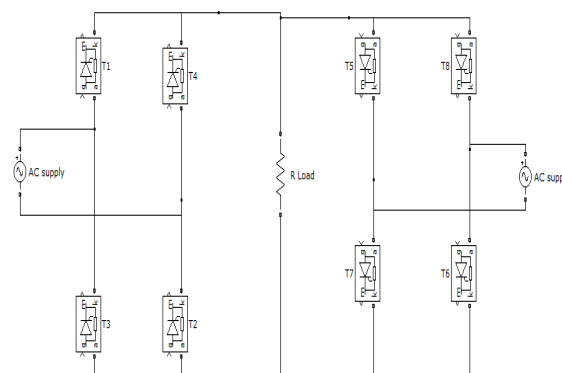**Fig (2) Mid – point cycloconverter circuit diagram**

The above circuit is a mid – point step down cycloconverter which produces output frequency less than the input frequency [2]. It uses four thyristors T1, T2, T3 and T4. When the supply is turned on, during the positive half cycle of the supply point A will be positive with respect to B and hence T1 or T3 is forward biased. Now T1 is triggered and hence positive half cycle is obtained as output. T1 is turned off due to line commutation at 180 deg. During the negative half cycle, A is negative with respect to B and hence T2 and T4 are forward biased. Now T2 is triggered and hence negative half cycle is rectified and obtained as output. Thus by triggering T1 and T2 at 0 deg and 180 deg respectively, positive and negative half cycle of input is obtained in output as shown.
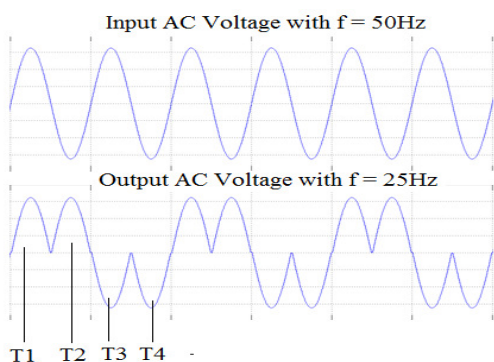
Fig (3) Input and output voltage waveform

Similarly during the next cycle of AC supply, T3 and T4 are triggered at 360 deg and 540 deg respectively. Thus the time period of the output waveform is doubled and therefore frequency if halved.

BRIDGE TYPE CYCLOCONVERTER

Fig (4) Bridge type cycloconverter circuit diagram

The above circuit diagram shows two bridge converters connected back to back (anti-parallel) to perform variable frequency operation. The same output AC waveform with frequency of 25Hz is possible with this circuit. For the positive have cycle of output waveform thyristors T1, T2 and T3, T4 should be triggered. For the negative half cycle thyristors T5, T6 and T7, T8 should be triggered. Care should be taken so that no two thyristors of same branch conduct.

STEP DOWN CYCLOCONVERTER

A circuit which produces output frequency (fo) less than input frequency (fin) is called step down cycloconverter. By using the above two configurations mid – point and bridge type topologies step down operation is possible. The circuit uses thyristors (SCR's) which should be triggered with required time delay to produce output a frequency of 50Hz, 25Hz, 16.6Hz, 12.5Hz, etc.
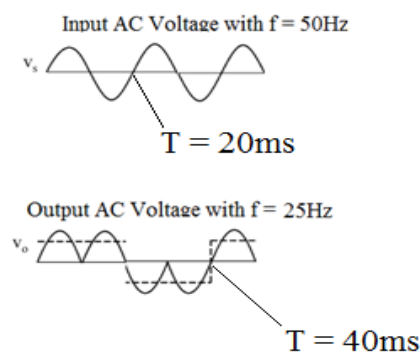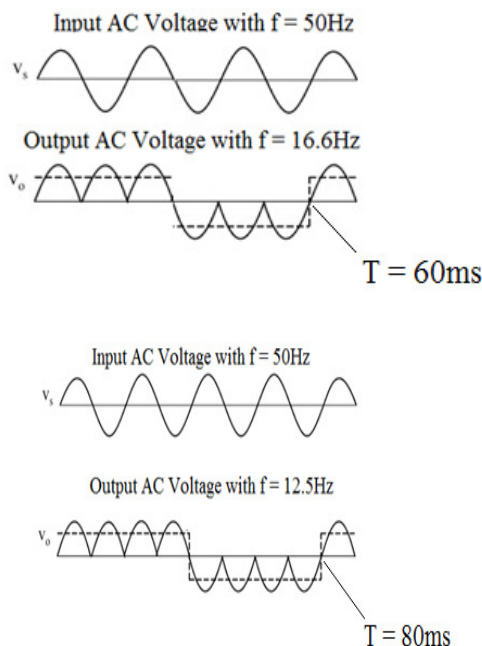
Fig (5) Input and output voltage waveform for various frequencies

From the above waveform it is clear that the frequency of input = fin = 50Hz
Therefore the time period of input waveform is
$$T = 1 / 50 = 20ms$$
In the waveform pattern for output frequency f = 25Hz, the time period of out is doubled ie. The time period of output of one cycle is 40ms. Therefore the frequency of output is
$$fo = 1 / T = 1000 / 40 = 25Hz$$
For time period of 60ms, fo = 1000/ 60 = 16.6 Hz
Similarly, for time period of 80ms, fo = 1000/ 80 = 12.5 Hz
All these frequencies below input frequency is possible by proper triggering of circuit thyristor. The turn on process of forward biased thyristor is possible by applying gate pulse and turn off process takes place by line commutation method. If we are using inverter for varying frequency then the circuit devices should undergo turn off process using external commutation method or forced commutation technique. Also single stage of conversion with better efficiency is not achieved by using inverter circuit as the input supply is DC.

For varying the voltage in cycloconverter, instead of firing the thyristor T_1 in mid – point converter at 0 deg, it can be triggered at 30 deg. So that T_2 can be triggered at 180+30 = 210deg, T_3 at 360+30 = 390 and T_4 at 540 +30 = 570 deg respectively.
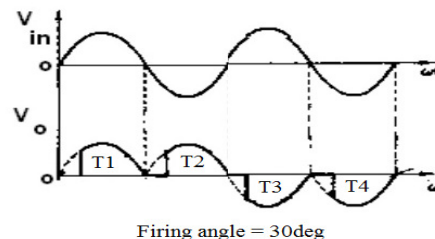
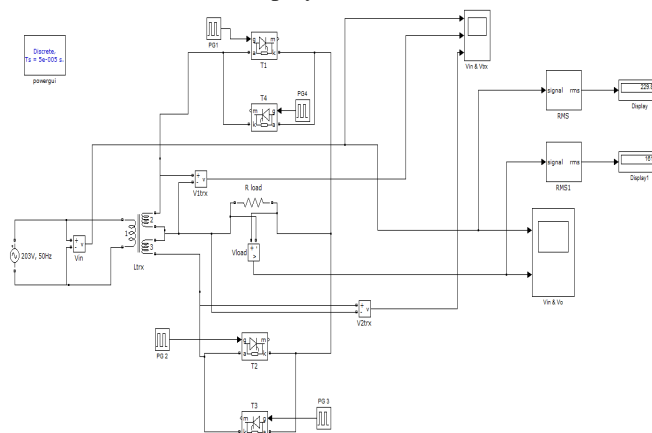**Fig (6) Output voltage waveform for firing angle = 30 deg**

The above output waveform is obtained by triggering SCR's at firing angle = 30deg. Since a part of the waveform is clipped the output waveform should be less than the rms value of input voltage. Thus voltage can be also varied by varying the firing angle. When firing angle is increased the output voltage is reduced further. Thus using cycloconverter both voltage and frequency is varied in single stage.

SIMULATION RESULTS

MID – POINT 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 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.

Fig (7) Mid – point Cycloconverter Simulation diagram
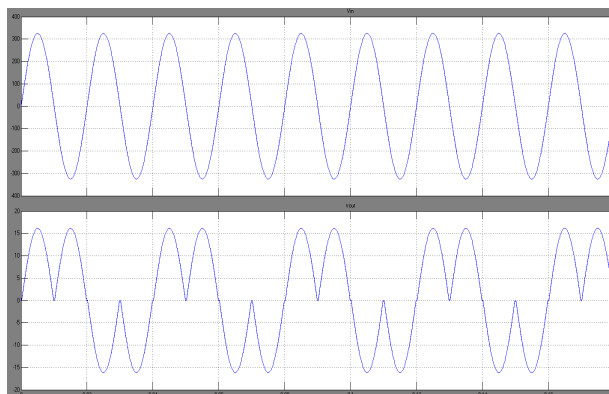
Fig (8) Input and output voltage waveform (f = 25Hz and firing angle = 0 deg)
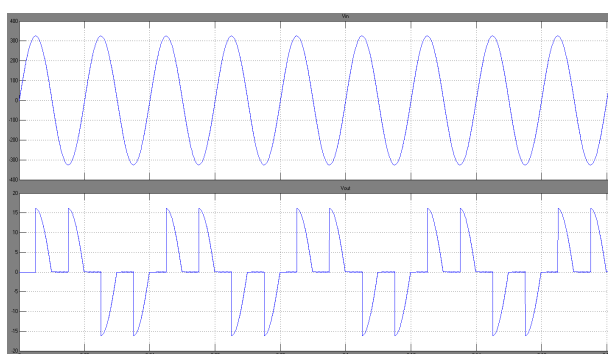
Fig (9) Input and output voltage waveform (f = 25Hz and firing angle = 90 deg)

The simulation is carried out to generate output frequency, fo = 25Hz. The input voltage and output voltage waveform for firing angle, $\alpha = 0^o$ and 90° is shown. The variation in firing angle helps to vary the output voltage as required and SCR's are triggered to obtain frequency of output is 25Hz.

S. No	Input Frequency in Hz	Output Frequency in Hz	Firing angle in degrees	RMS Output voltage in volts
1.			0	11.26
2.			30	11.11
3.	50	25	60	10.1
4.			90	7.923
5.			120	4.779
6.			150	1.687

Table 1: Variation of RMS output voltage for various firing angle for output frequency of 25Hz

The table 1 shows the variation of output voltage for various firing angle for a step down

frequency of 25Hz. As the firing angle goes on increasing the area of sine wave clipped also increases and hence output voltage decreases. The voltage input after stepping down using three winding transformer is 12V rms and hence variation of voltage between 0 to 12V is possible with this circuit with 25Hz output frequency.

BRIDGE TYPE CYCLOCONVERTER
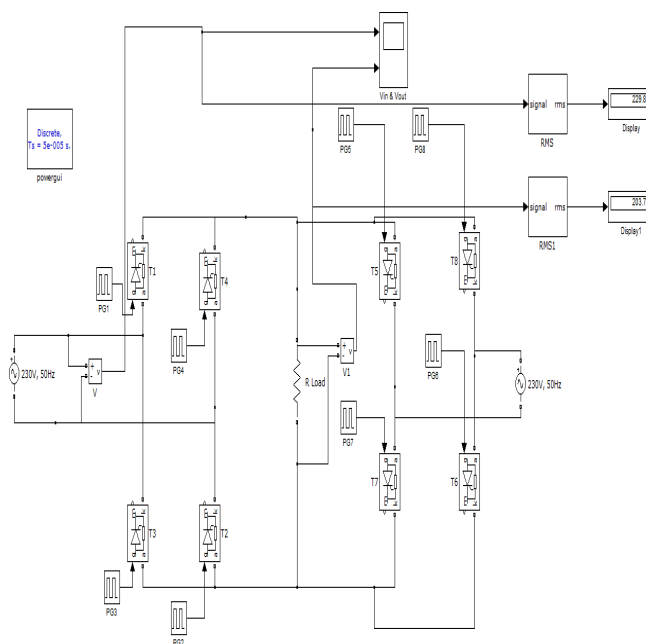
Fig (10) Bridge type cycloconverter Simulation diagram

The bridge type cycloconverter uses eight thyristors or two bridge circuits connected back to back (anti-parallel) each having four SCR's. One bridge converter acts as positive converter and other acts as negative converter. Here bridge with SCR's T1 to T4 acts as positive converter. These SCR's when triggered with proper firing angle produces positive half cycle of output and hence the name positive converter. Negative half cycle is produced by T5 to T8 SCR's and hence they form negative converter bridge. It should be also noted that no two thyristor of same branch is made to be conducted.The input voltage to this bridge is 230V, 50Hz supply and hence the output voltage can be varied between 0 to 230V by varying the firing angle and the circuit is triggered to obtain output frequency of 25Hz.
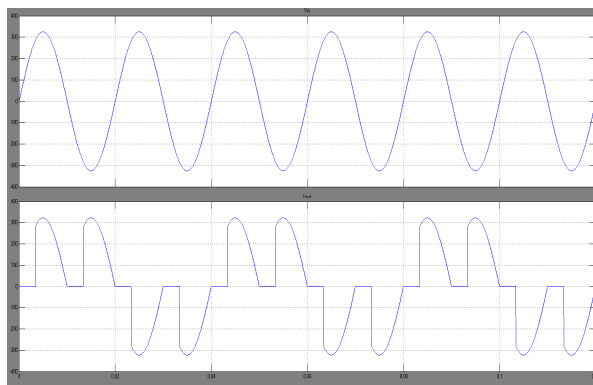
Fig (11) Input and output voltage waveform
(f = 25Hz and firing angle = 60 deg)
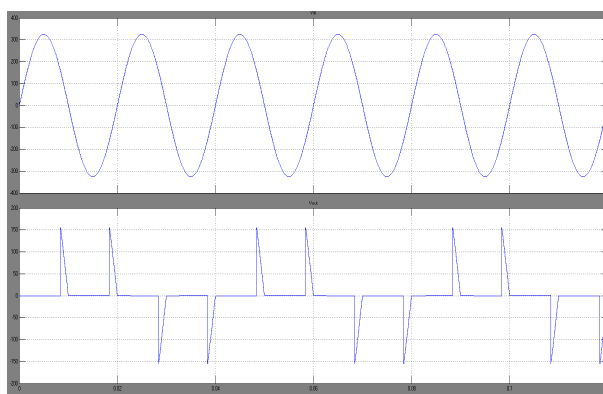
Fig (12) Input and output voltage waveform
(f = 25Hz and firing angle = 150 deg)

S. No	Input Frequency in Hz	Output Frequency in Hz	Firing angle in degrees	RMS Output voltage in volts
1.			0	227.9
2.			30	224.3
3.	50	25	60	203.7
4.			90	160.3
5.			120	98.33
6.			150	36.98

Table 2: Variation of RMS output voltage for various firing angle for output frequency of 25Hz

CONCLUSION

In this paper simulation of mid – point cycloconverter and bridge type cycloconverter for step down purpose is discussed using MATLAB simulink. Simulation is carried to produce output voltage with a frequency of 25Hz using both topologies. The variation of output voltage by varying firing angle is also shown. This feature helps them to find its application in induction and synchronous motor drives.

Reference

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.