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A Review of AC – AC Voltage and Frequency Controller

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ABSTRACT

With energy savings as main objective, controllers are designed using power electronic devices that provide variable ac output from fixed ac input sources. Nowadays applications stating from domestic to industries uses power electronic controllers for producing variable voltage, variable frequency to satisfy the load demand as well as to obtain optimum energy savings. In this paper, AC – AC voltage regulator or controller and cycloconverter circuits are studied using MATLAB simulation software to produce variable ac.

Keywords : AC – AC voltage controller; Cyclo-converter; MATLAB Simulink, THD, MOSFET

I. INTRODUCTION

AC – AC controller is a power electronic circuit used to convert fixed ac to variable ac. The parameter in the output that can be varied may be either voltage or frequency or both voltage and frequency. The conversion of fixed ac to variable ac can be also done by using autotransformers. This system suffers from disadvantages like power loss, heating, reduced system efficiency, high cost and occupying more space. Therefore it is required to go for an effective control technique [7].

The circuit that is used to obtain variable voltage as output is said to be AC voltage controller whereas both variable voltage and variable frequency is said to be cycloconverter. 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 [11]. In this paper, the study of AC voltage controller in Integral cycle control, Phase angle control and cycloconverter in mid-point step down and step up topologies are discussed.

II. AC VOLATGE CONTROLLER

Fixed ac voltage to variable ac voltage is possible using thyristors is possible using Integral cycle control, Phase angle control circuits [1].

2.1 Integral cycle control or ON – OFF cycle control:

In this method the thyristors are triggered at zero and made to conduct or turned on for ‘m’ number of cycles and turned off for ‘n’ number of cycles. Hence the name ON – OFF cycle control. The output waveform follows the shape of the input waveform but the output voltage does not appear across the load continuously. Therefore the main drawback is load has to sustain the voltage variations i.e., A full supply voltage during the ON period and zero voltage during the OFF period and output voltage control is not continuous. Duty cycle (ratio of on-time period to total time period) can be varied to vary the output voltage [4].

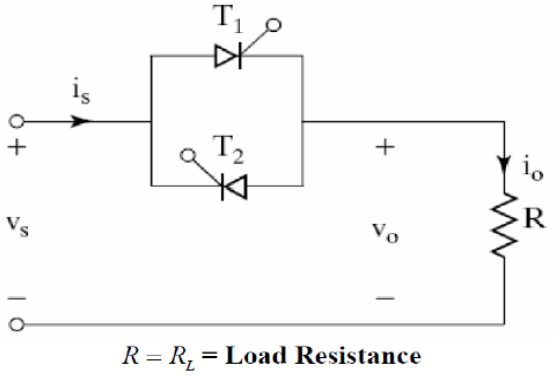

Figure 1. AC – AC Voltage controller circuit diagram

The expression for rms value of output voltage for resistive load is given by:

$$Vo(rms) = Vi(rms)\sqrt{ton/To} = Vs\sqrt{\frac{ton}{To}}$$

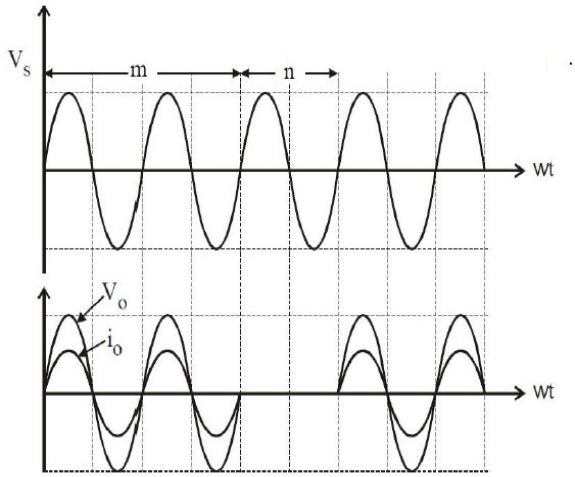

Figure 2. Input and output waveforms

where,

Ton – on time period = m x To

Toff – off time period = n x To

To – Total Time period

Vs – rms value of supply voltage

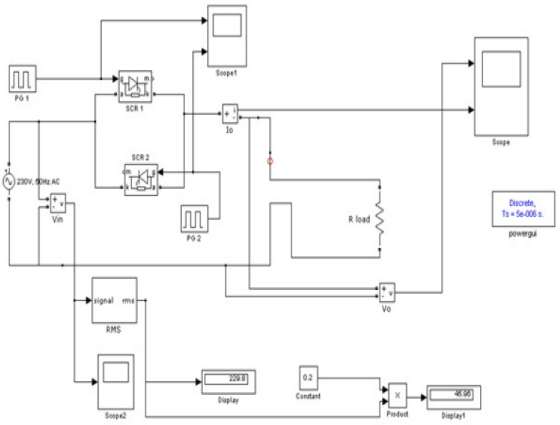

Figure 3. MATLAB Simulation circuit of AC Voltage controller

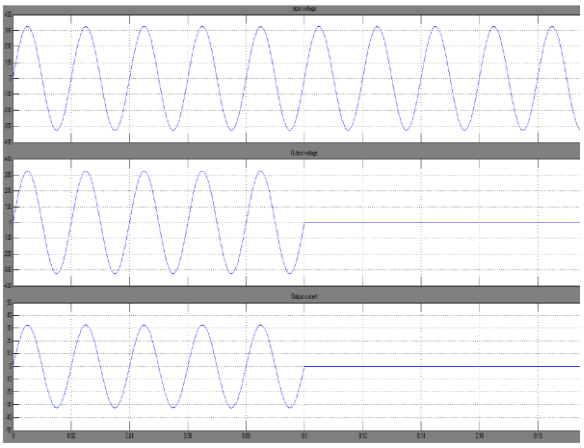

Figure 4. Simulated input and output waveforms

2.2 Phase Angle Control

In this method, the output voltage is controlled by triggering the SCRs T1 and T2. By varying the firing angle (α) the rms value of output voltage is varied [4]. The advantage of this method is continuous output voltage control is possible by varying the firing angle and no commutation circuit is required. Since the sine wave pattern is getting changed, harmonics will be introduced in the system and hence %THD will get increased when compared to ON – OFF cycle control [3].

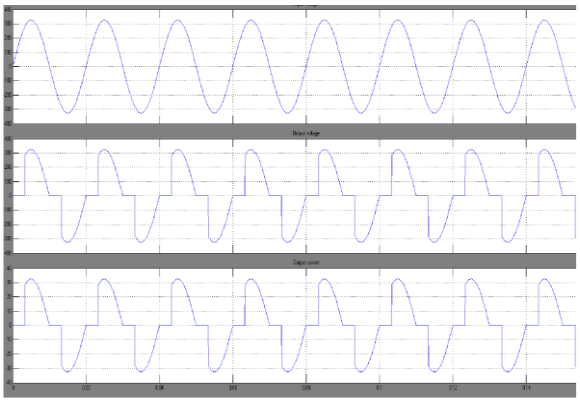

Figure 5.. Simulated input and output waveforms

The expression for rms value of output voltage for resistive load is given by:

$$Vo(rms) = Vs\sqrt{\frac{(\Pi - \alpha) + (\sin 2\alpha)/2}{\Pi}}$$

where, $Vs = \frac{Vm}{\sqrt{2}}$ = RMS Value of input supply voltage

III. CYCLOCONVERTER

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).

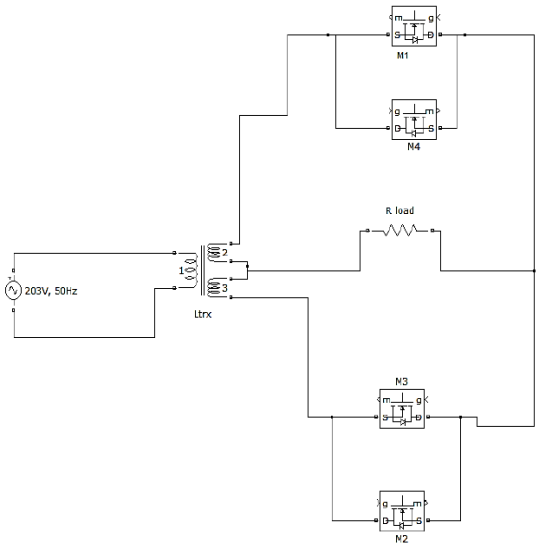

Figure 6. Circuit diagram

The above circuit diagram shown in Fig. 5 can be used to produce variable frequency output. Both greater than the input frequency (Step up cycloconverter) and less than the input frequency (Step down cycloconverter) is possible using this circuit. To obtain the desired output it requires turning on and turning off suitable MOSFET [8].

3.1 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 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 [11].

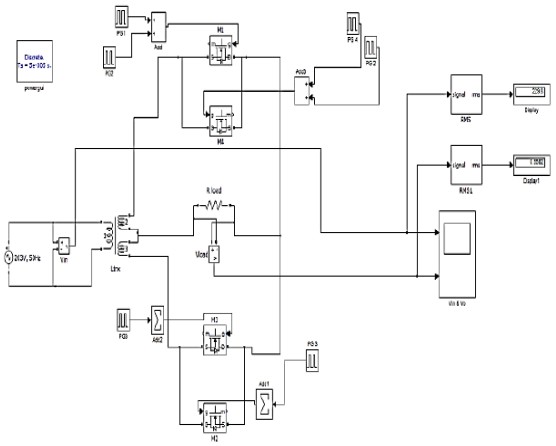

Figure 7. Simulation diagram of step up cycloconverter

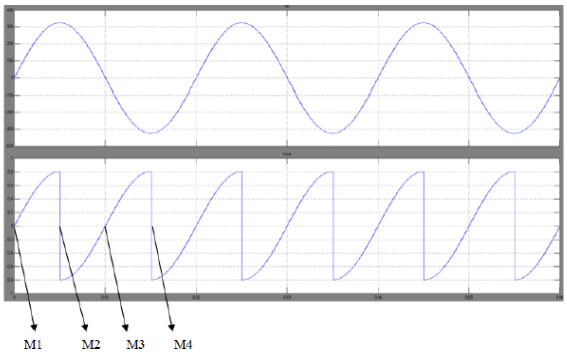

Figure 8. Input and output voltage waveform with frequency twice the input (Step up)

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.

The output voltage waveform has the time period half the input waveform as shown in Fig. 7. Thus the output has the frequency twice that of the input and hence it acts as step up cycloconverter.

3.2 Step down Cycloconverter

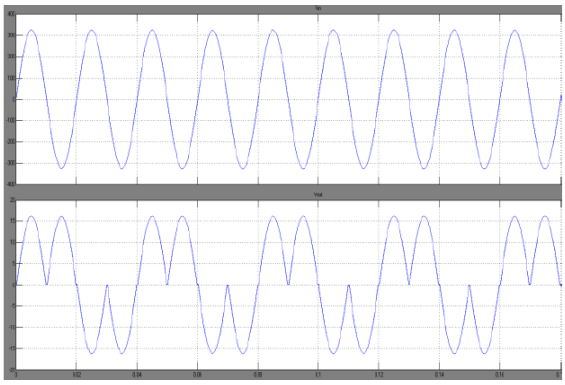

Figure 9. Input and output voltage waveform with frequency half the input (Step down)

Let us assume the frequency of input is the same 50Hz. Therefore the time period of the output waveform = 0.04 sec. Hence the output frequency = 1 / T = 1/ 0.04 = 25Hz. Thus the output has the frequency half that of the input and hence it acts as step down cycloconverter.

The simulation is performed to vary the supply frequency in step up and step down cycloconverter. To vary the rms value of supply voltage firing angle of the thyristor can be varied and hence variable voltage and frequency can be applied to the load. The drive that uses this technique is called variable voltage variable frequency drives.

IV. CONCLUSION

This paper presents the study of basic topologies of AC –AC voltage controller and cycloconverter for varying the supply voltage and frequency. For varying only voltage AC voltage controller may be preferred whereas single stage conversion of AC – AC with variable voltage and frequency is possible using cycloconverter.

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