Date : December 7, 2022
Experiment No : 04
Experiment Name: i) Study of AC Voltage Controller. ii) Study of Cycloconverter.

Theory :
AC Voltage Controllers : The circuits that are composed of semiconductor material and are designed to change constant alternating voltage directly to variable alternating voltage keeping the frequency unchanged. So, the frequency of the fixed as well as variable ac voltage will remain the same. It is sometimes also known as AC Regulators.
AC voltage controllers are regarded as thyristor power converters that transform constant voltage, ac input supply of fixed frequency into variable voltage ac output of the same frequency. It simply varies the RMS value of alternating voltage provided to the load circuit.
Majorly its applications include heating (either for domestic or industrial purposes), lighting control, speed controlling of ac drives, starting of induction motor, transformer tap changing, etc. The ac voltage controllers constituted by thyristors or triacs are highly efficient and are flexible, small-sized and requires less maintenance. These can also operate in conjunction with closed-loop control systems. By varying the firing angle α, the power that flows through the load as well as the output voltage both can be controlled.
There are basically, two types of control strategies in order to regulate the power flow are mentioned:
1) Phase Control
2) Integral Cycle Control
3) Single-Phase AC Voltage Controllers
The figure here shows the circuit representation of a single-phase ac voltage controller:

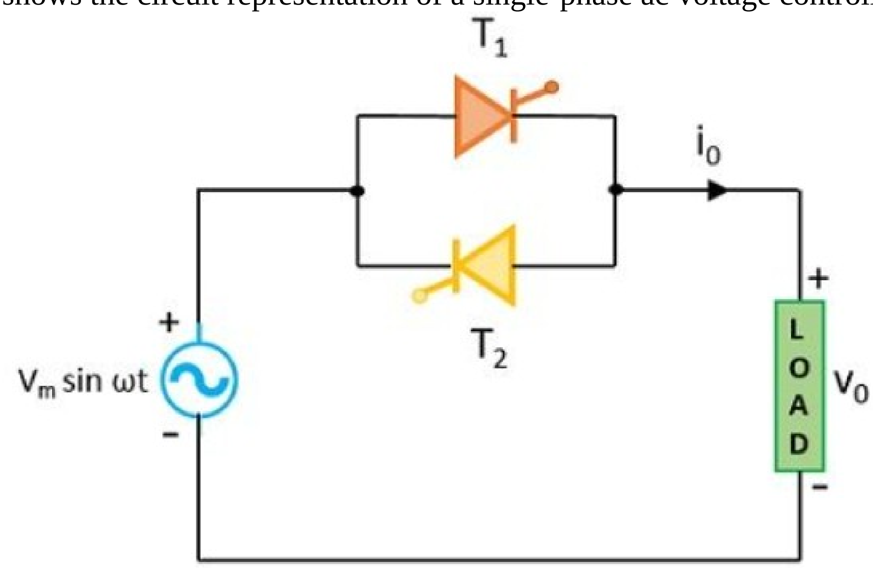

Figure 4.1 : Circuit of Single phase voltage controller

Here it is clearly shown that two thyristors are present in the circuit that exist in the antiparallel arrangement. It is to be kept in mind that the sources through which triggering to the thyristors is provided must be isolated from each other.

If we consider a single-phase full-wave voltage controller then it should contain 2 thyristors along with two diodes. In such case, during the first half of the ac signal, only a single thyristor and a diode will be in the conducting state while in the second half of the ac signal, the other thyristor and diode will offer conduction. There is a disadvantageous factor associated with this circuit which is that there will be more conduction losses thereby resultantly causing a reduction in the efficiency of the circuit.

Cyclo converter :

A cycloconverter (CCV) or a cycloinverter converts a constant voltage, constant frequency AC waveform to another AC waveform of a lower frequency by synthesizing the output waveform from segments of the AC supply without an intermediate DC link

One particular property of Cycloconverters is that it does not use a DC link in the conversion process thus making it highly efficient. The conversion is done by using power electronic switches likes Thyristors and switching them in a logical manner. Normally these Thyristors will be separated into two half, the positive half and the negative half. Each half will be made to conduct by turning them during each half cycle of the AC form thus enabling bi-directional power flow. For now imagine Cycloconverters as a black box which take in a fixed Voltage fixed Frequency AC power as input and provides a Variable frequency, variable Voltage as output as shown in the illustration below.

Based on the output frequency and number of phase in the input AC power source the Cycloconverters can be classified as below

1. Step-Up Cycloconverters
2. Ste-Down Cycloconverters

Single-Phase to Single-Phase Cycloconverter

Three-Phase to Single-Phase Cycloconverter

Three-Phase to Three-Phase Cycloconverter

Step-Up Cycloconverters: Step-Up CCV, as the name suggests this type of CCV provide output frequency greater than that of input frequency. But it is not widely used since it not have much particle application. Most application will require a frequency less than 50Hz which is the default frequency here in India. Also Step-Up CCV will require forced commutation which increases the complexity of the circuit.

Step-Down Cycloconverters: Step-Down CCV, as you might have already guessed it well.. just provides an output frequency which is lesser then the input frequency. These are most commonly used and work with help of natural commutation hence comparatively easy to build and operate. The Step-Down CCV is further classified into three types as shown below we will look into each of these types in detail in this article.

Single Phase to Single Phase Cycloconverters:

The Single Phase to Single Phase CCV is very rarely used, but to understand the operation of a CCV it should be first studied so that we can understand the Three Phase CCV. The Single Phase to Single Phase CCV has two pairs of full wave rectifier circuit, each consisting of four SCR. One set is placed straight while the other is placed in anti-parallel direction as shown on the picture below.

All the gate terminals of the SCR’s will be connected to a control circuit which is not shown in the circuit above. This control circuit will be responsible for triggering the SCRs. To understand the working of the circuit let us assume that he input AC supply is of 50Hz frequency and the Load to be a pure resistive load and the firing angle of the SCR (α) to be 0°. Since the firing angle is at 0° the SCR when turned on will act like a diode in forward direction and when turned off will act like a diode in reverse direction. Let us analyse the wave form below to understand how frequency is stepped down using a CCV.

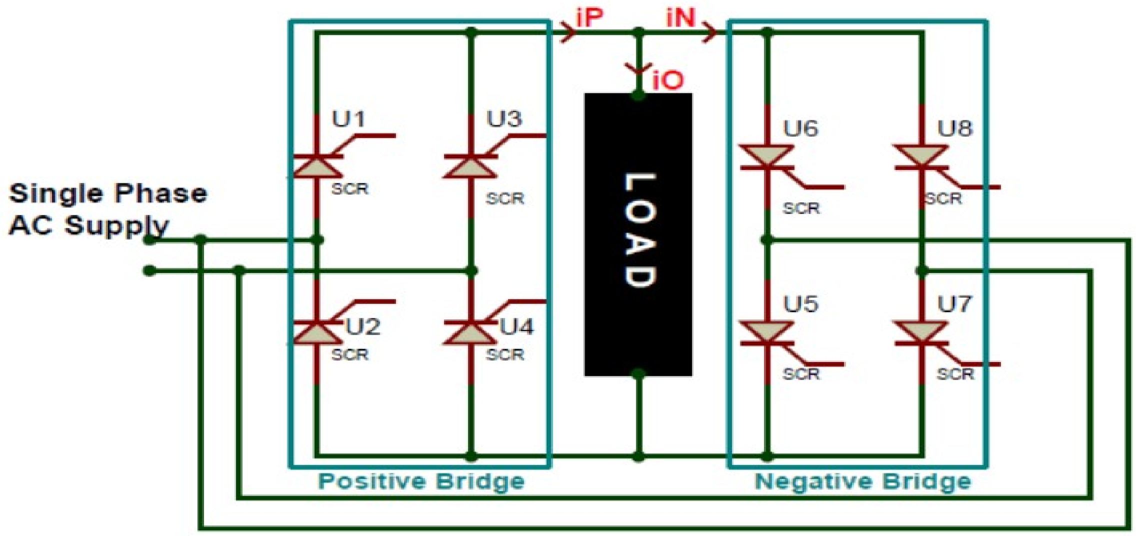

Figure 4.2 : Single phase bridge Cyclo converter

The waveform of the supply voltage frequency is denoted by Vs and the wave form of the output voltage frequency is denoted by Vo. Here we are trying to convert the supply voltage frequency to 1/4th of its value. So to do that for the first two cycles of the supply voltage we will use the positive Bridge rectifier and for the following next two cycles we will use the negative bridge rectifier. Thus we have four positive pulses in the positive region and then four in the negative region as shown in the output frequency waveform Vo. The current waveform for this circuit will be the same as voltage waveform since the load is assumed to be purely resistive. Although the magnitude of the waveform will change based on the value of resistance of the load.

The output frequency is represented using the dotted line on the Vo waveform, since it changes polarity only for every two cycles of the input waveform the output frequency with 1/4th of the input frequency, in our case for an input frequency of 50Hz the output frequency will be (1/4 * 50) around 12.5Hz. This output frequency can be controlled by varying the triggering mechanism in the control circuit.

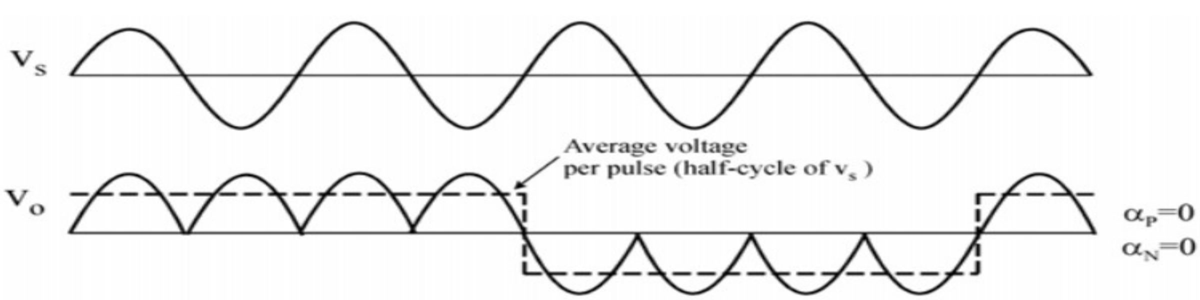

Figure 4.3 : Wave shaoe of single phase Cycloconverter

Required Apparatus :

No.	Apparatus name	Specification
01	Thyristor	
02	Resistor	10k
03	Ac supply	220V
04	Oscilloscope	TBS 1052B,50Hz,1GS/s
05	Connecting wire	

Simulated Diagram :

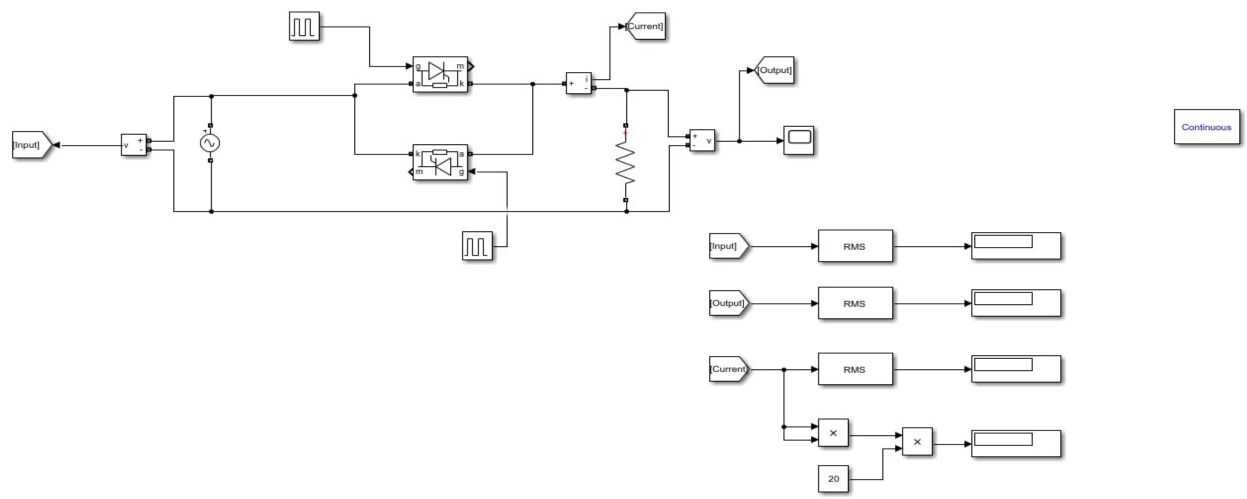

Figure 4.4 : Simulated AC voltage Controller Circuit

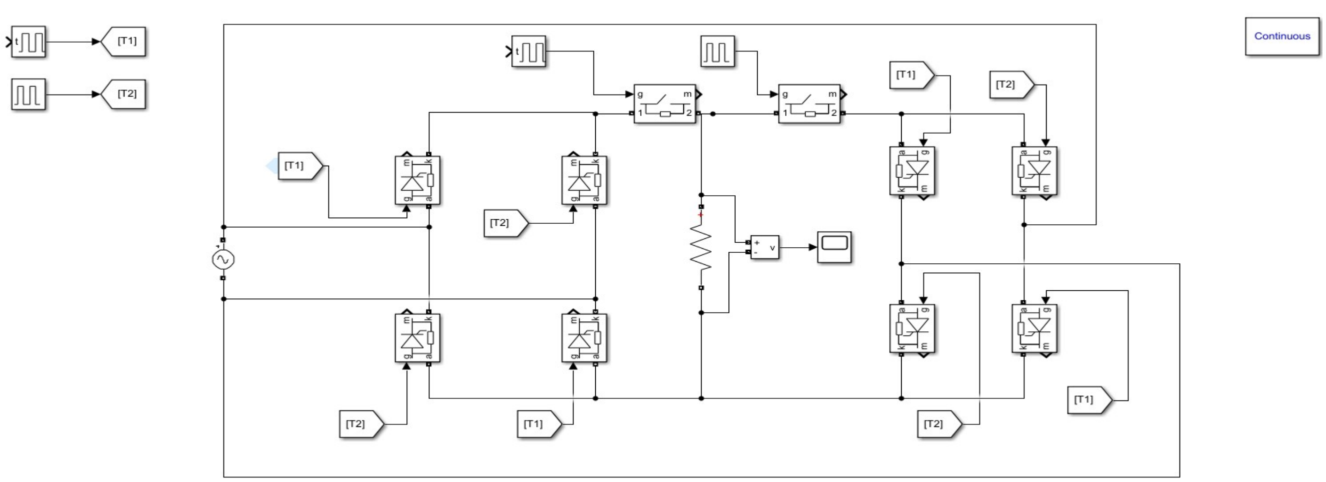

Figure 4.5 : Simulated single phase bridge cyclo converter

Wave shape :

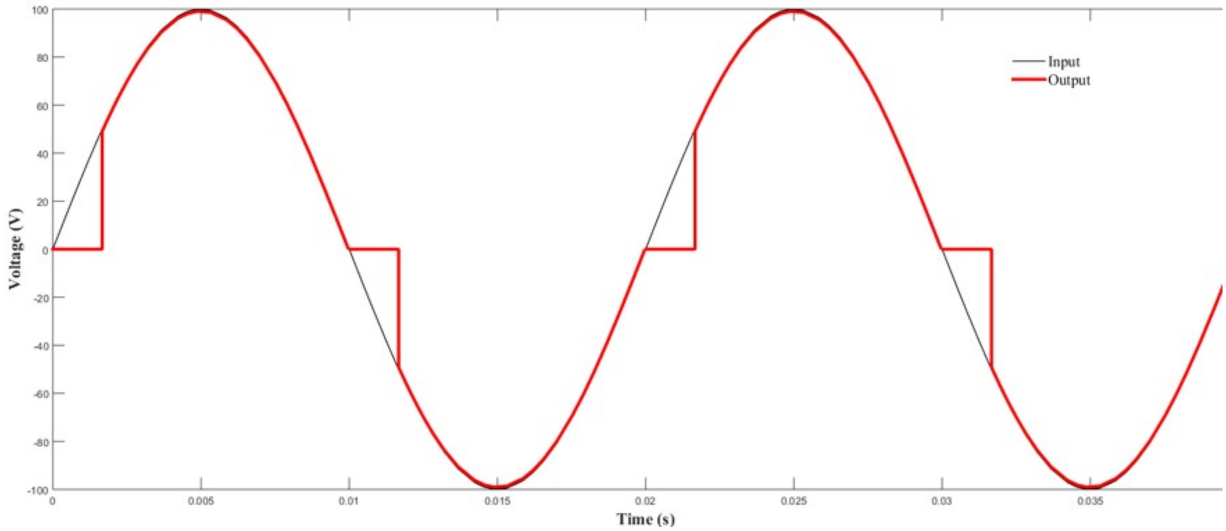

Figure 4.6 : Input Output waveshape of AC voltage controller

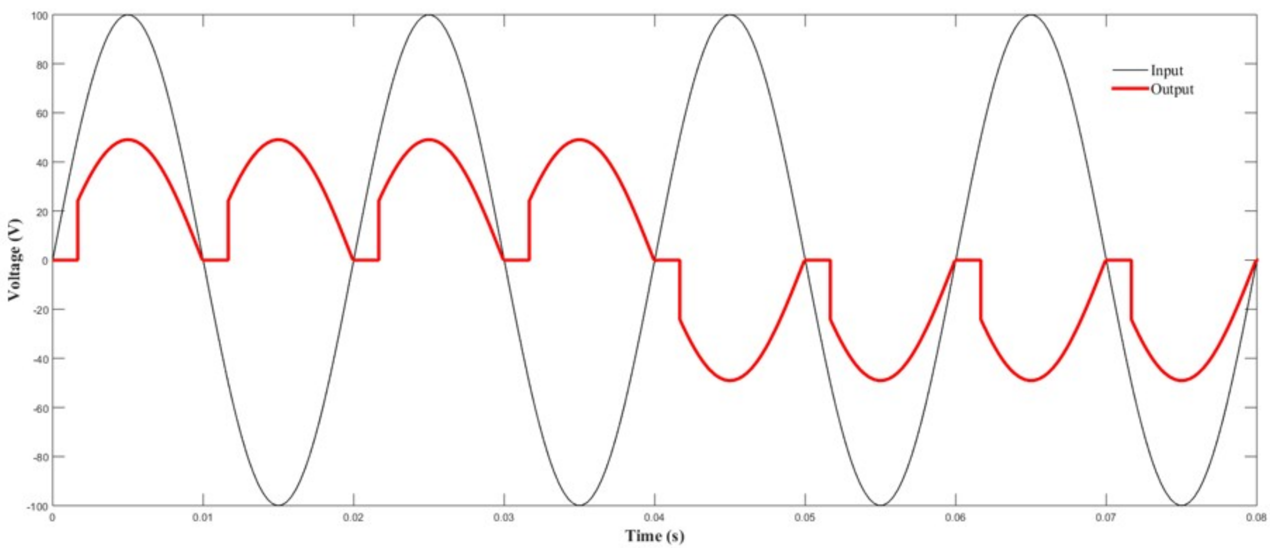

Figure 4.7 : Input output waveshape of Bridge cyclo converter.

Discussion and Conclusion : In this experiment we have simulated AC voltage controller which controlls the phase of the output. We also simulated the output of the bridge type single phase cyclo converter. The result was similar to the theory we learnt. We did not get the absolute sine wave. Because it is not possible getting the exact sine wave in power electronics. We can see that the result was expected.

Department of Electrical and Computer Engineering

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