AC-AC Converters

1. AC-AC Converters

1.1. The Purpose Of Experiment

To examine adjustable AC generating circuits with phase angle control method. In this experiment, circuits that obtain adjustable AC by phase angle control method using thyristors and triacs connected in reverse parallel will be examined. The behavior of each circuit under ohmic and inductive load will be observed.

1.2. General Information

If a thyristor switch is placed between the mains and the load, the power flow to the load can be adjusted by controlling the effective value of the AC voltage, and such circuits are called AC voltage controllers. They are circuits that are widely used in the speed control of lighting, heating and induction motors in industry. Two methods are generally used for this.

1. On-Off Control
2. Firing Angle Control

In the on-off control method, the switches open for a certain period and apply AC voltage to the load, and then they are silenced for a certain period of time and cut the voltage. In this way, the effective voltage applied to the load is adjusted. Waveforms related to this are shown in Figure 1.

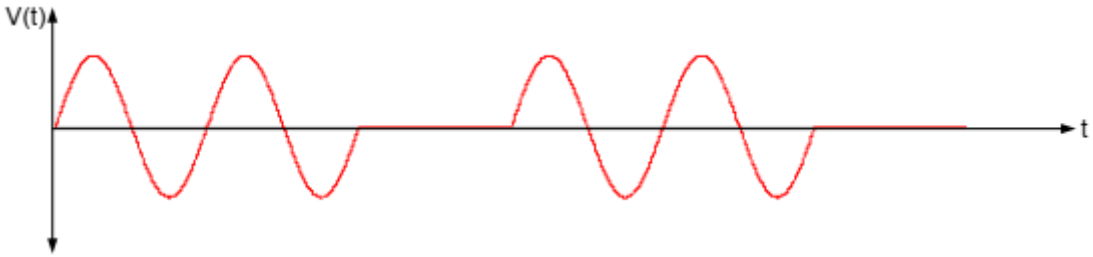


Figure 1. On-Off Control

As can be seen in Figure 1, voltage is applied for a certain period of m (2 periods for this figure) and cut for n periods (1 period for this figure), and accordingly an effective voltage will be obtained.

The phase angle control method, which is the main method to be examined in the experiment, is to control the effective value of the AC voltage by controlling the ignition angles of the thyristors as in the rectifiers. Since thyristors are unidirectional transmission elements, 2 thyristors or triacs connected in reverse parallel are used in these applications. The phase control principle is shown in Figure 2.

Phase control circuits can be single-phase or three-phase. In this experiment, only single-phase voltage choppers will be examined.

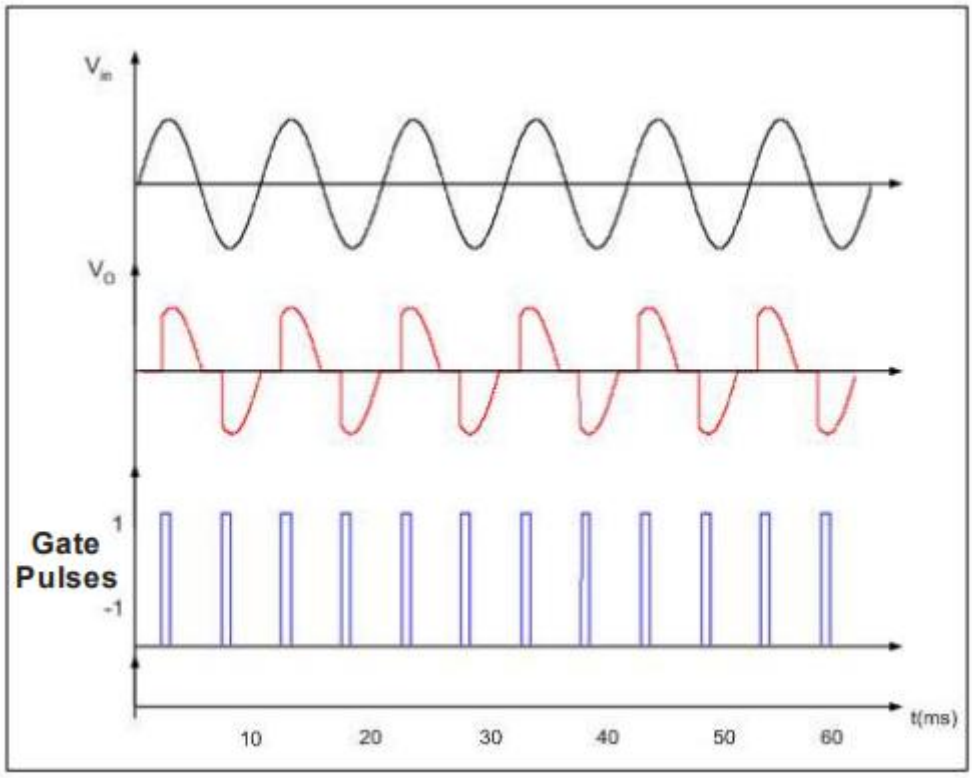


Figure 2. Phase Angle Control

According to the waveform in Figure 2, we can calculate the effective value of the AC voltage depending on the angle α.

$$V_{RMS} = \left(\frac{1}{T}\int_0^T V^2(wt)dwt\right)^{0.5} \tag{1}$$

$$V_{RMS} = \left(\frac{2}{2\pi}\int_a^{\pi} V_M^2 sin^2(wt)dwt\right)^{0.5} \rightarrow sin^2(wt) = \frac{1-\cos(2wt)}{2} \tag{2}$$

$$V_{RMS} = \left(\frac{V_M^2}{2\pi}\int_a^{\pi}(1-\cos(2wt))dwt\right)^{0.5} \rightarrow V_{RMS} = \left(\frac{V_M^2}{2\pi}\left(wt - \frac{1}{2}\sin(2wt)\right)_a^{\pi}\right)^{0.5} \tag{3}$$

$$V_{RMS} = \left(\frac{V_M^2}{2\pi}\left(\pi - a + \frac{1}{2}\sin(2a)\right)\right)^{0.5} \quad (4)$$

Where V_M is the peak of the AC voltage and α is the firing angle of the thyristor or triac in radians. As can be seen from the formula, the output voltage can be adjusted between the maximum effective value and zero by changing the ignition angle from 0 to 180 degrees.

Conducting Experiments

- **Set up the circuit shown in Figure 3.1. Measure the effective value of the voltage for 0, 45, 90, 135 degree ignition angles. Observe the typical waveform of the output voltage and current on the oscilloscope and get some drawings. Draw the voltage between the terminals of the thyristors. Plot the input current for at least one angle value.**

1.3. AC Voltage Control with Reverse Parallel Thyristors

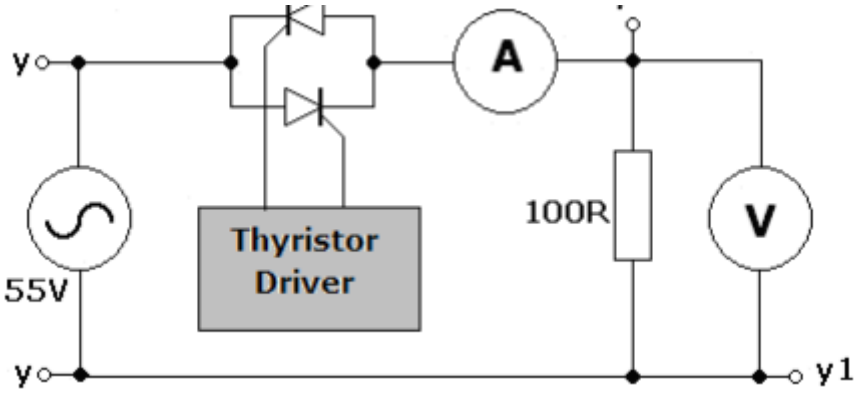


Figure 3. Reverse Parallel Thyristors (With Ohmic Load)

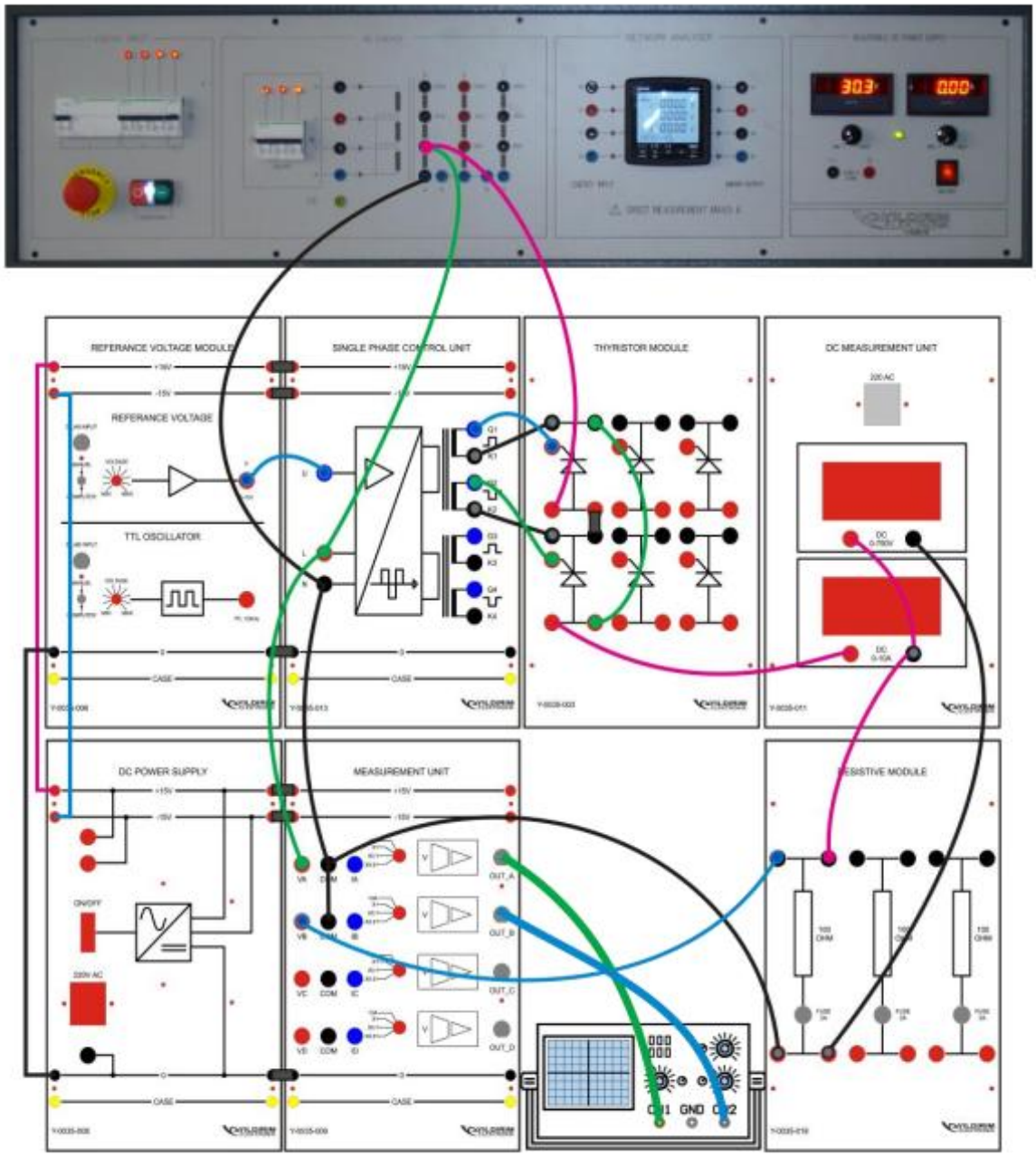


Figure 3.1. Connection Diagram

• Set up the circuit in Figure 4.1. Measure and note the effective values of the output current and voltage for different ignition angles. Also, draw the waveform of the output current and voltage by observing from the oscilloscope. Measure and note approximately the μ angle shown in Figure 4.1.1 using the oscilloscope screen.

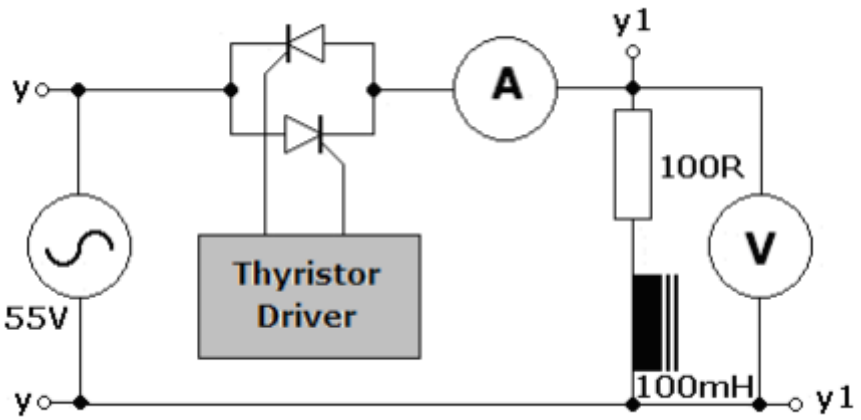
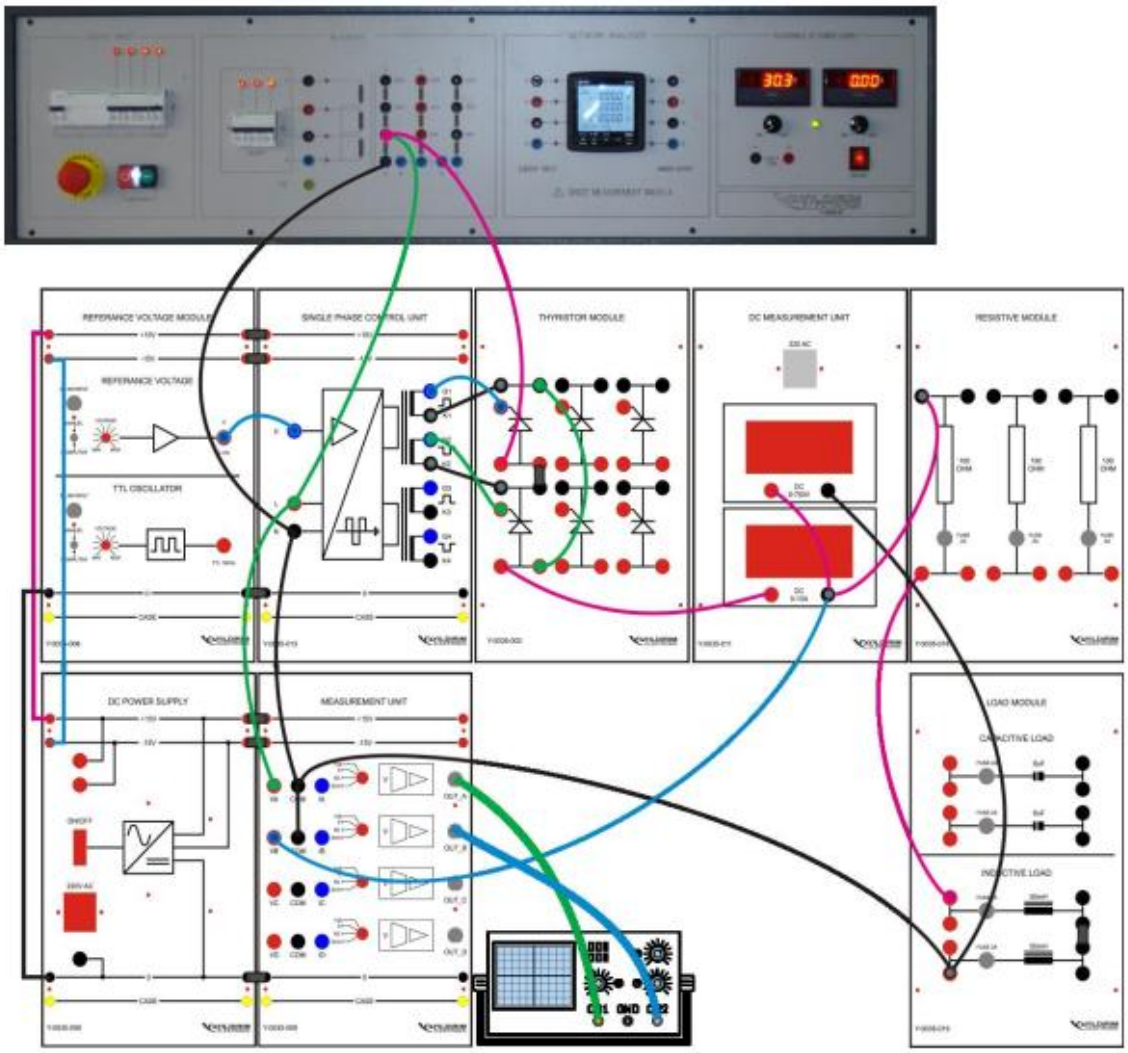
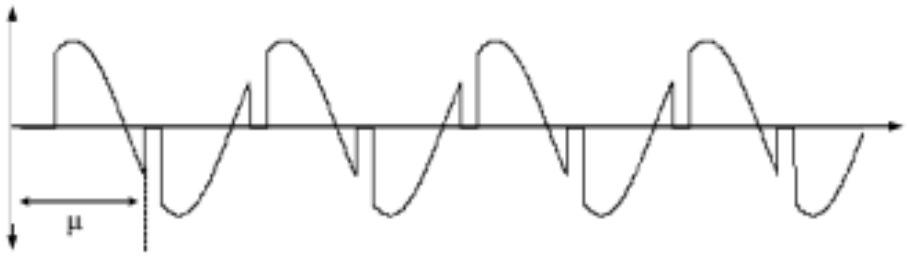


Figure 4. Reverse Parallel Connected Thyristors (Inductive Load)



Şekil 4.1. Connection Diagram



Şekil 4.1.1. Experiment Graph