Experiment 3: Study of Three-Phase Six Pulse Rectifiers using Power Diodes

Objectives:

- To become familiar with three phase six pulse diode rectifier.
- To observe the waveforms and the characteristics of the rectifier and compare them with those of the three phase three pulse rectifier.

Theory:

Figure 2-2 shows a three-phase, six-pulse rectifier, also called a three-phase bridge rectifier, which uses diodes as the rectifying device.

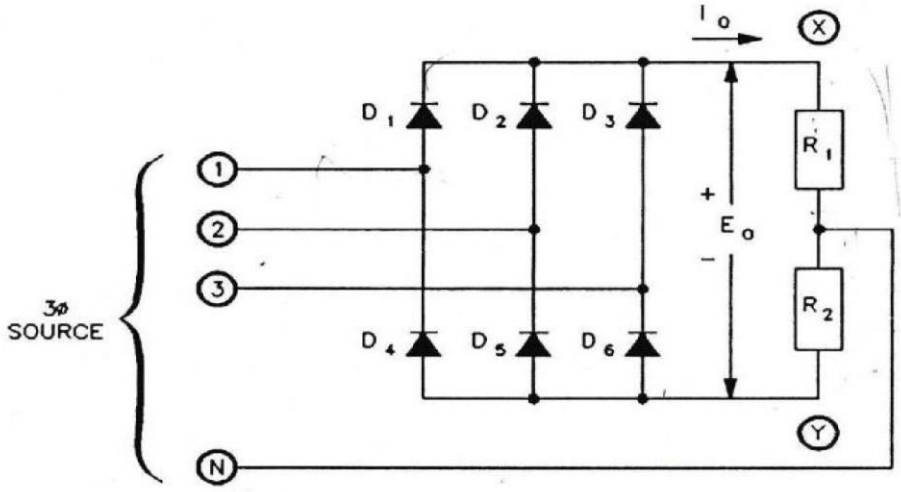


Figure 2-2. A three-phase, six-pulse rectifier using diodes.

The rectified output voltage E_O is equal to $E_{XN} + E_{NY}$ or $E_{XN} - E_{YN}$. Note that reversal of the subscripts makes $E_{NY} = -E_{YN}$. N is the neutral line of the three-phase source.

This circuit can be considered to be composed of two three-pulse rectifiers. E_{XN} is the output voltage of the three-pulse rectifier formed by D_1, D_2 and D_3. E_{YN} is of opposite polarity and is the output voltage of the three-pulse rectifier formed by D_4, D_5 and D_6.

The flow of current through R_1 is from X towards N. Current flows through R_2 from N towards Y. Since the average current flowing to or from N is zero. The N terminal of the three-phase source is not necessary for operation. It is shown here only to simplify the explanation of circuit operation. Figure 2-3 shows the output voltage waveform.

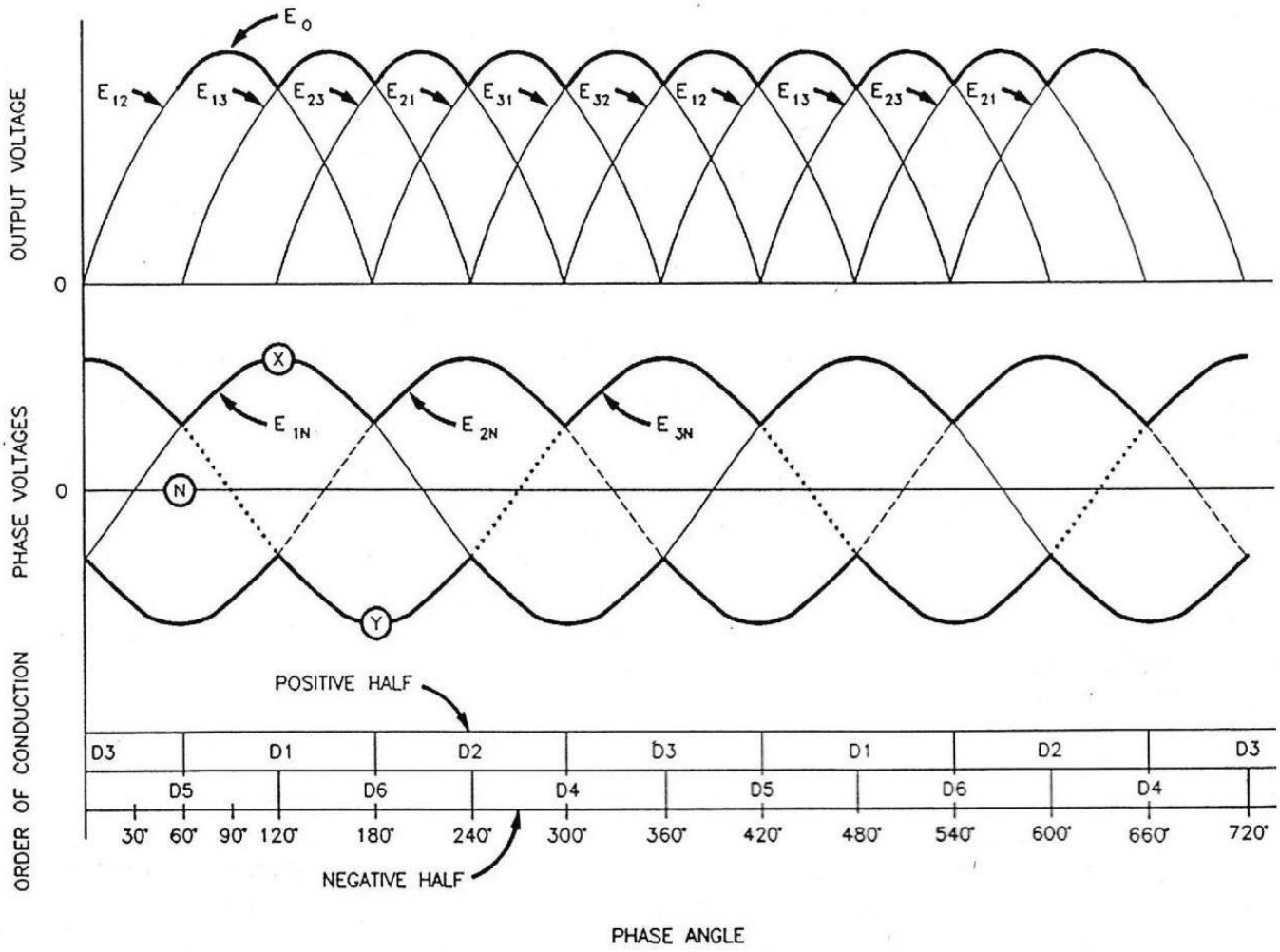


Figure 2-3. Voltage waveform of the three-phase six-pulse rectifier.

As shown in Figure 2-3, the maximum value of the output voltage is equal to the peak line-to-line voltage. The brick diagram underneath shows the order of conduction and the on-time of the six diodes. You will notice that I_O always flows through one diode of the "positive half" D_1, D_2 or D_3 and one diode of the "negative half" D_4, D_5 or D_6 of the bridge rectifier. For example,

if the phase angle is 30°, D_3 and D_5 conduct
if the phase angle is 90°, D_1 and D_5 conduct

The average value of E_O can be calculated with the equation:

$E_O = 1.35\ E_S$, where E_S = line-to-line voltage of the source [V ac]

Both the three-phase, three-pulse and the three-phase, six-pulse rectifiers can be used to supply power to an active load, as in a battery charger. They provide no means for electronically controlling the current.

Procedure summary

In the first part of the exercise, you will set up the equipment.

In the second part, you will set up a three-phase, three-pulse rectifier, observe the waveforms, and measure the output parameters.

EQUIPMENT REQUIRED

Refer to the Equipment Utilization Chart, in Appendix C of this manual, to obtain the list of the equipment required to carry out this exercise.

PROCEDURE

CAUTION!

High voltages are present in this laboratory exercise! Do not make or modify any banana jack connections with the power on unless otherwise specified!

Setting up the equipment

☐ 1. Install the Power Supply, the Enclosure / Power Supply, the Resistive Loads, the Smoothing Inductors, the DC Voltmeter/Ammeter, the AC Ammeter, and the Power Diodes modules in the Mobile Workstation.

☐ 2. Install the Current/Voltage Isolators in the Enclosure / Power Supply.

☐ 3. Make sure that the main power switch of the Power Supply is set to the O (OFF) position. Set the voltage control knob to 0. Connect the Power Supply to a three-phase wall receptacle.

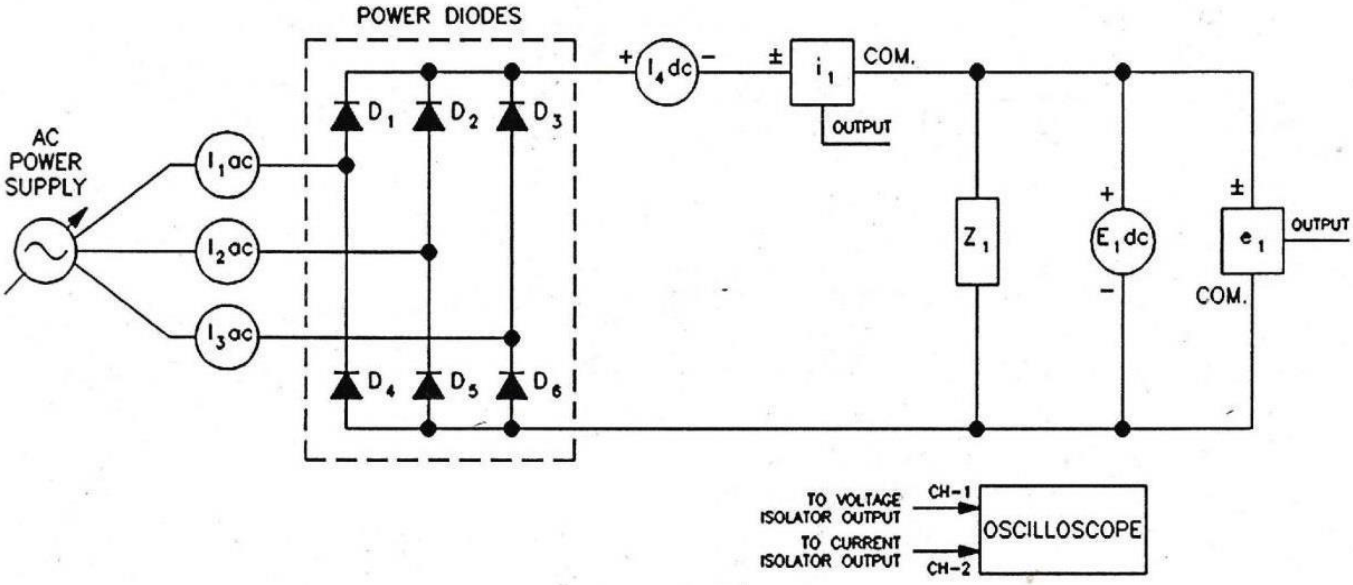
☐ 4. Plug the Enclosure / Power Supply line cord into a wall receptacle. Set the rocker switch of the Enclosure / Power Supply to the I (ON) position.

☐ 5. Make sure that the toggle switches on the Resistive Load are all set to the O (open) position.

Three-phase, six-pulse rectifier

☐ 11. Set up the circuit of Figure 2-6 using the resistive load Z_1(a).

Note: *Use two Resistive Load modules in series for Z_1. If one module is used the nominal voltage of the module will be greatly exceeded.*



LINE VOLTAGE (Vac)	I_{1-3} ac (A)	I_4dc (A)	i_1 (A)	E_1dc (V)	e_1 (V)	Z_1(a) R R	Z_1(b) R R L
120	2.5	2.5	10	300	300	R=150 Ω	R=150 Ω, L=0.2 H (3Adc max.)
220	1.5	1.5	5	600	600	R=550 Ω	R=550 Ω, L=0.8 H (1.5Adc max.)
240	1.5	1.5	5	600	600	R=600 Ω	R=600 Ω, L=0.8 H (1.5Adc max.)

Figure 2-6. Three-phase, six-pulse rectifier circuit.

☐ 12. On the Power Supply, make sure that the voltage control knob is set to the 0 position then set the main power switch to I (ON). Set the voltage control knob so that the voltage indicated by the Power Supply voltmeter is equal to 90 % of the nominal line-to-line voltage.

Sketch the voltage and current waveforms in Figure 2-7. Record the ripple frequency.

Ripple frequency = _____ Hz

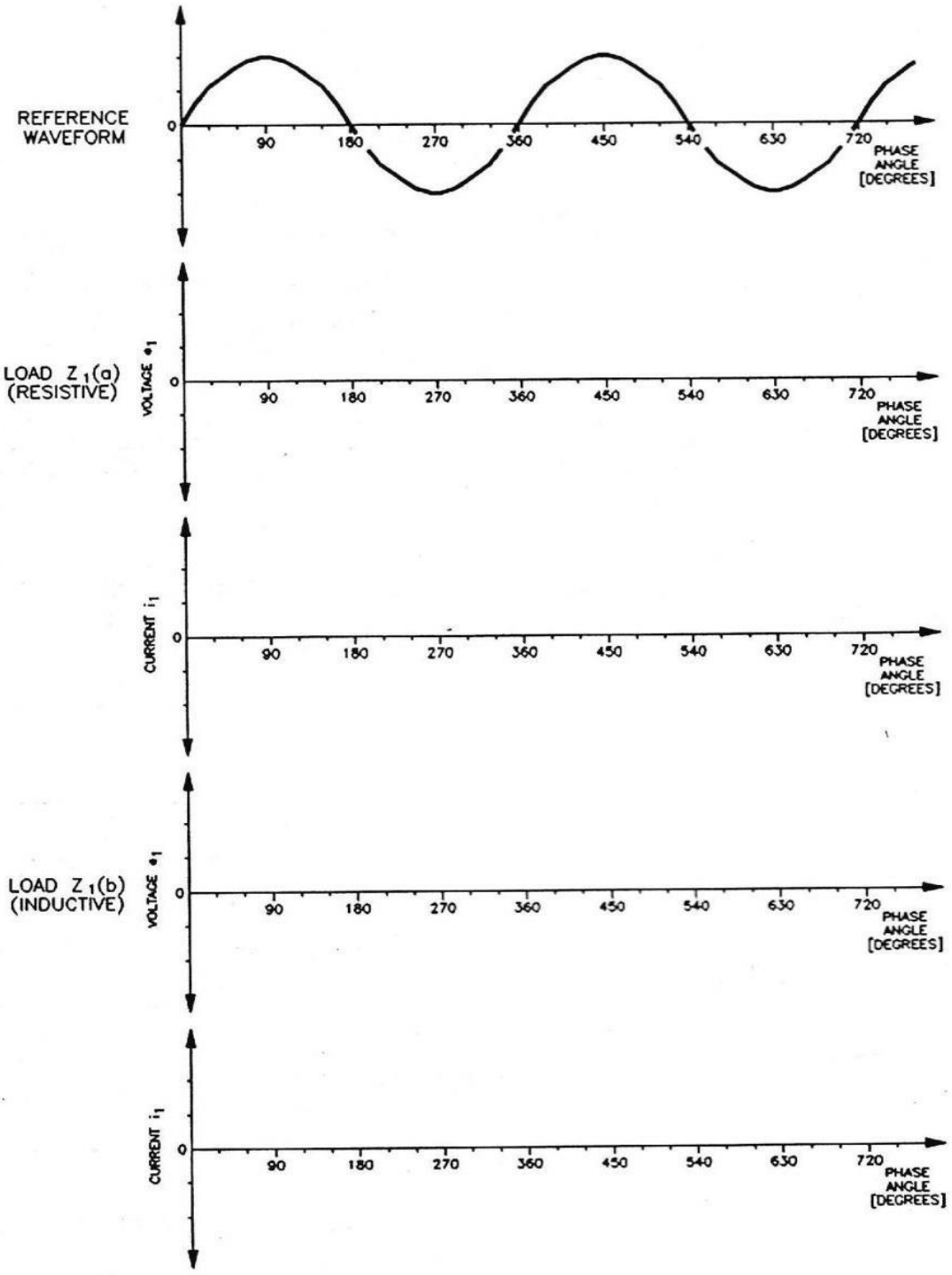


Figure 2-7. Voltage and current waveforms for three-phase, six-pulse rectifier.

Record the output voltage, current and power of the rectifier circuit in the first row of Table 2-2.

Load Z_1	Input Voltage L-L	Input Current	Output Voltage E_1 dc	Output Current I_4 dc	Output Power $P_O=E_1X\ I_4$	Conduction Angle (Theoretical)	T ON	T	Conduction Angle $(T_{ON}/T)*360$
	V	A	V	A	W	degrees	ms	ms	degrees
a)Resistive									
b)Inductive									

Table 2-2. Measurements for three-phase, six-pulse rectifier circuit.

☐ 13. To determine the diode conduction angle, connect the current isolator in series with diode D_1. Before changing any connections, set the voltage control knob on the Power Supply to 0, then set the main power switch to O (OFF).

☐ 14. With the power off, change the load in the circuit to the inductive load Z_1(b). Repeat the procedure steps necessary to complete Table 2-2 and Figure 2-7.

Compare the following characteristics of a three-phase, six-pulse rectifier to those of a three-phase, three-pulse rectifier.

Conduction angle: _____

_____

Ripple frequency: _____

_____

Average output voltage and power: _____

_____

Compare the output voltage of the circuit to the theoretical value.

Theoretical value: E_o = 1.35 E_s = _____ V dc

Measured value: E_1 = _____ V dc

☐ 15. On the Power Supply, set the voltage control knob to 0 then set the main power switch to O (OFF). Set the rocker switch on the Enclosure / Power Supply to the O position. Remove all leads and cables.

Review Questions:

1. What is the diode conduction angle in a three phase six pulse rectifier?

2. What is the average output voltage of a three phase six pulse rectifier operating on a line to line voltage 240V?

3. What are the advantages of a three phase six pulse rectifier over a three phase three pulse rectifier?

4. Write down the differences between three phase three pulse and three phase six pulse rectifiers.