Experiment 1

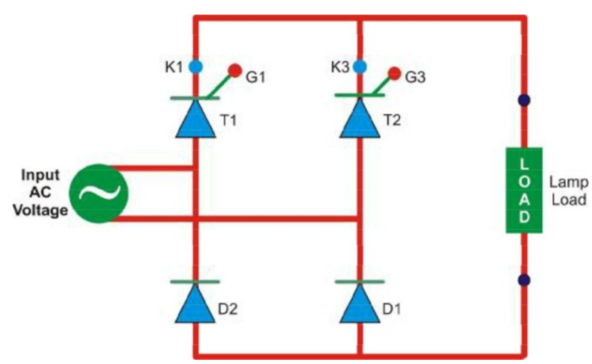
Study of Single Phase Semi-converter with R and RL load with and without freewheeling diode

Objective: Study of Single Phase Semi-converter (Common Cathode Configuration) with resistive load (Lamp load), RL load with and without freewheeling diode.

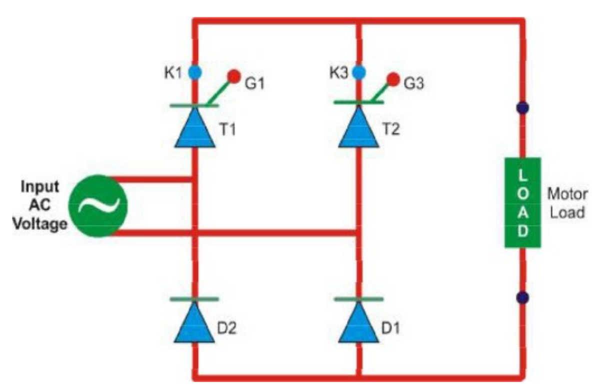
Equipments Needed:

1. Scientech 2700 High Voltage Power Electronics Lab
2. 2mm Patch Cord
3. 4mm Patch Cords
4. Product Tutorials

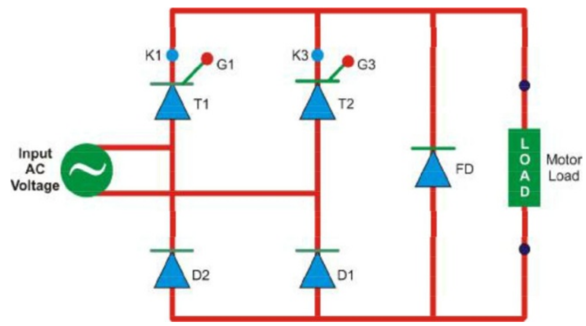
Circuit Diagram:



Single Phase Semi-converter (Common Cathode Configuration) with Lamp Load



Single Phase Semi-converter (Common Cathode Configuration) with Motor Load



Single Phase Semi-converter (Effect of Freewheeling Diode) with Motor Load

Procedure:

Make sure that there is no connection on the Work Bench initially.

1. Switch on the three phase MCB of back panel.
2. Red, Yellow and Blue indicator glow at front panel.
3. Connect +12V, +5V and ground (GND) and connect 18-0-18 at ramp comparator firing circuit from single phase low voltage power supply.
4. Use SCR1 and SCR2 from SCR Assembly and use diode D1 and diode D2 from Diode Assembly and to construct single phase semi-converter common cathode configuration.
5. Connect cathode of SCR1 to cathode of SCR2 and connect anode of diode D1 to anode of diode D2
6. Connect cathode of diode D1 to anode of SCR1 and connect cathode of diode D2 to anode of SCR2.
7. Connect Line Terminal (L) from single phase supply to anode of SCR1 or cathode of diode D1 and connect neutral terminal (N) to anode of SCR2 or cathode of diode D2.
8. Connect the one terminal of load from Load Assembly to common cathode terminal of SCR1 and SCR2 and other terminal of load is connect to common anode terminal of diode D1 and diode D2.
9. Connect gate pulse G1 at gate (G) of SCR1 and connect K1 at cathode of SCR1 from ramp comparator firing circuit.
10. Connect gate pulse G3 at gate (G) of SCR2 and connect K3 at cathode of SCR2 from ramp comparator firing circuit.
11. Verify the connections before switch on the MCB of single phase supply.
12. Connect BNC to BNC cable at CH1 of oscilloscope to output of Power Scope A.

13. Switch of ATT of A is x 100 position and switch of coupling of A is DC position.
14. Connect input of Power Scope A to the load.
15. Connect the Lamp at the Load.
16. Switch on MCB of Single Phase Supply and observe the output waveform of load terminals on the oscilloscope.
17. Connect the DC Voltmeter at the load and measure the output DC voltage across the load.
18. Observe the output waveform at the load as shown in figure.

Observation table:

R load:

Firing angle(α)	V_{avg}(Theoretical)	V_{avg}(Practical)	Time Period(ms)	V_{rms}(Theoretical)	V_{rms}(Practical)
30	193.2	193	1.667	226.66	234
40	182.54	179	2.2	222.34	227
88.2	106.79	123	4.9	166.03	184

RL load without freewheeling diode:

Firing angle(α)	V_{avg}(Theoretical)	V_{avg}(Practical)	Time Period(ms)	V_{rms}(Theoretical)	V_{rms}(Practical)
68.4	141.65	150	3.8	196.37	207
104.4	80.95	91.5	5.8	136.47	154
126	45.34	54.1	7	92.57	101

RL load with freewheeling diode:

Firing angle(α)	V_{avg}(Theoretical)	V_{avg}(Practical)	Time Period(ms)	V_{rms}(Theoretical)	V_{rms}(Practical)
68.4	141.65	151	3.8	196.37	206
102.6	80.95	97.7	5.7	136.47	160
124.2	45.34	73.3	6.9	92.57	134

Equations:

R load:

$$V_{0=}\frac{V_m}{\pi}(1+\cos\alpha)$$

$$V_{rms} = V_S \left[\frac{1}{\pi} \left[(\pi - \alpha) + \frac{\sin 2\alpha}{2} \right] \right]^{\frac{1}{2}}$$

RL load with and without freewheeling diode:

$$V_{0=} \frac{V_m}{\pi}(1 + \cos\alpha)$$

$$V_{rms} = V_S \left[\frac{1}{\pi} \left[(\pi - \alpha) + \frac{\sin 2\alpha}{2} \right] \right]^{\frac{1}{2}}$$

Theoretical calculations:

$\alpha = 30^0$ for R load

$$V_0 = \frac{230\sqrt{2}}{\pi}(1 + \cos 30^0) = 193.2 \text{ v.}$$

$$V_{rms} = 230 \left[\frac{1}{\pi} \left[(180 - 30)\frac{\pi}{180} + \frac{\sin 2(30)}{2} \right] \right]^{\frac{1}{2}} = 226.66\text{v.}$$

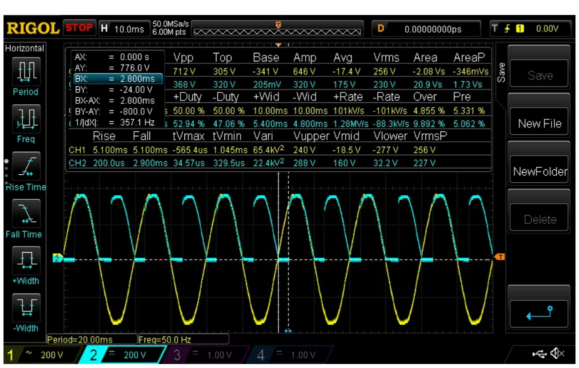
$\alpha = 68.4$ for RL load

$$V_0 = \frac{230\sqrt{2}}{\pi}(1 + \cos 68.4^0) = 141.65 \text{ v.}$$

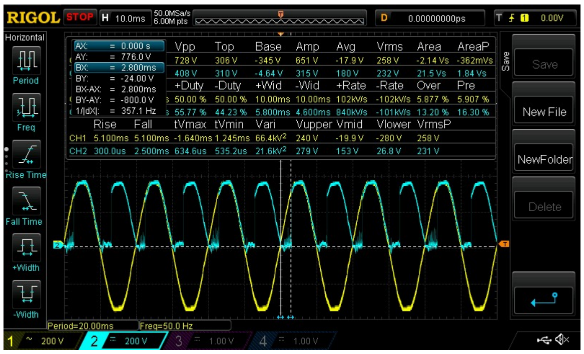
$$V_{rms} = 230 \left[\frac{1}{\pi} \left[(180 - 68.4)\frac{\pi}{180} + \frac{\sin 2(68.4)}{2} \right] \right]^{\frac{1}{2}} = 196.37\text{v.}$$

Experimental Waveforms:

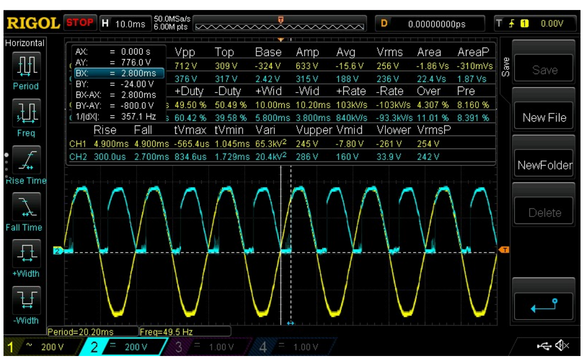
R load:



RL load:



RL load with freewheeling diode:



Conclusions: By varying the firing angle control potentiometer of ramp comparator firing circuit, output voltage across the loads, their waveform was observed.

Experiment 2

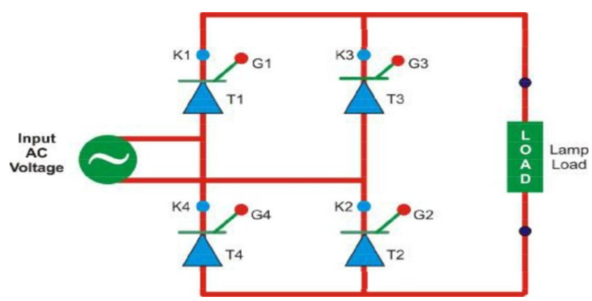
Study of Single Phase Bridge Controlled Rectifier with R and RL load with and without freewheeling diode

Objective: Study of Single Phase Bridge Controlled Rectifier with R (Lamp Load), RL (motor Load) with and without freewheeling diode.

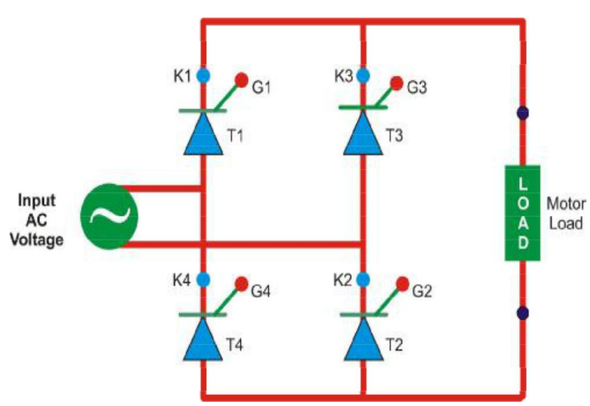
Equipments Needed:

1. Scientech 2700 High Voltage Power Electronics Lab
2. 2mm Patch Cord
3. 4mm Patch Cords
4. Product Tutorials

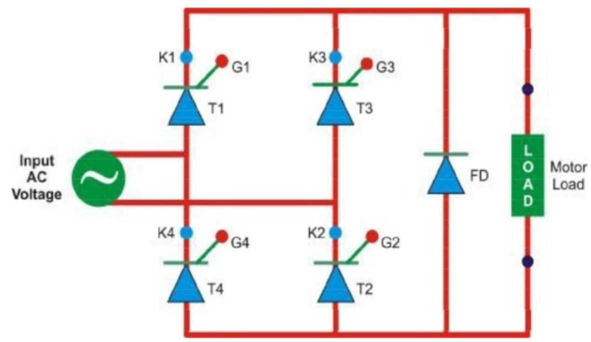
Circuit Diagram:



Single Phase Bridge Controlled Rectifier with Lamp Loa



Single Phase Bridge Controlled Rectifier with Motor Load



Single Phase Bridge Controlled Rectifier with Motor Load with freewheeling diode

Procedure:

Make sure that there is no connection on the Work Bench initially.

1. Switch on the three phase MCB of back panel.
2. Red, Yellow and Blue indicator glow at front panel.
3. Connect +12V, +5V and ground (GND) and connect 18-0-18 at ramp comparator firing circuit from single phase low voltage power supply.
4. Use SCR1, SCR2, SCR4 and SCR5 from SCR Assembly and to construct single phase bridge controlled rectifier configuration.
5. Connect cathode of SCR1 to cathode of SCR2 and connect anode of SCR4 to anode of SCR5.
6. Connect cathode of SCR4 to anode of SCR1 and connect cathode of SCR5 to anode of SCR2.
7. Connect Line Terminal (L) from single phase supply to anode of SCR1 or cathode of SCR4 and connect neutral terminal (N) to anode of SCR2 or cathode of SCR5.
8. Connect the one terminal of load from Load Assembly to common cathode terminal of SCR1 and SCR2 and other terminal of load is connect to common anode terminal of SCR4 and SCR5.
9. Connect gate pulse G1 at gate (G) of SCR1 and connect K1 at cathode of SCR1 from ramp comparator firing circuit.
10. Connect gate pulse G2 at gate (G) of SCR5 and connect K2 at cathode of SCR5 from ramp comparator firing circuit.

11. Connect gate pulse G3 at gate (G) of SCR2 and connect K3 at cathode of SCR2 from ramp comparator firing circuit.
12. Connect gate pulse G4 at gate (G) of SCR4 and connect K4 at cathode of SCR4 from ramp comparator firing circuit.
13. Verify the connections before switch on the MCB of single phase supply.
14. Connect BNC to BNC cable at CH1 of oscilloscope to output of Power Scope A.
15. Switch of ATT of A is x 100 position and switch of coupling of A is DC position.
16. Connect input of Power Scope A to the load.
17. Connect the Lamp at the Load.
18. Switch on MCB of Single Phase Supply and observe the output waveform of load terminals on the oscilloscope.
19. Connect the DC Voltmeter at the load and measure the output DC voltage across the load.
20. Observe the output waveform at the load as shown in figure.

Observation table:

R load:

Firing angle(α)	V_{avg}(Theoretical)	V_{avg}(Practical)	Time Period(ms)	V_{rms}(Theoretical)	V_{rms}(Practical)
30	193.2	207	1.667	226.66	239
60	155.3	151	3.33	206.3	209
108	51.76	55.9	6	127.33	128
120	71.54	58.8	6.667	101.69	120

RL load without freewheeling diode:

Firing angle(α)	V_{avg} (Theoretical)	V_{avg} (Practical)	Time Period(ms)	V_{rms} (Theoretical)	V_{rms} (Practical)	β (ms)	β (degrees)
60	140.68	150	3.33	209	208	11.5	207
108	57.12	68.7	6	130.195	140	11.3	203.4
120	37.34	22	6.66	109.34	99.8	11.7	210.6
150	-0.547	-8.24	8.33	56.039	44.2	11.7	210.6

RL load with freewheeling diode:

Firing angle(α)	V_{avg}(Theoretical)	V_{avg}(Practical)	Time Period(ms)	V_{rms}(Theoretical)	V_{rms}(Practical)
60	155.3	148	3.33	206.3	207
108	71.54	83.9	6	127.32	143
120	51.76	44	6.67	101.69	99.7
150	13.87	4.97	8.33	39.05	38.3

Equations:

R load:

$$V_{0=}\frac{V_m}{\pi}(1+\cos\alpha)$$

$$V_{rms}=V_S\left[\frac{1}{\pi}\left[(\pi-\alpha)+\frac{\sin 2\alpha}{2}\right]\right]^{\frac{1}{2}}$$

RL load with and without freewheeling diode:

$$V_{0=}\frac{V_m}{\pi}(\cos\alpha-\cos\beta)$$

$$V_{rms}=V_S\left[\frac{1}{\pi}\left[(\beta-\alpha)+\frac{\sin 2\alpha-\sin 2\beta}{2}\right]\right]^{\frac{1}{2}}$$

Theoretical calculations:

α=30^0 for R load

$$V_0=\frac{230\sqrt{2}}{\pi}\left(1+\cos 30^0\right)=193.2 \text{ v.}$$

$$V_{rms}=230\left[\frac{1}{\pi}\left[(180-30)\frac{\pi}{180}+\frac{\sin 2(30)}{2}\right]\right]^{\frac{1}{2}} = 226.66\text{v.}$$

α=60^0 for RL load without freewheeling diode

$$V_0=\frac{230\sqrt{2}}{\pi}(\cos 60-\cos 207)=140.88 \text{ v.}$$

$$V_{rms}=230\left[\frac{1}{\pi}\left[(207-60)\frac{\pi}{180}+\frac{\sin 2(60)-\sin 2(207)}{2}\right]\right]^{\frac{1}{2}} = 209\text{v.}$$

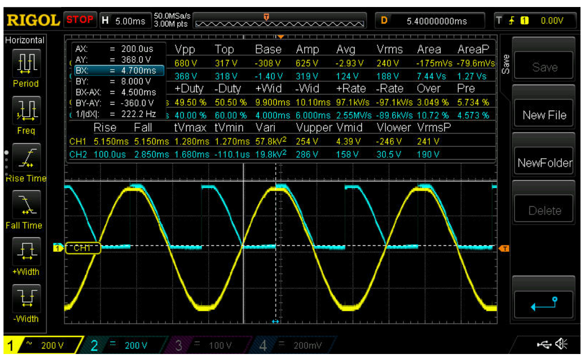
α=60^0 for RL load with freewheeling diode

$$V_0 = \frac{230\sqrt{2}}{\pi}\left(1 + \cos 60^0\right) = 155.3 \text{ v.}$$

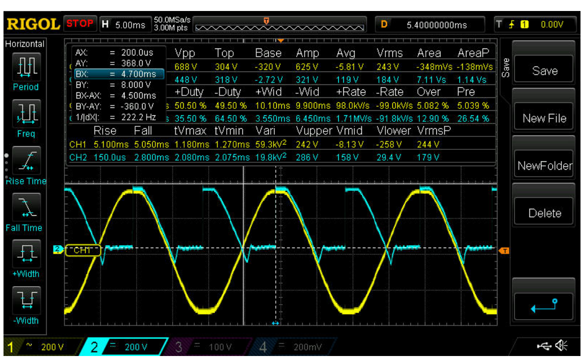
$$V_{rms} = 230\left[\frac{1}{\pi}\left[(180-60)\frac{\pi}{180} + \frac{\sin 2(60)}{2}\right]\right]^{\frac{1}{2}} = 206.3\text{v.}$$

Experimental Waveforms:

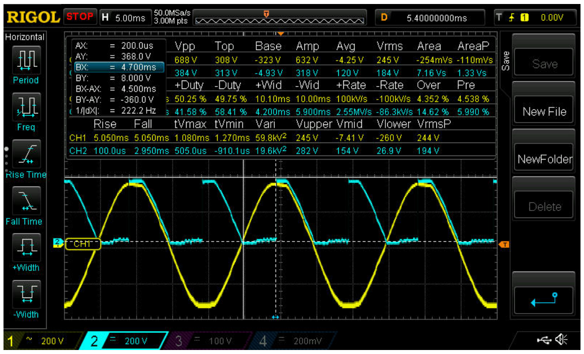
R load



RL load



RL load with Freewheeling Diode



Conclusions: By varying the firing angle control potentiometer of ramp comparator firing circuit, output voltage across the loads, their waveform for single phase full wave bridge converter was observed.

Experiment 3

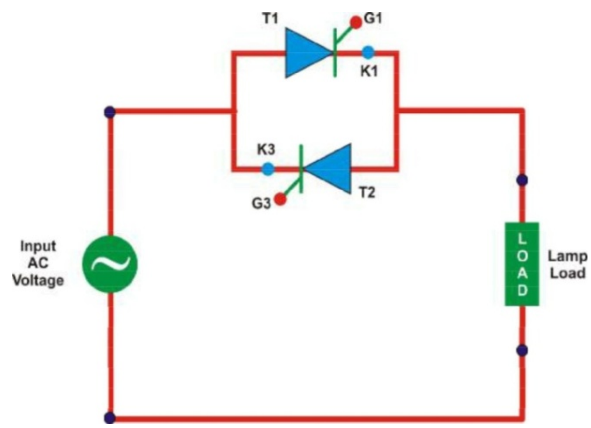
Study of Single Phase Full Wave AC Voltage Controller with R and RL load

Objective: Study of Single Phase Full Wave AC Voltage Controller with R(Lamp Load) and RL (motor load).

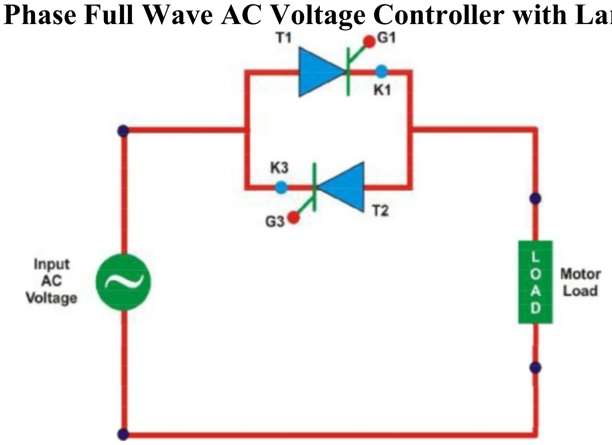
Equipments Needed:

1. Scientech 2700 High Voltage Power Electronics Lab
2. 4mm Patch Cords
3. Product Tutorials

Circuit Diagram:



Single Phase Full Wave AC Voltage Controller with Lamp Load



Single Phase Full Wave AC Voltage Controller with Motor Load

Procedure:

Make sure that there is no connection on the Work Bench initially.

1. Switch on the three phase MCB of back panel.
2. Red, Yellow and Blue indicator glow at front panel.
3. Connect +12V, +5V and ground (GND) and connect 18-0-18 at ramp comparator firing circuit from single phase low voltage power supply.
4. Use SCR1 and SCR2 from SCR Assembly and to construct single phase full wave AC voltage controller.
5. Connect cathode of SCR1 to anode of SCR2 and connect cathode of SCR2 to anode of SCR1.
6. Connect Line Terminal (L) from single phase supply to anode of SCR1 or cathode of SCR2.
7. Connect the one terminal of load from Load Assembly to common cathode anode terminal of SCR1 and SCR2 and other terminal of load is connect to neutral terminal (N) of single phase supply.
8. Connect gate pulse G1 at gate (G) of SCR1 and connect K1 at cathode of SCR1 from ramp comparator firing circuit.
9. Connect gate pulse G3 at gate (G) of SCR2 and connect K3 at cathode of SCR2 from ramp comparator firing circuit.
10. Verify the connections before switch on the MCB of single phase supply.
11. Connect BNC to BNC cable at CH1 of oscilloscope to output of Power Scope A.
12. Switch of ATT of A is x 100 position and switch of coupling of A is AC position.
13. Connect input of Power Scope A to the load.
14. Connect the Universal Motor at the Load.
15. Switch on MCB of Single Phase Supply and observe the output waveform of load terminals on the oscilloscope.
16. Connect the AC Voltmeter at the load and measure the output AC voltage across the load.

    Observe the output waveform at the load as shown in figure

Observation table:

R load:

Firing angle(α)	V_{avg}(Theoretical)	V_{avg}(Practical)	Time Period(ms)	V_{rms}(Theoretical)	V_{rms}(Practical)
59.4	0	-3.58	3.3	206.3	229
108	0	-6.9	6	127.33	161
120	0	-1.74	6.7	101.69	151

RL load :

Firing angle(α)	V_{avg} (Theoretical)	V_{avg} (Practical)	Time Period(ms)	V_{rms} (Theoretical)	V_{rms} (Practical)	β (ms)	β (degrees)
60	0	-7.51	3.33	214.98	227	11.5	207
90	0	-8.19	5	168.36	183	11.3	212.4
108	0	-3.55	6	134.59	152	12.3	221.4
120	0	-4.82	118.979	118.979	118	11.8	212.4

Equations:

R load:

$$V_{rms} = V_S\left[\frac{1}{\pi}\left[(\pi-\alpha)+\frac{\sin 2\alpha}{2}\right]\right]^{\frac{1}{2}}$$

RL load:

$$V_{rms} = V_S\left[\frac{1}{\pi}\left[(\beta-\alpha)+\frac{\sin 2\beta-\sin 2\alpha}{2}\right]\right]^{\frac{1}{2}}$$

α=59.4^0 for R load

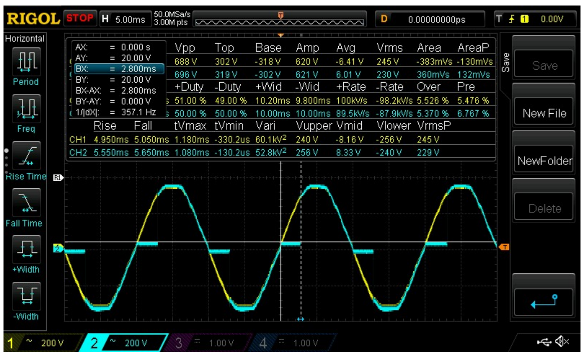
$$V_{rms} = 230\left[\frac{1}{\pi}\left[(180-59.4)\frac{\pi}{180}+\frac{\sin 2(59.4)}{2}\right]\right]^{\frac{1}{2}} = 206.93\text{v.}$$

α=60^0 for RL load

$$V_{rms} = 230\left[\frac{1}{\pi}\left[(207-60)\frac{\pi}{180}+\frac{\sin 2(207)-\sin 2(60)}{2}\right]\right]^{\frac{1}{2}} = 214.98\text{v.}$$

Experimental Waveforms:

R load



RL load

Conclusions: By varying the firing angle control potentiometer of ramp comparator firing circuit, output voltage across the loads, their waveform for single phase full wave AC voltage controller with R and RL Loads was observed.

Experiment 4

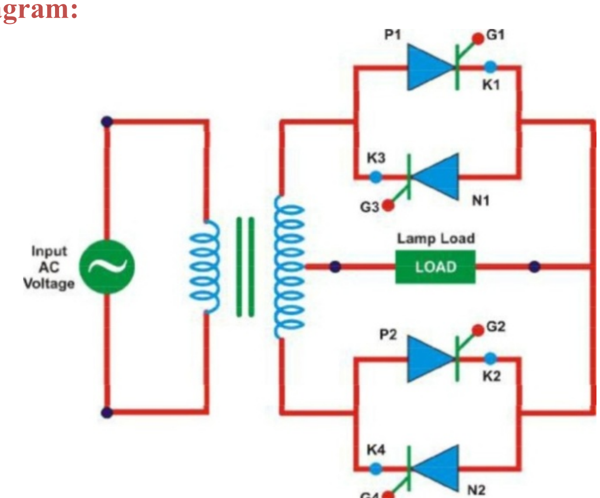
Study of Single Phase Cycloconverter with Lamp and motor Load.

Objective: Study of Single Phase Cycloconverter with Lamp and motor Load.

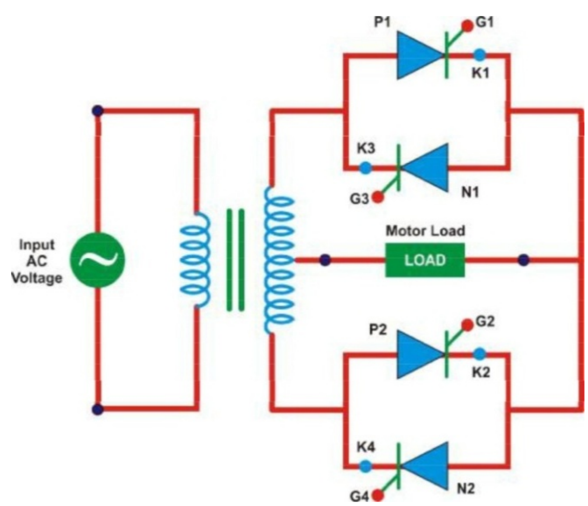
Equipments Needed:

1. Scientech 2700 High Voltage Power Electronics Lab
2. 4mm Patch Cords
3. Product Tutorials

Circuit Diagram:



Single Phase Cycloconverter with Lamp Load



Single Phase Cycloconverter with motor loa

Procedure:

Make sure that there is no connection on the Work Bench initially.

1. Switch on the three phase MCB of back panel.
1. Red, Yellow and Blue indicator glow at front panel.
2. Connect +12V, +5V, and ground (GND) and connect 18-0-18 at cycloconverter firing circuit from single phase low voltage power supply.
3. Use SCR1, SCR4, SCR2 and SCR5 and construct single phase cycloconverter configuration.
4. Connect the cathode of SCR1 to anode of SCR4 and connect the anode of SCR1 to cathode of SCR4.
5. Connect the cathode of SCR2 to anode of SCR5 and connect the anode of SCR2 to cathode of SCR5.
6. Connect the cathode of SCR1 to cathode of SCR2.
7. Connect the one terminal of load from load assembly to common cathode terminal of SCR1 and SCR2 and connect other terminal of load from load assembly to center tapped transformer output neutral (0) terminal from Single Phase Supply.
8. Connect 115V terminal from single phase supply to anode of SCR1 or cathode of SCR4.
9. Connect another 115V terminal from single phase supply to anode of SCR2 or cathode of SCR5.
10. Connect gate pulse G1 at gate (G) of SCR1 and connect K1 at cathode of SCR1 from cycloconverter firing circuit.
11. Connect gate pulse G3 at gate (G) of SCR4 and connect K3 at cathode of SCR4 from cycloconverter firing circuit
12. Connect gate pulse G2 at gate (G) of SCR2 and connect K2 at cathode of SCR2 from cycloconverter firing circuit
13. Connect gate pulse G4 at gate (G) of SCR5 and connect K4 at cathode of SCR5 from cycloconverter firing circuit.
14. Verify the connections before switch on the MCB of single phase supply.
15. Connect BNC to BNC cable at CH1 of oscilloscope to output of Power Scope A.
16. Connect input of Power Scope A to the load.
17. Switch of ATT of A is x 100 position and switch of coupling of A is AC position.
18. Connect the Lamp at the Load.
19. Switch on MCB of single phase supply and observe the output waveform of Load terminal on the oscilloscope.

20. Connect the AC voltmeter at the load and measure the output AC voltage across the load.
21. Observe the output waveform at the load as shown in figure.

Observation table:

With Ramp Comparator Firing Circuit:

R load:

Firing angle (α)	Time Period (ms)	Frequency	V_{rms} (Theoretical)	V_{rms} (Practical)	V_{avg} (Theoretical)	V_{avg} (Practical)
32.4	1.8	16.67	112.911	1.25	0	-8.82
64.8	3.6	16.67	100.428	111.6	0	10.6
90	5	16.67	81.317	97.4	0	-12.9
117	6.6	16.67	52.147	76	0	-10.9

RL load:

Firig angle (α)	V_{avg} (Theoretical)	V_{avg} (Practical)	V_{rms} (Theoretical)	V_{rms} (Practical)	β (ms)	Frequency
30	0	-7.21	115	124	11.6	16.67
90	0	-8.97	107.65	105	12.2	16.67
170	0	-13.9	108.686	80.2	12.6	16.67

With Cycloconverter Firing Circuit:

R load

Firing angle (α)	Time Period (ms)	Frequency	V_{rms} (Theoretical)	V_{rms} (Practical)	V_{avg} (Theoretical)	V_{avg} (Practical)
60	3.4	16.67	103.14	115	0	-3.18
90	5	16.67	81.317	95.2	0	-1.67
108	6	16.67	63.66	78.9	0	-2.94
117	6.6	16.67	54.09	68	0	-1.02

RL load

Firing angle (α)	β (ms)	Frequency	V_{rms} (Theoretical)	V_{rms} (Practical)	V_{avg} (Theoretical)	V_{avg} (Practical)
32.4	21.6	50	115.72	121	0	-10.2
60	230.4	50	110.79	119	0	-9.5
90	230.4	50	90.818	105	0	-8.49
117	230.4	50	67.538	16.9	0	-4.15

Equations:

R load:

$$V_{rms} = V_S\left[\frac{1}{\pi}\left[(\pi-\alpha)+\frac{\sin 2\alpha}{2}\right]\right]^{\frac{1}{2}}$$

RL load:

$$V_{rms} = V_S\left[\frac{1}{\pi}\left[(\beta-\alpha)+\frac{\sin 2\beta - \sin 2\alpha}{2}\right]\right]^{\frac{1}{2}}$$

$\alpha=60^0$ for R load

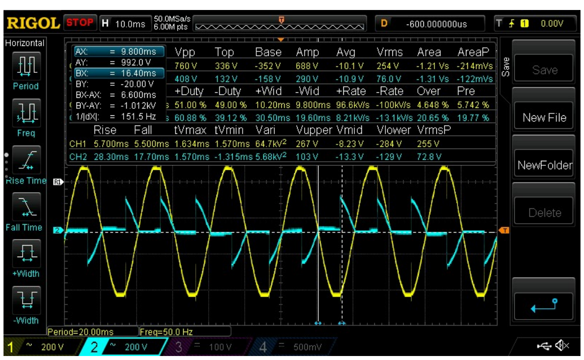
$$V_{rms} = 115\left[\frac{1}{\pi}\left[(180-60)\frac{\pi}{180}+\frac{\sin 2(60)}{2}\right]\right]^{\frac{1}{2}} = 103.14\text{v.}$$

$\alpha=60^0$ for RL load

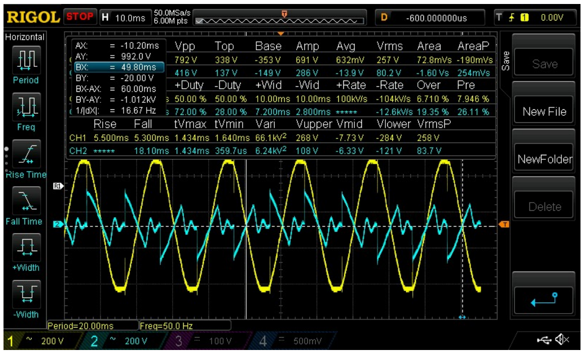
$$V_{rms} = 115\left[\frac{1}{\pi}\left[(216-32.4)\frac{\pi}{180}+\frac{\sin 2(216)-\sin 2(32.4)}{2}\right]\right]^{\frac{1}{2}} = 115.72\text{v.}$$

Experimental Waveforms:

R load



RL load



Conclusions: By varying the firing angle control potentiometer of ramp comparator firing circuit, output voltage across the loads, their waveform for single phase Cycloconverter controller with R and RL Loads was observed.

Experiment 5

Study the Characteristics of MOSFET

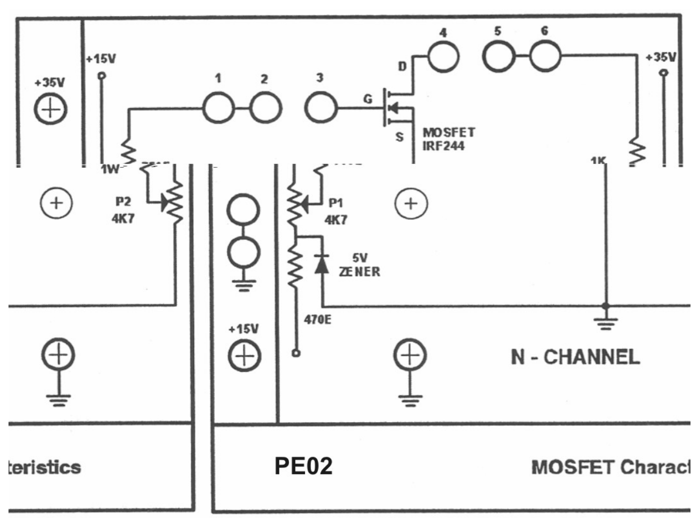
Objective: To Study the Characteristics of MOSFET.

Equipments Needed:

1. Power Electronics Board, **PE02**
2. DC power supplies + 15 V and + 35 V.
3. Digital multi-meter.
4. 2mm patch cords.

Circuit diagram:

Circuit used to plot different characteristics of MOSFET is shown in figure 5.



Procedure :

- Connect +35 V and +15 V DC power supplies at their indicated position from external source.

1. To plot drain characteristics proceed as follows:
2. Rotate both the potentiometer P_1 and P_2 fully in counter clockwise direction.
3. Connect Ammeter between test point '2' and '3' to measure gate current I_G (mA) between test point '4' and '5' to measure drain current I_D(mA).
4. Short or connect a 2mm patch cord between test point '4' and '5'.
5. Connect one voltmeter between test point '6' and ground to measure drain voltage V_{DS} other voltmeter between test point '1' and ground to measure gate voltage V_{GS}.
6. Switch 'On' the power supply.
7. Vary potentiometer P_2 and set a value of gate voltage V_{GS} at some constant value (3 V, 3.1 V, 3.2 V)
8. Vary the potentiometer P_1 so as to increase the value of drain voltage V_{DS} from zero to 35 V in step and measure the corresponding values of drain current I_E for different constant value gate voltage V_{GS} in an observation table.
9. Rotate potentiometer P_1 fully in counter clockwise direction.
10. Repeat the procedure from step 6 for different sets of gate voltage V_{GS}.
11. Plot a curve between drain voltage V_{GS} and drain current 10 using suitable scale with the help of observation table. This curve is the required drain characteristic.

Observation Table:

Transfer Characteristics:

V_{GS} (V)	I_D (μA)
0.5	0
1.1	0.1
1.4	1.2
1.5	10.8
1.8	400
1.9	1800
2	19600
2.1	44700
2.2	14800
2.3	25000
2.4	27400
2.5	27600
2.6	27700
3.6	27800

Output Characteristics:

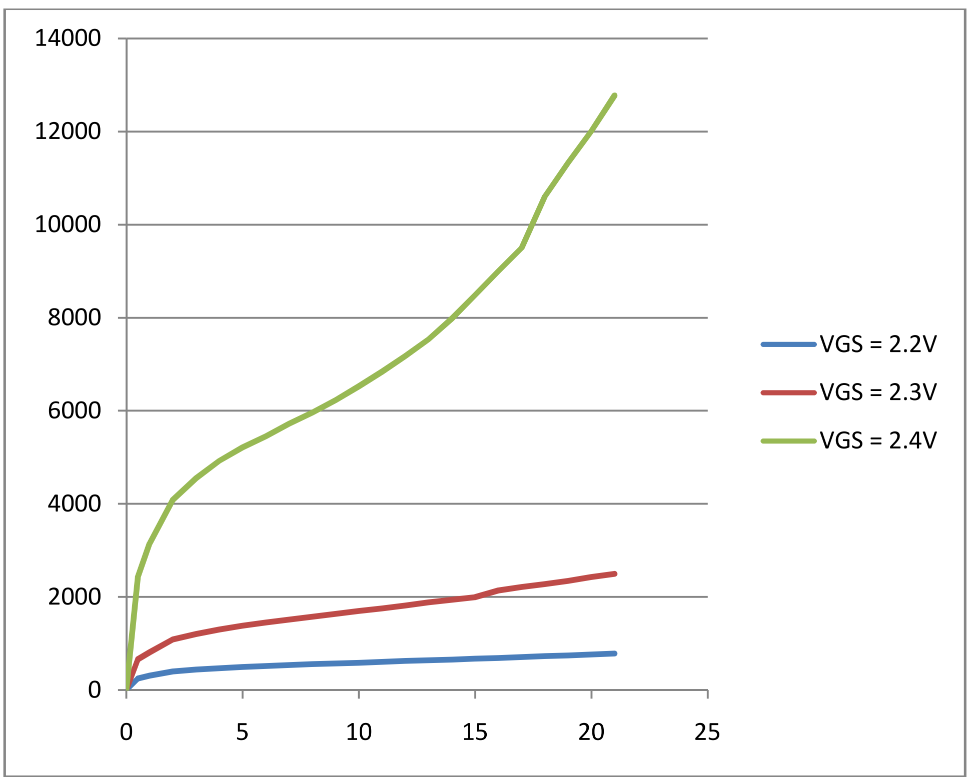
Drain current I_D(mA) at constant voltage of gate voltage

Drain Voltage VDS	Drain current ID(mA) at constant value of Gate Voltage		
	VGS = 2.2V	VGS = 2.3V	VGS = 2.4V
0.0	0.000	0.000	0.000
0.5	0.250	0.660	2.420
1.0	0.311	0.816	3.150
2.0	0.399	1.086	4.080
3.0	0.440	1.207	4.550
4.0	0.474	1.303	4.920
5.0	0.500	1.382	5.210
6.0	0.520	1.452	5.450
7.0	0.538	1.517	5.720
8.0	0.558	1.580	5.960
9.0	0.571	1.640	6.230
10.0	0.588	1.700	6.520
11.0	0.606	1.755	6.840

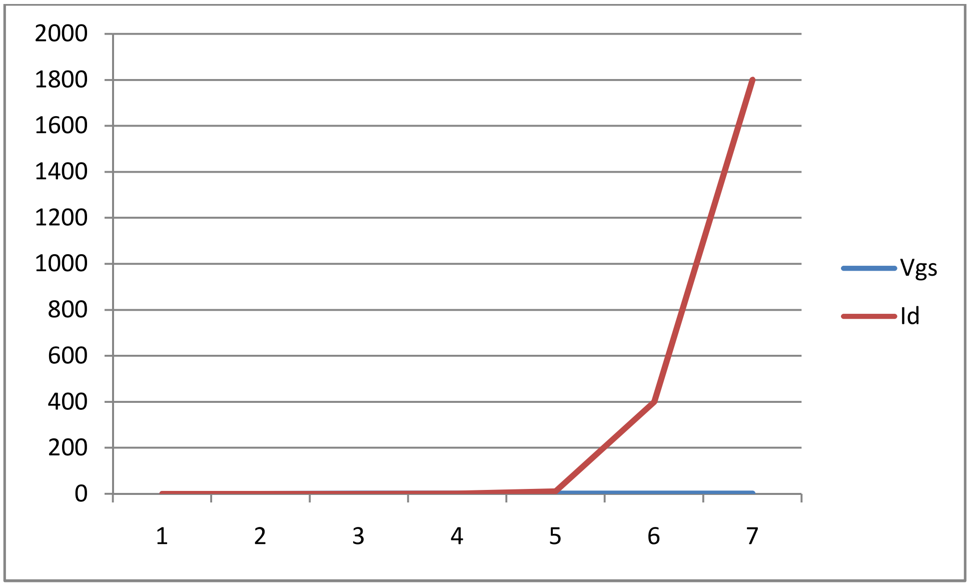
12.0	0.627	1.820	7.170
13.0	0.642	1.885	7.530
14.0	0.660	1.945	7.980
15.0	0.678	2.000	8.480
16.0	0.692	2.140	9.000
17.0	0.712	2.220	9.500
18.0	0.735	2.280	10.600
19.0	0.750	2.350	11.330
20.0	0.768	2.430	12.000
21.0	0.789	2.500	12.770

Experimental Waveforms:

Output Characteristics



Transfer Characteristics



c

Conclusions: Transfer and output characteristics of MOSFET are plotted on a graph with respective values.