Power Electronics Laboratory (EE3P004)

EXPERIMENT-2

Operation of Single-Phase AC Voltage with Different Types of Loads

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Aim of Experiment:

To study the operation of single-phase AC voltageregulator with different types of load.

Apparatus Required:

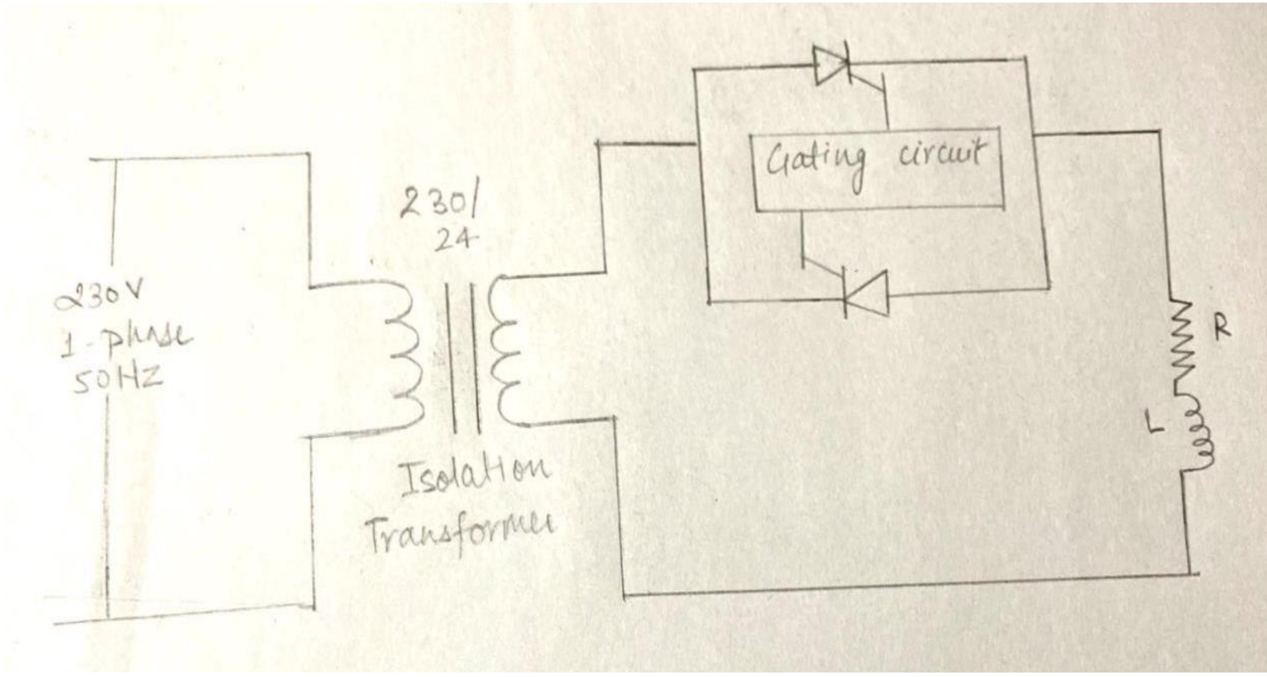
Sl. No.	Apparatus Required	Specification	Quantity
01	Module (Single Phase AC Voltage Controller)	Vi Microsys, (PEC14M14AC)	01No.
02	Digital Storage Oscilloscope (TDS 2014C)	4 Channel, 100 MHz, 2Gs/s	01No.
03	Voltage Probe (TPP0201)	200 MHz, 10 MΩ/<12pF, 10x	01No.
04	Extension Cord		01No.
05	Patch Chord		11 Nos.

Theory:

A single-phase AC regulator consists of two SCR’s connected in ant parallel. During positive half cycle SCR1 forward biased and the current flow through P-SCR1-Load-N. Negative cycle of input supply N-Load-SCR3-P. The firing pulses of SCR1, SCR3 are kept at 450

For R-L load during positive half cycle SCR1 is triggered into firing angle delay α. The current raises slowly due to inductance load. The current continue flow even after the supply voltage reverse polarity because of stored energy in the inductor. As long as SCR1 conducts,SCR3 will be on reverse bias, hence SCR3 will not turn ON even if gating signal is applied.SCR3 can be triggered into conduction during negative half cycle after SCR1, turns off.

CIRCUIT DIAGRAM:



Observation Table:

Table-1 (R Load)

Sl. No.	Control voltage	Firing angle α in degree	Measured o/p voltage	Calculated o/p voltage
1	27.5	0	26.3	27.5
2	27.5	36	26	26.82
3	27.5	72	23.5	22.90
4	27.5	108	16.8	14.95
5	27.5	144	7.55	6.06

Table-2 (for R-L load)

Sl. No.	Control voltage	Firing angle in degree	Extinction angle in degree β	Measured o/p voltage	Calculated o/p voltage
1	27.5	0	0	26.7	27.5
2	27.5	36	18	26.4	26.91
3	27.5	72	18	23.5	23.0081
4	27.5	108	18	16.4	15.3
5	27.5	144	18	7.08	6.642

Calculations:

1) For: R Load :→

$$V_{rms_o} = V_{rms}\sqrt{\frac{1}{\pi}\left\{(\pi-\alpha) + \frac{\sin(2\alpha)}{2}\right\}}$$

$V_{rms} = \frac{V_m}{\sqrt{2}}$; $V_{rms} = 27.5V$ (V_{rms} of Input Voltage)

1) $\alpha = 0^\circ$

$$V_{rms_o} = 27.5\sqrt{\frac{1}{\pi}\left\{(\pi-0) + \frac{\sin(2\cdot 0)}{2}\right\}} = 27.5V$$

2) $\alpha = 36^\circ$

$$V_{rms_o} = 27.5\sqrt{\frac{1}{\pi}\left\{(\pi-36^\circ) + \frac{\sin(72^\circ)}{2}\right\}} = 26.82\ V$$

3) $\alpha = 72^\circ$

$$V_{rms_o} = 27.5\sqrt{\frac{1}{\pi}\left\{(\pi-72^\circ) + \frac{\sin(144^\circ)}{2}\right\}} = 22.9\ V$$

4) $\alpha = 108^\circ$

$$V_{rms_o} = 27.5\sqrt{\frac{1}{\pi}\left\{(\pi-108^\circ) + \frac{\sin(216^\circ)}{2}\right\}} = 14.95V$$

5) $\alpha = 144^\circ$

$$V_{rms_o} = 27.5\sqrt{\frac{1}{\pi}\left[(\pi - 144^\circ) + \frac{\sin(288^\circ)}{2}\right]} = 6.06\,V$$

2) For R-L Load :→

$$V_o = V_{rms}\sqrt{\frac{1}{\pi}\left\{(\pi + \beta - \alpha) + \frac{\sin(2\alpha) - \sin(2\beta)}{2}\right\}}$$

$V_{rms} = 27.5\,V$

1) $\alpha = 0$, $\beta = 0$

$$V_o = 27.5\sqrt{\frac{1}{\pi}\left[\pi + \frac{\sin(0^\circ)}{2}\right]} = 27.5\,V$$

2) $\alpha = 36^\circ$, $\beta = 18^\circ$

$$V_{rms} = 27.5\sqrt{\frac{1}{\pi}\left(\frac{9\pi}{10} + \frac{\sin(72) - \sin(36)}{2}\right.} = 26.91\,V$$

3) $\alpha = 72^\circ$; $\beta = 18^\circ$

$$V_{rms} = 27.5\sqrt{\frac{1}{\pi}\left\{\pi + \frac{\pi}{10} - \frac{4\pi}{10} + \frac{\sin(144) - \sin(36)}{2}\right.} = 23.0081\,V$$

4) $\alpha = 108^\circ$, $\beta = 18^\circ$

$$V_{rms} = 27.5\sqrt{\frac{1}{\pi}\left\{\pi + \frac{\pi}{10} - \frac{6\pi}{10} + \frac{\sin(216) - \sin(36)}{2}\right.} = 15.3\,V$$

5) $\alpha = 144^\circ$; $\beta = 18^\circ$

$$V_{rms} = 27.5\sqrt{\frac{1}{\pi}\left\{\pi + \frac{\pi}{10} - \frac{8\pi}{10} + \frac{\sin(288) - \sin(36)}{2}\right.} = 6.642\,V$$

Conclusion

Thus AC voltage controller using SCR in anti-parallel connection was constructed and theperformance was also analyzed. This was done with both R load and R-L load.

Discussion

1. Why does the negative notch in output voltage appears with R-L load but is notpresent with R load?

   In case of R load V=IR where voltage and current follow each other. When I=0, Vin=0 in case of R-L load (V_{in}= $L*di_L/dt+i_L*R$) due to presence of inductor it stores energy in positive half cycle and when input voltage is zero it uses its energy to conduct in negative cycle until voltage across inductor is less than voltage across input or current reaches zero. When Vin=0, $I_L \neq 0$; there will be a phase difference between Vin, I_L.

2. Is a thyristor a voltage bidirectional or unidirectional device? Is it a currentbidirectional or unidirectional device?

   Thyristor is current unidirectional that is it will conduct current in one direction only. It is voltage bidirectional cause it can withstand very high reverse breakdown voltageand also capable of carrying high current.

3. Can the extinction angle be larger than the firing angle? If no why? If yes why?

Extinction angle is the angle at which the load current falls to zero, measured fromthe point of the beginning of the positive half cycle of input supply to the point where the load current falls to zero. Extinction depends on the load we connect. Bychanging the parameters ω, R and L we can make the extinction angle greater than firing angle.