Electric Light Dimmer Circuit Using TRIAC

❖ AIM OF THE EXPERIMENT:

To study the performance and waveforms of electric light dimmer using TRIAC.

❖ APPARATUS REQUIRED:

Sl. No.	Name of the Instrument	Specifications	Model No. of the Instrument	Quantity
1	TRIAC	-	BT139	1
2	DIAC	-	DB3	1
3	Resistor	10kΩ	-	1
4	Capacitor	0.033µF	2J333J	1
5	PCB Board	-	-	1
6	Bulb	60W	-	1
7	Potentiometer	100kΩ	B100K	1

❖ TESTING APPARATUS REQUIRED:

Sl. No.	Name of the Instrument	Specifications	Model No. of the Instrument	Make
1	Digital Storage Oscilloscope	70MHz, 1GSa/s	SDS 1072 CML+	Siglent
2	Single Phase Auto Transformer	Input: 240V, 50/60Hz Output: 0-240V or 0-270V	1310023	-
3	Multimeter	AC Voltage: 200V/600V Resistance: 200Ω/2kΩ/20kΩ/200kΩ/2MΩ	MAS830L	Mastech
4	Current Probe (AC/DC)	Input: 0-70A RMS/ 100A peak AC or DC Frequency: DC to 100kHz Output: 10mV/A, 100mV/A	1146B	Keysight
5	Differential Probe	1000 V(rms) max, 25MHz	N2791A	Keysight

❖ THEORY:

Figure 1 shows the construction of the light dimmer circuit with the triac. The circuit is designed such that only a portion of the 50Hz sine wave from the Variac passes through the light bulb. To accomplish this, a bilateral diac is used to control the current flow to the triac. Initially, the capacitor is discharged, and during each half cycle of the input from the Variac, Van, the capacitor is charged to its breakover voltage. When this occurs the diac begins to conduct and discharges the capacitor through the triac gate. This point in time is known as firing and it allows the voltage on Vs to be applied to the light bulb. For most of this experiment, the Variac was set to 90V AC.

The intensity of the light is controlled by varying the firing angle for the circuit. This is accomplished by controlling the rate at which the capacitor charges, and is determined by the RC time constant of the series potentiometer and capacitor. In Figure 1, the time constant can be seen as the 10kΩ resistor plus the value of the potentiometer times the 0.033µF capacitance. Thus, to control the intensity of the light, one simply controls the value of the resistance on the potentiometer, which determines the rate at which the capacitor reaches the breakover voltage of DIAC(32V). The smaller the RC time constant, the quicker the capacitor reaches the breakover voltage, and thus the more of the 50Hz sine wave that is applied over the light bulb. The greatest intensity of the light can be seen when the resistance of the potentiometer is set to zero, and the greatest portion of the sine wave is applied over the bulb. The R1 protects VR1 damage from too many currents.

Caution: This circuit must be in an electricity insulation box that closes all the time. It has high voltage electricity flows through.

$$V_s = \sqrt{2}\sin\ \omega t$$

$$Vo\_rms = \left[\frac{2}{2\pi}\int_{\alpha}^{\pi} 2{V_s}^2\sin^2\ \omega t d(\omega t)\right]^{\frac{1}{2}}$$

$$Vo\_rms = V_s\left[\frac{1}{\pi}\left(\pi - \alpha + \frac{\sin\ 2\alpha}{2}\right)\right]^{\frac{1}{2}}$$

By varying α from 0 to π , Vo rms can be varied from Vs to 0.

$$Io\_rms = Vo\_rms/R$$

$$P_0 = (Io_{rms})^2 * R$$

❖ **CIRCUIT DIAGRAM:**

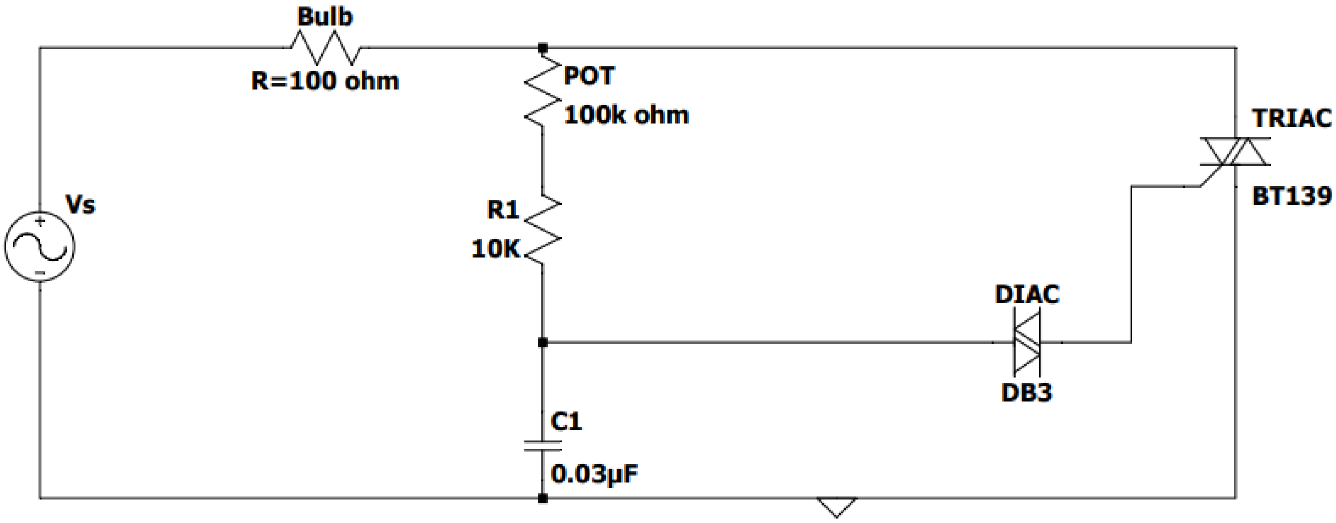
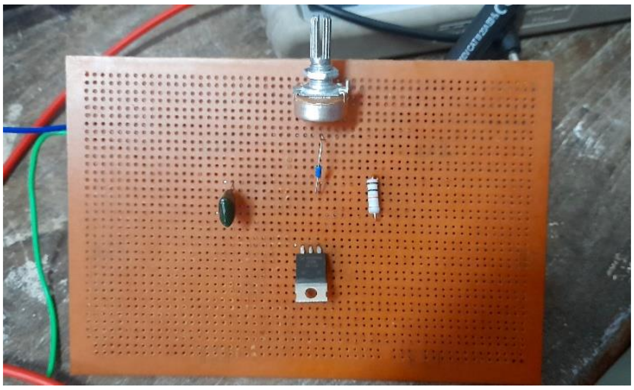
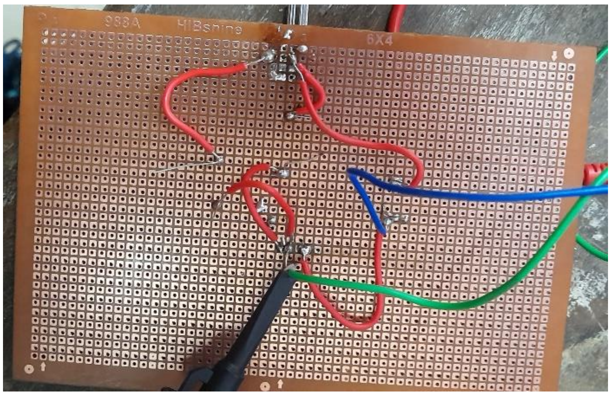
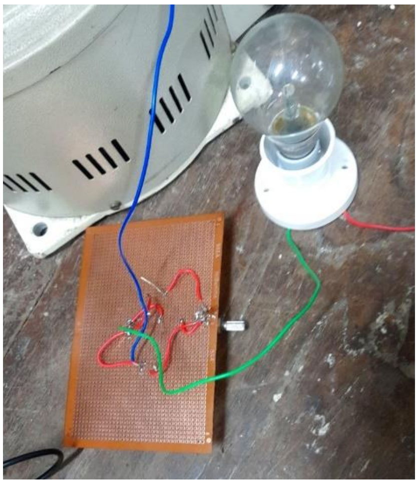


Fig 1: Light Dimmer Circuit with TRIAC

❖ **EXPERIMENTAL SETUP:**







Circuit Connection

Electric Light Dimmer Circuit

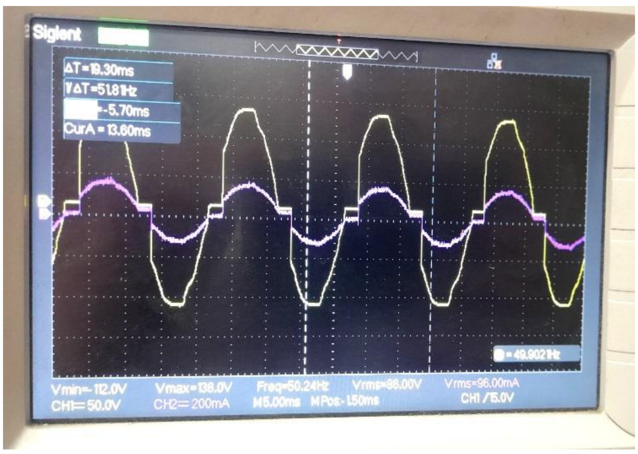
❖ PROCEDURE:

1) Connect the circuit diagram of Triac light dimmer as shown in Fig 1.
2) Switch on the supply and set the Variac voltage to 90V.
3) Connect the oscilloscope channel across the load terminals.
4) Vary a variable resistive pot (R) in steps gradually from minimum to maximum and observe the light bulb and note the firing angle.
5) For each firing angle measure the load R.M.S. Voltage and Current.

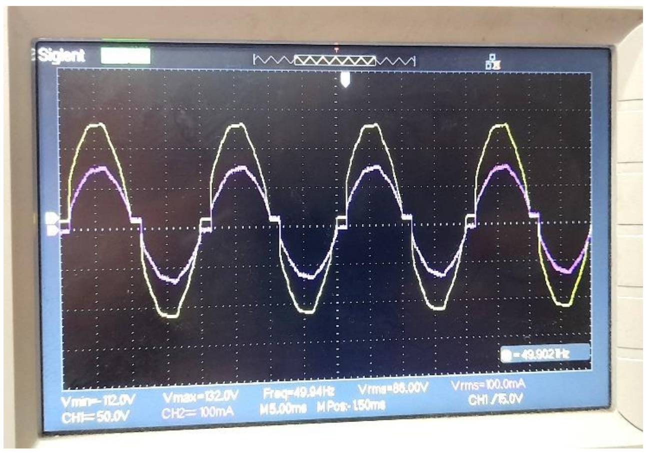
❖ OBSERVATIONS:

WAVE FORMS

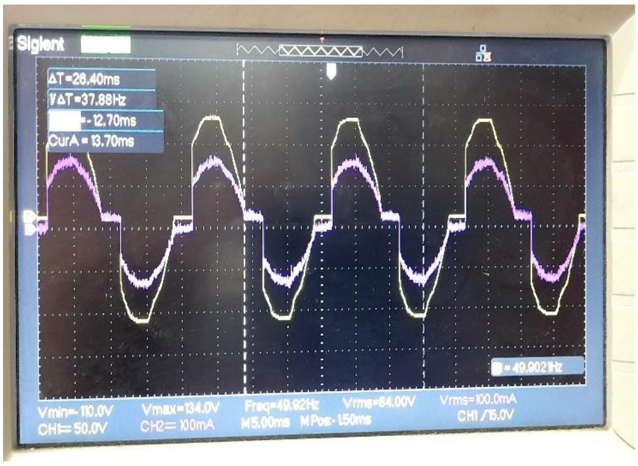
Channel 1 Voltage across Load(Vo)
Channel 2 Current across Load(Io)



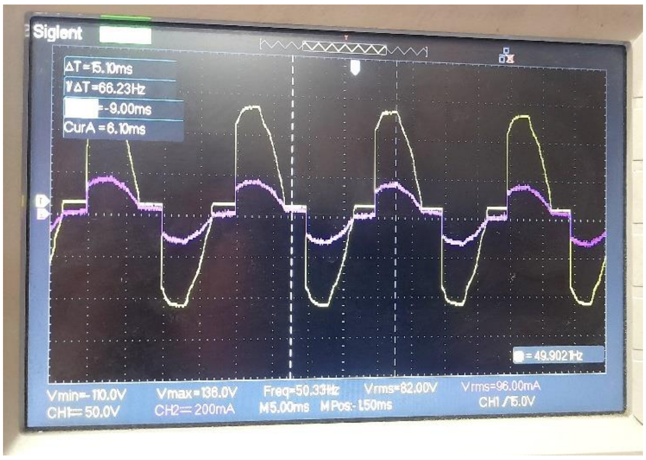
1) α=26.64°
Vo_rms= 86V
Io_rms=96mA



2) α=34.74°
Vo_rms= 88V
Io_rms=100mA



3) α=47.34°
Vo_rms= 84V
Io_rms=100mA



4) α=54.36°
Vo_rms= 82V
Io_rms=96mA

5) α=60.48°
Vo_rms= 80V
Io_rms=96mA

❖ TABLE

Supply Voltage (Vs) = 90V
Load Resistance (R)= 100Ω

Sl. No.	Firing Angle (in degree)	Vo_rms(V) (DSO)	Io_rms(mA) (DSO)	Vo_rms(V) (M.meter)	Vo_rms(V) (calc.)	Io_rms(A) (calc.)	Po(W) (calc.)
1	26.64	86	96	85.1	89.08	0.89	79.21
2	34.74	88	100	82.4	88	0.88	77.44
3	47.34	84	100	76.6	85.17	0.85	72.25
4	54.36	82	96	72.2	82.91	0.82	67.24
5	60.48	80	96	68.7	80.52	0.80	64

❖ CALCULATIONS

1.α =26.64

$$Vo\_rms = 90\left[\frac{1}{\pi}\left((180-26.64)*\pi/180+\frac{\sin 2*26.64}{2}\right)\right]^{\frac{1}{2}}$$

Vo_rms=89.08V

Io_rms= 89.08/100 = 0.89A

$P_0 = (0.89)^2 * 100$ = 79.21W

2. α =34.74

$$Vo\_rms = 90\left[\frac{1}{\pi}\left((180-34.74)*\pi/180+\frac{\sin 2*34.74}{2}\right)\right]^{\frac{1}{2}}$$

Vo_rms=88V

Io_rms= 88/100 = 0.88A

$P_0 = (0.88)^2 * 100$ = 77.44W

2. α =47.34

$$Vo\_rms = 90\left[\frac{1}{\pi}\left((180-47.34)*\pi/180+\frac{\sin 2*47.34}{2}\right)\right]^{\frac{1}{2}}$$

Vo_rms=85.17V

Io_rms= 85.17/100 = 0.85A

$P_0 = (0.85)^2 * 100$ = 72.25W

2. α =54.36

$$Vo\_rms = 90\left[\frac{1}{\pi}\left((180-54.36)*\pi/180+\frac{\sin 2*54.36}{2}\right)\right]^{\frac{1}{2}}$$

Vo_rms=82.19V

Io_rms= 82.19/100 = 0.82

$P_0 = (0.82)^2 * 100$ = 67.24W

2. α =60.48

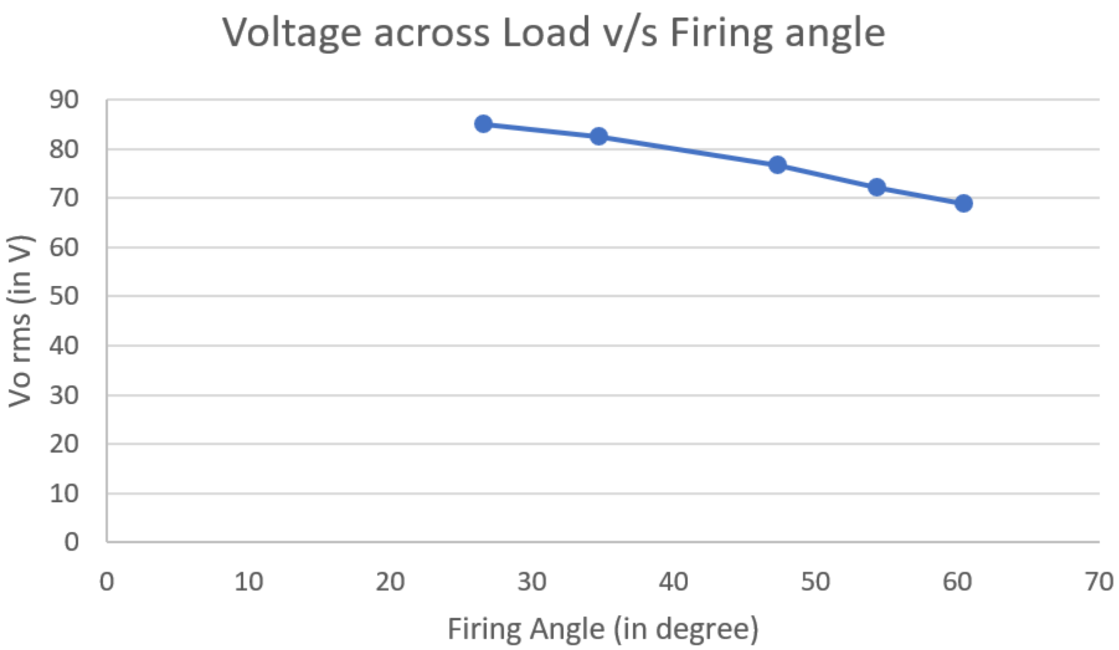
$$Vo\_rms = 90\left[\frac{1}{\pi}\left((180-60.48)*\pi/180+\frac{\sin 2*60.48}{2}\right)\right]^{\frac{1}{2}}$$

Vo_rms=80.52V

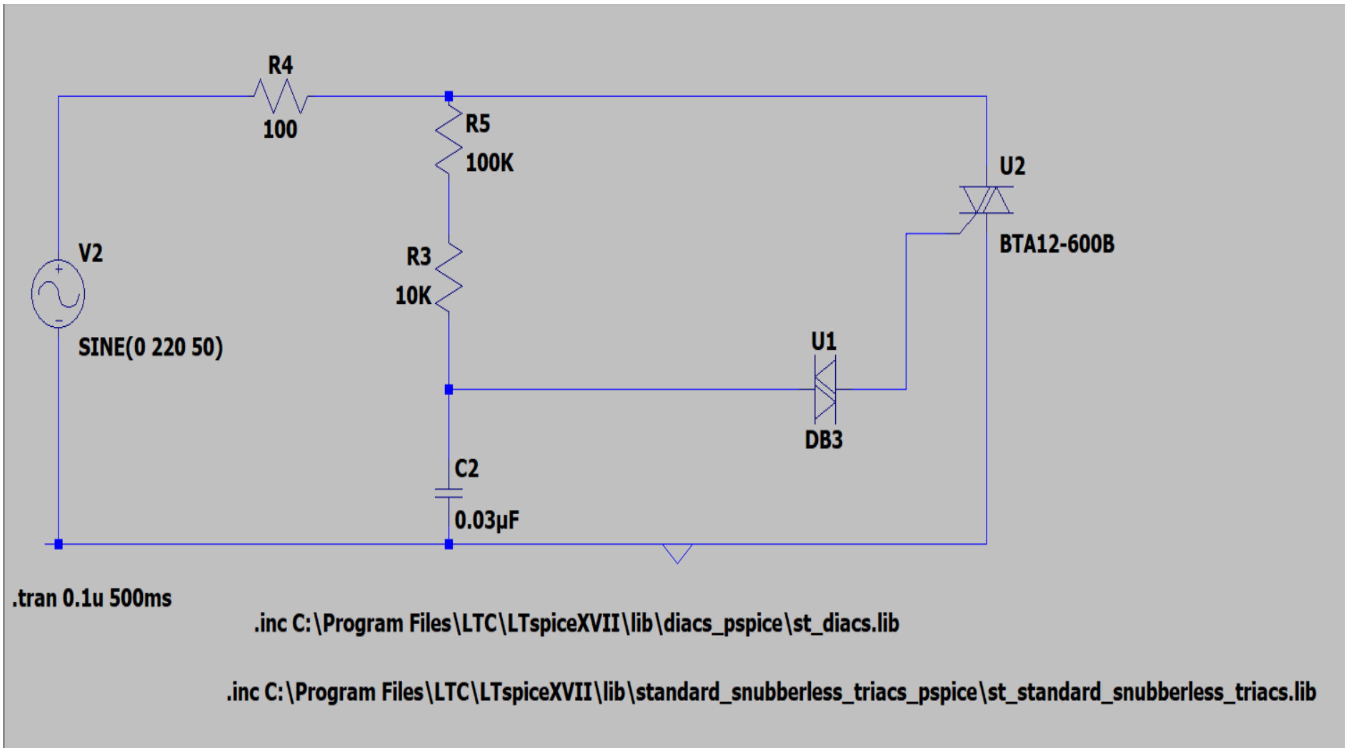
Io_rms= 80.52/100 = 0.80A

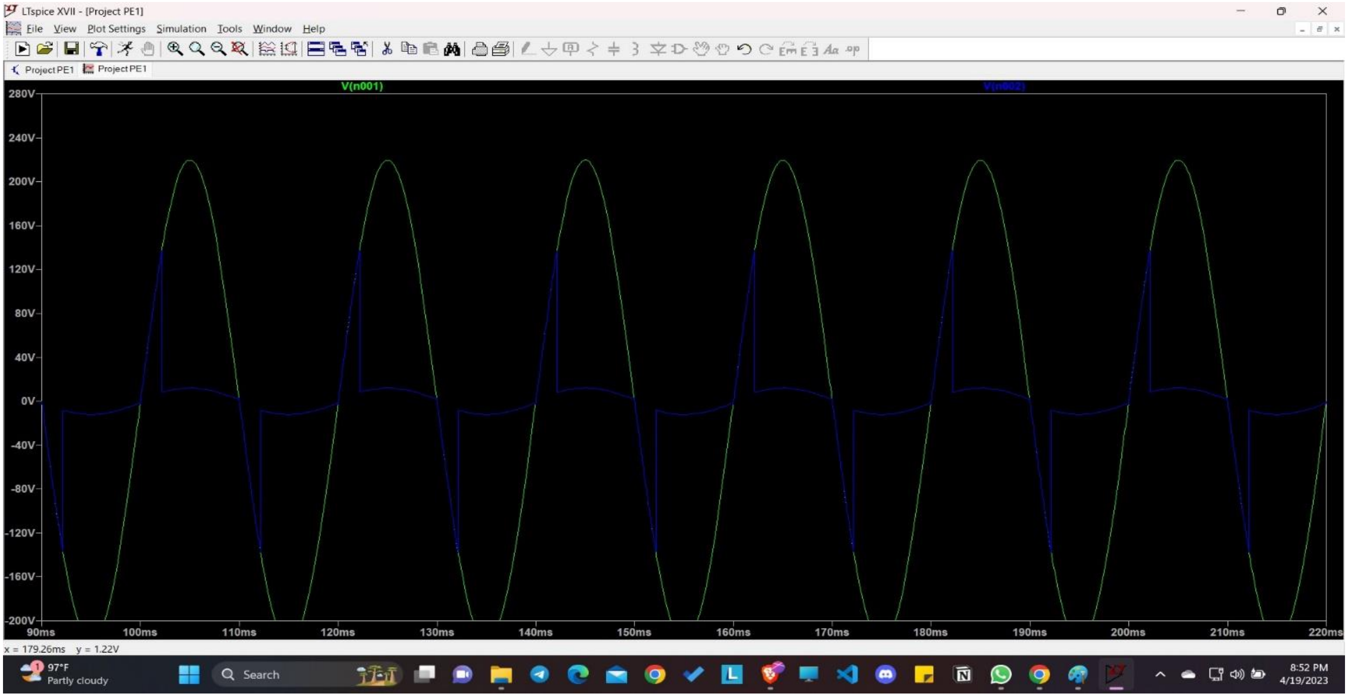
$P_0 = (0.8)^2 * 100$ = 64W

❖ GRAPH



❖ SIMULINK





From this graph α value is

$$\alpha = (t_{off}/T_{period})*180$$

$$\alpha = (2.4ms/10\ ms)*180$$

$$\alpha = 43.2\ deg$$

❖ DISCUSSION:

- From the observations we can see that as firing angle increases, the intensity of the bulb decreases which shows that the voltage across the bulb is decreasing as the conduction period of TRIAC is increasing.
- From the observation Table we can note that the load voltage calculated, and experimental are decreasing steadily.
- As resistance of pot increases, the firing angle increases and therefore the intensity decreases.

❖ CONCLUSION

We have successfully demonstrated the operation of the triac light dimmer circuit. With this circuit we have shown that one can regulate the intensity of a light using an AC wall outlet as a source, and varying the RC time constant used to determine the point in time that the triac conducts the AC wave through the light during each half cycle. In addition we have demonstrated the concept of a firing angle, α, and its relation to the RMS voltage applied to the light bulb.