Experiment No.2

Half Wave Single Phase Uncontrolled Rectifier

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Objective : To study the single phase half wave rectifier behavior for resistive load.

Apparatus Used :

1. ST2712 board 2. AVO meter 3. Oscilloscope. 4. Resistances 10 Ω and 270Ω

Theory :

A simple diode represents a switch and its use in many applications for example in a single phase uncontrolled rectifier. Although the half wave rectifier is not a useful circuit for high power applications, it nevertheless permits a number of useful principles to be explained in their simplest terms.

Figure (1) shows the half wave rectifier with purely resistive load, the output voltage waveform consists of half cycles of a sine wave separated by half cycles of zero output voltage, for which the average value is ,

$$Vmean = \frac{1}{2\pi}\int_0^{\pi} Vm\sin(wt)d\,(wt) = \frac{Vm}{\pi} = 0.318\,Vm$$

The current waveform is identical in shape to the voltage waveform, and the average current is:

Imean = 0.318 Vm / R   (R is the load resistance)

In case of R-L or R-C or any combined load, where the load impedence is Z_L, the load current is,

Imean = Vmean / │Z│

The rms value of the output voltage is,

$$V_{rms} = \sqrt{(1/(2\pi)\int_0^{\pi} V_m^2\, sin^2(wt)d(wt)} = 0.5\text{ Vm}$$

and

Irms = 0.5 Vm / R

or

Irms = Vrms / │Z│

Vrms also can be calculated from the following formula;

$Vrms = \sqrt{(Vdc^2 + V_{ac}^2)}$; where Vac is the rms value of the ripple output voltage.

Where Vm is the maximum value of the input voltage, and Vrms is the r.m.s. value.

On the other hand, if the load is purely inductive, the waveforms change considerably. During the positive half cycle, the current builds up from zero to a peak value. During the positive half cycle the energy transferred from the source to the inductor, and (1/2) L Ip^2 watt-seconds are stored in the magnetic field. However the diode cannot interrupt the non-zero current which exist. When the source reverses polarity the diode must wait for the current to goes to zero by itself before conduction ceases. In fact, the diode will continue to conduct throughout the negative half cycle, during which the output voltage is negative and the total energy stored in the inductor is returned to the source. If the inductor is lossless, the diode will conduct continuously, and at the end of each full cycle the total net energy transferred is zero. Note that although the instantaneous output voltage goes negative, the current never does. If the current did not go negative, it would be violate the assumed behavior of the ideal diode. In practice, no exists some inductor with lossless, so we must consider at least series resistance as shown in figure (2) where output waveform is included. Since the output voltage depends on the inductor value of the load, the negative voltage that appears in the output can be cancelled by means of the connection of a free wheeling diode across the load (see figure (2)).

Due to the inductive load the conduction period of the diode D1 will extend beyond 180^O until the current becomes zero at $wt=\pi + \sigma$ (σ is the angle during which the diode conducts in the negative half cycle) . The waveform for the current and voltage are shown in figure (2.3).

It should be noted that the average ($V_{inductor}$) of the inductor is zero. The average output voltage is,

$$Vdc = \frac{Vm}{2\pi}\int_{0}^{\pi+\sigma} \sin wt \, d(wt) = \frac{Vm}{2\pi}(1-\cos(\pi+\sigma))$$

Since the output voltage depends on the inductor value of the load, the negative voltage that appears in the output can be cancelled by means of the connection of a free wheeling diode across the load (see figure (2)). $\delta = \tan^{-1}(X_L/R)$.

However, if the load is capacitive with a resistance in parallel combination, the capacitor tends to smooth the ripple in the output voltage, but the current in the diode occurs in brief spikes. Note that, in contrasts to an inductive load which tends to postpone commutation after the voltage zero crossing, a capacitive load causes commutation to occur before the voltage zero crossing. Figure (3) shows the circuit diagram and output waveforms of a capacitive-resistive load.

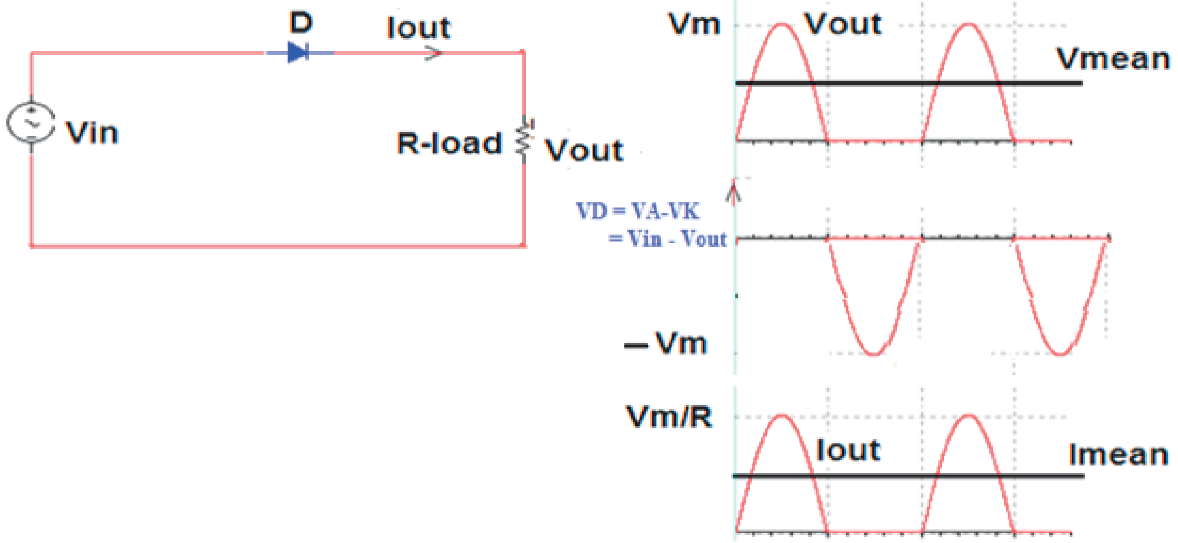

Figure (1) Half wave single phase rectifier circuit and waveforms for pure resistive load.

Procedure :

R Load

1. Connect the circuit as shown in figure (4).
2. Switch on the power supply of the board.
3. Measure the load dc and ac voltage values, record the result in table I.
4. Display the load voltage and current waveforms on the oscilloscope.
5. Display the voltage waveform across the diode on the oscilloscope
6. Plot the displayed waveforms in your graph paper.
7. Switch off the power supply.

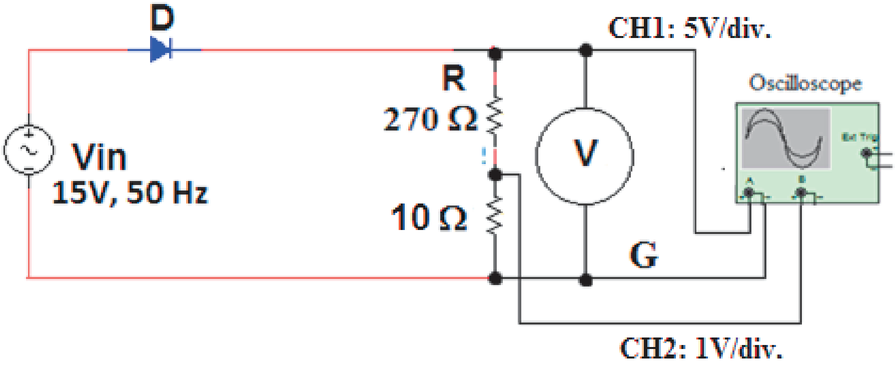

Figure (2) Practical circuit for half-wave single phase rectifier with R load.

Table (I) experimental results.

Load Type	Value	V_{load} (dc)	V_{load} (ac)	V_{load} (rms) $= \sqrt{(Vdc^2 + V_{ac}^2)}$	F.F.	R.F.	η (%)
R	270 Ω						

FWD : Free Wheeling Diode. , F.F= Vrms/Vdc, R.F.= $= \sqrt{(FF^2 - 1)}$, η=Pdc/Pac *100%

Discussion

1. comment on your results
2. find the PIV for the diode
3. Draw I-V characteristics curve based on your results