International Journal of Multidisciplinary Research and Development 2014; 1(2): 1-5

International Journal of Multidisciplinary Research and Development

IJMRD 2014; 1(2): 1-5
www.allsubjectjournal.com
Received: 24-06-2014
Accepted: 29-06-2014
e-ISSN: 2349-4182
p-ISSN: 2349-5979

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Experiments on ripples present in a rectified D.C signal

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Abstract
Rectified D.C contains a large amount of ripple components which may be filtered using a capacitor of suitable capacitance. A capacitor blocks D.C and allows A.C. Hence a capacitor should sop D.C components and allow A.C components of a rectified signal to pass through. This should be able to make a speaker (used in radios) vibrate. The vibration produces a faint humming sound which is totally different from that produced by a pure D.C source e.g. a battery. This circuit can be designed for low voltages like 6V, 9V and 12V rectified D.C. A quite different circuit with different characteristics can be designed using a half wave rectifier. In this circuit the characteristics of both a pure D.C source as well as a source having ripples can be found. This paper aims to depict the construction and behavior of such circuits.

Keywords: Capacitor; Ripple; D.C; Rectifier.

1. Introduction
A speaker is so designed that its membrane vibrates on application of an electrical signal. With a pure D.C signal (with no ripple components) the membrane vibrates as soon as the signal is applied but stops almost instantaneously. To sustain the vibration, the circuit must be interrupted constantly. The reason is that repeated connecting and breaking the circuit makes the nature of the signal pulsating. A rectifier circuit gives pulsating signal which makes the speaker vibrate continuously.
Again the waveform and the nature of the pulsating signal vary according to the type of rectifier used i.e. half wave or full wave. Both can cause vibrations in the speaker, but in a slightly different manner.
The vibrating sound is different from that obtained by excitation using a pure A.C signal. In A.C he current alters its polarity continuously depending on the frequency of the signal. The current in the circuit can be controlled using a capacitor only. But the difference lies in the fact that in this case we require an A.C capacitor which generally has a low capacitance generally a maximum of 5μF. In D.C circuit electrolyte capacitors may be used having capacitances as high as 4700μF. Hence, the current in a D.C circuit is higher and the sound obtained is more intense than that obtained from a pure A.C signal.

The current in both cases is of the order of a few mA. The currents have been determined using voltmeter ammeter method using *Ohm's law i.e. I=V/R*. The power has been obtained from *P=VI*.

2. Apparatus and specifications:
1. Step down transformer 230-12V, 3A.
2. IN4007 diodes.
3. Electrolyte capacitors 4700μF, 2200μF, 4.7μF.
4. A.C capacitors 2.5μF, 474pF.
5. Carbon film resistors 2.7KΩ-1/4W.
6. Radio speaker 6W.

Circuit diagram:

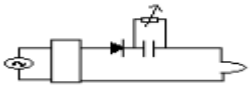
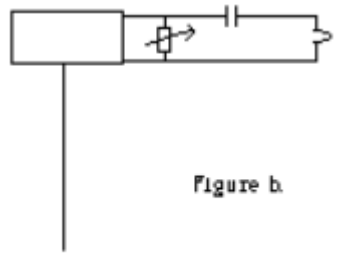


Figure a



3. Experimental: First of all a few constants were determined like diode resistance e.t.c. which has been given under:-

1. Forward resistance of each diode=595Ω
2. Resistance of the speaker= 20.4Ω
3. D.C resistance of L.V side of transformer=1.9Ω
4. Transformer open circuit voltage=16.5V (This is because the
5. primary was excited from a 250V source instead of 230V).
6. Open circuit voltage of a half wave rectifier=8.04V
7. Open circuit voltage of bridge rectifier=12.97V

The entire experiment was divided in to sections:

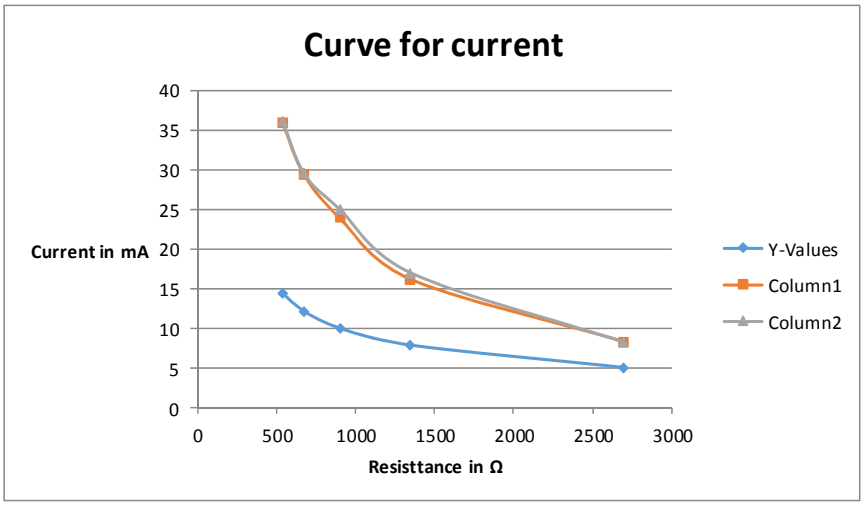
Experiment no. 1
Refer to figure a. The experiment was performed using a half wave rectifier using a single diode. The variable resistance was varied as 2700Ω, 1350Ω, 900Ω; 675Ω and 540Ω using a parallel combination of 2.7KΩ carbon resistors. The capacitors used in parallel were varied as 4700µF, 2200µF and 4.7µF. The D.C voltage across the resistor was measured in each case using a digital multimeter. Current was found out using the relation *I=V/R*.

Experiment no. 2
Refer to figure b. The experiment was carried out using a full wave bridge rectifier using 4 diodes. The output of the rectifier was fed into the speaker through a capacitor. A resistor was put in parallel with the entire combination i.e. both in parallel with the capacitor and the speaker. Again the capacitance was varied as 4700µF, 2200µF and 4.7µF. The resistors used to be in the same sequence as in the above experiment. The current was found out in each case.

Experiment no. 3
Refer to figure c. The experiment was carried using pure A.C. The resistor was used to control current while a capacitor was connected in parallel with it. The A.C voltage across the resistor was measured in each case and the current was calculated. The same resistances as the above two experiments were used.

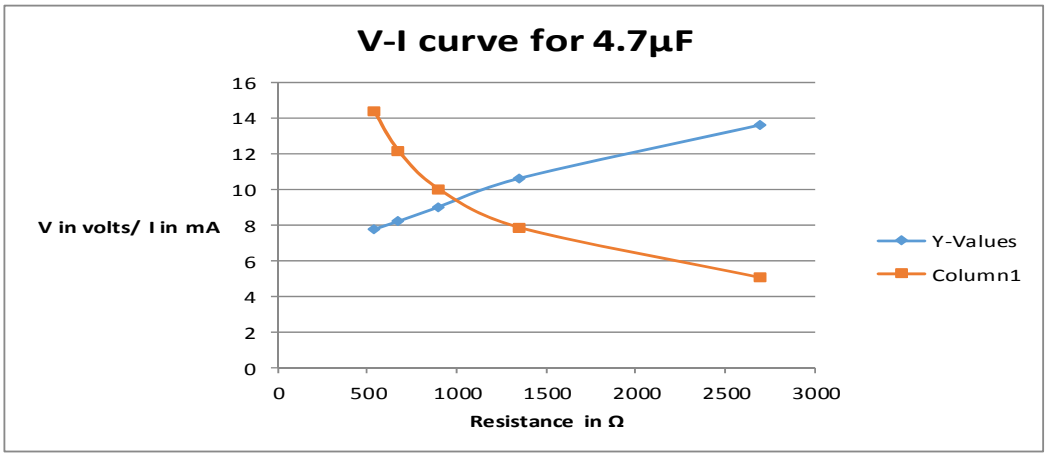
4. Observations: The current in the half wave circuit was found by voltmeter, ammeter method and plotted on a single graph. The blue line corresponds to 4.7µF, the redline for 2200µF and the green line for 4700µF. It is evident from the curve that though 4700µF is more than double of 2200µF the current does not increase appreciably. The speaker produces a very distinct humming sound in case of 4700µF and 2200µF. It was quite low but audible for 4.7µF.

Graph no. 1

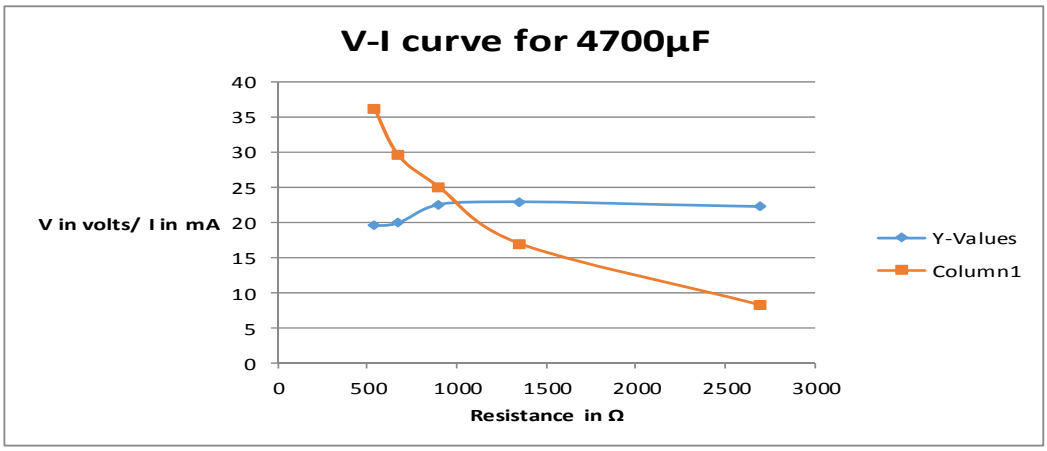


It is obvious that the voltage across the resistor decreases slightly while the current increases with a decrease in the value of resistance. But the change varies with variation in capacitance of the capacitor used. To show this, the characteristics of 4.7µF and 4700µF were plotted. The reason behind this was that the two capacitances bear a large integral ratio (1000).

Graph no.2

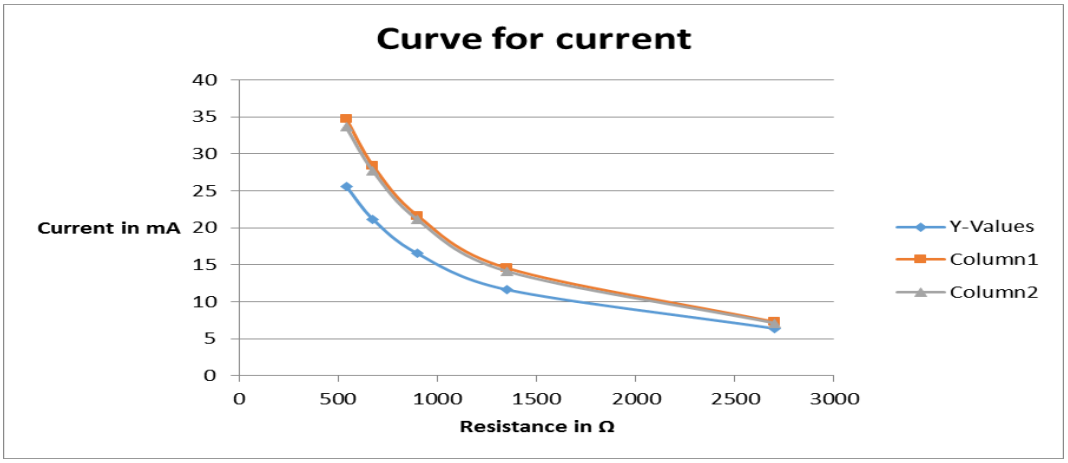


Graph no.3



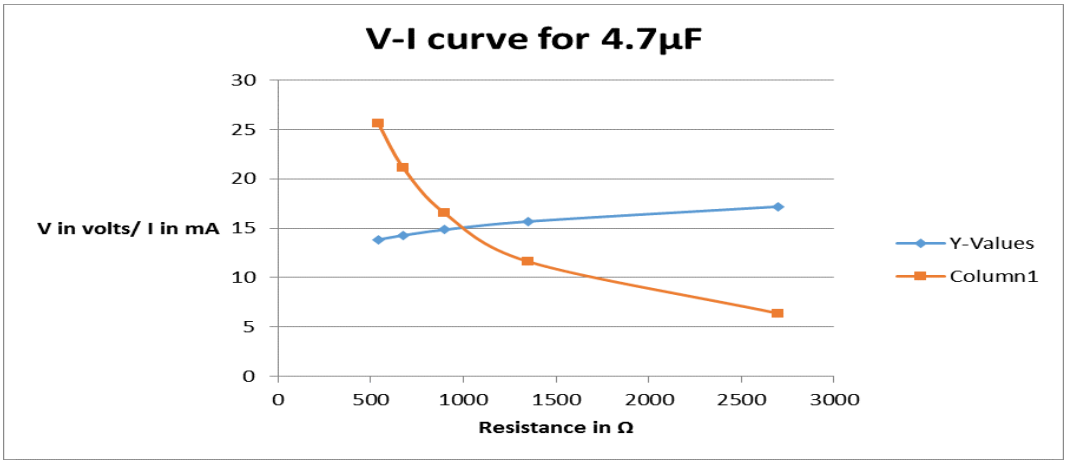
It is seen that the curves the nature of current (shown in red) remain almost similar. For 4.7µF voltage increases almost linearly with increase of resistance. But in case of 4700µF the voltage curve shows almost flat characteristics.
The same curves for the bridge circuit were plotted starting with current.

Graph no. 4

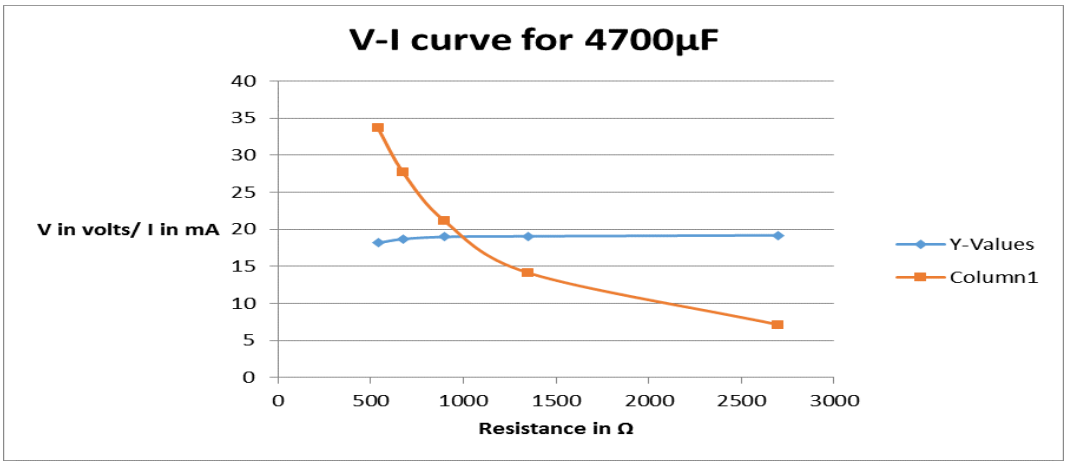


Unlike half wave circuit 4700µF gives lower current than 2200µF. Also, we see that the currents corresponding to 2700Ω are of almost the same magnitude for the three capacitors.

Graph no. 5



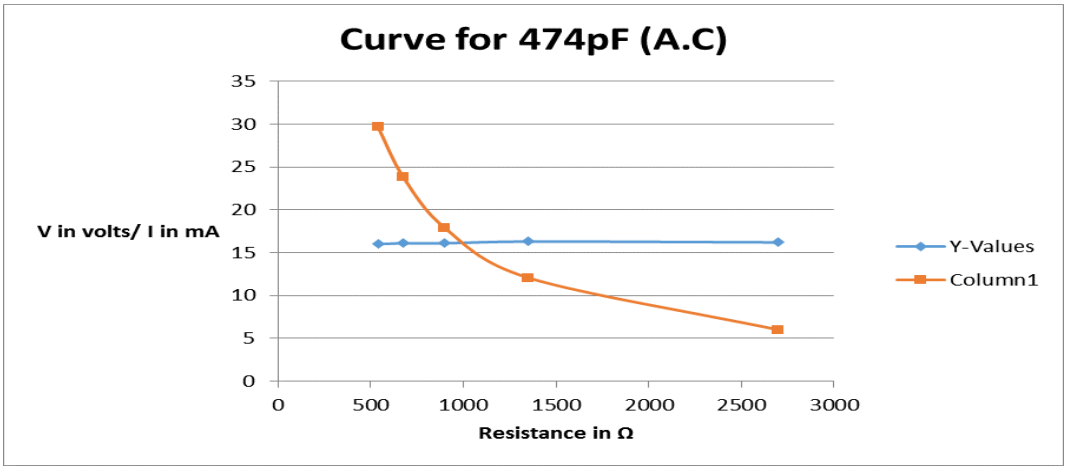
Graph no.6



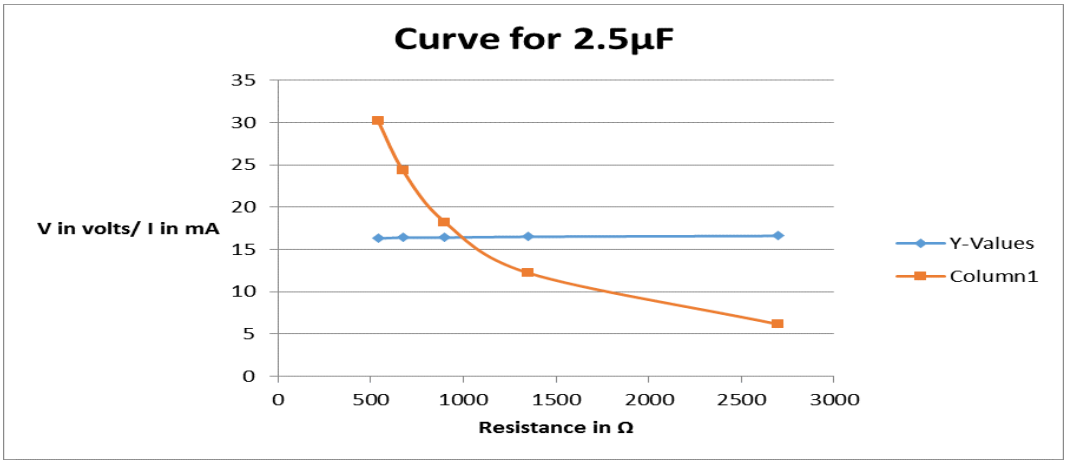
These two curves have identical nature as graph nos. 2&3 respectively. But the curve corresponding to 4.7µF shows flatter characteristics in case of a bridge rectifier circuit.

For the circuits using A.C input the curve for current was not plotted. The voltage, current curves were plotted corresponding to 474pF and 2.5µF.

Graph no.7



Graph no.8



These curves show identical nature as that of a bridge rectifier circuit.

5. Results and discussion:

The experiment was carried out to determine the difference in nature of noise produced by ripple components in a rectified D.C signal. Along with the variations in vibrations the characteristics of the circuit were also studied. The important results can be summarized as under:-

1. A very distinct humming sound is obtained from a bridge rectifier. A half wave rectifier also gives the desired output.
2. A half wave rectifier produces continuous and distinct sound only if a capacitor is put in parallel with the current controlling resistor as shown in figure a.
3. In any case the increase in current is not as much as the decrease in resistance. The resistors change in the ratio of 1/2, 1/3, 1/4 and 1/5. The corresponding currents are not exactly twice, thrice, four times or five times but slightly less.
4. The deviation from ideal ratio is maximum of 4.7µF and minimum for 4700µF in case of a half wave rectifier. In case of bridge circuit the deviation is least for 2200µF.
5. The voltage vs. Resistance curve maintains flat characteristics in most cases. The only exception is seen when a 4.7µF capacitor is used along with a half wave rectifier (refer to graph no. 2). In this case the voltage increases linearly with increase in resistance.
6. A full wave circuit gives peak current corresponding to 2200µF whereas a half wave circuit gives peak at 4700µF.
7. The noise produced in a pure A.C circuit different from that produced by a D.C signal. This is due to the difference in the waveform and the comparatively lower value of capacitance used in an A.C circuit.

6. Conclusion: Rectified D.C having ripple components can be used to make a speaker, vibrate, producing a continuous 'humming' sound. The nature of sound produced varies with the type of rectifier used. For a full wave bridge rectifier circuit it is quite intense. For a half wave rectifier it is less, but considerable. The intensity of noise depends on the value of capacitance used in the circuit. The current in the circuit is minimal in the range of only a few mA and hence power consumption is also in the range of mW.

7. Acknowledgements: This work has been encouraged by Mr. Pannag Bhusan Nandi and Mrs. K. Nandi.

8. References: The basic connection of a rectifier circuit (half wave and bridge wave) has been taken from 'Basic Electrical and Electronics Engineering-2', Tata McGraw Hill Education Private Limited.