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Grade . . . . .

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Evaluated by . . . . .

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## EXPERIMENT 3

# CONSTRUCTION AND CHARACTERISATION OF POWER SUPPLIES & FILTERS

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### Structure

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  - Objectives
- 3.2 Apparatus
- 3.3 Study Material
- 3.4 Precautions
- 3.5 The Experiments
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  - Full Wave Rectifier
  - Capacitor Input Filter
  - Inductor Filter
  - LC and PI Filters
- 3.6 Conclusions

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### 3.1 INTRODUCTION

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You have seen in daily life many electronic instruments including domestic electronics like radio, tape recorders, T.V, amplifiers, musical keyboards etc. Do you know whether these instruments work on D.C. (Direct Current) or A.C. (Alternating Current)? In fact they all operate on D.C. So when we connect such equipment to the mains (A.C.), it is necessary to convert this A.C. into D.C. In all these electronic instruments **there** is a section inside the equipment, known as the **power** supply section which converts this A.C. into D.C. with the help of rectifiers **etc.** This rectified voltage is pulsating and has some (small) A.C. component. It is **desirable** to convert this pulsating **D.C. into** constant D.C. and reduce the A.C. component of the **rectified** voltage so that the output is a pure D.C. voltage. This is accomplished **by means** of **filters**, which are composed of suitably connected capacitors, inductors and their combinations in different ways.

The effectiveness of the filter is given by the **RIPPLE FACTOR**  $\gamma$ . It is defined as the ratio of **rms\*** value of the A.C. component of the voltage to the D.C. voltage (or **average** value of the voltage). In this way we **can** identify the purity of the D.C. output in **terms** of ripple factor. It is desirable that the ripple factor is as small as possible. The capacitance filter has low ripple **at** heavy loads, while the inductor filter has low ripple at small loads. Depending on the requirements suitable filters can be selected.

\* The rms of value of A.C current is one that will produce the same quantity of heat as that of a D.C current. The voltage measured using the A.C range in a multimeter gives the rms value of the A.C. voltage.

In the first part of the experiment we will construct half-wave and full-wave rectifiers and observe the wave forms on the cathode ray oscilloscope (C.R.O.). Then we will use capacitors and inductors as filters and observe the wave forms on the C.R.O. We will also measure the output voltages (both D.C. and A.C.) with the help of a multimeter and then calculate the ripple factor of these two filters. In laboratories not equipped with CRO, only multimeter readings need be used.

In the second part of this experiment we observe the effect of L and PI filters on the output wave form of a full wave rectifier and then calculate the ripple factors in these two filters.

## Objectives

After doing this experiment you will be able to :

- \* Design and construct half and full wave rectifier using step-down transformer and diodes.
- \* Show the output waveform of a full wave and halfwave rectifier on a CRO screen.
- \* Show the effect of the filter (capacitor, inductor, L and PI filter) on the output voltage of a rectifier and compute ripple factor.
- \* Distinguish between output of L and PI filters.
- \* Trouble-shoot a power supply when it is defective.

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## 3.2 APPARATUS

1. Centre-tapped transformer (9 V - 0 - 9 V)
2. Diodes - four numbers - (IN4007 or BY126 or BY127)
3. Electrolytic capacitors (1000  $\mu$ F, 25 V)
4. Inductors - (150 mH)
5. Resistors - (100  $\Omega$  - 2R)
6. Connecting wires, soldering iron, soldering flux (rosin), lead (solder)
7. CRO
8. Multimeter etc.,

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## 3.3 STUDY MATERIAL

### 3.3.1 Half Wave Rectifier

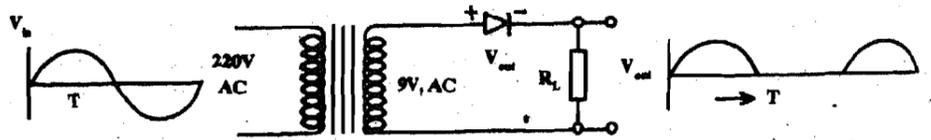


Fig.3.1

Consider the circuit given in Fig 3.1, where we have used a step down transformer, a semiconductor diode and a load resistance. A sinusoidal 9 V from a stepdown transformer

is applied across the series-connected diode  $D$ , and the load resistor  $R_L$ . The input voltage  $V_{in}$  is an A.C. voltage which changes its polarity every  $1/10$  sec. During the positive alternation the anode is positive (forward biased) with respect to the cathode and the current flows through the diode. During the negative alternation there is no current, because the anode is negative with respect to the cathode (reverse biased). The variation of current through the diode will result in the variation of voltage drop across  $R_L$ , as shown in the Fig.3.1.

### 3.3.2 Full Wave Rectifier

Here we use a centre tapped stepdown transformer and two diodes to achieve full wave rectification as shown in Fig.3.2.

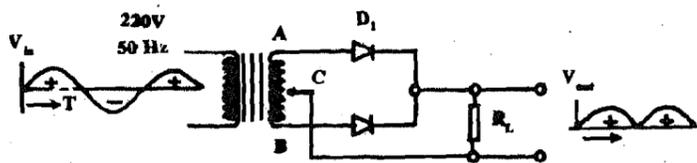


Fig. 3.2

At any moment during a cycle of  $V_{in}$  if point  $A$  is positive relative to  $C$ , point  $B$  is negative relative to  $C$ . The voltage applied to the anode of each diode is equal but opposite in polarity at any given instant.

When  $A$  is positive relative to  $C$ , the anode of  $D_1$  is positive with respect to its cathode. Hence  $D_1$  will conduct but  $D_2$  will not. During the second alternation,  $B$  is positive relative to  $C$ . The anode of  $D_2$  is therefore positive with respect to its cathode, and conducts while  $D_1$  will not.

There is conduction by either  $D_1$  or  $D_2$  during the entire input voltage cycle.

Since the two diodes have a common-cathode load resistor  $R_L$  the output voltage across  $R_L$  will result from the alternate conduction of  $D_1$  and  $D_2$ . The output waveform  $V_{out}$  across  $R_L$  is shown in Fig. 3.2.

The output of a full wave rectifier is also pulsating direct current as seen from the Fig. 3.2.

### 3.3.3 Capacitor Input Filter

Capacitor input filter is shown in Fig. 3.3.b.

Here the high value capacitor is connected across the output voltage. The working principle is as follows.

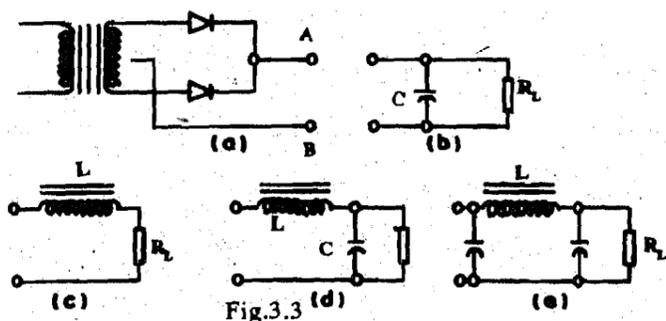


Fig.3.3

The output of the rectifier contains both A.C. and D.C. When the capacitor is connected across the output terminal, A and B in Fig. 3.3.a, A.C. components are by-passed while the D.C. component is blocked and they develop a voltage across the capacitor. Now the capacitor is discharged through the load resistance  $R_L$ , which is of high value. So it delivers continuous D.C. across the load resistor.

### 3.3.4 Inductor Filters

Connect between A and B in Fig. 3.3.a inductor L and the load resistor  $R_L$  given in Fig. 3.3.c.

In the experiment of Lab 1 you have studied inductive reactance (denoted by  $X_L$ ). The impedance of an inductor is equal to  $2\pi fL$ , where  $f$  = frequency and  $L$  = inductance. If both A.C. and D.C. are flowing through an inductor, it has a high impedance for A.C. but not for D.C. So we will find a constant D.C. voltage across the load. In this way it will remove ripples (i.e. A.C. components) and convert pulsating D.C. into constant D.C.

The ripple factor can be further reduced by a combination of inductor and capacitor. The combination of L and C given in Fig. 3.3.d is known as LC filter and the combination of L and C shown in Fig. 3.3.e is known as a  $\pi$  section LC filter.

### 3.4 Precautions

- While measuring voltages using multimeters, select the correct (appropriate) ranges and keep the selector knobs in the correct positions.
- Check the polarity of the diode using the multimeters and make sure that you have connected them correctly. How to check?
- Make sure that you are connecting the electrolytic capacitor with correct polarity.
- Soldering should be done perfectly.

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## 3.5 THE EXPERIMENT

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### 3.5.1 Half Wave Rectifier

To construct a half wave rectifier and observe the output waveform using a CRO and measure the output voltage.

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### APPARATUS

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Stepdown transformer, diode, resistors, soldering iron, solder and rosin.

#### Step (1)

Check the continuity of the primary and secondary winding of the stepdown transformer.

#### Step (2)

Find the polarity of the diode using the multimeter. (By applying either forward bias or reverse bias one can identify the polarity of the diode.)

Note : Other ways of identifying the polarity of the diode.

- (a) A band at one end of the diode indicates cathode (e.g. IN4007) as shown in Fig.3.4.

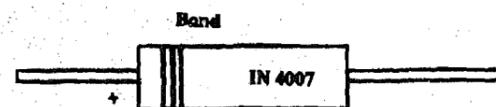


Fig.3.4

(b) A Flat portion in a diode like BY126 or BY127 is anode and the curved end or an arrow shaped portion is cathode as shown in Fig.3.5.

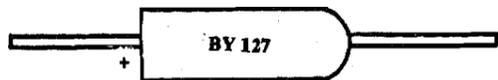


Fig.3.5

**Step (3)**

Connect the circuit as shown in Fig.3.1.

**Step 3(c)**

Give input voltage (220V A.C)

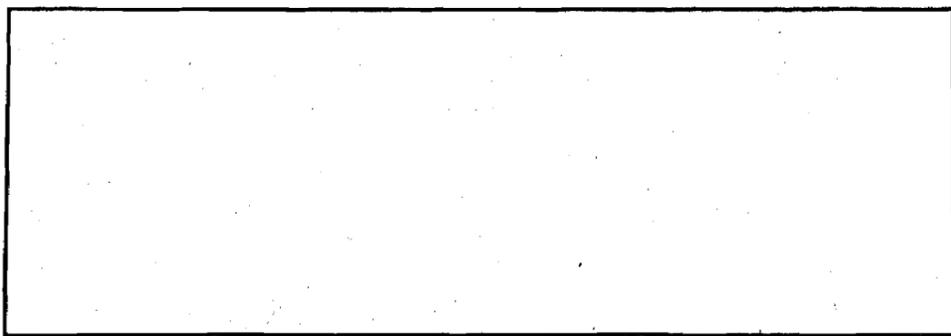
**Step 4:**

Measure the A.C. input voltage, A.C.output voltage and the rectified voltage across the load resistance  $R_L$  using a multimeter.

**Step 5**

The output voltage across the  $R_L$  is given to the Y-Y input of the CRO. Adjust the appropriate knobs to get the wave pattern of the output .

Trace the output on a tracing paper, and paste it in this report, below. Compare the figure with the expected figure.



**3.5.2 Full Wave Rectifier**

To construct a full wave rectifier and observe the output waveform using a CRO and measure the output voltage.

**PROCEDURE**

Take a centre-tapped stepdown transformer (9V - 0 - 9V)

**Step 1**

Follow step 1 and 2 of the experiment in Section 3.5.1 (Here two diodes have to be checked)

**Step 2**

Connect the circuit as given in Fig. (3.2)

**Step 3**

Measure the A.C.input voltage, A.C.output voltage and the rectified (D.C) voltage across the load resistance  $R_L$  using a multimeter.

Step 4  
Voltages across  $R_L$ , Diode 1, Diode 2 are measured using a CRO as in the experiment in section 3.5.1.

Trace the output waveform on a tracing paper, and paste it in this report in the space below.

### 3.5.3 Capacitor Input Filters

To study the capacitor filter and calculate the ripple factor and record the output wave form with and without filters.

**step 1**

Connect a high value (1000  $\mu$ F, 25 V) capacitor (electrolytic capacitor) across  $R_L$  as shown in Fig. 3.3.b and connect it between A and B as shown in Fig 3.3.a.

The circuit has only a simple capacitor filter.

**step 2**

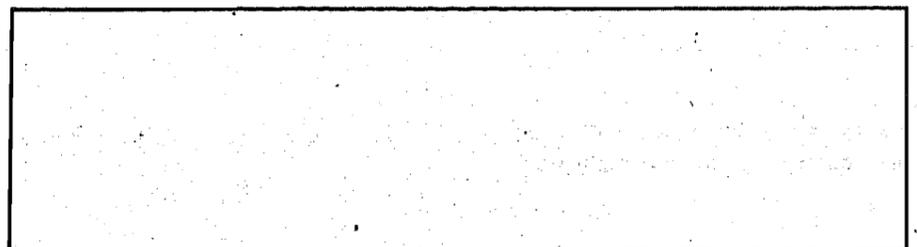
Measure the D.C. and A.C. voltage across  $R_L$ . Repeat the experiment for different  $R_L$  values and calculate the ripple factor for each load and tabulate the values.

TABLE I

| S.NO. | Load resistance | Output (d.c) voltage | Output (a.c) Voltage | ripple factor $\gamma = \frac{E_{ma}}{E_{dc}}$ |
|-------|-----------------|----------------------|----------------------|------------------------------------------------|
|       |                 |                      |                      |                                                |

**Step 3**

Record the wave form of the output voltage with and without capacitor (trace it from the CRO screen and paste it below)



**SAQ**

Note down your observations when you compare the wave form of the output with and without the capacitor.

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**3.5.4 Inductor Filters**

To study the inductor filter and calculate the ripple factor.

**step 1**  
Follow step 1 and 2 of the experiment in Section 3.5.1.

**step 2**  
With the circuit given in Fig. 3.3.a, between A and B connect the circuit given in Fig. 3.3.c. Here the inductor is connected in series. The circuit is called inductor filter.

**Step 3**  
Connect the primary of the transformer to the mains and measure the output voltage across  $R_L$  (both A.C. and D.C). Repeat the experiment for different load values and tabulate your data:

**TABLE II**

| S.NO. | Load resistance | Output (d.c) Voltage | Output (a.c) Voltage | ripple factor $\gamma = \frac{E_{rms}}{E_{dc}}$ |
|-------|-----------------|----------------------|----------------------|-------------------------------------------------|
|       |                 |                      |                      |                                                 |

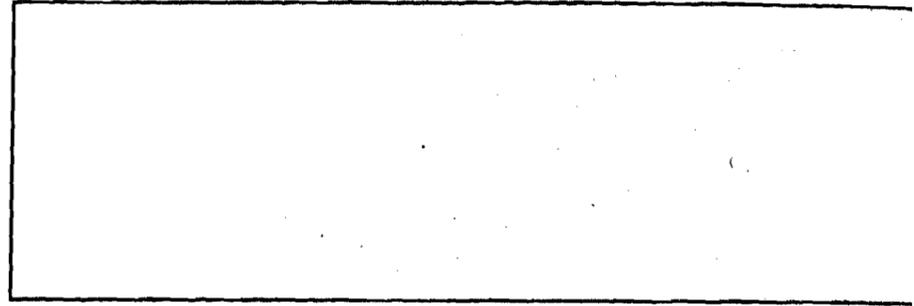
**3.5.5 LC and  $\pi$  Filters**

To study LC and  $\pi$  Filters and compare the ripple factor in these two filters.

Procedure:

in the previous part of the experiment you have used an inductor as a filter. Now, connect a capacitor in parallel to the load resistance as shown in Fig. 3.3.d. This combination of inductor and capacitor is known as an LC filter. Now measure D.C. and A.C. voltages across the load as

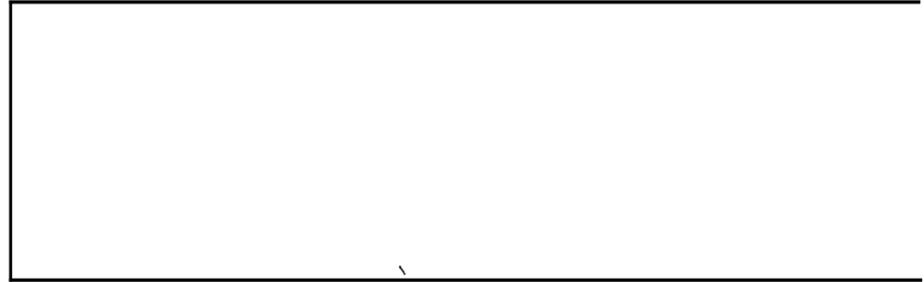
measured in the previous part of this experiment. Repeat the experiment for different load resistances and record your data in Table III. Calculate the ripple factor for each load.



**TABLE III**

| S.NO. | Load resistance | Output (d.c) Voltage | Output (a.c) Voltage | ripple factor $y = \frac{E_{rma}}{E_{dc}}$ |
|-------|-----------------|----------------------|----------------------|--------------------------------------------|
|       |                 |                      |                      |                                            |

Now connect the output of load resistance  $R_L$  to the Y plate of the oscilloscope. You will find the output waveform. Now, you trace these wave forms on a tracing paper and paste in the space given below:



**SAQ**

Compare the waveform of C, L and LC filter.

Write your conclusion in **the** space below :

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**SAQ**

What is the difference in the ripple factor in L, C, and LC filter?

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Now connect one more capacitor before the inductor, in parallel to the previous capacitor. It is shown in Fig.3.3.e.

Such a combination is known as a  $\Pi$  filter. Now measure D.C. and A.C. voltages across load resistance  $R_L$  as measured in the above part of this experiment. Repeat the experiment for different load and record your data in Table IV. Calculate the ripple factor for different loads.

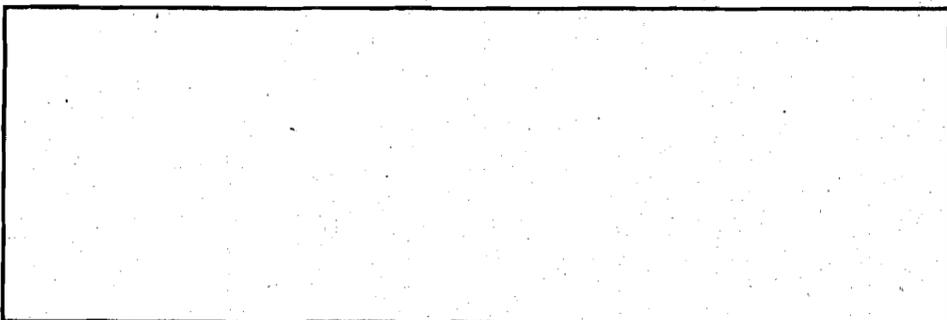
TABLE IV

| S.NO. | Load resistance | Output (d.c) Voltage | Output (a.c) Voltage | ripple factor $\gamma = \frac{E_{rms}}{E_{dc}}$ |
|-------|-----------------|----------------------|----------------------|-------------------------------------------------|
|       |                 |                      |                      |                                                 |

Write your conclusion in the space given below:

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Now connect the output of the load resistance  $R_L$  to the Y-Y input of the oscilloscope. You will find the output wave form. Now, you trace this wave form on a tracing paper and paste in the space given below:



**SAQ**

From your **data** find the difference between the waveforms of the LC and  $\pi$  filters. Write your conclusion in **the** space given below:

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NOTE Due to technological advancement, the present day **power** supplies are made **more compact** by using integrated chips (like 7905) for **power** regulation instead of all **kinds of filters**.

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**3.6 CONCLUSIONS**

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You **have constructed** half and **full** wave rectifiers and smoothed the output using different types of filters. Now answer the **questions** below in a brief manner.

(a) What will happen if **you** give an unfiltered voltage to a radio set ? .

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(b) At heavy **loads** which kind of filter is **preferable** ?.

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(c) How will you **check** the polarity of a semiconductor diode ?

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(d) How does **an inductor filter** work?

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