وزارة التعليم العالى

المعهد العالى للهندسة والتكنولوجيا بالمنزلة

منشأ بالقرار الوزارى رقم (2354) لسنة 2019

# Fundamental of electronic circuit

# Laboratory Handbook


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**Name:………………………………………………………………………………**

**ID Number:…………………………………………………………………….…...**

**Group Number:…………………………………………………………………..**

# Attention

## Lab Rules &Regulations

Before entering the lab. , student must read and follow up the lab rules and regulations for his safety .The violation of these rules and regulations may inhibit the student to continue the course.

The rules and regulations are:

1) Read carefully carefully the safety rules of the lab.
2) Prepare the lab experiment before attending the lab period. The preparation includes reading of the procedures and understanding the theoretical background of the experiment.
3) The student builds up the experiment according to set-up scheme keeping the power off.
4) No student is allowed to switch on the power of the experiment without the lab. Instructor's permission and supervision.
5) At the end of the lab session, the student has to switch off the power supply and disconnect the wiring and the cables of the experiment. Then, the student has to get back the original status of the working place{put the components, cables, and measuring equipment at its original places}
6) It is recommended that student delivers the lab report by the end of the lab session. The final deadline for getting the lab. Report signed by the instructor is at the beginning of the next lab session.
7) If any equipment is broken or doesn't work properly, make sure that the lab. Instructor is informed before you leave the lab.
8) Students are not allowed to enter the lab without the presence of the instructor
9) No food or drink is allowed in the lab.

10) Switch off your cell phone before entering the lab.

# Attendance Sheet

**Name:………………………………………………………………………………**

**ID Number:…………………………………………………………………………...**

**Group Number:……………………………………………………………………..**

| Experiment Number | Date | Instructor Signature | Notes |
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# Experiment (1)

## V-I charactristics of diode ( normal )

**Aim**

1-We try to see the Voltage-Current realtion in Diodes by applying a voltage across it and measuring the corressponding current flowing through it

**Apparatus required :**

a) A diode

b) A DC voltage supplier

c) Bread board

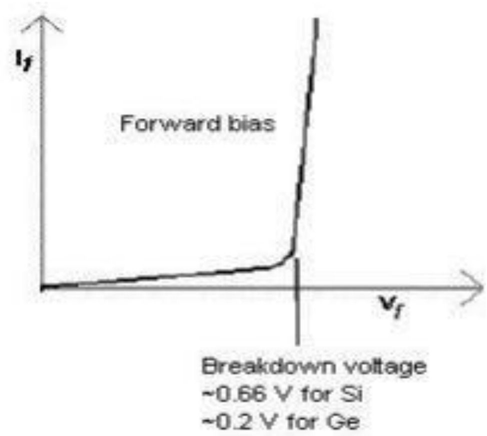
d) 100Ω resistor

e) 2 multimeter for measuring current and voltage

f) Connecting wires

**Theory of experiment :**

The diode is a device formed from a junction of n-type and p-type semiconductor material. The lead connected to the p-type material is called the anode and the lead connected to the n-type material is the cathode. In general, the cathode of a diode is marked by a solid line on the diode.The primary function of the diode is rectification. When it is forward biased (the higher potential is connected to the anode lead), it will pass current. When it is reversed biased ( the higher potential is connected to the cathode lead), current flow is blocked.A general curve looks like this:



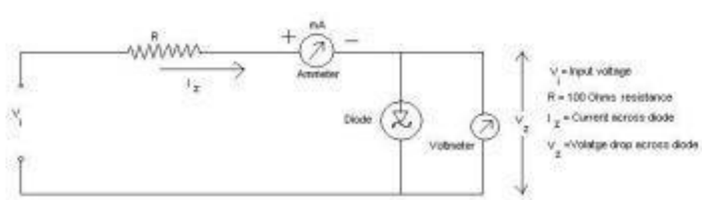

In the forward-bias region the V-I relationship is described as follows:

$$I = Is(e\ V\ nVT - 1)$$

In the above equation, I is the forward current, V is the forward voltage, It is the saturation current, and $VT = kT/q$ is the thermal voltage. Initially, the V vs I graph is linear but then after reaching breakdown, it becomes exponential.

**Procedure :**

First, complete a circuit as shown below with a 100Ω resistor and an variable DC input voltage source.

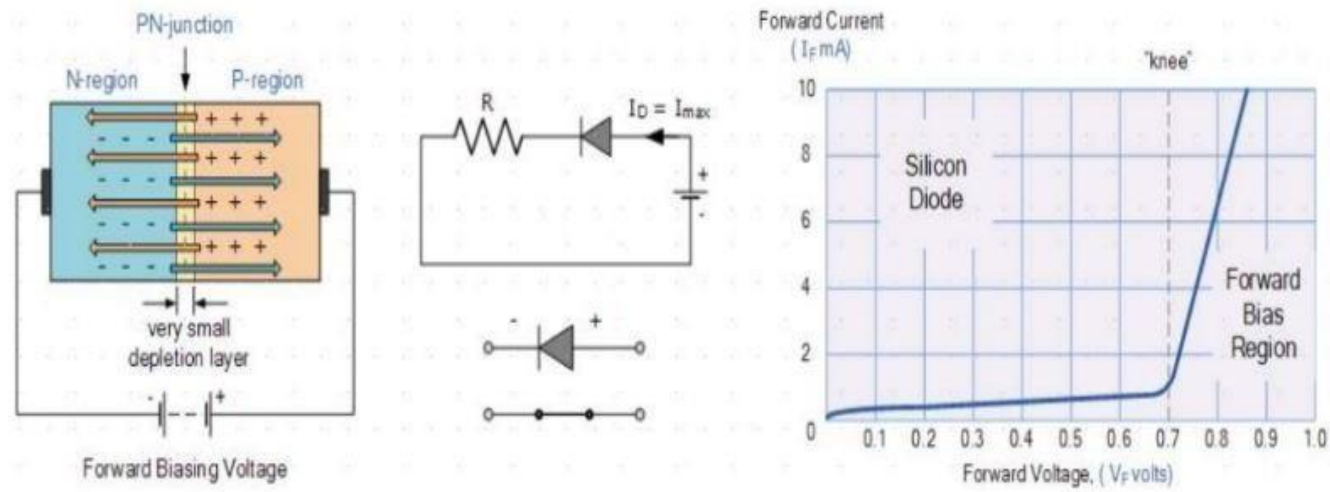



We first note the point where the ammeter starts deflecting. We note this point and gradually increase the input voltage and take the corressponding current readings. We have to take many readings till the input voltage is

about 30V. On plotting an V vs I curve, we will get a clear picture of the diode characteristic. Now, we change the direction of voltage that is being applied. Then, we can get the readings in reverse bias. These readings on plotting will be linear.

**Forward Biased PN Junction Diode :**

When a diode is connected in a Forward Bias condition, a negative voltage is applied to the N-type material
and a positive voltage is applied to the P-type material. If this external voltage becomes greater than
the value of the potential barrier, approx. 0.7 volts for silicon and 0.3 volts for germanium, the potential
barriers opposition will be overcome and current will start to flow.
This is because the negative voltage pushes or repels electrons towards the junction giving them the
energy to cross over and combine with the holes being pushed in the opposite direction towards the junction
by the positive voltage. This results in a characteristics curve of zero current flowing up to this voltage
point, called the knee on the static curves and then a high current flow through the diode with little
increase in the external voltage as shown below.

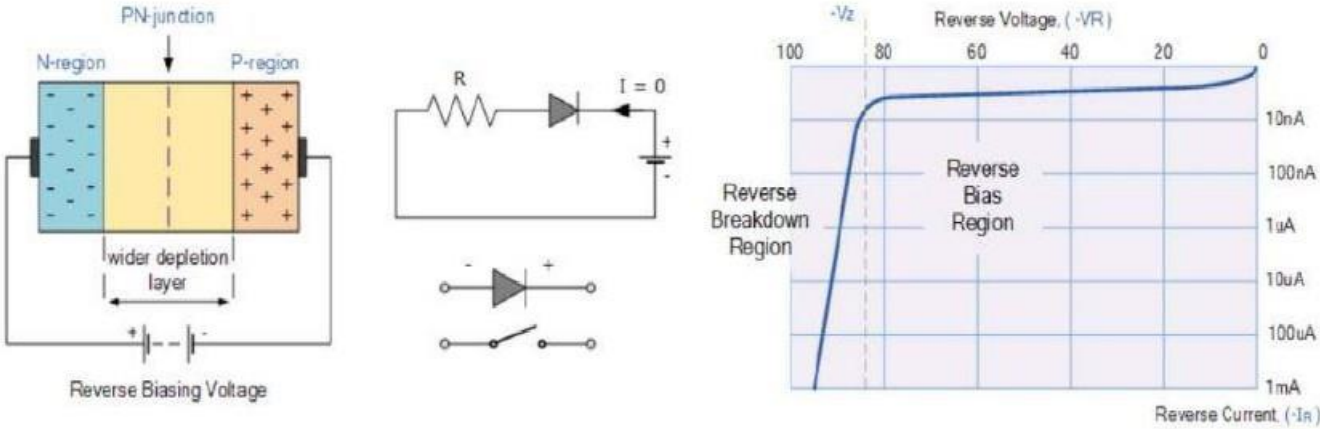



Since the diode can conduct infinite current above this knee point as it effectively becomes a short circuit, therefore resistors are used in series with the diode to limit its current flow. Exceeding its maximum forward current specification causes the device to dissipate more power in the form of heat than it was designed for resulting in a very quick failure of the device

**Reverse Biased PN Junction Diode :**

When a diode is connected in a Reverse Bias condition, a positive voltage is applied to the N-type material and a negative voltage is applied to the P-type material. The positive voltage applied to the N-type material attracts electrons towards the positive electrode and away from the junction, while the holes in the P-type end are also attracted away from the junction towards the negative electrode.

The net result is that the depletion layer grows wider due to a lack of electrons and forms a potential barrier which prevent the current from flowing through the semiconductor material .

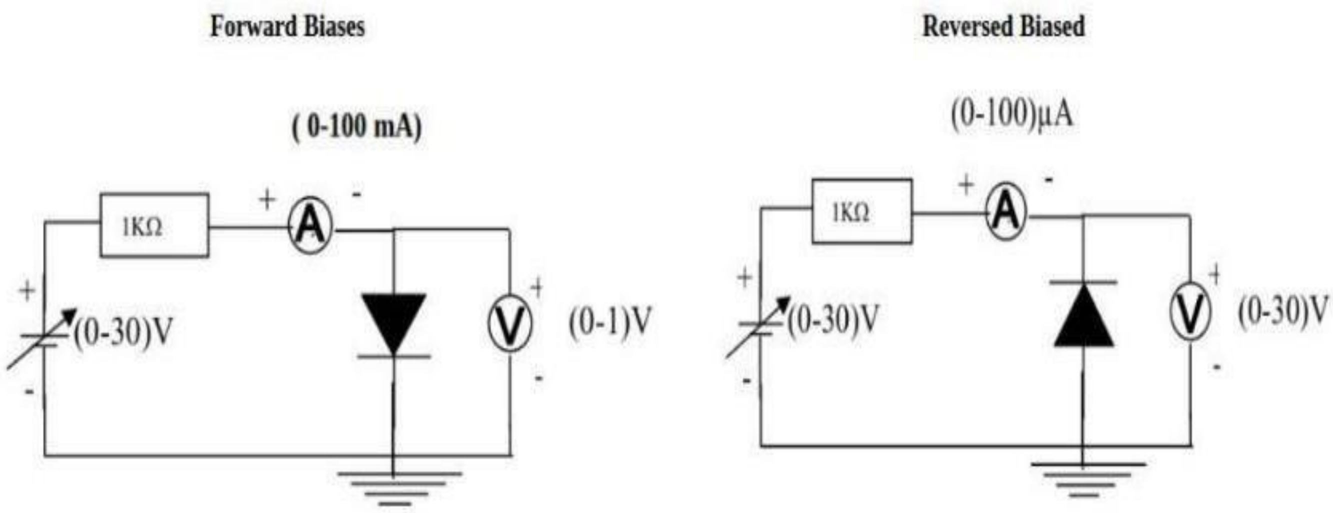



This condition represents a high resistance value to the PN junction and practically zero current flows through the junction diode with an increase in bias voltage. However, a very small leakage current does flow through the junction which can be measured in micro-amperes.

One final point, if the reverse bias voltage Vr applied to the diode is increased to a sufficiently high enough value, it will cause the diodes PN junction to overheat and fail due to the avalanche effect around the junction. This may cause the diode to become shorted and will result in the flow of maximum circuit current, and this shown as a step downward slope in the reverse static characteristics curve.

Sometimes this avalanche effect has practical applications in voltage stabilizing circuits where a series limiting resistor is used with the diode to limit this reverse breakdown current to a preset maximum value thereby producing a fixed voltage output across the diode. These types of diodes are commonly known as Zener Diodes and are discussed in next experiment .

**Circuit Diagram:**




**Procedure :**

**FORWARD BIASED :**

1. Connect the circuit as per the diagram.
2. Vary the applied voltage V in steps of 0.1V.
3. Note down the corresponding Ammeter readings $I_F$ .
4. Plot a graph between $V_F$ and $I_F$

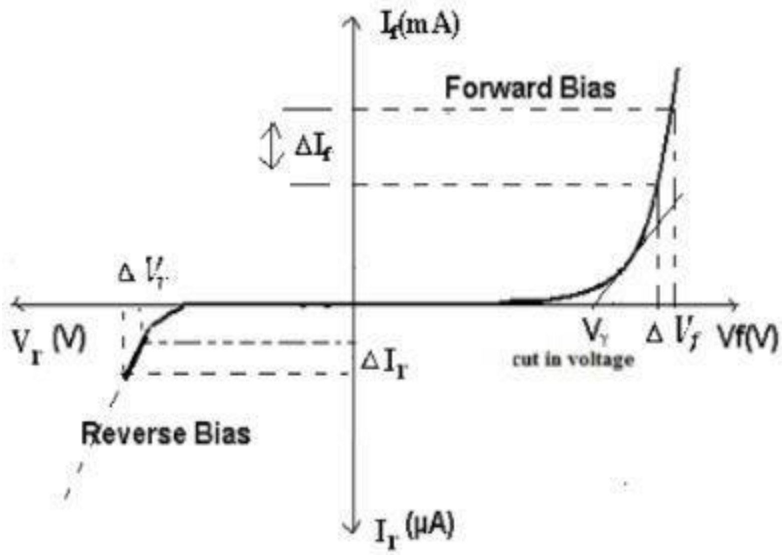
**REVERSE BIASED :**

1. Connect the circuit as per the diagram.
2. Vary the applied voltage $V_R$ in steps of 0.5V.
3. Note down the corresponding Ammeter readings $I_r$ .
4. Plot a graph between $V_R$ and $I_R$

**Observations:**

Least count of voltmeter =..........V
Zero error of voltmeter =......... V
Range of milli-ammeter = ......... mA

Least count of milli-ammeter =......... mA
Zero error of milli-ammeter = ......... mA




**Forward Biased**

| S.No. | VOLTAGE($V_f$) (In Volts) | CURRENT($I_f$) (In mA) |
|---|---|---|
| | | |

**Reversed Biased**

| S..No. | VOLTAGE($V_r$) (In Volts) | CURRENT($I_r$) (In μA) |
|---|---|---|
| | | |

**Result:**

Thus the VI characteristics of PN junction diode is verified. and it is found that:

1. Cut in voltage = ........ V
2. Static forward resistance = ....... Ω
3. Dynamic forward resistance =........Ω
4. Dynamic Reverse resistance = .......Ω
5. Static Reverse resistance =....... Ω

**Precautions and sources of error:**

1. All connections should be neat, clean and tight.
2. Forward-bias voltage beyond breakdown should not be applied.
3. Reverse-bias voltage beyond breakdown should not be applied.
4. Connect voltmeter and Ammeter in correct polarities as shown in the circuit diagram.
5. Do not switch ON the power supply unless you have checked the circuit connections as per the circuit
diagram

# EXPERIMENT 2
# ZENER I-V CHARACTERISTICS

**AIM:**

1) Obtain I-V characteristics of Zener diode

2) To study Zener diode as voltage regulator

3) To calculate % line and load regulation

**APPARATUS:**

Zener diode is a P-N junction diode specially designed to operate in the reverse biased mode. It is acting as normal diode while forward biasing. It has a particular voltage known as break down voltage, at which the diode break downs while reverse biased. In the case of normal diodes the diode damages at the break down voltage. But zener diode is specially designed to operate in the reverse breakdown region

**THEORY:**

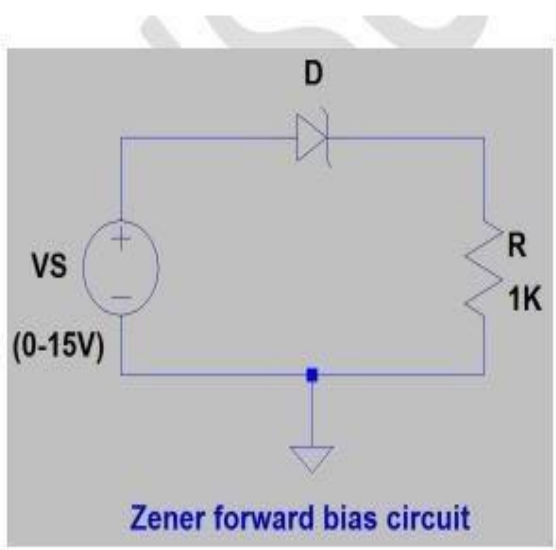
Zener diode is a P-N junction diode specially designed to operate in the reverse biased mode. It is acting as normal diode while forward biasing. It has a particular voltage known as break down voltage, at which the diode break downs while reverse biased. In the case of normal diodes the diode damages at the break down voltage. But zener diode is specially designed to operate in the reverse breakdown region.

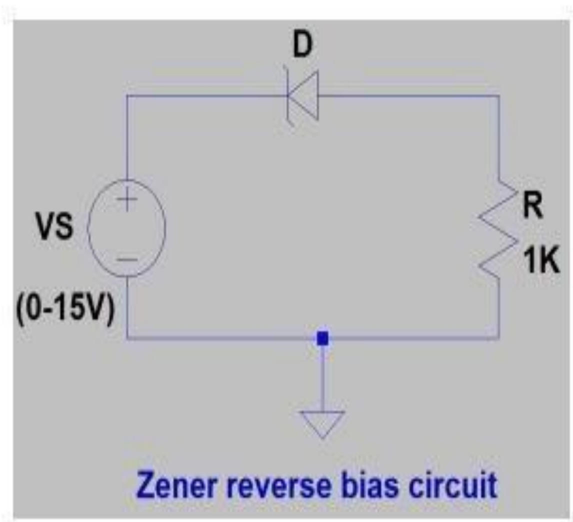
The basic principle of zener diode is the zener breakdown. When a diode is heavily doped, it's depletion region will be narrow. When a high reverse voltage is applied across the junction, there will be very strong electric field at the junction.

And the electron hole pair generation takes place. Thus heavy current flows. This is known as zener breakdown.

The breakdown voltage depends upon the amount of doping. For a heavily doped diode depletion layer will be thin and breakdown occurs at low reverse voltage and the breakdown voltage is sharp, whereas a lightly doped diode has a higher breakdown voltage.

This explains the zener diode characteristics in the reverse bias region. So a zener diode, in a forward biased condition acts as a normal diode. In reverse biased mode, after the break down of junction current through diode increases sharply. But the voltage across it remains constant. This principle is used in voltage regulator using zener diodes.



# Experiment (3)

# Rectifier Circuits

## Objectives

The purpose of this experiment is to demonstrate the operation of three different diode rectifier circuits which are the half-wave rectifier, center-tapped full-wave rectifier, and the bridge full-wave rectifier. In addition to that, the operation of a capacitor filter connected to the output of the rectifier will also be demonstrated.

## Required Parts and Equipments

1- Digital Multimeters
2- Electronic Test Board
3- Step-down center-tapped transformer (220V/12Vr.m.s)
4- Dual-Channel Oscilloscope
5- General Purpose Silicon Diodes 1N40076- Resistor 100kΩ
7- Capacitors 2.2µF, 10µF
8- Leads and BNC Adaptors

## 1. Theory

The rectifier is circuit that converts the AC input voltage into a pulsed waveform having an average (or DC) value. This waveform can then be filtered to remove the unwanted variations. Rectifiers are widely used in power supplies which provide the DC voltage necessary for electronic circuits. The three basic rectifier circuits are the half-wave, the center-tapped full-wave, and the full-wave bridge rectifier circuits. The most important parameters for choosing diodes for these circuits are the maximum forward current, and the peak inverse voltage rating (PIV) of the diode. The peak inverse voltage is the maximum voltage the diode can withstand when it is reverse-biased. The amount of reverse voltage that appears across a diode depends on the type of circuit in which it is connected. Some characteristics of the three rectifier circuits will be investigated in this experiment.

### 1.1 Half-Wave Rectifier

Figure 1 shows a schematic diagram of a transformer coupled half-wave rectifier circuit. The transformer is useful in electrically isolating the diode rectifier circuit from the 220V AC source, and also is used to step-down the input line voltage into a suitable value according to

the turns ratio.
The transformer's turns ratio is defined by:

$$n = \frac{V_{pr(r.m.s)}}{V_{s(r.m.s)}} \quad (1)$$

Where $V_{pr(r.m.s)}$ is the *r.m.s* value of the transformer primary winding voltage, and $V_{s(r.m.s)}$ is the *r.m.s* value of the transformer secondary winding voltage.
In the circuit of Fig.1, $V_{pr(r.m.s)} = 220V$

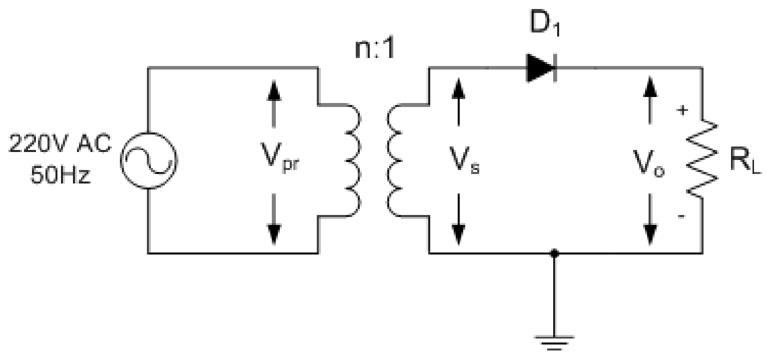



*Figure 1: Half-Wave Rectifier with Transformer-Coupled Input Voltage*

The peak value of the secondary winding voltage $V_{sp}$ is related to the *r.m.s* value by the relation:

$$V_{sp} = \sqrt{2}.V_{S(r.m.s)} \tag{2}$$

When the sinusoidal voltage across the secondary winding of the transformer goes positive, the diode is forward-biased and conducts current through the load resistor $R_L$. Thus, the output voltage across $R_L$ has the same shape as the positive half-cycle of the input voltage.

When the secondary winding voltage goes negative during the second half of its cycle, the diode is reverse-biased. There is no current in this case, so the voltage across the load resistor is 0V. The net result is that only the positive half-cycles of the AC input voltage on the secondary winding appear across the load as shown in Fig.2. Since the output does not change polarity, it is a pulsating DC voltage with frequency equals to that of the input AC voltage.

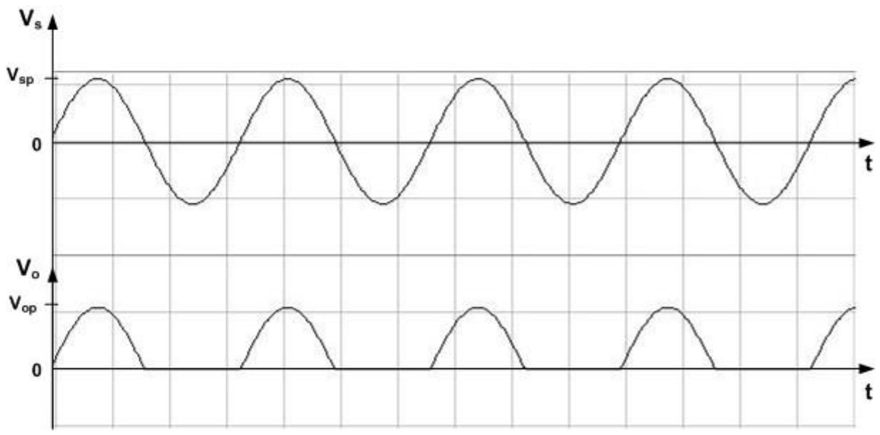



*Figure 2: Waveforms of the Half-Wave Rectifier Circuit*

When taking the voltage drop across the diode into account, the peak value of the output voltage is given by:

$$V_{op} = V_{sp} - 0.7 \tag{3}$$

In equation (3), it was assumed that the voltage drop across the silicon diode is 0.7V when it conducts.

It can be verified that the average (or DC) value of the output voltage is given by:

$$V_{dc} = \frac{V_{op}}{\pi} = \frac{V_{sp} - 0.7}{\pi} \tag{4}$$

The peak inverse voltage (PIV) of the diode for this circuit equals the peak value of the secondary winding voltage:

$$PIV = V_{sp} = V_{op} + 0.7 \tag{5}$$

## 1.2 Center-Tapped Full-Wave Rectifier

The full-wave center-tapped rectifier uses two diodes connected to the secondary of a center-tapped transformer as shown in Fig.3.

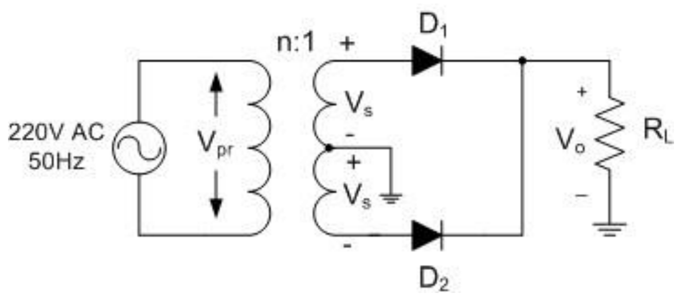
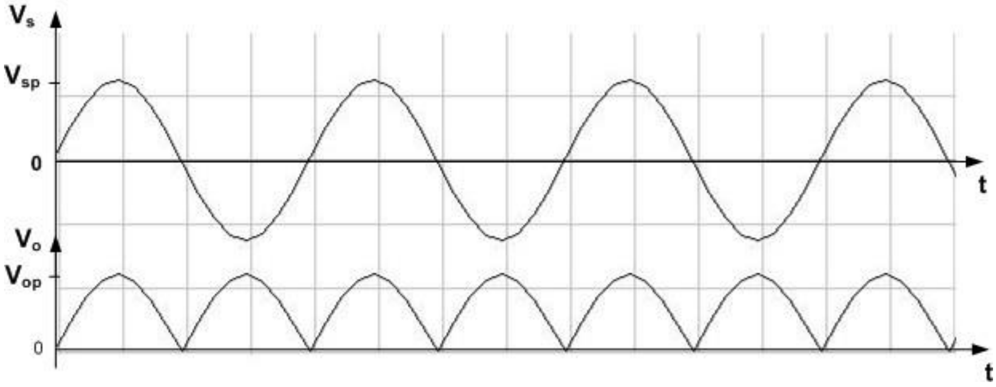



*Figure 3: The Center-Tapped Full-Wave Rectifier Circuit*

The Input voltage is coupled through the transformer to the center-tapped secondary. For the positive half cycle of the input signal, the polarities of the secondary winding voltages are shown in Fig.3. This makes the upper diode $D_1$ conducting and the lower diode $D_2$ to be reverse-biased. The current path is through $D_1$ and the load resistor $R_L$. For the negative half cycle of the input voltage, the voltage polarities on the secondary winding of the transformer will be reversed causing $D_2$ to conduct, while reverse-biasing $D_1$.The current path is through $D_2$ and $R_L$. Because the output current during both the positive and negative portions of the input cycle is in the same direction through the load, the output voltage developed across the load resistor is a full-wave rectified DC voltage as shown in Fig.4.



The DC output voltage of the full-wave rectifier is given by:

$$V_{dc} = \frac{2V_{op}}{\pi} = \frac{2(V_{sp} - 0.7)}{\pi} \quad (6)$$

The peak inverse voltage (PIV) of each diode in this circuit is obtained as:

$$PIV = 2V_{sp} - 0.7 = 2V_{op} + 0.7 \quad (7)$$

The frequency of the output voltage equals twice the line frequency as shown from the waveform of the output voltage.

## 1.3 Full-Wave Bridge Rectifier

The full-wave bridge rectifier uses four diodes as shown in Fig.5. When the input cycle is positive, diodes $D_1$ and $D_2$ are forward biased and conduct current. A voltage is developed across $R_L$ which looks like the positive half of the input cycle. During this time, diodes $D_3$ and $D_4$ are reverse-biased.

When the input cycle is negative, diodes $D_3$ and $D_4$ become forward-biased and conduct current in the same direction through $R_L$ as during the positive half-cycle. During the negativehalf-cycle, $D_1$ and $D_2$ are reverse biased. A full-wave rectified output voltage appears across $R_L$ as a result of this action.

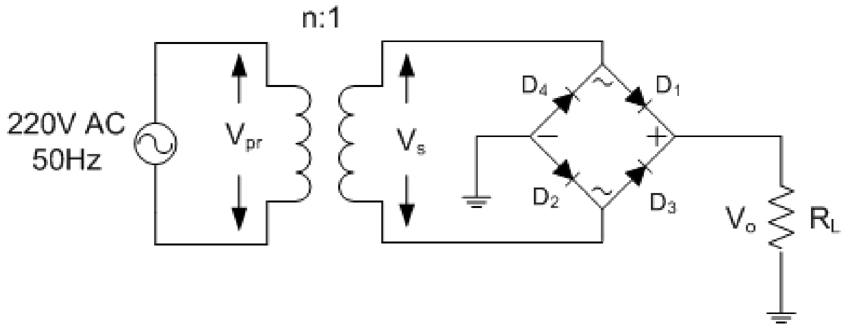



*Figure 5: The Full-Wave Bridge Rectifier Circuit*

In this circuit, two diodes are always in series with the load resistor during both the positive and negative half-cycles. If these diode drops are taken into account, the output peak voltage is:

$$V_{op} = V_{sp} - 1.4$$

(8)

The DC output voltage is given by:

$$V_{dc} = \frac{2V_{op}}{\pi} = \frac{2(V_{sp} - 1.4)}{\pi} \quad (9)$$

The peak inverse voltage of each diode in the circuit is given by:

$$PIV = V_{sp} - 0.7 = V_{op} + 0.7 \quad (10)$$

## **1.4** Capacitor Filter

As stated previously, the filter is used to reduce the ripples in the pulsating waveform of the rectifier. A half-wave rectifier with a capacitor filter is shown in Fig.6.

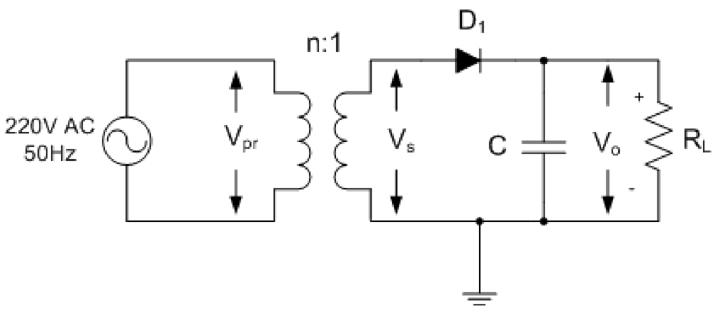



*Figure 6: Half-Wave Rectifier with a Capacitor Filter*

During the positive first quarter-cycle of the input signal, the diode is forward-biased, allowing the capacitor to charge to within 0.7V of the peak value of the secondary winding voltage. When the input begins to decrease below its peak, the capacitor retains its charge and the diode becomes reverse-biased because the cathode is more positive than the anode. During the remaining part of the cycle, the capacitor can discharge only through the load resistance at a rate determined by the $R_L C$ time constant, which is normally long compared to the period of the input signal. Figure 7 shows the output voltage of the filter circuit.

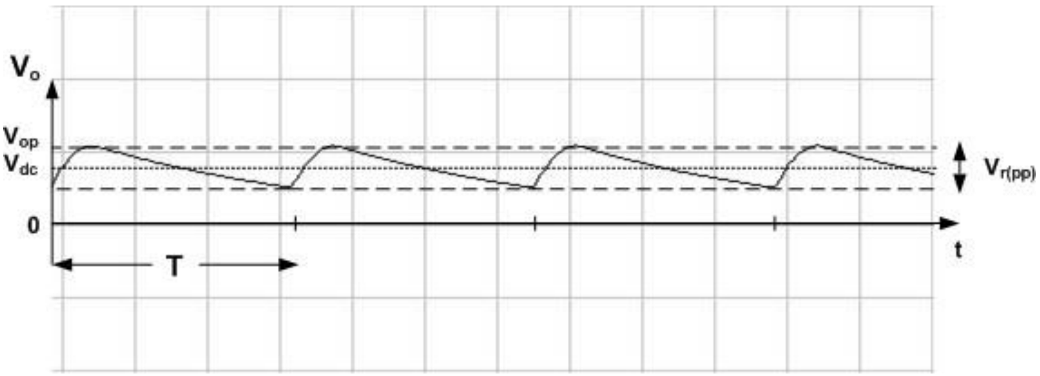



*Figure 7: Output Waveform of the Capacitor Filter Connected with the Half-Wave Rectifier*

The variation in the capacitor voltage due to the charging and discharging is called the ripple voltage as illustrated in Fig.7. Generally, ripple is undesirable. Thus, the smaller the ripple, the better the filtering action.

For a half-wave rectified capacitor filter, the approximate value of the peak-to-peak ripple voltage is given by:

$$V_{r(pp)} \approx \left(\frac{1}{fR_L C}\right) V_{op} \tag{11}$$

Where $f$ is the frequency of the input signal, and $V_{op}$ is the measured peak value of the output waveform.

The DC voltage of the output waveform can be approximated by:

$$V_{dc} \approx V_{op} - \frac{V_{r(pp)}}{2} \tag{12}$$

Or,

$$V_{dc} \approx \left(1 - \frac{1}{2fR_L C}\right) V_{op} \tag{13}$$

$L$

For the full-wave rectifier, the output frequency is twice that of the half-wave rectifier. This makes a full-wave rectifier easier to filter because of the shorter time between peaks. The peak-to-peak ripple voltage for the full-wave rectified capacitor filter is given by:

$$V_{r(pp)} = \left(\frac{1}{2fR_L C}\right)V_{op} \qquad (14)$$

The DC voltage of the output waveform for the full-wave rectified capacitor filter can be approximated by:

$$V_{dc} = \left(1 - \frac{1}{4fR_L C}\right)V_{op} \qquad (15)$$

The ripple factor is an indication of the effectiveness of the filter and is defined as:

$$r = \frac{V_{r(pp)}}{V_{dc}} \qquad (16)$$

The lower the ripple factor, the better the filter. The ripple factor can be lowered by increasing the value of the filter capacitor or increasing the load resistance.

## 2. Procedure

1. Connect the half-wave rectifier circuit shown in Fig.8. Measure the DC output voltage, peak value of the secondary winding voltage, and the peak value of the outputvoltage as tabulated in Table 1. Sketch the output waveform.

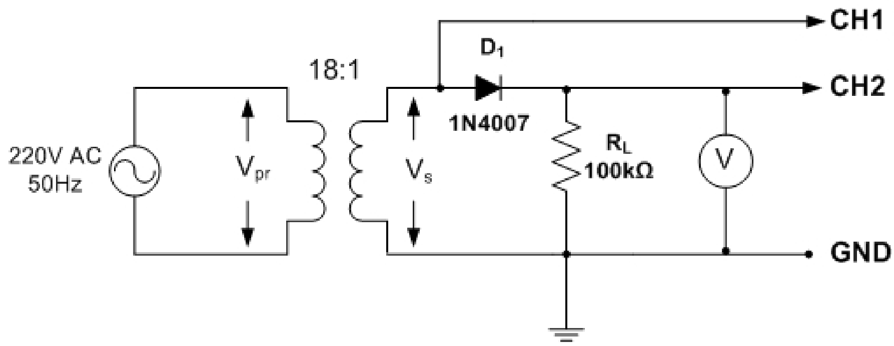



*Figure 8: The Practical Half-Wave Rectifier Circuit*

Table 1: Recorded Data for the Half-wave Rectifier Circuit

| Quantity | Measured Value | Calculated Value |
|---|---|---|
| $V_{sp}$ | | |
| $V_{op}$ | | |
| $V_{dc}$ | | |

1. Connect a capacitor filter at the output of the half-wave rectifier as shown in Fig.9,and measure the DC output voltage and peak-to-peak ripple voltage in the output.

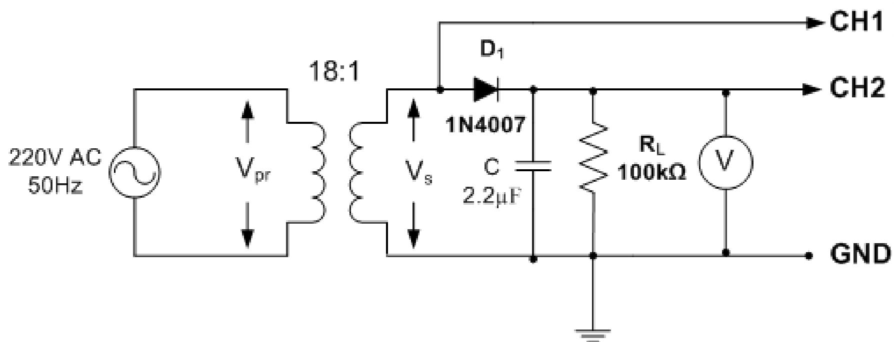



*Figure 9: Practical Capacitor Filter Connected to the Half-Wave Rectifier*

Table 2: Recorded Data for the Half-wave Rectifier and Filter Circuit

| Quantity | Measured Value | Calculated Value |
|---|---|---|
| $V_{dc}$ | | |

| $V_{r(pp)}$ | | |
|---|---|---|

2. Repeat step 2 after replacing the filter capacitor with another one of value 10μF.

3. Connect the full-wave center-tapped transformer rectifier circuit shown in Fig.10. Measure the DC output voltage, peak value of the secondary winding voltage, and the peak value of the output voltage as tabulated in Table 3. Sketch the output waveformin this case.

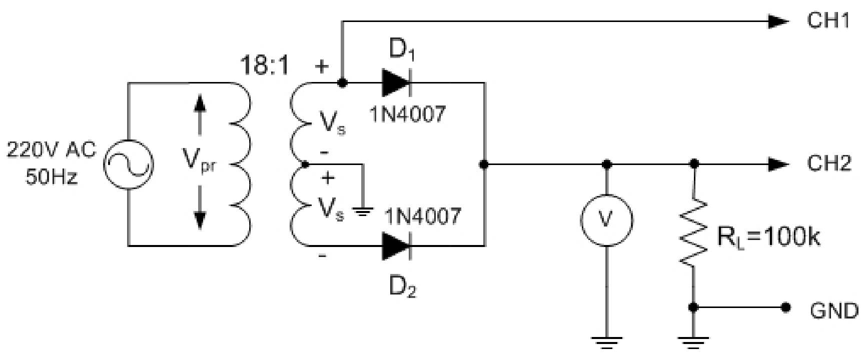



*Figure 10: Practical Circuit for the Center-Tapped Full-Wave Rectifier*

Table 3: Recorded Data for the Center-Tapped Rectifier Circuit

| Quantity | Measured Value | Calculated Value |
|---|---|---|
| $V_{sp}$ | | |
| $V_{op}$ | | |
| $V_{dc}$ | | |

1. Connect a capacitor filter at the output of the full-wave rectifier as shown in Fig.11,and measure the DC output voltage and peak-to-peak ripple voltage at the output.

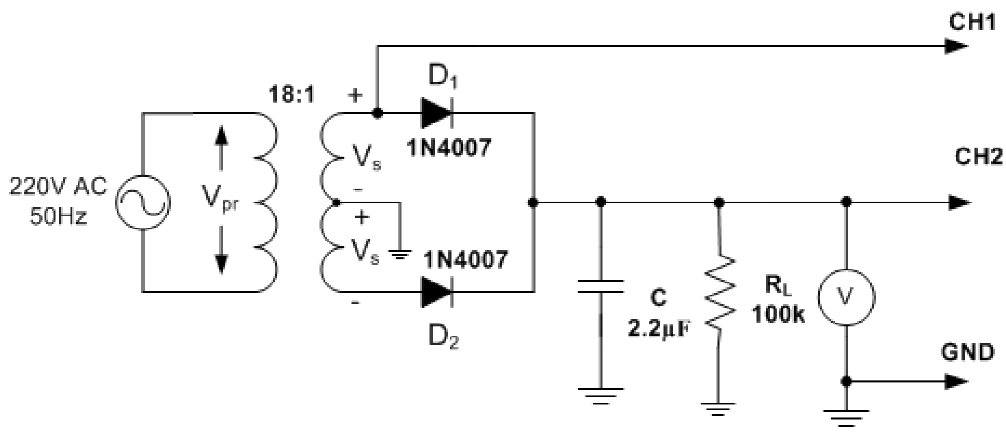



*Figure 11: Practical Circuit for the Center-Tapped Full-WaveRectifier with the Capacitor Filter*

Table 4: Recorded Data for the Full-wave Center-Tapped Rectifier and Filter Circuit

| Quantity | Measured Value | Calculated Value |
|---|---|---|
| $V_{dc}$ | | |
| $V_{r(pp)}$ | | |

2. Replace the filter capacitor with another one of value 10μF and repeat step 5.

3. Connect the full-wave bridge rectifier circuit shown in Fig.12. Measure the DC output voltage, and the peak value of the output voltage as tabulated in Table 5. Sketch the output waveform in this case. It should be noted that the secondary winding waveformin this case is similar to that of the center-tapped full-wave rectifier.

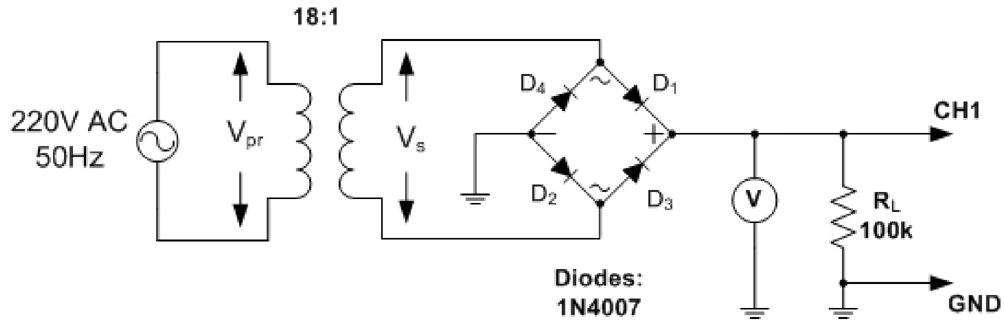



*Figure 12: The Practical Full-Wave Bridge Rectifier Circuit*

Table 5: Recorded Data for the Full-Wave Bridge Rectifier Circuit

| Quantity | Measured Value | Calculated Value |
|---|---|---|
| $V_{op}$ | | |
| $V_{dc}$ | | |

4. Connect a capacitor filter at the output of the full-wave bridge rectifier as shown inFig.13, and measure the DC output voltage and peak-to-peak ripple voltage at the output.

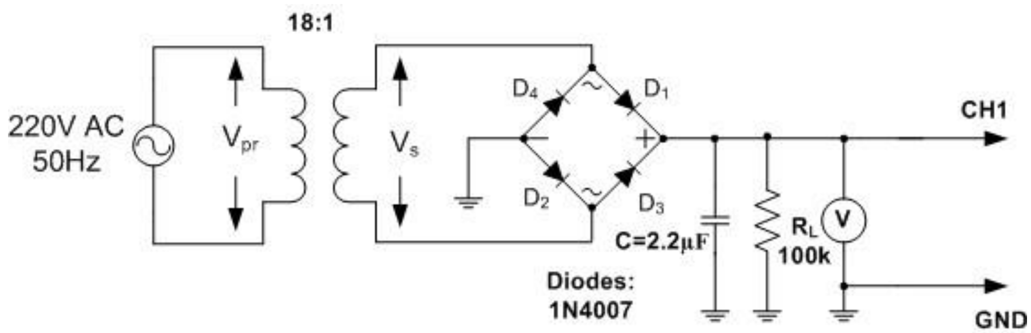



*Figure 13: Practical Circuit for the Full-Wave BridgeRectifier with the Capacitor Filter*

Table 6: Recorded Data for the Full-wave Bridge Rectifier and Filter Circuit

| Quantity | Measured Value | Calculated Value |
|---|---|---|
| $V_{dc}$ | | |
| $V_{r(pp)}$ | | |

5. Replace the filter capacitor with another one of value 10µF and repeat step 8.

## 3. Calculations and Discussion

1. Calculate the theoretical output DC voltage of the half-wave rectifier circuit andcompare it with measured value. For the capacitive filter, obtain the theoretical values of the DC output voltage and the ripple voltage and compare these values with the measured quantities. Determine also the practical and theoretical values of the ripple factor.

2. Calculate the theoretical output DC voltage of the center-tapped full-wave rectifier circuit and compare it with measured value. For the capacitive filter, obtain thetheoretical values of the DC output voltage and the ripple voltage and compare these values with the measured quantities. Determine also the practical and theoreticalvalues of the ripple factor.

3. Repeat the calculations for the full-wave bridge rectifier and filter circuit.

4. Determine the peak inverse voltage (PIV) on each diode in the three rectifier circu

4. If diode $D_4$ in the bridge rectifier circuit of *Figure 5* was removed or burned, explain the operation of the circuit in this case and sketch the predicted waveform of the output.

5. Explain the effect of increasing the filter capacitance on the output voltage in the half- wave rectifier and filter circuit.

6. Compare the DC output voltages of the three rectifier circuits. Which circuit has the highest output? On the other hand, which circuit has the lowest peak inverse voltage on each diode?

7. What value of filter capacitor is required to produce 1% ripple factor for a full-wave rectifier having a load resistance of 1.5kΩ? Assume that the peak value of the output voltage is 1

# Experiment (4)

## The Input & Output characteristics of CE (Common emitter ) configuration of BJT

**Objective :**

**The objective of this experiment is to study characteristics of a commonemitter transistor.Study how it controls the flow of current and simulatethe workings of 2N2222 BJT at different input voltages**

**Equipment and Components :**

**(1)2N2222 Bipolar Junction Transistor**

**(2) Resistor 100k ohm and 1k ohm**

**(3)Interactive DC Power supply**

**(4) Chords and Wires**

**(5) Digital mutimeter**

## Procedure:

The procedures that I followed to carry out the experiment are written below:

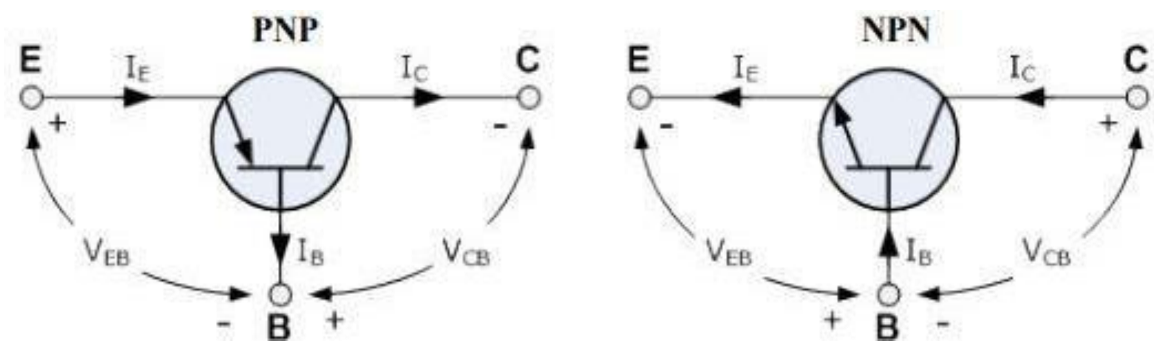
(1) I pressed ctrl + W and selected group Sources and under family I selected SIGNAL VOLTAGE SOURCES, from there I chose the DCINTER ACTIVE VOLTAGE and placed in on the other side of the diode

(2) Simiarly I chose the GROUND from the Sources group by pressing ctrl+ wand opening the componenets menu.

(3) Again I pressed ctrl + W and selected the group Basic and under family option I selected Resistor

## Overview:

A Bipolar Junction Transistor, or BJT is a three terminal device having two PNjunctions connected together in series. Each terminal is given a name to identify it and these are known as the Emitter (E), Base (B) and Collector (C). There are two basic types of bipolar transistor construction, NPN and PNP, which basically describes the physical arrangement of the P-type and N-type semiconductor materials from which they are made. Bipolar Transistors are "CURRENT" Amplifying or current regulating devices that control the amount of current flowing through them in proportion to the amount of biasing current applied to their base terminal. The principle of operation of the two transistor types NPN and PNP, is exactly the same the only difference being in the biasing (base current) and the polarity of the power supply for each type.




The symbols for both the NPN and PNP bipolar transistor are shown above along with the direction of conventional current flow. The direction of the arrow in the symbol shows current flow between the base and emitter terminal, pointing from the positive Ptype region to the negative N-type region, exactly the same as for the standard diode symbol. For normal operation, the emitter-base junction is forward-biased and the collector-base junction is reverse-biased.

## Common Emitter Transistor Characteristics :

In a common emitter configuration, emitter is common to both input and output as shown in its circuit diagram.

**(1) Input Characteristics:**

The variation of the base current IB with the base-emitter voltage VBE keeping the collector-emitter voltage VCE fixed, gives the input characteristic in CE mode.

**Input Dynamic Resistance (ri):**

This is defined as the ratio of change in base emitter voltage (ΔVBE) to the resulting change in base current (ΔIB) at constant collector-emitter voltage (VCE). This is dynamic and it can be seen from the input characteristic, its value varies with the operating current in the transistor:

$$r_i = \left.\frac{\Delta V_{BE}}{\Delta I_B}\right|_{V_{CE}}$$

The value of ri can be anything from a few hundreds to a few thousand ohms.

**(2) Output Characteristics:**

The variation of the collector current IC with the collectoremitter voltage VCE is called the output characteristic. The plot of IC versus VCE for different fixed values of IB gives one output characteristic. Since the collector current changes with the base current, there will be different output characteristics corresponding to different values of IB.

**Output Dynamic Resistance (ro):**

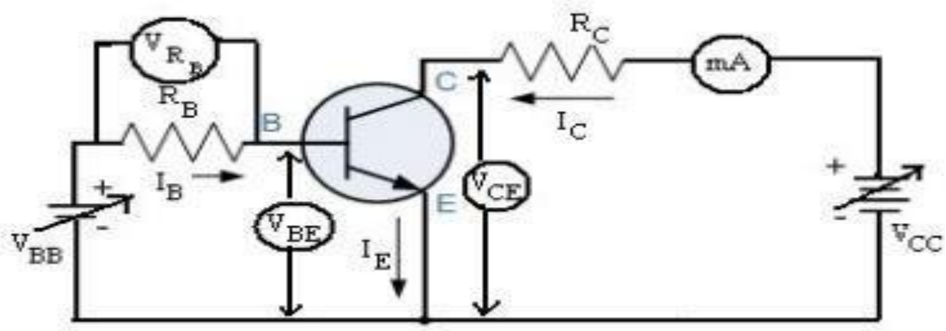
This is defined as the ratio of change in collector emitter voltage (ΔVCE) to the change in collector current (ΔIC) at a constant base current IB

$$r_o = \left.\frac{\Delta V_{CE}}{\Delta I_C}\right|_{I_B}$$

The high magnitude of the output resistance (of the order of 100 kW) is due to the reverse-biased state of this diode.

**(3) Transfer Characteristics:**

The transfer characteristics are plotted between the input and output currents (IB versus IC). Both IB and IC increase proportionately.




**NPN transistor in CE configuration**

**Procedure:**

1. Note down the code of the transistor.

2. Identify different terminals (E, B and C) and the type (PNP/NPN) of the transistors.

For any specific information refer to the datasheet of the transistors.

**(I) NPN Common Emitter (CE) characteristics**

1. Now configure CE circuit using the NPN transistor as per the circuit diagram. Use RB = 100kΩ and RC = 1 kΩ.

2. For input characteristics, first fix the voltage VCE by adjusting VCC to the minimum possible position. Now vary the voltage VBE slowly (say, in steps of 0.05V) by varying VBB. Measure VBE using a multimeter. If VCE varies during measurement bring it back to the set value To determine IB, measure VRB across the resistor RB and use the relation IB = VRB/RB.

3. Repeat the above step for another value of VCE say, 2V.

4. For output characteristics, first fix IB = 0, i.e. VRB = 0. By adjusting VCC, vary the collector voltage VCE in steps of say 1V and measure VCE and the corresponding IC using multimeters. If needed vary VCE in negative direction as described for CB configuration and measure both VCE and IC, till you get 0 current.

5. Repeat the above step for at least 5 different values of IB by adjusting VBB. You may need to adjust VBB continuously during measurement in order to maintain a constant IB.

6. Plot the input and output characteristics by using the readings taken above and determine the input and output dynamic resistance.

7. To plot transfer characteristics, select a suitable voltage VCE well within the active region of the output characteristics, which you have tabulated already (no need to take further data). Plot a graph between IC and the corresponding IB at the chosen voltage VCE. Determine βac from the slope of this graph.

**Observations: Transistor code:_________, RB =______, RC =_________.**
**Table (1): Input Characteristics :**

| Sl. No. | $V_{CE}$ = ___ V | | |
|---|---|---|---|
| | $V_{BE}$ (V) | $V_{RB}$ (V) | $I_B$ (μA) |
| 1 | | | |
| 2 | | | |
| .. | | | |
| 10 | | | |

**Table (2): Output Characteristics**

| Sl. No. | $I_{B1} = 0$ | | $I_{B2} =$ __ | | $I_{B3} =$ __ | | $I_{B4} =$ __ | | $I_{B5} =$ __ | |
|---|---|---|---|---|---|---|---|---|---|---|
| | $V_{CE}$ (V) | $I_C$ (mA) | $V_{CE}$ (V) | $I_C$ (mA) | $V_{CE}$ (V) | $I_C$ (mA) | $V_{CE}$ (V) | $I_C$ (mA) | $V_{CE}$ (V) | $I_C$ (mA) |
| 1 | | | | | | | | | | |
| 2 | | | | | | | | | | |
| .. | | | | | | | | | | |
| .. | | | | | | | | | | |
| 10 | | | | | | | | | | |

**Table (3): Transfer Characteristics VCE =________V**

| Sl. No. | $I_B$ (µA) | $I_C$ (mA) |
|---|---|---|
| 1 | | |
| 2 | | |
| 3 | | |
| 4 | | |
| 5 | | |

# Experiment 5

# The Common Emitter Amplifier

## Objectives

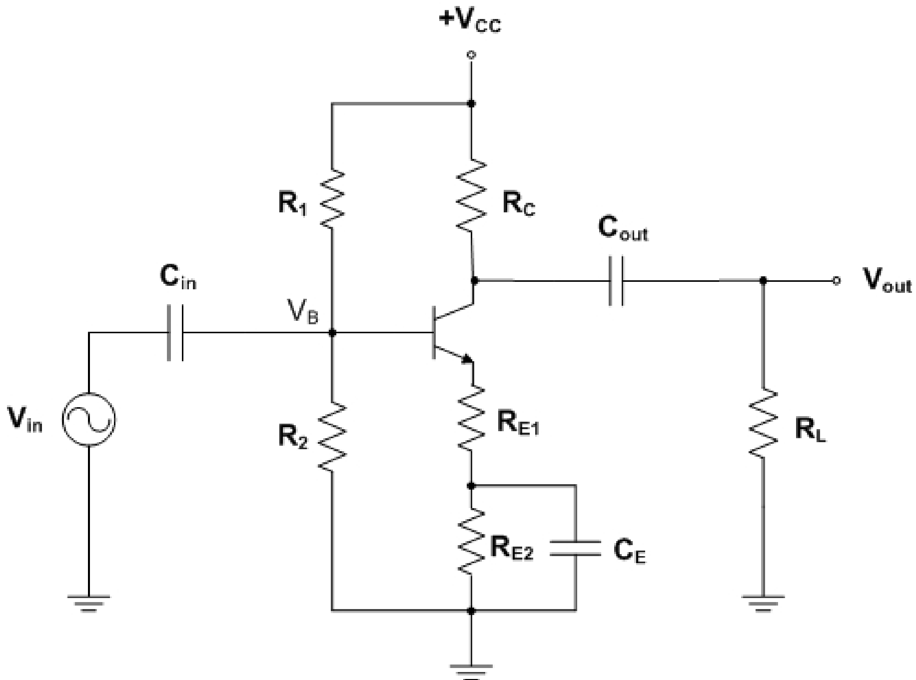
The purpose of this experiment is to demonstrate the operation of the small signal common-emitter amplifier and investigate the factors influencing the voltage gain as well as to determine the input and output impedances.

## Required Parts and Equipments

1. Experimental Test Board
2. Function Generator
3. DC Power Supply
4. Two-channel Oscilloscope
5. DC Multimeter
6. BC107 NPN Silicon Transistor
7. Resistors 10 KΩ, 3.3 KΩ, 2.7 KΩ, 1 KΩ, 120 Ω.
8. Capacitors 2.2 µF and 10 µF.

## 1. Theory

The common-emitter amplifier is characterized by the application of the input signal to the base lead of the transistor while taking the output from the collector, which always gives 180$^o$ phase shift between the input and output signals. Figure 1 presents a schematic diagram for a typical common-emitter amplifier using the voltage-divider bias configuration.




## 2. Procedure

1. Connect the circuit shown in Fig.5 and measure the DC voltages $V_B$, $V_E$, and $V_C$. Try to measure the DC current gain of the BC107 transistor $h_{FE}$ using a multi-meter. Tabulate your results as illustrated in Table-1.

Table-1: Measured Quantities for the DC Bias Circuit

| **Parameter** | β | $V_B$ | $V_E$ | $V_C$ | $I_{CQ}$ | $V_{CEQ}$ | $V_{BEQ}$ | $r_e$ |
|---|---|---|---|---|---|---|---|---|
| **Value** | | | | | | | | |
| | | | | | | | | |

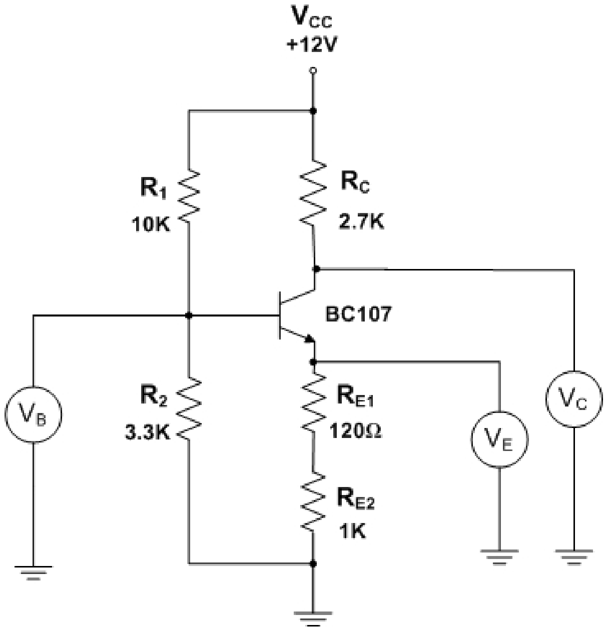



*Figure 5: The DC Bias Circuit of the Common Emitter Amplifier*

2. Connect the amplifier circuit shown in Fig.6, and apply a sinusoidal source signal with peak amplitude of 0.1V and frequency of 10 KHz. Display both the input (source) and output (load) signals on the oscilloscope. Try to measure the voltage gain $A_v$, where $A_v = V_{out}/V_S$.

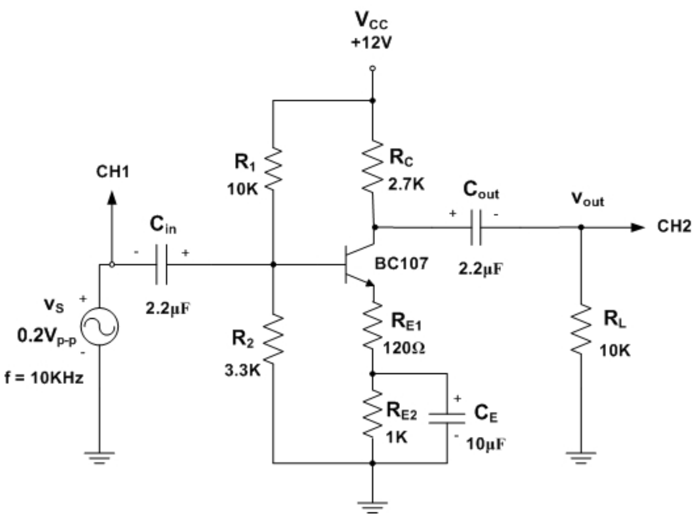



*Figure 6: The Practical Common Emitter Amplifier Circuit*

3. Remove load resistor $R_L$ and re-measure the voltage gain.

4. Remove the bypass capacitor $C_E$ and measure the voltage gain with the load resistor $R_L$ connected at the output. Tabulate your results as shown in Table-2.

Table-2: Voltage Gain for Different Cases

| **Case** | **Voltage Gain** |
|---|---|
| Normal ($R_L$=10KΩ) | |
| No-Load ($R_L = \infty$) | |
| No Bypass Capacitor | |

# Experiment No.6

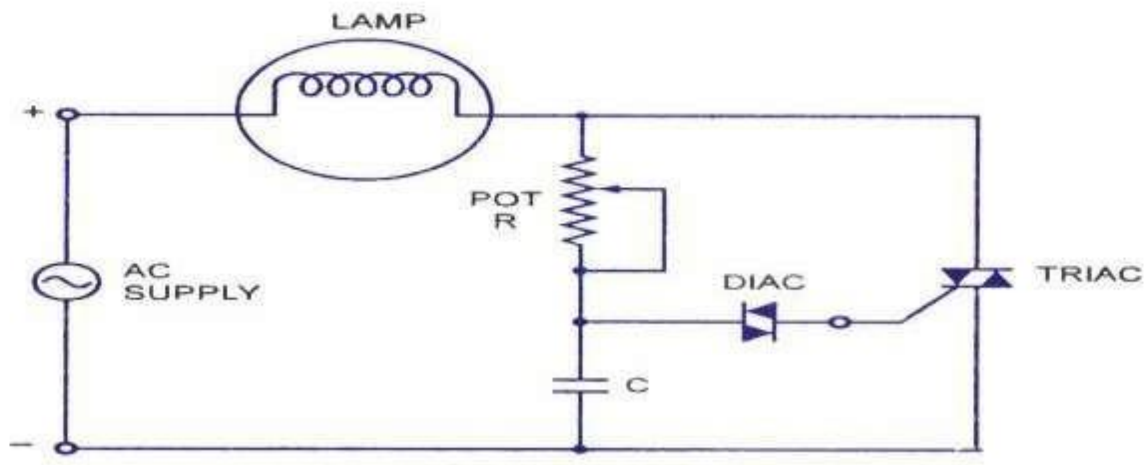
## Experiment Title: Phase control using SCR and TRIAC.

**Aim:-** To study fan control using SCR and lamp dimmer using TRIAC. (Phase control using SCR and TRIAC.)

**Objective: :-** To study fan control using SCR and lamp dimmer using TRIAC.

**Apparatus:-** Circuit board, Connecting wires, Isolation transformer, CRO, true value multimeter.

**Circuit Diagram:-**



*Triac Lamp Dimmer Circuit*

**Theory:**

This is the circuit diagram of the simplest lamp dimmer or fan regulator.The circuit is based on the principle of power control using a Triac.The circuit works by varying the firing angle of the Triac. Resistors R1, R2 and capacitor C2 are associated with this. The firing angle can be varied by varying the value of any of these components. Here R1 is selected as the variable element. By varying the value of R1 the firing angle of Triac changes (in simple words, how much time should Triac conduct) changes. This directly varies the load power, since load is driven by Triac. The firing pulses are given to the gateof Triac T1 using Diac D1

**Procedure:-**

1. Make connections as per Circuit diagram.

2. Observe the variation in light intensity in case of lamp dimmer and speed of fan in case of fan regulator.
3. Switch off the mains and remove connections

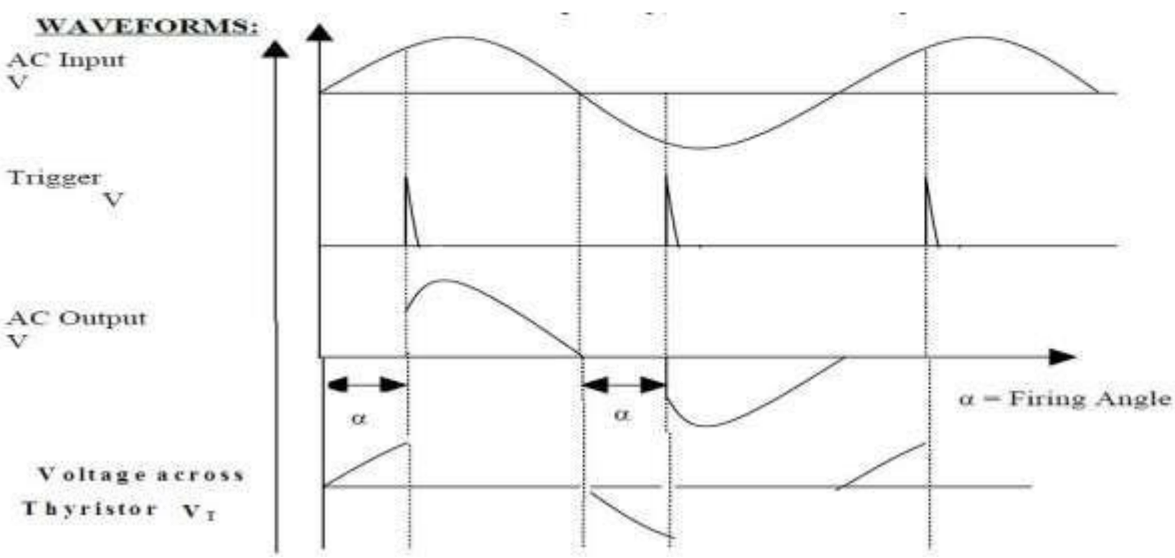
**<u>Observations:-</u>**

**: A.C** freq = 50 Hz, $\alpha = \omega t = 2\pi ft$

| **SR.NO** | **VOLTAGE ACROSS LOAD (V)** | **TIME PEROID (msec)** | **FIRING ANGLE (α)** |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

Plot graph in between V and α

**Waveforms:**




**<u>Result</u>: -** Thus we have studied phase control using SCR & TRIAC.

5. Remove the bypass capacitor $C_E$ and measure the voltage gain with the load resistor $R_L$ connected at the output. Tabulate your results as shown in Table-2.

Table-2: Voltage Gain for Different Cases

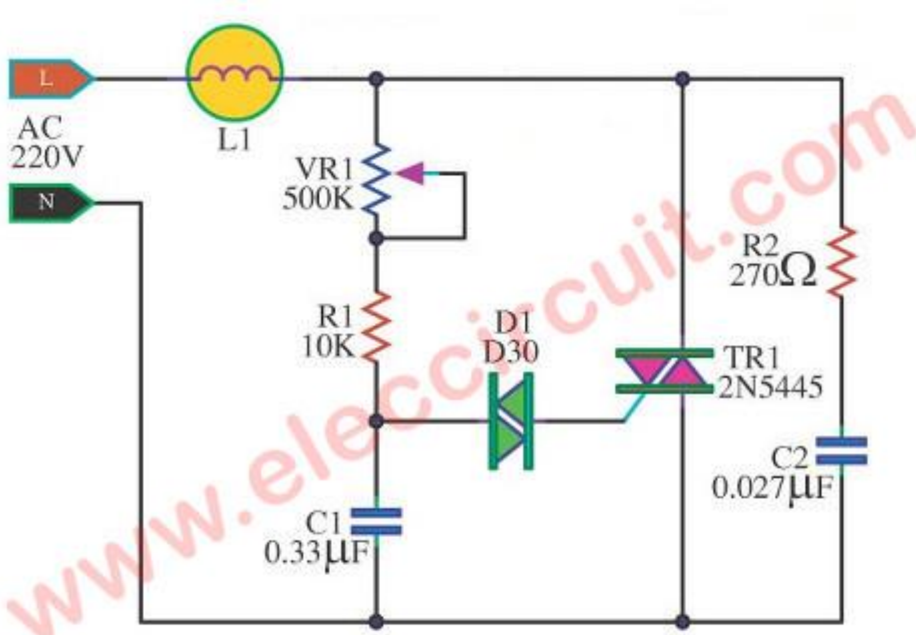
| **Case** | **Voltage Gain** |
|---|---|
| Normal ($R_L$=10KΩ) | |
| No-Load ($R_L = \infty$) | |
| No Bypass Capacitor | |

## Application Example

## # 5: AC Light Dimmer Circuit Using TRIAC and DIAC

This circuit use more components than the above circuit. Sure, it is better.

How?




**AC light dimmer circuit using TRIAC and DIAC (update from the Previous circuit)**

**Operation of the circuit**

The lightness of lamp-L1 is adjusted by VR1. Which controls the speed of charging of C1. Then this charging voltage will control the works of Triac.

Suppose that we adjust VR1 less, C1 charges faster. It causes L1 is more brightest. In contrast, VR1 is much, C1 charges slowly. It makes L1 is less bright.

Because time periods that Triac runs are shorter than it does not run.

In conclusion, the brightness level of L1 will be adjusted according to the adjustment of VR1.

The R1 protects VR1 damage from too many currents.

R2 and C2 eliminate the disturbance signal, both inside and outside the circuit.