EC 1030: Electrical & Electronics Laboratory

List of Experiments

1. Introduction of electronics laboratory and familiarization with different component and instruments viz CRO, Function Generator, Multimeter, Dual DC Power Supply.
2. To plot V-I characteristic of a Silicon diode.
3. To design an inverting (Gain = 10) and non-inverting amplifier (Gain = 51) circuits using OPAMP 741.
4. To verify the truth tables of logic gates (OR, AND, NOT, NAND, NOR, XOR) using their respective ICs.
5. Design and implementation using NAND gate (NOT using NAND, AND using NAND, OR using NAND).
6. To plot input and output characteristics of an NPN transistor in common-emitter configuration.

List of Additional Experiments

7. To realize Half Adder and Full Adder using basic logic gates.
8. Demonstrate the process of semiconductor fabrication.
9. Demonstrate the PCB Design Software.

Course Outcome

[EC1030.1] - To study basics of semiconductor & devices and their applications in different areas.

[EC1030.2] - To study different biasing techniques to operate transistor and operational amplifier in different modes.

[EC1030.2] - To study different logic gates and verifying the truth table.

Manual

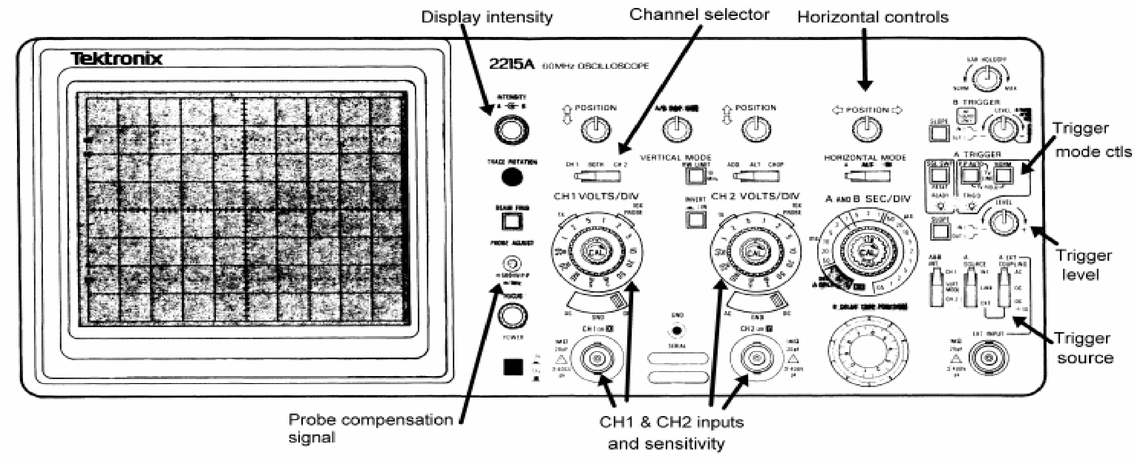
Experiment 1 - Introduction of electronics laboratory and familiarize with different component.

This experiment will provide exposure to various equipment used in electronics experiments. The devices and components will be used include function generators, oscilloscopes, breadboards, multimeter, resistors, diodes, capacitors, inductors, and transistors.

Theory:

Cathode Ray Oscilloscope (CRO)

The oscilloscopes are basically a graph displaying device. It draws the graph of an electrical signal. It is employed for the study of several types of waveforms. Some of the waveforms are displayed in figure 1. It can measure various quantities such as peak voltage, frequency, phase difference, pulse-width, delay time, rise time, and fall time. The CRO comprises of a cathode-ray tube (CRT), and input circuitry for focusing and amplification.



Function Generator

A function generator is a very versatile instrument that is used in electronics, mechanics, bioengineering, physics, and many other fields. A wide variety of synthesized electrical signals and waveform can be created for testing, repairing and diagnostic applications. It produces different types of waveforms such as sine, square, triangle and saw-tooth over a wide range of frequencies.

Dual Power Supply

Scientech 4075 DC Dual Power Supply is designed as a Constant Current (CC) and Constant Voltage (CV) source for use in laboratories, industries, and field testing. With compact size, light weight, and low power loss, it provides DC output voltages for Analog and Digital testing. A special automatic overload (current) protection circuit limits the maximum current to 2 A. Two displays (one 3-digit display for voltage & other 3-digit for current) are used to read the values. These two can be switched simultaneously for either of the DC outputs. Scientech 4075 has excellent line and load regulation and is provided with protective circuits to ensure trouble free operation.

Digital Multimeter (DMM)

Multimeter is an electronic measuring instrument combination of different measuring devices used to measure resistance, current, voltage. Mainly the multimeter are of two types:

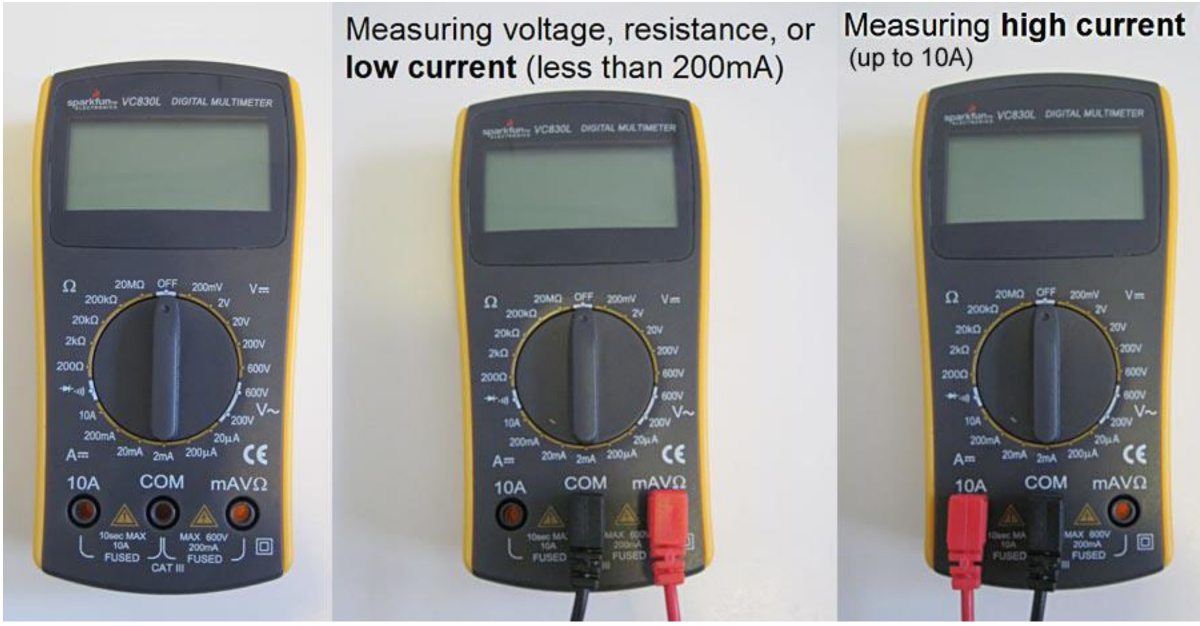
i) Analog multimeter

ii) Digital multimeter

Analog multimeters use a microammeter whose pointer moves over a scale calibrated for all the different measurements that can be made. Digital multimeters (DMM, DVOM) display the measured value in numerals, Digital

multimeters are now far more common than analog ones, but analog multimeters are still preferable in some cases, for example when monitoring a rapidly varying value. A multimeter can be a hand-held device useful for basic fault finding and field service work, or a bench instrument which can measure to a very high degree of accuracy. They can be used to troubleshoot electrical problems in a wide array of industrial and household devices such as electronic equipment, motor controls, domestic appliances, power supplies, and wiring systems.

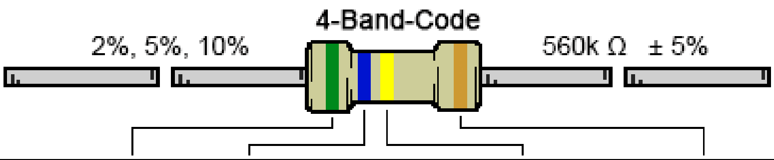
The Digital multimeter is a portable professional measuring instrument with large LCD to show three lines of readings, as well as back light for easily reading. The digital multimeter can perform measurements of AC/DC voltage and current, resistance, frequency, duty cycle, capacitance, as well as continuity and diode test. Both the reading and unit of measurement are displayed on the LCD. The humidity and temperature functions are suitable for measuring ambient humidity and temperature, as well as temperature of objects.



Resistors

A resistor is a component that resists the flow of current. It's one of the most basic components used in electronic circuits. Resistors come in a variety of resistance values (how much they resist current, measured in units called ohms and designated by the symbol Ω and power ratings (how much power they can handle without burning up, measured in watts).

The resistors value is encoded as pattern of different colours as shown above. The value of resistance can be computed by using the colour code scheme shown below:



COLOR	1ST BAND	2ND BAND	3RD BAND	MULTIPLIER	TOLERANCE
Black	0	0	0	1Ω	
Brown	1	1	1	10Ω	± 1% (F)
Red	2	2	2	100Ω	± 2% (G)
Orange	3	3	3	1KΩ	
Yellow	4	4	4	10KΩ	
Green	5	5	5	100KΩ	± 0.5% (D)
Blue	6	6	6	1MΩ	± 0.25% (C)
Violet	7	7	7	10MΩ	± 0.10% (B)
Grey	8	8	8	100MΩ	± 0.05%
White	9	9	9	1GΩ	
Gold				0.1Ω	± 5% (J)
Silver				0.01Ω	± 10% (K)

Capacitor

A capacitor (originally known as a condenser) is a passive two-terminal electrical component used to store energy electrostatically in an electric field. The forms of practical capacitors vary widely, but all contain at least two electrical conductors (plates) separated by a dielectric (i.e., insulator). The conductors can be thin films of metal, aluminium foil or disks, etc. The 'nonconducting' dielectric acts to increase the capacitor's charge capacity. A dielectric can be glass, ceramic, plastic film, air, paper, mica, etc. Capacitors are widely used as parts of electrical circuits in many common electrical devices. Unlike a resistor, a capacitor does not dissipate energy. Instead, a capacitor stores energy in the form of an electrostatic field between its plates

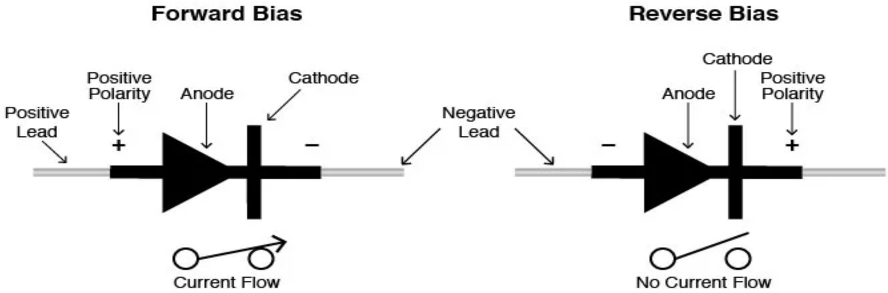
When there is a potential difference across the conductors (e.g., when a capacitor is attached across a battery), an electric field develops across the dielectric, causing positive charge (+Q) to collect on one plate and negative charge (-Q) to collect on the other plate. If a battery has been attached to a capacitor for enough time, no current can flow through the capacitor. However, if an accelerating or alternating voltage is applied across the leads of the capacitor, a displacement current can flow.

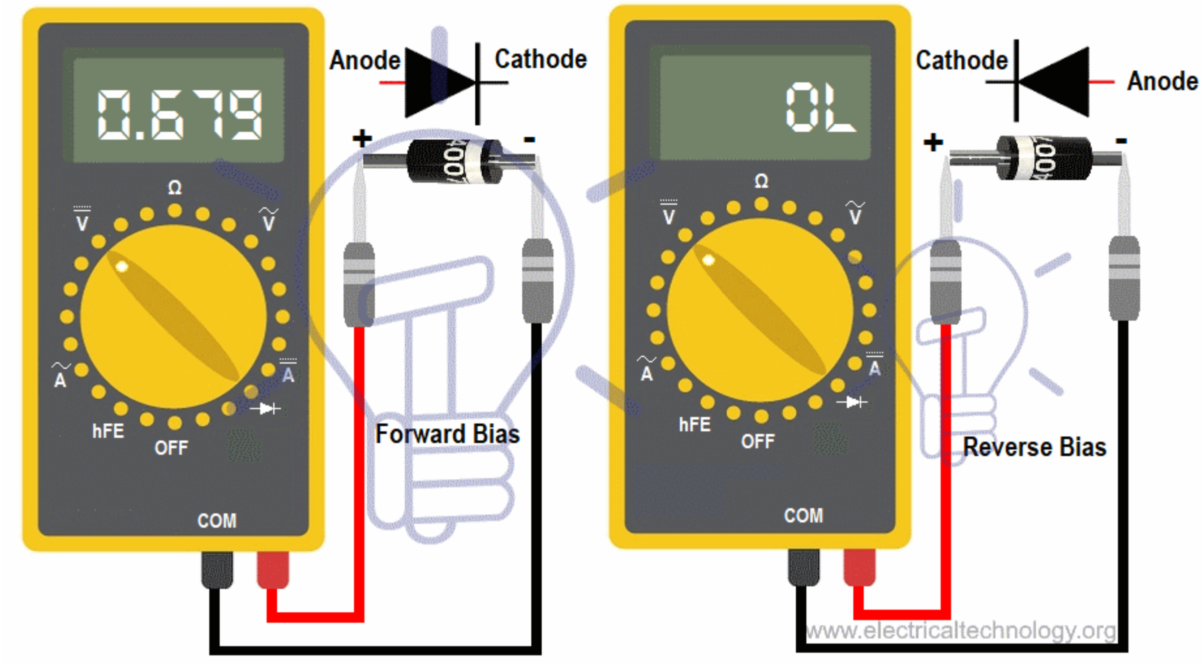
Diodes

A multimeter's Diode Test mode produces a small voltage between test leads. The multimeter then displays the voltage drop when the test leads are connected across a diode when forward biased. The Diode Test procedure is conducted as follows: Make certain a) all power to the circuit is OFF and b) no voltage exists at the diode. Voltage may be present in the circuit due to charged capacitors. If so, the capacitors need to be discharged. Set the multimeter to measure ac or dc voltage as required. Turn the dial (rotary switch) to Diode Test mode. It may share a space on the dial with another function. Connect the test leads to the diode. Record the measurement displayed. Reverse the test leads. Record the measurement displayed.

Diode test analysis

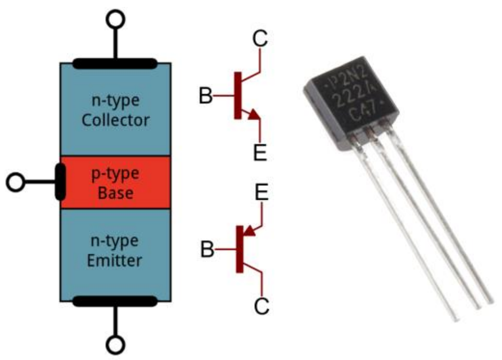
A good forward-based diode displays a voltage drop ranging from 0.5 to 0.8 volts for the most used silicon diodes. Some germanium diodes have a voltage drop ranging from 0.2 to 0.3 V. The multimeter displays OL when a good diode is reverse-biased. The OL reading indicates the diode is functioning as an open switch. A bad (opened) diode does not allow current to flow in either direction. A multimeter will display OL in both directions when the diode is opened.

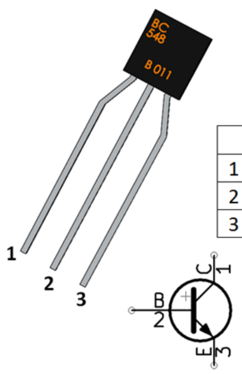




Transistors

A transistor is an electronic device having three terminals where small current at one terminal is used to control current at the other terminals. Transistors are mainly used for the amplification of the electronic signal.





BC-548	
1	Collector
2	Base
3	Emitter

Experiment 2

Aim of the Experiment:

We try to see the Voltage-Current relation in Diodes by applying a voltage across it and measuring the corresponding current flowing through it.

Apparatus Required

a) A diode

b) A DC voltage supply

c) Bread board

d) 1kΩ resistor

e) 2 mustimeters 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:

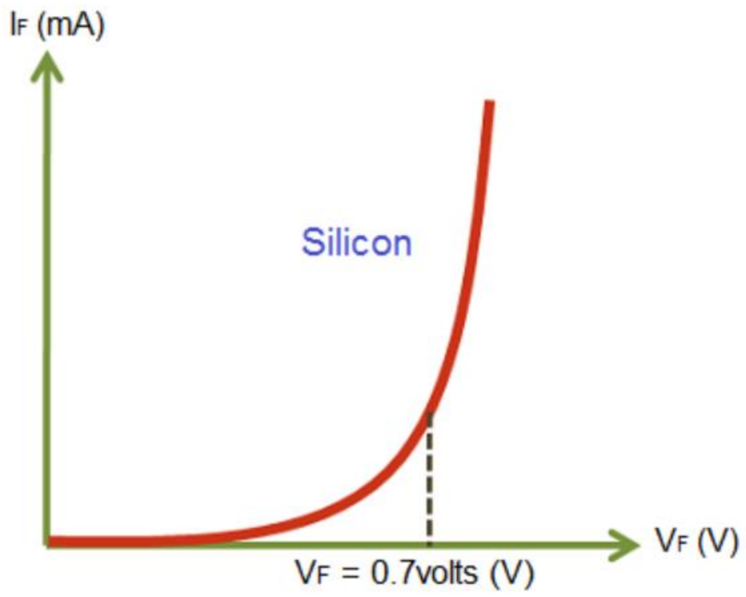
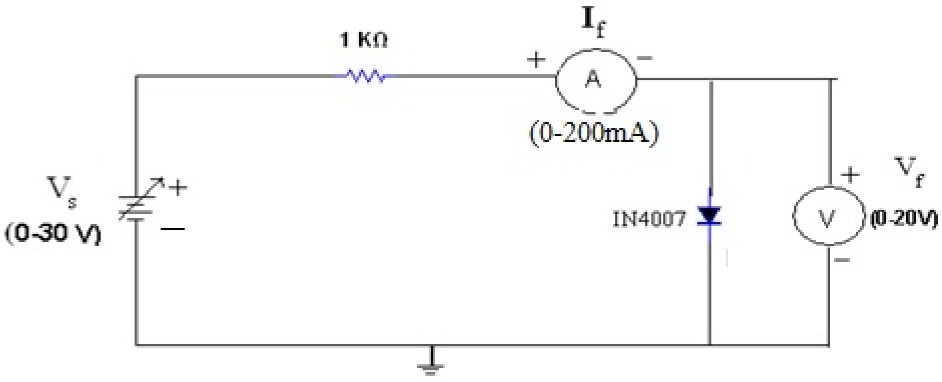


Fig. 1 Forward biasing of Si Diode

In the forward-bias region the V-I relationship is described as follows: $I = I_s\,(e^{V/nVT} - 1)$ In the above equation, I is the forward current, V is the forward voltage, it is the saturation current, and $V_T = kT/q$ 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 1kΩ resistor and a 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 corresponding current readings. We must take many readings till the input voltage is 2 about 30V. On plotting a 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.

Result

Sl. No.	Voltage (V)	Current (mA)

Experiment 3

Aims & Objectives:

To design an inverting (Gain = 10) and non-inverting amplifier (Gain = 51) circuits using OPAMP 741.

Equipment & Accessories Required:

CRO, Function Generator, Power Supply, Multimeter, Bread Board, and CRO probes.

Components Required: Resistors, Op Amp IC 741.

Inverting Amplifier:

The inverter is the basic building block of any circuit. This is perhaps the most widely used of all the Op Amp circuits. The circuit of inverting amplifier is shown in Fig.1.1. The output voltage v_o is feedback to the inverting input terminal through the resistor R_F and R_1 network. Input signal v_i (ac) is applied to the inverting input terminal through R_1 and non-inverting input terminal of Op Amp is grounded. For simplicity let us assume an ideal Op Amp. As $v_d = 0$, node 'a' is at virtual ground potential. Writing nodal equation at point 'a' yields;

$$i_i + i_f = 0, \frac{v_i}{R_1} + \frac{v_o}{R_F} = 0$$

$$v_o = -\frac{R_F}{R_1} v_i \quad (1)$$

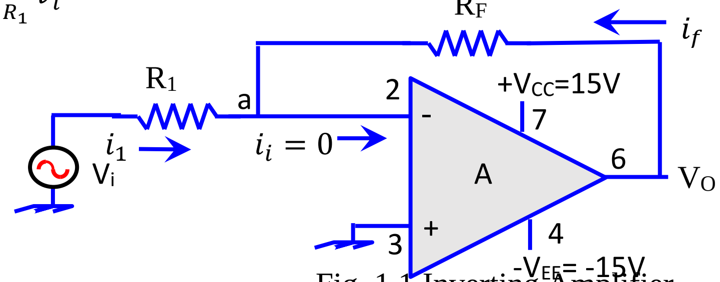


Fig. 1.1 Inverting Amplifier

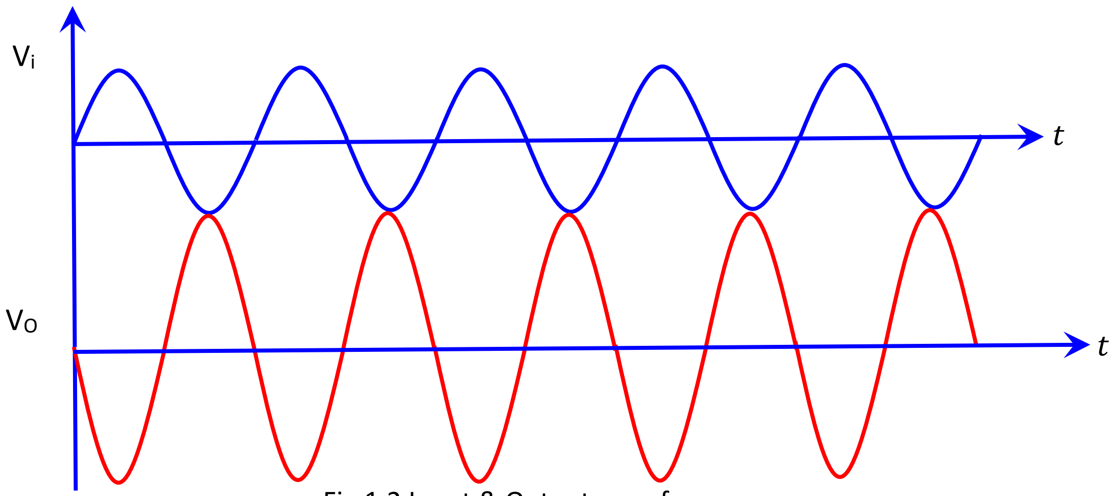


Fig.1.2 Input & Output waveforms

Non-inverting Amplifier:

If a signal (ac) is applied to the non-inverting input terminal and feedback is given as shown in Fig.1.3, the circuit amplifies the input signal without inverting it. Such a circuit is called non-inverting amplifier. It may be noted that it is also a negative feedback system as output is being fed back to the inverting input terminal.

As the differential input voltage v_d at the input terminal of Op Amp is zero, the voltage at node 'a' in Fig.1.3 is v_i, same as the input voltage applied to non-inverting input terminal. Now R_F and R_1 forms a potential divider. Writing nodal equation at point a yields;

$$i_1 = i_f, \frac{v_i}{R_1} = \frac{v_o - v_i}{R_F}, \frac{v_i}{R_1} + \frac{v_i}{R_F} = \frac{v_o}{R_F}$$

$$v_o = \left\{1 + \frac{R_F}{R_1}\right\} v_i \qquad (1)$$

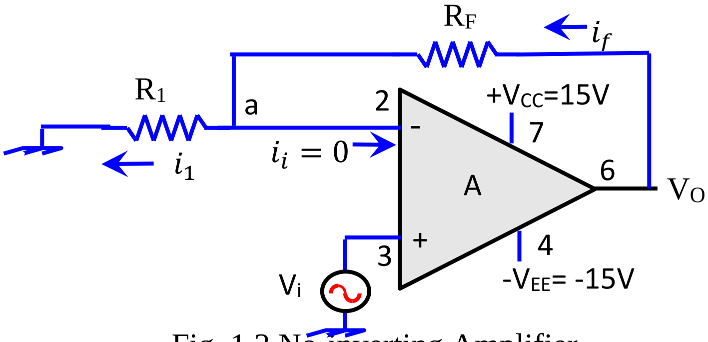


Fig. 1.3 No-inverting Amplifier

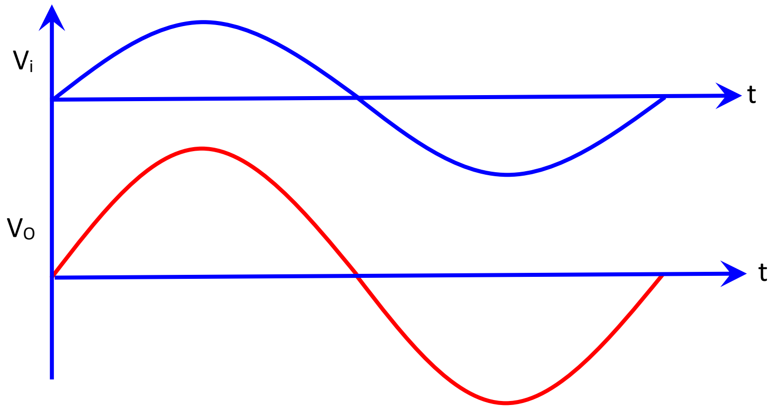


Fig.1.4 input & output Waveforms

Procedure:

1. Rig up the circuit on the breadboard.
2. Apply the given inputs and observe the corresponding output voltages on CRO, keeping the
   Frequency of the input signal fixed.
3. Draw the input and output waveforms on tracing paper.
4. Change the practical values of resistors R_1 & R_F for variable the gain and observe the output.
5. Calculate the gain for various values of R_1 & R_F.
6. Plot the outputs waveform for various values of R_F on the graph paper for a fixed value of R_1.

Observations:

Inverting Amplifier:

S No.	Resistors		Input		Output	Gain	Comment
	R_1	R_F	Voltage	Frequency	Voltage		
1.			10mV	1kHz			
2.			20mV	1kHz			
3.			30mV	1kHz			
4.			40mV	1kHz			
5.			50mV	1kHz			
6.			60mV	1kHz			
7.	1kΩ	10kΩ	70mV	1kHz			

Non-inverting Amplifier

S No.	Resistors		Input Voltage	Output Voltage	Gain	Comments
	R_1	R_F				
1.			10mV			
2.			20mV			
3.			30mV			
4.			40mV			
5.			50mV			
6.			60mV			
7.	1kΩ	50kΩ	70mV			

Calculations:

Gain Calculation: Inverting Amplifier:

Non Inverting Amplifier:

Experiment 4

Aim of the Experiment

To verify the truth tables of logic gates (OR, AND, NOT, NAND, NOR, XOR) using their respective ICs.

Apparatus Required:

Logic gate ICs (e.g., 7400 for NAND, 7402 for NOR, 7404 for NOT, etc.)

Breadboard or circuit board

Connecting wires

Power supply (usually +5V and ground)

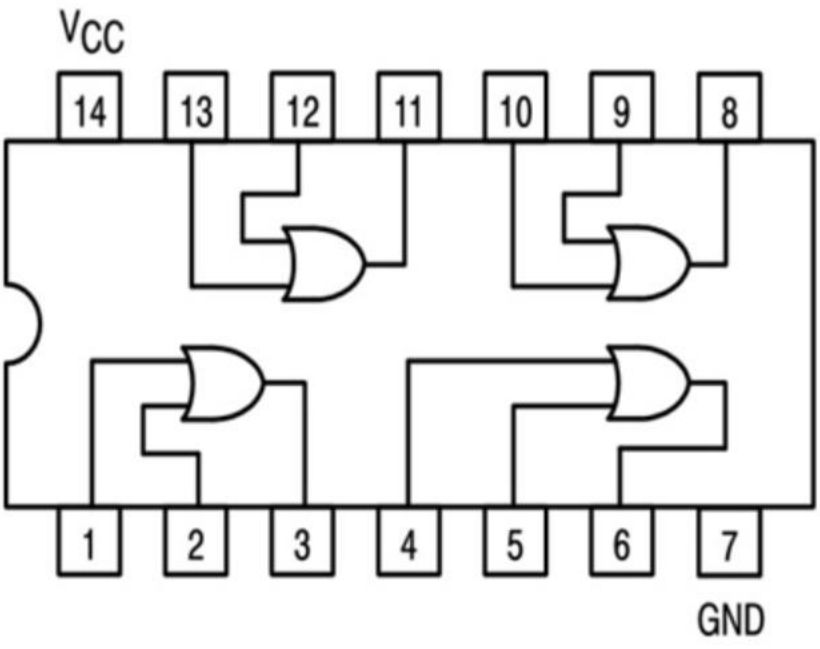
Push buttons or switches (optional, for manual input)

Procedure:

OR Gate (e.g., 7432):

Truth Table:

Input		**Output**
A	**B**	**Y**
0	**0**	**0**
0	**1**	**1**
1	**0**	**1**
1	**1**	**1**



Connect the power supply's +5V and ground pins to the IC.

Connect the input pins (1, 2, 3, 4) to the desired input sources (push buttons or switches).

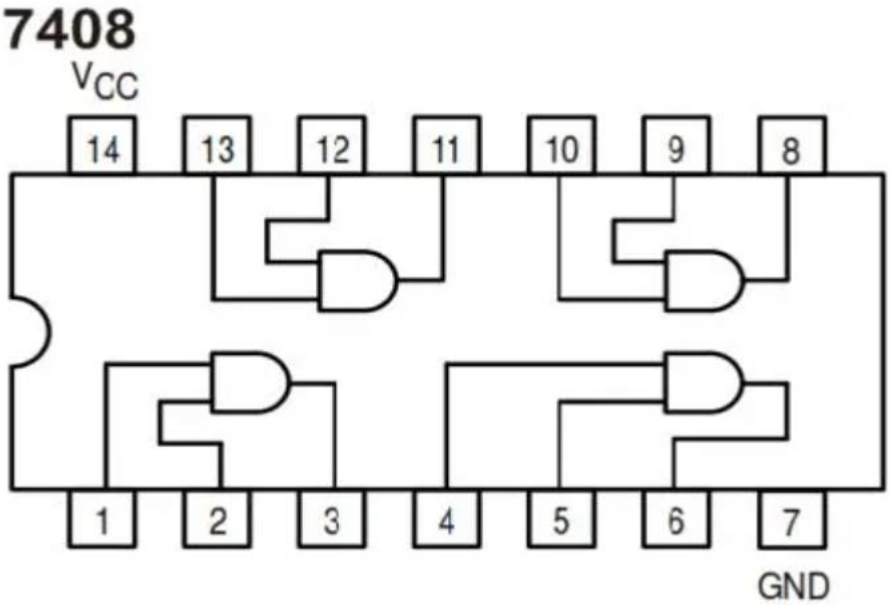
Connect pin 5 (output) to an LED through a current-limiting resistor.

Arrange the inputs to simulate all possible input combinations and observe the output LED. Compare the observed results with the OR gate's truth table.

AND Gate (e.g., 7408):

Truth Table:

Input		**Output**
A	**B**	**Y**
0	**0**	**0**
0	**1**	**0**
1	**0**	**0**
1	**1**	**1**



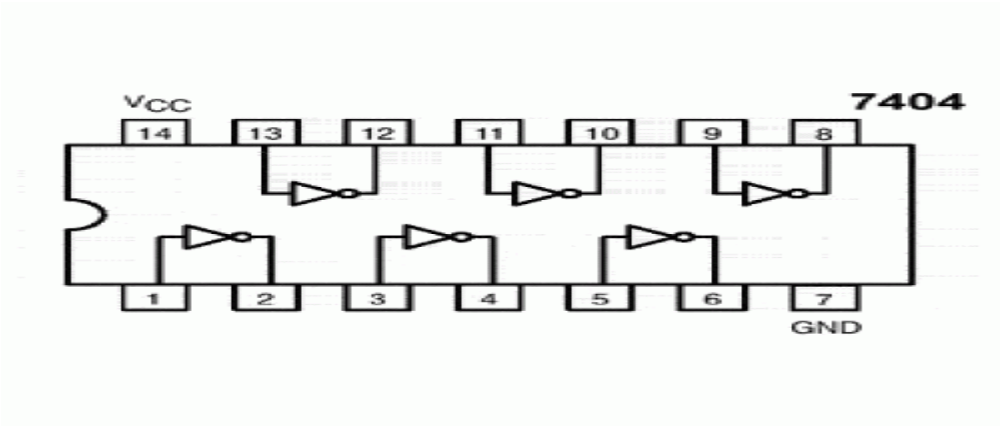
Connect the power supply's +5V and ground pins to the IC.

Connect the input pins (1, 2, 3, 4) to the desired input sources.

Connect pin 5 (output) to an LED through a current-limiting resistor.

Arrange the inputs to simulate all possible input combinations and observe the output LED. Compare the observed results with the AND gate's truth table.

NOT Gate (e.g., 7404):



Connect the power supply's +5V and ground pins to the IC.

Connect an input pin (1) to the desired input source.

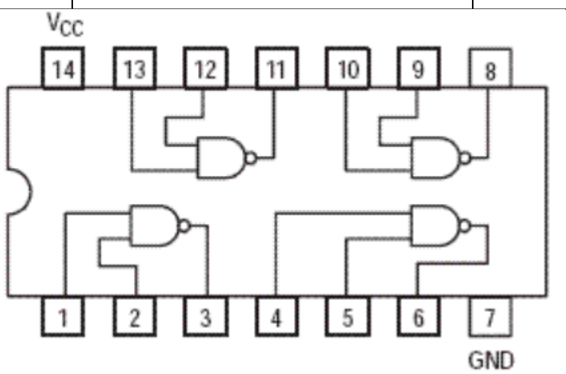
Connect pin 2 (output) to an LED through a current-limiting resistor.

Observe the output LED while toggling the input. Compare the observed results with the NOT gate's truth table.

NAND Gate (e.g., 7400):

Truth Table:

Input		**Output**
A	**B**	**Y**
0	**0**	**1**
0	**1**	**1**
1	**0**	**1**
1	**1**	**0**



Connect the power supply's +5V and ground pins to the IC.

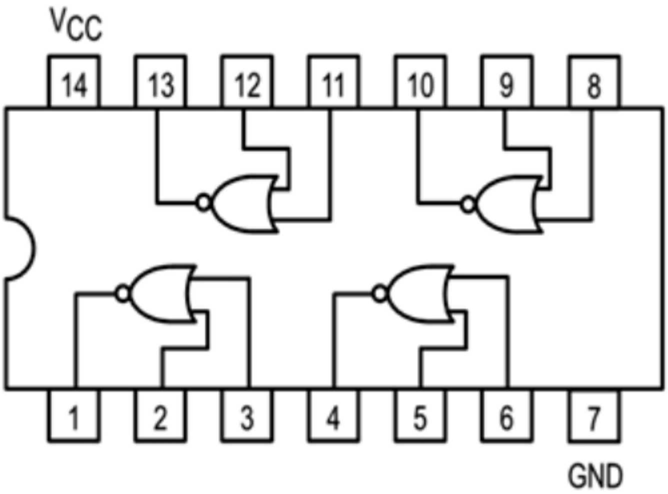
Connect the input pins (1, 2, 3, 4) to the desired input sources.

Connect pin 5 (output) to an LED through a current-limiting resistor.

Arrange the inputs to simulate all possible input combinations and observe the output LED. Compare the observed results with the NAND gate's truth table.

NOR Gate (e.g., 7402):

Input		**Output**
A	**B**	**Y**
0	**0**	**1**
0	**1**	**0**
1	**0**	**0**
1	**1**	**0**



Connect the power supply's +5V and ground pins to the IC.

Connect the input pins (1, 2, 3, 4) to the desired input sources.

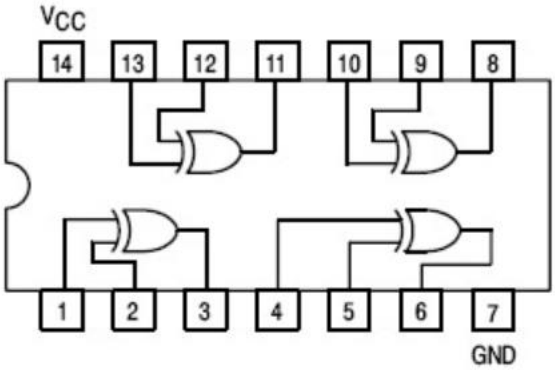
Connect pin 5 (output) to an LED through a current-limiting resistor.

Arrange the inputs to simulate all possible input combinations and observe the output LED. Compare the observed results with the NOR gate's truth table.

XOR Gate (e.g., 7486):

Truth Table:

Input		**Output**
A	**B**	**Y**
0	**0**	**0**
0	**1**	**1**
1	**0**	**1**
1	**1**	**0**



Connect the power supply's +5V and ground pins to the IC.

Connect the input pins (1, 2, 3, 4) to the desired input sources.

Connect pin 5 (output) to an LED through a current-limiting resistor.

Arrange the inputs to simulate all possible input combinations and observe the output LED.

Compare the observed results with the XOR gate's truth table.

Experiment 5

Design and implementation using NAND gate (NOT using NAND, AND using NAND, OR using NAND).

Apparatus Required:

Power supply, Connecting wires and Breadboard and Gates etc.

Theory:

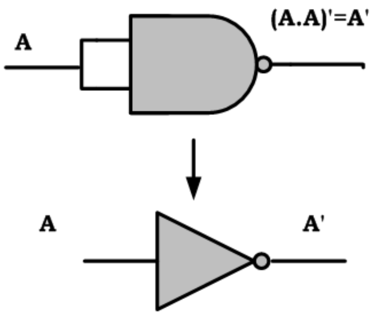
AND, OR, NOT is called basic gates as their logical operation cannot be simplified further. NAND and NOR are called universal gates as using only NAND or only NOR, any logic function can be implemented. Using NAND and NOR gates and De Morgan's Theorems different basic gates & EX-OR gates are realized.

Implementing NOT gate using NAND gate:

The figure shows two ways in which a NAND gate can be used as an inverter (NOT gate).

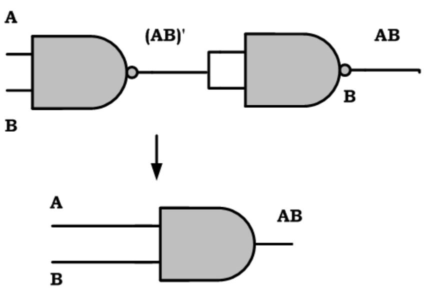
1. All NAND input pins connect to the input signal A gives an output

2. One NAND input pin is connected to the input signal A while all other input pins are connected to logic 1. The output will be A'



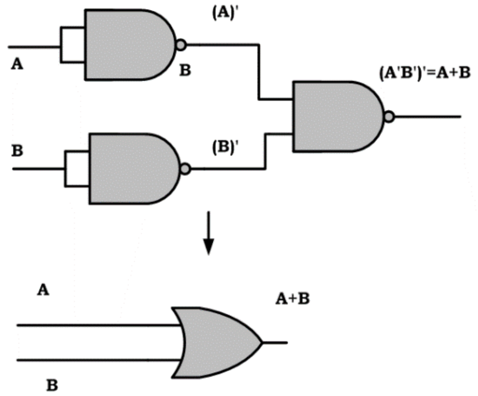
Implementing AND gate using NAND gate:

An AND gate can be replaced by NAND gates as shown in the figure (The AND is replaced by a NAND gate with its output complemented by a NAND gate inverter).



Implementing OR gate using NAND gate:

An OR gate can be replaced by NAND gates as shown in the figure (The OR gate is replaced by a NAND gate with all its inputs complemented by NAND gate inverters).



Procedure:

1. Connect the trainer kit to ac power supply.
2. Connect the NAND gates/NOR gates for any of the logic functions to be realized.
3. Connect the inputs of first stage to logic sources and output of the last gate to logic indicator.
4. Apply various input combinations and observe output for each one.
5. Verify the truth table for each input/ output combination.
6. Repeat the process for all logic functions.
7. Switch off the ac power supply.

Result:

Experiment 6

Aim:
To plot the input and Output characteristics of NPN transistor in CE configuration.

Requirement:
Dual Power supply (0-30V), Multimeter (4), Transistor (BC547), Resistances (1kΩ & 56kΩ))

Circuit Diagram:

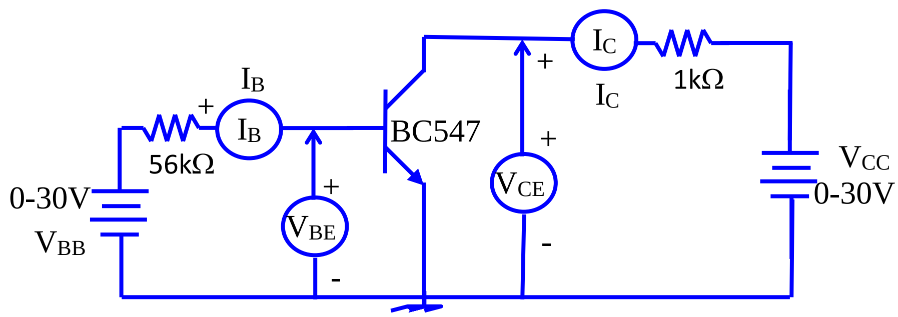


Fig.10.1 CE transistor configuration

Theory:

In this configuration we use emitter as common terminal for both input and output. This common emitter configuration is an inverting amplifier circuit. Here the input is applied between base-emitter region and the output is taken between collector and emitter terminals. In this configuration the input parameters are V_{BE} and I_B and the output parameters are V_{CE} and I_C.
This type of configuration is mostly used in the applications of transistor based amplifiers. In this configuration the emitter current is equal to the sum of small base current and the large collector current. i.e. $I_E = I_C + I_B$. We know that the ratio between collector current and emitter current gives current gain alpha in Common Base configuration similarly the ratio between collector current and base current gives the current gain beta in common emitter configuration.
Current gain (α) = I_C/I_E
Current gain (β) = I_C/I_B
Collector current $I_C = \alpha\, I_E = \beta I_B$

Input Characteristics
The input characteristics of common emitter configuration are obtained between input current I_B and input voltage V_{BE} with constant output voltage V_{CE}. Keep the output voltage V_{CE} constant and vary the input voltage V_{BE} for different points, now record the values of input current at each point. Now using these values we need to draw a graph between the values of I_B and V_{BE} at constant V_{CE}. The equation to calculate the input resistance R_{in} is given below.

$$R_{in} = V_{BE}/I_B \text{ (when } V_{CE} \text{ is at constant)}$$

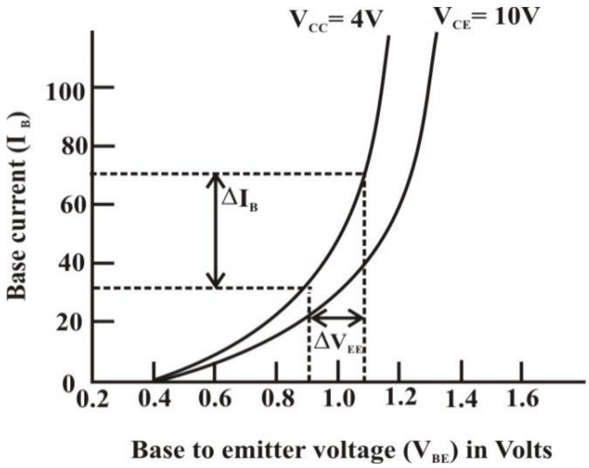


Fig. 10.2 Input characteristics of CE configuration

Output Characteristics

The output characteristics of common emitter configuration are obtained between the output current I_C and output voltage V_{CE} with constant input current I_B. Keep the base current I_B constant and vary the value of output voltage V_{CE} for different points, now note down the value of collector I_C for each point. Plot the graph between the parameters I_C and V_{CE} in order to get the output characteristics of common emitter configuration. The equation to calculate the output resistance from this graph is given below.

$$R_{out} = V_{CE}/I_C \text{ (when } I_B \text{ is at constant)}$$

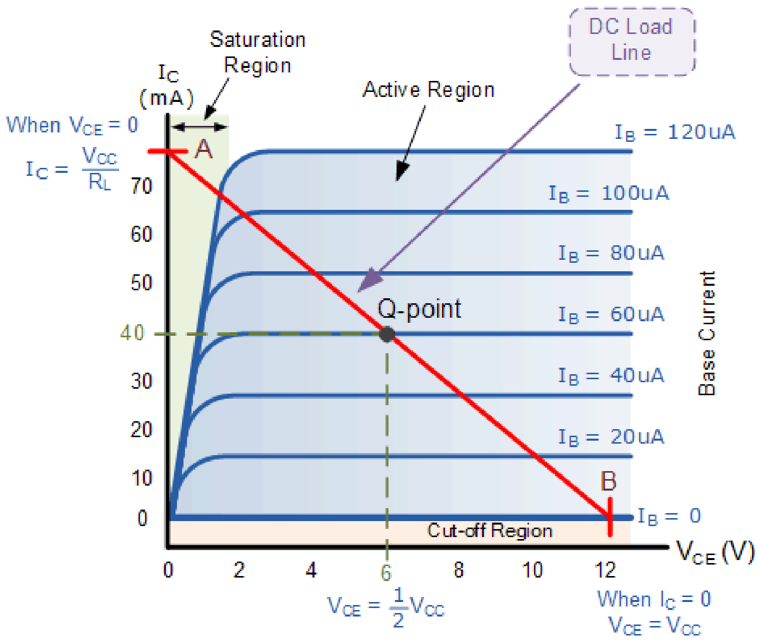


Fig. 10.3 Output characteristics of CE configuration

Procedure:

(i) Characteristics of NPN transistor-

Input characteristics:

(a) Connect the circuit as in Fig. 10.1.
(b) Make V_{CE} = 2V with the help of V_{CC}.
(c) Now increase the V_{BB} voltage and measure V_{BE} and I_B while maintaining V_{CE} constant.
(d) Plot the graph between V_{BE} vs I_B.
(e) Now make V_{CE} = 5V by varying V_{CC}.
(f) Repeat steps from (c) to (e).

Output characteristics:

(a) Connect the circuit as per the circuit diagram.
(b) Fix I_B = 20 μA and maintain it constant.
(c) Now vary V_{CC} and measure I_C and V_{CE}.
(d) Plot a graph between V_{CE} and I_C.
(e) Now make I_B = 60μA and repeat the steps from (c) to (e).

Result: