DEPARTMENT OF
ELECTRONICS AND COMMUNICATION
ENGINEERING

COLLEGE OF TECHNOLGY AND ENGINEERING

MAHARANA PRATAP UNIVERSITY OF AGRICULTURE & TECHNOLGY, UDAIPUR

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LAB MANUAL

EC223 – Applied Electronics Circuits

PREPARED BY

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EC 223 Applied Electronics Circuits

Lab Manual

Table of Content

Experiment No. -1

Aim/Objective: Design and assemble Mono-stable Multi-vibrator circuit using IC-555 and calculate its duty cycle.

Component Required: 555 timer IC, Resistors, capacitors, breadboard, 5V DC supply, DSO and connecting wire.

Theory:

It has one stable and one quasi stable state. The circuit is useful for generating single output pulse of time duration in response to a triggering signal. The width of the output pulse depends only on external components connected to the op-amp. The diode gives a negative triggering pulse. When the output is +Vsat, a diode clamps the capacitor voltage to 0.7V then, a negative going triggering impulse magnitude Vi passing through RC and the negative triggering pulse is applied to the positive terminal. Let us assume that the circuit is instable state. The output Vo is at +Vsat. The diode D1 conducts and Vc the voltage across the capacitor 'C' gets clamped to 0.7V, the voltage at the positive input terminal through R1 R2 potentiometer divider is +ß Vsat. Now, if a negative trigger of magnitude Vi is applied to the positive terminal so that the effective signal is less than 0.7V.the output of the Op-Amp will switch from +Vsat to −Vsat. The diode will now get reverse biased and the capacitor starts charging exponentially to −Vsat. When the capacitor charge Vc becomes slightly more negative than −ßVsat, the output of the op-amp switches back to +Vsat. The capacitor 'C' now starts charging to +Vsat through R until Vc is 0.7V.

Circuit Diagram:
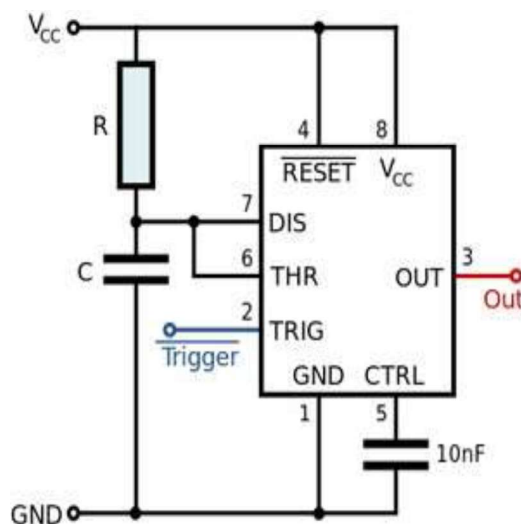
Wave form of Monostable operation:
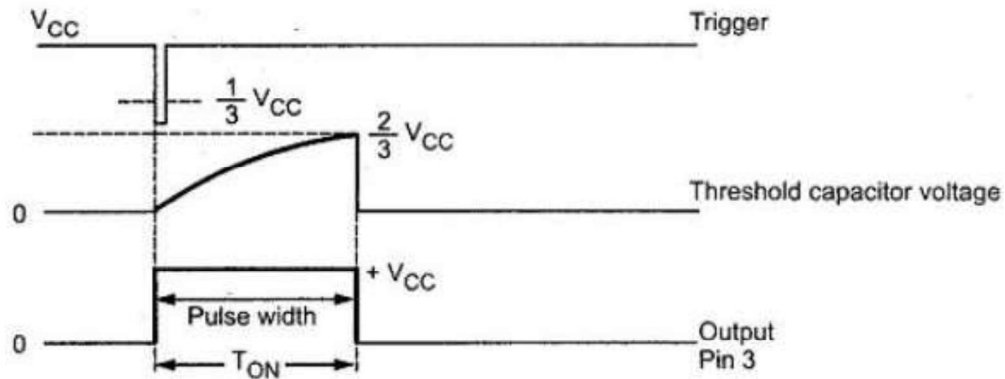
Procedure:

1. Connect the circuit as shown in the circuit diagram.

2. Apply Negative triggering pulses at pin 2 of frequency 1 KHz as shown in Fig.

3. Observe the output waveform and capacitor voltage as shown in Figure and measure the pulse duration.

4. Theoretically calculate the pulse duration as T_{high}=1.1 RC

5. Compare it with experimental values.

Observation:

Trace the time period of the output wave form and compare it with the given one.

Result & Discussion:

The waveform is observed and verified with stated condition

Experiment No. -2

Aim/Objective: Design and assemble A-stable Multi-vibrator circuit using IC-555 and calculate its duty cycle.

Component Required: 555 timer IC, Resistors, capacitors, breadboard, 5V DC supply, DSO and connecting wire.

Theory:

In the 555 Oscillator above, pin 2 and pin 6 are connected together allowing the circuit to re-trigger itself on each and every cycle allowing it to operate as a free running oscillator. During each cycle capacitor, C charges up through both timing resistors, R1and R2but discharges itself only through resistor, R2as the other side of R2is connected to the discharge terminal, pin 7. Then the capacitor charges up to 2/3Vcc (the upper comparator limit) which is determined by the 0.693(R1+R2) C combination and discharges itself down to 1/3Vcc (the lower comparator limit) determined by the 0.693(R2.C) combination. This results in an output waveform whose voltage level is approximately equal to Vcc -1.5V and whose output "ON" and "OFF" time periods are determined by the capacitor and resistors combinations. The individual times required completing one charge and discharge cycle of the output is therefore given as:

t_1= 0.693 (R1+R2)C, t_2= 0.693 R2C, T = t_1 + t_2.

Circuit Diagram:

Procedure:

1. Connect the circuit as shown in the figure.

2. Use potentiometer in case output is not proper

Observation:

Trace the output waveform and calculate the frequency from the fundamental period of the wave.

Result & Discussion:

The waveform was traced and compared with the designed theoretical one.

Experiment No. -3

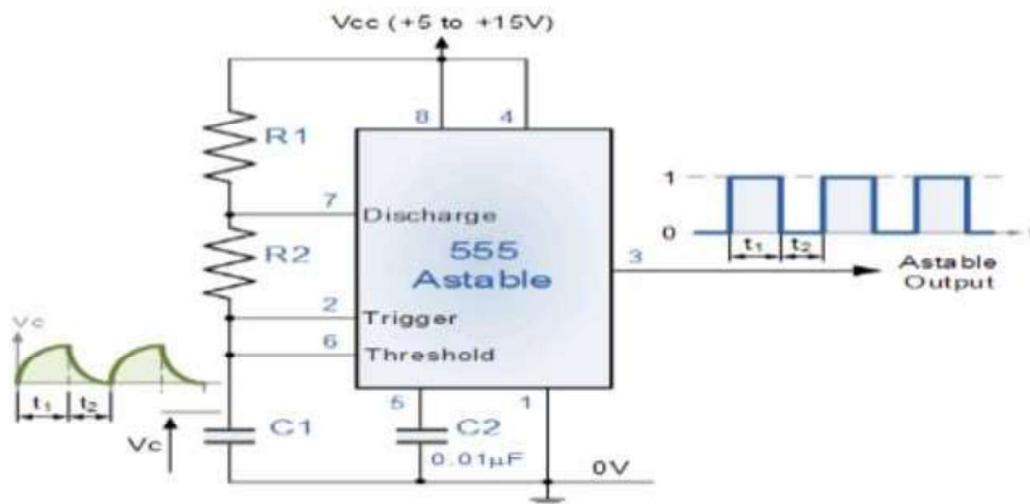**Aim/Objective**: Design and assemble Schmitt trigger circuit using IC-555 and check the waveform on CRO.

Component Required: 555 timer IC, Resistors, capacitors, breadboard, 5V DC supply, DSO and connecting wire.

Theory:

The high and low transitions on the inputs of most of the CMOS devices should be fast edges. If the edges are not fast enough, they tend to provide more current and this might damage the device. Analog signals are generally not perfect and might not have clean edges all the times. Schmitt Trigger is a special type of comparator that is used to avoid such signals.

A comparator is a device that compares two voltages and the outcome is the indication of whether one voltage is higher than the other or not. Schmitt trigger, also called as Regenerative Comparator, compares the input voltage to two reference voltages and produces an equivalent output. The output of a Schmitt trigger is always a square or rectangular wave irrespective of the shape of the input. It is often used when we need to do the following:

- Convert sine wave to square wave
- To clean up the noisy signals
- To convert slow edges (like in a triangular wave) into fast edges (like a square wave)

Schmitt can be constructed from a 555 timer. Some of the other function of the 555 timer, apart from the timer operation, is to use the two internal comparators as independent units to form a Schmitt Trigger. The general operation of the Schmitt trigger built from a 555 timer is inverting but the discussion will be for non-inverting.
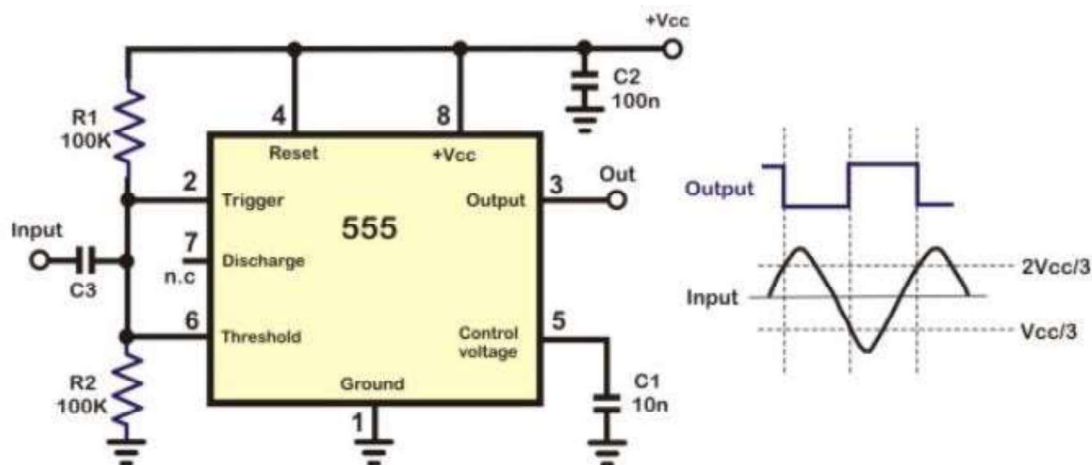

Fig. 1

In Fig. 1 Pins 4 and 8 are connected to the supply (Vcc). The pins 2 and 6 are tied together and the input is given to this common point through a capacitor C. this common point is

supplied with an external bias voltage of Vcc / 2 with the help of the voltage divider circuit formed by the resistors R1 and R2. The important characteristic of the Schmitt trigger is Hysteresis. The output of the Schmitt trigger is high if the input voltage is greater than the upper threshold value and the output of the Schmitt trigger is low if the input voltage is lower than the lower threshold value. The output retains its value when the input is between the two threshold values. The usage of two threshold values is called Hysteresis and the Schmitt trigger acts as a memory element (a bistable multivibrator or a flip-flop).The threshold values in this case are 2/3 Vcc and 1/3 Vcc i.e. the upper comparator trips at 2/3 Vcc and the lower comparator trips at 1/3 Vcc. The input voltage is compared to these threshold values by the individual comparators and the flip-flop is SET or RESET accordingly. Based on this the output becomes high or low.

When a sine wave of amplitude greater than Vcc / 6 is applied at the input, the flip-flop is set and reset alternately for the positive cycle and the negative cycle. The output is a square wave and the waveforms for input sine wave and output square wave are shown below in Fig 2.
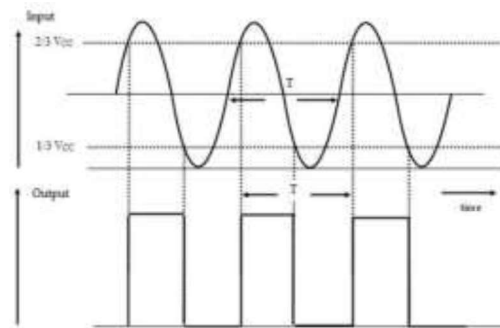
Fig. 2

Inverting Schmitt Trigger

The normal operation of the 555 timer as a Schmitt trigger is inverting in nature. When the trigger input, which is same as the external input, falls below the threshold value of 1/3 Vcc, the output of the lower comparator goes high and the flip-flop is SET and the output at pin 3 goes high. Similarly, when the threshold input, which is same as the external input, rises above the threshold value of 2/3 Vcc, the output of the upper comparator goes high and the flip-flop is RESET and the output at pin 3 goes low. The waveform of the inverting Schmitt trigger is shown below in Fig 3.

Fig. 3

Procedure:

1. Connect the circuit as shown in the figure.

2. Use potentiometer in case output is not proper.

Observation:

Trace the output waveform and calculate the frequency from the fundamental period of the wave.

Result & Discussion:

The waveform was traced and compared with the designed theoretical one.

Experiment No. -4

Aim/Objective: Design a Voltage Controlled Oscillator using IC-555 and find its control voltage and output frequency.

Component Required: 555 timer IC, Resistors (4.7k &10k), capacitors (0.1μf), breadboard, 5V DC supply, DSO and connecting wire.

Theory:

The circuit is sometimes called a **voltage-to-frequency converter** because the output frequency can be changed by changing the input voltage.

Pin 5 terminal is voltage control terminal and its function is to control the threshold and trigger levels. Normally, the control voltage is $++2/3V_{CC}$ because of the internal voltage divider. However, an external voltage can be applied to this terminal directly or through a pot, as illustrated in figure, and by adjusting the pot, control voltage can be varied. Voltage across the timing capacitor is depicted in figure, which varies between $+V_{control}$ and $\frac{1}{2} V_{control}$. If control voltage is increased, the capacitor takes a longer to charge and discharge; the frequency, therefore, decreases. Thus the frequency can be changed by changing the control voltage. Incidentally, the control voltage may be made available through a pot, or it may be output of a transistor circuit, op-amp, or some other device.

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Circuit Diagram:
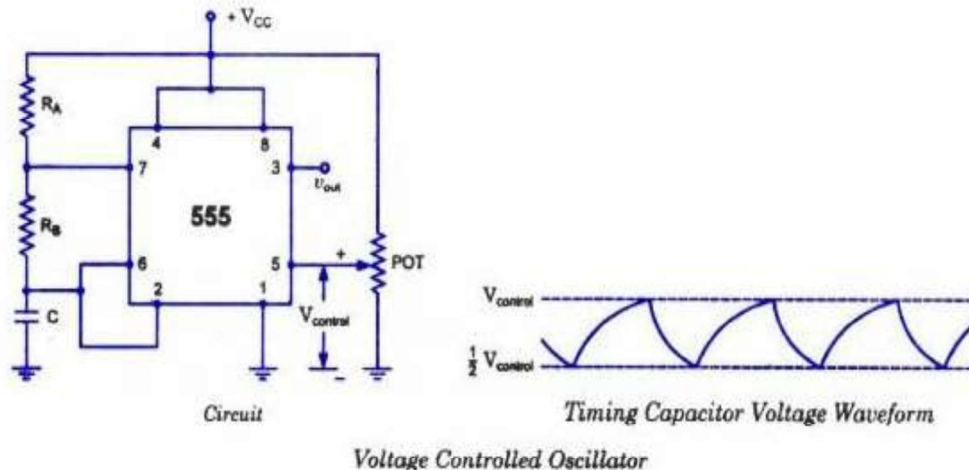
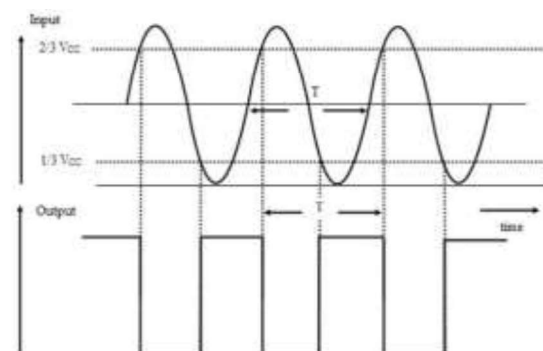Circuit   Timing Capacitor Voltage Waveform
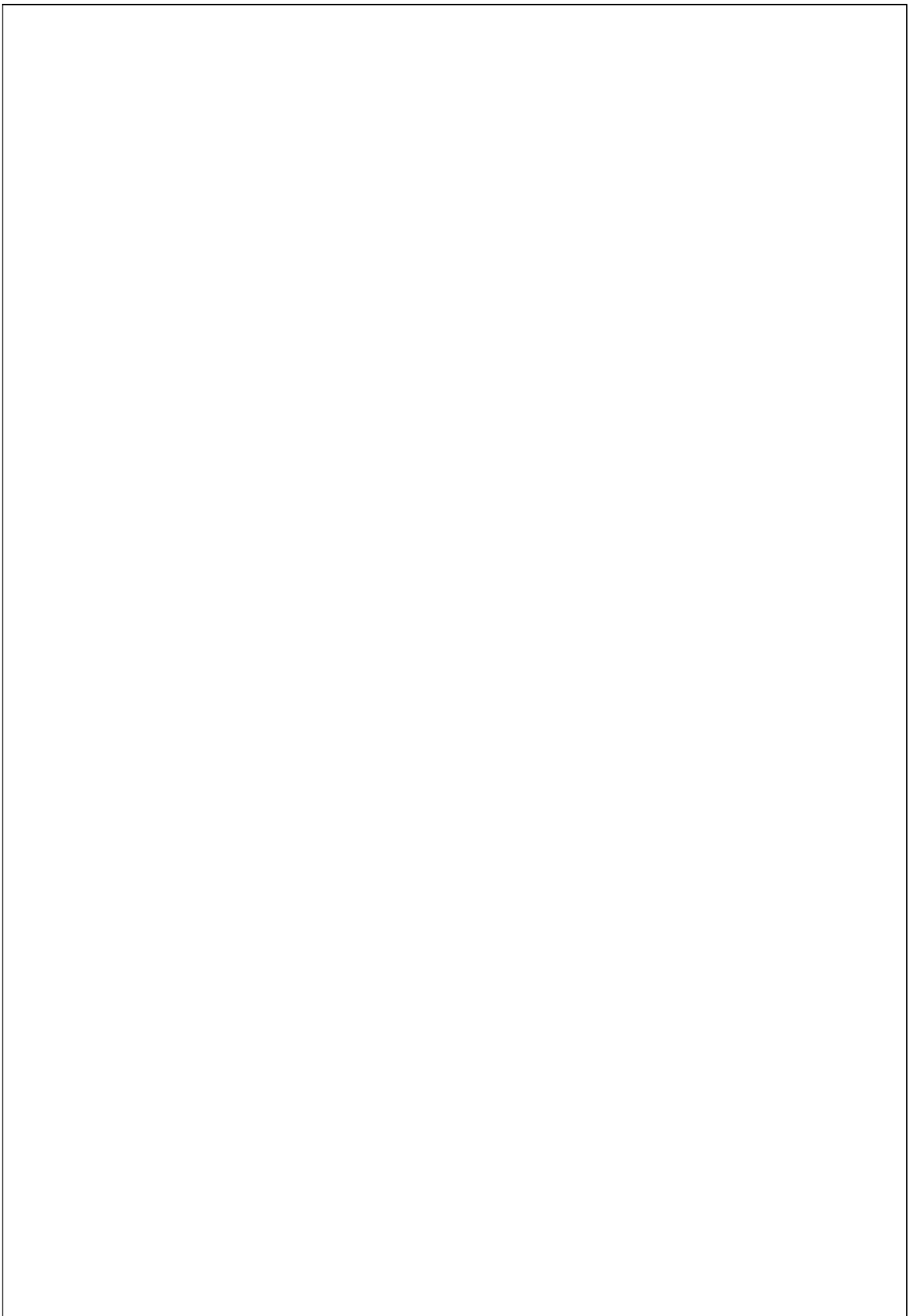
Voltage Controlled Oscillator

Procedure:

1. Connect the circuit as shown in the figure.

2. Use potentiometer in case output is not proper

Observation:

Trace the output waveform and calculate the frequency.

S.N	Voltage	Frequency

Result & Discussion:

The waveform was traced and compared with the designed theoretical one.

Experiment No. -5

<u>Aim/Objective</u>: Design and assemble RC phase shift oscillator circuit and measure the frequency of oscillations.

<u>Component Required:</u> Resistors (1kΩ, 10kΩ, 100kΩ), capacitors (0.01μf, 10μf), DSO, Breadboard, connecting wires, transistor BC 547

<u>Theory:</u>

RC phase-shift oscillators use resistor-capacitor (RC) network (Figure 1) to provide the phase-shift required by the feedback signal. RC phase-shift oscillator is formed by cascading three RC phase-shift networks, each offering a phase-shift of 60º, as shown by Figure 1. Here the collector resistor RC limits the collector current of the transistor, resistors R1 and R (nearest to the transistor) form the voltage divider network while the emitter resistor RE improves the stability. Next, the capacitors CE and Co are the emitter by-pass capacitor and the output DC decoupling capacitor, respectively. Further, the circuit also shows three RC networks employed in the feedback path.

This arrangement causes the output waveform to shift by 180º during its course of travel from output terminal to the base of the transistor. Next, this signal will be shifted again by 180º by the transistor in the circuit due to the fact that the phase-difference between the input and the output will be 180o in the case of common emitter configuration. This makes the net phase-difference to be 360º, satisfying the phase-difference condition. One more way of satisfying the phase-difference condition is to use four RC networks, each offering a phase-shift of 45º. Hence it can be concluded that the RC phase-shift oscillators can be designed in many ways as the number of RC networks in them is not fixed. However it is to be noted that, although an increase in the number of stages increases the frequency stability of the circuit, it also adversely affects the output frequency of the oscillator due to the loading effect.

The generalized expression for the frequency of oscillations produced by a RC phase-shift oscillator is given by

$$f = \frac{1}{2\pi RC\sqrt{2N}}$$

where N is the number of RC stages formed by the resistors R and the capacitors C.

Circuit Diagram:
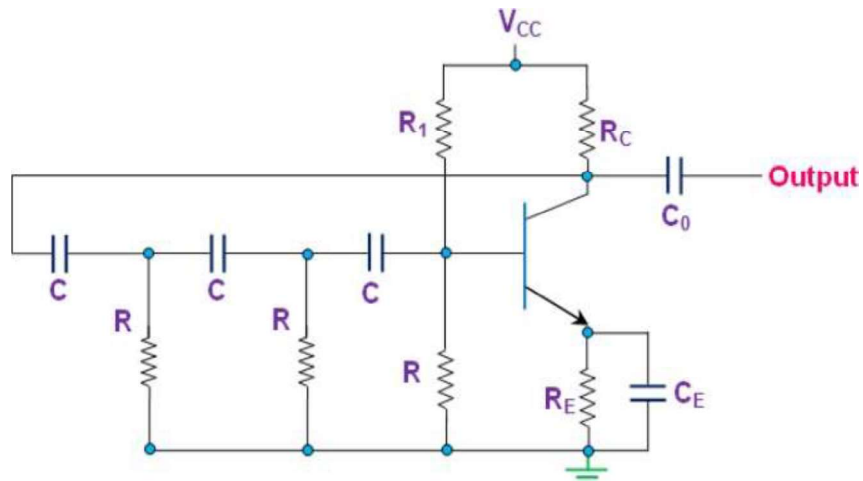
RC Phase-Shift Network
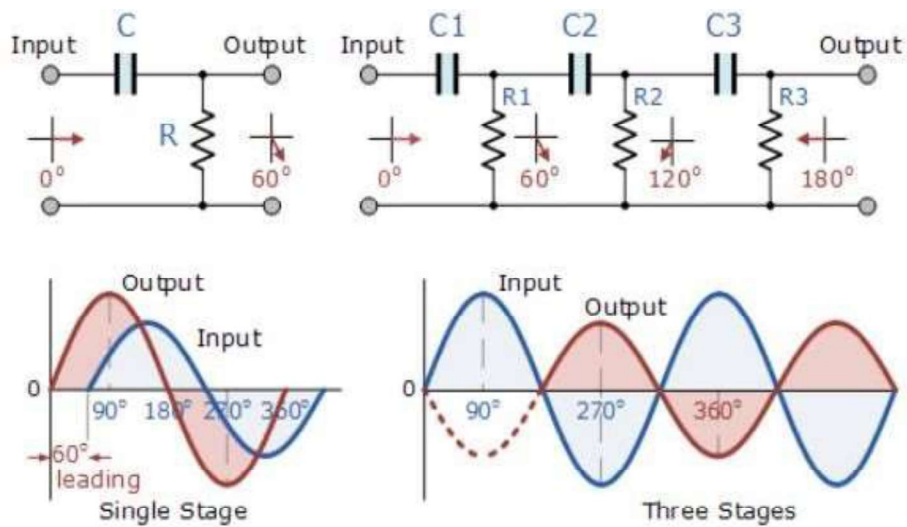
Procedure:

1. Connect the circuit as shown in the figure.

2. Use potentiometer in case output is not proper

Result & Discussion: Successfully design and assemble RC phase shift oscillator circuit and measure the frequency of oscillations.

Experiment No. -6

Aim/Objective: To design and assemble Feedback amplifier circuits and find their input and output resistances.

(a) Voltage Series feedback circuit

(b) Voltage Shunt feedback circuit

Component Required: Transistor (BC 547), resistor (2.2kΩ, 50kΩ, 10kΩ), breadboard, connecting wires, variable battery, multimeter.

Theory:

(a) In the voltage series feedback circuit, a fraction of the output voltage is applied in series with the input voltage through the feedback circuit. This is also known as **shunt-driven series-fed** feedback, i.e., a parallel-series circuit. The following figure shows the block diagram of voltage series feedback, by which it is evident that the feedback circuit is placed in shunt with the output but in series with the input.
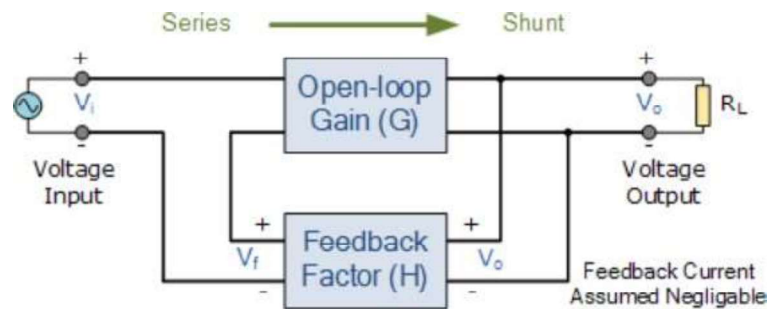
As the feedback circuit is connected in shunt with the output, the output impedance is decreased and due to the series connection with the input, the input impedance is increased.

(b) In the voltage shunt feedback circuit, a fraction of the output voltage is applied in parallel with the input voltage through the feedback network. This is also known as **shunt-driven shunt-fed** feedback i.e., a parallel-parallel proto type. The below figure shows the block diagram of voltage shunt feedback, by which it is evident that the feedback circuit is placed in shunt with the output and also with the input.

Formulation of Input Resistance, Output Resistance and Voltage Gain
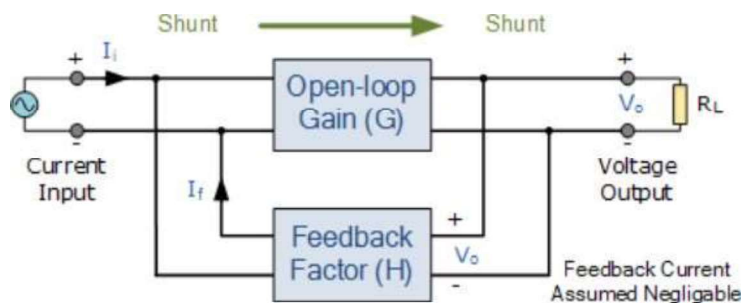
Feedback topologies: Voltage Shunt Feedback

Voltage Gain :

$$V_o = A \cdot I_i = A(I_S - I_f)$$
$$I_f = \beta \cdot V_o$$
$$A(I_S - \beta V_o) = V_o$$
$$AI_S = (1 + \beta A)V_o$$
$$A_f = \frac{V_o}{I_S} = \left(\frac{A}{1 + \beta A}\right)$$

Input Impedance :

$$Z_{in} = \frac{V_i}{I_S} = \frac{V_i}{I_i + I_f}$$
$$= \frac{I_i \cdot r_i}{I_i + \beta V_o} = \frac{I_i \cdot r_i}{I_i + \beta A I_i}$$
$$Z_{in} = \frac{r_i}{(1 + \beta A)}$$

Output Impedance :

$$Z_{out} \big|_{V_S=0} = \frac{V_o}{I_o}$$

from input port,

$$I_i = -I_f = -\beta V_o$$

from output port,

$$I_o = \frac{V_o - AI_i}{r_o} = \frac{V_o + \beta A V_o}{r_o}$$

$$\boxed{Z_{out} = \frac{V_o}{I_o} = \frac{r_o}{(1 + \beta A)}}$$

Basic amplifier

Feedback network
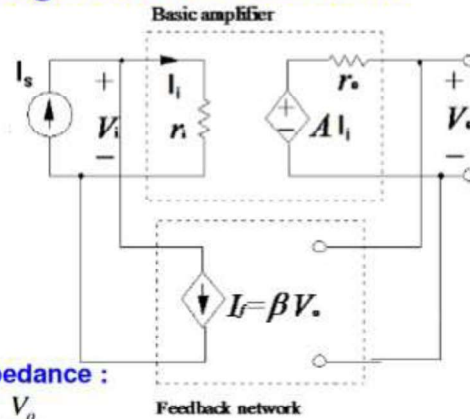
Feedback topologies: Voltage Series Feedback

Voltage Gain :

$$V_o = A \cdot V_i = A(V_S - V_f)$$
$$V_f = \beta \cdot V_o$$
$$A(V_S - \beta V_o) = V_o$$
$$AV_S = (1 + \beta A)V_o$$
$$A_f = \frac{V_o}{V_S} = \left(\frac{A}{1 + \beta A}\right)$$

Input Impedance :

$$Z_{in} = \frac{V_S}{I_S} = \frac{V_i + V_f}{I_S}$$
$$= \frac{V_i + \beta V_o}{I_S} = \frac{V_i + \beta A V_i}{I_S}$$
$$Z_{in} = \frac{V_i(1 + \beta A)}{I_S} = r_i(1 + \beta A)$$

Output Impedance :

$$Z_{out} \big|_{V_S=0} = \frac{V_o}{I_o}$$
$$I_o = \frac{V_o - A \cdot V_i}{r_o}$$
$$V_i + \beta \cdot V_o = V_S = 0$$
$$V_i = -\beta \cdot V_o$$
$$I_o = \frac{V_o + A \cdot \beta \cdot V_o}{r_o}$$
$$Z_{out} = \frac{V_o}{I_o} = \frac{r_o}{1 + A \cdot \beta}$$

Basic amplifier

Feedback network

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Observation:

S.N	Input Voltage	Output Voltage	Input Resistance	Output Resistance	Voltage Gain

Result & Discussion:

Input resistance, output resistance and voltage gain are calculated for the given feedback circuits.

Experiment No. -7

Aim/Objective: To design and assemble Feedback amplifier circuits and find their input and output resistances:

(a) Current Series feedback circuit

(b) Current shunt Feedback circuit

omponent Required: Transistor (BC 547), resistor (2.2kΩ, 50kΩ, 10kΩ), breadboard, connecting wires, variable battery, multimeter.

Theory:

(a) In the current series feedback circuit, a fraction of the output voltage is applied in series with the input voltage through the feedback circuit. This is also known as **series-driven series-fed** feedback i.e., a series-series circuit.The following figure shows the block diagram of current series feedback, by which it is evident that the feedback circuit is placed in series with the output and also with the input.
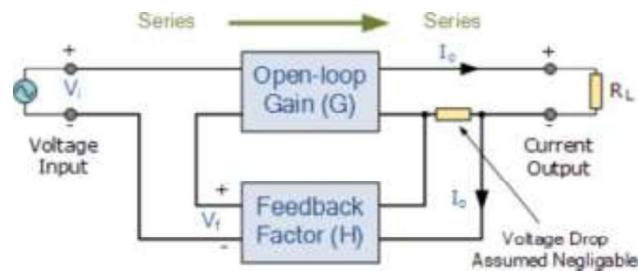

As the feedback circuit is connected in series with the output and the input as well, both the output impedance and the input impedance are increased.

(b) In the current shunt feedback circuit, a fraction of the output voltage is applied in series with the input voltage through the feedback circuit. This is also known as **series-driven shunt-fed** feedback i.e., a series-parallel circuit. The below figure shows the block diagram of current shunt feedback, by which it is evident that the feedback circuit is placed in series with the output but in parallel with the input.
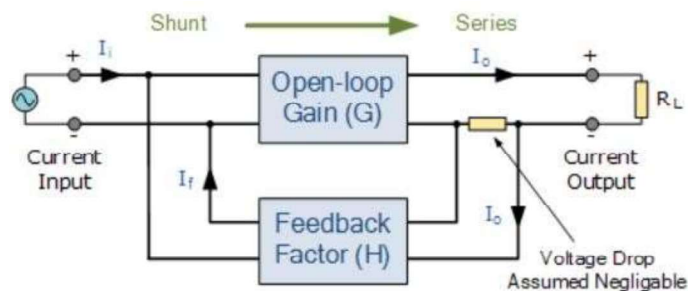
As the feedback circuit is connected in series with the output, the output impedance is increased and due to the parallel connection with the input, the input impedance is decreased.

Formulation of Input Resistance, Output Resistance and Voltage Gain

Feedback topologies: Current Series Feedback
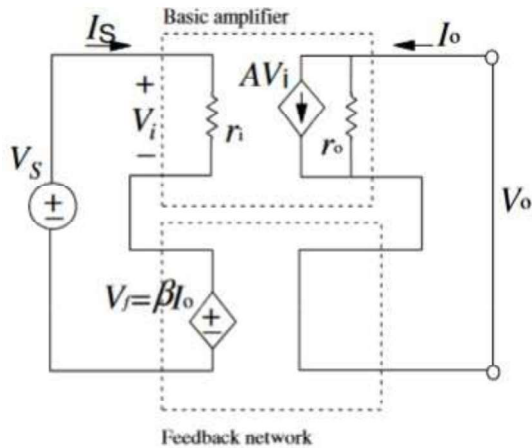
Voltage Gain :

$$I_o = A \cdot V_i = A(V_s - V_f)$$

$$V_f = \beta \cdot I_o$$

$$A(V_s - \beta I_o) = I_o$$

$$AV_s = (1 + \beta A) I_o$$

$$A_f = \frac{I_o}{V_s} = \left(\frac{A}{1 + \beta A}\right)$$

Input Impedance :

$$Z_{in} = \frac{V_s}{I_s} = \frac{V_i + V_f}{I_s}$$

$$= \frac{V_i + \beta V_o}{I_s} = \frac{V_i + \beta A V_i}{I_s}$$

$$Z_{in} = \frac{V_i(1 + \beta A)}{I_s} \qquad \text{A)}$$

Output Impedance :

$$Z_{out}|_{V_s = 0} = \frac{V_o}{I_o}; I_o = \frac{V_o - A \cdot V_i}{r_o}$$

$$V_i + V_f = V_s = 0$$

$$I_o = \frac{V_o + A \cdot \beta \cdot I_o}{r_o}$$

$$Z_{out} = \frac{V_o}{I_o} = \frac{r_o}{1 + A \cdot \beta}$$

Observation:

S.N	Input Voltage	Output Voltage	Input Resistance	Output Resistance	Voltage Gain

Result & Discussion:

Input resistance, output resistance and voltage gain are calculated for the given feedback circuits.

Experiment No. -8

Aim/Objective: To measure voltage gain of Complementary Symmetry Push Pull amplifier circuit.

Component Required: Transistor BC 547, Resistors, capacitors, breadboard, 5V DC supply, DSO and connecting wire.
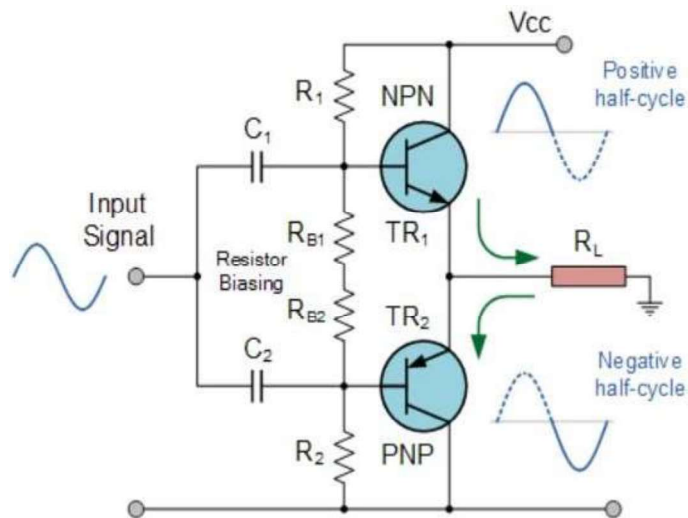
Theory:

To improve the full power efficiency of the previous Class A amplifier by reducing the wasted power in the form of heat, it is possible to design the power amplifier circuit with two transistors in its output stage producing what is commonly termed as a **Class B Amplifier** also known as a **push-pull amplifier** configuration.

Push-pull amplifiers use two "complementary" or matching transistors, one being an NPN-type and the other being a PNP-type with both power transistors receiving the same input signal together that is equal in magnitude, but in opposite phase to each other. This results in one transistor only amplifying one half or 180o of the input waveform cycle while the other transistor amplifies the other half or remaining 180o of the input waveform cycle with the resulting "two-halves" being put back together again at the output terminal. Then the conduction angle for this type of amplifier circuit is only 180o or 50% of the input signal. This pushing and pulling effect of the alternating half cycles by the transistors gives this type of circuit its amusing "push-pull" name, but are more generally known as the **Class B Amplifier** as shown below.

The Class B amplifier circuit above uses complimentary transistors for each half of the waveform and while Class B amplifiers have a much high gain than the Class A types, one of the main disadvantages of class B type push-pull amplifiers is that they suffer from an effect known commonly as Crossover Distortion. It takes approximately 0.7 volts (measured from base to emitter) to get a bipolar transistor to start conducting. In a pure class B amplifier, the output transistors are not "pre-biased" to an "ON" state of operation. This means that the part of the output waveform which falls below this 0.7 volt window will not be reproduced accurately as the transition between the two transistors (when they are switching over from one transistor to the other), the transistors do not stop or start conducting exactly at the zero crossover point even if they are specially matched pairs. The output transistors for each half of the waveform (positive and negative) will each have a 0.7 volt area in which they are not conducting. The result is that both transistors are turned "OFF" at exactly the same time.

A simple way to eliminate crossover distortion in a Class B amplifier is to add two small voltage sources to the circuit to bias both the transistors at a point slightly above their cut-off point. This then would give us what is commonly called an Class AB Amplifier circuit. However, it is impractical to add additional voltage sources to the amplifier circuit so PN- junctions are used to provide the additional bias in the form of silicon diodes.

Circuit Diagram:

Procedure:

1. Connect the circuit as shown in the figure.

2. Use potentiometer in case output is not proper

Observation:

S.N	Input Voltage (V_{in})	Output Voltage (V_{out})	Gain

.

Result & Discussion:

The average voltage gain of Complementary Symmetry Push Pull amplifier circuit is obtained.

Experiment No. -9

**Aim/Objective**: To measure the voltage gain of Class C Power amplifier circuit.

Component Required: Class C power amplifier Kit, 5V DC supply, DSO and connecting wire, probes.

Theory:

Class C power amplifier is a type of amplifier where the active element (transistor) conducts for less than one half cycle of the input signal. Less than one half cycles means the conduction angle is less than 180° and its typical value is 80° to 120°. The reduced conduction angle improves the efficiency to a great extend but causes a lot of distortion. Theoretical maximum efficiency of a Class C amplifier is around 90%.

Due to the huge amounts of distortion, the Class C configurations are not used in audio applications. The most common application of the Class C amplifier is the RF (radio frequency) circuits like RF oscillator, RF amplifier etc where there are additional tuned circuits for retrieving the original input signal from the pulsed output of the Class C amplifier and so the distortion caused by the amplifier has little effect on the final output
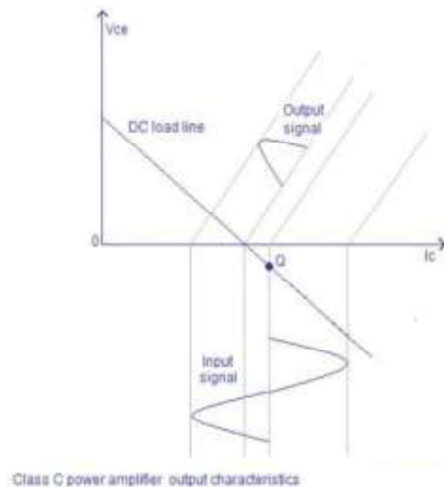
Circuit Diagram:

Class C power amplifier
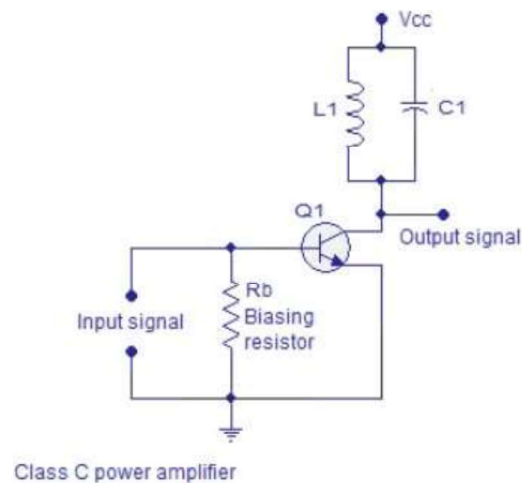
Biasing resistor Rb pulls the base of Q1 further downwards and the Q-point will be set some way below the cut-off point in the DC load line. As a result the transistor will start conducting only after the input signal amplitude has risen above the base emitter voltage (Vbe~0.7V) plus the downward bias voltage caused by Rb. That is the reason why the major portion of the input signal is absent in the output signal.

Inductor L1 and capacitor C1 forms a tank circuit which aids in the extraction of the required signal from the pulsed output of the transistor. Actual job of the active element (transistor) here is to produce a series of current pulses according to the input and make it flow through

the resonant circuit. Values of L1 and C1 are so selected that the resonant circuit oscillates in the frequency of the input signal. Since the resonant circuit oscillates in one frequency (generally the carrier frequency) all other frequencies are attenuated and the required frequency can be squeezed out using a suitably tuned load. Harmonics or noise present in the output signal can be eliminated using additional filters. A coupling transformer can be used for transferring the power to the load.

Output Characteristics

Class C power amplifier output characteristics

Procedure:

1. Connect the circuit as shown in the figure.

2. Use potentiometer in case output is not proper

Observation:

S.N	Input Voltage (V_{in})	Output Voltage (V_{out})	Gain

.

Result & Discussion:

The average voltage gain of Class C power amplifier circuit is obtained.

Experiment No. -10

Aim/Objective: To measure the voltage gain of Common Source FET amplifier circuit.

Component Required: FET kit, 5V DC supply, DSO and connecting wire, probes.

Theory:

In the figure shows a common-source amplifier using n-channel D-MOSFET. Since the source terminal is common to the input and output terminals, the circuit is called common source amplifier. The circuit is zero biased with an a.c. source coupled to the gate through the coupling capacitor C_1 .The gate is at approximately 0V d.c. and the source terminal is grounded, thus making $V_{GS} = 0V$

The input signal (V_{in}) is capacitively coupled to the gate terminal. In the absence of the signal, d.c. value of $V_{GS} = 0V$.

When signal (V_{in}) is applied, V_{gs} swings above and below its zero value, producing a swing in drain current I_d .

A small change in gate voltage produces a large change in drain current as in JFET. This fact makes MOSFET capable of raising the strength of a weak signal; thus acting as an amplifier.

During the positive half-cycle of the signal, the positive voltage on the gate increases and produces the enhancement-mode .This increases the channel conductivity and hence the drain current during the negative half-cycle of the signal, the positive voltage decreases and produces depletion-mode. This decreases the conductivity and hence the drain current. The result of above action is that a small change in gate voltage produces a large change in the drain current. This large variation in drain current produces a large a.c. output voltage across drain resistance R_D.

Circuit Diagram:
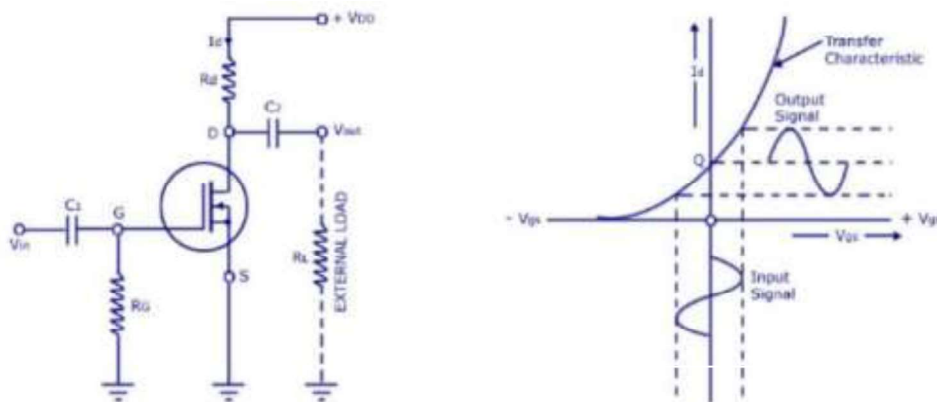
Observation:

S.N	Input Voltage (V_{in})	Output Voltage (V_{out})	Voltage Gain

.

Result & Discussion:

The voltage gain of Common Source FET amplifier circuit is obtained.

COLLEGE OF TECHNOLGY AND ENGINEERING

MAHARANA PRATAP UNIVERSITY OF AGRICULTURE & TECHNOLGY, UDAIPUR

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

LAB MANUAL

EC224 - MICROPROCESSOR ARCHITECTURE & APPLICATION

PREPARED BY

Mr. NEERAJ CHAUDHARY

SYLLABUS FOR MICROPROCESSOR LAB

1. Write a program using 8085 Microprocessor for Decimal, Hexadecimal addition and subtraction of two Numbers.

2. Write a program using 8085 Microprocessor for addition and subtraction of two BCD numbers.

3. To perform multiplication and division of two 8 bit numbers using 8085.

4. To find the largest and smallest number in an array of data using 8085 instruction set.

5. To write a program to arrange an array of data in ascending and descending order.

6. To convert given Hexadecimal number into its equivalent ASCII number and vice versa using 8085 instruction set.

7. To write a program to initiate 8251 and to check the transmission and reception of character.

8. To interface 8253 programmable interval timer to 8085 and verify the operation of 8253 in six different modes.

9. To interface DAC with 8085 to demonstrate the generation of square, saw tooth and triangular wave.

10. Serial communication between two 8085 through RS-232 C port.

STUDY AND EVALUATION SCHEME

SESSIONAL EVALUATION:-

CLASS TEST	**:**	**10 MARKS**
TEACHER'S ASSESMENT	**:**	**10 MARKS**
EXTERNAL EXAM	**:**	**30 MARKS**
TOTAL	**:**	**50 MARKS**

INDEX

S.NO.	NAME OF EXPERIMENT	DATE OF EVALUATION	GRADE

EXPERIMENT NO. – 1(a)

OBJECTIVE:
Write a program to add two hexadecimal & decimal numbers.

APPARATUS REQUIRED: -

| Sr. no.	Name of equipments/components/software	Specification/range/rating/version	Quantity
1	8085 Microprocessor programming kit, instruction coding sheet.	SCIENTECH-8085	1
2.	Power supply	A.C (230V Mains)	

DESCRIPTION/ALGORITHM:-

Hexadecimal Addition: The program takes the content of 2009, adds it to 200B & stores the result back at 200C.

Steps: 1. Initialize HL Reg. pair with address where the first number is lying.
   2. Store the number in accumulator.
   3. Get the second number.
   4. Add the two numbers and store the result in 200B.
   5. Go back to Monitor

Let: (2009 H) = 80 H
        (200B H) = 15 H
        Result = 80 H + 15 H = 95 H
        (2009 H) $\longrightarrow$ A
          A $\longrightarrow$ B
        (200B H) $\longrightarrow$ A
          A + B $\longrightarrow$ A
            A $\longrightarrow$ (200C H)

FLOWCHART : -
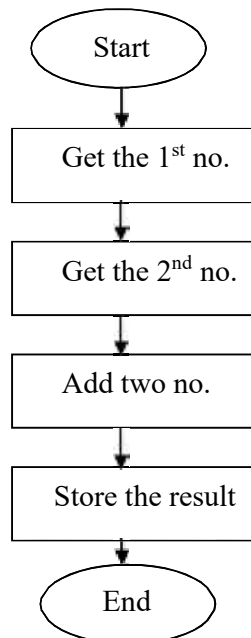
PROGRAM:-

```
LXI H, 2009    ;    Point 1st no.
MOV A, M       ;    Load the acc.
INX H          ;    Adv Pointer
ADD M          ;    ADD 2nd NO.
INX H          ;    Adv Pointer
MOV M, A       ;    Store Result
RST 5
```
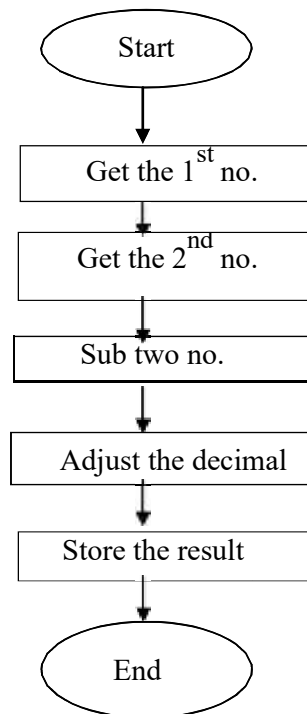
Decimal Addition:

Steps: 1. Initialize HL Reg. pair with address where the first number is lying.
2. Store the number in accumulator.
3. Get the second number.
4. Add the two numbers and store the result in 200B.
5. Go back to Monitor

FLOWCHART:-

```
        ┌─────────┐
        │  Start  │
        └────┬────┘
             │
             ▼
    ┌────────────────┐
    │ Get the 1st no.│
    └────────┬───────┘
             │
             ▼
    ┌────────────────┐
    │ Get the 2nd no.│
    └────────┬───────┘
             │
             ▼
    ┌────────────────┐
    │   Add two no.  │
    └────────┬───────┘
             │
             ▼
    ┌────────────────┐
    │Adjust the decimal│
    └────────┬───────┘
             │
             ▼
    ┌────────────────┐
    │ Store the result│
    └────────┬───────┘
             │
             ▼
        ┌─────────┐
        │   End   │
        └─────────┘
```

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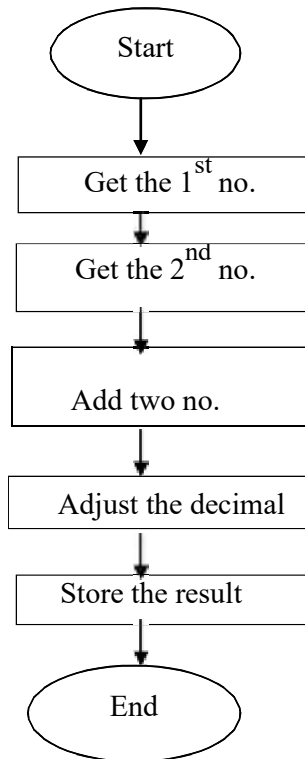
PROGRAM:-

```
LXI H, 2009   ;      Point 1st no.
MOV A, M      ;      Load the acc.
INX H         ;      Adv Pointer
ADD M         ;      ADD 2nd NO.
DAA           ;       Adjust the decimal
INX H         ;      Adv Pointer
MOV M, A      ;      Store Result
RST 5
```

REULTS:-

Thus the numbers at 2009H and at memory are added.

CONCLUSION:-

Thus the program to add two 8-bit numbers was executed.

PRECAUTION:-

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EXPERIMENT NO. – 1 (b)

OBJECTIVE:- Write a program to subtract two hexadecimal & decimal numbers

APPARATUS REQUIRED: -

Sr. no.	Name of equipments/components/software	Specification/range/rating/version	Quantity
1	8085 Microprocessor programming kit, instruction coding sheet.	SCIENTECH-8085	1
2.	Power supply	A.C (230V Mains)	

DESCRIPTION/ALGORITHM:-

Hexadecimal Subtraction : The program takes the content of 2009, subtracts it to 200B & stores the result back at 200C.

Steps:-

1. Initialize HL Reg. pair with address where the first number is lying.
2. Store the number in accumulator.
3. Get the second number.
4. Subtract second no from acc and store the result in 200B.
5. Go back to Monitor

FLOWCHART:-
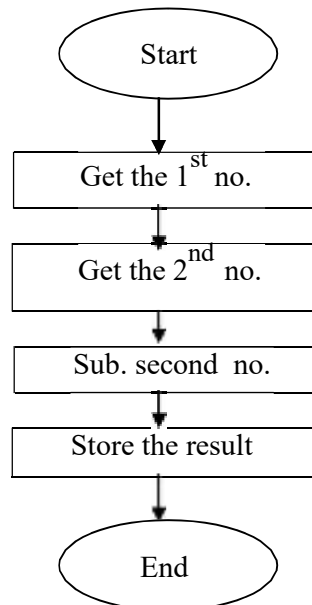
PROGRAM:-

```
LXI H, 2009    ;    Point 1st no.
MOV A, M       ;    Load the acc.
INX H          ;    Adv Pointer
SUB M          ;    Subtract IIND NO.
INX H          ;    Adv Pointer
MOV M, A       ;    Store Result
RST 5
```
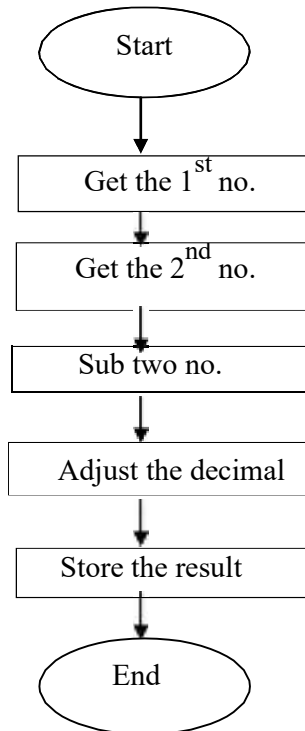
Decimal Subtraction :

Steps:-

1. Initialize HL Reg. pair with address where the first number is lying.
2. Store the number in accumulator.
3. Get the second number.
4. Subtract second no from acc and store the result in 200B.
5. Adjust the decimal
6. Go back to Monitor

FLOWCHART:-

```
        ( Start )
            |
            v
   +-------------------+
   | Get the 1st no.   |
   +-------------------+
            |
            v
   +-------------------+
   | Get the 2nd no.   |
   +-------------------+
            |
            v
   +-------------------+
   | Sub two no.       |
   +-------------------+
            |
            v
   +-------------------+
   | Adjust the decimal|
   +-------------------+
            |
            v
   +-------------------+
   | Store the result  |
   +-------------------+
            |
            v
        (  End  )
```

PROGRAM:-

```
LXI H, 2009    ;      Point 1st no.
MOV A, M       ;      Load the acc.
INX H          ;      Adv Pointer
SUB M          ;      Subtract IIND NO.
DAA            ;      Adjust the decimal
INX H              ; Adv Pointer MOV
M, A    ;    Store Result RST 5
```

REULTS:-

Numbers at 2009H and in HL pairs (Memory) are subtracted

CONCLUSION:-

Thus the subtraction operation is taken out using assembly language.

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PRECAUTION:-

PRE EXPERIMENT QUESTION BANK:-

Study how to operate the microprocessor in single stepping. It is very useful in debugging.
Identify the clock crystal and record its frequency. Calculate the time for opcode fetch.
Identify 8255 programmable peripheral enter face. Find out the address of parts from manual.
Identify the ROM & RAM and show in the memory map.

POST EXPERIMENT QUESTION BANK:-

Write a small program to enter a data to accumulator and move it to all registers.
Find out how to read the contents of registers and flags. Read the content of PC, SP.
Why DAA instruction is to be written just after ADD instruction.
In above program why MOV A,M instruction is used if direct instruction LDA, address is available.

EXPERIMENT NO. –0 2

OBJECTIVE:- Write a program using 8085 Microprocessor for addition and subtraction of two BCD numbers.

APPARATUS REQUIRED: -

Sr. no.	Name of equipments/components/software	Specification/range/rating/version	Quantity
1	8085 Microprocessor programming kit, instruction coding sheet.	SCIENTECH-8085	1
2.	Power supply	A.C (230V Mains)	

DESCRIPTION/ALGORITHM:-

Steps: 1. Initialize HL Reg. pair with address where the first number is lying.
2. Store the number in accumulator.
3. Get the second number.
4. Add the two numbers and store the result in 200B.
5. Go back to Monitor
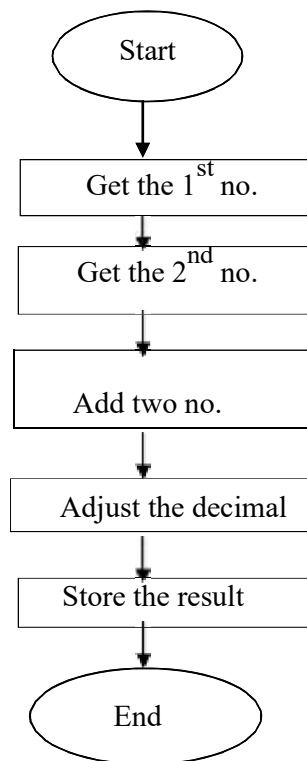
FLOWCHART:-

Steps:-

7. Initialize HL Reg. pair with address where the first number is lying.
8. Store the number in accumulator.
9. Get the second number.
10. Subtract second no from acc and store the result in 200B.
11. Adjust the decimal
12. Go back to Monitor

FLOWCHART:-

```
            ┌─────────┐
           (   Start  )
            └─────────┘
                 │
                 ▼
        ┌─────────────────┐
        │  Get the 1st no.│
        └─────────────────┘
                 │
                 ▼
        ┌─────────────────┐
        │ Get the 2nd no. │
        └─────────────────┘
                 │
                 ▼
        ┌─────────────────┐
        │   Sub two no.   │
        └─────────────────┘
                 │
                 ▼
        ┌─────────────────┐
        │Adjust the decimal│
        └─────────────────┘
                 │
                 ▼
        ┌─────────────────┐
        │ Store the result│
        └─────────────────┘
                 │
                 ▼
            ┌─────────┐
           (   End    )
            └─────────┘
```

PROGRAM:-

```
LXI H, 2009   ;      Point 1st no.
MOV A, M      ;      Load the acc.
INX H         ;      Adv Pointer
SUB M         ;      Subtract IIND NO.
DAA           ;      Adjust the decimal
INX H         ;      Adv Pointer
MOV M, A      ;      Store Result
RST 5
```

REULTS:-
The BCD numbers at 2009H and memory are added or substracted.

CONCLUSION:-
Thus the substracttion operation is taken out using assembly language.

PRE EXPERIMENT QUESTION BANK:-

1. Explain the following instructions with addressing modes & no of byte.
   (a). LHLD 8050
   (b). XTHL
   (c). DADH.
2. What is the necessity to have two status lines S_1 & S_0 in 8085 ?

POST EXPERIMENT QUESTION BANK:-

3. Write a program to exchange the contents of memory location 1000H and 2000H.
4. Why $AD_0 - AD_7$ lines are multiplexed ?
5. Give the difference between machine language, assembly language and high level language.

OBJECTIVE: - Write a program to perform multiplication of two 8 bit numbers using bit addition method

APPARATUS REQUIRED: -

Sr. no.	Name of equipments/ components/ software	Specification/range/rating/ version	Quantity
1	8085 Microprocessor programming kit, instruction coding sheet.	SCIENTECH-8085	1
2.	Power supply	A.C (230V Mains)	

DESCRIPTION/ALGORITHM:-

1) Start the program by loading HL register pair with address of memory location.
2) Move the data to a register (B register).
3) Get the second data and load into Accumulator.
4) Add the two register contents.
5) Check for carry.
6) Increment the value of carry.
7) Check whether repeated addition is over and store the value of product and carry in memory location.

FLOWCHART:

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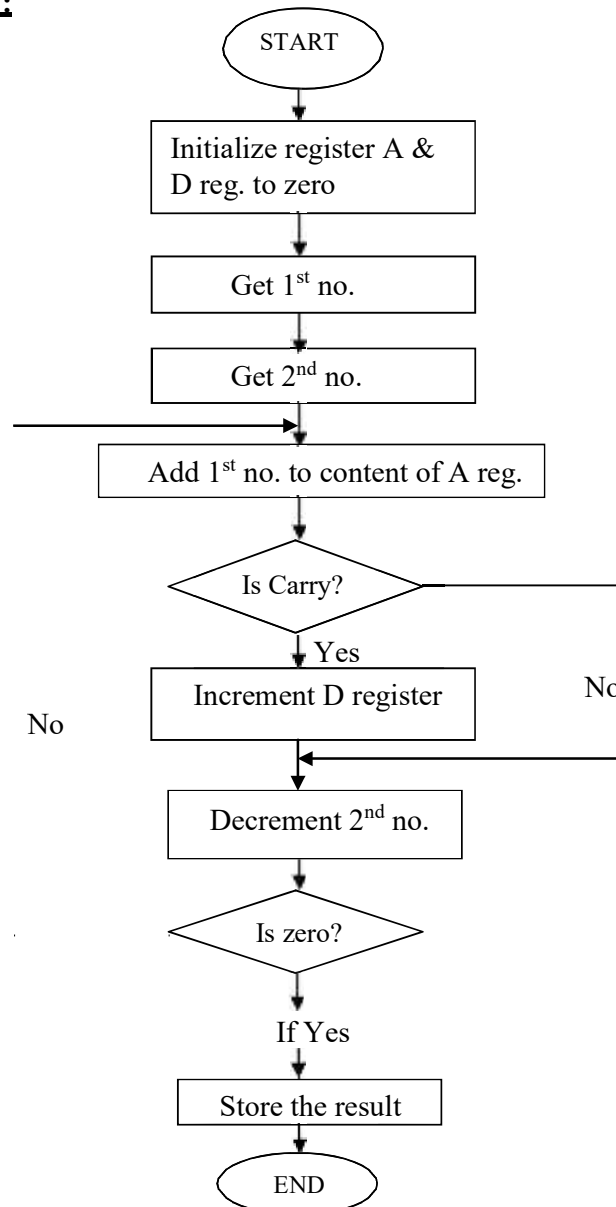
PROGRAM:

MVI D, 00	;	Initialize register D to 00
MVI A, 00	;	Initialize Accumulator content to 00
LXI H, 4150	;	HL Points 4150
MOV B, M	;	Get the first number in B - register
INX H	;	HL Points 4151
MOV C, M	;	Get the second number in C- reg.
LOOP : ADD B	;	Add content of A - reg to register B.
JNC NEXT	;	Jump on no carry to NEXT.
INR D	;	Increment content of register D
NEXT : DCR C	;	Decrement content of register C.
JNZ LOOP	;	Jump on no zero to address
STA 4152	;	Store the result in Memory
MOV A, D	;	Get the carry in Accumulator
STA 4153	;	Store the MSB of result in Memory
HLT	;	Terminate the program.

REULTS:-

Input: FF (4150)
   FF (4151)
Output: 01 (4152)
FE (4153)

CONCLUSION:-

Thus the multiplication process is taken out using assembly language for 8085 microprocessor

OBJECTIVE: - Write a program to perform multiplication of two 8 bit numbers using bit rotation method

APPARATUS REQUIRED: -

Sr. no.	Name of equipments/components/software	Specification/range/rating/version	Quantity
1	8085 Microprocessor programming kit, instruction coding sheet.	SCIENTECH-8085	1
2.	Power supply	A.C (230V Mains)	

DESCRIPTION/ALGORITHM:-

1) Start the program by loading HL register pair with address of memory location.
2) Move the data to a register (E register).
3) Get the second data and load into Accumulator.
4) Add the two register contents.
5) Check for carry.
6) Increment the value of carry.
7) Check whether repeated addition is over and store the value of product and carry in memory location.
8) Terminate the program.

EXAMPLE :

Steps	Product	Multiplier	Comments

B_7 B_6 B_5 B_4 B_3 B_2 B_1 B_0 CY B_3 B_2 B_1 B_0

	$B_7 B_6 B_5 B_4 B_3 B_2 B_1 B_0$	CY $B_3 B_2 B_1 B_0$	
	0 0 0 0 0 0 0 0	0 0 1 0 1	Initial Stage
Step 1	0 0 0 0 0 0 0 0	0 1 0 1 0	Shift left by 1
	0 0 0 0 0 0 0 0	0 1 0 1 0	Don't add since CY= 0
Step 2	0 0 0 0 0 0 0 0	1 0 1 0 0	Shift
	0 0 0 0 1 1 0 0	1 0 1 0 0	Add multiplicand;CY=1
Step 3	0 0 0 1 1 0 0 0	0 1 0 0 0	Shift left by 1
	0 0 0 1 1 0 0 0	0 1 0 0 0	Don't add since CY= 0
Step 4	0 0 1 1 0 0 0 0	1 0 0 0 0	Add multiplicand;CY=1

PROGRAM:

```
        LXI H, 2200 H      ;    Initialize the memory pointer
        MOV E , M          ;    Get multiplicand
        MVI D, 00 H        ;    Extend to 16 bits
        INX H              ;    Increment memory pointer
        MOV A , M          ;    Get Multiplier
        LXI H , 0000 H     ;    Product = 0
        MVI B, 08 H        ;    Initialize counter with count 8
LOOP:   DAD H              ;    Product = product X 2
```

```
            RAL
            JNC XYZ          ;     Is carry from multiplier 1?
            DAD  D           ;     Yes, product = product + multiplicand
      XYZ: DCR  B            ;     Is counter = 0
            JNZ  LOOP        ;     No, repeat
            SHLD 2300 H      ;     Store the result
            HLT
```

REULTS:-

Multiplication has been carried out between the data of 2200H and 2201 H.

CONCLUSION:-

Thus the multiplication process for 8 bit binary numbers is taken out in 8085 microprocessor

PRE EXPERIMENT QUESTION BANK:-

1. Define the following terms.
   (a) operand (b) opcode
2. What is meant by addressing modes
3. 3.Give the addressing modes of the following instructions.
   (a) ADI B7H
   (b) SUB B
   (c) DCX D
   (d) RRC

     The contents of register (B) and accumulator (A) of 8085 microprocessor are 49H & 39H respectively. What are the contents of A and the status of carry flag (CY) and sign flag (S) after exceeding SUB B instructions.

     Calculate the time required to execute the following two instructions if the system clock frequency is 750KHZ.

MOV C, E   4T   states
JMP,   2050H   10T states.

OBJECTIVE: - Write a program to perform division of two 8 bit numbers using Repeated Subtraction method.

APPARATUS REQUIRED: -

Sr. no.	Name of equipments/components/software	Specification/range/rating/version	Quantity
1	8085 Microprocessor programming kit, instruction coding sheet.	SCIENTECH-8085	1
2.	Power supply	A.C (230V Mains)	

DESCRIPTION/ALGORITHM:-

1) Start the program by loading HL register pair with address of memory location.
2) Move the data to a register (B register).
3) Get the second data and load into Accumulator.
4) Compare the two numbers to check for carry.
5) Subtract the two numbers.
6) Increment the value of carry.
7) Check whether repeated subtraction is over and store the value of product and Carry in memory location.
8) Terminate the program.

PROGRAM:

```
          LXI H, 4150
          MOV B , M      ;      Get the dividend in B – reg.
          MVI C, 00      ;    Clear C – reg for qoutient
          INX H          ;
          MOV A , M      ;      Get the divisor in A – reg.
   NEXT:  CMP B          ;    Compare A - reg with register B.
          JC LOOP        ;     Jump on carry to LOOP
          SUB B          ;    Subtract A – reg from B- reg.
          INR C          ;     Increment content of register C.
          JMP NEXT       ;      Jump to NEXT
   LOOP:  STA 4152       ;    Store the remainder in Memory
          MOV A, C       ;
          STA 4153       ;     Store the quotient in memory
          HLT            ;     Terminate the program.
```

RESULTS:

Input: FF (4150)
FF (4251)
Output: 01 (4152) ---- Remainder
FE (4153) ----- Quotient

OBJECTIVE:- Write a program to perform division of two 8 bit numbers using bit rotation method.

APPARATUS REQUIRED: -

Sr. no.	Name of equipments/components/software	Specification/range/rating/version	Quantity
1	8085 Microprocessor programming kit, instruction coding sheet.	SCIENTECH-8085	1
2.	Power supply	A.C (230V Mains)	

PROGRAM:

MVI E, 00 H	;	Quotient = 0
LHLD 2200 H	;	Get Dividend
LDA 2300 H	;	Get Divisor
MOV B , A	;	Store Divisor
MVI C , 08 H	;	Count = 08
NEXT : DAD H	;	Dividend = Dividend X 2
MOV A , E		
RLC		
MOV E , A	;	Quotient = X 2
MOV A , H		
SUB B	;	Is MSB of dividend > divisor
JC SKIP	;	No go to next step
MOV H , A	;	Yes subtract divisor
INR E	;	Quotient = Quotient + 1
SKIP : DCR C	;	Count = count – 1
JNZ NEXT	;	Is count = 0 repeat
MOV A , E		
STA 2401 H	;	Store Quotient
MOV A , H		
STA 2401 H	;	Store Remainder
HLT	;	End of program

REULTS:-
Number at 220H is divided from the number at 2300H

CONCLUSION:-
Thus the division process is taken out in 8085 microprocessor

PRE EXPERIMENT QUESTION BANK:-

1. If A=47 H, B=98H and the instruction ADD B is executed give the status of flag register after execution.
2. List out the instructions that clean the accumulator.
3. Explain any two stack related instructions.
4. Compare the action of microprocessor for the following pair of instructions.
   (a) NOP & HLT   (b) RLC & RAL

OBJECTIVE:- Finding the largest and smallest number from an array.

APPARATUS REQUIRED: -

Sr. no.	Name of equipments/components/software	Specification/range/rating/version	Quantity
1	8085 Microprocessor programming kit, instruction coding sheet.	SCIENTECH-8085	1
2.	Power supply	A.C (230V Mains)	

DESCRIPTION/ALGORITHM:-

Write a program to find the largest number in a given array of 16 elements. The array is stored in memory from 9200H onwards. Store the result at the end of the array.

FLOWCHART:-
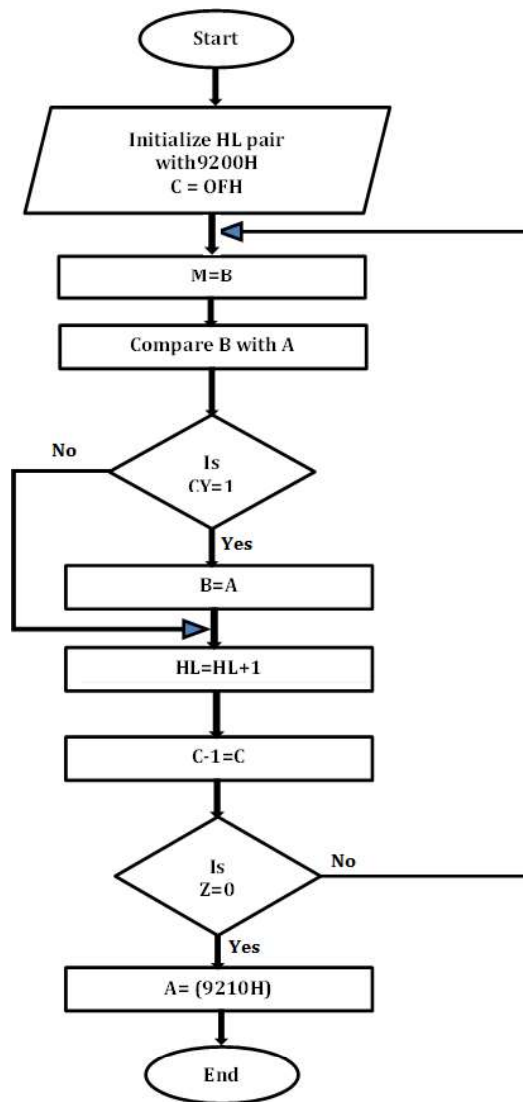
PROCEDURE:-

To find largest of given no. of a given string we compare all given no. one by one. Suppose given no. is 2, 4, 3, 1, 0 1st we compare 2 & 4 (2 is in register A & 4 is in Register B).
A < B so put B into (A) & Compare with next number i.e. 3 Here A > B so directly compare 4 with 1 then 0.

RESULT AND INFERENCE:-
The largest number from the array of 16 numbers from memory location 9200H is found out and stored at 9210H

PRECAUTION:- Take memory locations according model of kit.

QUESTIONS:-

1. The following instructions have be executed by an 8085 microprocessor.

ADDRESS (HEX)	Instruction
6010H	LXI H, 8A79H
6013H	MOVA, L
6015H	ADDH

2. Suppose HL=ABCD, stack painter = 1234, what happens after SPHL is executed.
3. Explain any instructions in which 8085 uses the registers W & Z.
4. Write a segment of program to exchange of BC register pair with DE register pair without using MOV instructions.
5. Write two instructions which can be used to initialize stack pointer at FFFFH.

EXPERIMENT NO.- 6

AIM:- Finding the smallest number from an array.

      Write a program to find smallest number from an array of 16 elements the array is stored in memory from 9200H onwards. Store the result at memory location 9210H.

REQUIREMENT:- 8085 microprocessor programming kit, instruction coding sheet.

THEORY:- Same as largest no. we compare two number one by one but comparison process is reverse.

PROCEDURE:-
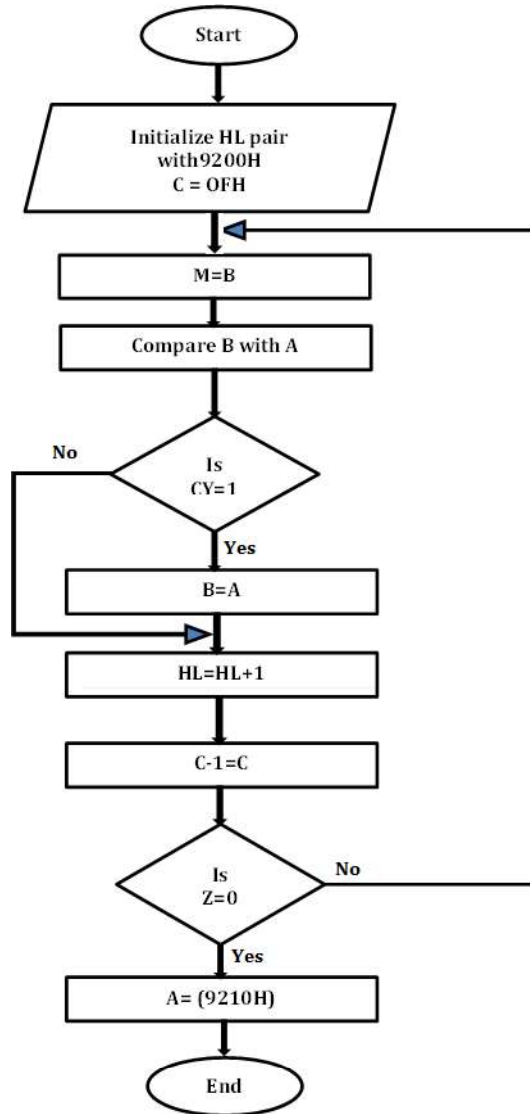
RESULTS:
Smallest number has been found out from a 16 bit array starting from 9200H and is stored at 9210H.

CONCLUSION:
Thus the smallest number has been found out from the array in assembly language for 8085 microprocessor

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OBJECTIVE:- Interfacing a program to initiate 8251 and to check transmission and reception of character

APPARATUS REQUIRED: -

Sr. no.	Name of equipments/components/software	Specification/range/rating/version	Quantity
1	8085 Microprocessor programming kit, instruction coding sheet.	SCIENTECH-8085	1
2.	Power supply	A.C (230V Mains)	

DESCRIPTION/ALGORITHM:-

Steps:
1. Intitialize timer IC
2. Move the mode command word to A
3. Output it to port address C2
4. Moce the command instruction word to A reg.
5. Output it to port address C2
6. Move the data to be transferred to A
7. Output it to port address C0
8. Reset the system
9. Get data from input port C0
10. Store the value in memory
11. Reset the system

PROGRAM:

```
MVI A,36H
Out CEH
MVI A,0AH
Out C8H
LXI H,4200H
MVI A,4EH
Out C2H
MVI A, 37H
Out C2H
MVI A, 42H
Out C0H
RST 1
ORG 4200H
In C0H
STA 4500H
RST 1
```

RESULT
Output at 4500=1

CONCLUSION
Thus the 8251 was initiated and the transmission and reception character was done successfully.

EXPERIMENT NO.- 8

OBJECTIVE:- To interface Programmable Interval timer to 8085 and verify the operation of 8253 in six different modes

APPARATUS REQUIRED: -

Sr. no.	Name of equipments/components/software	Specification/range/rating/version	Quantity
1	8085 Microprocessor programming kit, instruction coding sheet.	SCIENTECH-8085	1
2.	Power supply	A.C (230V Mains)	
3.	CRO	20MHz	1

DESCRIPTION/ALGORITHM:-

MODE 0- Interrupt On Terminal Count:

At first let us see the channel in mode0. Connect the CLK0 to the debounce circuit and execute the following program.

Program:

MVI A, 30H
OUT CEH
MVI A, 05H
OUT C8H
MVI A, 00H
OUT C8H
HLT

MODE 1- Programmable One Shot

After loading the count, the output will remain low following the rising edge of the gate input.The output will go high on the terminal count.
The program initializes channel 0 of 8253 in Mode 1 and also initializes triggering of gate.

Program:

MVI A, 32H
OUT CEH
MVI A, 05H
OUT C8H
MVI A,00H
OUT C8H
OUT DOH
HLT

MODE 3-Square Generation
In this the output will remain high until one half of the count and goes low for the order half provided the count is an even number. This mode is used to generate the baud rate of 8251.

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Program:

MVI A, 36H
OUT CEH
MVI A, 0AH
OUT C8H
MVI A, 00H
OUT C8H
HLT

RESULT:
Thus the 8253 PIT was interfaced to 8085 and the operations for mode 0, 1 and 3 were verified.

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COLLEGE OF TECHNOLGY AND ENGINEERING

MAHARANA PRATAP UNIVERSITY OF AGRICULTURE & TECHNOLGY, UDAIPUR

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

LAB MANUAL

EC225 – Telecomm. Engg.

PREPARED BY

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Telecommunication Engineering (EC225)

NAME OF EXPERIMENT

1. Design an attenuation circuit using T-type and π-type network to attenuate a signal.
2. Demonstrate the Characteristics of low pass filter using RF analyzer and measure S11 (return loss) and S21 (insertion loss).
3. Demonstrate the Characteristics of band pass filter using RF analyzer and measure S11 (return loss) and S21 (insertion loss).
4. Design open and short transmission line using RF analyzer and measure S11 (return loss) and S21 (insertion loss).
5. Design thru transmission line using RF analyzer and measure S11 (return loss) and S21 (insertion loss).
6. Design T-type impedance matched transformer using RF analyzer and measure S11 (return loss) and S21 (insertion loss).
7. Design π-type impedance matched transformer using RF analyzer and measure S11 (return loss) and S21 (insertion loss).
8. Design T-type power attenuator using RF analyzer and measure S11 (return loss) and S21 (insertion loss).
9. Design π-type power attenuator using RF analyzer and measure S11 (return loss) and S21 (insertion loss).
10. Demonstrate the Characteristics of BJT amplifier using RF analyzer and measure S11 (return loss) and S21 (insertion loss).
11. Determine attenuation and characteristics parameter at different length of transmission line.
12. Measure the input impedance at different length of transmission line.
13. Determine the stationary wave ratio at different length of transmission line.
14. To measure the test point voltages and test point waveforms of different sections of Telephone handset instrument.

Experiment 1

Design the attenuation circuit using the T-Type and π-Type power attenuator.

Apparatus and trainers required: T-type and π-Type attenuator trainer, connecting probes and cables, DSO, etc.

Theory:

Attenuators: Attenuators are passive devices. It is convenient to discuss them along with decibels. Attenuators weaken or *attenuate* the high level output of a signal generator, for example, to provide a lower level signal for something like the antenna input of a sensitive radio receiver. (Figure below) The attenuator could be built into the signal generator, or be a stand-alone device. It could provide a fixed or adjustable amount of attenuation. An attenuator section can also provide isolation between a source and a troublesome load.
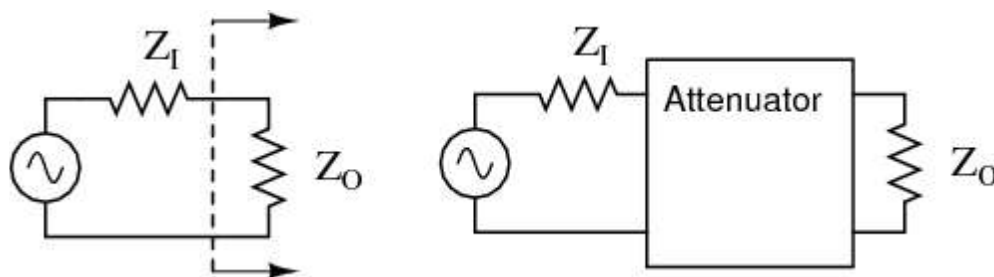
In the case of a stand-alone attenuator, it must be placed in series between the signal source and the load by breaking open the signal path as shown in Figure above. In addition, it must match both the source impedance ZI and the load impedance ZO, while providing a specified amount of attenuation. In this section we will only consider the special, and most common, case where the source and load impedances are equal. Not considered in this section, unequal source and load impedances may be matched by an attenuator section. However, the formulation is more complex.

T section and Π section attenuators: Common configurations are the T and Π networks shown in Figure above Multiple attenuator sections may be cascaded when even weaker signals are needed as in Figure below.

T attenuator   Π attenuator
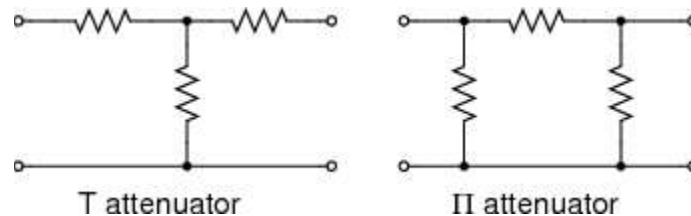
<u>Decibels:</u> Voltage ratios, as used in the design of attenuators are often expressed in terms of decibels. The voltage ratio (K below) must be derived from the attenuation in decibels. Power ratios expressed as decibels are additive. For example, a 10 dB attenuator followed by a 6 dB attenuator provides 16dB of attenuation overall.

$$10 \text{ dB} + 6 \text{ db} = 16 \text{ dB}$$

Changing sound levels are perceptible roughly proportional to the logarithm of the power ratio (P_I / P_O).

$$\text{sound level} = \log_{10}(P_I / P_O)$$

A change of 1 dB in sound level is barely perceptible to a listener, while 2 db is readily perceptible. An attenuation of 3 dB corresponds to cutting power in half, while a gain of 3 db corresponds to a doubling of the power level. A gain of -3 dB is the same as an attenuation of +3 dB, corresponding to half the original power level.

The power change in decibels in terms of power ratio is:

$$dB = 10 \log 10(PI / PO)$$

Assuming that the load RI at PI is the same as the load resistor RO at PO (RI = RO), the decibels may be derived from the voltage ratio (VI / VO) or current ratio (II / IO):

$$PO = V \text{ O IO} = VO2 / R = IO2 \text{ R PI} = V \text{ I II} = V 2 / R = I 2 \text{ R}$$
$$dB = 10 \log 10(PI /^I PO) = 10 \log 10(V 2 / VO2) = 20 \log 10(VI/VO) \ dB = 10$$
$$\log 10(PI / PO) = 10 \log 10(I 2 / IO2) = 20 \log 10(II/IO)$$

The two most often used forms of the decibel equation are:

$$dB = 10 \log 10(PI / PO) \text{ or}$$
$$dB = 20 \log 10(VI / VO)$$

We will use the latter form, since we need the voltage ratio. Once again, the voltage

ratio form of equation is only applicable where the two corresponding resistors are equal. That is, the source and load resistance need to be equal.

Example: Power into an attenuator is 10 Watts, the power out is 1 Watt. Find the attenuation in dB.

dB = 10 log10(PI / PO) = 10 log10 (10 /1) = 10 log10 (10) = 10 (1) = 10 dB

Example: Find the voltage attenuation ratio (K= (VI / VO)) for a 10 dB attenuator.
$$dB = 10 = 20 \log10(VI / VO)$$
$$10/20 = \log10(VI / VO)$$
$$10^{10/20} = 10\log (V / V)$$
$$3.16 = (VI / VO) = AP(ratio)$$
Example: Power into an attenuator is 100 milliwatts, the power out is 1 milliwatt. Find the attenuation in dB.
dB = 10 log10(PI / PO) = 10 log10 (100 /1) = 10 log10 (100) = 10 (2) = 20 dB
 Example: Find the voltage attenuation ratio (K= (VI / VO)) for a 20 dB attenuator.
$$dB = 20 = 20 \log10(VI / VO)$$
$$10^{20/20} = 10 \log (V / V)$$
$$10 = (VI / VO) = K$$

T-section attenuator

The T and Π attenuators must be connected to a Z source and Z load impedance. The Z-(arrows) pointing away from the attenuator in the figure below indicate this. The Z-(arrows) pointing toward the attenuator indicates that the impedance seen looking into the attenuator with a load Z on the opposite end is Z, Z=50 Ω for our case. This impedance is a constant (50 Ω) with respect to attenuation– impedance does not change when attenuation is changed.The table in Figure below lists resistor values for the T and Π attenuators to match a 50 Ω source/ load, as is the usual requirement in radio frequency work.Telephone utility and other audio work often requires matching to 600 Ω. Multiply all R values by the ratio (600/50) to correct for 600 Ω matching. Multiplying by 75/50 would convert table values to match a 75 Ω source and load.

dB = attenuation in decibels
Z = source/load impedance (resistive)
K > 1

$$K = \frac{V_I}{V_O} = 10^{\,dB/20}$$

$$R_1 = Z\left(\frac{K-1}{K+1}\right)$$

$$R_2 = Z\left(\frac{2K}{K^2-1}\right)$$

T attenuator

Resistors for T-section			
Z = 50			
Attenuation			
dB	K=Vi/Vo	R1	R2
1.0	1.12	2.88	433.34
2.0	1.26	5.73	215.24
3.0	1.41	8.55	141.93
4.0	1.58	11.31	104.83
6.0	2.00	16.61	66.93
10.0	3.16	25.97	35.14
20.0	10.00	40.91	10.10

Formulas for T-section attenuator resistors, given K, the voltage attenuation ratio, and ZI = ZO = 50 Ω.The amount of attenuation is customarily specified in dB (decibels). Though, we need the voltage (or current) ratio K to find the resistor values from equations. See the dB/20 term in the power of 10 term for computing the voltage ratio K from dB, above.The T (and below Π) configurations are most commonly used as they provide bidirectional matching. That is, the attenuator input and output may be swapped end for end and still match the source and load impedances while supplying the same attenuation.Disconnecting the source and looking in to the right at VI, we need to see a series parallel combination of R1, R2, R1, and Z looking like an equivalent resistanceof ZIN, the same as the source/load impedance Z: (a load of Z is connected to the output.)

$$ZIN = R1 + (R2 \,\|(R1 + Z))$$

For example, substitute the 10 dB values from the 50 Ω attenuator table for R1 and R2 as shown in Figure below.

$$ZIN = 25.97 + (35.14 \,\|(25.97 + 50))$$
$$ZIN = 25.97 + (35.14 \,\| 75.97)$$
$$ZIN = 25.97 + 24.03 = 50$$

This shows us that we see 50 Ω looking right into the example attenuator (Figure below) with a 50 Ω load.Replacing the source generator, disconnecting load Z at VO, and looking in to the left, should give us the same equation as above for the impedance at VO, due to symmetry. Moreover, the three resistors must be values which supply the required attenuation from input to output. This is accomplished by the equations for R1 and R2 above as applied to the T-attenuator below.

T attenuator

10 dB attenuators for matching input/output to Z= 50 Ω.

10 dB T-section attenuator for insertion between a 50 Ω source and load.

PI-section attenuator

The table in Figure below lists resistor values for the Π attenuator matching a 50 Ω source/ load at some common attenuation levels. The resistors corresponding to other attenuation levels may be calculated from the equations.

dB = attenuation in decibels
Z = source/load impedance (resistive)
K > 1

$$K = \frac{V_I}{V_O} = 10^{dB/20}$$

$$R_3 = Z\left(\frac{K^2-1}{2K}\right)$$

$$R_4 = Z\left(\frac{K+1}{K-1}\right)$$

Π attenuator

Resistors for Π-section			
Z=50.00			
Attenuation			
dB	K=Vi/Vo	R3	R4
1.0	1.12	5.77	869.55
2.0	1.26	11.61	436.21
3.0	1.41	17.61	292.40
4.0	1.58	23.85	220.97
6.0	2.00	37.35	150.48
10.0	3.16	71.15	96.25
20.0	10.00	247.50	61.11

Formulas for Π-section attenuator resistors, given K, the voltage attenuation ratio, and ZI = ZO = 50 Ω.

What resistor values would be required for both the Π attenuators for 10 dB of attenuation matching a 50 Ω source and load?

Π attenuator

10 dB Π-section attenuator example for matching a 50 Ω source and load.
The 10 dB corresponds to a voltage attenuation ratio of K=3.16 in the next to last line of the above table. Transfer the resistor values in that line to the resistors on the schematic diagram in Figure above.

Observations :
Value of K in T-type attenuator =…………………
Value of K in π-type attenuator=………………….

Result: We have attenuated the signal using T-type and π-Type power attenuator

Experiment 2

Demonstrate the Characteristics of low pass filter using RF analyzer and measure S11 (return loss) and S21 (insertion loss).

THEORY:

REQUIRED TRAINERS AND APPRATUS: MOTECH RF2000 Trainer, connecting cables etc.

LOW PASS FILTER:

Low Pass filters are filters that allow the passage of low frequency signals and attenuate high frequency signals.

How is this possible?

A first order low pass filter consists of an inductor in series with the load resistor or a capacitor in parallel with the load resistor.

Inductive Model of a First Order Low Pass Filter

As the frequency at the input increases, the impedance of the inductor increases. Hence, the high frequency signals do not pass through the inductor onto the load. However, the low frequency signals pass through.
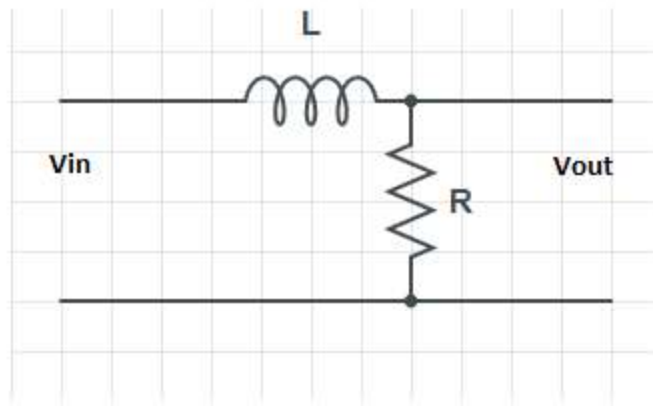
$$Transfer\ Function: H(jw) = \frac{R}{(jwL) + R}$$

$$Phase\ Of\ Transfer\ Function = -\tan^{-1}(wL/R)$$

Capacitive Model of a First Order Low PassFilter

As the frequency at the input increases, the impedance of the capacitor decreases. Hence, the high frequency signals go through the capacitor and most of the voltage is dropped across the load.

$$Transfer\ Function:\ H(jw) = \frac{1/(jwC)}{R + (1/jwC)}$$

$$Phase\ of\ Transfer\ Function = -tan^{-1}(wRC)$$
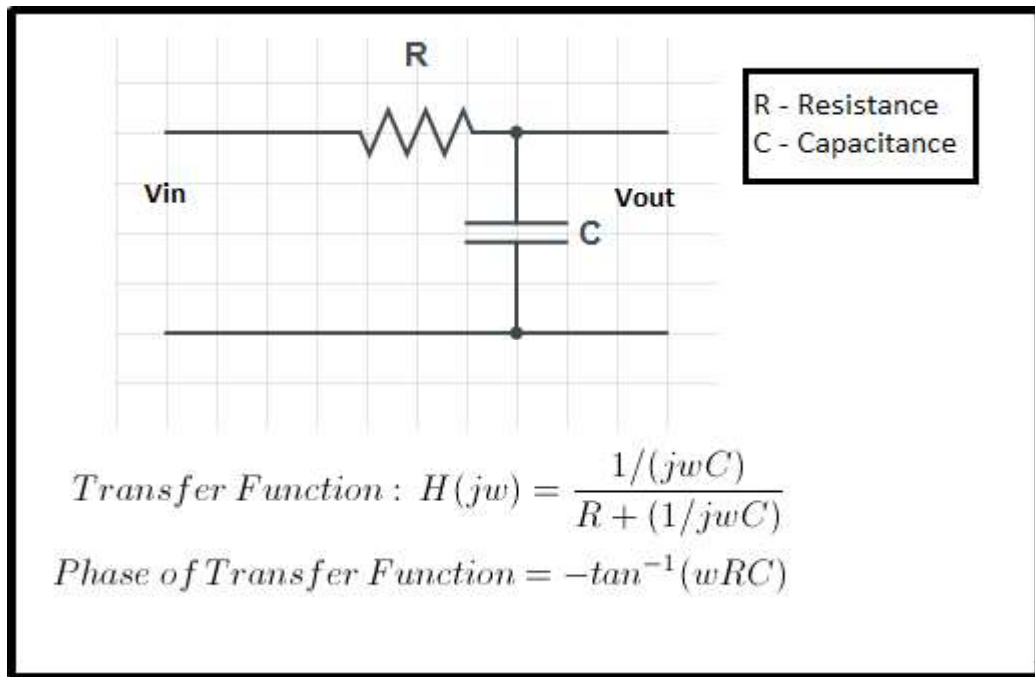
A second order low pass filter blocks high pass frequencies more effectively due tothe presence of energy storing elements (capacitor andinductor).
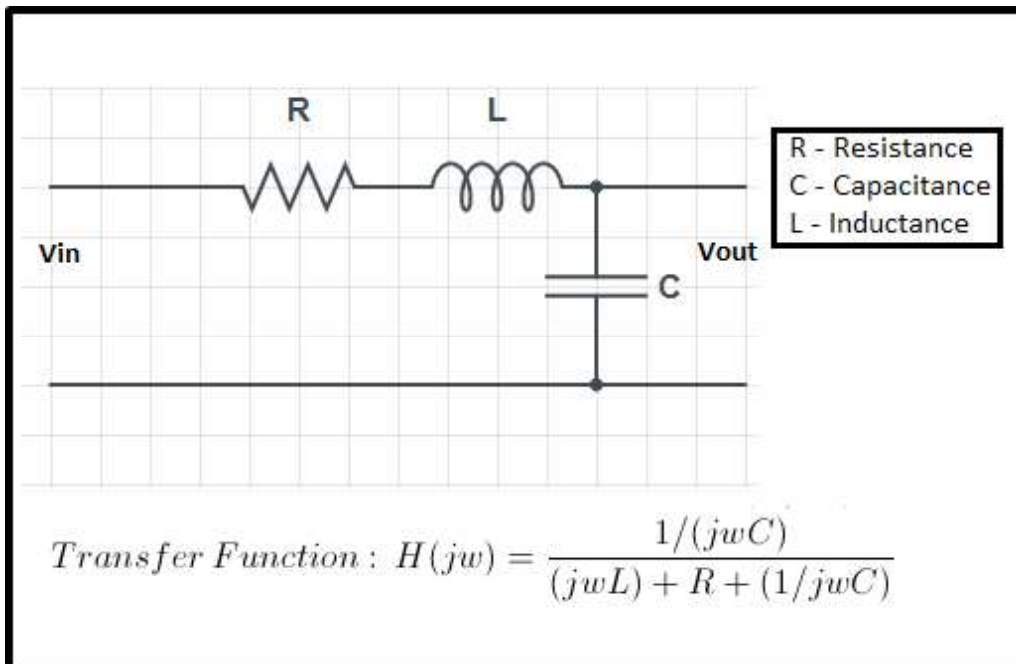
Cut off Frequency

This is the frequency at which the magnitude of the transfer function is 0.707 which is $1/\sqrt{2}$

Procedure:
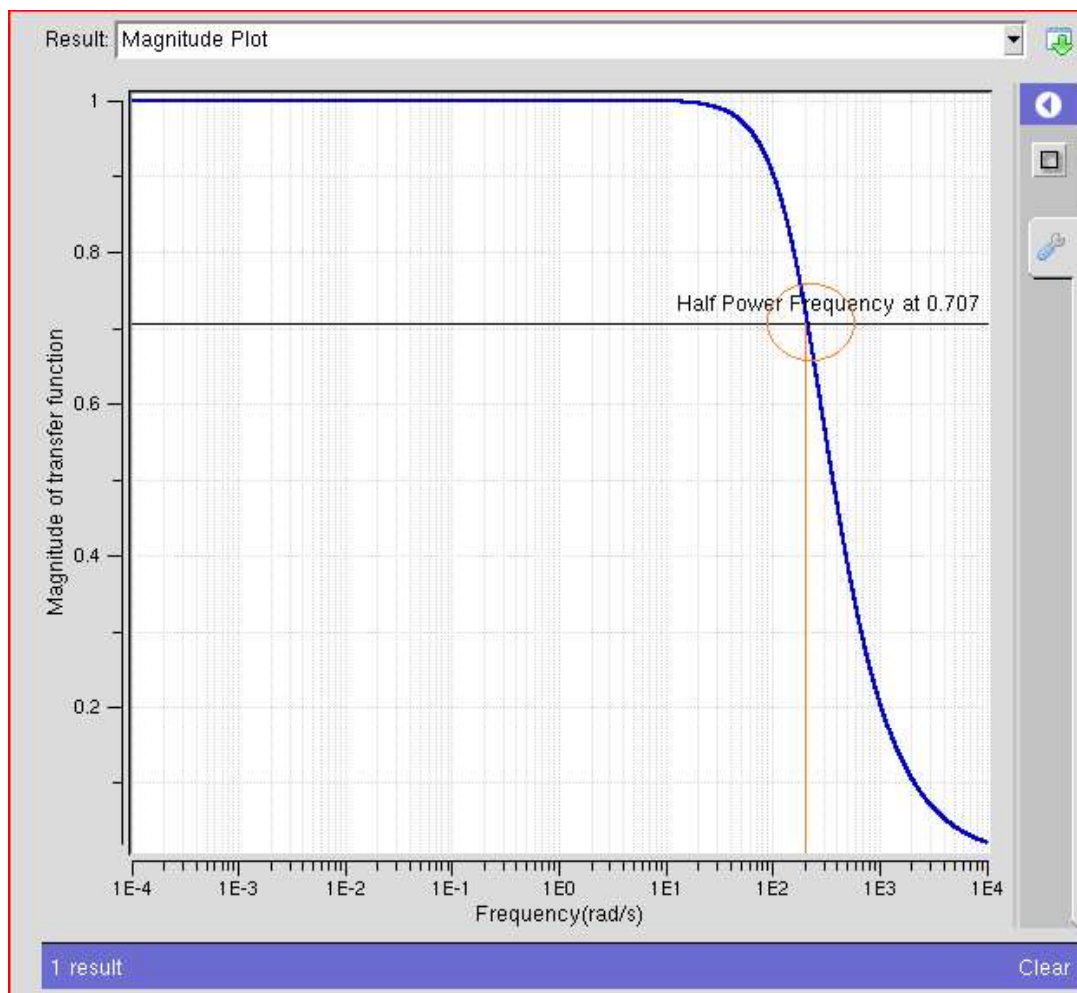
step	Name	Description
1	Equipment preparation	I. Connect oscilloscope to RF-2000 II. Set oscilloscope CH1 and CH2 ground to line 9 and set voltage scale for CH1 and CH2 then set both of them to dc couple. III. Set oscilloscope to x-y mode without module connected.
2	Power on	Press RF − 2000 power on/off switch
3	Select measurement frequency band	Press RF − 2000 BAND switch to select the measurement frequency band.
4	Set frequency range	I. Press FREQ to select start. II. Use up and down switch to select the start measurement frequency.

		III.	Press FREQ to select stop.
		IV.	Use up and down switch to select the stop measurement frequency
5	Set frequency mark	I.	Press FREQ to select mark.
		II.	Use up and down switch to select the mark measurement frequency.
6	Set swap frequency mode	Press SWEEP/CW1 to select the sweep mode.	
7	S_{11} measurement return loss	I.	Press S11/S22 to select the return loss or insertion loss.
		II.	Connect CH on-1 adaptor RF – 2000 SWEEP|CW| out terminator and CA-1 to RF – in .

Observation table: -

1) Measurement of S_{11}(return loss)

Frequency (Mhz)	Power loss

2) Measurement of S_{21}(insertion loss)

Frequency (Mhz)	Power loss

Experiment 3

Demonstrate the Characteristics of band pass filter using RF analyzer and measure S11 (return loss) and S21 (insertion loss).

Theory:

REQUIRED TRAINERS AND APPRATUS: MOTECH RF2000 Trainer, connecting cables etc.

Band Pass Filter

A band-pass filter is a circuit which is designed to pass signals only in a certain band of frequencies wh
attenuating all signals outside this band. The parameters of importance in a bandpass filter are the high a
low cut-off frequencies (fH and fl), the bandwidth (BW), the centre frequency fc, centre- frequency gain, a
the selectivity or Q. There are basically two types of bandpass filters viz wide bandpass and narrow bandp
filters. Unfortunately, there is no set dividing line between the two. However, a bandpass filter is defined a
wide bandpass if its figure of merit or quality factor Q is less than 10 while the bandpass filters with Q >
are called the narrow bandpass filters. Thus Q is a measure of selectivity, meaning the higher the value of
the more selective is the filter, or the narrower is the bandwidth (BW). For a wide bandpass filter the cer
frequency can be defined as where fH and fL are respectively the high and low cut-off frequencies in Hz.I
narrow bandpass filter, the output voltage peaks at the center frequency fc.

Wide Bandpass Filter:

Circuit Diagram

Wide Band Pass Filter

www.CircuitsToday.com

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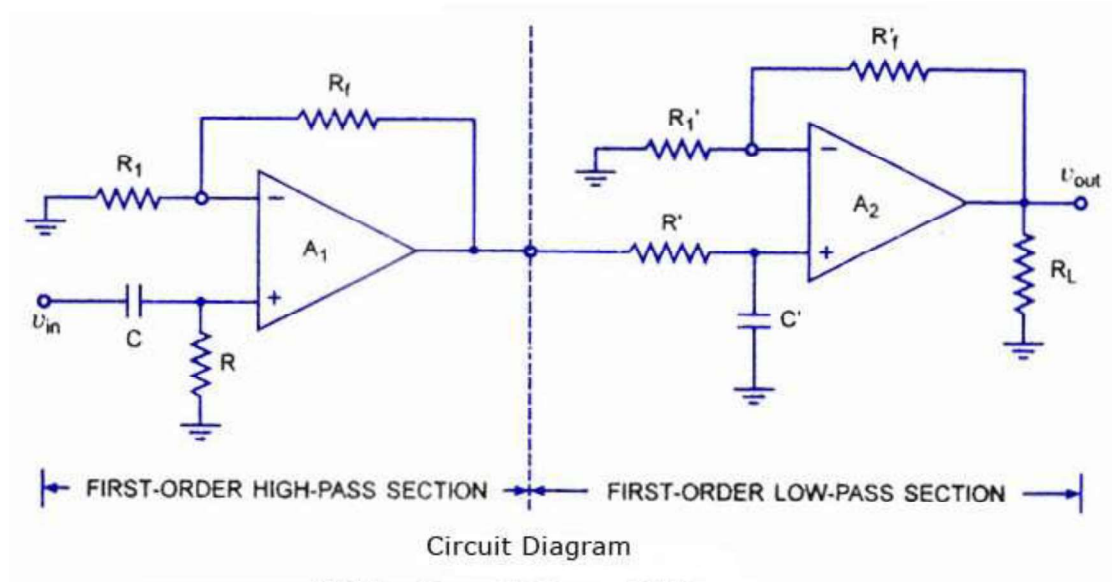
A wide bandpass filter can be formed by simply cascading high-pass and low-pass sections and is gener the choice for simplicity of design and performance though such a circuit can be realized by a numbe possible circuits. To form a ± 20 db/ decade bandpass filter, a first-order high-pass and a first-order low-p sections are cascaded; for a ± 40 db/decade bandpass filter, second-order high- pass filter and a second-o low-pass filter are connected in series, and so on. It means that, the order of the bandpass filter is gover by the order of the high-pass and low-pass filters. A ± 20 db/decade wide bandpass filter composed of a f
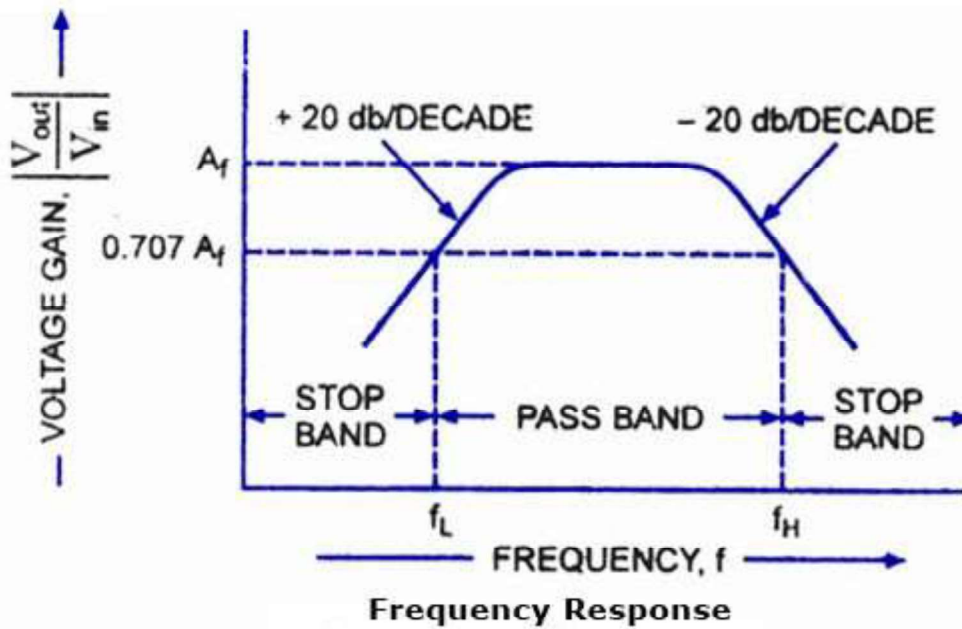
Frequency Response wide bandpass filter

order high-pass filter and a first-order low-pass filter, is illustrated in fig. (a). Its frequency respons illustrated in fig. (b).

PROCEDURE:-

Step	Name	Description
1	Equipment preparation	Connect oscilloscope to RF-2000 Set oscilloscope CH1 and CH2 ground to line 9 and set voltage scale for CH1 and CH2 then set both of them to dc couple. Set oscilloscope to x-y mode without module connected.
2	Power on	Press RF – 2000 power on/off switch
3	Select measurement frequency band	Press RF – 2000 BAND switch to select the measurement frequency band.

4	Set frequency range	Press FREQ to select start. Use up and down switch to select the start measurement frequency. Press FREQ to select stop. Use up and down switch to select the stop measurement frequency
5	Set frequency mark	Press FREQ to select mark. Use up and down switch to select the mark measurement frequency.
6	Set swap frequency mode	Press SWEEP/CW1 to select the sweep mode.
7	S11 measurement return loss	Press S11/S22 to select the return loss or insertion loss. Connect CH on-1 adaptor RF – 2000 SWEEP|CW| out terminator and CA-1 to RF – in .

OBSERVATIONS:-

1) Measurement of S11(return loss)

Frequency (Mhz)	Power loss

2) Measurement of S21(insertion loss)

Frequency (Mhz)	Power loss

.

RESULT: We have drawn the characteristics of band pass filter using MOTECH RF2000.

Experiment 4

Design open and short transmission line using RF analyzer and measure S11 (return loss) and S21 (insertion loss).

Theory:

TransmissionLine

- Transmission lines are used in power distribution (at low frequencies), and in communications (at hi[g]h frequencies).

- A transmission line consists of two or more parallel conductors used to connect a source to a load., t[he] source may be a generator, a transmitter, or an oscillator and the load may be a factory, an antenna, or [an] oscilloscope, respectively.

- Transmission lines include coaxial cable, a two wire line, a parallel plate or planar line, a wire abo[ve] the conducting plane, and a micro-strip line

- Cross sectional views of these lines consists of two conductors in figure
,each of these lines consists of two conductors in parallel

- Coaxial cables are used in electrical laboratories and in connecting T.V sets to T.V antennas

- Micro-strip lines are important in integrated circuits where metallic strips connecting electron[ic] elements are deposited on dielectric substrates.

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There are different types of modes propagator between the two conductors of transmission line as:

- TE, transverse electric, i.e. $EZ \neq 0, HZ \square 0$
- TM, transverse magnetic, i.e. $HZ \neq 0, EZ \square 0$
- TEM, transverse electro-magnetic i.e. $HZ \square EZ \square 0$
- Propagate in Z-direction, HZ , EZ

transmission line problems are usually solved using EM field theory and electric theory, the two maj
theories on which electrical engineering is based, we use circuit theory because it is easier to deal wi
mathematics. Our analysis of transmission lines will include the derivation of transmission line equatio
and characteristic quantities, the use of Smith chart, various practical applications of transmission lines, a
transients on transmission lines.
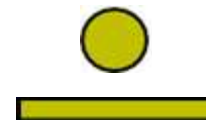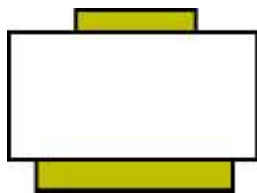
Cross sectional view of transmission lines
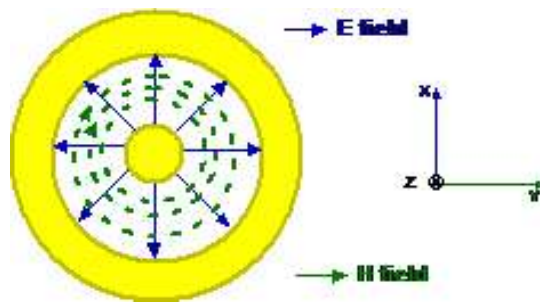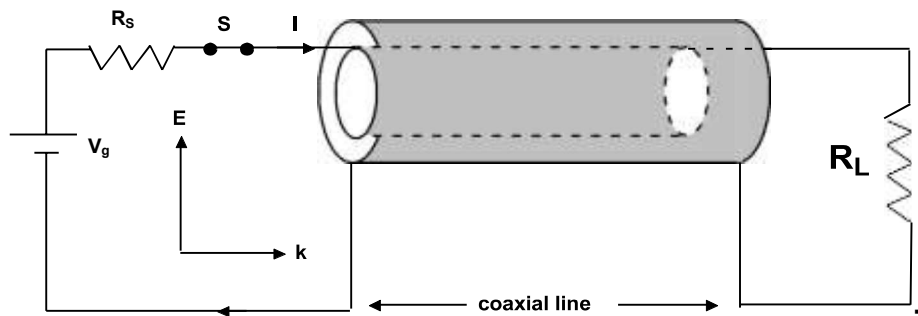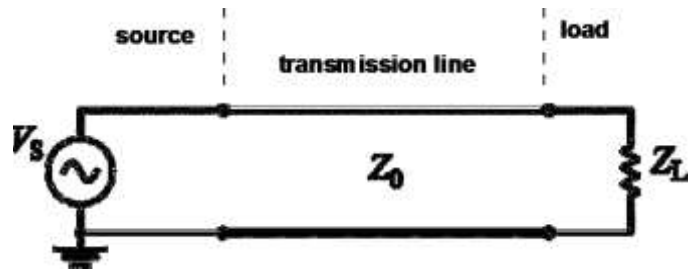
PROCEDURE:

step	Name	Description
1	Equipment preparation	VII. Connect oscilloscope to RF-2000

		VIII. Set oscilloscope CH1 and CH2 ground to line 9 and set voltage scale for CH1 and CH2 then set both of them to dc couple. IX. Set oscilloscope to x-y mode without module connected.
2	Power on	Press RF – 2000 power on/off switch
3	Select measurement frequency band	Press RF – 2000 BAND switch to select the measurement frequency band.
4	Set frequency range	IX. Press FREQ to select start. X. Use up and down switch to select the start measurement frequency. XI. Press FREQ to select stop. XII. Use up and down switch to select the stop measurement frequency
5	Set frequency mark	V. Press FREQ to select mark. VI. Use up and down switch to select the mark measurement frequency.
6	Set swap frequency mode	Press SWEEP/CW1 to select the sweep mode.
7	S_{11} measurement return loss	V. Press S11/S22 to select the return loss or insertion loss. VI. Connect CH on-1 adaptor RF – 2000 SWEEP|CW| out terminator and CA-1 to RF – in .

OBSERVATIONS:

1) **Measurement of S_{11}(return loss)**

Frequency (Mhz)	Power loss

2) **Measurement of S_{21}(insertion loss)**

Frequency (Mhz)	Power loss

RESULT: We have designed the open and short transmission line using MOTECH RF2000.

Experiment 5

Design thru transmission line using RF analyzer and measure S11 (return loss) and S21 (insertion loss).

THEORY:

Apparatus and trainers required: MOTECH RF2000, connecting cables etc.

Transmission Line.

- Transmission lines are used in power distribution (at low frequencies), and in communications (at high frequencies).
- A transmission line consists of two or more parallel conductors used to connect a source to a load., the source may be a generator, a transmitter, or an oscillator and the load may be a factory, an antenna, or an oscilloscope, respectively.
- Transmission lines include coaxial cable, a two wire line, a parallel plate or planar line, a wire above the conducting plane, and a micro-strip line
- Cross sectional views of these lines consists of two conductors in figure
,each of these lines consists of two conductors in parallel
- Coaxial cables are used in electrical laboratories and in connecting T.V sets to T.V antennas
- Micro-strip lines are important in integrated circuits where metallic strips connecting electronic elements are deposited on dielectric substrates.

There are different types of modes propagatr between the two conductorsof transmission line as:

- TE, transverse electric,   i.e. $EZ \neq 0, HZ \neq 0$
- TM, transverse magnetic,   i.e. $HZ \neq 0, EZ \neq 0$
- TEM, transverse electro-magnetic   i.e. $HZ \neq EZ \neq 0$
- Propagate in Z-direction, HZ, EZ

PROCEDURE:

step	Name	Description
1	Equipment preparation	X. Connect oscilloscope to RF-2000 XI. Set oscilloscope CH1 and CH2 ground to line 9 and set voltage scale for CH1 and CH2 then set both of them to dc couple. XII. Set oscilloscope to x-y mode without module connected.
2	Power on	Press RF – 2000 power on/off switch
3	Select measurement frequency band	Press RF – 2000 BAND switch to select the measurement frequency band.
4	Set frequency range	XIII. Press FREQ to select start. XIV. Use up and down switch to select the start measurement frequency. XV. Press FREQ to select stop. XVI. Use up and down switch to select the stop measurement frequency
5	Set frequency mark	VII. Press FREQ to select mark. VIII. Use up and down switch to select the mark measurement frequency.
6	Set swap frequency mode	Press SWEEP/CW1 to select the sweep mode.
7	S11 measurement return loss	VII. Press S11/S22 to select the return loss or insertion loss. VIII. Connect CH on-1 adaptor RF – 2000 SWEEP|CW| out terminator and CA-1 to RF – in .

OBSERVATIONS:

3) Measurement of S11(return loss)

Frequency (Mhz)	Power loss

4) Measurement of S21(insertion loss)

Frequency (Mhz)	Power loss

RESULT: We have designed the thru transmission line using MOTECH RF2000.

Experiment :-6

To design the T-type impedance matched transformer using RF analyzer and measure s11 (Return loss)and s21(Insertion loss).

Appratus and trainers required:MOTECH RF2000,connecting cables etc.
Theory:
T-Type impedance transformer:

The T-match impedance matching circuit is one of the circuits used to match the impedance between two points, usually a source and a load. The circuit got its name because the inductor and the capacitor form a T-shape as shown in the schematic diagram below. You can either pass or block DC current depending on the placement of the inductors and capacitors. The circuit below is a pass dc current circuit. Interchange the inductors and the capacitor and you have a block DC current circuit.

Applications
Impedance matching is important in electrical engineering because it allows for maximum power transfer between two points. In telephone systems, for example, minimizing echo on long-distance lines is achieved using match impedances. The

telephone hybrid coil, where two wires are converted into four wires can also be achieved via matching.

In audio amplifiers, impedances are not matched as it is typical for amplifiers to have output impedances that is lower than the load impedance for better speaker damping. But for higher-power amplifiers, such as those that use vacuum tubes, impedance-changing circuits are used to get a low output impedance in order to better match the amplifier's performance to the load impedance.

PROCEDURE:-

step	Name	Description
1	Equipment preparation	Connect oscilloscope to RF-2000 Set oscilloscope CH1 and CH2 ground to line 9 and set voltage scale for CH1 and CH2 then set both of them to dc couple. Set oscilloscope to x-y mode without module connected.
2	Power on	Press RF – 2000 power on/off switch
3	Select measurement frequency band	Press RF – 2000 BAND switch to select the measurement frequency band.
4	Set frequency range	Press FREQ to select start. Use up and down switch to select the start measurement frequency. Press FREQ to select stop. Use up and down switch to select the stop measurement frequency
5	Set frequency mark	Press FREQ to select mark. Use up and down switch to select the mark measurement frequency.
6	Set swap frequency mode	Press SWEEP/CW1 to select the sweep mode.
7	S11 measurement return loss	Press S11/S22 to select the return loss or insertion loss. Connect CH on-1 adaptor RF – 2000 SWEEP|CW| out terminator and CA-1 to RF – in .

OBSERVATIONS:-

Measurement of S11(return loss)

Frequency (Mhz)	Power loss

Measurement of S21(insertion loss)

Frequency (Mhz)	Power loss

.

RESULT:- We have drawn the characteristics of T-Type impedance matched transformer using MOTECH RF2000.

EXPERIMENT :7

To design the π-type impedance matched transformer using RF analyzer and measure s11 (Return loss)and s21(Insertion loss).

Appratus and trainers required: MOTECH RF2000, connecting cables etc.
Theory: **Π-Type impedance matched transformer:**

The Pi match impedance matching circuit is used to match the impedance between two points, usually a source and a load. The circuit got its name because the inductor and the capacitor form a Pi symbol (see schematic below).

This calculator will help you determine the correct values for the inductor and capacitor in a Pi match impedance matching circuit. The required parameters are the signal (or source) frequency, the impedance of the source and the impedance of the load. You can also specify if the circuit will pass or block the direct current (DC). The inductor quality factor is also computed.
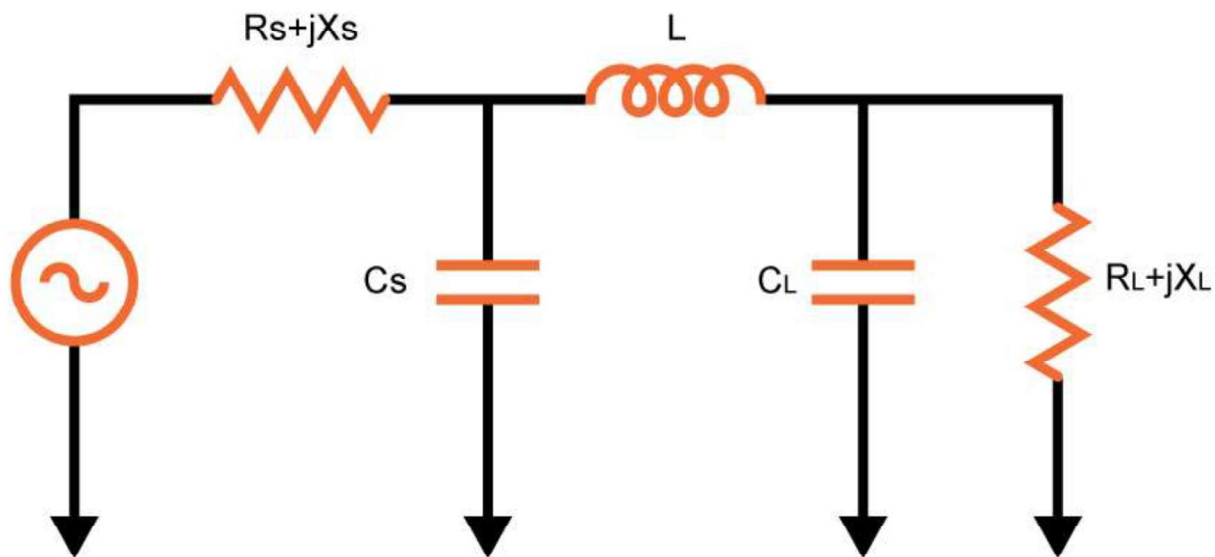
Equations

For Pass DC Current:

$$Zinput=\{[(RL+jXL)//(1j\omega\cdot CL)]+j\omega\cdot L\}//(1j\cdot\omega\cdot Cs)Zinput=\{[(RL+jXL)//(1j\omega\cdot CL)]+j\omega\cdot L\}//(1j\cdot\omega\cdot Cs)$$

For Block DC Current:

$$Zinput=\{[(RL+jXL)//(j\omega\cdot LL)]+1j\omega\cdot C\}//(j\omega\cdot Ls)Zinput=\{[(RL+jXL)//(j\omega\cdot LL)]+1j\omega\cdot C\}//(j\omega\cdot Ls)$$

Applications

Impedance matching is important in electrical engineering because it allows for maximum power transfer between two points. In telephone systems, for example, minimizing echo on long-distance lines is achieved using match impedances. The telephone hybrid coil, where two wires are converted into four wires can also be achieved via matching.

In audio amplifiers, impedances are not matched as it is typical for amplifiers to have output impedances that is lower than the load impedance for better speaker damping. But for higher-power amplifiers, such as those that use vacuum tubes, impedance-changing circuits are used to get a low output impedance in order to better match the amplifier's performance to the load impedance.

PROCEDURE:-

step	Name	Description
1	Equipment preparation	XIII. Connect oscilloscope to RF-2000 XIV. Set oscilloscope CH1 and CH2 ground to line 9 and set voltage scale for CH1 and CH2 then set both of them to dc couple. XV. Set oscilloscope to x-y mode without module connected.
2	Power on	Press RF – 2000 power on/off switch
3	Select measurement frequency band	Press RF – 2000 BAND switch to select the measurement frequency band.
4	Set frequency range	VII. Press FREQ to select start. VIII. Use up and down switch to select the start measurement frequency. XIX. Press FREQ to select stop. XX. Use up and down switch to select the stop measurement frequency
5	Set frequency mark	IX. Press FREQ to select mark. X. Use up and down switch to select the mark measurement frequency.
6	Set swap frequency mode	Press SWEEP/CW1 to select the sweep mode.
7	S11 measurement return loss	IX. Press S11/S22 to select the return loss or insertion loss. X. Connect CH on-1 adaptor RF – 2000 SWEEP|CW| out terminator and CA-1 to RF – in .

OBSERVATIONS:-

3) Measurement of S11(return loss)

Frequency (Mhz)	Power loss

4) Measurement of S21(insertion loss)

Frequency (Mhz)	Power loss

.

RESULT:- We have drawn the characteristics of π-Type Impedance transformer using MOTECH RF2000.

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Experiment:-8

To design the T-type Power attenuator using RF analyzer and measure s11 (Return loss)and s21(Insertion loss)

Appratus and trainers required:MOTECH RF2000,connecting cables etc.
Theory:
T-Type Power Attenuator:

The T and Π attenuators must be connected to a Z source and Z load impedance. The Z-(arrows) pointing away from the attenuator in the figure below indicate this. The Z-(arrows) pointing toward the attenuator indicates that the impedance seen looking into the attenuator with a load Z on the opposite end is Z, Z=50 Ω for our case. This impedance is a constant (50 Ω) with respect to attenuation– impedance does not change when attenuation is changed.

The table in Figure below lists resistor values for the T and Π attenuators to match a 50 Ω source/ load, as is the usual requirement in radio frequency work.

Telephone utility and other audio work often requires matching to 600 Ω. Multiply all R values by the ratio (600/50) to correct for 600 Ω matching. Multiplying by 75/50 would convert table values to match a 75 Ω source and load.

dB = attenuation in decibels

Z = source/load impedance (resistive)

K > 1

$$K = \frac{V_I}{V_O} = 10^{dB/20}$$

$$R_1 = Z\left(\frac{K-1}{K+1}\right)$$

$$R_2 = Z\left(\frac{2K}{K^2-1}\right)$$

T attenuator

Resistors for T-section			
Z = 50			
Attenuation			
dB	K=Vi/Vo	R1	R2
1.0	1.12	2.88	433.34
2.0	1.26	5.73	215.24
3.0	1.41	8.55	141.93
4.0	1.58	11.31	104.83
6.0	2.00	16.61	66.93
10.0	3.16	25.97	35.14
20.0	10.00	40.91	10.10

Formulas for T-section attenuator resistors, given K, the voltage attenuation ratio, and ZI = ZO = 50 Ω.

The amount of attenuation is customarily specified in dB (decibels). Though, we need the voltage (or current) ratio K to find the resistor values from equations. See the dB/20 term in the power of 10 term for computing the voltage ratio K from dB, above.

Hi

The T (and below Π) configurations are most commonly used as they provide bidirectional matching. That is, the attenuator input and output may be swapped end for end and still match the source and load impedances while supplying the same attenuation.

Disconnecting the source and looking in to the right at VI, we need to see a series parallel combination of R1, R2, R1, and Z looking like an equivalent resistance of ZIN, the same as the source/load impedance Z: (a load of Z is connected to the output.)

ZIN = R1 + (R2 ||(R1 + Z))

For example, substitute the 10 dB values from the 50 Ω attenuator table for R1 and R2 as shown in Figure below.

ZIN = 25.97 + (35.14 ||(25.97 + 50))

ZIN = 25.97 + (35.14 || 75.97)

ZIN = 25.97 + 24.03 = 50

This shows us that we see 50 Ω looking right into the example attenuator (Figure below) with a 50 Ω load.

Replacing the source generator, disconnecting load Z at VO, and looking in to the left, should give us the same equation as above for the impedance at VO, due to symmetry. Moreover, the three resistors must be values which supply the required attenuation from input to output. This is accomplished by the equations for R1 and R2 above as applied to the T-attenuator below.

T attenuator

10 dB attenuators for matching input/output to Z= 50 Ω.

10 dB T-section attenuator for insertion between a 50 Ω source and load.

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PROCEDURE:-

step	Name	Description
1	Equipment preparation	XVI. Connect oscilloscope to RF-2000 VII. Set oscilloscope CH1 and CH2 ground to line 9 and set voltage scale for CH1 and CH2 then set both of them to dc couple. VIII. Set oscilloscope to x-y mode without module connected.
2	Power on	Press RF – 2000 power on/off switch
3	Select measurement frequency band	Press RF – 2000 BAND switch to select the measurement frequency band.
4	Set frequency range	XXI. Press FREQ to select start. XII. Use up and down switch to select the start measurement frequency. XIII. Press FREQ to select stop. XIV. Use up and down switch to select the stop measurement frequency
5	Set frequency mark	XI. Press FREQ to select mark. XII. Use up and down switch to select the mark measurement frequency.
6	Set swap frequency mode	Press SWEEP/CW1 to select the sweep mode.
7	S11 measurement return loss	XI. Press S11/S22 to select the return loss or insertion loss. XII. Connect CH on-1 adaptor RF – 2000 SWEEP|CW| out terminator and CA-1 to RF – in .

OBSERVATIONS:-

5) Measurement of S11(return loss)

Frequency (Mhz)	Power loss

6) Measurement of S21(insertion loss)

Frequency (Mhz)	Power loss

.

RESULT:- We have drawn the characteristics of T-type power attenuator using MOTECH RF2000.

Experiment:9

To design the T-type Power attenuator using RF analyzer and measure s11 (Return loss)and s21(Insertion loss)

Appratus and trainers required: MOTECH RF2000,connecting cables etc.

Theory:

PI-section attenuator

The table in Figure below lists resistor values for the Π attenuator matching -a 50 Ω source/ load at some common attenuation levels. The resistors corresponding to other attenuation levels may be calculated from the equations.

dB = attenuation in decibels
Z = source/load impedance (resistive)
K > 1

$$K = \frac{V_I}{V_O} = 10^{dB/20}$$

$$R_3 = Z\left(\frac{K^2-1}{2K}\right)$$

$$R_4 = Z\left(\frac{K+1}{K-1}\right)$$

Π attenuator

Resistors for Π-section Z=50.00			
Attenuation			
dB	K=Vi/Vo	R3	R4
1.0	1.12	5.77	869.55
2.0	1.26	11.61	436.21
3.0	1.41	17.61	292.40
4.0	1.58	23.85	220.97
6.0	2.00	37.35	150.48
10.0	3.16	71.15	96.25
20.0	10.00	247.50	61.11

Formulas for Π-section attenuator resistors, given K, the voltage attenuation ratio, and ZI = ZO = 50 Ω.

The above apply to the π-attenuator below.

What resistor values would be required for both the Π attenuators for 10 dB of attenuation matching a 50 Ω source and load?

$R_3=71.2$

$R_4= 96.2$

Π attenuator

10 dB Π-section attenuator example for matching a 50 Ω source and load.

65
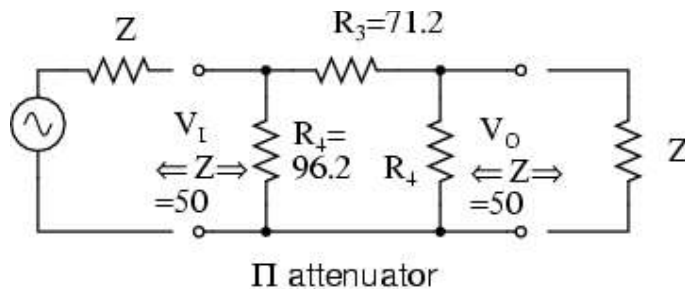
The 10 dB corresponds to a voltage attenuation ratio of K=3.16 in the next to last line of the above table. Transfer the resistor values in that line to the resistors on the schematic diagram in Figure above.

PROCEDURE:

step	Name	Description
1	Equipment preparation	XIX. Connect oscilloscope to RF-2000 XX. Set oscilloscope CH1 and CH2 ground to line 9 and set voltage scale for CH1 and CH2 then set both of them to dc couple. XXI. Set oscilloscope to x-y mode without module connected.
2	Power on	Press RF – 2000 power on/off switch
3	Select measurement frequency band	Press RF – 2000 BAND switch to select the measurement frequency band.
4	Set frequency range	XV. Press FREQ to select start. XVI. Use up and down switch to select the start measurement frequency. VII. Press FREQ to select stop. VIII. Use up and down switch to select the stop measurement frequency
5	Set frequency mark	XIII. Press FREQ to select mark. XIV. Use up and down switch to select the mark measurement frequency.
6	Set swap frequency mode	Press SWEEP/CW1 to select the sweep mode.
7	S11 measurement return loss	XIII. Press S11/S22 to select the return loss or insertion loss. XIV. Connect CH on-1 adaptor RF – 2000 SWEEP|CW| out terminator and CA-1 to RF – in .

OBSERVATIONS:-

7) Measurement of S11(return loss)

Frequency (Mhz)	Power loss

8) Measurement of S21(insertion loss)

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Frequency (Mhz)	Power loss

.

RESULT:- We have drawn the characteristics of π-type power attenuator using MOTECH RF2000.

Experiment :-10

To design the BJT Amplifier using RF analyzer and measure s11 (Return loss)and s21(Insertion loss).

Appratus and trainers required: MOTECH RF2000,connecting cables etc.

Theory:
BIPOLAR JUNCTION TRANSISTOR:

A Bipolar Junction Transistor, or BJT is a three terminal device having two PN-junctions 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.
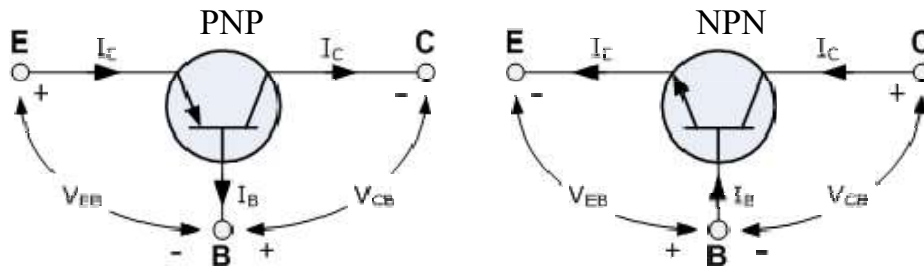
The symbols for both the NPN and PNP bipolar transistor are shown above along with the direction of conventional current flow. The direction of the arrow in the symbol shows current flow between the base and emitter terminal, pointing from the positive P-type region to the negative N-type region, exactly 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.

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Transistor Configurations

There are three possible configurations possible when a transistor is connected in a circuit: (a) Common base, (b) Common emitter (c) Common collector. We will be focusing on the first two configurations in this experiment. The behaviour of a transistor can be represented by
d.c. current-voltage (I-V) curves, called the static characteristic curves of the device. The three important characteristics of a transistor are: (i) Input characteristics, (ii) Output characteristics and (iii) Transfer Characteristics. These characteristics give information about various transistor parameters, e.g. input and out dynamic resistance, current amplification,factors, etc.

Common Base Transistor Characteristics

In common base configuration, the base is made common to both input and output as shown in its circuit diagram.

(1) Input Characteristics: The input characteristics is obtained by plotting a curve between IE and VEB keeping voltage VCB constant. This is very similar to that of a forward-biased diode and the slope of the plot at a given operating point gives information about its input dynamic resistance.

Input Dynamic Resistance (ri) This is defined as the ratio of change in base emitter voltage (ΔVEB) to the resulting change in emitter current (ΔIE) at constant collector-emitter voltage (VCB). This is dynamic as its value varies with the operating current in the transistor.

$$ri \ \square \ \frac{\Delta V_{EB}}{\Delta I_E}\bigg|_{VCB}$$

(2) Output Characteristics: The output characteristic curves are plotted between IC and VCB, keeping IE constant. The output characteristics are controlled by the input characteristics. Since IC changes with IE, there will be different output characteristics corresponding to different values of IE. These curves are almost horizontal. This shows that the output dynamic resistance, defined below, is very high.

Output Dynamic Resistance (ro): This is defined as the ratio of change in collector-base voltage (ΔVCB) to the change in collector current (ΔIC) at a constant base current IE.

$$\text{ro} \quad \Box \qquad\qquad \left.\frac{\Delta V_{CB}}{\Delta I_C}\right|$$
$$\text{IE}$$

(3) Transfer Characteristics: The transfer characteristics are plotted between the input and output currents (IE versus IC).

Current amplification factor (α)

This is defined as the ratio of the change in collector current to the change in emitter current at a constant collector-base voltage (VCB) when the transistor is in active state.

$$\Box \text{ dc } \Box \qquad\qquad \left.\frac{I_C}{I_E}\right|_{\text{VCB}}$$

Since IC increases with IE almost linearly, the values of both αdc and αac are nearly equal.

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.

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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:

$$ri \ \square \ \left. \frac{\Delta V_{BE}}{\Delta I_B} \right|_{VCE}$$

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 collector-emitter 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.

$$ro \ \square \ \left. \frac{\Delta V_{CE}}{\Delta I_C} \right|_{IB}$$

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.

Current amplification factor (β)

This is defined as the ratio of the change in collector current to the change in base current at a constant collector-emitter voltage (VCE) when the transistor is in active state.

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Since IC increases with IB almost linearly, the values of both βdc and βac are nearly equal.

Circuit components/Equipments:

(i) Transistors (2 Nos: 1 PNP (CK 100 or equivalent) and 1 NPN (BC 107 or equivalent)), (ii) Resistors (4 Nos.) (iii) Multimeters (3 Nos.), (iv) D.C. power supply, (v) Connecting wires and (vi) Breadboard.

Circuit Diagrams:
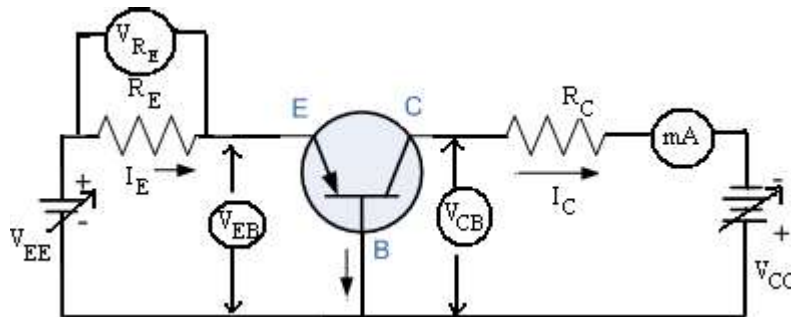
PNP transistor in CB configuration
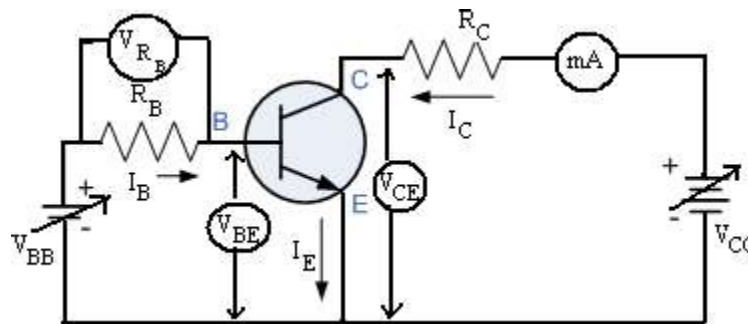
NPN transistor in CE configuration
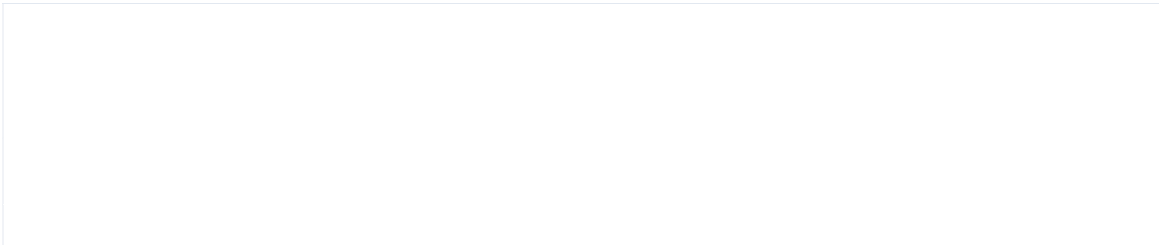
PROCEDURE:-

step	Name	Description
1	Equipment preparation	XII. Connect oscilloscope to RF-2000 XIII. Set oscilloscope CH1 and CH2 ground to line 9 and set voltage scale for CH1 and CH2 then set both of them to dc couple. XIV. Set oscilloscope to x-y mode without module connected.
2	Power on	Press RF – 2000 power on/off switch
3	Select measurement frequency band	Press RF – 2000 BAND switch to select the measurement frequency band.
4	Set frequency range	XIX. Press FREQ to select start. XX. Use up and down switch to select the start measurement frequency. XXI. Press FREQ to select stop. XII. Use up and down switch to select the stop measurement frequency
5	Set frequency mark	XV. Press FREQ to select mark. XVI. Use up and down switch to select the mark measurement frequency.
6	Set swap frequency mode	Press SWEEP/CW1 to select the sweep mode.
7	S11 measurement return loss	XV. Press S11/S22 to select the return loss or insertion loss. XVI. Connect CH on-1 adaptor RF – 2000 SWEEP|CW| out terminator and CA-1 to RF – in .

OBSERVATIONS:-

9) Measurement of S_{11}(return loss)

Frequency (Mhz)	Power loss

10)   **Measurement of S_{21}(insertion loss)**

Frequency (Mhz)	Power loss

.

RESULT:- We have drawn the characteristics of BJT amplifier using MOTECH RF2000.

Experiment 11

To measure the attenuation of transmission line at different lengths.

THEORY:

MEASURING THE ATTENUATION OF LINE: The ohmic resistance R & the conductance G are responsible for energy dissipation in the form of heat. These losses, which determine the attenuation characteristics, are expressed in terms "attenuation" "a" and can be calculatedby

$$a = 20 \log (V_2 / V_1)$$

Where   V1 = amplitude of signal at I/P V2 = amplitude of signal at

O/P a = attenuation for givenlength

In this experiment we will measure the attenuation for the different trunks of transmission line available on the trainer.
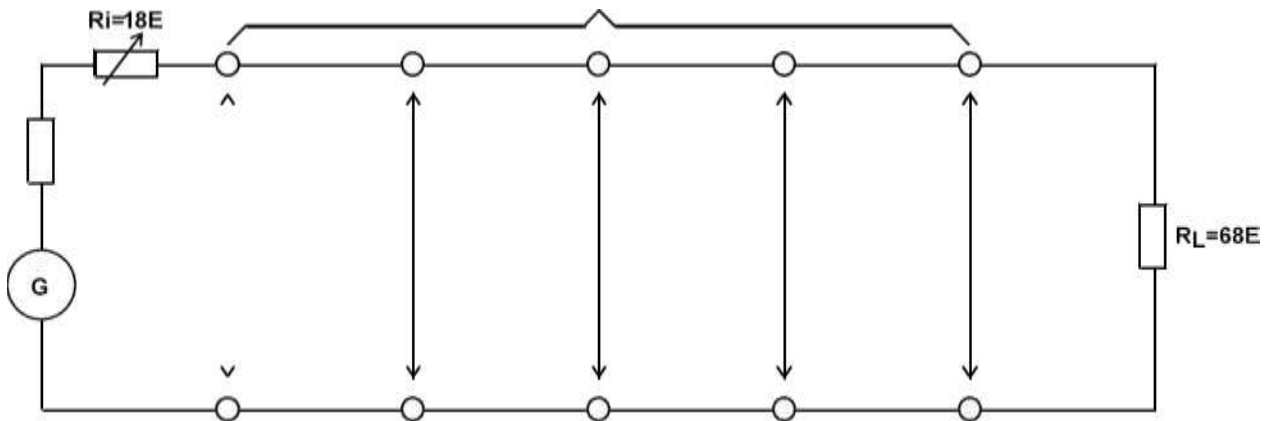
Concept of matched line:

Though the concept of match line is not treated in this manual in detail but the subject is certainly known to the students from the theoretical course. We have already found out the characteristics impedance of the line as 50E from the previous experiment. The short- circuited resistance of the line when measured with Digital Multimeter is shown to be 18E. Therefore; the total effective resistance of the line is 68E. For optimum power transfer we should have the source resistance and terminating resistance also as 68E. Assuming generator resistance R_g as 50E we must connect 18E Ri in series with the generator to match the line. For this purpose, it is recommended that the student must set Ri to 18E using DMM and RL to 68E initially and this setting should be utilized for all the experiments wherever terminated line experiment is done.

PROCEDURE:
- Adjust Ri and R_L for 18E and 68E respectively with the help of DMM.
- Make connections as shown in Diagram
- Set the sine-wave frequency to approx. 100 KHz and level to 0.4Vpp
- Oscilloscope ch I shows applied input ch II shows outputs
- Measure signal level at Input, and at 25, 50, 75 and 100mlengths.
- Tabulate asunder

25		
50		
75		
100		

- Now, calculate the attenuations in dB at various lengths by the formula givenbelow
  a = 20 Log V2/V1 08
  The attenuation is approx. -2dB at 100m
- Try the same with open-ended line and short-endedline.
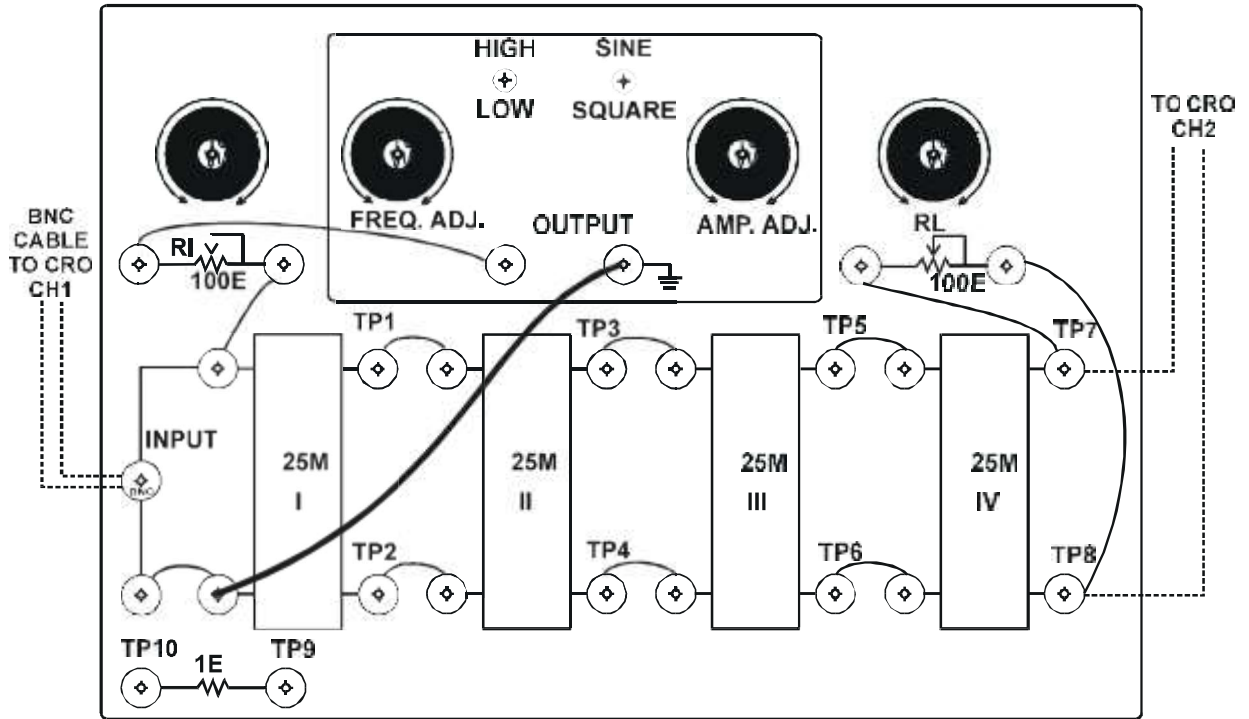
RESULT: We have calculated the attenuation of transmission line at different lengths.

Experiment 12
To measure the input impedance of transmission line at different lengths.

THEORY:

Measuring the Input impedance of transmission line

The input impedance of the line depends on features like the ohmic resistance, the conductance, the inductance and the capacitance. It is also related to the resistance that loads the line at the opposite end and to both the frequency and voltage of the signal. The purpose of the first part of the test is to measure the I/P impedance of the line under different loadconditions:

- Line terminated with matched load

- Open line

- Short-circuited line

In the second part of the test we will measure the phase displacement between the I/P voltage and current, under the 3 conditions of line termination. When the modulus and the phase displacement are known the impedance vector is fully identified.
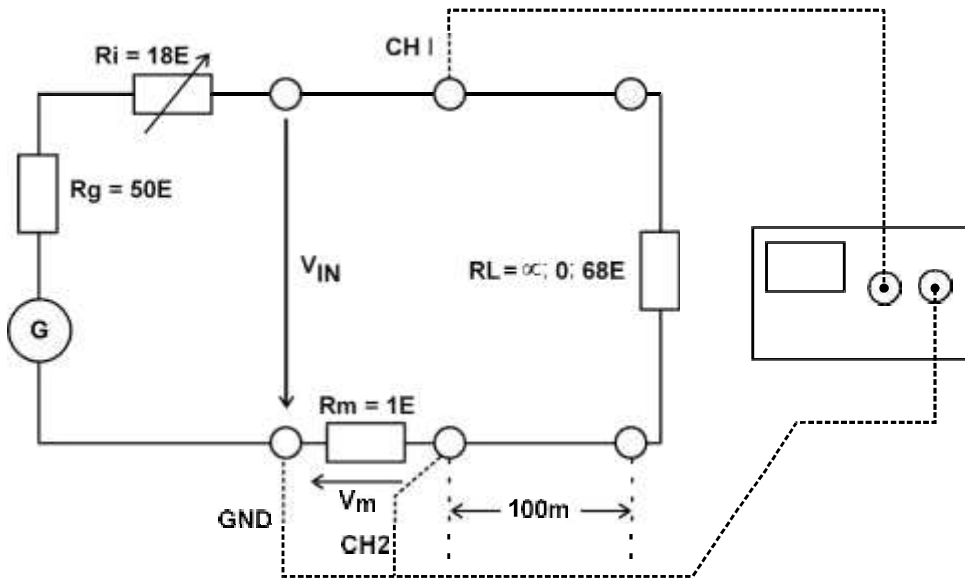
- **PROCEDURE:**

- Adjust Ri and RL for 18E and 68E respectively with the help of DMM

- Make the connections as shown in Dia

- A 1E resistance in series between the generator and the transmission line as shown in Dia. 4 allows to measure the value of I/Pcurrent.

- Set the I/P at 0.4 Vpp and freq 100 KHz of sine-wave (both measurement on CRO)

- Take readings of Vin and Vm (across 1E) onoscilloscope

- Calculate the input impedance according to the followingformula:

- Zin = Vin / I = Vin / Vm x 1E

- Change the frequency to 1 MHz and note the values of Vin and Vm at this frequency. Note down these results. The input impedance at 100 KHz is around 80E and at 1MHz is around50E

RESULT: We have calculated the input impedance of transmission line at different lengths.
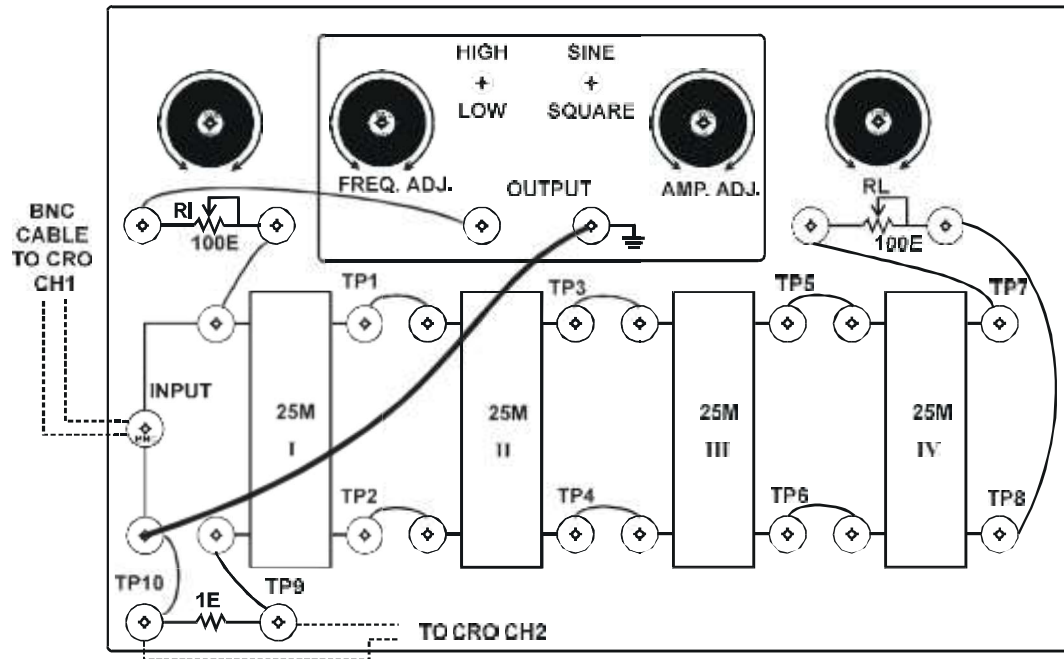
Experiment 13

Determine the stationary wave ratio at different length of transmission line.

THEORY:

STATIONARY WAVE RATIO OF TRANSMISSION LINE: A line that has not been terminated with a load equal to its characteristic impedance is subject to a reflection phenomenon of the power from the remote end. The amount of the reflected power depends on the amount of mismatch between the characteristic impedance of the line and the load impedance. In the extreme cases of short-circuited line (RL = 0) and open line (RL = □) a situation of total reflection occur for either the current wave or the voltage wave. The purpose of this test is to study the establishment of the stationary waves within the time, see Fig. 13.
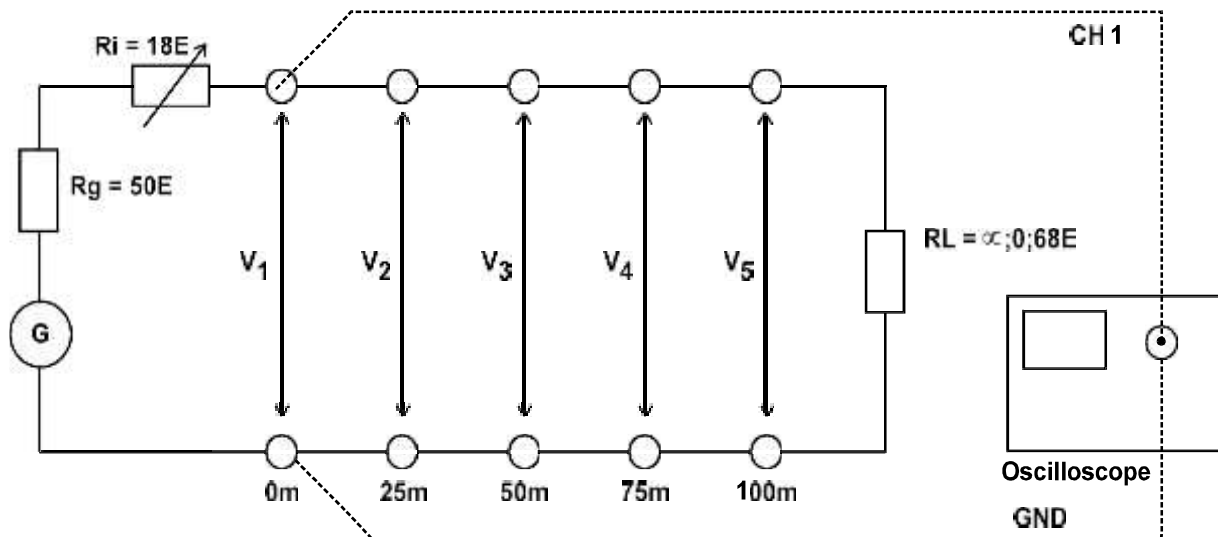
PROCEDURE

- Adjust Ri and RL for 18E and 68E respectively with the help of DMM.

- Make the connections as shown in Dia. 5

- Set oscilloscope to 0.1 V / div for bothchannels
- Adjust the sine generator for an O/P of 0.2 Vpp (2 div. Deflection on ch I) and at frequency 100KHz.

- Observe the peak to peak voltages on ch II at 100m and at intermediate sockets at 75m, 50m, 25m &0m.

Tabulate results asunder

Distance	Vpp
0m	
25m	
50m	
75m	
100m	

- Now, calculate the attenuations in dB at various lengths by the formula givenbelow

$$a = 20 \, Log \quad V_2/V_1$$

- The attenuation is approx. -2dB at 100m

- Try the same with open-ended line and short-endedline.
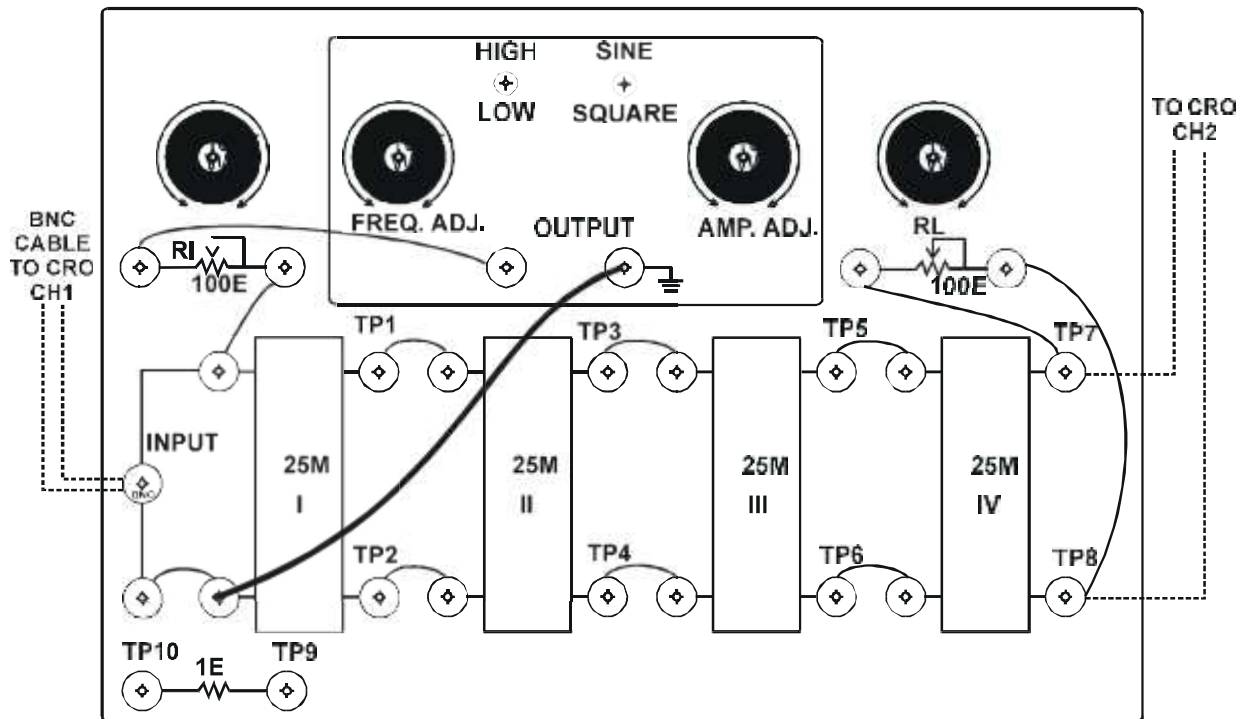
RESULT: Thus we have calculated the SWR for the different lengths of transmission line.

Experiment 14

To measure the test point voltages and Test point Waveforms of different sections of Telephone Handset instrument.

THEORY:

FEATURES:
- Key-lock
- Ringer with adjustable volume
- Tone Pulse Switchable
- Redial (can store up to 31 digits)
- Mute
- Flash
- Pause

INSTALLATION AND CONNECTION: Connect Plug of the line cord with the Telephone line through the line jack unit. Pick up the handset, keep Hook on/Off switch to Off Hook position and listen to the dial tone.

Your phone is now ready to use.

HOW TO USE TELEPHONE: This is a TONE/PULSE Switchable telephone, which can be used to access both types of exchanges i.e. Pulse dialing (Loop Signaling) and Tone dialing (DTMF signaling). The telephone can be set to either of the two signaling modes through the T/P switch. The phone is capable of switching dynamically to the Tone Mode, while operating in pulse Mode, by pressing" * " key.

LAST NUMBER REDIAL: Your phone remembers the last number dialed. Simply press the hook switch to get the dial tone followed by pressing the REDIAL key. Your number will be automatically redialed.

RINGER VOLUME CONTROL SWITCH: For a soft ring, set the switch to position M, for louder ring, set the switch to position H. For low Ringer volume, set the switch to position L.

PAUSE: Allow you to access dial toile of second exchange while redialing a number, when connected- behind an EPABX. A pause can be entered into the dialing sequence by pressing the PAUSE button.

MUTE: As long as MUTE button is kept pressed no Speech will be transmitted to the other party.

FLASH: The FLASH button can be used for call waiting. It may be used to access facilities offered by some EPABXs or Network services provided by the telephone company.

KEY-LOCK: Your phone is equipped with mechanical lock to activate/inactivate the dialing circuit. When in lock position, you will not be able to dial any number.

To measure Test Point Voltages for different sections.

Theory:

V1. Voltage Measurements:

On Hook: Line Voltage: 57 Volt DC

OFF Hook: Line Voltage: 7.4 Volt DC

V2. Dial Tone O/P Voltage In Pulse Mode: (Line O/P)

While Dialing the number: 37 Volt DC

When Not Dialing the number: 7.2 Volt DC

V3. Dial Tone O/P Voltage In Tone Mode: (Line O/P)

While Dialing the number: 7.2 Volt DC

When Not Dialing the number: 7.2 Volt DC   3

Result :-

TEST POINT WAVEFORMS FOR DIFFERENT SECTIONS

Polarity GuardSection

T1 & T2 = 58 AC Voltage on Ring Time

Ringer Section (IC2418) (Incoming Call) T3.
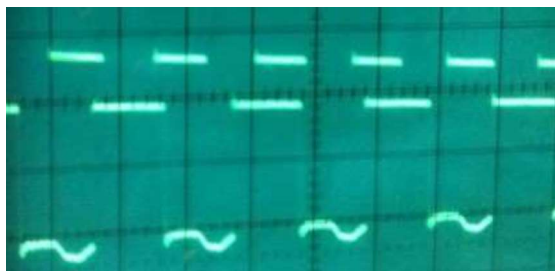
Vout = 12VPP
Freq. = 1 KHz

T4 = GND

Voltage Dropper Section T5 = OFF Hook DialTone

Speech Processing Section T6 = Speech Waveform
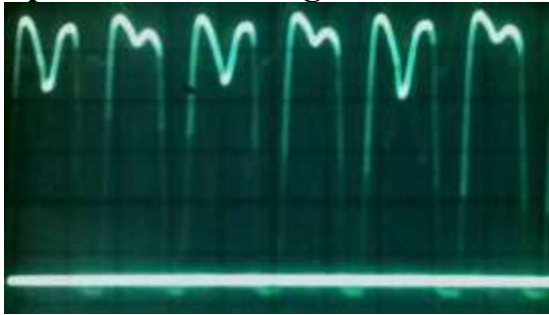
T7 = Loudspeaker O/P**T8** = MikeO/P

Dialer Section DTMF

Result: We have measured the all test point voltages and test point waveforms of different sections of telephone handset instrument.

COLLEGE OF TECHNOLGY AND ENGINEERING

MAHARANA PRATAP UNIVERSITY OF AGRICULTURE & TECHNOLGY, UDAIPUR

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

EC 227 Electronics Workshop & Practices

Lab Manual

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4	Demonstrate and perform operation of drilling on PCB.
5	Design PCB artwork for a given electronic circuit on a simulator e g. Express PCB.
6	Demonstrate PCB fabrication procedure for preparation of PCB on a PCB fabrication machine.
7	Testing of various digital and analog integrated circuits using IC tester.
8	Study of data sheet of various electronic components e.g. Transistors, diodes ,capacitors etc.
9	Demonstrate various technical faults observed and their rectification on CRO trainer kit.
10	Design a minor project of at least 20 components and demonstrate the working of same.

Experiment No. -1

Aim/Objective: Testing and identification of various electronics components using DMM and CRO.

Component Required: DMM and CRO, Resistors, capacitors, zener diodes, transistors, LEDs and connecting wire.

Theory:-In component testing process, we test the continuity and the I-V characteristics of various component like resistor, capacitor, diode and transistors.

Wires and Connectors:

We use the following wires:

i. Single Strand wire of SWG 22 or SWG23. SWG22 is preferred because it snugly fits the solder-less, spring loaded contact points in the breadboard. SNUGLY means neither loose nor tight. SWG is Standard Wire Guage. 22 means diameter $\varphi = (1/22)$ inch. These are used as hookup wire for making connections on the breadboard.
ii. Multistrand wires are flexible wires used as connecting wires between the Power supply and the bus of the circuit. Bus are lines which act as GROUND/EARTH, lines which act as (+)ve bus or as (-)ve bus. The guage of multi-strand wire can be SWG 7/36 or SWG 14/36.

SWG 14/36 means 14 strands and 1/36 inch in dia. These multistrand wires have banana plug on one end and crocodile clip on the other. By banana plug they are fitted on the banana socket on the power supply and by crocodile clip it is clipped on the hook up wire connected in the bread board.There are various types of wires. There are two cores or three cores shielded wires. In one sheath there are two or three insulated SWG14/36 wires. The sheath can be shielded in wire-mesh shields. This prevents Electro-magnetic interference and pick-up. There are unshielded wires with two and three cores. There are coaxial cables which are used as connectors . A coaxial cable with BNC Connector on one end and crocodile clips on the other are used for feeding the signal from Function Generators to the circuit under test. A coaxial cable with BNC Connector on one end and oscilloscope probes or crocodile clips on the other are used for feeding the signal from the circuit under test to the oscilloscope.

Procedure:-

• Set up the component in the breadboard which has to be tested & probed by the mulimiter as well as C.R.O.
• First of all we calculate the theoretical value of resistor through colour coding and than obtain practical value through multimeter.
• Next we find the I-V characteristic curve i.e forward and reverse characteristics of diode with the help of C.R.O.

Resistances:-

i. **Carbon Film Reistances.**

There is a carbon film deposited on the former. These are the cheapest and most widely used resistances. The resistances are given in colour codes. Colour code is Gray, White, Violet ,Blue ,Green, Yellow, Orange, Red Brown and Black. These stand for 9,8,7,6,5,4,3,2,1 and 0 respectively. The first two bands on the left give tens and units. The third band gives the exponent to the base 10. Fourth band gives the tolerance. Golden Band gives 5% and Silver Band gives 10% tolerance.

S.N.	1st,2nd,3rd and 4th band of colours	Nominal Value (Ω)	Practical Value (Ω)	Tolerance (± %)	Percentage Error

1	Yellow, Violet, Orange, Silver	47k	47.2k	10	0.423
2	Red, Violet, Red, Gold	2.7k	2.748k	5	1.746

The resistances have power rating and tolerance. Power rating tell the maximum power dissipation permitted. These are generally 1/4W or 1/2W rating in carbon film resistances. The fourth band tells the tolerance. Zero Tolerance resistance is a precision resistance. Less than 1% tolerance is close tolerance component. More than 5% tolerance is a wide tolerance component.

ii. Thin Film Resistances:Thin Film Resistances are made of Nichrome which is 80% Nickel and 20% Chromium alloy. These are of 0.1% tolerance and the temperature coefficient of resistance (t.c.r) is 100 parts per million per degree centigrade (PPM/°C). These are also called precision resistances.

i. **CERMETS** are film resistances where ceramic and metal films are used. These are also of 0.1% tolerance and zero t.c.r. Ceramic has a negative t.c.r. and Metal has positive t.c.r. Hence a proper combination of Ceramic and Metal gives zero t.c.r. These are truly precision components used in Intrumentation.
ii. **Wire Wound Resistances:** These are power resistances which can go up to 100W maximum power dissipation. These are green in colour and robust in appearance.
iii. **Variable Resistances:** These are carbon track potentiometers and Rheostats. Carbon track resistances are used in Electronics Lab and are of less than 1W rating. Rheostats are used in Electrical Engineering Labs and can go up to 1000W. Rheostat are made of Cu/Ni or Ni/Cr alloy of low t.c.r.. In Carbon Track Potentiometer there is a carbon track on which a wiper sweeps from one end to the other. The two terminals connected to the two ends of the carbon track give a fixed resistance while the resistance between one of the end terminals and the terminal connected to the wiper is a variable resistance.

Capacitor:

i. **Ceramic Disc Capacitances:**

These are the cheapest and most widely used capacitances. The values are given as 103. 103 means 10×10^3pF (pF is called PUF). This is 10^{-8}F=0.01μF.

i. **Paper/Mica Capacitances.**
ii. **Polyesterene Capacitances:** These are low loss angle high quality capacitances.
iii. **Electrolytic Capacitances:** The large magnitude of capacitances more than 1μF up to 1000μF can be realized by electrolytic Capacitances. These are polar capacitances. The polarity of the DC Voltage applied should be correct so that the electrolyte between the electrodes act like dielectric. If the polarity is reversed then it becomes a conductor.
iv. **Variable Capacitances:** Gang Capacitances- these are air-gap capacitances used as tuning capacitances in Radio-Broadcast Receivers. Trimmers and Padders are used for alignment of the tuned circuits in Radio Receivers.
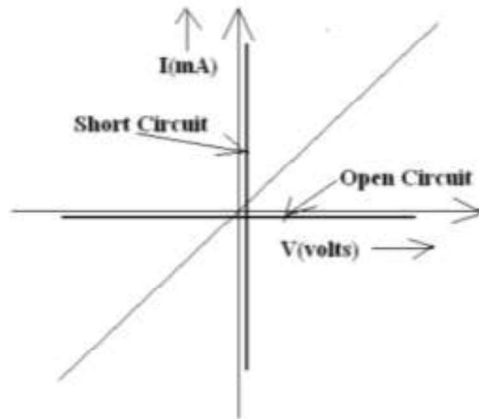
I-V Characteristics of a resistance.
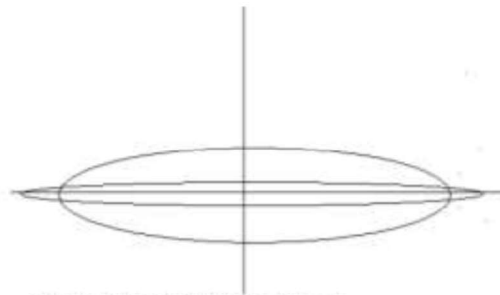
I-V Characteristics of Capacitance.
High eccentricity ellipse is for Ceramic Disk Capacitances
Low eccentricity ellipse is for Electrolytic Capacitance.
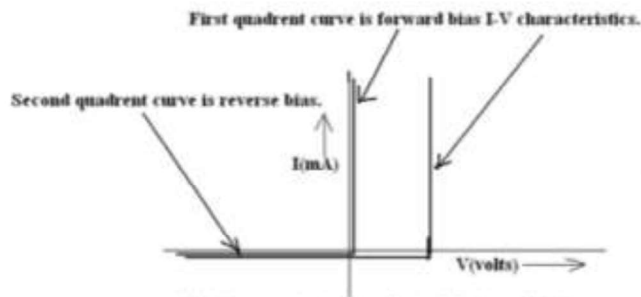
I-V Characteristics of a classical diode and LED.

In first quadrent we see the cut-in voltage,
Cut-in Voltage is 0v for Ge Diode, it is 0.5V for Si Diode
but it is 1.2V or higher for Compound Semiconductor.
LED are always made of Direct-Band-Gap material and
hence it is made of Compund Semiconductor.

I(mA)

Zener Breakdown

(V$_Z$)

V(volts)
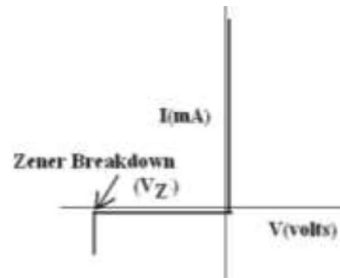
I-V characteristics of Zener Diode.
Zener Diode is Quantum-mechanical Diode.
It is heavily doped.
It experiences Zener Breakdown by Quantum
Mechanical Tunneling.
Zener Break Down occurs below 4V.
Avalanche Breakdown occurs above 6V to
100V.
Between 4V to 6V there is a combination of
Zener Breakdown and Avalanche Breakown.
Hence it can have ZERO tcr.
Zener Breakdown has (-)ve tcr and Avalanche
Breakdown has (+)ve tcr.

EB diode curve

CB diode curve

I(mA)

I(mA)

V(volts)

V(volts)
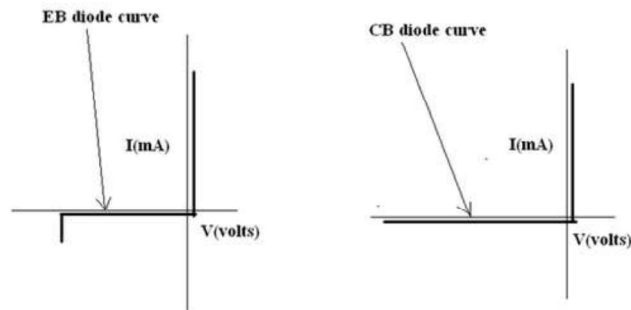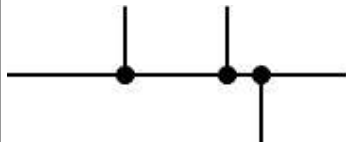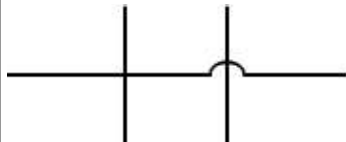
I-V characteristics between Base and Emitter Diode and between Base and
Collector Diode.
Emitter has a doping density of 10^{18}/cc , Base has 10^{17}/cc and Collector
has 10^{16}/cc.
EB diode behaves like a Zener Diode because of vey high doping hence its I-V
characteristics is like that of a Zener Diode.
BC diode behaves like Classical Diode because of moderate doping hence its
I-V characteristics is that of a classical diode.
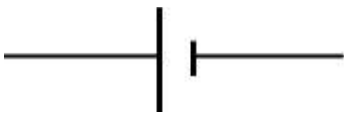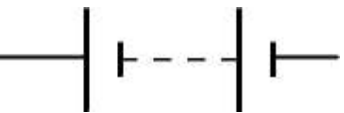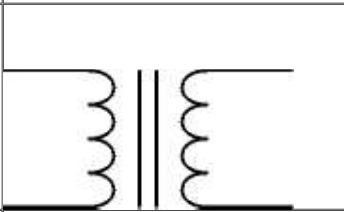
Experiment No. -2

Aim/Objective: Study of technical symbols used for various electronic components.
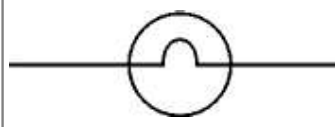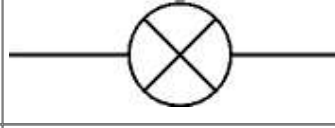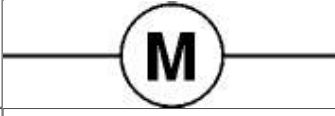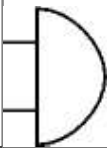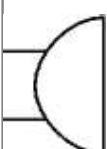
Theory:

Wires and connections		
Component	**Circuit Symbol**	**Function of Component**
Wire		To pass current very easily from one part of a circuit to another.
Wires joined		A 'blob' should be drawn where wires are connected (joined), but it is sometimes omitted. Wires connected at 'crossroads' should be staggered slightly to form two T-junctions, as shown on the right.
Wires not joined		In complex diagrams it is often necessary to draw wires crossing even though they are not connected. I prefer the 'bridge' symbol shown on the right because the simple crossing on the left may be misread as a join where you have forgotten to add a 'blob'!

Power Supplies		
Component	**Circuit Symbol**	**Function of Component**
Cell		Supplies electrical energy. The larger terminal (on the left) is positive (+). A single cell is often called a battery, but strictly a battery is two or more cells joined together.
Battery		Supplies electrical energy. A battery is more than one cell. The larger terminal (on the left) is positive (+).
DC supply		Supplies electrical energy. DC = Direct Current, always flowing in one direction.
AC supply		Supplies electrical energy. AC = Alternating Current, continually changing direction.

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Fuse		A safety device which will 'blow' (melt) if the current flowing through it exceeds a specified value.
Transformer		Two coils of wire linked by an iron core. Transformers are used to step up (increase) and step down (decrease) AC voltages. Energy is transferred between the coils by the magnetic field in the core. There is no electrical connection between the coils.
Earth (Ground)		A connection to earth. For many electronic circuits this is the 0V (zero volts) of the power supply, but for mains electricity and some radio circuits it really means the earth. It is also known as ground.
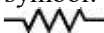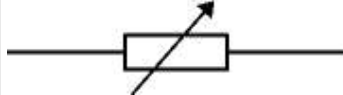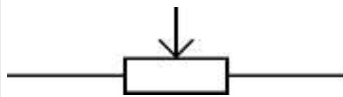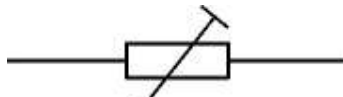
Output Devices: Lamps, Heater, Motor, etc.

Component	Circuit Symbol	Function of Component
Lamp (lighting)		A transducer which converts electrical energy to light. This symbol is used for a lamp providing illumination, for example a car headlamp or torch bulb.
Lamp (indicator)		A transducer which converts electrical energy to light. This symbol is used for a lamp which is an indicator, for example a warning light on a car dashboard.
Heater		A transducer which converts electrical energy to heat.
Motor		A transducer which converts electrical energy to kinetic energy (motion).
Bell		A transducer which converts electrical energy to sound.
Buzzer		A transducer which converts electrical energy to sound.
Inductor		A coil of wire which creates a magnetic field when current passes through it. It may have an iron core inside the coil. It can be used as a transducer converting electrical energy to
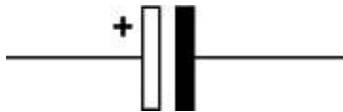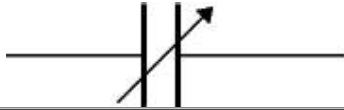
(Coil, Solenoid)	mechanical energy by pulling on something.

Switches

Component	Circuit Symbol	Function of Component
Push Switch (push-to-make)		A push switch allows current to flow only when the button is pressed. This is the switch used to operate a doorbell.
Push-to-Break Switch		This type of push switch is normally closed (on), it is open (off) only when the button is pressed.
On-Off Switch (SPST)		SPST = Single Pole, Single Throw. An on-off switch allows current to flow only when it is in the closed (on) position.
2-way Switch (SPDT)		SPDT = Single Pole, Double Throw. A 2-way changeover switch directs the flow of current to one of two routes according to its position. Some SPDT switches have a central off position and are described as 'on-off-on'.
Dual On-Off Switch (DPST)		DPST = Double Pole, Single Throw. A dual on-off switch which is often used to switch mains electricity because it can isolate both the live and neutral connections.
Reversing Switch (DPDT)		DPDT = Double Pole, Double Throw. This switch can be wired up as a reversing switch for a motor. Some DPDT switches have a central off position.
Relay	NO COM NC	An electrically operated switch, for example a 9V battery circuit connected to the coil can switch a 230V AC mains circuit. NO = Normally Open, COM = Common, NC = Normally Closed.
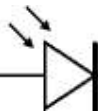
Resistors
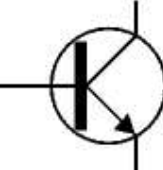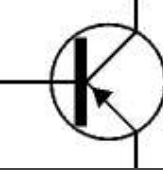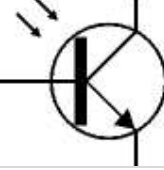
Component	Circuit Symbol	Function of Component
Resistor		A resistor restricts the flow of current, for example to limit the current passing through an LED. A resistor is used with a capacitor in a timing circuit. Some publications still use the old resistor symbol:
Variable Resistor (Rheostat)		This type of variable resistor with 2 contacts (a rheostat) is usually used to control current. Examples include: adjusting lamp brightness, adjusting motor speed, and adjusting the rate of flow of charge into a capacitor in a timing circuit.
Variable Resistor (Potentiometer)		This type of variable resistor with 3 contacts (a potentiometer) is usually used to control voltage. It can be used like this as a transducer converting position (angle of the control spindle) to an electrical signal.
Variable Resistor (Preset)		This type of variable resistor (a preset) is operated with a small screwdriver or similar tool. It is designed to be set when the circuit is made and then left without further adjustment. Presets are cheaper than normal variable resistors so they are often used in projects to reduce the cost.
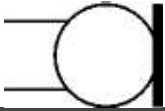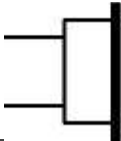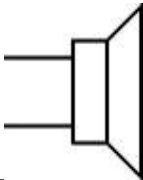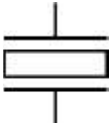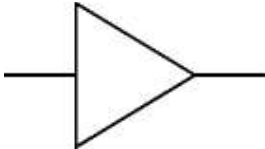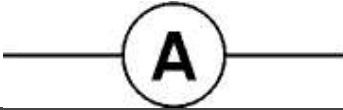
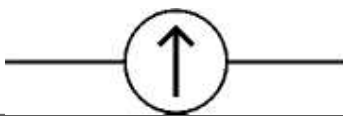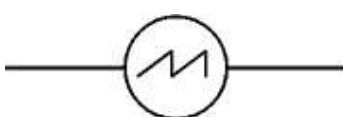| Capacitors		
Component	Circuit Symbol	Function of Component
Capacitor		A capacitor stores electric charge. A capacitor is used with a resistor in a timing circuit. It can also be used as a filter, to block DC signals but pass AC signals.
Capacitor, polarised		A capacitor stores electric charge. This type must be connected the correct way round. A capacitor is used with a resistor in a timing circuit. It can also be used as a filter, to block DC signals but pass AC signals.
Variable Capacitor		A variable capacitor is used in a radio tuner.

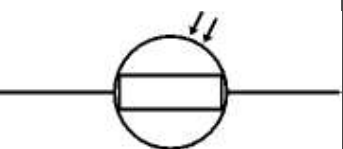|		This type of variable capacitor (a trimmer) is operated with a small screwdriver or similar tool. It is designed to be set when the circuit is made and then left without further adjustment.
Trimmer Capacitor		

Diodes

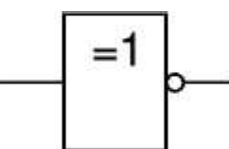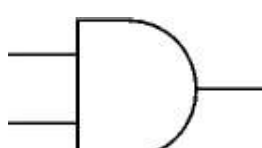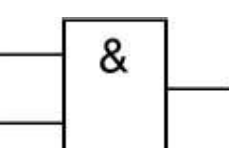| Component	Circuit Symbol	Function of Component
Diode		A device which only allows current to flow in one direction.
LED Light Emitting Diode		A transducer which converts electrical energy to light.
Zener Diode		A special diode which is used to maintain a fixed voltage across its terminals.
Photodiode		A light-sensitive diode.
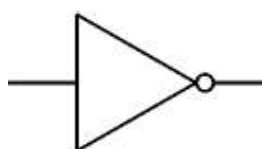
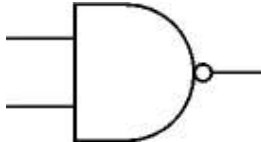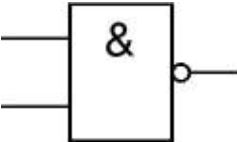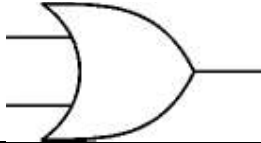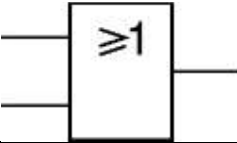| Component	Circuit Symbol	Function of Component
Transistor NPN		A transistor amplifies current. It can be used with other components to make an amplifier or switching circuit.
Transistor PNP		A transistor amplifies current. It can be used with other components to make an amplifier or switching circuit.
Phototransistor		A light-sensitive transistor.
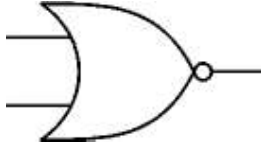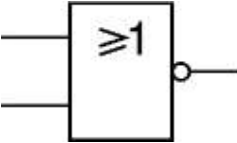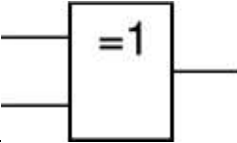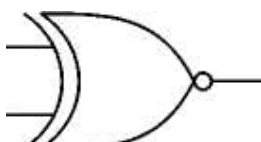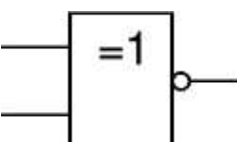
Audio and Radio Devices

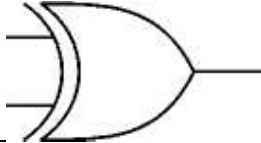| Component	Circuit Symbol	Function of Component
Microphone		A transducer which converts sound to electrical energy.
Earphone		A transducer which converts electrical energy to sound.
Loudspeaker		A transducer which converts electrical energy to sound.
Piezo Transducer		A transducer which converts electrical energy to sound.
Amplifier (general symbol)		An amplifier circuit with one input. Really it is a block diagram symbol because it represents a circuit rather than just one component.
Aerial (Antenna)		A device which is designed to receive or transmit radio signals. It is also known as an antenna.

Meters and Oscilloscope

Component	Circuit Symbol	Function of Component
Voltmeter		A voltmeter is used to measure voltage. The proper name for voltage is 'potential difference', but most people prefer to say voltage!
Ammeter		An ammeter is used to measure current.

Galvanometer		A galvanometer is a very sensitive meter which is used to measure tiny currents, usually 1mA or less.
Ohmmeter		An ohmmeter is used to measure resistance. Most multimeters have an ohmmeter setting.
Oscilloscope		An oscilloscope is used to display the shape of electrical signals and it can be used to measure their voltage and time period.

Sensors (input devices)

Component	Circuit Symbol	Function of Component
LDR		A transducer which converts brightness (light) to resistance (an electrical property). LDR = Light Dependent Resistor
Thermistor		A transducer which converts temperature (heat) to resistance (an electrical property).

LOGIC GATES

Gate Type	Traditional Symbol	IEC Symbol	Function of Gate
NOT		=1	A NOT gate can only have one input. The 'o' on the output means 'not'. The output of a NOT gate is the inverse (opposite) of its input, so the output is true when the input is false. A NOT gate is also called an inverter.
AND		&	An AND gate can have two or more inputs. The output of an AND gate is true when all its inputs are true.

99

NAND			A NAND gate can have two or more inputs. The 'o' on the output means 'not' showing that it is a Not AND gate. The output of a NAND gate is true unless all its inputs are true.
OR			An OR gate can have two or more inputs. The output of an OR gate is true when at least one of its inputs is true.
NOR			A NOR gate can have two or more inputs. The 'o' on the output means 'not' showing that it is a Not OR gate. The output of a NOR gate is true when none of its inputs are true.
EX-OR			An EX-OR gate can only have two inputs. The output of an EX-OR gate is true when its inputs are different (one true, one false).
EX-NOR			An EX-NOR gate can only have two inputs. The 'o' on the output means 'not' showing that it is a Not EX-OR gate. The output of an EX-NOR gate is true when its inputs are the same (both true or both false).

10

Experiment No. -3

Aim/Objective: Demonstrate and perform operation of soldering and de-soldering on general purpose PCB.

Practical significance:

This section describes and covers the process of soldering and desoldering. Electronic devices are composed of distinct component. Each one of them has a specific function. By joining this component together in different ways you can build electronic devices from a child's toy to an aircraft. Soldering is the process in which two or more metals are joined together using molten filler metal. Relevant course outcomes: use electrical tools, instruments, devices and equipment for basic level maintenance of computers and peripherals Practical learning outcomes: use soldering process to join electronic component on PCB Theoretical background:

Soldering Techniques-

1. Soldering is a process in which two or more metal items are joined together by melting and then flowing a filler metal having a relatively low melting point.1.Solder–it is an alloy of tin and lead. The solder used for electronics is frequently called 60/40 solder because it is made of 63% tin and 37% lead. 60/40 solders melts at 361F.

2. Soldering iron –it is the most commonly used tool to solder components on PCBs. The iron is heated to a temperature of about 420 degrees Celsius, which is enough to quickly melt the solder flux.

3. Soldering Process--The component to be soldered is first positioned on the PCB such that its pins are aligned with their corresponding pads on the board. In the next step, the solder wire is brought into contact with the interface between the first pin and its pad. Briefly touching this wire at the interface with the heated soldering iron tip melts the solder. The molten solder flows on the pad and covers the component pin. After solidifying, it creates a strong bond between the pin and the pad. Since the solidification of the solder happens quickly, within two to three seconds.

Desoldering techniques-

1. In electronics desoldering is the removal of solder and component from circuit board for trouble shooting repair and replacement without damaging component or PCB either from excessive heator from rough handling.1.Desoldering with copper braid-Copper braid is commonly used to desolder electronic components. The braid is placed on the solid solder and gently pressed with a heated soldering iron tip. The tip melts the solder, which is quickly absorbed by the braid. This is an efficient but slow method of desoldering components since each soldered joint must be worked on individually.

2. desoldering with solder sucker -Solder sucker is basically a small tube connected to a vacuum pump. Its purpose is to suck the molten flux off of pads. A heated soldering iron tip is first placed on the solid solder until it melts. The solder sucker is then placed directly on the molten flux and a button on its side is pushed that quickly sucks the flux.

3. desoldering with heat gun -. In this method, the board is placed on a perfectly flat place and a heat gun is pointed directly at the components to be desoldered for a few seconds. This quickly melts the solder and on the pads, loosening the components. They are then immediately lifted with the help of tweezers.

A good solder joint

Poor solder joints
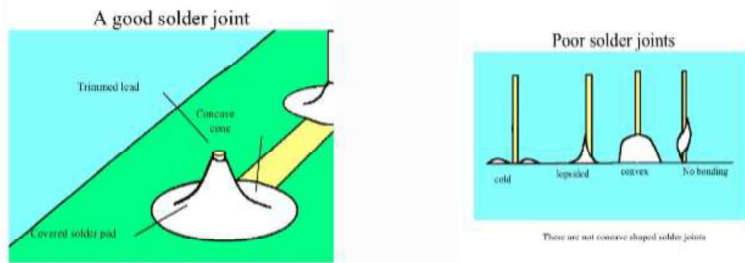
Resources required:

Soldering iron, solder, electronics Component, desoldering pump, desoldering and copper braid.

Soldering Safety-

- Place soldering iron in an approved holder when not in use. The iron is hot and can cause burns.
- Verify that the tip on the soldering iron has a sharp point and has not been damaged in any way.
- Tie back long hair and remove or tuck loose clothing.
- Make sure that leads do not short across other traces or leads.
- Thoroughly wash your hands after handling solder.

Soldering iron

Soldering station

Desoldering pump

Desoldering copper braid

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Experiment No. -4

AIM/OBJECTIVE: Demonstrate and perform operation of drilling on PCB.

APPARATUS REQUIRED:-
- Etching machine
- Ferric chloride
- Drilling Machine

THEORY:

This is an important and critical step in chemical processing of direct etched boards. Although basically this operation of chemical removal of unwanted copper portion ferric chloride is widely used for copper and copper alloys. He removed the unwanted copper from laminate by photo etching machine. In this machine laminate put in tank filled with chemical ferric chloride which is agitated by a pump and a heater. The heater helps the chemical become to warm and help it to etch PCB faster. Fresh chemical is available to the surface area that dissolved the metal from surface is rinsed away simultaneously. Sensor is provided for maintaining temperature.

DRILLING:-

After etching, drilling of PCB is done for making holes on the conductor pattern for inserting the component leads to the solder of PCB.

RESULTS:
- PCB is fabricated according to the required circuit board.

PRECAUTIONS:
- Clean and etch the board after completion of etching.
- Drilling should be done carefully.

Experiment No. -5

AIM/OBJECTIVE: Design PCB artwork for a given electronic circuit on a simulator e g. Express PCB.

LAYOUT PLANNING:-

1. Depending on the accuracy required artwork should be produced at a ratio of 1:1 or 4:1.
2. Use of grid system in layout and artwork design is a commonly accepted practice.
3. Use of grid gives more convenience in placement of components and conductors.
4. Selection of Board type-single sided.
5. MATERIAS AND AIDS: (a) Simple approach and sketching of components.(b) Layout sketching with puppets.
6. To prepare each and every PCB layout as viewed from component side.
7. Unless and unstill absolutely cleared circuit diagram is available. Startingly the designing of layout is not possible.
8. Complete the layout work and start with interconnection.
9. Develop the layout in direction of single flow.
10. Among the components the longer one is placed first then the space in between is filled with smaller one.
11. Design and interconnection can be done by pencil line.

GENERAL ARTWORK RULE:-

1. In PCB artwork higher conductor density is an established practice.
2. To run the conductors on one side in given direction.
3. Where conductors have to be placed in other direction preference should be given to 48 direction or 30/60 direction.
4. It is a good rule, to begin and end the conductors in solder pad.
5. Where one or several conductors have to pass between pads or other conducting
6. carrier, spacing has to be equally distributed.

COMPONENTS POLARITY IDENTIFICATION:-

It is very essential when artwork is completed, a thorough check is carried out to prepare band to prove its exact correspondence with circuit diagram**.**

DOCUMENTATION:-
1. Circuit diagram.
2. Legend.
3. Artwork
4. Drill Problem.
5. Soldier masks.
6. Green masks.
7. Component layout.
8. Component list.

Experiment No. -6

AIM/OBJECTIVE: Demonstrate PCB fabrication procedure for preparation of PCB on a PCB fabrication machine.

APPARATUS REQUIRED:-
1. Photo-resist slip coating machine.
2. U.V exposer unit.
3. Photo developer dye machine.
4. Photo curing machine (oven).

THEORY:-
The manual artwork PCB design is the method used by most manufacturing of PCB with this method extremely accurate, high density PCB can be constructed. This artwork is then photographed to produce a negative which can be used with sensitized printed circuit. Exposing of the negative by contact with coated circuit board is done first and then developing and other process are required for a PCB.

PROCESS:-
1. Clean the laminate:-Before the metal surface is coating with crescent photo resist. Clean surface thoroughly so as to make a completely free of physical and chemical continuation.
2. Coating the laminate:-Crescent Photo-resist can apply precisely and economically be using a dipping process, done by a photo-resist to coats.
3. Thinner:-The thinner is used to dilute the photo-resist as it tends to get the thick during non-use. The use of thinner will depend upon the method of coating.
4. Prefacing:-After coating the laminate allow it to dry naturally for 5 min. this helps to evaporate the solvents completely.
5. Exposer:-The coated laminate is normally exposed in contact with photographic. Negative and Positive crescent photo-resist is sensitive to U.V radiation and therefore U.V tube based U.V exposer can be used for exposer.
6. Development:-The exposed plate should be placed into the solvents based developer. This will remove unexposed area of the photo-resist and will produce colorless resist image which has plastic like appearance.
7. Washing:-Immediately after developer is over, wash it on running water of natural pH. After washing and drying, dying is carried out to improve the visibility of image.
8. Drying the Image:-Immense the dried that plate in the dye developer bath. The surface of the board is colored with the dye developer. The board is put under the running water of neutral pH, in order to wash off the dye stain from unexposed area, which results into a clean dyed image of photo-resist and the dry.
9. Post curing:-The post-baked surface will be stronger than the unbaked one. This process can be done on PCB curing machine.

RESULT:-

After this process, circuit resist has left on required part of PCB and now coated or unprotected metal may be etched in etching solution to prepare PCB.

PRECAUTIONS:-

- Worktable, apparatus, tanks, traces should be completely free from dust and dirt.
- Use of thinner should be done carefully.

Experiment No. -7

AIM/OBJECTIVE: Testing of various digital and analog integrated circuits using IC tester

APPARATUS REQUIRED: Digital IC tester

THOERY:

IC testers or integrated circuit tester are used to test or check the condition of IC before it is used in any circuit. It functionally tests variety of ICs and displays PASS or FAIL accordingly. Reasons to test after the IC has been placed on the board:

- To verify the proper chip orientation
- To verify its correct device
- To verify basic operations of the board
- To program and verify In-System-Programmable(ISP) device contents.

It is of two kinds: Analog and Digital IC testers. We also have Universal IC tester which can test both analog and digital ICs. The digital IC tester is discussed in the later sections; though the universal IC tester is almost same in its functionality.

FEATURES

- An IC tester is normally compact, rugged and easy to use.
- It is a portable device.
- It can automatically test variety of digital ICs of 6, 8, 10, 14, 16, 18, 20, 24, 28, and 40 pins.
- Requires no add-on or plug-in hardware for testing, all the required hardware is in-built.
- Facility to test ICs now and again until it is stopped
- Self testing facility through 'PIN TEST FACILITY' of the keyboard.
- Facility to identify the IC number using 'AUTO FIND' of selective IC only.
- Audio buzzer for bringing the user's attention.
- The **front panel** of digital IC tester contains sixteen keys keyboard with the functions engraved on it, six seven segment display and 40 pin ZIF (Zero Insertion force) socket.

10

Six seven segment digital display

ZIF socket
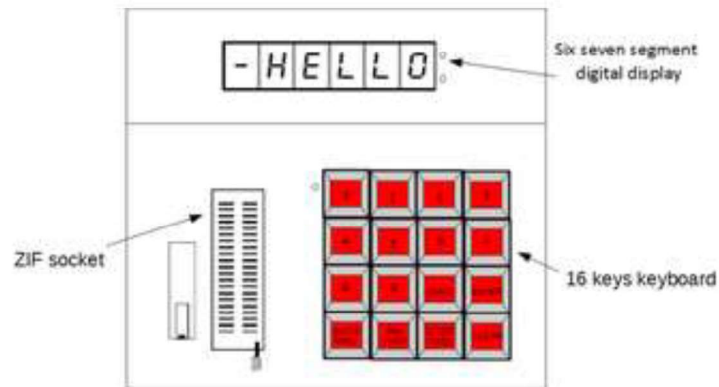
16 keys keyboard

KEYS AND FUNCTIONS

The IC tester has a 16 keys keyboard, each key with a specific function. The keys can be broadly classified into two categorizes: DATA INPUT KEYS and COMMAND INPUT KEYS.

- **DATA INPUT KEYS:** These keys are used to used to enter the IC number. Keys with markings 0, 1, 2,3, 4, 5, 6, 7, 8 and 9 come in this category. They are sometimes called numeric keys
- **COMMAND INPUT KEYS:** ALGO, ENTER, AUTO FIND, PIN TEST, LOOP TEST and CLEAR keys are the six command input keys which are used to give command to the device.

Serial no.	Key Description	Key Function
1.	0 to 9	To enter numeric portion of IC number
2.	CLEAR	Clear the complete display
3.	ENTER	To start the testing of IC which is entered in display
4.	ALGO	The key shows the entire range of the devices whose algorithm is same to the device which is entered
5.	AUTO FIND	It locates the digital IC number upto 20 pins.
6.	PIN TEST	Used to test the pins from 1 to 39 of ZIF socket.
7.	LOOP TEST	This key is used to test a device for continuously

FUNCTIOBAL OPERATION

10

The command input keys offers following functions:

    i.   LOOP TEST
   ii.   PIN TEST
  iii.   AUTO FIND
  iv.   ALGORITHM CHECK
   v.   CLEAR

APPLICATION

IC tester is used in labs to test ICs where we use it to make circuits. In general, IC tester can be used wherever IC testing is required.

LIST OF ICs THAT COULD BE USED WITH THIS IC TESTER

- CMOS ICs (40 series) e.g, 4000, 4001 etc
- CMOS ICs (MC140 family) e.g, MC14XXX
- CMOS ICs (45 series) e.g, 4501, 4502 etc
- Opto couplers e.g, 521-1, 821-2s, 4N26
- TTL74/54 series e.g, 74/5400, 74/5408 etc
- Linear e.g, LM535, LM139
- 75/55 series e.g, 75/55107, 75/55108
- Microprocessor, EPROM, RAM and other digital ICs
- Transistor arrays e.g, ULN2002, ULN2003 and ULN2004

Experiment No. -8

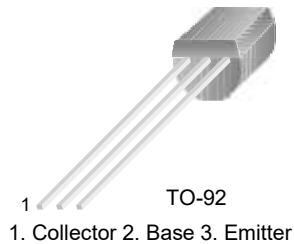**AIM:** Study of data sheet of various electronic components e.g. Transistors, diodes ,capacitors etc.

FAIRCHILD
SEMICONDUCTOR®

BC546/547/548/549/550

Switching and Applications

- High Voltage: BC546, V_{CEO}=65V
- Low Noise: BC549, BC550
- Complement to BC556 ... BC560

TO-92
1. Collector 2. Base 3. Emitter

NPN Epitaxial Silicon Transistor

Absolute Maximum Ratings T_a=25°C unless otherwise noted

Symbol	Parameter	Value	Units
V_{CBO}	Collector-Base Voltage : BC546	80	V
	: BC547/550	50	V
	: BC548/549	30	V
V_{CEO}	Collector-Emitter Voltage : BC546	65	V
	: BC547/550	45	V
	: BC548/549	30	V
V_{EBO}	Emitter-Base Voltage : BC546/547	6	V
	: BC548/549/550	5	V
I_C	Collector Current (DC)	100	mA
P_C	Collector Power Dissipation	500	mW
T_J	Junction Temperature	150	°C
T_{STG}	Storage Temperature	-65 ~ 150	°C

Electrical Characteristics T_a=25°C unless otherwise noted

Symbol	Parameter	Test Condition	Min.	Typ.	Max.	Units
I_{CBO}	Collector Cut-off Current	V_{CB}=30V, I_E=0			15	nA
h_{FE}	DC Current Gain	V_{CE}=5V, I_C=2mA	110		800	
V_{CE} (sat)	Collector-Emitter Saturation Voltage	I_C=10mA, I_B=0.5mA		90	250	mV
		I_C=100mA, I_B=5mA		200	600	mV
V_{BE} (sat)	Base-Emitter Saturation Voltage	I_C=10mA, I_B=0.5mA		700		mV
		I_C=100mA, I_B=5mA		900		mV
V_{BE} (on)	Base-Emitter On Voltage	V_{CE}=5V, I_C=2mA	580	660	700	mV
		V_{CE}=5V, I_C=10mA			720	mV
f_T	Current Gain Bandwidth Product	V_{CE}=5V, I_C=10mA, f=100MHz		300		MHz
C_{ob}	Output Capacitance	V_{CB}=10V, I_E=0, f=1MHz		3.5	6	pF
C_{ib}	Input Capacitance	V_{EB}=0.5V, I_C=0, f=1MHz		9		pF
NF	Noise Figure : BC546/547/548	V_{CE}=5V, I_C=200μA		2	10	dB
	: BC549/550	f=1KHz, R_G=2KΩ		1.2	4	dB
	: BC549	V_{CE}=5V, I_C=200μA		1.4	4	dB
	: BC550	R_G=2KΩ, f=30~15000MHz		1.4	3	dB

h_{FE} Classification

Classification	A	B	C
h_{FE}	110 ~ 220	200 ~ 450	420 ~ 800

Typical Characteristics

100

$I_B = 400\mu A$

80

$I_B = 350\mu A$

$I_B = 300\mu A$

$I_B = 250\mu A$

60

$I_B = 200\mu A$

$I_B = 150\mu A$

40

$I_B = 100\mu A$

20

$I_B = 50\mu A$

0

$I_C[mA]$, COLLECTOR CURRENT

0   2   4   6   8   10   12   14   16   18   20

$V_{CE}[V]$, COLLECTOR-EMITTER VOLTAGE
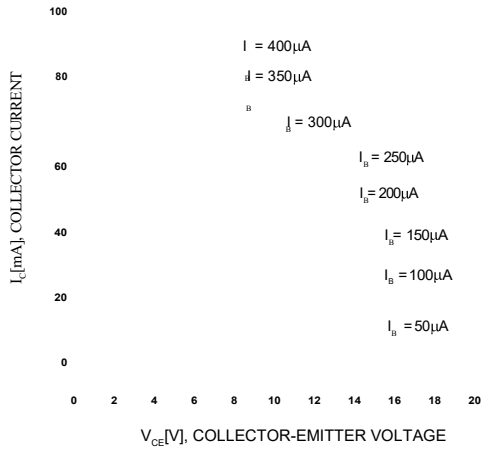
Figure 1. Static Characteristic

100

$V_{CE} = 5V$

10

1

0.1

$I_C[mA]$, COLLECTOR CURRENT

0.0   0.2   0.4   0.6   0.8   1.0   1.2

$V_{BE}[V]$, BASE-EMITTER VOLTAGE
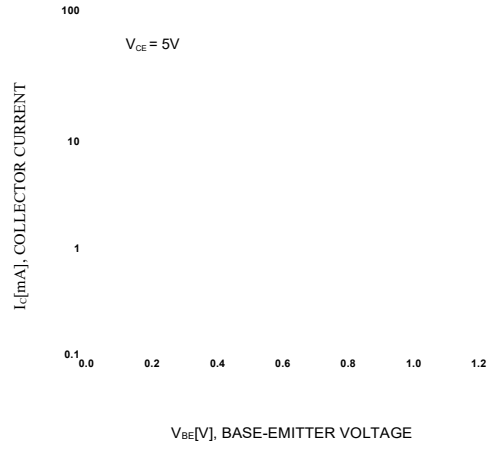
Figure 2. Transfer Characteristic

$V_{CE} = 5V$

1000

100

10

1

h_{FE}, DC CURRENT GAIN

1   10   100   1000

$I_C[mA]$, COLLECTOR CURRENT

Figure 3. DC current Gain

10000

$I_C = 10 \ I_B$

1000

$V_{BE}(sat)$

100

$V_{CE}(sat)$

10

$V_{BE}(sat), V_{CE}(sat)[mV]$, SATURATION VOLTAGE
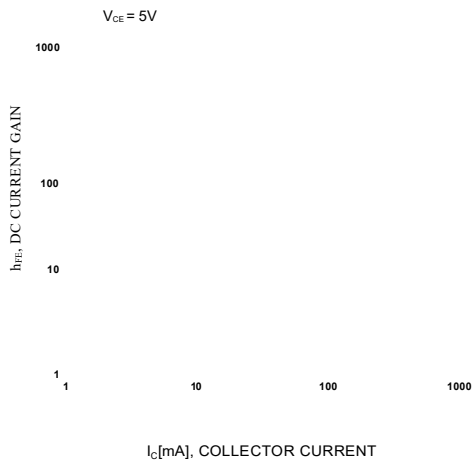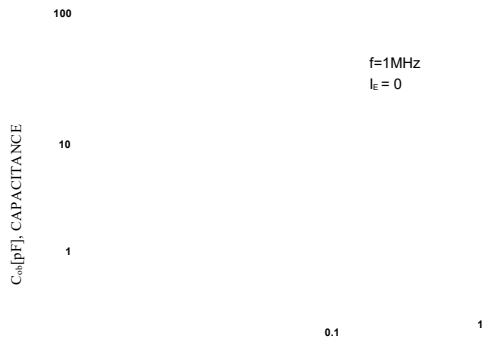
1   10   100   1000

$I_C[A]$, COLLECTOR CURRENT
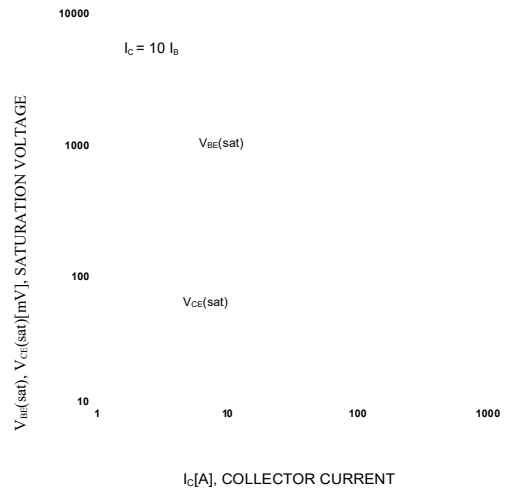
**Figure 4. Base-Emitter Saturation Voltage
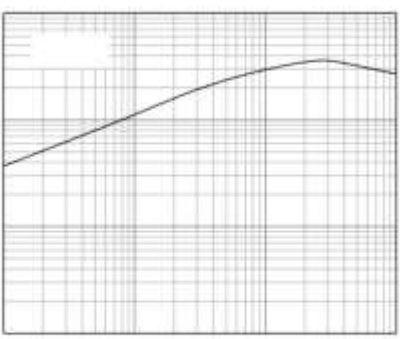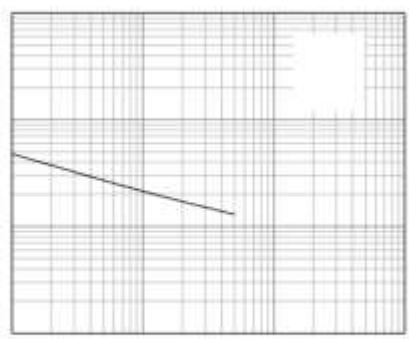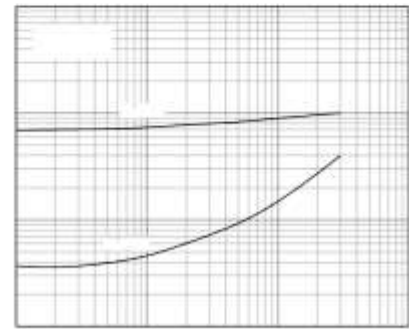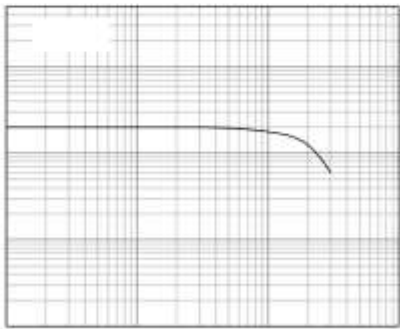Collector-Emitter Saturation Voltage**

100

f=1MHz
$I_E = 0$

10

1

$C_{ob}[pF]$, CAPACITANCE

0.1   1

1000

$V_{CE} = 5V$

100

10

10

100

1000

1
0
.
1

1

1
0

10

100

V$_{CB}$[V], COLLECTOR-BASE VOLTAGE

I$_C$[mA], COLLECTOR CURRENT

Figure 5. Output Capacitance

Figure 6. Current Gain Bandwidth Product

Package Dimensions

TO-92

4.58 +0.25 −0.15

4.58 ±0.20

0.46 ±0.10

14.47 ±0.40

1.27TYP
[1.27 ±0.20]

1.27TYP
[1.27 ±0.20]

0.38 +0.10 −0.05

3.60 ±0.20

3.86M

1.02±0.10

0.38 +0.10 −0.05

(0.2

(R2.29)

Dimensions in Millimeters
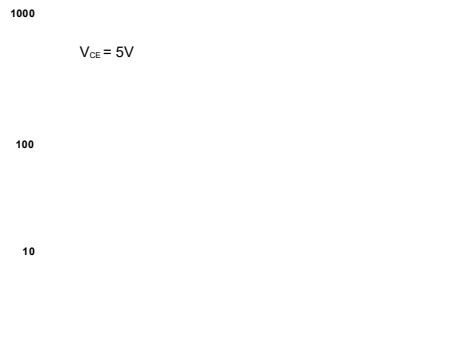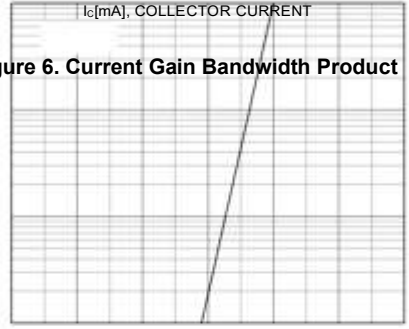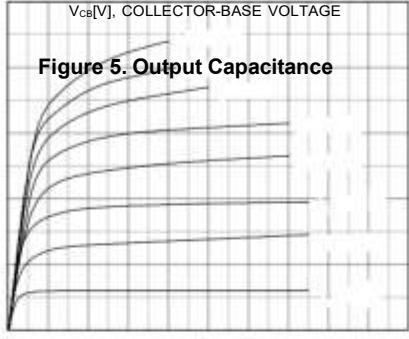
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Bottomless™	FAST®	LittleFET™	Power247™	SuperSOT™-3
CoolFET™	FASTr™	MicroFET™	PowerTrench®	SuperSOT™-6
CROSSVOLT™	FRFET™	MicroPak™	QFET™	SuperSOT™-8
DOME™	GlobalOptoisolator™	MICROWIRE™	QS™	SyncFET™
EcoSPARK™	GTO™	MSX™	QT Optoelectronics™	TinyLogic™
E²CMOS™	HiSeC™	MSXPro™	Quiet Series™	TruTranslation™
EnSigna™	I²C™	OCX™	RapidConfigure™	UHC™
Across the board. Around the world.™		OCXPro™	RapidConnect™	UltraFET®
The Power Franchise™		OPTOLOGIC®	SILENT SWITCHER®	VCX™
Programmable Active Droop™		OPTOPLANAR™	SMART START™	

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2. A critical component is any component of a life support device or system whose failure to perform can be reasonably expected to cause the failure of the life support device or system, or to affect its safety or effectiveness.

PRODUCT STATUS DEFINITIONS

Definition of Terms

Datasheet Identification	Product Status	Definition
Advance Information	Formative or In Design	This datasheet contains the design specifications for product development. Specifications may change in any manner without notice.
Preliminary	First Production	This datasheet contains preliminary data, and supplementary data will be published at a later date. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.
No Identification Needed	Full Production	This datasheet contains final specifications. Fairchild Semiconductor reserves the right to make changes at any time without notice in order to improve design.

Obsolete	Not In Production	This datasheet contains specifications on a product that has been discontinued by Fairchild semiconductor. The datasheet is printed for reference information only.