# Third Year Manuals

# ANALOG ELECTRONIC CIRCUITS

**(EE-325-F)**

# LAB MANUAL

**V SEMESTER**

# LIST OF EXPERIMENTS

| S.NO. | NAME OF THE EXPERIMENT |
|---|---|
| 1 | Design & measure the frequency response of an RC coupled amplifier using discrete components. |
| 2 | Design a two stage RC coupled amplifier and determine the effect of cascading on gain and bandwidth. |
| 3 | Study the effect of voltage series, current series, voltage shunt and current shunt feedback on amplifier using discrete components. |
| 4 | Design & realize inverting, non-inverting and buffer amplifier using ⍰⍰⍰ op-amps. |
| 5 | Verify the operation of a differentiator circuit using op amp )C ⍰⍰⍰ and show that it acts as a high pass filter. |
| 6 | Verify the operation of a integrator circuit using op amp 741 and show that it acts as a low pass filter. |
| 7 | Design & Verify the operation of adder and subtractor circuit using op amp 741. |
| 8 | Plot frequency response of AC coupled amplifier using op amp 741 and study the effect of negative feedback on the bandwidth and gain of the amplifier. |
| 9 | Study of IC 555 as astable and monostable multivibrator. |
| 10 | Design & realize using op amp ⍰⍰⍰, wein-bridge oscillator |
| 11 | To design & realize using op amp 741, square wave generator |
| 12 | To design & realize using op amp 741, logarithmic amplifier and VCCS. |
| 13 | Study of 8-bit monolithic Analog to digital converter. |
| 14 | Study of R-2R ladder network and 8-bit monolithic Digital to analog converter. |

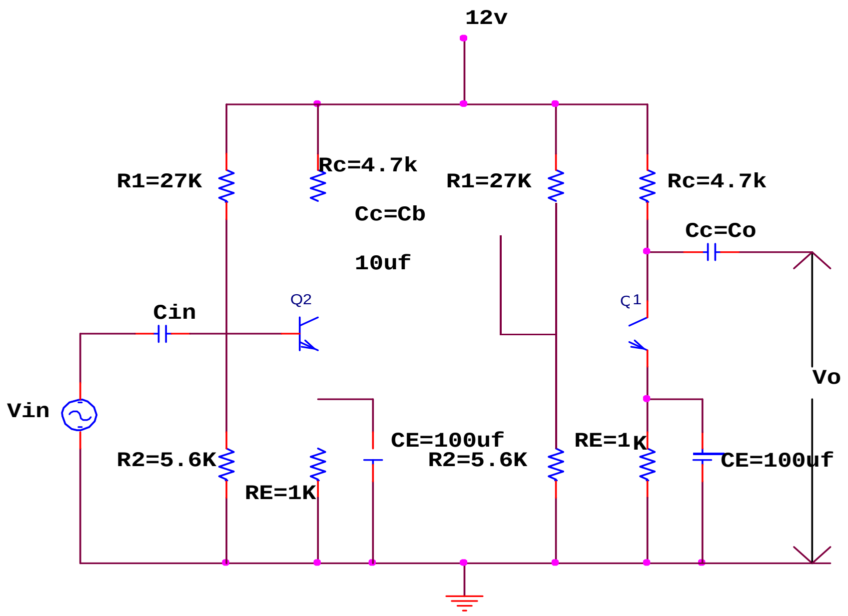
# EXPERIMENT No. 1

**AIM: - Design & measure the frequency response of an RC coupled amplifier using discrete components.**

**APPARATUS REQUIRED: -** CRO, function generator, breadboard, transistor BC 104 (2 pcs), capacitor10µF (3 pcs), 100µF (2pcs), resistor 4.7K (2pcs), 5.6K (2pcs), 1K (2pcs), ± 12 V supply and connecting leads**.**

**THEORY: -** RC coupled amplifier is a coupling of two emitter biased transistor circuit to form a single cascade network. The output Vi of one stage is coupled to the input of the next stage. A blocking capacitor is used to keep the DC component f the output voltage at Vo1. The emitter resistor $R_E$ and resistor $R_1$ and $R_2$ are used for biasing. The bypass capacitor is used to present loss of Amplification due to negative feedback. Output is taken across capacitor Cc.

**CIRCUIT DIAGRAM: -**




RC COUPLED AMPLIFIER

**PROCEDURE: -**

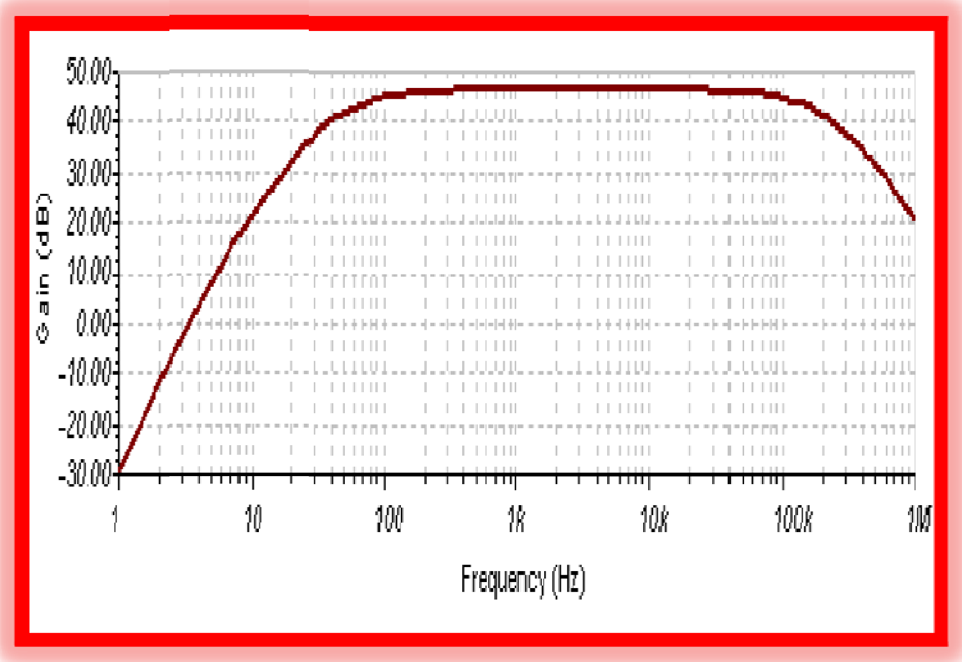
(1) Apply input signal of 10 mv amplitude and frequency 50 Hz at input terminal.
(2) Varying the frequency of the input signal from 10Hz to1MHz.
(3) Measure the output signal amplitude.
(4) Study the frequency response characteristics of RC coupled amplifier.
(5) Determine lower cut-off frequency and upper cut-off frequency from the graph.
(6) Calculate Bandwidth.

## OBSERVATION TABLE:-

INPUT VOLTAGE (Vin) = Constant

| S.NO. | FREQUENCY (Hz) | OUTPUT VOLTAGE (Vout) | GAIN (Vout/ Vin) IN dB |
|---|---|---|---|
| | | | |

## FREQUENCY RESPONSE & BANDWIDTH CALCULTIO :-




## PRECAUTIONS:-

1. Do not use open ended wires for connecting to 230 V power supply.
2. Before connecting the power supply plug into socket, ensure power supply should be Switched off.
3. Ensure all connections should be tight before switching on the power supply.
4. Take the reading carefully.
5. Power supply should be switched off after completion of experiment.

**DISCUSSION: -** What is the application of RC coupled amplifier?

**RESULT: -** The output of RC coupled amplifier is a sinusoidal wave having same phase as the input signal.

## QUIZ QUESTIONS WITH ANSWERS:-

Q1. In RC coupled amplifier which component is responsible for reduction in voltage gain in the high frequency range?
Ans. Shunt capacitance in the input circuit.

Q2. In RC coupled amplifier which component's value is responsible for low 3-dB frequency?
Ans. Increasing the value of coupling capacitor $C_b$.

Q3. In RC coupled amplifier which component's value is responsible for high 3-dB frequency?
Ans. By reducing the total effective shunt capacitance in the input circuit of hybrid pie model.

Q4. In a single stage RC coupled amplifier, what is the phase shift introduced in the true middle frequency?
Ans. 180˚

Q5. Which type of coupling capacitor is used in RC coupled amplifier?
Ans. 0.05 µf paper capacitor.

Q6. What is the application of RC coupled amplifier?
Ans. It is widely used as a voltage amplifier.

Q7. In single stage RC coupled amplifier, what is the phase shift at low 3-dB frequency?
Ans. 225˚

Q8. In single stage RC coupled amplifier, what is the phase shift at high 3-dB frequency?
Ans. 135˚

Q9. In RC coupled amplifier what is the effect of low 3-dB frequency by increasing the value of coupling capacitor $C_b$?
Ans. Decreasing.

Q10. In RC coupled amplifier what is the effect of low 3-dB frequency by increasing the value of total effective shunt capacitor?
Ans. Decreasing.

# EXPERIMENT NO. 2

**AIM:-Design a two stage RC coupled amplifier and determine the effect of cascading on gain and bandwidth.**

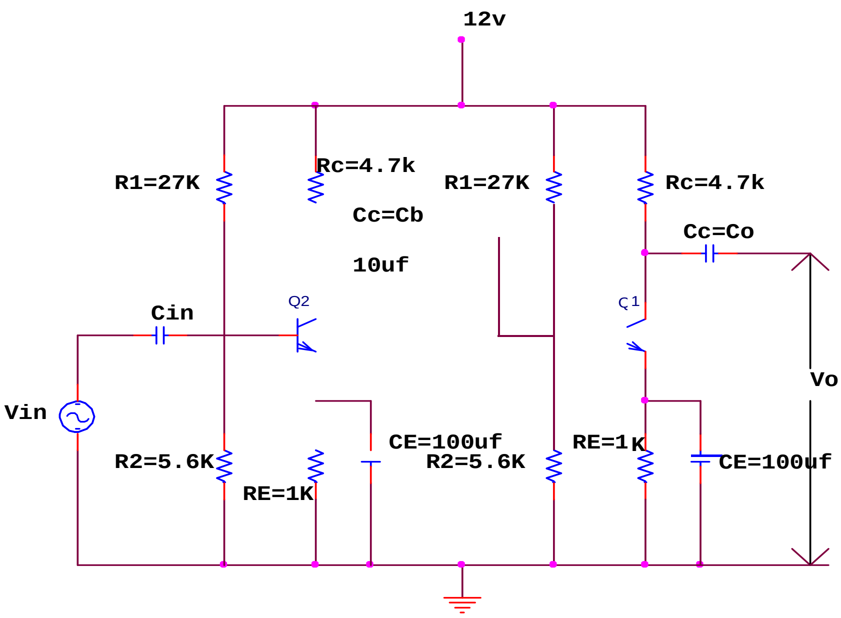
**APPARATUS REQUIRED:** - CRO, function generator, breadboard, transistor BC 104 (2 pcs), capacitor10µF (3 pcs), 100µF (2pcs), resistor 4.7K (2pcs), 5.6K (2pcs), 1K (2pcs), ± 12 V supply and connecting leads.

**THEORY:** - When the voltage gain provided by a single stage is not sufficient, we use more than one stage of the amplifier. The overall gain of the two-stages is given by

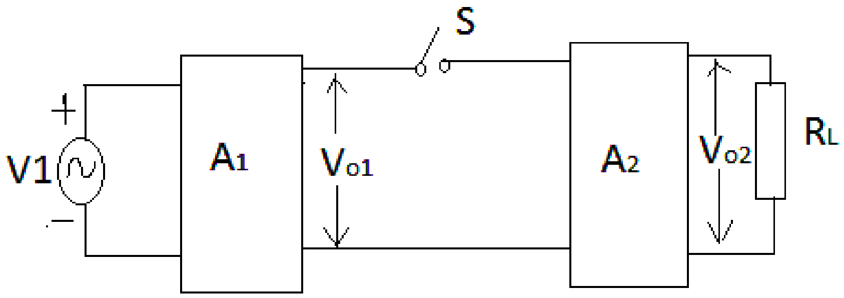
$$A=A_1 * A_2$$

Where $A_1$ is the voltage gain of first stage and $A_2$ is the voltage gain of the second stage. When the load resistance of first stage is reduced, the gain and hence output voltage also reduces.

**CIRCUIT DIAGRAM:-**




RC COUPLED AMPLIFIER



Two Stage amplifier (Block Diagram)

## PROCEDURE: -

(1) Connect the circuit properly.
(2) Feed the ac signal at input of first stage. Adjust the frequency at 1 KHZ. See the output wave shapes on the CRO.
(3) Go on increasing the input ac voltage and measure ac voltage at (i) output of first stage (ii) output of second stage
(4) Repeat the same experiment with a single stage by opening the switch ‘S’.
(5) Disconnect the second stage and then measure the output voltage of the first stage. Calculate the voltage gain of first stage under this condition and compare it with overall voltage gain of two stage amplifier.

## OBSERVATIONS:-

1. Voltage Gain

| S.No. | Input Voltage | Output of First stage | Output of Second stage | $A_1$ | $A_2$ | $A=A_1 * A_2$ |
|---|---|---|---|---|---|---|
| 1. | | | | | | |
| 2. | | | | | | |

2. Voltage gain with second stage disconnected

| S.No. | Input Voltage | Output of First stage | Gain ($A_1$) |
|---|---|---|---|
| 1. | | | |
| 2. | | | |

## RESULT:-

**1.** Two stage amplifier gain= ………. db
Single stage amplifier gain= ……… db
Overall voltage gain of two stage amplifier is higher than single stage amplifier.
Gain of two stage amplifier is equal to the product of gains of individual stages. In practice total gain A is less than A1*A2 due to loading effect of following stages.

**2.** Bandwidth = upper cut-off frequency- lower cut off frequency (From Exp. 1)

## QUIZ QUESTIONS WITH ANSWERS:-

Q1. In RC coupled amplifier which component is responsible for reduction in voltage gain in the high frequency range?
Ans. Shunt capacitance in the input circuit.

Q2. In RC coupled amplifier which component's value is responsible for low 3-dB frequency?
Ans. Increasing the value of coupling capacitor Cb.

Q3. In RC coupled amplifier which component's value is responsible for high 3-dB frequency?
Ans. By reducing the total effective shunt capacitance in the input circuit of hybrid pie model.

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Ans. 0.05 μf paper capacitor.

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Q8. In single stage RC coupled amplifier, what is the phase shift at high 3-dB frequency?
Ans. $135^\circ$

Q9. In RC coupled amplifier what is the effect of low 3-dB frequency by Increasing the value of coupling capacitor $C_b$?
Ans. Decreasing.

Q10. In RC coupled amplifier what is the effect of low 3-dB frequency by Increasing the value of total effective shunt capacitor?
Ans. Decreasing.

# EXPERIMENT NO. 3

## AIM: - Study the effect of voltage series, current series, voltage shunt and current shunt feedback on amplifier using discrete components.

## THEORY:-

**Voltage Series Feedback:-**This is also called the shunt-derived series feedback. In this circuit, Amplifier and feedback network are connected in series-parallel. A fraction of the output voltage is applied in series opposition to the input voltage through feedback network. The feedback voltage is derived from the voltage divider circuit formed of resistors R1 and R2. The feedback voltage is given as:

$$V_f= \beta\ V_{out}=R1/R1+R2V_{out}$$

$$\text{Thus } \beta =R1/R1+R2$$

And the overall gain of the amplifier is:

$$A_f =V_{out}\ /V_s=R1+R2/R1=1/\ \beta$$

**Voltage Shunt Feedback**:- This is also called the shunt-derived shunt feedback. A small portion of the output voltage is coupled back to the input voltage since the feedback network shunt both the input and output of the amplifier, both the input and output impedances are reduced by a factor 1/ (1+ β A).

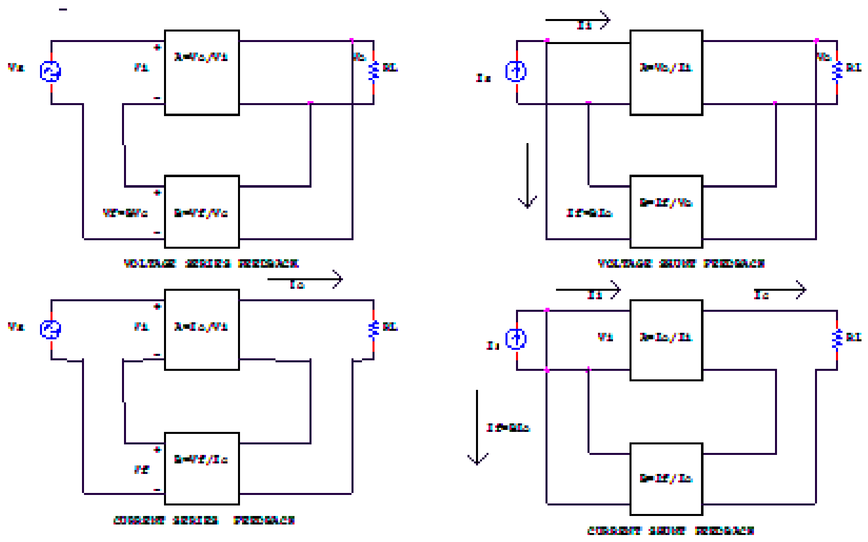
The feedback is proportional to the output voltage $V_{out}$ and feedback current $I_f$. $I_f$gets added in shunt with the input. Thus this circuit from the case of voltage shunt inverse feedback amplifier.

Feedback current, $I_f=V_{in} – V_{out}/R_F$ =Vout/RF=$\beta V_{out}$

**Current Series Feedback: -** This is also called the series derived series feedback. In such a feedback circuit, a part of the output current is made to develop voltage proportional to the output current and supplied back in series with the input .Since feedback network is in series with the amplifier on the output end as well as on the input end , both input and output impedances are increased with negative feedback. The current feedback can be obtained by removing the bypass capacitor across the emitter resistor $R_E$.

**Current Shunt Feedback: -** It is also known as series derived shunt feed feedback or current shunt inverse feedback. In this circuit the feedback network pick up a part of the output current and produces a feedback voltage in parallel with the input signal voltage. input impedance is reduced with feedback where as the output impedance is increased because of feedback network being in series with the output.

## CIRCUIT DIAGRAM:-




**DISCUSSION:-**What are the applications of voltage series feedback amplifier?

**RESULT:-**Series and parallel voltage & current feedback circuit have been studied.

## QUIZ QUESTIONS WITH ANSWERS:-

Q1. What is the application of negative feedback amplifier?
Ans. Negative feedback amplifier makes the circuit stable.

Q2. What is voltage series feedback amplifier?
Ans. It is that amplifier in which output voltage feedback in voltage series with input Signal, resulting in an overall gain reduction.

Q3. What is the overall voltage gain with feedback in voltage series feedback amplifier?
Ans. The overall voltage gain with feedback in voltage series feedback amplifier is given by:-

$A_F = V_O/V_s = A/(1+A\beta)$

Where A= gain without feedback, β= feedback

Q4. What is the effect on input resistance due to series feedback connections?
Ans. Series feedback connections tend to increase the input resistance.

Q5. What is the effect on input resistance due to shunt feedback connections?
Ans. Shunt feedback connections tend to decrease the input resistance.

Q6. What is the effect on output impedance due to voltage feedback
Ans. Voltage feedback tends to decrease the output impedance.

Q7. What is the effect on output impedance due to current feedback
Ans. Current feedback tends to increase the output impedance.

Q8. Which factor reduces the input noise & non-linear distortions of the amplifier?
Ans. $(1+A\beta)$

Q9. What is the effect of frequency on phase shift of an amplifier?
Ans. Phase Shift of an amplifier will change with frequency.

Q10. What is the effect on output impedance of the voltage series feedback amplifier?
Ans. $Z_{of} = Z_o/(1+A\beta)$

# EXPERIMENT NO:4

**AIM:-Design and realize Inverting, Non-Inverting and buffer amplifier using 741 Op-amp.**

**APPARATUS REQUIRED: -** CRO, Function Generator, Bread Board, 741 IC, ±12V supply, resistors 1K∧, 10K∧, and connecting leads.

**THEORY: -** The op-amp is a multi-terminal device used in a number of electronic circuits.

**Inverting Amplifier: -** In the inverting amplifier only one input is applied and that is to the inverting input (V2) terminal. The non-inverting input terminal (V1) is grounded.

Since,

$$V1 = 0\ V\ \&\ V2 = V_{in}$$
$$Vo = -Av_{in}$$

The negative sign indicates the output voltage is 180° out of phase with respect to the input and amplified by gain A.

**Non-Inverting Amplifier: -** The input is applied to the non-inverting input terminal and the Inverting terminal is connected to the ground.

$$V1 = V_{in} \text{ and } V2 = 0 \text{ volts}$$
$$Vo = Av_{in}$$

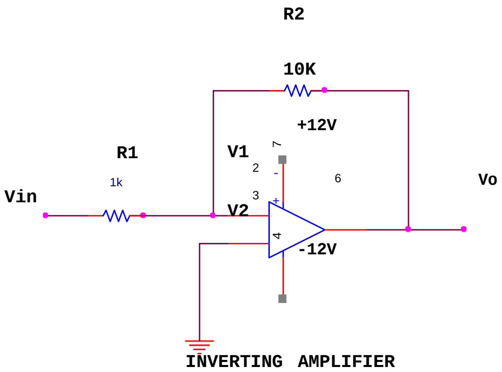
The output voltage is larger than the input voltage by gain A & is in phase with the input signal.

**Buffer amplifier**:-The lowest gain that can be obtained from a non-inverting amplifier with Unity feedback. When the non-inverting amplifier is for unity gain it is called a voltage follower because the output voltage is equal to and in phase with the input .In the Voltage follower the output follows the input Since the voltage follower is a special case of the non inverting amplifier, all the Formulae developed for the latter are applicable to the former aspect that the gain of the feedback circuit is UNITY.

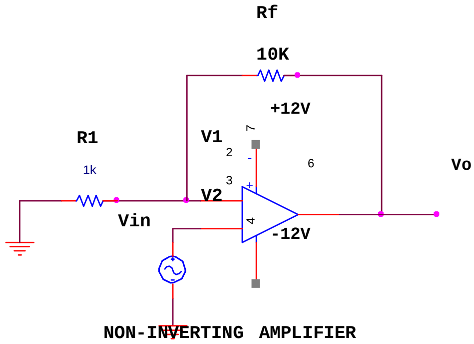
$$A_f = 1$$
$$R(if) = A\,Ri$$
$$R(of) = Ro/A$$
$$Vo = \pm Vsat/A$$
$$\text{Since } (1+A) \cong A$$

The voltage follower is also called a non inverting buffer because, when placed between two networks, it removes the loading on the first network.

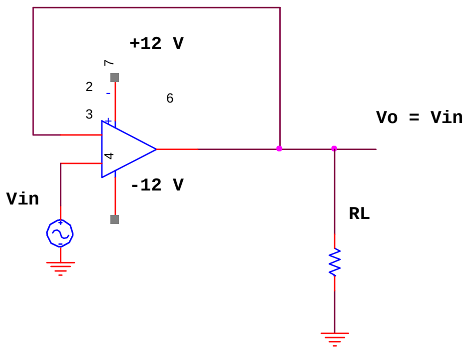
## CIRCUIT DIAGRAM: -




INVERTING AMPLIFIER




NON-INVERTING AMPLIFIER




BUFFER AMPLIFIER

## PROCEDURE: -

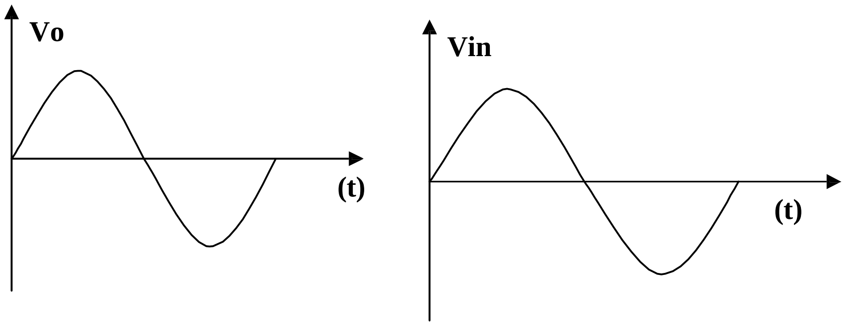
(1) Connect the circuit for inverting, non-inverting and buffer amplifier on a breadboard.
(2) Connect the input terminal of the op-amp to function generator and output terminal to CRO.
(3) Feed input from function generator and observe the output on CRO.
(4) Draw the input and output waveforms on graph paper.

## OUTPUT WAVEFORM:-

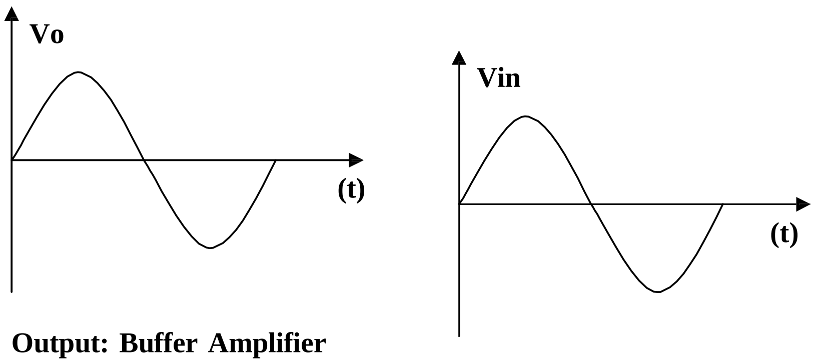
**Vo** **Vin**

**TIME (t)** **TIME (t)**

**Output: Inverting Amplifier**




**Output: Non- Inverting Amplifier**




**Output: Buffer Amplifier**

## PRECAUTIONS:-

1. Do not use open ended wires for connecting to 230 V power supply.
2. Before connecting the power supply plug into socket, ensure power supply should be switched off
3. Ensure all connections should be tight before switching on the power supply.
4. Take the reading carefully.
5. Power supply should be switched off after completion of experiment.

**DISCUSSIONS:-**What are the application of inverting, non-inverting and buffer amplifier?

**RESULT: -** Amplified output waveforms are obtained.

## QUIZ QUESTIONS WITH ANSWERS:-

Q1. What is the significance of a differential amplifier?
Ans. The differential amplifier is capable of amplifying dc as well as ac input signals.

Q2. what are the applications of a differential amplifier?
Ans. In instrumentation systems

Q3. What is the meaning of CMRR?

Ans. It is the ratio of the differential voltage gain $A_d$ to the common mode voltage gain $A_{cm}$.

Q4. What is the unit of CMRR?
Ans. Decibels (dB)

Q5. What is the value of CMRR for the 742 IC /
Ans. 90 dB

Q6. what is the gain of the inverting amplifier in terms of resistances?
Ans. Gain (- Rf/Ri)

Q7. what is the gain of the non- inverting amplifier in terms of resistances?
Ans. Gain = (1+Rf/Ri)

Q8. what is the condition for averaging amplifier?
Ans. Rf/Ri =1/n, where n is no. of inputs applied.

Q9. What is the effect of –ve feedback on the voltage gain of an amplifier?
Ans. Increases the stability of its voltage gain.

Q10. What is meaning of gain of an amplifier with feedback?
Ans. Closed loop voltage gain

# EXPERIMENT NO.5

**AIM: - Verify the operation of a differentiator circuit using op amp 741 and show that it acts as a high pass filter.**

**APPARATUS REQUIRED**:- CRO, Function Generator, ± 12 Supply, Connecting Leads, 741 IC, capacitor 0.1µf, resistor **1K∧,** Breadboard.

**THEORY: -** Differentiator circuit as its name implies, performs the mathematical operation of differentiation, that is, the output waveform is the derivative of the input. The differentiator may be constructed from a basic inverting amplifier when an input resistor $R_1$ is replaced by a capacitor C,

$$V_o = - R_f\, C\, dV_{in}/dt$$

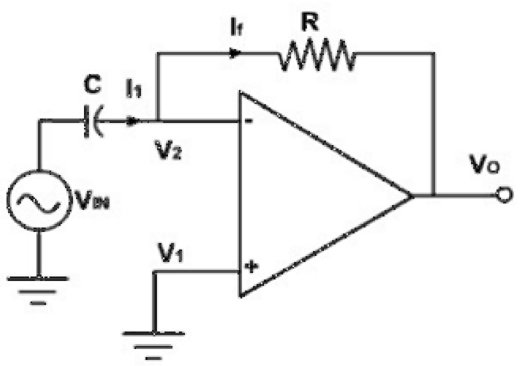
Thus, the output Vo is equal to the $R_f$ C times the negative instantaneous rate of change of the input voltage $V_{in}$ with time. The true differentiation is a form of high pass filtering.

$$H(j\omega) = -Z_f / Zi = -R_f /1/j\omega C$$

$$H(j\omega) = - R_f\, j\omega C$$

Magnitude of H (jω) is M (ω) = $\omega R_f C$ The function is very small at low frequencies but increases linearly as the frequency increases. This explanation indicates that true differentiator is a form of high, pass filtering.

**CIRCUIT DIAGRAM:-**



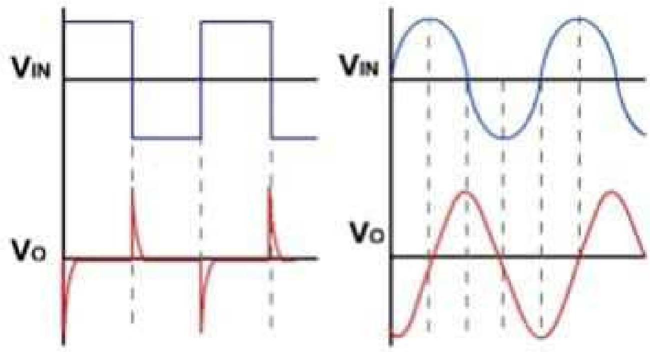

**PROCEDURE: -**

(1) Connect the circuit. according to the circuit diagram.
(2) Apply square wave to the input terminal of differentiator circuit.
(3) Set the input voltage at 1V peak to peak and frequency at 1 KHz.
(4) Note down the input and output waveform.

**OBSERVATION TABLE:-**

| S.NO | I/P Voltage Vin | O/P Voltage Vo | Frequency in KHz. | Gain=20log V0/Vin |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |

**GRAPH:-**




**PRECAUTIONS:-**

1. Do not use open ended wires for connecting to 230 V power supply.
2. Before connecting the power supply plug into socket, ensure power supply should be switched off
3. Ensure all connections should be tight before switching on the power supply.
4. Take the reading carefully.
5. Power supply should be switched off after completion of experiment.

**DISCUSSION: -** What is the application of differentiator?

**RESULT: -**Wave forms shows integrator is a high pass filter.

**QUIZ QUESTIONS WITH ANSWERS:-**

Q1.What is the differentiator?
Ans. The differentiator is that circuit in which o/p waveforms is the derivative of the input waveforms.

Q2. What is non-linear wave shaping?
Ans. Non-linear wave shaping is the process on applying any wave at input of a non-linear device, the shape of the output waves varies non-linearly with the input wave.

Q3. Give the application of a differentiator?
Ans. It is used in wave shaping circuits to detect high frequency components in an input signal and also as a rate of change of detector in F.M modulation.

Q4. What is the significance of input capacitor in a differentiator?
Ans. Input capacitor in a differentiator combines with feedback resister, selects lower cut off frequency.

Q5. When input of a differentiator is sine wave, then what is the output of the Differentiator ?
Ans. Cosine wave.

Q6. What is the condition of differentiator for proper operating?
Ans. $T > R_f C_1$.

Q7. When input of a differentiator is square wave, then what is the output of a differentiator?
Ans. Spikes waves

Q8. Give the examples of linear circuits.
Ans. Adder, Subtractor, Integrator, Differentiator

Q9. When a number of stages are connected in parallel, the overall gain is the product of the individual stage gains.
Ans. False statement

Q10. A filter that provides a constant output from dc up to a cutoff frequency and passes no signal above that frequency is called a__________filter.
Ans. Low-pass

# EXPERIMENT NO. 6

**AIM: - Verify the operation of Integrator circuit using op amp 741 and show that it acts as a low pass filter.**

**APPARATUS REQUIRED: -** CRO, Function generator, ±12V supply, 741 IC, Breadboard, Resistors10K∧, 1K∧, capacitor 0.1µf and connecting leads

**THEORY: -** A circuit in which the output waveform is the integral of the input wave is the integrator. Such a circuit is obtained by using a basic inverting amplifier configuration. If the feedback resistor $R_f$ is replaced by a capacitor C. The output voltage can be obtained by,

$$V_o = -\frac{1}{R C_f}\int V_{in}\, dt + C$$

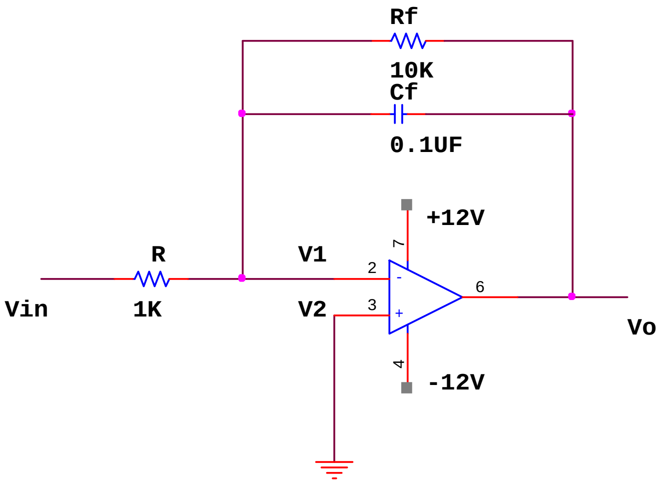
Where C is the integration constant and proportional to the value of the output Voltage Vo at time t = 0 sec. Thus, the output voltage is directly proportional to the negative integral of the input voltage and inversely proportional to the time constant R $C_f$. The convenient way to introduce the AC integration circuit is through frequency response and impedance consideration. The transfer function for the true integrator is given by

$$H(j\omega) = -Z_f / Z_i = \frac{-1/j\omega c}{R}$$

$$H(j\omega) = -1/ j\omega cR$$

Amplitude response, M (ω) = 1 / ωRC It is clear that integration is a form of low pass filtering i.e., the function is very large at low frequency and decreases as the frequency increases.

**CIRCUIT DIAGRAM: -**




**INTEGRATED CIRCUIT**

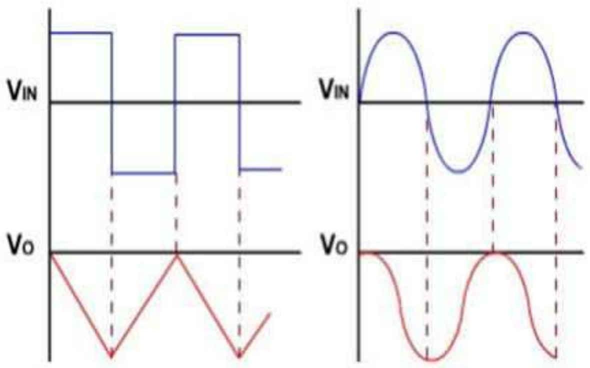
## PROCEDURE: -

(1) Connect the circuit according to the circuit diagram.
(2) Apply square wave to the input terminal of integrator circuit.
(3) Set the input voltage at 1V peak to peak and frequency at 1 KHz.
(4) Note down the input and output waveform.
(5) Draw the waveform on graph paper.

## OBSERVATION TABLE: -

| S.NO | I/P Voltage Vin | O/P Voltage Vo | Frequency in KHz. | Gain=20log Vo/ Vin |
|---|---|---|---|---|
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |
| | | | | |

## GRAPH:-




## PRECAUTIONS:-

1. Do not use open ended wires for connecting to 230 V power supply.
2. Before connecting the power supply plug into socket, ensure power supply should be switched off.
3. Ensure all connections should be tight before switching on the power supply.
4. Take the reading carefully.
5. Power supply should be switched off after completion of experiment.

**DISCUSSION: -** What is the application of integrator?

**RESULT: -** Waveforms shows Integrator acts as low pass filter.

**QUIZ QUESTIONS WITH ANSWERS:-**

Q1. What is the integrator?
Ans. The integrator is that circuit in which output voltage is equal to the –ve of integral of input voltage.

Q2. What is the input offset voltage?
Ans. Input offset voltage is the error voltage that occurs at the i/p of op-amp, which causes to produce o/p offset voltages.

Q3. Why we use capacitor Cf in feedback loops of the integrator?
Ans. The feedback capacitor Cf combine with Rf is used to select cut off voltage.

Q4. What is the relation between input and output voltage?
Ans. Output voltage Vo is equal to the –ve of integral of input voltage.

Q5. If input of the integrator is sine wave, then which type of waveforms will obtain at the output of the integrator?
Ans. Cosine wave

Q6. What is the effect of resistor $R_f$ that is connected across the feedback capacitor Cf in practical integrator?
Ans. The feedback resistor $R_f$ that remove the high frequency noise signals.

Q7. If input of the integrator is d.c. voltage, then which type of waveforms will be obtained at the output of the integrator?
Ans. Ramp waveforms.

Q8. If input of the integrator is square wave , then, which type of waveforms will be obtain at the output of the integrator.
Ans. Triangular waveforms

Q9. What are the applications of an integrator?
Ans. It is used in analog computer, ADC, signal wave shaping circuits.

Q10. What is the effect of input bias current?
Ans. Input bias current produces output offset voltage at the output of an op-amp.

# EXPERIMENT NO. 7

**AIM: - Design & verify the operations of op amp adder and subtractor circuit.**

**APPARATUS REQUIRED:-** CRO, function generator, ± 12V supply, breadboard, 741 IC, resistors 1KΩ (7 pieces), and Connecting leads.

## THEORY: -

**Adder: -** If the input to the inverting amplifier is increased, the resulting circuit is known as Adder. Output is a linear summation of number of input signals. Each input signal produces a component of the output signal that is completely independent of the other input signal. When there are two inputs i.e.

$$Vo = -(V1 + V2)$$

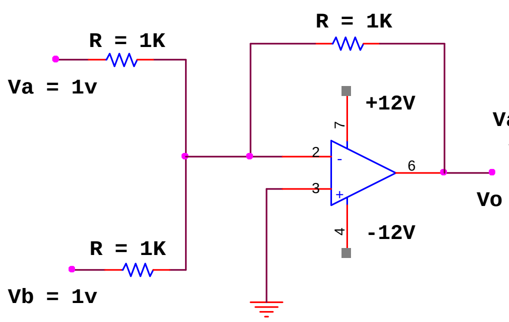
This is the inverted algebraic sum of all the inputs. If we connect the inputs to non-inverting, terminal then the adder is non-inverting adder.

**Subtractor: -** A circuit that finds the difference between two signals is called a subtractor. The two inputs are applied at the inverting & non-inverting terminal of op-amp. If all external resistance are equal in value, so the gain of the amplifier is equal to 1.The output voltages of the differential amplifier with a gain of unity is,

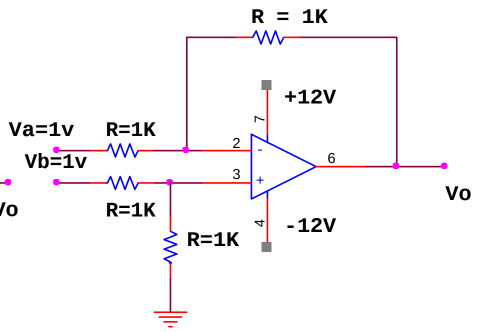
$$Vo = -R\backslash R(Va-Vb)$$

$$Vo = (Vb-Va)$$

## CIRCUIT DIAGRAM: -




ADDER

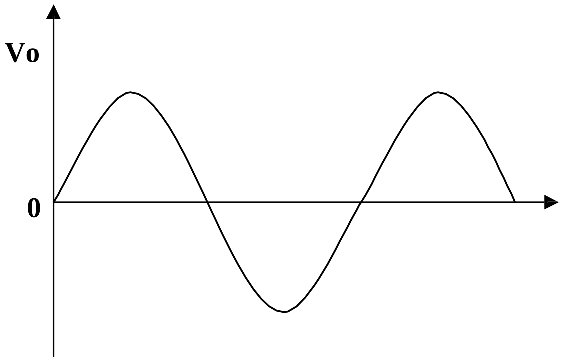



SUBTRACTOR

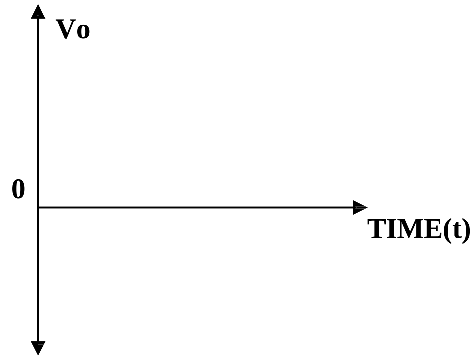
## PROCEDURE: -

(1) Apply two different sine waves signal to the input of the adder and subtractor.
(2) Give the input amplitude of 5v peak to peak and frequency of 1 kHz.
(3) Verify the output on CRO.

## WAVE FORM: -




**ADDER**




**SUBTRACTOR**

## PRECAUTIONS:-

1. Do not use open ended wires for connecting to 230 V power supply.
2. Before connecting the power supply plug into socket, ensure power supply should be switched off
3. Ensure all connections should be tight before switching on the power supply.
4. Take the reading carefully.
5. Power supply should be switched off after completion of experiment.

**DICUSSION:-**Name the areas where adder and sub tractor circuits are used.

**RESULT: -** Output is a true replica of the subtraction values of the two inputs and addition of two input values.

## QUIZ QUESTIONS WITH ANSWERS:-

Q1. What is adder?
Ans. Adder is that circuit which adds the magnitude of input signals.

Q2. What is scaling amplifier?
Ans. Scaling amplifier is that circuit in which each i/p is amplified by a weighted differently at the o/p and values of resistors are different.

Q3. What is average amplifier?
Ans. Average amplifier is that circuit in which each output is equal to the average of all the input voltage and the gain by which each input is amplified must be equal to 1 over the number of inputs.

Q4. What is the subtractor?
Ans. Subtract or is that circuit which subtracts the magnitude of input signals.

Q5. What is the use of offset minimizing resistor Rom?
Ans. To reduce the effect of i/p bias current on the o/p offset o/p.

Q6. What is gain of the inverting amplifier?
Ans. AF= - Rf / Ri

Q7. What are the applications of subtractor?
Ans. Computer, calculators, microprocessor.

Q8. what is the use of offset null compensating network in the adder?
Ans. To improves the accuracy of the adder.

Q9. What is the gain of an inverting amplifier?
Ans. Output voltage is equal to the –ve of ratio of feedback and i/p resistance.

Q10. What are the applications of adder?
Ans. Computer, calculators, microprocessor.

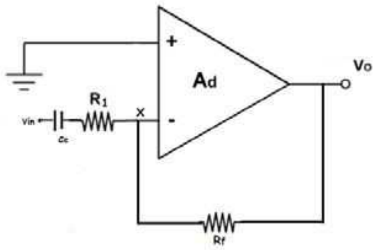
# EXPERIMENT NO.8

**AIM:-Plot frequency response of ac coupled amplifier using opamp 741 and study the effect of negative feedback on the bandwidth and gain of the amplifier.**

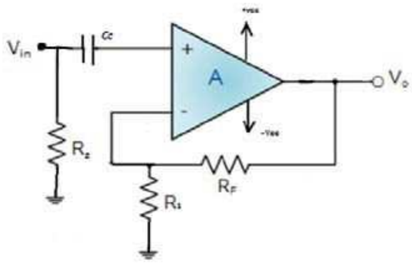
**APPARATUS REQUIRED: -** CRO, Function Generator, Bread Board, 741 IC, ±12V supply, resistors 1K⋀, 10K⋀, capacitors and connecting leads.

**THEORY:-**Inverting and non inverting amplifier respond to both ac and dc. For studying only ac frequency response, or if the ac input signal is superimposed on some dc level, it is necessary to block dc component, by using ac coupling capacitor. Two types of AC amplifier:-

1) Inverting
2) Non inverting




Inverting AC amplifier




Non-Inverting AC amplifier

**PROCEDURE: -**

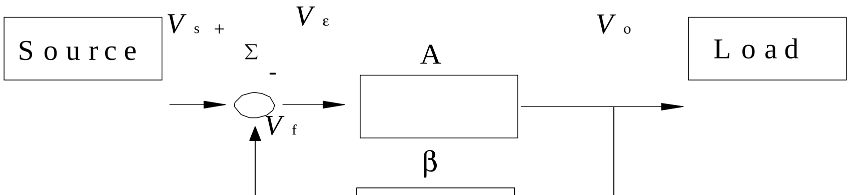
(1) Set the input voltage at 1V peak to peak and frequency at 1 KHz.
(2) Varying the frequency of the input signal from 10Hz to1MHz.
(3) Measure the output signal amplitude.
(4) Draw the frequency response characteristics of AC coupled amplifier.

**OBSERVATION TABLE:-**

| S.NO. | FREQUENCY (Hz) | OUTPUT VOLTAGE (Vout) | GAIN (Vout/ Vin) IN dB |
|---|---|---|---|
| | | | |

| | | | |
|---|---|---|---|

## EFFECT OF NEGATIVE FEEDBACK ON GAIN AND BANDWIDTH:-




$A$: Open Loop Gain $A = V_o / V_\varepsilon$

β : Feedback factor $\beta = V_f / V_o$

Negative feedback takes a sample of the output signal and applies it to the input to get several desirable properties. In amplifiers, negative feedback can be applied to get the following properties

- – Desensitized gain : gain less sensitive to circuit component variations
- – Reduce nonlinear distortion : output proportional to input (constant gain independent of signal level)
- – Reduce effect of noise
- – Control input and output impedances by applying appropriate feedback topologies
- – Extend bandwidth of amplifier

All of these properties can be achieved by trading off gain

**NEGATIVE FEEDBACK**: - If the signal fed back is of opposite polarity or out of phase by 180° (or odd integer multiple of 180°) with respect to input signal, feedback is called negative feedback.

- Negative feedback is also known as **degenerative feedback** because when used it degenerates (reduces)the output voltage amplitude and in turn reduces the voltage gain.

**USES:**

- When used in amplifier, negative feedback stabilizes the gain, increases the bandwidth and changes the input and output resistances, reduced voltage gain, decrease in non linear distortion and reduces the effect of variations in temperature and supply voltages on the output of op-amp.

## RESULT:-

(a) Frequency response curve of AC coupled amplifier has been plotted
(b) Negative feedback increases the bandwidth and stabilizes the gain.

## QUIZ QUESTIONS WITH ANSWERS:-

Q1. What is feedback in amplifiers?
Ans. The process of combining a fraction of output energy back to the input is called feedback.

Q2. What is the application of negative feedback amplifier?
Ans. Negative feedback amplifier makes the circuit stable.

Q3. What is voltage series feedback amplifier?
Ans. It is that amplifier in which output voltage feedback in voltage series with input Signal, resulting in an overall gain reduction.

Q4. By Which factor reduces the input noise & non-linear distortions of the amplifier?
Ans. $(1+A\beta)$

Q5. what is the effect of frequency on phase shift of an amplifier?
Ans. Shift of an amplifier will change with frequency.

Q6. How does negative feedback increase bandwidth of an amplifier?
Ans. The bandwidth of an amplifier without feedback is equal to separation between 3 db frequencies f1 and f2. If A is the gain, then gain bandwidth product is A* BW. With the negative feedback the amplifier gain is reduced and since gain bandwidth product has to remain constant in both cases, so the bandwidth will increase to compensate for the reduction in gain.
Q7.How do series and shunt feedback differ from each other?
Ans. Series means feedback connecting in series with input signal while shunt means feedback connecting in shunt with input signal.

Q8. Distortion in an amplifier with negative feedback increases or decreases?
Ans. Decreases

Q9. Feedback in an amplifier always helps to
Ans. Control its output

Q10.When negative feedback is applied to an amplifier, its bandwidth:
Ans. Increased.

# EXPERIMENT NO.9

**AIM: -Study of IC 555 as astable and monostable multivibrator.**

**APPARATUS REQUIRED: -** IC 555

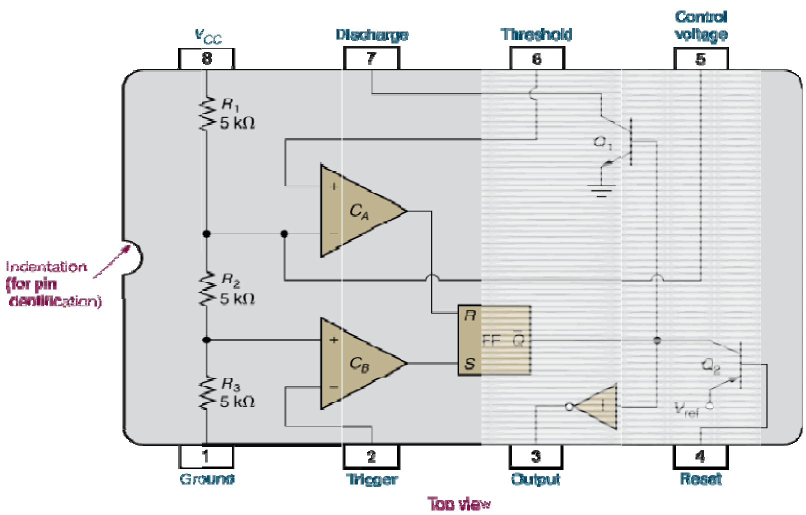
**THEORY: -**

**555 timer** – An 8-pin IC designed for use in a variety of switching applications.
**Multivibrator** – A circuit designed to have zero, one, or two stable output states. There are three types of multivibrators:

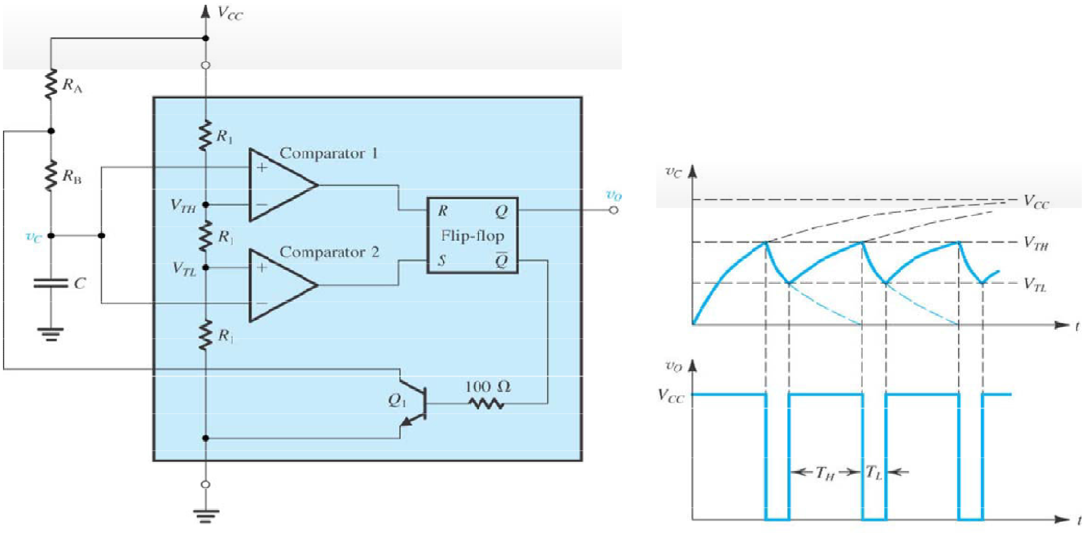
- Astable (or Free-Running Multivibrator)
- Monostable (or One-Shot)
- Bistable (or Flip-Flop)

**Astable multivibrator** – A switching circuit that has no stable output state. The astable multivibrator is a rectangular wave oscillator. Also referred to as a free-running multivibrator.
**Monostable multivibrator** – A switching circuit with one stable output state. Also referred to as a one-shot. The one-shot produces a single output pulse when it receives a valid input trigger signal.
**Bistable multivibrator** – A switching circuit with two stable output states. Also referred to as a flip-flop. The output changes state when it receives a valid input trigger signal, and remains in that state until another valid trigger signal is received.

**PIN CONFIGURATION OF IC 555:-**

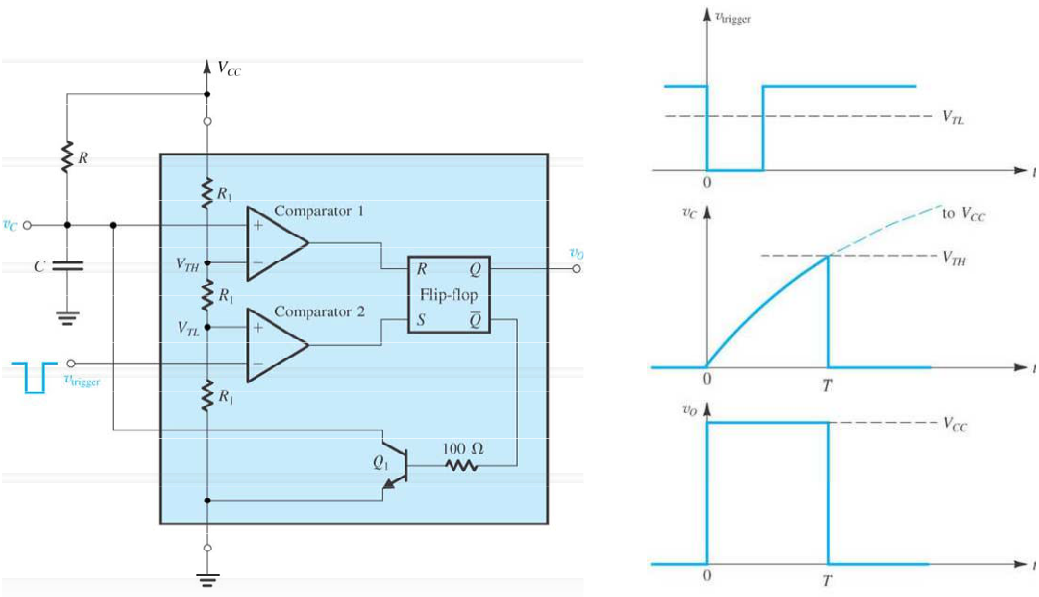


**CIRCUIT DIAGRAM & WAVEFORM OF ASTABLE MULTIVIBRATOR: -**




(a) (b)

**CIRCUIT DIAGRAM & WAVEFORM OF MONOSTABLE MULTIVIBRATOR: -**




(a) (b)

**RESULT: -** Astable and monostable multivibrator has been studied.

## QUIZ QUESTIONS WITH ANSWERS:-

Q1. Why astable multivibrator is known as free running multivibrator?
Ans. A multivibrator that generates square wave of its own is known as astable multivibrator. This has no stable state. There are two quasi stable states. The circuit changes automatically from one quasi state to another without any external triggering pulse. Thus it is just an oscillator since it does not require any external pulse for its operation so it is known as free running multivibrator.

Q2.In an astable multivibrator, the frequency of output mainly depends on:
Ans. Values of R and C in circuit.

Q3. A monostable multivibrator has:
Ans. only one stable stage

Q4. A bistable multivibrator has:
Ans. two stable stages

Q5. A circuit that generates square wave is called:
Ans. Astable multivibrator

Q6. What is the use of reset pin in IC 555?
Ans. Reset pin controls flip flop directly.

Q7. What is the use of discharge pin in IC 555?
Ans. discharge pin used for discharging the capacitor.

Q8. What are the applications of multivibrators?
Ans: (i) used to generate square wave and pulse generator
(ii) used as frequency dividers
(iii) used in radar and TV circuits

Q9.Which type of feedback is used in multivibrator?
Ans: A multivibrator circuit is essentially an amplifier with 100% positive feedback.

Q10. How many states in switch?
Ans: Two

# EXPERIMENT NO.10

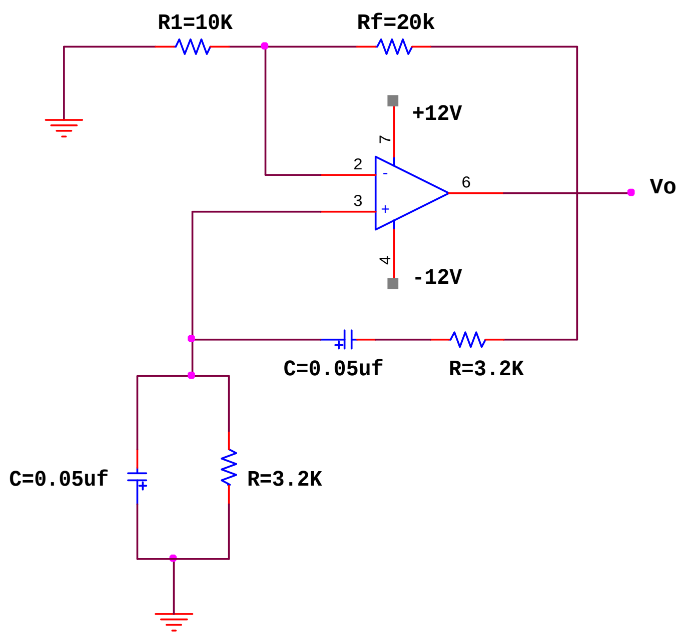
**AIM: - Design and realize using op amp741, wein bridge oscillator.**

**APPARATUS REQUIRED:-** Bread board, CRO, ± 12V power supply, Resistors 10K⋀, 20K⋀, 3.2K⋀, 0.05µf, and connecting leads.

**THEORY: -** In Wein bridge oscillator, Wein bridge circuit are connected between amplifier input and output terminal. The bridge have a series RC network in one arm and a Parallel RC network in adjoining arm, on the remaining two arms of bridge, resistor $R_1$ and $R_f$ are connected. The phase angle criterion for oscillator is that the total phase shift around the circuit must be 0°.This condition occurs only when the bridge is balanced, i.e. at resonance. The frequency of oscillation $f_0$ is exactly the resonant frequency of the balanced wein bridge and is given by

$$f_0 = 1/2\pi RC = 0.159/RC$$

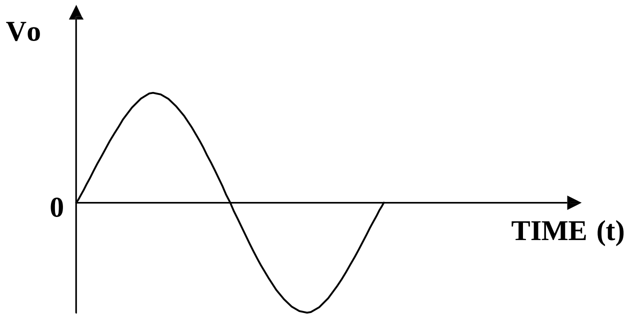
**CIRCUIT DIAGRAM:-**




WEIN BRIDGE OSCILLATOR

**PROCEDURE: -**
(1) Connect the circuit as per the circuit diagram.
(2) Switch 'on' the power supply.
(3) Output of the circuit is shown on CRO.

## WAVE FORM: -




## PRECAUTIONS:-

1. Do not use open ended wires for connecting to 230 V power supply?
2. Before connecting the power supply plug into socket, ensure power supply should be switched off
3. Ensure all connections should be tight before switching on the power supply.
4. Take the reading carefully.
5. Power supply should be switched off after completion of experiment.

**DICUSSION: -** Wein bridge oscillator generates sine wave forms.

**RESULT: -** Sine wave is generated on CRO.

## QUIZ QUESTIONS WITH ANSWERS:

Q1. What is the oscillator?
Ans. The oscillator is a circuit that generates repetitive waveforms of fixed amplitudes and frequency without any external i/p signal.

Q2. What is the application of the oscillator?
Ans. A radio, T.V., Computers and communications.

Q.3 what is the principle of the oscillator?
Ans. If the signal feedback is of proper magnitude and phase, the circuit produces alternating currents or voltage.

Q4. what are the two requirements for oscillation?
Ans. 1. Magnitude of the loop gain must be at least 1
2. Total phase shift of the loop gain must be equal to 0 or 360 degree.

Q5. What is frequency stability?
Ans. The ability of the oscillator circuit to oscillate at one exact frequency is frequency stability.

Q6. What is the total phase for oscillation?
Ans. 360 or 0 degree.

Q7. What is the condition for wein bridge oscillator to balance?
Ans. Total phase shift around the circuit must be 0 degree.

Q8. What is wein bridge oscillator?
Ans. Wein bridge oscillators that circuit in which the wein bridge circuit is connected between the amplifiers i/p terminals and the o/p terminals.

Q9. Which type of feedback used in oscillator?
Ans. +ve feedback

Q10. What is the frequency response for a wein bridge oscillator?
Ans. F= 0.159/RC

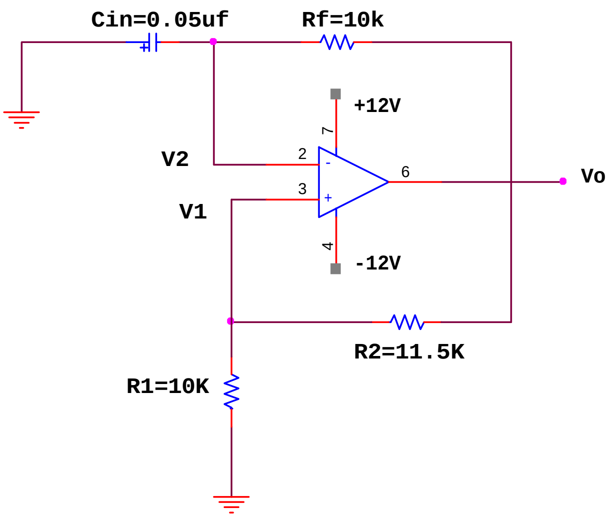
# EXPERIMENT NO.11

**AIM: - To design and realize using op amp741, square wave generator.**

**APPARATUS REQUIRED: -** Power supply, CRO, Function Generator, Connecting Leads, Breadboard, 741 IC, Resistance (10K∧, 11.5K∧), 0.05μf capacitor.

**THEORY: -** Square Waves are generated when the Op-Amp is forced to operate in the saturation region. That is, the output of the op-amp is forced to swing respectively between $+V_{sat.}$ and $-V_{sat}$. resulting in the generation of square wave. The square wave generator is also called a free- running or astable multivibrator. Assuming the voltage across capacitor C is zero at the instant the d.c Supply voltage at +Vcc and $-V_{EE}$ are applied. Initially the capacitance C acts, as a short circuit. The gain of the Op-Amp is very large hence $V_1$ drives the output of the Op-Amp to its saturation.

**CIRCUIT DIAGRAM: -**

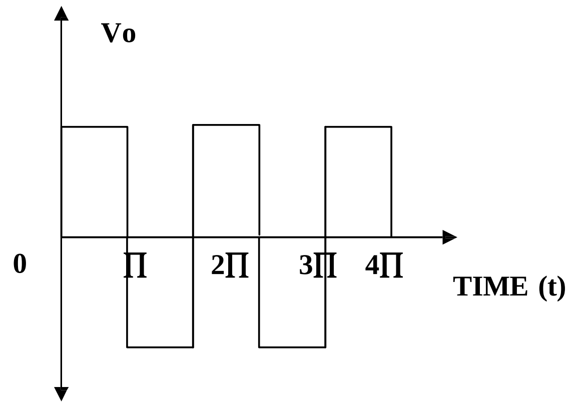



SQUARE WAVE GENERATOR

**PROCEDURE: -**

(1) Connect the circuit as shown in figure Switch ‘ON’ the supply.
(2) No. Input signal is feed from the generator. It is self-generating.
(3) Frequency can be varied by changing RC combination.
(4) Output is obtained at Pin 6 of op-Amp.

## WAVE FORM:




## PRECAUTIONS:-

1. Do not use open ended wires for connecting to 230 V power supply.
2. Before connecting the power supply plug into socket, ensure power supply should be switched off.
3. Ensure all connections should be tight before switching on the power supply.
4. Take the reading carefully.
5. Power supply should be switched off after completion of experiment.

**DICUSSION:-**What is the application of squire wave generator.

**RESULT: -** Squire Wave is obtained on CRO.

## QUIZ QUESTIONS WITH ANSWERS:-

Q1.What is square wave generator?
Ans. In this circuit, square wave output is generated when the op-amp is forced to Operates in the saturated region.

Q2.What is other name of square wave generator?
Ans. Free running or a stable multivibrator.

Q3**.** Give the application of a square wave generator
Ans. To generate square wave form at the output of a square wave generator.

Q4. What is the use of zener diode?
Ans. To set amplitude of square wave at the input of a square wave generator.

Q5. What is the effect of slew rate of the op-amp in the square wave generator?
Ans. The highest frequency generated by square wave generator is set by slew rate of the op-amp.

Q6. Which type of wave forms obtained at the output of a square wave generator?
Ans. Square wave waveforms

Q7. When input of a square wave generator is a D.C signal, then what is the output of a square wave generator?
Ans. Ramp signal.

Q8. What is the comparator?
Ans. Comparator compares two input signal i.e. know voltage with a reference voltage.

Q9. What are the applications of a comparator?
Ans. Analog to digital converter (ADC), Schmitt Trigger.

Q10. Which component is required to convert a square wave into a triangular wave?
Ans. Integrator.

# EXEPERIMENT NO.12

**AIM: - To design and realize using op amp 741, logarithmic amplifier & VCCS.**

**APPARATUS REQUIRED**: - CRO, function generator, breadboard, resistor 10K$\wedge$, 1 K$\wedge$ and 12V supply, diode IN 4007 and connecting leads.

**THEORY OF LOGARITHMIC AMPLIFIER:** - In fig., there is an op-amp with the feedback resister R replaced by the diode D. Logarithmic amplifier is used when it is desired to have the output voltage proportional to the logarithm of the input voltage. We know from the volt-ampere diode characteristic

$$\text{If} \quad I = I_o\,(e^{Vf/nVt} - 1)$$

$$I = I_o\,e^{Vf/nVt}$$

Provided that $V_f/nV_t >> 1$ or $If >> Io$. Hence

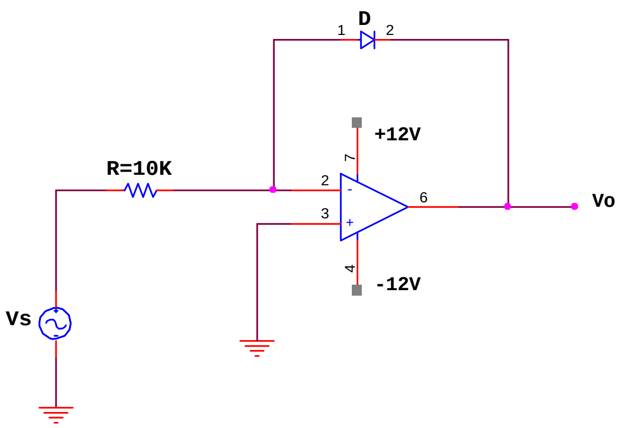
$$V_f = nVt\,(I_n\,I_f - I_n\,I_o) \quad \text{---------} \quad (1)$$

Since $I_f = I_s = V_s/R$ due to the virtual ground at the amplifier input, then

$$V_o = -V_f = -nVt\,(I_n\,V_s/R - I_n\,I_o) \quad \text{------------} \quad (2)$$

From Eq$^n$. (2) the output voltage $V_o$ is temperature dependent due to the scale factor $nV_t$ and to the saturation current Io.

**CIRCUIT DIAGRAM:-**




LOGARITHMIC AMPLIFIER

**PROCEDURE: -**

(1) Connect the circuit on the breadboard as per circuit diagram.
(2) Switch on the power supply and observe the output waveform on the CRO.

## WAVE FORM: -

**Vi**

**V0**

**0**

**π** **2π** **3π** **TIME (t)0**

## THEORY OF VCCS (VOLTAGE CONTROLLED CURRENT SOURCE):-

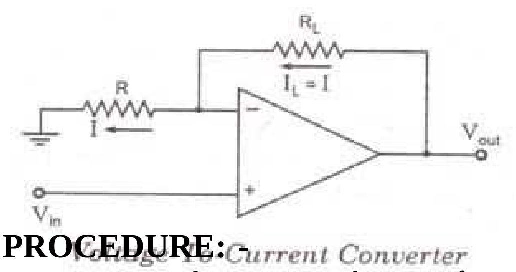
In many applications, one may have to convert a voltage signal to a proportional output current. A circuit which can perform this job is called a voltage –to- current converter. For this, there are two types of circuits possible:

V-I Converter with floating load
V-I Converter with grounded load

$I_L = I = V_{in} / R$

From above Eq. it is obvious that the output current $I_L$ is independent of load resistance $R_L$ and is proportional to the input voltage $V_{in}$ . This is because of the virtual ground at the inverting input terminal of the op-amp. Such a circuit is employed in analog-to- digital converter (ADC).One good thing about the Op-amp. Voltage –to- current converter is that it can be driven by a voltage source which is itself not capable of supplying the load current called $I_L$. This is because the voltage source only has a drive a Non- inverting Op-amplifier, whose input impedance is very high. The load current itself is supplied by the Op-amplifier.

## CIRCUIT DIAGRAM: -




## PROCEDURE: -

Voltage To Current Converter

1. Connect the circuit as shown in figure Switch ‘ON’ the supply.
2. A voltage is given to the input pin.
3. Output is obtained at Pin 6 of op-Amp.

## PRECAUTIONS:-

1. Do not use open ended wires for connecting to 230 V power supply
2. Before connecting the power supply plug into socket, ensure power supply should be switched off
3. Ensure all connections should be tight before switching on the power supply.
4. Take the reading carefully.
5. Power supply should be switched off after completion of experiment.

**DICUSSION: -** How can we use logarithmic amplifier as a clipper circuit?
How VCCS is ideal circuit for low voltage dc and ac voltmeters?

**RESULT:** -Output is the negative of the log of an input.
In VCCS, load current depends upon the input voltage Vin and resistor R.

## QUIZ QUESTIONS WITH ANSWERS:-

Q1. what is sample and hold circuit?
Ans. A sample and hold circuit samples an input signal and holds on to its last sampled value until the input sampled again.

Q2. what is the application of sample and hold circuit?
Ans. Digital interfacing, ADC, pulse code modulation system.

Q3. what is the application of logarithmic amplifier?
Ans. Calculator, computer.

Q4. what is the function of a diode in a feedback loop in a logarithmic amplifier?
Ans. In logarithmic amplifier circuit, diode acts as clipper.

Q5. what is the other name of clamper?
Ans. DC inserter or restorer.

Q6. what is the use of resistor R in clamper?
Ans. The resistor R is used to protect the OP-AMP. Against excessive discharge current from capacitor especially when the DC supply voltages are switched off.

Q7. What is positive clipper?
Ans. Positive calipers are one which removes the positive half cycles of the input voltage.

Q8. what is negative clipper?
Ans. Negative calipers are one which removes negative half cycles of the input voltage.

Q9. what is clamping?
Ans. A circuit that places either the positive or negative half cycles of the input voltage.

Q10. How many types of clampers are there?
Ans. There are two types of clampers

(1) Positive clamper
(2) Negative clamper

Q11. What is current to voltage converter?
Ans: A device that produces a voltage proportional to input signal current is called I to V converter.

Q12. What are the applications of VCCS?
Ans; It is an ideal circuit for low voltage dc and ac voltmeter, LED and zener diode tester.

Q13. What are the applications of I to V converter?
Ans: used in sensing current from photodetectors and in digital to analog converter.

Q14. what is Voltage to Current converter.
Ans. A circuit that produces output current proportional to input voltage.

Q15. How many types of voltage to current converter are there?
Ans. There are two types of voltage to current converter: With floating load and with grounded load.

Q16. What is good thing about op-amp.
Ans. It I can be driven by a voltage source which itself is not capable of supplying the load current.

Q17. In V-C converter output current is proportional to,
Ans. The light flux.

Q18. what is the equation of output current,
Ans. I=Vin/R

# EXPERIMENT NO: 13

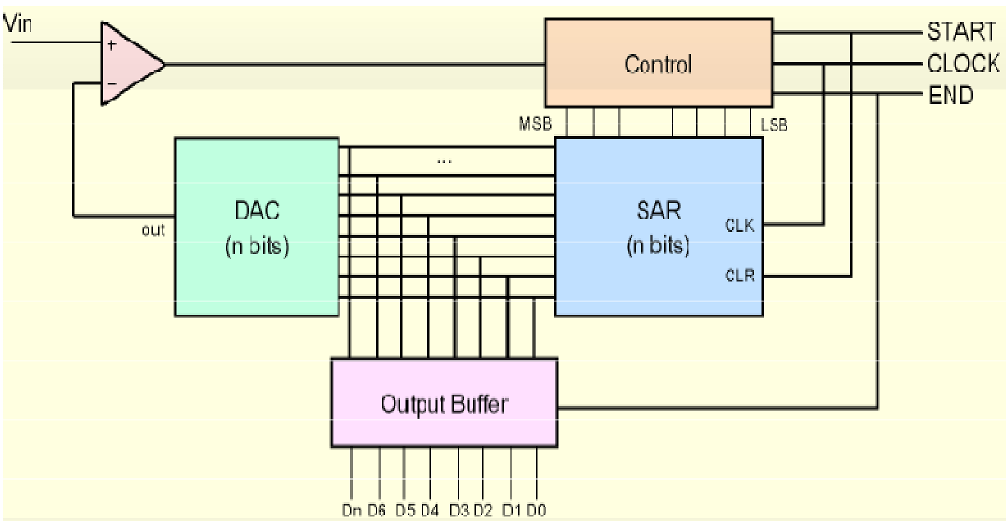
**AIM: -Study of 8-bit monolithic Analog to digital converter.**

**APPARATUS REQUIRED: -** ST2601 with power supply cord, Connecting Cords

**THEORY: -** Successive approximation ADC uses one or a few comparators, operated iteratively, to yield high accuracy conversion with far fewer components than flash conversion.

A/D converter using successive approximation technique effectively performs a binary search in a digital analog look up table and using a digital to analog converter (DAC) and comparator circuit. Successive approximation converters also allow higher resolutions but tend to be slower since they usually require N cycles to produce the answer. Successive approximation ADC operates at much slower conversion rates than flash ADC. Sub ranging analog to digital converters provide an intermediate compromise between flash ADCs and successive approximation ADCs. Sub ranging analog to digital converters typically use a low resolution flash quantizer during a first or coarse pass to convert the analog input signal into the most significant bits (MSB) of its digital value. A digital to analog converter (DAC) then generates an analog version of the MSB word. The residue signal is sent through one or more fine passes to produce the lower significant bits of the input signal. The lower significant bits and the MSB word are then combined by digital error correcting circuitry to produce the desired digital output word. A switched capacitor analog to digital converter (ADC) operated according to successive approximation register technique comprises a plurality of weighted capacitors with associated switches and a local DAC. The capacitors are charged by a voltage sample of an analog signal to be converted. The voltage sample is compared with an analog signal generated by the local DAC.

**CIRCUIT DIAGRAM:-**



## PROCEDURE:-

1. Connect supply to the trainer.
2. Make the connections as shown in figure.
   a. Connect the USB/ BOB to GND.
   b. Connect the DC output to $V_i$ of Monolithic converter.
   c. Keep the DC potentiometer in counterclockwise direction.
   d. Keep the Auto /Manual switch in Auto position.
3. Switch ON the power supply.
4. Vary the DC potentiometer and observe the corresponding digital output on LEDs.
5. Now keep the Auto /Manual switch in Manual position.
6. Keep the Blank / Convert switch in Blank position
7. Vary the DC potentiometer
8. Set the switch to convert position, The LEDs will light forming a digital word which corresponds to the digital conversion of the analog voltage applied to the input.
9. Perform the same procedure with different DC voltages.
10. Now, connect the USB / BOB terminal to +5V and bipolar o/p to Vi. This gives Output voltage from +2.5V to -2.5V.
11. Keep the switch in Auto position.
12. Vary the Bipolar potentiometer from -2.5V to +2.5V, and note the corresponding digitized outputs.
13. Set the Auto / Manual switch to manuals position.
14. Keep the Blank / Convert switch to blank position.
15. Now to observe the conversion you have to throw the switch to convert position.
16. Perform the experiment with various DC inputs.

**RESULTS:-**According to applied input signal in form of DC level it provides the digital signals in 1 and 0 forms.

## QUIZ QUESTIONS WITH ANSWERS:-

Q1. What is Analog to digital converter?
Ans: Analog to Digital Converters (ADC) is device that converts continuous signals to discrete digital numbers.

Q2. How many types of analog to digital converters are there?
Ans: Analog to Digital Converters is commonly of two types.

- Linear Analog to Digital Converter is designed to produce an output which is a linear function or proportional to the output.
- The other common type of Analog to Digital Converter is the Logarithmic Analog to Digital Converter, which functions by using voiced communications systems to increase the entropy of the digitized signal.

Q3. Why to use analog to digital converter?
Ans: A digital signal is superior to an analog signal because it is more robust to noise and can easily be recovered, corrected and amplified. For this reason, the tendency today is to change an analog signal to digital data.

Q4. What are the steps to execute the process of analog to digital converter?
Ans: Analog to digital converter process is executed in three steps:
1. Sampling
2. Quantizing
3. Coding

Q5. What do you mean by sampling?
Ans: To convert continuous time signal to discrete time signal, a process is used called as sampling.

Q6. What is sampling theorem?
Ans: The Sampling Theorem states that a signal can be exactly reproduced if it is sampled at a frequency Fs , where Fs is greater than twice the maximum frequency Fmax in the signal.

$$Fs > 2 \cdot Fmax$$

Q7. Which of the following is a type of error associated with digital-to-analog converters (DACs)?
Ans. nonmonotonic and offset error

Q8. A 4-bit R/2R digital-to-analog (DAC) converter has a reference of 5 volts. What is the analog output for the input code 0101.
Ans. 3.125V

Q9. What is the resolution of a digital-to-analog converter (DAC)?
Ans. It is the smallest analog output change that can occur as a result of an increment in the digital input.

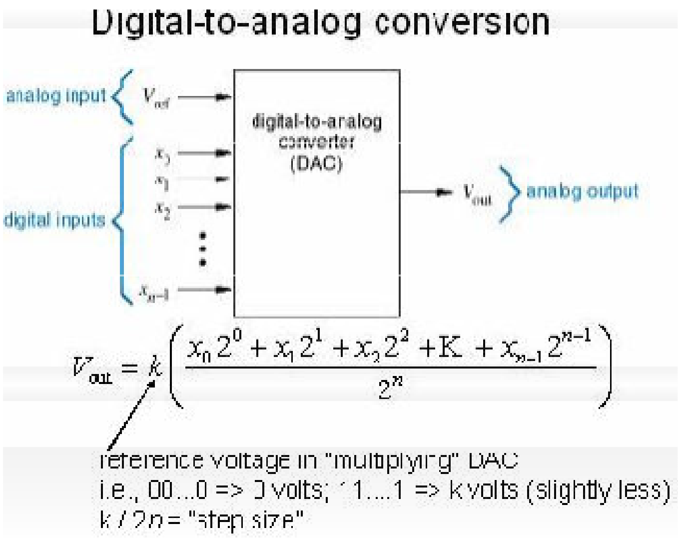
Q10. The practical use of binary-weighted digital-to-analog converters is limited to:
Ans: 4-bit D/A converters

# EXPERIMENT NO: 14

**AIM: -Study of R-2R ladder network and 8-bit monolithic digital to analog converter.**

**APPARATUS REQUIRED: -** ST2602 with power supply cord, Connecting Cords.

**THEORY: -**The digital to analog converters compose the devices transforming a digital word, binary encoded and generated for example by a computer, into a discrete analog signal, in the sense that to every input digital word a single output analog value corresponds.




**PROCEDURE:-**

1. Connect the power supply to the board.
2. Connect the $D_0$- $D_3$ of the logic switches to the corresponding jacks $B_0$-$B_3$ of the converter.
3. Set the switches $S_0$-$S_3$ to logic level 0.
4. Connect the $V_{REF}$ socket to +5V.
5. Connect a Multi meter as voltmeter for DC, to the output $V_0$ of the converter.
6. Switch the logic switches in binary progression & measure & record the output voltage in correspondence of every combination of the input code.
7. With input code $S_3$ $S_2$ $S_1$ $S_0$ = 0000 the output voltage $V_O$ has to be null: eventual little deviations against zero are due to the operational amplifier offset.
8. Switch off the power supply.

## OBSERVATION TABLE: -

| S0 | S1 | S2 | S3 | Vo(V) |
|---|---|---|---|---|
| 0 | 0 | 0 | 0 | |
| 0 | 0 | 0 | 1 | |
| 0 | 0 | 1 | 1 | |
| 0 | 0 | 1 | 1 | |
| 0 | 1 | 0 | 0 | |
| 0 | 1 | 0 | 1 | |
| 0 | 1 | 1 | 0 | |
| 0 | 1 | 1 | 1 | |
| 1 | 0 | 0 | 0 | |
| 1 | 0 | 0 | 1 | |
| 1 | 0 | 1 | 0 | |
| 1 | 0 | 1 | 1 | |
| 1 | 1 | 0 | 0 | |
| 1 | 1 | 0 | 1 | |
| 1 | 1 | 1 | 0 | |
| 1 | 1 | 1 | 1 | |

**RESULT:-**As per the applied inputs through the switches then according to the reference voltage the output voltage is generated in analog form.

## QUIZ QUESTIONS:-

Q1.The difference between analog voltage represented by two adjacent digital codes, or the analog step size, is the:
Ans: Resolution

Q2. The primary disadvantage of the flash analog-to digital converter (ADC) is that:
Ans: a large number of comparators is required to represent a reasonable sized binary number

Q3.What is the major advantage of the R/2R ladder digital-to-analog (DAC), as compared to a binary-weighted digital-to-analog DAC converter?
Ans. It only uses two different resistor values.

Q4. The resolution of a 0–5 V 6-bit digital-to-analog converter (DAC) is:
Ans. 1.56 %

Q5. In a flash analog-to-digital converter, the output of each comparator is connected to an input of a:
Ans. Priority Encoder

Q6. Which is not an analog-to-digital (ADC) conversion error?
Ans. differential nonlinearity

Q7. Sample-and-hold circuits in analog-to digital converters (ADCs) are designed to:
Ans. stabilize the input analog signal during the conversion process

Q8. A 4-bit R/2R digital-to-analog (DAC) converter has a reference of 5 volts. What is the analog output for the input code 0101.
Ans. 3.125V

Q9. What is the resolution of a digital-to-analog converter (DAC)?
Ans. It is the smallest analog output change that can occur as a result of an increment in the digital input.

Q10. The practical use of binary-weighted digital-to-analog converters is limited to:
Ans: 4-bit D/A converters

# ELECTRONIC MEASUREMENT & INSTRUMENTATION LAB

**(EE-323-F)**

**LAB MANUAL**

**V SEMESTER**

## LIST OF EXPERIMENTS

| S.No. | NAME OF THE EXPERIMENT |
|---|---|
| 1 | TO STUDY BLOCKWISE CONSTRUCTION OF A ANALOG OSCILLOSCOPE & FUNCTION GENERATOR. |
| 2 | TO STUDY BLOCKWISE CONSTRUCTION OF A MULTIMETER & FREQUENCY COUNTER. |
| 3 | TO STUDY MEASUREMENT OF DIFFERENT COMPONENTS AND PARAMETERS LIKE Q OF A COIL USING LCR Q-METER. |
| 4 | TO STUDY DISTORTION FACTOR METER AND DETERMINATION OF THE % DISTORTION OF THE GIVEN OSCILLATOR. |
| 5 | TO DETERMINE OUTPUT CHARATERISTICS OF LVDT AND MEASURE DISPLACEMENT USING LVDT. |
| 6 | TO STUDY CHARACTERISTICS OF TEMPREATURE TRANSDUCER LIKE THERMOCOUPLE,THERMISTOR AND RTD WITH IMPLEMENTATION OF A SMALL PROJECT USING SIGNAL CONDITIONING CIRCUITS LIKE INSTRUMENTATION AMPLIFIER. |
| 7 | MEASUREMENT OF STRAIN USING STRAIN GAUGE. |
| 8 | TO STUDY DIFFERENTIAL PRESSURE TRANSDUCER & SIGNAL CONDITIONING OF OUTPUT SIGNAL. |
| 9 | MEASUREMENT OF LEVEL USING CAPACITIVE TRANSDUCER. |
| 10 | STUDY OF DISTANCE MEASUREMENT USING ULTRASONIC TRANSDUCER. |

# EXPERIMENT No.1

**AIM:-** To study blockwise construction of Analog Oscilloscope & Function Generator.

**THEORY:-**

**CRO**

The Cathode Ray Oscilloscope is probably the most versatile tool for deployment of electronic circuit and system. The CRO allow the amplitude of the electronic signals where they are voltage, current or power to be displayed as a function of time. The CRO depends on the moments of an electron beam which is being bombarded (impinged) on a screen coated with a fluorescent material to produce a visual spot. If the electron is being deflected along the conventional axes, i.e. x-axis & y-axis, two different displays are produced.

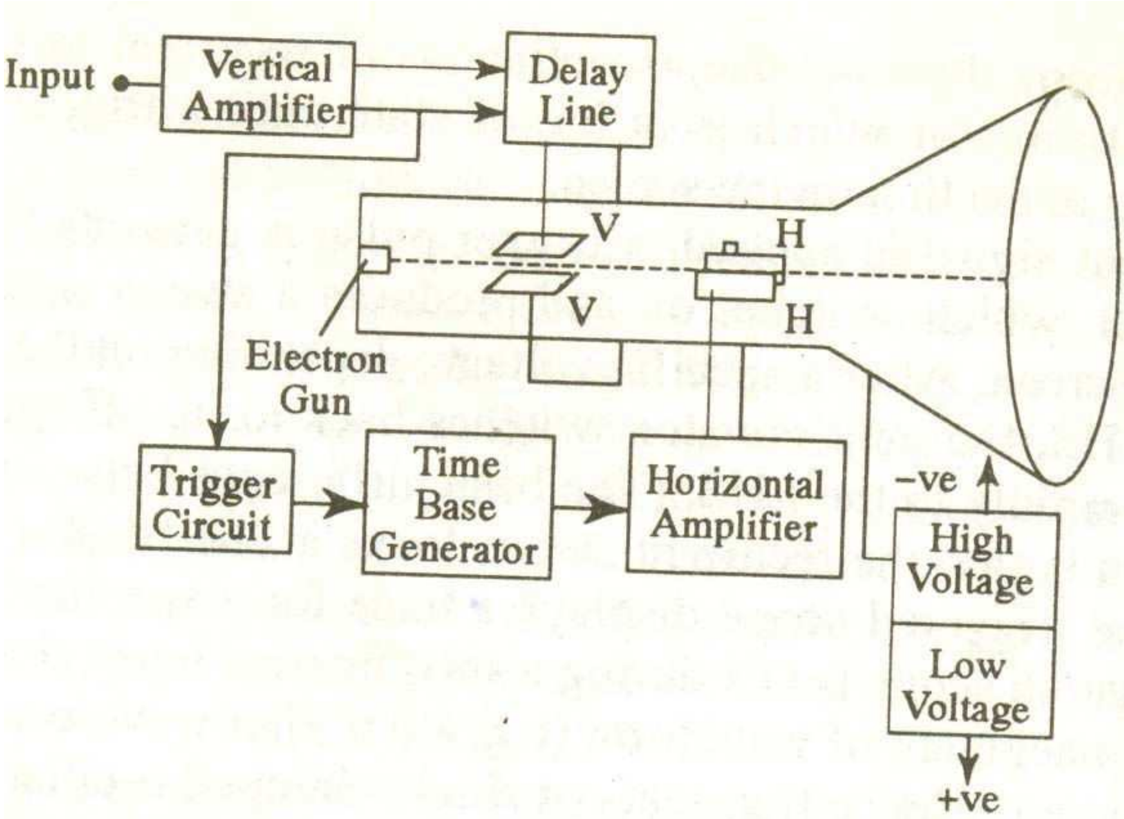



**Fig:1 Block Diagram of CRO**

**Main parts of CRO-**

**CRT: -** This is cathode ray tube in which electron beam strikes the screen internally to provide visual display of signal.

**VERTICAL AMPLIFIER:-** This is a wide band amplifier used to amplify signal in the vertical section of the signal.

**DELAY LINE: –** It is used to delay signal for sometime in the vertical section.

**TIME BASE: –** It is used to generate sawtooth voltage which it is applied to Horizontal deflection plates.

**HORIZONTAL AMPLIFIER: -** This is used to amplify the sawtooth voltage before it is applied to horizontal deflection plates.

**TRIGGER CIRCUIT: -** This is used to convert the incoming signal into trigger pulse so that the input signal and the sweep frequency can be synchronized.

**POWER SUPPLY: –** There are two power supplies, A negative high voltage (HV). supply and a +ve low voltage supply (LV). . The +ve voltage supply is from +300V to 400V, the negative voltage supply is from -1000V to -1500V.

## Front panel controls

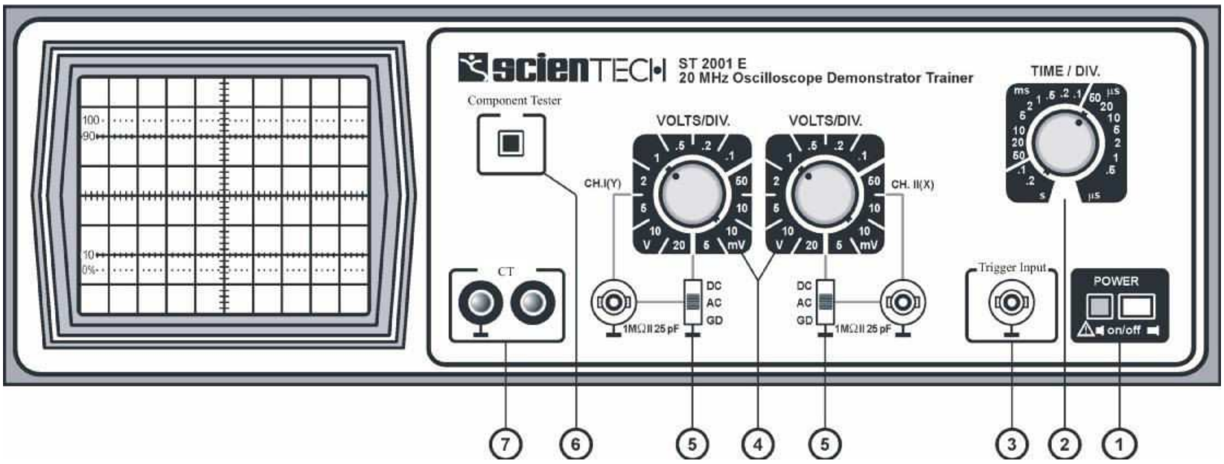



**Fig:2 Front Panel of CRO**

**(1) Power 'On/Off' :** Turns 'On' & 'Off'. LED indicates power 'On'. Use position & Int/Focus controls to get the beam. All are push buttons.
**(2) Time / Div :** Rotary Switch for TB speed control.
**(3) Trigger Input :** For feeding external trigger signal.
**(4) Volts/Div :** For sensitivity selection of CH 1 & CH 2.
**(5) DC-AC-Gnd :** Switch provided for Input coupling. BNC inputs provided for connecting the Input signal.
**(6) Component Tester :** Switch when pressed converts scope into Component Tester mode.
**(7) CT :** Input & Gnd terminals to be used for CT.

## Controls on PCB

**(1) Intensity :** Controls the brightness
**(2) Focus :** Controls the sharpness
**(3) Trace Rotation :** Controls the horizontal alignment of the trace.
**(4) X Pos :** Controls the horizontal position
**(5) Y Pos I & II :** Controls vertical position of the trace.

**(6) X Y :** When pressed cuts-off internal TB & connects external horizontal signal via. CH II
**(7) X 5 :** When pressed gives 5 times magnification.
**(8) External :** When pressed allows ext. trigger.

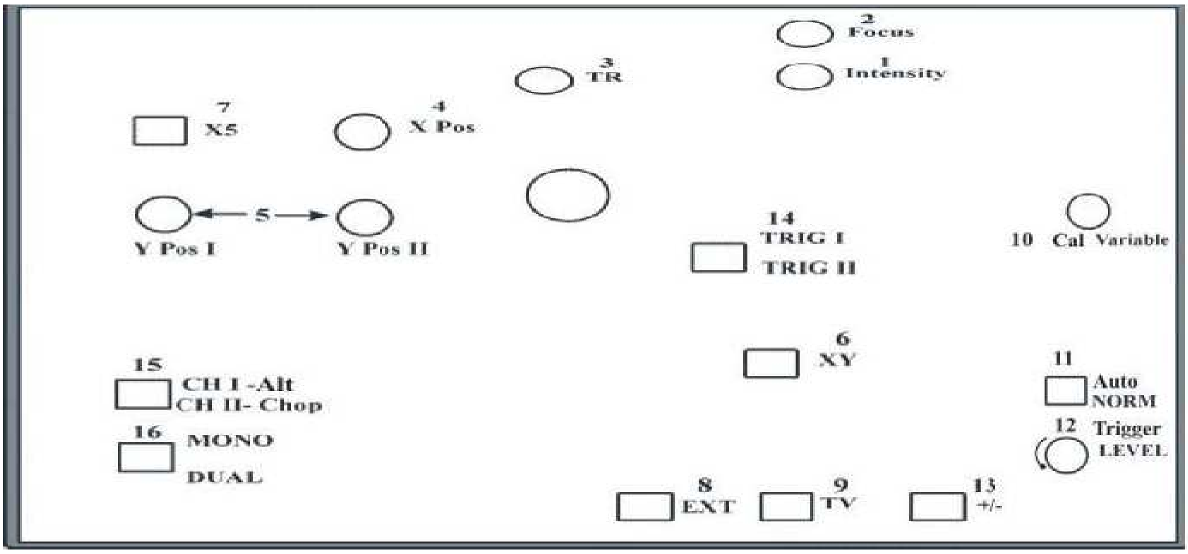



**Fig:3 Controls on PCB**

**(9) TV :** When pressed allows TV frame to be synchronized.
**(10) Cal Variable :** Controls the time speed in between the steps.
**(11) Auto/ Norm :** In AT gives display of trace & auto trigger.When pressed becomes normal & gives variable level trigger.
**(12) Level :** Controls the trigger level from positive peak to negative peak.
**(13) + / - :** Selects the slope of triggering.
**(14) Trig 1/ Trig 2 :** When out triggers CH I and when pressed triggers CH II
**(15) CH I Alt/ :** When out selects CH I and when pressed selects CH II. When dual switch also pressed this selects Alt or Chop modes.
**(16) Mono / Dual :** When out, selects CH I only. When pressed selects both.

**Amplitude Measurements :**

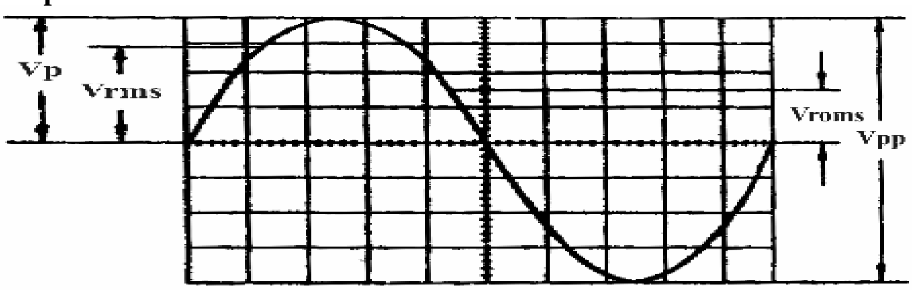



**Fig:4 Amplitude measurement using CRO**

Vrms = effective value
Vp = simple peak or crest value
Vpp = peak-to-peak value
Vmom = momentary value.

**Frequency measurement**

T = time in seconds for one period
F = recurrence frequency in Hz of the signals,
F = 1/T,

$T_{tot}$ = 1.6 cm x 0.5 s/cm : 5 = 160ns

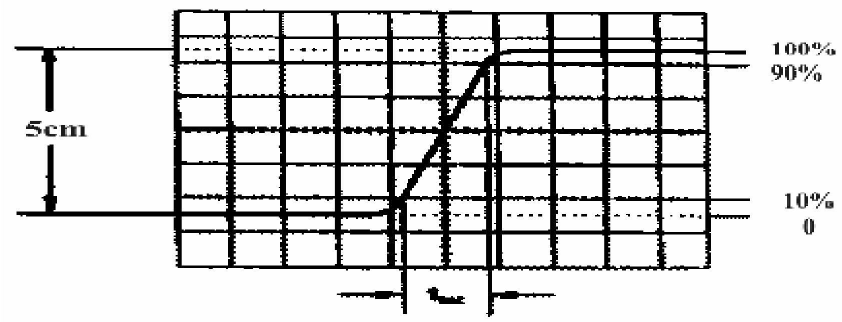



**Fig:5 Frequency measurement using CRO**

**Phase Measurement**

Sin q = a/b

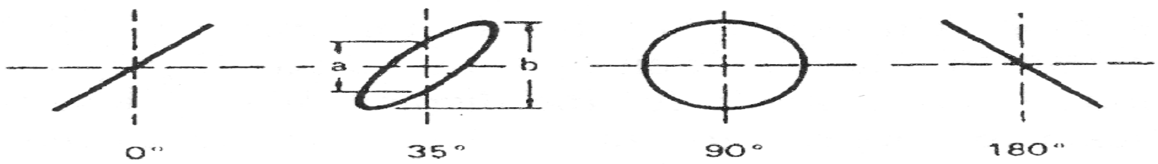



**Fig: 6 Phase measurement using CRO**

**FUNCTION GENERATOR**

**What is a function generator?**
A function generator is a device that can produce various patterns of voltage at a variety of frequencies and amplitudes.

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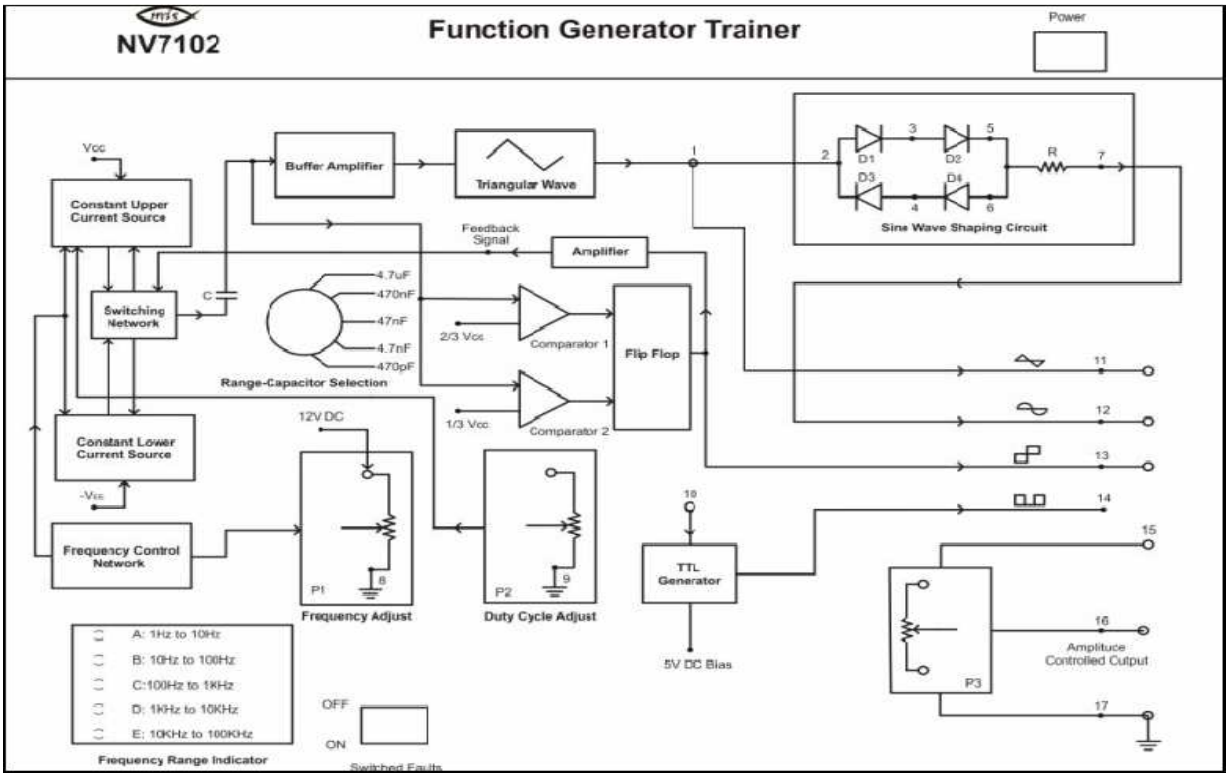



**Fig:7 Function generator circuit diagram**

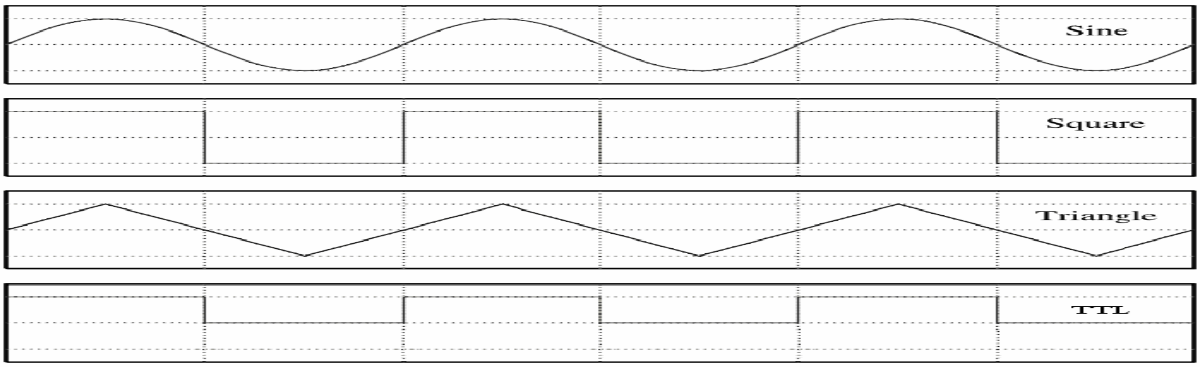



**Fig:8 Waveforms of function generator**

**Technical Specifications:-**

**Frequency Ranges : Selectable**

**a)** 1 Hz to 10 Hz
**b)** 10 Hz to 100 Hz
**c)** 100 Hz to 1 KHz
**d)** 1 KHz to 10 KHz

**e)** 10 KHz to 100 KHz

**Amplitude Control Output**
Sine Wave **:** 6V $V_{PP}$
Square Wave **:** 6V $V_{PP}$
Triangular Wave **:** 6V $V_{PP}$
TTL Output **:** 5V
**Duty Cycle :** Variable
**Sine Wave Generation :** By wave shaping circuit
**Switched Faults :** 4 Nos.
**Fuse :** 500 mA, slow blow
**Power Supply :** 230V±10%, 50 Hz
**Note:** Being a trainer it includes a lot of onboard test points which need the expansion of wires & tracks from the main circuit. Due to this a slight variation (10 to15%) in frequency may be observed while we change duty cycle of signal.

**QUIZ/ANSWERS:-**

Q1 What do you mean by CRO?
A1. Cathode Ray Oscilloscope.

Q2 Which component of CRO is termed as major or heart of CRO?
A2. CRT ( Cathode Ray Tube)

Q3 What are the major component of CRO?
A3. CRT, Vertical Amplifier, Delay line,Time base generator, Horizontal amplifier Trigger circuit, Power supply are the major component of CRO.

Q4 What is the need of sweep generator in CRO?
A4. To sweep the electron beam from left to right.

Q5 Name the material with which the screen is coated.
A5. Phosphor.

Q6 What is the function of function generator?
A6.To generate various waveforms like sine,square,triangular and pulse .

Q7 What is the name of coating for secondary electron absorption?
A7. Aquadag Coating

Q8 How many signals can be applied simultaneously to CRO?
A8. Two

Q9 What is the role of grid in CRO?
A9. To control the no. of electrons from cathode.

Q10 How is input applied to CRO?
A10. Through function generator.

## EXPERIMENT No.2

**AIM**:- TO study blockwise construction of a multimeter & frequency counter.

**APPARATUS REQUIRED:-** Multimeter Demonstrator NV7106 and Frequency Counter Trainer NV7105 Kits

**THEORY:-**

**Multimeter**

Multimeter Demonstrator **NV7106** is a versatile training system used in the Electronic Instrumentation laboratories. With this demonstrator students can easily understand the concept behind the measurement of different electrical quantities like voltage, current and resistance.
A multimeter or a multitester, is an electronic measuring instrument that combines several measurement functions in one unit. So we can say that multimeter is a common multi-purpose instrument used to measure different electrical quantities in a circuit.
In our multimeter demonstrator, we have three measurement sections- Voltage Measurement (both AC and DC), Current Measurement, Resistance Measurement; Signal Conditioning and Conversion Section along with Display; and a Continuity Tester. Rotary Switches are provided for the Function, Range and Decimal Selection.

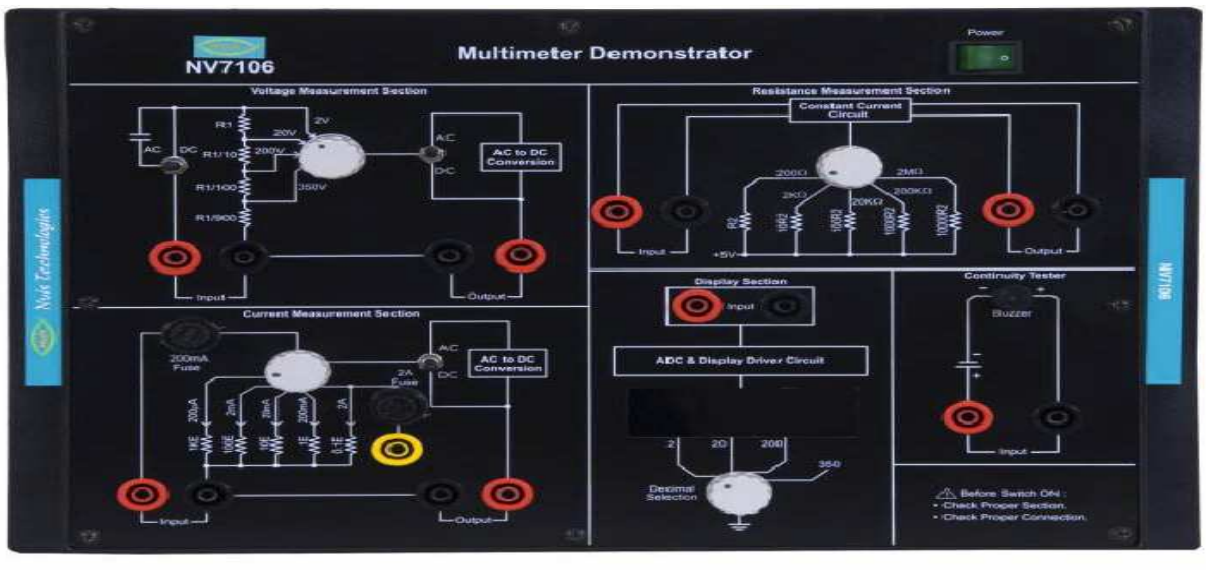



**Fig:1 Multimeter circuit diagram**

Digital instruments are rapidly replacing their analog counterparts. Signals can be processed more efficiently by Digital techniques than by Analog techniques. This has resulted in devices that are more advanced than available before. While most signals are analog in nature, the processing of signals is being performed by Digital techniques. All engineering disciplines now use digital techniques, which are almost indispensable in many fields. The parameters of interest in a laboratory environment are (1) Voltage (2) Current (3) Resistance(4) and Frequency (5).

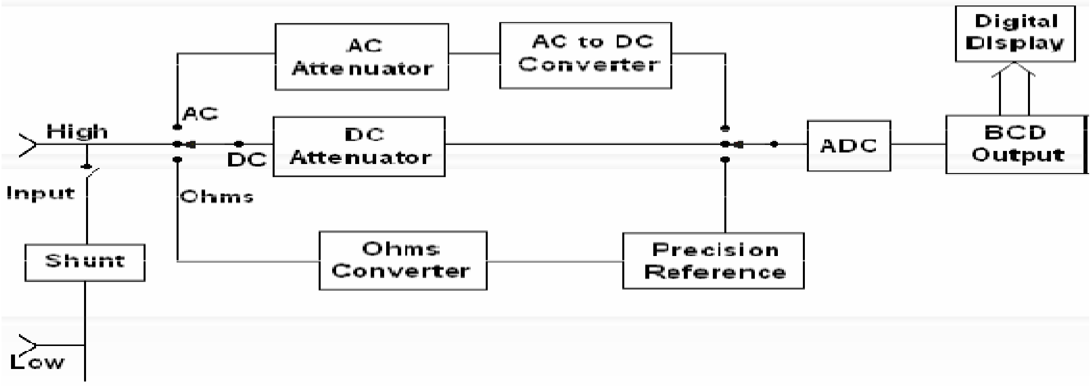



**Fig:2 Block diagram of digital multimeter**

**Digital Frequency Counter**

**NV7105 Frequency Counter Trainer** consists of five blocks, namely, attenuator circuit, wave shaping circuit, frequency divider circuit, frequency counter, display driver circuit, and gate time circuit. All these circuits are incorporated on a single board for study/verification of attenuation, wave shaping, frequency division, and display driving mechanism. The board has inbuilt (SMPS) for DC power supply, so it can be taken as stand alone unit without any external power supply.

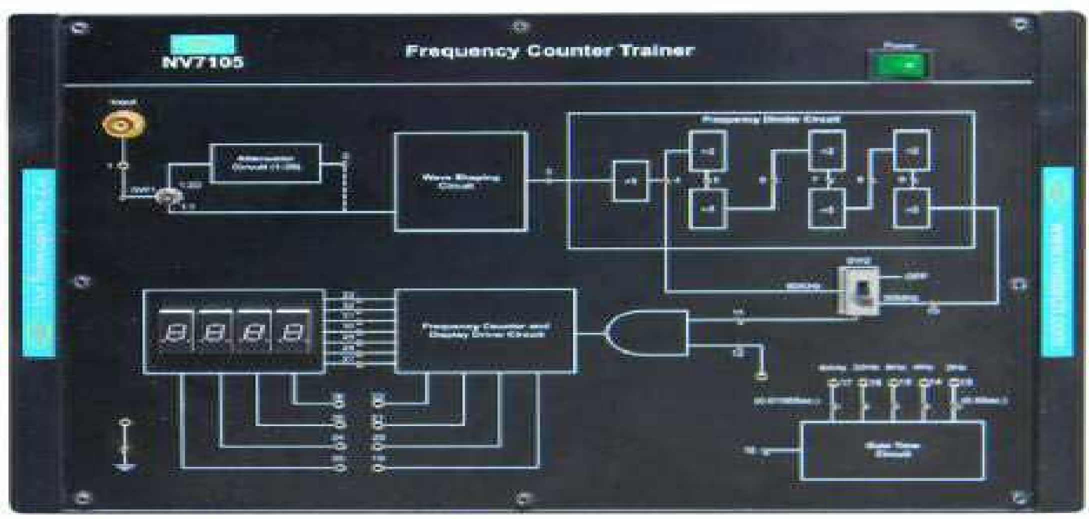



**Fig:3 Frequency Counter Ckt. Diagram**

The signal wave form is converted to trigger pulses and applied continuously to an AND gate, as shown in figure 1. A pulse of 1s is applied to the other terminal, and the number of pulses counted during this period indicates the frequency.

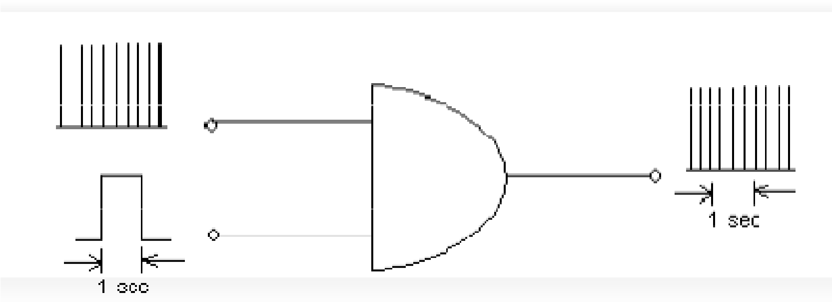



**Fig:4 Frequency Counter**

The signal whose frequency is to be measured is converted into a train of pulses; one pulse for each cycle of the signal. The number of pulses occurring in a definite interval of time is then counted by an electronic counter. Since each pulse represents the cycle of the unknown signal, the number of counts is a direct indication of the frequency of the signal (unknown). Since electronic counters have a high speed of operation, high frequency signal can be measured.

**QUIZ/ ANSWERS:-**

Q.1What is the function of a multimeter?
A.1 To measure voltage(AC or DC), current(AC or DC) and resistance.

Q.2 Write down the types of multimeter.
A.2 Analog and digital multimeter.

Q.3 What is the purpose of frequency counter?
A.3 By using frequency counter we can measure frequency,time period and time interval of any waveform.

Q.4 Which multimeter is advantageous ?
A.4 Digital multimeter.

Q.5 What is the accuracy of frequency counter?

A.5 The accuracy of a frequency counter is strongly dependent on the stability of its timebase. Highly accurate circuits are used to generate this for instrumentation purposes, usually using a quartz crystal oscillator within a sealed temperature-controlled chamber known as a *crystal oven* or OCXO (oven controlled crystal oscillator).

Q.6 Why time period measurement is done in frequency meters ?
A.6 For achieving high accuracy in the case of low frequency measurement.

Q.7 What is the order of input impedance in digital instruments ?
A.7 Mega ohms

Q.8 What is the use of Schmitt trigger in digital frequency meter?
A.8 Converts sine wave into rectangular pulses.

Q.9Why are multimeters provided with separate scale for low ac voltages?
A.9 To take into account the high value of resistance of rectifier at low voltages.

Q.10 For high value of resistance measurement is done by which instrument?
A.10 Meggar.

# EXPERIMENT No.3

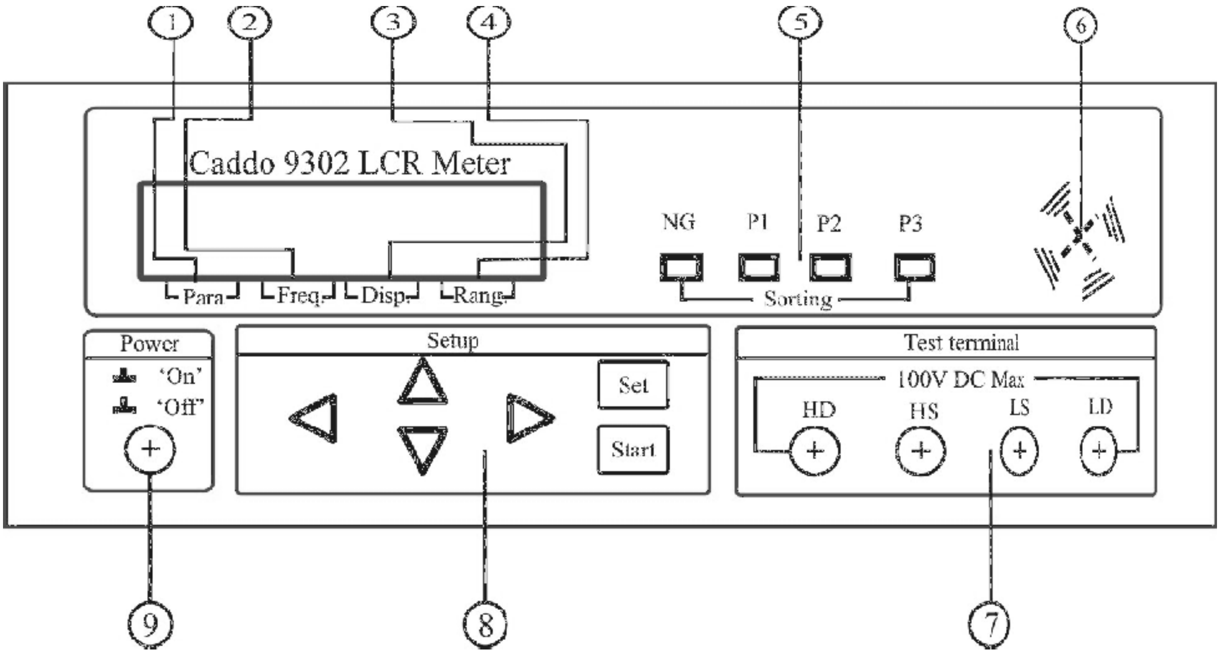
**AIM:-** To study measurement of different componenets & parameters like Q of a coil etc. using LCR Q meter.

**APPARATUS REQUIRED: -** Caddo 9302 LCR meter.

**THEORY**:-

Model **Caddo 9302** LCR meter is a micro desktop instrument by using microprocessor technology. It can measure six basic parameters ie., inductance L, capacitance C, resistance R, impedance Z, dissipation factor D and quality factor Q, which can fulfill the measurement needs of various components manufacturers and maintenance technicians.

**FRONT PANEL**




1 **Parameter**
Displaying current measured parameters:
L-Q, C-D, R-Q, Z-Q, Z-D or AUTO
**2 Frequency**
Displaying current frequency; 100 Hz, 120 Hz or
1 KHz
**3 DisplayMode** Displaying current display mode of the primary parameter: DIR %
**4 Range** Displaying range state: Auto, Hold or current range.

**5 Pins Indication**
NG: No-good; P1: Pass1; P2: Pass2; P3: Pass3;

▪,

P1, P2, P3 Priority is lower in turn.
**6 Buzzer**
**7 Test Terminals HD, HS, LS and LD**
Cursor keys Function table moving and rolling
Setup key Entering 8 Key function table setting
Start key The executing confirmation of command
**9 Power** Power switch

**Features**
**1. Zero Correction :**
Open sweep correction of open circuit;
Short sweep correction of short circuit
**2. Display Format :**
Direct actual measured value absolute delta between the measured value and the reference value; delta percent between the measured value and the reference value.
**3. Range Hold :** When measuring a large number of components with the same nominal value, this function can effectively improve the measuring speed.
**4. Comparator Function : Caddo 9302**s built-in comparator can sort components into a maximum of four bins (NG, P1, P2 and P3).
**5. Equivalent Measurement Circuit :** There are two equivalent circuit models: parallel and series.

**OPERATION**

**1 Direct function setup—— Parameter, frequency, display and range :**
**a)** Press keys to move the cursor and select one of the four direct functions.
**b)** Press keys to select.

**2** When measurement range is set to Auto, the instrument first estimates if current range is the correct range, if it’s the correct range, then the instrument calculates and displays the measurement value, otherwise instrument has to change to the correct range and start measurement again. Therefore, in range Auto mode, one more measurement will be taken if the measurement range has to be changed. So more time is taken in range Auto mode.

**3** If a large number of devices under test belong to the same range, the correct range can be locked to raise the measurement speed. For the instrument do not have to take any time to find the correct the range.

**4** When measurement range is set to Hold, if the impedance under test exceeds the effective measuring range of the locked measurement range, overload symbols

**5.** How to calculate the measurement range
Example: Suppose capacitance C=210pF, dissipation D=0.0010 and

test frequency f=1KHz.
Solution:We can calculate: Zx = 757.9

**Indirect Functions Setup :**
Indirect functions are Clear “0”, Sorting, Auto-LCZ, Buzzer, Change cursor, Advanced set, and State save & exit.
Press Setup key to enter the setup menu in measurement state. Pressing Setup key again, the instrument returns back to the measurement state.

**PRECAUTIONS:-**

**Tuning On :**
**A.** Display company name and version the indicator lamps of P1, P2, P3, NG flash in turn.
**B.** Starting power-on self tests
**1.** EEPROM Memory checking
**2.** ADC AD converter checking
**C** Entering-measuring state after self-tests
The factory settings are listed as follows and can be reset according to the operation
**1.** Parameter: C-D;
**2.** Frequency: 100 Hz;
**3.** Display: Dir (direct reading);
**4.** Range:AUTO (automation);
**5.** Equivalent: SER (serial);
**6.** Alarm Bin: P1(Pass #1);
**7.** LCZ automation: Off;
**8.** Cursor

**QUIZ/ ANSWERS:-**

Q.1 What do you mean by Q factor?
A.1 It is quality analysis of capacitor and inductor.

Q.2 What is the purpose of LCR Q meter?
A.2 It can measure 6 basic parameters, they are inductance L,capacitance C, resistance R, impedance Z, dissipation factor D and quality factor Q.

Q.3 What is the resonance condition?
A.3 $X_L=X_C$

Q.4 What is the formula of quality factor for inductor?
A.4 $Q= X_L/R$

Q.5 What is the range of shunt resistance in Q meter?
A.5 Miliohms

Q.6 The Q factor of a coil at the resonant frequency 1.5 MHz of an RLC series circuit is 150.The bandwidth is ------ .
A.6 10 KHz

Q.7 What are the applications of Q-meter?
A.7 Measurement of Q, inductance, effective resistance, self capacitance, bandwidth and capacitance.

Q.8 What are the different methods of measurement of effective resistance?
A.8 1)resistance variation method
2)reactance variation method

Q.9What is use of T-network?
A.9 T networks are very useful for measurement of inductance,capacitance,resistance and frequency in the high frequency range.

Q.10 What is the formula of distributed capacitance?
A.10 $C_d = C_1 - 4C_2/3$(where $C_1$ and $C_2$ are tuning capacitors for resonant frequencies $f_1$ and $f_2$).

## EXPERIMENT No.4

**AIM:-** Study of distortion factor meter and determination of the % distortion of the given oscillator.

**APPARATUS REQUIRED:-**Caddo 4092 distortion Meter.

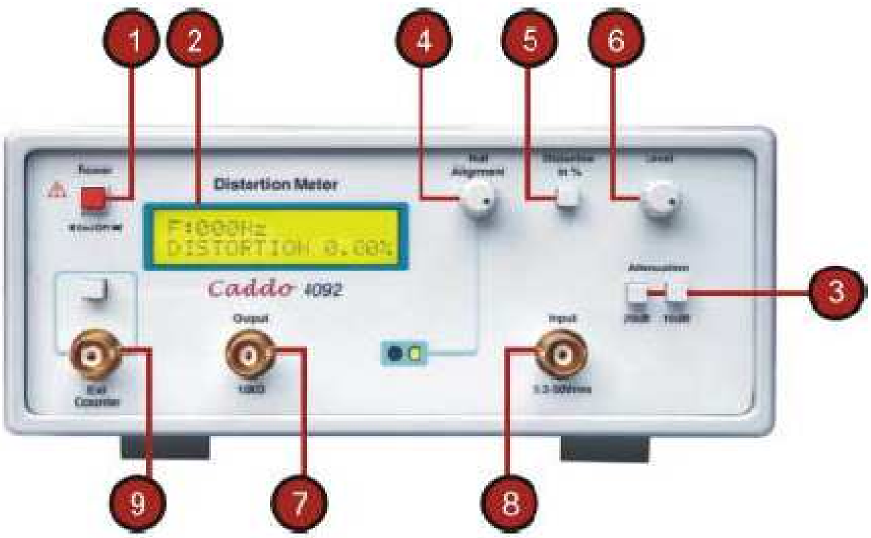
**THEORY:-**

The **Caddo 4092** distortion Meter was developed for the measurement of non-linear distortion in the audio frequency range. Due to its low residual distortion and noise of 0.005% it is ideally suited for tests and measurements of high quality audio systems.
The **Caddo 4092** features an LCD Display readout with a resolution of 0.1 % to simplify and enhance distortion measurements. A calibrated distortion output is provided for visual inspection or spectral analysis of the input signal after the fundamental has been filtered out.
Together with pushbutton frequency range selectors and single control frequency tuning, the automatic frequency nulling with 20% capture range ensures quick and easy measurements with the **Caddo 4092**.

**Features**

Frequency Range 20 Hz to 20 KHz
DistortionMeasurement up to 0.1%
LCD Readout For Frequency and DistortionMeasurement
Automatic Frequency Ranging & Nulling Facility
Output for Distortion Analysis
In built 50 MHz Frequency Counter

**Front panel**




**1) Power:** Push button, selects instrument to switch 'On'

**2) LCD Display:** LCD Readout for indication of the measured distortion factor in %.
**3) Attenuator (Pushbutton):** Input signal attenuation with two pushbutton switches of 20dB or 10dB attenuation, respectively. They can be used separately. Both push button switches activated, together with the variable attenuator (9) must enable a 100% reading when in the calibration mode; otherwise the input voltage should be adjusted.
**4) Tuning control with LED Indicator (LED):** If the built-in filter is incorrectly tuned, one of the two LEDs will indicate in which direction the filter frequency deviates from the input frequency. Turn tuning Knob (5) (N.A) in the opposite direction until the LED goes out.
**5) Level\Distortion (Pushbutton switch):** Adjustment for 100% reading with Level and then selection for 100% full scale.
**6) Level (Adjusting knob):** Continuous attenuation of input signal up to max. 50dB to achieve 100% reading when in the calibration mode.
**7) Output (BNC Connector):** Monitor output for distortion factor. (Residual distortion). Output voltage is 1mV/digit.
**8) Input (BNC Connector):** Input for measurement signal. The permissible input voltage range is 0.3V-50V for a valid measurement.
**9) External Counter:** It is the input for external signal whose frequency is to be measured.

**<u>PRECAUTION:-</u>**

**Use proper Mains cord :** Use only the mains cord designed for this instrument. Ensure that the mains cord is suitable for your country.
**Ground the Instrument :** This instrument is grounded through the protective earth conductor of the mains cord. To avoid electric shock the grounding conductor must be connected to the earth ground. Before making connections to the input terminals, ensure that the instrument is properly grounded.
**Observe Terminal Ratings :** To avoid fire or shock hazards, observe all ratings and marks on the instrument.
**Use only the proper Fuse :** Use the fuse type and rating specified for this instrument.
**Use in proper Atmosphere :** Please refer to operating conditions given in the manual.
1. Do not operate in wet / damp conditions.
2. Do not operate in an explosive atmosphere.
3. Keep the product dust free, clean and dry.

**QUIZ/ANSWERS:-**

Q.1 What is the use of distortion meter?
A.1 Distortion Meter for the measurement of non-linear distortion in the audio frequency range.

Q.2 Write down the types of distortion.
A.2 Frequency and Phase distortion.

Q.3 What is the meaning of IMD.
A.3 Intermodulation distortion,it is ratio of $A_M$ to $A_{C.}$

Q.4 What are the types of distortion?
A.4(1)Frequency distortion( 2)Phase distortion(3)Amplitude distortion(4)intermodulation distortion(5)Cross-over distortion

Q.5 What is the reason of distortion?
A.5 Distortion is caused by many devices and components which form an electronic circuit.

Q.6 What is total harmonic distortion?
A.6 Total harmonic distortion is measured in terms of the harmonic content of the wave.

Q.7 Explain cross over distortion?
A.7 This type of distortion occurs in push pull amplifiers on account of incorrect boas levels.

Q.8 What is transient intermodulation distortion?
A.8 Transient intermodulation distortion occurs because an amplifier is not able to respond rapidly to changing inputs.

Q.9 Why frequency distortion occurs?
A.9 This type of distortion occurs because the amplification factor of the amplifier is different for different frequencies.

Q.10 Why harmonic distortion occurs?
A.10 Harmonic distortion occurs due to the fact that the amplifier generates harmonics of the fundamental of the input signal.

# EXPERIMENT No.5

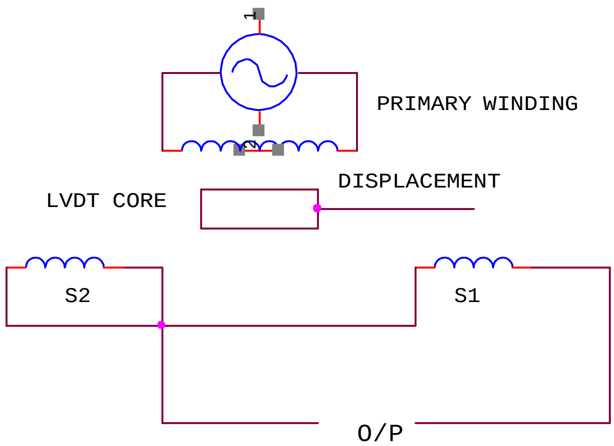
**AIM:-** Measurement of displacement using LVDT.

**APPARATUS REQUIRED: -** LVDT kit, multimeter, connecting wires.

**THEORY: -**

The differential transformer is a passive inductive transformer also known as Linear Variable Differential Transformer (LVDT). LVDT has a soft iron core which slides within the hollow transformer & therefore affects magnetic coupling between the primary and two secondaries. The displacement to be measured is applied at its arm attached to soft iron core. When core is in normal position (null), equal voltages are induced in the two secondaries. The frequency of ac applied to the primary winding ranges from 50Hz to 20KHz.

**CIRCUIT DIAGRAM**



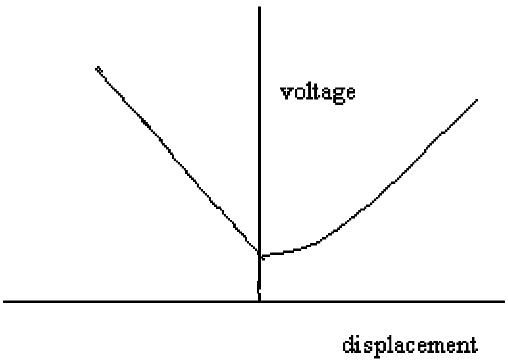

**PROCEDURE: -**

1. Connect the circuit according to circuit diagram.
2. Switch on the power supply.
3. The core is initially brought to null position.
4. First turn the nut in clockwise direction to move core inwards i.e. left of null position & take respective voltage readings on the voltmeter.
5. Now turn nut in anticlockwise direction to move the core towards right of null point & again take respective voltage reading from voltmeter.
6. Plot the graph from the observations taken.

**OBSERVATIONS TABLE**

| S.No. | Displacement Micrometer (mm) | Displacement Reading (mm) | Analog o/p |
|---|---|---|---|
| | | | |
| | | | |
| | | | |

**GRAPH**




**<u>RESULT: -</u>** Graph between voltage and displacement is plotted.

**PRECAUTIONS: -**

1. Handle all equipments with care.
2. Make connections according to the circuit diagram.
3. Take the readings carefully.
4. The connections should be tight.

**QUIZ/ANSWERS:-**

Q1 What is LVDT?
A1 Linear Variable Differential Transformer.

Q2 Uses of LVDT
A2 Measurement of displacement, thickness measurement, level indicators

Q3 Core of LVDT is made up of which material?
A3 Soft iron

Q4 LVDT is active transducer or passive?
A4 Passive

Q5 what is the working principle of LVDT?
A5 Mutual Induction

Q6 Write any two advantages of LVDT.
A6 can tolerate vibrations and shocks, Good linearity

Q7 Any one disadvantage of LVDT.
A7 Affected due to stray magnetic fields.

Q8 How many secondaries are there in LVDT?
A8 Two

Q9 LVDT is which type of transducer?
A9 Inductive type

Q10 How do we take the output of LVDT?
A10 We take differential output of the two secondary.

## EXPERIMENT No.6

**AIM:-** Measurement of temperature using thermocouple,thermistor and RTD.

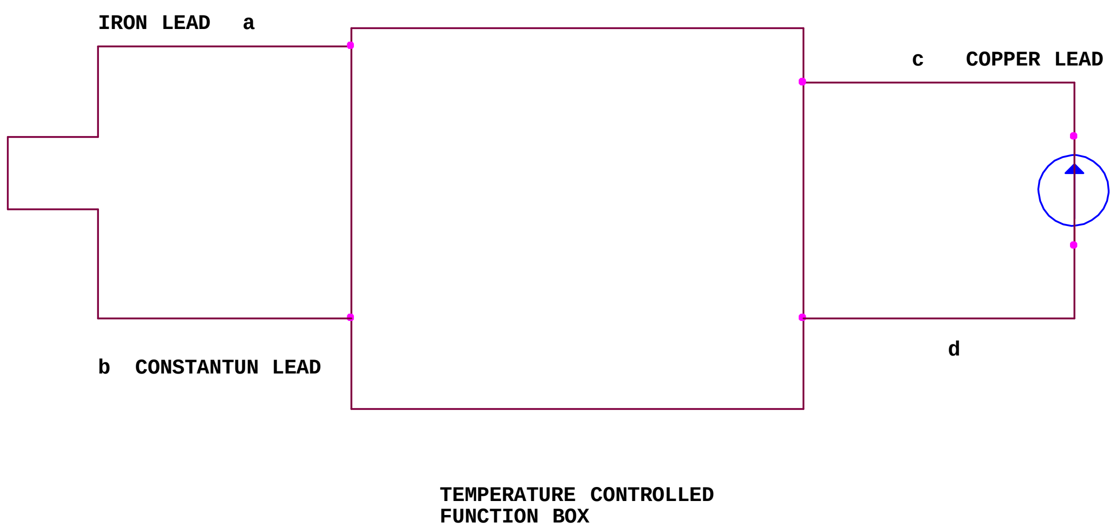
**APPARATUS REQUIRED: -** Thermocouple kit, Thermistor kit, RTD kit, heating arrangement, Ice, Thermometer, $H_2O$.

**THEORY: -**

**THERMOCOUPLE**

This transducer is widely used in industrial applications for temperature measurement. Thermocouple is active transducer because there is no need of voltage source and transducer bridge circuitry. The working principle of thermocouple is explained below: - When two dissimilar metals A & B are joined together to form a closed circuit and the junctions $J_1$ and $J_2$ are kept at two different temperatures $T_1$ and $T_2$ then an e.m.f. is generated resulting flow of current in the loop or circuit. The two junctions in the loop are reference or cold junction which is generally kept at $0^0$C and the other is hot junction at which the temperature is to be measured. The e.m.f. generated is proportional to the difference of temperatures, the materials used for thermocouple. This phenomenon is called as Seeback effect. Thermocouple is having a lot of advantages like low cost, mechanically rigid and strong, high range etc. But the main disadvantage is that it requires a compensation arrangement.

**CIRCUIT DIAGRAM**




**THERMISTORS:**

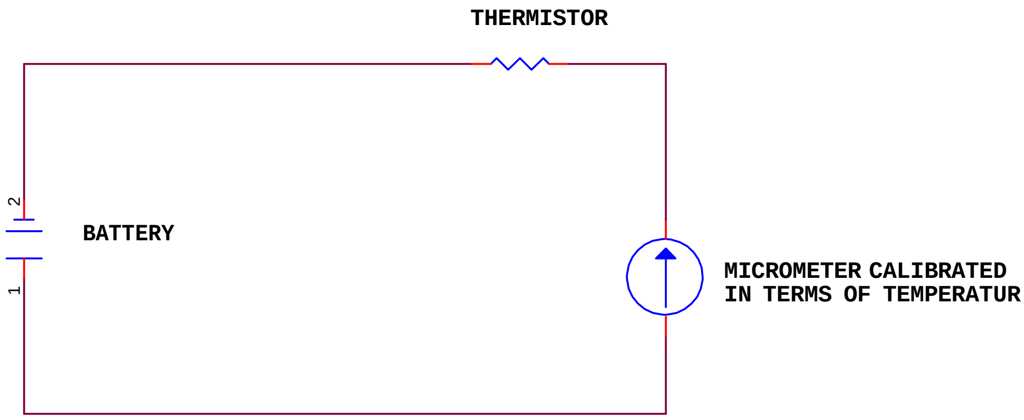
Thermistors are also called thermal resistors. For thermistor the absolute temperature- resistance relationship is given by

$$R_T = RT_1 \exp\left[\beta(1/T_1 - 1/T_2)\right]$$

Where $R_T$=Resistance of the thermistor at absolute temperature T
$R_{T1}$= Resistance of the thermistor at absolute temperature $T_1$
$\beta$= Constant
$T_1$ and $T_2$= Absolute temperatures

Thermistors are made up of semiconductor materials. As temperature changes the resistance of materials also changes. The temperature range for thermistor is $-60^0$C to $+15^0$C. Its resistance varies from 0.5⋀ to 0.75M⋀. Thermistor is placed in contact with the media whose temperature is to be measured. As the temperature of the media changes, the resistance of the thermistor gets changed. This change of resistance can be measured by connecting the thermistor in any one arm
of the Wheat stone bridge.

**CIRCUIT DIAGRAM**




**RTD:**

This type of transducer is used for temperature measurement. Here the basic concept used is that electrical resistance of different metal changes in accordance with the temperature i.e. for temperature measurement. Principle used is that the resistance of a conductor changes in proportion with the change in temperature. The unknown temperature is determined in terms of electrical resistance of the conductor, which senses the temperature. The change in resistance of this device is precisely determined either by bridge circuit or by ohmmeter. Resistance of a conductor changes with change in temperature. This property is used for the measurement of temperature and each transducer is called Resistive Thermometer and falls in the category of electrical resistive transducer. The variation of resistance 'R' with temperature 'T' can be presented as:

$$R = R_0 (1 + \alpha_1 T + \alpha_2 T^2 + \ldots)$$

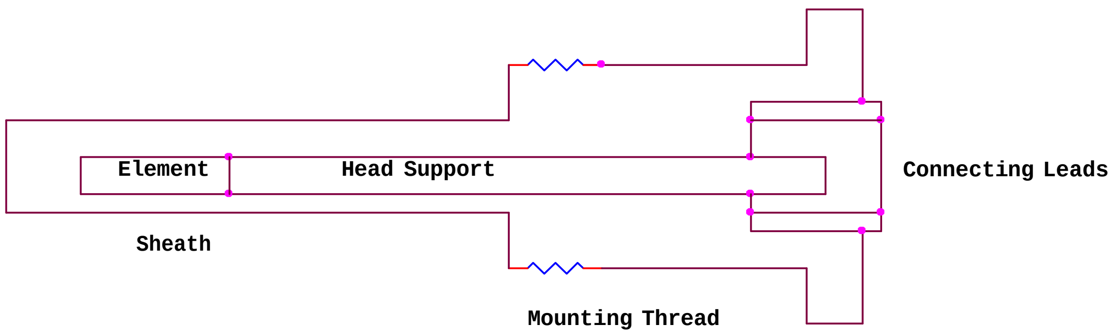
Where $R_0$ ⇨ resistance at $0^0C$

$\alpha_1, \alpha_2$ ⇨ constant

Generally the metals used are Platinum. This is used because of following features:

1. Platinum provides good stability and accuracy.
2. It can operate on wide range of temperature.
3. It has good linearity over wide temperature range.
4. Less errors during operation.

**CIRCUIT DIAGRAM**




**PROCEDURE: -**

**THERMOCOUPLE**

1. Connect the main power cord at I/P main socket.
2. Switch ON the power supply
3. Connect the thermocouple sensor at the pin connector.
4. Keep the thermocouple in boiling water & adjust the display ranging 100 by the adjustment span knob.

**THERMISTOR**

1. Connect the main power cord at I/P main socket.
2. Switch ON the power supply
3. Connect the thermistor sensor at the pin connector.
4. Keep the thermistor in boiling water & adjust the display ranging 100 by the adjustment span knob.

**RTD**

1. Connect the input power supply to main power.
2. Switch on the power supply, the red LED will glow.
3. Connect the RTD source/sensor at a pin connector & $100^0$C temperature is calibrated.

**OBSERVATION TABLE**

| S.No. | Temperature | Display Reading (mv) Thermocouple | Display Reading (mv) Thermistor | Display Reading (mv) RTD |
|---|---|---|---|---|
| | **Temp with Ice point** | | | |
| | **Temp with Boiling Point** | | | |

**RESULT: -** We have measured the temperature using Thermocouple,Thermistor and RTD.

**PRECAUTIONS: -**

5. Handle all equipments with care.
6. Make connections according to the circuit diagram.
7. Take the readings carefully.
8. The connections should be tight.

**QUIZ / ANSWERS: -**

Q1 What is the working principle of thermocouple?
A1 When two dissimilar metals A & B are joined together to form a closed circuit and the junctions $J_1$ and $J_2$ are kept at two different temperatures $T_1$ and $T_2$ then an e.m.f. is generated resulting flow of current in the loop or circuit.
Q2 What are the types of thermocouple?
A2 J, K, E, T, S, R.

Q3 What is the cold junction compensation techniques?
A3 1. Hardware compensation.
2. Software compensation.

Q4 What are the advantages of thermistors?
A4 Small size, Compact, Good stability.

Q5 What are the limitations of thermistors?
A5 Non-linear, low temperature range, requires bridge arrangement.

Q6 What are the various configurations of thermistors?
A6 Bead, Probe, Disc and Rod.

Q7 What do you mean by RTD?
A7 Resistance Temperature Detector.

Q8 Which material is generally used in the construction of RTD?
A8 Platinum

Q9 What are the uses of RTD?
A9 Temperature measurement of solid, fluid and gases.

Q10 What are the applications of themocouples?
A10 They are extensively used in various automation systems for temperature measurements.

## EXPERIMENT No.7

**AIM:-** Measurement of strain using strain gauge.

**APPARATUS REQUIRED: -** Strain cantilever kit, multimeter, connecting wires.

**THEORY: -**

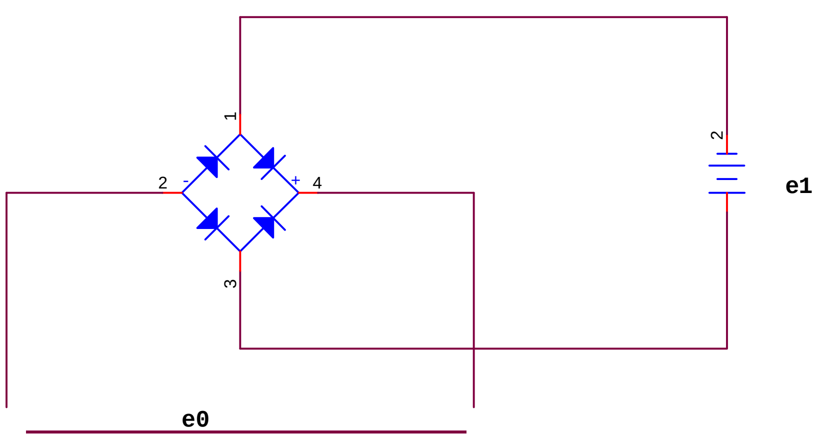
Strain is defined as compression per unit area. The primary quantities like resistance, capacitance are measured with the strain gauge element, where force applied to any elastic material, results in strain.

$$R = \rho L / A$$

Where R= resistance (Ω)
ρ= Resistivity (Ω-m)
L= Length of wire (m)
A= Uniform cross- sectional area of wire ($m^2$)

If a metal wire or conductor is stretched or compressed its resistance changes because of change in length, change in resistivity and change in cross sectional area. This effect is called piezoresistive effect. The cantilever used in the primary elastic transducer of force measuring system, where a known mass is attached to cantilever, the unbalanced voltage, can be calibrated in terms of either force or weight.

**CIRCUIT DIAGRAM**




**PROCEDURE: -**

1. Connect the strain cantilever at the experimental kit.

2. Switch ON the power supply.
3. Give some time to stabilize the instrument.
4. Balance the strain cantilever bridge by corresponding zero, then turn trim port.
5. Set the gain of strain cantilever by SPAN, then turn trim port.
6. Now apply weight at the cantilever beam and take readings.

**OBSERVATION TABLE**

| S.No. | Weight | Display Reading | Analog O/P (volt) | Signal (mV) |
|---|---|---|---|---|
| | | | | |
| | | | | |

**SAMPLE CALCULATION**

$$R = \rho L / A$$

Where R= resistance (⌃)

ρ= Resistivity (⌃-m)

L= Length of wire (m)

A= Uniform cross- sectional area of wire ($m^2$)

**<u>RESULT: -</u>** Weight can be measured by using strain gauge
.

**<u>PRECAUTIONS: -</u>**

9. Handle all equipments with care.
10. Make connections according to the circuit diagram.
11. Take the readings carefully.
12. The connections should be tight.

**<u>QUIZ / ANSWERS :</u>-**

Q1 What is the working principle of strain gauge?
A1 Piezoresistive effect

Q2 Which type of transducer is strain gauge?
A2 Resistive

Q3 What are the advantages of strain gauges?
A3 High gauge factor and excellent hysteresis characteristics

Q4 What are the uses of strain gauges?
A4 Measurement of force & pressure, displacement, acceleration etc

Q5 What do we call the combination of gauges?
A5 Rossettes

Q6 Is it active type of transducer or of passive type?
A6 passive

Q7 How would you classify strain gauge?
A7 Bonded wire, Bonded metal, Semiconductor type etc

Q8 What is strain?
A8 Strain is defined as compression per unit area.

Q9 What is gauge factor?
A9 Gauge factor is defined as the ration of per unit change in resistance to per unit change in length.

Q10What is Poisson's ratio?
A10 Poisson's ratio, $\gamma = -(\partial D/D)/(\partial L/L)$

# EXPERIMENT No. 8

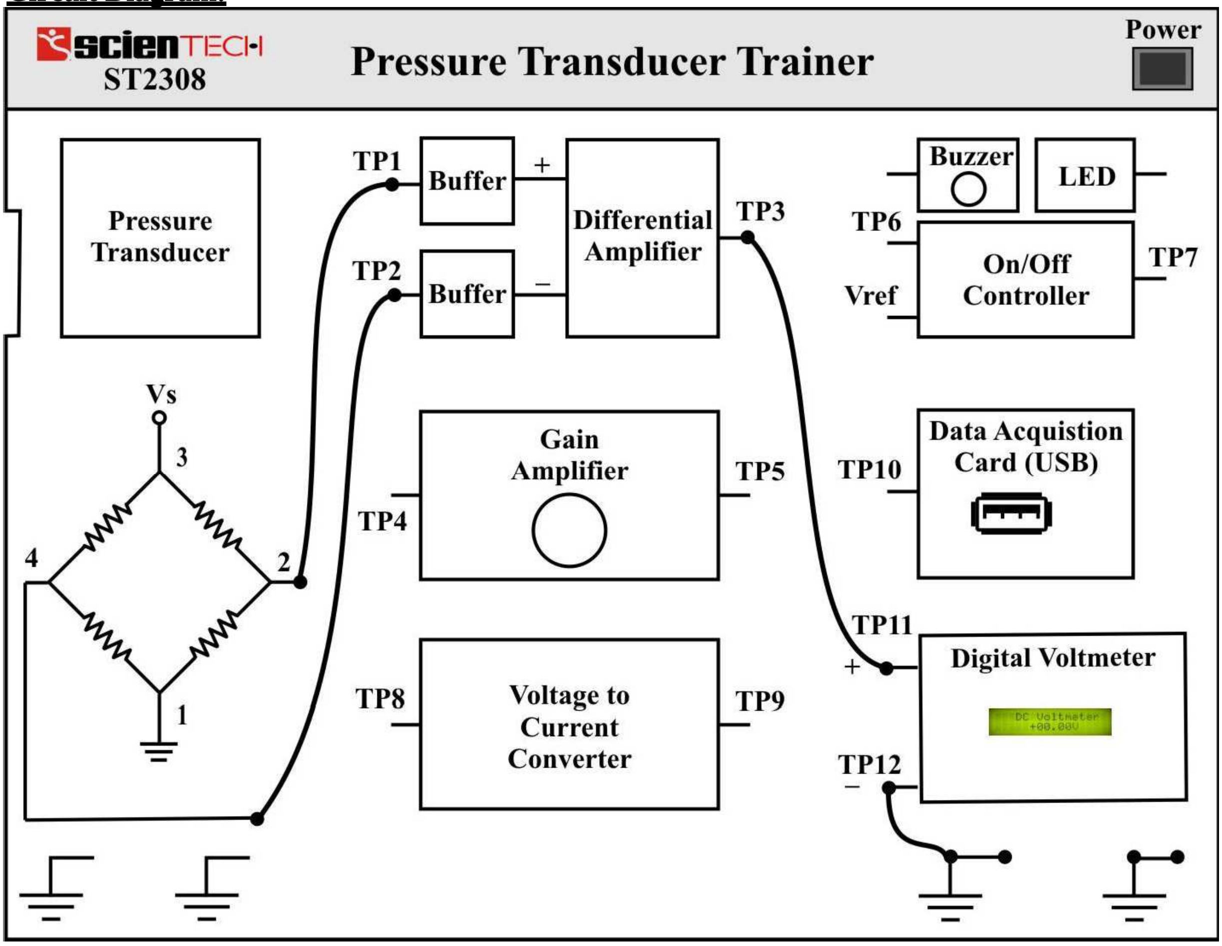
**AIM:-** Study of Differential Pressure Transducer & signal conditioning of output signal.

**APPARATUS REQUIRED: -** ST2308 Pressure Transducer Trainer**,** Pressure Vessel, Foot Pump, Connecting Tube (1.5 meters)

**THEORY: -**

Differential pressure = the difference between two referenced pressures. So gauge pressure is a sort of differential pressure where one of the referenced pressures is atmospheric pressure.
All pressure measurements are differential. The reference can be zero absolute pressure), atmospheric pressure (the barometric pressure), or another pressure.

**Circuit Diagram:**




## PROCEDURE:

1. Fill the pressure vessel up to *90 psi (don't cross the range)* with the help of foot

pump, while filling be sure that the outlet valve is closed (Off Position).
2. Connect the outlet (valve with lever) of the Pressure Vessel to any one of the inlet (either P1 or, P2) of the Pressure Transducer with the help of tube provided.
3. Keep the other inlet (P1 or, P2) of the Transducer, so that the other pressure will be the Atmospheric pressure.
4. Connect the circuit as shown in the *figure* .
5. Switch on the power of **ST2308 Pressure Transducer Trainer**
6. Now, very slowly open the valve in order to release the pressure from the vessel and flow to the transducer's input.
7. Observe the DVM and Pressure Gauge, and note down the readings in observation table.
8. Plot the Graph according to the readings

## OBSERVATION:

| Sr. No. | DVM Voltage (volts) | Pressure Gauge (psi) |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | | |
| 5. | | |
| 6. | | |
| 7. | | |
| 8. | | |
| 9. | | |

**Plot the graph between pressure vs voltage**

## PRECAUTIONS:

1. Use the trainer kit with care.
2. To avoid fire or shock hazards, observe all ratings and marks on the instrument.
3. Do not operate in wet / damp conditions
4. Use the fuse type and rating specified for this instrument.

## QUIZ / ANSWERS:-

Q1 What is differential pressure?
A1 When absolute pressure is measured with respect to some reference pressure.

Q2 Which is the general reference pressure used?
A2 Atomospheric pressure.

Q3 What is pressure?
A3 It is defined as the force per unit area.

Q4 Describe the working principle of differential presure transducer.
A4 When different pressures are applied at two points of force collecting arrangement such as resistive strain gauge, resistance at the preessurised point changes and hence voltage unbalancing occurs.

Q5 Give some examples of applications of DPT?
A5 It finds application in flow measurement , fluid pressure measurement, orifice flow measurement etc.

Q6 Which states of matter generally allow pressure measurement?
A6 Liquids and gases.

Q7 What is signal conditioning?
A7 When the output from the transducer is modified such as to bring it to prsentable level, it is called signal conditioning.

Q8 Give some units of pressure.
A8 psi, atm, torr,pascal, mm Hg etc.

Q9 What is strain?
A9 Strain is defined as compression per unit area

Q10**.** Give examples of active and passive transducers.
A10: Active transducer: Solar cell, Piezo Electric crystal, Thermocouple
Passive transducer: LDR, Photo diode, RTD

# EXPERIMENT No.9

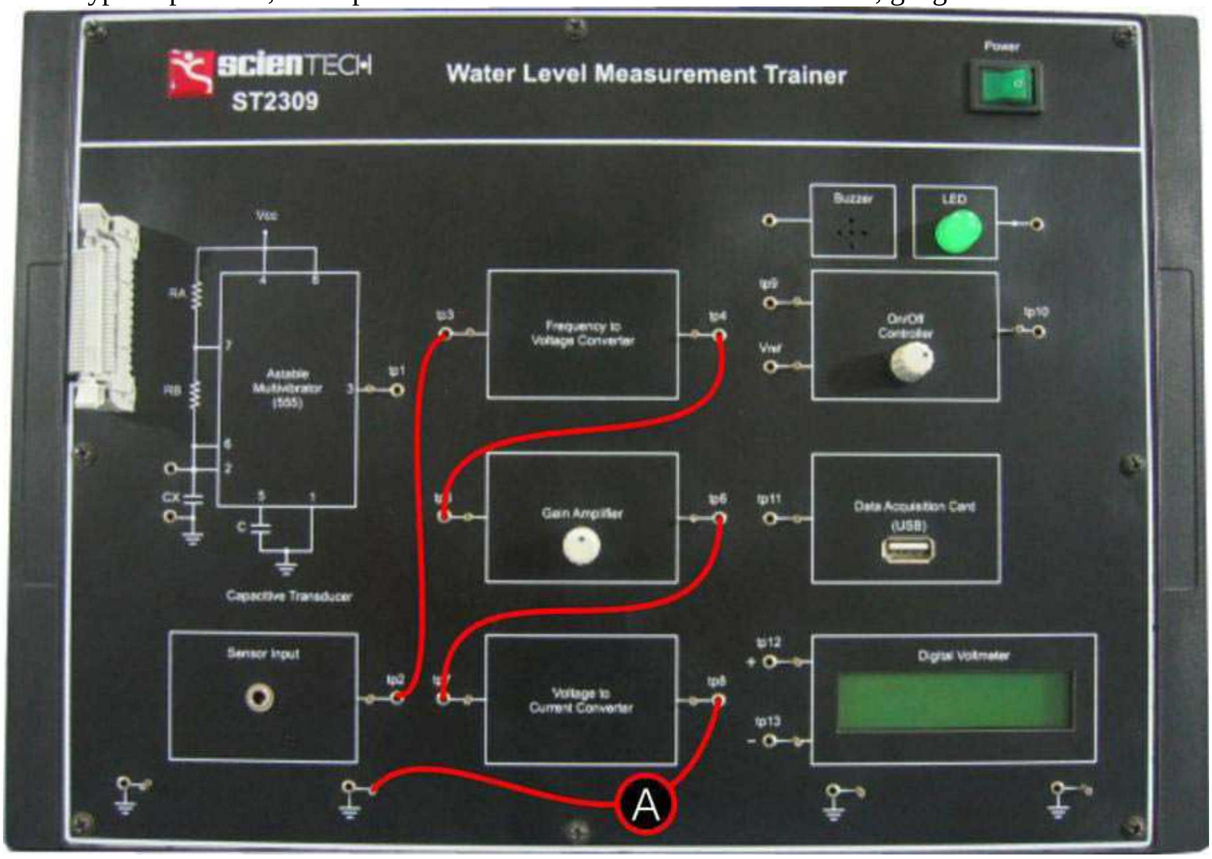
**<u>AIM:-</u>** Study of water level measurement using capacitive transducer.

**<u>APPARATUS REQUIRED: -</u>** ST2309 with power supply cord, Water Level Sensor, Measuring Tank, Ammeter, 2mm Patch Cords (5Nos).

## <u>THEORY: -</u>

### Capacitive Pressure Transducer:

Capacitance pressure transducers were originally developed for use in low vacuum research. This capacitance change results from the movement of a diaphragm element . The diaphragm is usually metal or metal-coated quartz and is exposed to the process pressure on one side and to the reference pressure on the othere principle of “Strain Gauge” i.e when any pressure (force) is exerted on the strain gauge, there is corresponding change in its resistance. This change in resistance will produce an electrical output in the range of millivolts that is proportional to the applied pressure. Depending on the type of pressure, the capacitive transducer can either be an absolute, gauge.




## <u>PROCEDURE :</u>

1. Connect aWater Level sensor across the Sensor Input provided on the Trainer.

2. Make the connection in the trainer as shown in the *figure* .
3. Connect the output of Voltage to Current Converter to the positive terminal of an Ammeter.
4. Ground the negative terminal of the Ammeter.
5. Switch ‘On’ the power supply.
6. Gradually add water to the Measuring Tank.
7. Note the change in Current after every 100ml rise in water level in the measuring tank.
8. Note the Current Readings and corresponding Water Level change in the observation table.
9. Shift the Gain amplifier to least, middle & maximum position & repeat the above Procedure to get different readings.
10. Sketch a graph between voltage & water Level.

**OBSERVATION TABLE**

| Sr. No. | Water Level (ml) | Voltage (Volts) |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | | |
| 5. | | |
| 6. | | |

**PRECAUTIONS:-**

1. Use the trainer kit with care.
2. To avoid fire or shock hazards, observe all ratings and marks on the instrument.
3. Do not operate in wet / damp conditions.
4. Use the fuse type and rating specified for this instrument.

**QUIZ/ANSWERS:-**

Q1. What is capacitor?
A1 A capacitor is a small device that can be charged up with electrical energy,store it and then release it.

Q2 What do you understand by transducer and inverse transducers?
A2: Transducers can be broadly defined as a device which converts a non electrical quantity into an electrical quantity. An inverse transducer is a device which converts an electrical quantity into a non electrical quantity.

Q3 What is the construction of capacitor?

A3 A capacitor is made from two metal plates or metal foils separated by an insulator called a Dielectric material. The Dielectric materials can be made from Ceramic, Mica, Polypropylene, Polyester, Electrolytic, Tantalum and even air.

Q4 What are the Characteristics of Transducer?
A4 When choosing a transducer for any application, the input, transfer & output characteristics have to be taken into account.

Q5 Give examples of transducer and inverse transducers?
A5 Transducer: Microphone
Inverse Transducer: Loud speaker

Q6. What do you understand by primary and secondary transducers?
A6 A primary transducer is one which responds to physical phenomenon or a change in physical phenomenon. The response of primary transducer must be closely related to the physical phenomenon. A secondary transducer is one which transforms the output of the primary transducer to an electrical output.

Q7 Give examples of primary and secondary transducers?
A7 Primary Transducers: LDR, Photo diode, RTD
Secondary Transducer: Wheat Stone Bridge, LVDT

Q8 What is the function of 555 timers?
A8 The **555 Timer** is a very cheap, popular and useful precision timing device that can act as either a simple timer to generate single pulses or long time delays, or as a relaxation oscillator producing stabilized waveforms of varying duty cycles from 50 to 100%.

Q9 Explain the constructional details of 555 timer?
A9 The single 555 Timer chip in its basic form is a Bipolar 8-pin mini Dualin-line Package (DIP) device consisting of some 25 transistors, 2 diodes and about 16 resistors arranged to form two comparators, a flip-flop and a high current output stage.

Q10 Write the application of 555 timer?
A10 The 555 timer chip is extremely robust and stable 8-pin device that can be operated either as a very accurate **Monostable**, **Bistable** or **Astable** multi vibrator to produce a variety of applications such as one-shot or delay timers, pulse generation, LED and lamp flashers, alarms and tone generation, logic clocks, frequency division, power supplies and converters etc.

## EXPERIMENT No.10

**AIM:-** Study of Distance measurement using Ultrasonic Transducer.

**APPARATUS REQUIRED: -** ST2312 trainer with power supply cord, 2mm Patch Cords (8 pieces) and Power Cord

**THEORY: -**

Ultrasonic is defined as that band above 20 KHz. It continues up into the MHz range and finally, at around 1 GHz.Ultrasonic sensors (also known as transducers when they both send and receive) work on a principle similar to radar or sonar which evaluate attributes of a target by interpreting the echoes from radio or sound waves respectively. Ultrasonic sensors generate high frequency sound waves and evaluate the echo which is received back by the sensor. Sensors calculate the time interval between sending the signal and receiving the echo to determine the distance to an object.
Ultrasonic sensors are active, visible, volumetric sensors.

**PROCEDURE:**

1. Connect the mains chord to Trainer.
2. Make the Connection in the trainer as shown in *figure*.
3. Switch 'On' the Power Supply.
4. Keep the toggle switch at '1' position as shown in *figure*.
5. Connect a voltmeter as shown in the *figure.*
6. Adjust the knob of Threshold Detector so the voltmeter reading becomes 4 V.
7. Move any flat object up and down the ultrasonic sensors. Make sure that the object is parallel to the trainer.
8. Observe the seven segment display as it shows the distance (in meters) between the ultrasonic sensors and the object.

**OBSERVATION**

The output is observed on seven segment display.

**PRECAUTIONS:**

1. Use the trainer kit with care.
2. To avoid fire or shock hazards, observe all ratings and marks on the instrument.
3. Do not operate in wet / damp conditions.

**QUIZ/ANSWERS:-**

Q1 What is the difference between sensor and transducer?
A1 The sensor senses the condition, state or value of the process variable and produces an output which reflects this condition, state or value.The transducer transforms the energy of the process variable to an output of some other energy which is able to operate some control device.

Q2 What are the features of ultra sonic waves?
A2 There are two unique features of ultrasonic waves:

- Ultrasonic waves travel slowly, about 100,000 times slower than electromagnetic waves. This provides a way to display information in time, create variable delay, etc.
- Ultrasonic waves can easily penetrate opaque materials, whereas many other types of radiation such as visible light cannot. Since ultrasonic wave sources are inexpensive, sensitive, and reliable, this provides a highly desirable way to probe and image the interior of opaque object.

Q3 What is ultra sonic transducer?
A3 An ultrasonic transducer is a device that converts energy into ultrasound,or sound waves above the normal range of human hearing.

Q4 What is the function of ultra sonic sensors?
A4 Ultrasonic sensors generate high frequency sound waves and evaluate the echo which is received back by the sensor. Sensors calculate the time interval between sending the signal and receiving the echo to determine the distance to an object.

Q5 What is the frequency range of ultra sonic waves?
A5 They establish a detection field using energy in the acoustic spectrum typically in the frequency range between 19 and 40 KHz.

Q6 How ultra sonic transducer works?
A6 Ultrasonic range sensor works by emitting a short burst of 40 KHz ultrasonic sound from a piezoelectric transducer. A small amount of sound energy is reflected by objects in front of the device and returned to the detector, another piezoelectric transducer. The receiver amplifier sends these reflected signals (echoes) to microcontroller which times them to determine how far away the objects are, by using the speed of sound in air. The calculated range is then displayed on the screen.

Q7 What are the advantages of ultrasonic signals?
A7 The advantages of ultrasonic signals are:

- Long range detection
- Broad area detection
- Widest range of target materials
- Non contact distance measuring
- Unaffected by atmospheric conditions

Q8 What are the Characteristics of Transducer?
A8 When choosing a transducer for any application, the input, transfer & output characteristics have to be taken into account.

Q9 What are the conditions are considered for Output Characteristics?
A9 The three conditions in the output characteristics which should be considered:
a. Type of electrical output,
b. Output Impedance,
c. Useful Range.

Q10. Give examples of active and passive transducers?
A10. Active transducer: Solar cell, Piezo Electric crystal, Thermocouple
Passive transducer: LDR, Photo diode, RTD

# MICROPROCESSOR AND INTERFACING
## (EE-329-F)

# LAB MANUAL

## V SEMESTER

# MICROPROCESSOR AND INTERFACING LAB

## LIST OF EXPERIMENTS
## V SEM.(ECE, CSE, IT,BME)

| S.NO. | NAME OF THE EXPERIMENT |
|---|---|
| 1 | STUDY ARCHITECTURE OF 8085 & 8086 AND FAMILIARIZATION WITH ITS HARDWARE, COMMANDS & OPERATION OF MICROPROCESSOR KIT. |
| 2 | WRITE A PROGRAM USING 8085 & VERIFY FOR :<br>A. ADDITION OF TWO 8-BIT NUMBERS.<br>B. ADDITION OF TWO 16-BIT NUMBERS. (WITH CARRY) |
| 3 | WRITE A PROGRAM USING 8085 & VERIFY FOR :<br>A. SUBTRACTION OF TWO 8-BIT NUMBERS. (DISPLAY OF BARROW)<br>B. SUBTRACTION OF TWO 16-BIT NUMBERS. (DISPLAY OF BARROW) |
| 4 | WRITE A PROGRAM USING 8085 & TEST FOR TYPICAL DATA:<br>A. MULTIPLICATION OF TWO 8-BIT NUMBERS BY BIT ROTATION METHOD<br>B. DIVISION OF TWO 8-BIT NUMBERS BY REPEATED SUBTRACTION METHOD |
| 5 | WRITE A PROGRAM USING 8086 FOR DIVISION OF A DEFINED DOUBLE WORD BY ANOTHER WORD & VERIFY. |
| 6 | WRITE A PROGRAM USING 8085 FOR FINDING SQUARE-ROOT OF A NUMBER & VERIFY. |
| 7 | WRITE A PROGRAM USING 8086 FOR COPYING 12 BYTES OF DATA FROM SOURCE TO DESTINATION & VERIFY. |
| 8 | WRITE A PROGRAM USING 8086 FOR ARRANGING AN ARRAY OF NUMBERS IN DESCENDING ORDER & VERIFY. |
| 9 | WRITE A PROGRAM TO INTERFACE ADC & DAC WITH 8085 & DEMONSTRATE GENERATION OF SQUARE WAVE. |
| 10 | WRITE A PROGRAM TO CONTROL THE OPERATION OF STEEPER MOTOR USING 8085 AND 8255 PPI. |
| 11 | WRITE A PROGRAM TO CONTROL THE TRAFFIC LIGHT SYSTEM USING 8085 AND 8255 PPI. |

# EXPERIMENT NO. 1(A)

**AIM :** STUDY OF 8085-MICROPROCESSOR KIT.

**APPARATUS**: 8085 microprocessor kit.

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**THEORY :**

Intel 8085 is an 8-bit microprocessor. It is 40-pin IC package fabricated on a single LSI chip. It uses a single +5 V supply. Its clock speed is about 3 MHz. It consists of three main sections: -

1.*ALU (Arithmetic and logic unit):-*

The ALU performs the arithmetic and logical operation, addition, subtraction, logical AND, OR, EX-OR, Complement, Increment, Decrement, shift, clear.

2.*Timing and Control Unit:-*

It generates timing and control signals, which are necessary for the execution of instruction.

3.*Registers: -*

These are used for temporary storage of data and instruction. INTEL 8085 has following registers: -

i) One 8 bit accumulator
ii) Six 8 bit registers (B, C, D, E, H, L)
iii) One 16 bit stack pointer, SP
iv) One 16 bit program counter, PC
v) Instruction register
vi) Status register
vii) Temporary registers

PC contains the address of next instruction.
IR holds the instruction until it is decoded.
SP holds the address of the stack top.
Accumulator is used during execution of program for temporary storage of data.

Status flags are as follows: -

i) Carry (CS)
ii) Zero (Z)
iii) Sign (S)
iv) Parity (P)
v) Auxiliary Carry (AC)

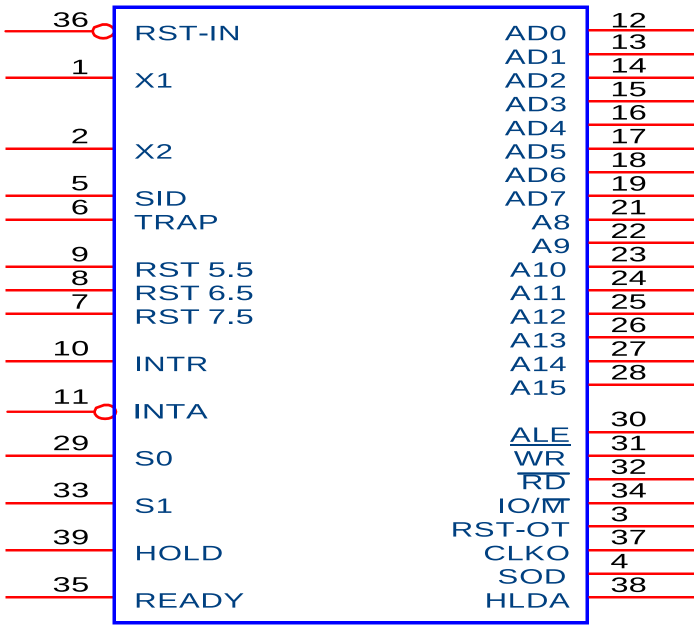
**PSW**

This 8-bit program status word includes status flags and three undefined bits.

**Data and Address bus**

Data bus is 8- bit wide and 8 bits of data can be transmitted in parallel. It has 16-bit wide address bus as the memory addresses are of 16 bits.

## CIRCUIT DIAGRAM(PIN DIAGRAM):-




**PIN CONFIGURATION**

**A8-A15 (Output):-**

These are address bus and used for the most significant bits of memory address.

**AD0-AD7 (Input/Output):-**

These are time multiplexed address data bus. These are used for the least significant 8 bits of the memory address during first clock cycle and then for data during second and third clock cycle

**ALE (Address Latch Enable)**

It goes high during the 1st clock cycle of a machine. It enables the lower 8 bits of address to be latched either in the memory or external latch.

**IO/M**

It is status signal, when it goes high; the address on address bus is for I/O device, otherwise for memory.

**So, S1**

These are status signals to distinguish various types of operation

| S1 | So | Operation |
|---|---|---|
| 0 | 0 | Halt |
| 0 | 1 | Write |
| 1 | 0 | Read |
| 1 | 1 | Fetch |

**RD (output)**

It is used to control read operation.

**WR (output)**

It is used to control write operation

**HOLD (input)**

It is used to indicate that another device is requesting the use of address & data bus.

**HLDA (output)**

It is acknowledgement signal used to indicate HOLD request has been received.

**INTR (input)**

When it goes high, microprocessor suspends its normal sequence of operations.

**INTA (output)**

It is interrupt acknowledgement signal sent by microprocessor after INTR is received.

**RST 5.5,6.5,7.5 and TRAP**

These are various interrupt signals. Among them TRAP is having highest priority

**RESET IN (input)**

It resets the PC to zero.

**RESET OUT(output)**

It indicates that CPU is being reset.

**X1, X2 (input)**

This circuitry is required to produce a suitable clock for the operation of microprocessor. .

**Clk (output)**

It is clock output for user. Its frequency is same at which processor operates.

**SID (input)**

It is used for data line for serial input.

**SOD (output)**

It is used for data line for serial output.

**Vcc**

+5 volts supply

**Vss**

Ground reference

## EXPERIMENT NO .1 (B)

**AIM** : STUDY OF 8086 MICROPROCESSOR KIT.

**APPARATUS**: 8086 microprocessor kit.

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**THEORY :**The 8086 is a 16-bit, N-channel, HMOS microprocessor. The term HMOS is used for high-speed MOS". The 8086 uses 20 address lines and 16 data lines. It can directly address up to $2^{20}$ = 1Mbytes of memory. The 16-bit data word is divided into a low-order byte and a high-order byte. The 20 address lines are time multiplexed lines. The 16 low-order address lines are time multiplexed with data, and the 4 high-order address lines are time multiplexed with status signals.

**OPERATING MODES OF 8086**

There are two modes of operation for Intel 8086, namely the minimum mode and the maximum mode. When only one 8086 CPU is to be used in a microcomputer system the 8086 is used in the minimum mode of operation. In this mode the CPU issues the control signals required by memory and I/O devices. In case of maximum mode of operation control signals are issued by Intel 8288 bus controller which is used with 8086 for this very purpose. When MN/MX is high the CPU operates in the minimum mode. When it is low the CPU operates in the maximum mode.

**Pin Description For Minimum Mode**

For the minimum mode of operation the pin MN/$\overline{\text{MX}}$ is connected to 5V d.c supply. The description of the pins from 24 to 31 for the minimum mode is as follows:

**$\overline{\text{INTA}}$(Output):** Pin no. 24 Interrupt acknowledge. On receiving interrupt signal the processor issues an interrupt acknowledge signal. It is active LOW.

**ALE(Output) :** Pin no. 25 Address latch enable. It goes HIGH during T1. The microprocessor sends this signal to latch the address into the Intel 8282/8283 latch.

**DEN(Output) :** Pin no. 26 Data enable. When Intel 8286/8287 octal bus transceiver is used this signal acts as an output enable signal. It is active LOW.

**DT/R(Output) :** Pin no. 27 Data Transmit/Receive. When Intel 8286/8287 octal bus transceiver is used this signal controls the direction of data flow through the transceiver. When it is High data are sent out. When it is LOW data are received.

**M/$\overline{\text{IO}}$(Output) :** Pin no. 28.Memory or I/O access. When it is HIGH the CPU wants to access memory. When it is LOW the CPU wants to access I/O device.

**WR (Output) :** Pin no. 29. Write. When it is LOW the CPU performs memory or I/O write Operation.

**HLDA (Output) :** Pin no. 30.HOLD acknowledge. It is issued by the processor when it receives HOLD signal. It is active HIGH signal. When HOLD request is removed HLDA goes LOW.

**HOLD (Output) :** Pin no. 31.Hold. when another device in microcomputer system wants to use the address and data bus, it sends a HOLD request to CPU through this pin. It is an active HIGH signal.

**Pin Description For Maximum Mode**

For the maximum mode of operation the pin MN/$\overline{MX}$ is made LOW. It is grounded. The description of the pins from 24 to 31 is as follows:

**QS1, QS0(Output):** Pin no. 24,25 Instruction Queue status. Logic are given below:

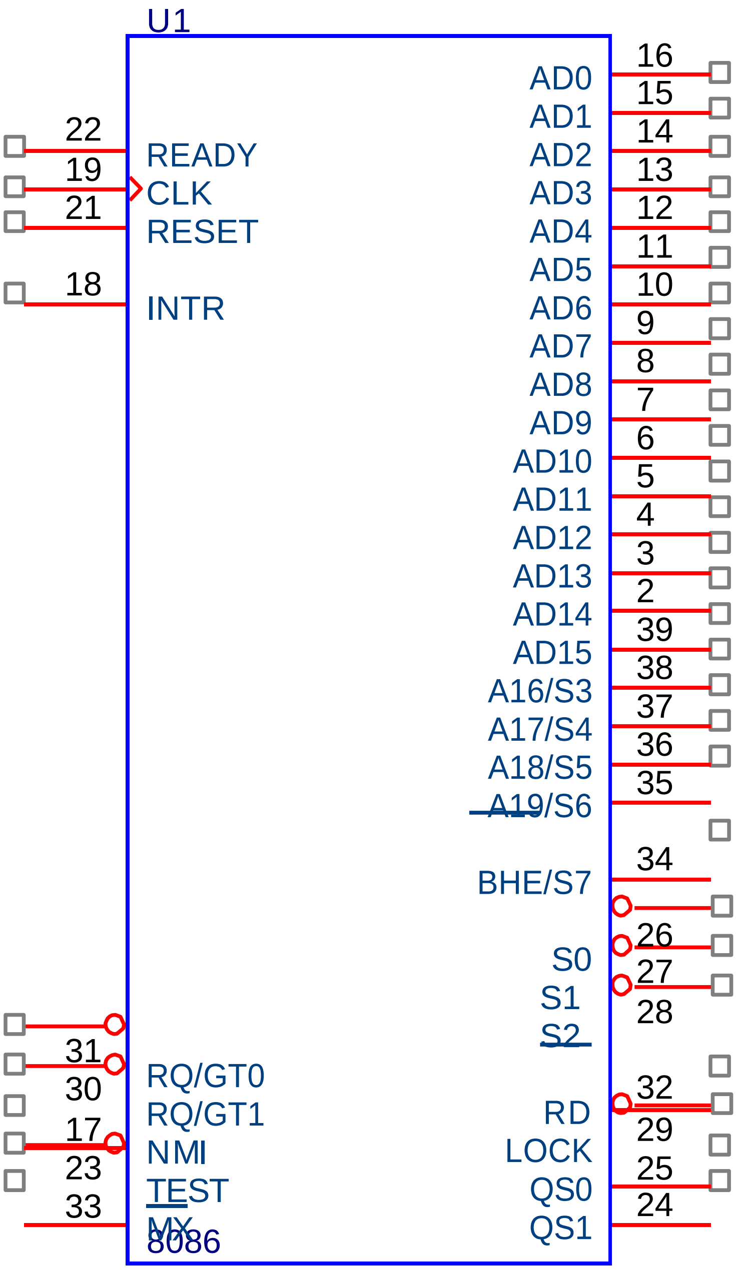
| QS1 | QS0 | |
|---|---|---|
| 0 | 0 | No operation |
| 0 | 1 | 1st byte of opcode from queue |
| 1 | 0 | Empty the queue |
| 1 | 1 | Subsequent byte from queue |

**$\overline{S0}$,$\overline{S1}$,$\overline{S2}$(Output) :** Pin nos. 26,27,28.status signals. These signals are connected to the bus controller Intel 8288.The bus controller generates memory and I/O access control signals. Table for status signals is :

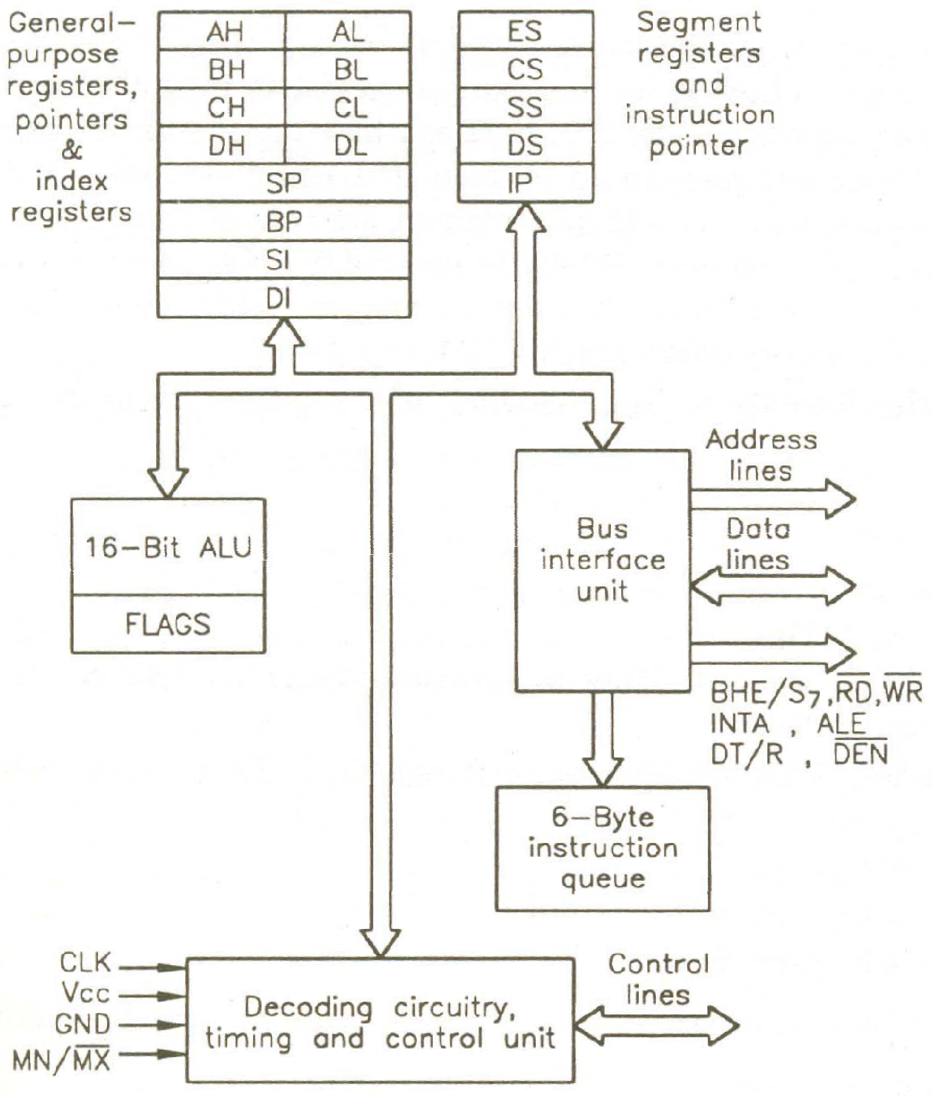
| S2 | $\overline{S1}$ | $\overline{S0}$ | |
|---|---|---|---|
| 0 | 0 | 0 | Interrupt acknowledge |
| 0 | 0 | 1 | Read data from I/O port |
| 0 | 1 | 0 | Write data into I/O port |
| 0 | 1 | 1 | Halt |
| 1 | 0 | 0 | Opcode fetch |
| 1 | 0 | 1 | Memory read |
| 1 | 1 | 0 | Memory write |
| 1 | 1 | 1 | Passive state. |

**LOCK(Output) :** Pin no. 29.It is an active LOW signal. When it is LOW all interrupts are masked and no HOLD request is granted. In a multiprocessor system all other processors are informed by this signal that they should not ask the CPU for relinquishing the bus control.

**$\overline{RQ}$ / $\overline{GT_1}$, $\overline{RQ}$ / $\overline{GT_0}$ (Bidirectional) :** Pin no. 30,31. Local bus Priority control. Other processors ask the CPU through these lines to release the local bus. **$\overline{RQ}$ / $\overline{GT_1}$** has higher priority than **$\overline{RQ}$ / $\overline{GT_0}$**




PIN DIAGRAM OF 8086




Block Diagram of Intel 8086 Microprocessor

**BLOCK DIAGRAM OF 8086:**

**REGISTERS OF 8086 :** The Intel 8086 contains the following registers:

a) General Purpose Register
b) Pointer and Index Registers
c) Segment Registers
d) Instruction Registers
e) Status Flags

# EXPERIMENT NO. 2(A)

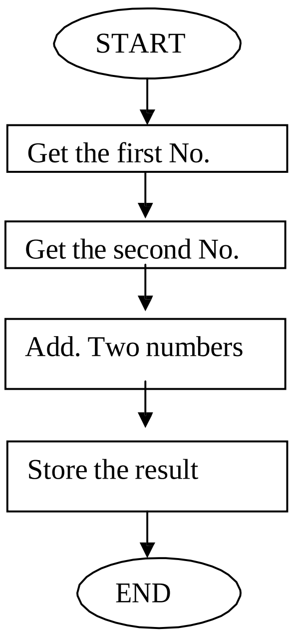
**AIM** : WRITE A PROGRAM USING 8085 & VERIFY FOR :
(a) ADDITION OF TWO 8-BIT NUMBERS.

**APPARATUS** : 8085 microprocessor kit, 5V power supply, Keyboard.

**THEORY (Program)**

| Memory address | Machine code | Mnemonics | Operands | Commands |
|---|---|---|---|---|
| 7000 | 21,01,75 | LXI | H,7501 | Get address of 1st no. in HL pair |
| 7003 | 7E | MOV | A,M | Move Ist no. in accumulator |
| 7004 | 23 | INX | H | HL points the address 7502H |
| 7005 | 86 | ADD | M | Add the 2nd no. |
| 7006 | 23 | INX | H | HL points 7503H |
| 7007 | 77 | MOV | M,A | Store result in 7503H. |
| 7008 | CF | RST 1 | | Terminate |

**CIRCUIT DIAGRAM / BLOCK DIAGRAM:-**



**PROCEDURE:-**

| ANSHUMAN | SCIENTECH |
|---|---|
| S | Reset |
| Enter Enter | Exmem |
| Program Address | Starting Address |
| Write Program | Next |
| | Write Program |
| **Execution Steps** | **Execution Steps** |
| Esc | Reset |
| G | GO |
| Enter-enter | Starting Address |
| Prog. Address | Fill |
| Enter | Reset |
| S | Exmem |
| Enter | Result Address |
| Any key-2 | |
| Enter-2 | |
| Register Name | |

**INPUT DATA**

7501- 13H
7502- 12H

**OUTPUT DATA**

7503- 25H

**PRECAUTIONS:-**

Make sure that all the machine codes should be as per specified in the program.

# EXPERIMENT NO. 2(B)

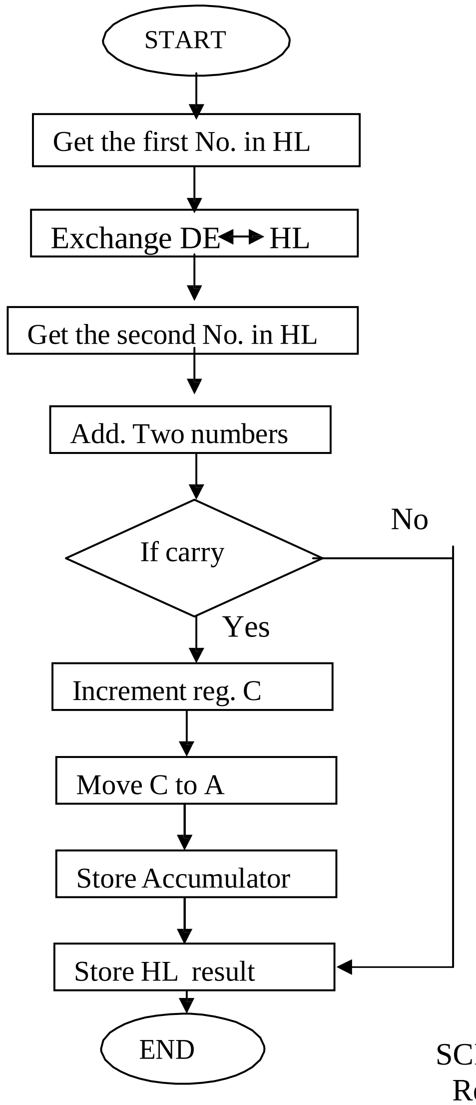
**AIM** : WRITE A PROGRAM USING 8085 & VERIFY FOR :
(b) ADDITION OF TWO 16-BIT NUMBERS(WITH CARRY).

**APPARATUS :** 8085 microprocessor kit, 5V power supply, Keyboard.

**THEORY (Program)**

| Memory address | Label | Machine code | Mnemonics | Operands | Commands |
|---|---|---|---|---|---|
| 7000 | | 2A,01,76 | LHLD | 7601H | Get 1st no. in HL pair from memory (7601) |
| 7003 | | EB | XCHG | | Exchange cont. of DE ↔HL |
| 7004 | | 2A,03,76 | LHLD | 7603H | Get 2nd no. in HL pair from location 7603 |
| 7007 | | 0E,00 | MVI | C,00H | Clear reg. C. |
| 7009 | | 19 | DAD | D | Get HL+DE & store result in HL |
| 700A | | D2,12,70 | JNC | 7012(loop) | If no carry move to loop/if carry then move to next step. |
| 700D | | 0C | INR | C | Increment reg C |
| 700E | | 79 | MOV | A,C | Move carry from reg. C to reg. A |
| 7011 | | 32,02,75 | STA | 7502 | Store carry at 7502H |
| 7012 | loop | 22,00,75 | SHLD | 7500 | Store result in 7500H. |
| 7015 | | CF | RST1 | | Terminate |

## CIRCUIT DIAGRAM / BLOCK DIAGRAM:-




## PROCEDURE:-

| ANSHUMAN | SCIENTECH |
|---|---|
| S | Reset |
| Enter Enter | Exmem |
| Program Address | Starting Address |
| Write Program | Next |
| | Write Program |
| **Execution Steps** | **Execution Steps** |
| Esc | Reset |
| G | GO |
| Enter-enter | Starting Address |
| Prog. Address | Fill |
| Enter | Reset |
| S | Exmem |
| Enter | Result Address |
| Any key-2 | |
| Enter-2 Register Name | |

**INPUT DATA**

7601 : 13H
7602 : 31H
7603 : 12H
7604 : 10H

**OUTPUT DATA**

7500 : 25H
7501 : 41H
7502 : 00H

**PRECAUTIONS:-**

Make sure that all the machine codes should be as per specified in the program.

**Question & Answer:**

Q.l Explain MOV r,M ?
Ans: Move the content of memory to register.

Q.2 How many T-state are in MOV instruction?
Ans: 4 T-state.

Q.3 Explain the addressing mode of MOV r,M?
Ans: Register indirect.

Q.4 How many machine cycles are in MOV instruction?
Ans: 2 machine cycle.

Q.5 What is MOV M,r ?
Ans: move the content of register to memory

Q.6 Which flag is affected in MOV instruction?
Ans: none

Q.7 What is MVI r,data?
Ans: move immediate data to register

Q.8 How many T-state are in MVI instruction?
Ans: seven T-states.

Q.9 Explain the addressing mode of MVI r,data?
Ans: immediate

Q.10 How many machine cycles are in MVI instruction?
Ans: 3 machine cycles.

## EXPERIMENT NO. 3(A)

**AIM** : WRITE A PROGRAM USING 8085 & VERIFY FOR :

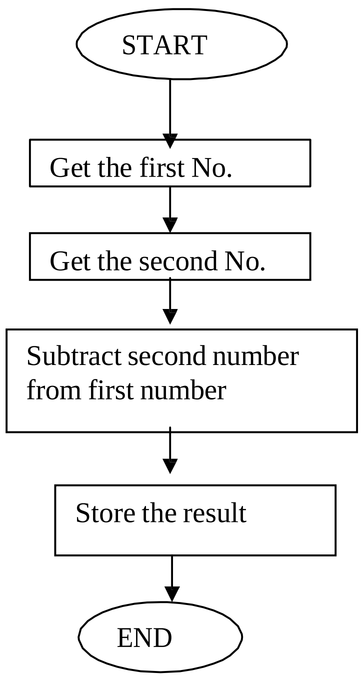
A. SUBTRACTION OF TWO 8-BIT NUMBERS. (DISPLAY OF BARROW).

**APPARATUS** : 8085 microprocessor kit, 5V power supply, Keyboard.

**THEORY(Program)** :

| **Memory address** | **Opcode** | **Mnemonics** | **Operands** | **Comments** |
|---|---|---|---|---|
| 7000 | 21,01,75 | LXI | H, 7501 | Get address of ist no. in HL pair |
| 7003 | 7E | MOV | A, M | Move Ist no. in accumulator |
| 7004 | 23 | INX | H | HL points 7502H. |
| 7005 | 96 | SUB | M | Substract 2$^{nd}$ no. from Ist no. |
| 7006 | 23 | INX | H | HL points 7503 H. |
| 7007 | 77 | MOV | M, A | Move contents of acc. to memory |
| 7008 | CF | RST 1 | | Stop |

**CIRCUIT DIAGRAM / BLOCK DIAGRAM :-**



**PROCEDURE:-**

| ANSHUMAN | SCIENTECH |
|---|---|
| S | Reset |
| Enter Enter | Exmem |
| Program Address | Starting Address |
| Write Program | Next |
| | Write Program |
| **Execution Steps** | **Execution Steps** |
| Esc | Reset |
| G | GO |
| Enter-enter | Starting Address |
| Prog. Address | Fill |
| Enter | Reset |
| S | Exmem |
| Enter | Result Address |
| Any key-2 | |
| Enter-2 | |
| Register Name | |

**INPUT DATA**

7501 : 20H
7502 : 10H

**OUTPUT DATA**

7503 : 10H

**PRECAUTIONS:-**

Make sure that all the machine codes should be as per specified in the program.

# EXPERIMENT NO. 3 (B)

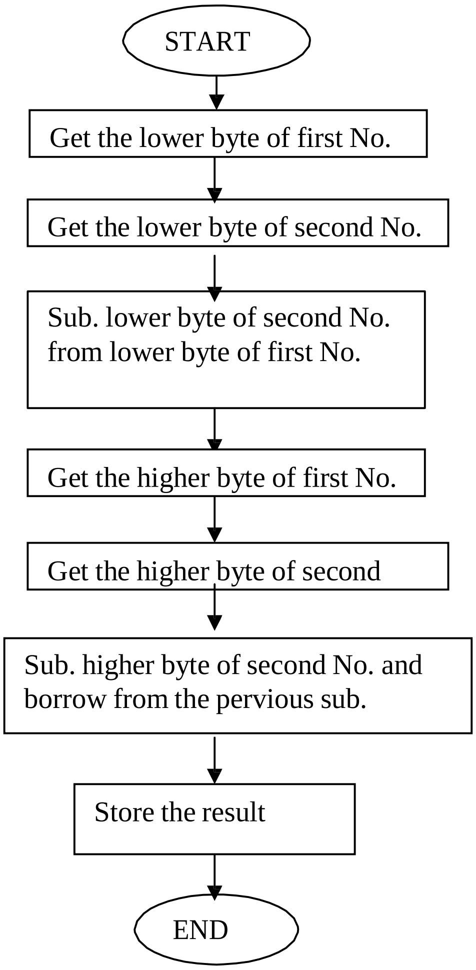
**AIM :** WRITE A PROGRAM USING 8085 & VERIFY FOR :
B. SUBTRACTION OF TWO 16-BIT NUMBERS. (DISPLAY OF BARROW)

**APPARATUS** : 8085 microprocessor kit, 5V power supply, Keyboard.

**THEORY (Program) :**

| **Memory Address** | **Machine Code** | **Mnemonics** | **Operands** | **Comments** |
|---|---|---|---|---|
| 7000 | 2A, 01,75 | LHLD | 7501 H | Get 1st 16 bit no. in HL pair |
| 7003 | EB | XCHG | | Exchange HL pair with DE. |
| 7004 | 2A, 03,75 | LHLD | 7503 H | Get 2nd 16 bit no. in HL pair |
| 7007 | 7B | MOV | A, E | Get lower byte of ist no. |
| 7008 | 95 | SUB | L | Subtract lower byte of 2nd no. |
| 7009 | 6F | MOV | L, A | Store the result in reg. L |
| 700A | 7A | MOV | A, D | Get higher byte of Ist no. |
| 700B | 96 | SBB | H | Subtract higher byte of 2nd no. with borrow |
| 700C | 67 | MOV | H,A | Move from acc. To H |
| 700D,E, F | 22,05,75 | SHLD | 7505H | Store 16 bit result at 7505&7506 |
| 7010 | CF | RST 1 | | Terminate |

## CIRCUIT DIAGRAM / BLOCK DIAGRAM :-




## PROCEDURE:-

| ANSHUMAN | SCIENTECH |
|---|---|
| S | Reset |
| Enter Enter | Exmem |
| Program Address | Starting Address |
| Write Program | Next |
| | Write Program |
| **Execution Steps** | **Execution Steps** |
| Esc | Reset |
| G | GO |
| Enter-enter | Starting Address |
| Prog. Address | Fill |
| Enter | Reset |
| S | Exmem |
| Enter | Result Address |
| Any key-2 | |

Enter -2
Register Name

**INPUT DATA**

7501 : 30H
7502 : 40H
7503 : 10H
7504 : 20H

**OUTPUT DATA**

7505 : 20H
7506 : 20H

**PRECAUTIONS:-**

Make sure that all the machine codes should be as per specified in the program.

**Question & Answer:**

Q.1 Explain LXI rp,data 16 ?
Ans: load register pair immediate.

Q.2 How many T-state are in LXI instruction?
Ans: 10 T –states.

Q.3 Explain the addressing mode of LXI rp,data?
Ans: Immediate

Q.4 How many machine cycles are in LXI instruction?
Ans: 3 machine cycles.

Q.5 What is LDA addr ?
Ans: load accumulator direct.

Q.6 How many T-state are in LDA instruction?
Ans: 13 T –states.

Q.7 Explain the addressing mode ofLDA addr?
Ans: Direct

Q.8 How many machine cycles are in LDA instruction?
Ans: 4

Q.9 What is STA addr?
Ans: store accumulator direct

Q.10 How many T-state are in STA instruction?
Ans: 13

# EXPERIMENT NO. 4(A)

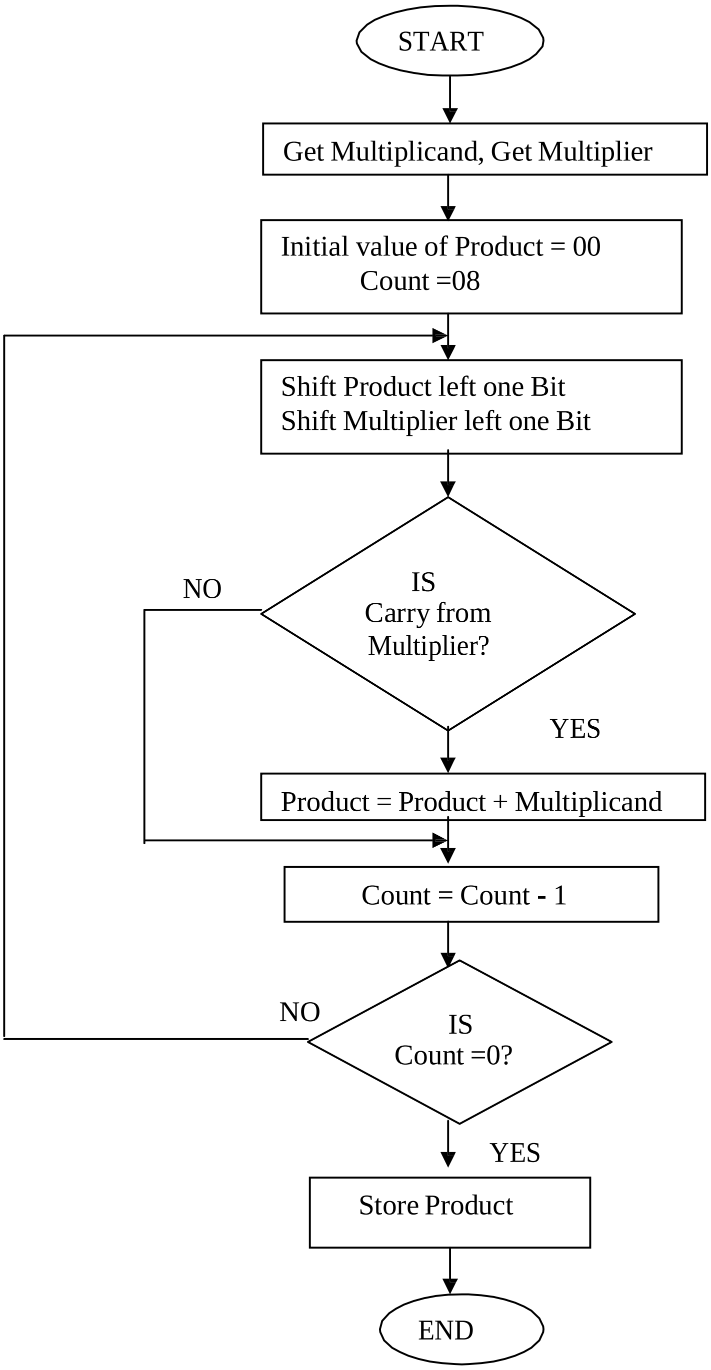
**AIM :** WRITE A PROGRAM USING 8085 FOR MULTIPLICATION OF TWO 8-BIT NUMBERS BY BIT ROTATION METHOD & VERIFY.

**APPARATUS :** 8085 microprocessor kit,5 V power supply, Keyboard.

**THEORY(Program)**

| Memory Address | Label | Machine Code | Mnemonics | Operands | Comments |
|---|---|---|---|---|---|
| 7000 | | 2A,01,75 | LHLD | 7501 H | Get Multiplicand in H-L pair. |
| 7003 | | EB | XCHG | | Exchange HL pair with DE pair |
| 7004 | | 3A,03,75 | LDA | 7503 H | Get 2nd no. in acc. |
| 7007 | | 21,00,00 | LXI | H,0000 | Initial product in HL=00 |
| 700A | | 0E,08 | MVI | C,08H | Count=08 in reg .C |
| 700C | Loop | 29 | DAD | H | Shift partial product left by 1 bit |
| 700D | | 17 | RAL | | Rotate multiplication by 1 bit. Is multiplier = 1? |
| 700E | | D2,12,70 | JNC | Ahead(7012) | No, go to ahead |
| 7011 | | 19 | DAD | D | Product=Product + Multiplicand |
| 7012 | Ahead | 0D | DCR | C | Decrement Count |
| 7013 | | C2,0C,70 | JNZ | Loop(700C) | |
| 7016 | | 22,04,75 | SHLD | 7504 | Store result |
| 7019 | | CF | RST 1 | | Terminate |

**CIRCUIT DIAGRAM / BLOCK DIAGRAM :-**



**PROCEDURE:-**

| ANSHUMAN | SCIENTECH |
|---|---|
| S | Reset |
| Enter Enter | Exmem |
| Program Address | Starting Address |
| Write Program | Next |
| | Write Program |
| **Execution Steps** | **Execution Steps** |
| Esc | Reset |
| G | GO |
| Enter-enter | Starting Address |
| Prog. Address | Fill |
| Enter | Reset |
| S | Exmem |
| Enter | Result Address |
| Any key-2 | |
| Enter-2 | |
| Register Name | |

**INPUT DATA**

7501- 25H
7502- 00H
7503- 05H

**OUTPUT DATA**

7504- B9H
7505- 00H

**PRECAUTIONS:-**

Make sure that all the machine codes should be as per specified in the program.

# EXPERIMENT NO. 4(B)

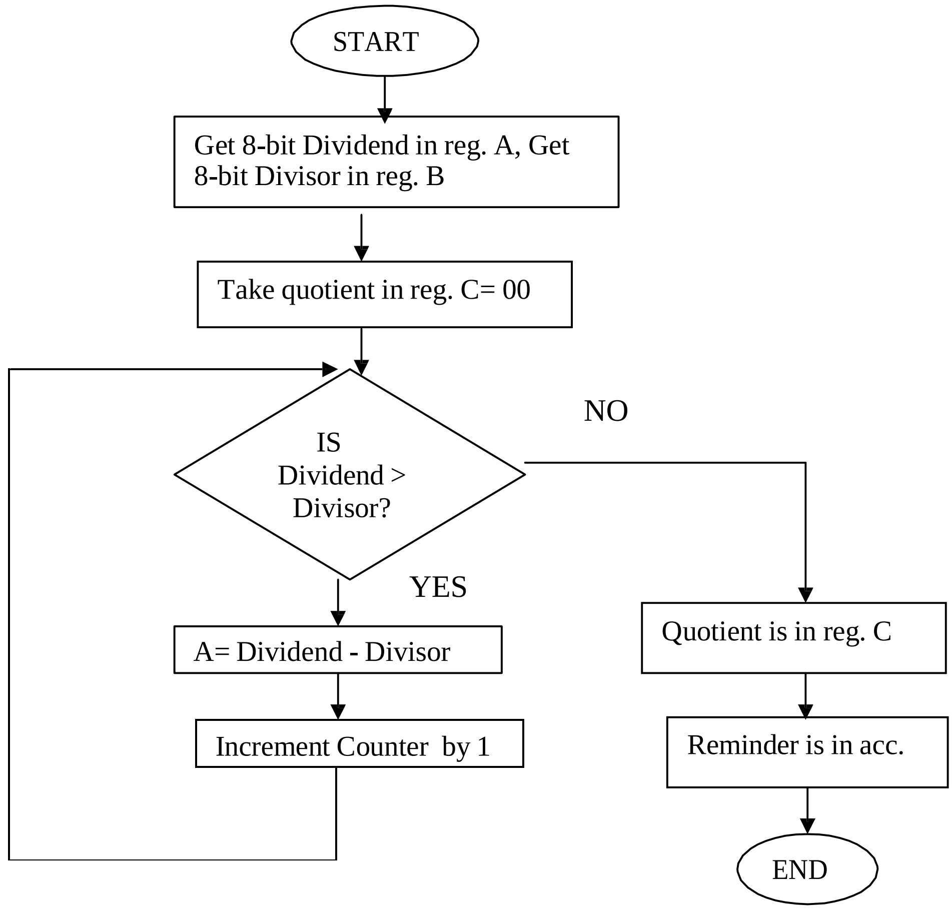
**AIM :** WRITE A PROGRAM USING 8085 FOR DIVISION OF TWO 8-BIT NUMBERS BY REPEATED SUBTRACTION METHOD & TEST FOR TYPICAL DATA.

**APPARATUS :** 8085 microprocessor kit, 5V power supply, Key board.

**THEORY (Program) :**

| Memory Address | Label | Machine Code | Mnemonics | Operands | Comments |
|---|---|---|---|---|---|
| 7000 | | 3A,01,75 | LDA | Divisor(7501) | |
| 7003 | | 47 | MOV B,A | | Take divisor in reg,B |
| 7004 | | 3A,02,75 | LDA | Dividend(7502) | Take dividend in reg,A |
| 7007 | | 0E,00 | MVI | C,00 | Quotient=00 |
| 7009 | | B8 | CMP | B | |
| 700A | | DA,13,70 | JC | Loop(7013) | |
| 700D | loop1 | 90 | SUB | B | Dividend-divisor=>A |
| 700E | | 0C | INR | C | C=C+1 |
| 700F | | B8 | CMP | B | Is dividend < divisor |
| 7010 | | D2,0D,70 | JNC | Loop1(700D) | If not,go back |
| 7013 | loop | 32,03,75 | STA | Remainder(7503) | Store Remainder |
| 7016 | | 79 | MOV | A,C | |
| 7017 | | 32,04,75 | STA | Quotient(7504) | Store Quotient |
| 701A | | CF | RST 1 | | Terminate. |

**CIRCUIT DIAGRAM / BLOCK DIAGRAM:-**




**PROCEDURE:-**

| | |
|---|---|
| | SCIENTECH |
| ANSHUMAN | Reset |
| S | Exmem |
| Enter Enter | Starting Address |
| Program Address | Next |
| Write Program | Write Program |
| **Execution Steps** | **Execution Steps** |
| Esc | Reset |
| G | GO |
| Enter-enter | Starting Address |
| Prog. Address | Fill |
| Enter | Reset |
| S | Exmem |
| Enter | Result Address |
| Any key-2 | |
| Enter-2 | |
| Register Name | |

**INPUT DATA**

7501- Divisor
7502-Dividend

**OUTPUT DATA**

7503-Remainder
7504-Quotient

**PRECAUTIONS**:-

Make sure that all the machine codes should be as per specified in the program.

**Question & Answer**

Q.1 Explain the addressing mode ofSTA addr?
Ans: Direct

Q.2 How many machine cycles are in STA instruction?
Ans: 4

Q.3 What is LHLD addr?
Ans: load H - L pair direct.

Q.4 How many T-state are in LHLD instruction?
Ans: 24 sixteen T –states..

Q.5 Explain the addressing mode of LHLD addr?
Ans: Direct

Q.6 How many machine cycles are in LHLD instruction?
Ans: 5

Q.7 What is SHLD addr ?
Ans: store H-L pair direct.

Q.8 How many T-state are in SHLD instruction?
Ans: 16

Q.9 Explain the addressing mode of SHLD addr?
Ans: Direct

Q.10 How many machine cycles are in SHLD instruction?
Ans: 5.

## EXPERIMENT NO. 5

**AIM :** WRITE A PROGRAM USING 8085 FOR FINDING SQUARE-ROOT OF A NUMBER

**APPARATUS :** 8085 microprocessor kit, 5V power supply, Keyboard.

**THEORY(Program):**

| Memory Address | Label | Machine Code | Mnemonics | Operands | Comments |
|---|---|---|---|---|---|
| 2000 | | 0E,01 | MVI | C,01H | Place 01 in reg.C |
| 2002 | | 06,01 | MVI | B,01H | Place odd number 1 in reg.B |
| 2004 | | 3E,36 | MVI | A,36 | Load accumulator with the given number |
| 2006 | Loop | 90 | SUB | B | Subtract odd number from the accumulator |
| 2007 | | CA,10,20 | JZ | Ahead(2010) | If accumulator contents are zero, go to Ahead |
| 200A | | 0C | INR | C | Increment reg. C |
| 200B | | 04 | INR | B | Increment odd number |
| 200C | | 04 | INR | B | Increment odd number |
| 200D | | C3,06,20 | JMP | Loop(2006) | Repeat subtraction |
| 2010 | Ahead | 79 | MOV | A,C | Move the contents of C to A |
| 2011 | | 32,50,20 | STA | 2050H | Store the result in the memory location 2050H. |
| 2014 | | CF | RST1 | | Stop |

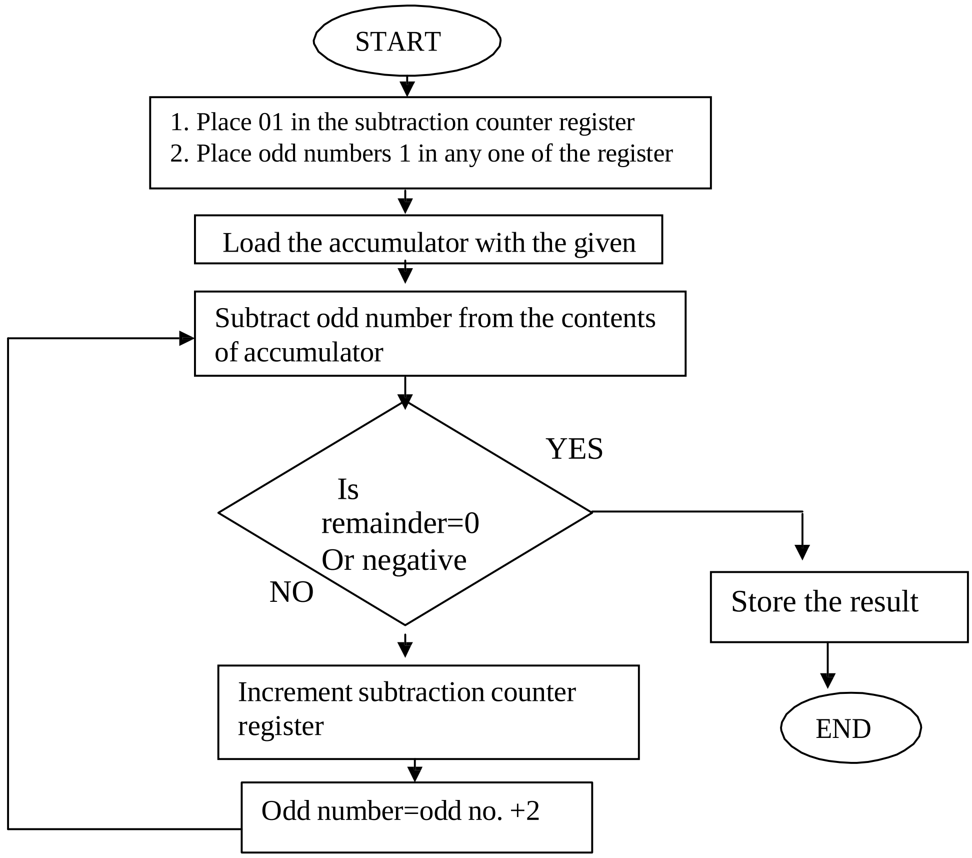
**PROCEDURE:-**

| ANSHUMAN | SCIENTECH |
|---|---|
| | Reset |
| S | Exmem |
| Enter Enter | Starting Address |
| Program Address | Next |
| Write Program | Write Program |

| **Execution Steps** | **Execution Steps** |
|---|---|
| Esc | Reset |
| G | GO |
| Enter-enter | Starting Address |
| Prog. Address | Fill |
| Enter | Reset |

S Exmem
Enter Result Address
Any key-2
Enter
Name
Register

**CIRCUIT DIAGRAM / BLOCK DIAGRAM:-**




**INPUT DATA**

2500-10H
2501- 00H

**OUTPUT DATA**

2550- 04H

**PRECAUTIONS:-**

Make sure that all the machine codes should be as per specified in the program.

**Question & Answer ;**

Q.1 What is LDAX rp?
Ans: Load accumulator indirect.

Q.2 How many T-state are in LDAX instruction?
Ans: 7

Q.3 Explain the addressing mode ofLDAX rp?
Ans: Register indirect .

Q.4 How many machine cycles are in LDAX instruction?
Ans: 2

Q.5 What is STAX rp ?
Ans: Store accumulator indirect

Q.6 How many T-state are in STAX instruction?
Ans: 7

Q.7 Explain the addressing mode ofSTAX rp?
Ans: Register indirect.

Q.8 How many machine cycles are in STAX instruction?
Ans: 2

Q.9 What is XCHG ?
Ans: Exchange the contents of H-L pair with D-E pair

Q.10 How many T-state are in XCHG instruction?
Ans: 4

## EXPERIMENT NO. 6

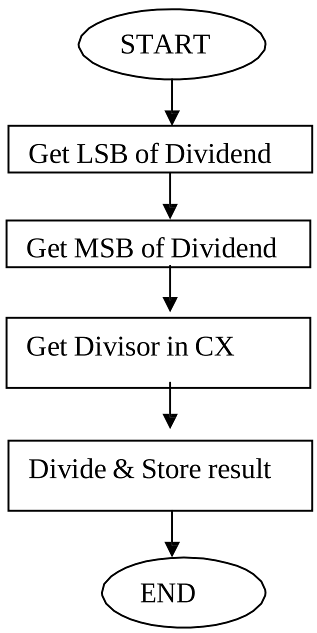
**AIM :** WRITE A PROGRAM USING 8086 FOR DIVISION OF A DEFINED DOUBLE WORD BYANOTHER WORD & VERIFY.

**APPARATUS :** 8086 microprocessor kit, 5V power supply, Keyboard.

**THEORY(Program)**

| Memory Address | Machine Code | Mnemonics | Operands | Comments |
|---|---|---|---|---|
| 1000 | B8,78,56 | MOV | AX,5678H | Move 5678 to AX |
| 1003 | BA,34,12 | MOV | DX,1234H | Move 1234 to DX |
| 1006 | B9,25,25 | MOV | CX,2525 | Move 2525 to CX |
| 1009 | F7,F1 | DIV | CX | Divide AX&DX by CX |
| 100b | CD,A5 | INT | A5 | |

**CIRCUIT DIAGRAM / BLOCK DIAGRAM:-**,



**PROCEDURE:-**

| ANSHUMAN | SCIENTECH |
|---|---|
| ANSHUMAN | Reset |
| S | O |
| Enter Enter | EB/AX |
| SRC-SEGM Address | |
| Enter | Starting Address |
| Program Address | Next |
| Write Program | Write Program |

| **Execution Steps** | **Execution Steps** |
|---|---|
| Esc | Reset |
| G | GO |
| Enter-enter | Starting Address |
| SRC-SEGM Add | Fill |
| Enter | Reset |
| Prog. Address | O |
| Enter | EB/AX |
| S | |
| Enter | Result Address |
| Any key-2 | |
| Enter-2 | |
| Register Name | |

**INPUT DATA**

AX : 5678H
DX : 1234H
CX : 2525H

**OUTPUT DATA**

AX : 7D77(Quotient)
DX : 0145(Remainder)

**PRECAUTIONS:-**

Make sure that all the machine codes should be as per specified in the program.

**Question & Answer:**

Q.l Explain the addressing mode of XCHG?
Ans: Register

Q.2 How many machine cycles are in XCHG instruction?
Ans: 1

Q.3 What is ADD r ?
Ans: Add register to accumulator.

Q.4 How many T-state are in ADD instruction?
Ans: 4

Q.5 Explain the addressing mode of ADD?
Ans: Register

Q.6 How many machine cycles are in ADD instruction?
Ans: 2

Q.7 What is ADC r?
Ans: Add register with carry to accumulator.

Q.8 How many T-state are in ADC r instruction?
Ans: 4

Q.9 Explain the addressing mode of ADC ?
Ans: Register

Q.10 How many machine cycles are in ADC instruction?
Ans: 1

# EXPERIMENT NO. 7

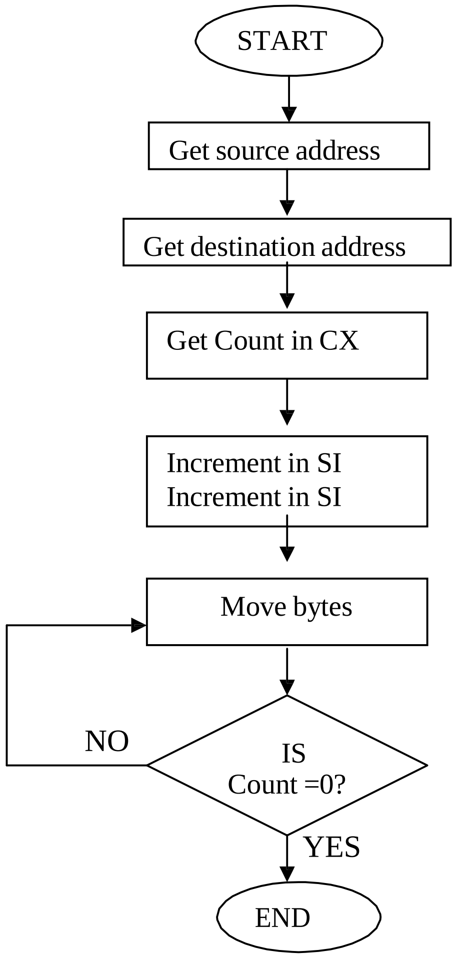
**AIM :** WRITE A PROGRAM USING 8086 FOR COPYING 12 BYTES OF DATA FROM SOURCE TO DESTINATION & VERIFY.

**APPARATUS :** 8086 microprocessor kit, 5V power supply, Keyboard.

**THEORY(Program)**

| **Memory Address** | **Label** | **Machine Code** | **Mnemonics** | **Operands** | **Comments** |
|---|---|---|---|---|---|
| 0101 | | FC | CLD | | Clear direction flag DF |
| 0102 | | BE,00,03 | MOV | SI,0300 | Source address in SI |
| 0105 | | BF,02,02 | MOV | DI,0202 | Destination address in DI |
| 0108 | | 8B,0C | MOV | CX,[SI] | Count in CX |
| 010A | | 46 | INC | SI | Increment SI |
| 010B | | 46 | INC | SI | Increment SI |
| 010C | BACK | A4 | MOV | SB | Move byte |
| 010D | | E2,FD | LOOP | BACK | Jump to BACK until CX becomes zero |
| 010F | | CC | INT | | Interrupt program |

**CIRCUIT DIAGRAM / BLOCK DIAGRAM:-**




**INPUT DATA**

| | |
|---|---|
| 0300 | : 0B |
| 0301 | : 00 |
| 0302 | : 03 |
| 0303 | : 04 |
| 0304 | : 05 |
| 0305 | : 06 |
| 0306 | : 15 |
| 0307 | : 07 |
| 0308 | : 12 |
| 0309 | : 08 |
| 030A | 09 |
| 030B | : 0A |
| 030C | : 0B |
| 030D | : 0E |

**OUTPUT DATA**

| | |
|---|---|
| 0202 | 03 |
| 0203 | : 04 |
| 0204 | : 05 |
| 0205 | : 06 |
| 0206 | : 15 |
| 0207 | : 07 |

| | | | |
|---|---|---|---|
| 0208 | : 12 | 020B | : 0A |
| 0209 | : 08 | 020C | : 0B |
| 020A | 09 | 020D | : 0E |

**PRECAUTIONS:-**

Make sure that all the machine codes should be as per specified in the program.

**Question & Answer:**

Q.1 Explain ADI data?
Ans: Add immediate data to accumulator

Q.2 How many T-states are in ADI instruction?
Ans: 7

Q.3 Explain the addressing mode of ADI?
Ans: Immediate

Q.4 How many machine cycles are in ADI instruction?
Ans: 2

Q 5 Explain DAD rp ?
Ans: Add register pair to HL pair.

Q.6 How many T-states are in DAD instruction?
Ans: 10

Q.7 Explain the addressing mode of DAD.
Ans: Register

Q.8 How many machine cycles are in DAD instruction?
Ans: 3

Q.9 Explain DAA.
Ans: Decimal adjust accumulator

Q.10 What is INX rp?
Ans: Increment register pair

# EXPERIMENT NO.8

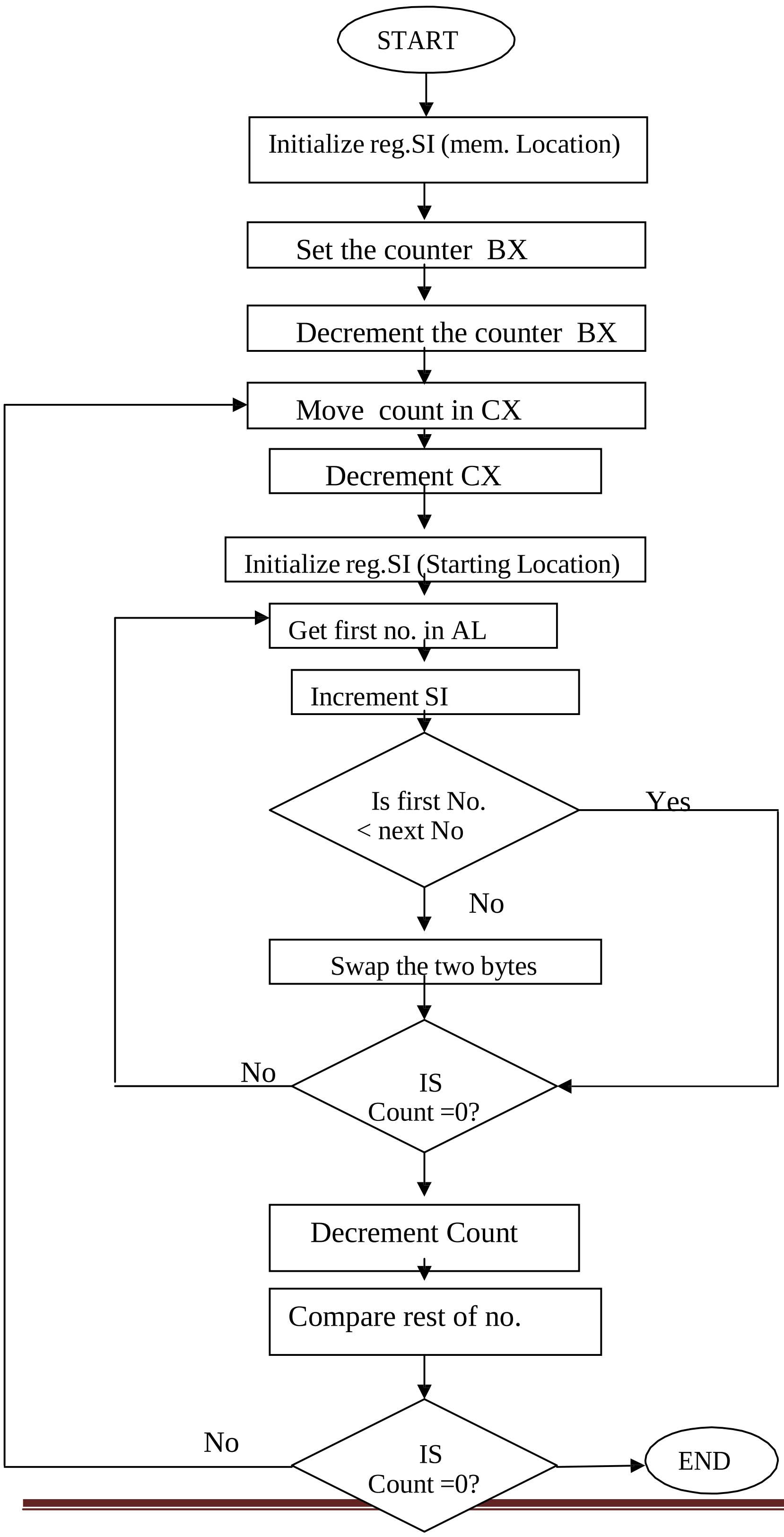
**AIM :** WRITE A PROGRAM USING 8086 FOR ARRANGING AN ARRAY OF NUMBERS IN DESCENDING ORDER & VERIFY.

**APPARATUS :** 8086 microprocessor kit, 5V power supply, Keyboard.

**THEORY(Program)**

| Memory Address | Label | Machine Code | Mnemonics | Operands | Comments |
|---|---|---|---|---|---|
| 0200 | | BE,00,03 | MOV | SI,0300 | Initialize SI Reg. with Memory Location. 0300. |
| 0203 | | 8B,1C | MOV | BX,[SI] | BX has no. of bytes |
| 0205 | | 4B | DEC | BX | Decrement the no. of bytes by one |
| 0206 | (3) | 8B 0C | MOV | CX (SI) | Move no. of bytes in CX |
| 0208 | | 49 | DEC | CX | Decrement the no. of bytes by one |
| 0209 | | BE,02,03 | MOV | SI,0303 | Initialize SI reg. with the starting address of string |
| 020C | (2) | 8A,04 | MOV | AL,[SI] | Move first data byte of string into AL |
| 020E | | 46 | INC | SI | Point at the next bytes of the string |
| 020F | | 3A,04 | COMP | AL,[SI] | Com. the two bytes of string. |
| 0211 | | 73,06 | JAE | (1) | If two bytes are equal or 1st byte is above that the second byte branch to (1) |
| 0213 | | 86,04 | XCHG | AL,[SI] | Else |
| 0215 | | 4E | DEC | SI | Second byte is less than first byte and swap the two bytes. |
| 0216 | | 88,04 | MOV | [SI],AL | |
| 0218 | | 46 | INC | SI | Point at next location of string |
| 0219 | (1) | E2,F1 | LOOP | (2) | Loop if CX is not zero |
| 021B | | 4B | DEC | BX | |
| 021C | | BE,00,03 | MOV | SI,0300 | |
| 021F | | 75,E5 | JNZ | (3) | |
| 0221 | | F4 | HLT | | Halt. |

**CIRCUIT DIAGRAM / BLOCK DIAGRAM:-**



**PROCEDURE:-**

ANSHUMAN
S
Enter Enter
Program Address
Write Program

**Execution Steps**

Esc
G
Enter-enter
Prog. Address
Enter
S
Enter
Any key-2
Enter-2
Register Name

SCIENTECH
Reset
Exmem
Starting Address
Next
Write Program

**Execution Steps**

Reset
GO
Starting Address
Fill
Reset
Exmem
Result Address

**INPUT DATA**

| | |
|---|---|
| 0300 | 05 |
| 0301 | : 00 |
| 0302 | : 20 |
| 0303 | : 25 |
| 0304 | : 28 |
| 0305 | : 15 |
| 0306 | : 07 |

**OUTPUT DATA**

| | |
|---|---|
| 0302 | 28 |
| 0303 | : 25 |
| 0304 | : 20 |
| 0305 | : 15 |
| 0306 | : 07 |

**PRECAUTIONS:-**

Make sure that all the machine codes should be as per specified in the program.

**Question & Answer:**

1. What is microprocessor?

Ans It is a program controlled semi conductor device (IC), which fetches, decodes and execute instructions.

2. What are the basic units of microprocessor?

Ans The basic units or blocks of microprocessor are ALU, an array of registers and control unit.

3. What is a bus?

Ans Bus is a group of conducting lines that carries data, address and control signals.

4. Why data bus is bi-directional?

Ans The microprocessor is to fetch (read) the data from memory or input device for processing and after processing it has to store (write) the data to memory or output devices. Hence the data bus is bi-directional.

5. Why data bus is bi-directional?

Ans The address is an identification number used by the microprocessor to identify or access a memory location or input/output device. It is an output signal from the processor. Hence the address bus is unidirectional.

6. Define machine cycle?

Ans Machine cycle is defined as the time required to complete one operation of accessing memory input/output, or acknowledging an external request. This cycle may consists of three to six T-states.

7. Define T-state?

Ans T-state is defined as one subdivision of operation performed in one clock period. These subdivisions are internal states synchronized with the system clock, and each T-state is precisely equal to one clock period.

8. What is an instruction cycle?

Ans The sequence of operations that a processor has to carry out while executing the instruction is called instruction cycle. Each instruction cycle of processor contains a number of machine cycles.

9. What is fetch and execute cycle?

Ans The instruction cycle is divided in to fetch and execute cycles. The fetch cycle is executed to fetch the opcode from memory. The execute cycle is executed to decode the instruction and to perform the work instructed by the instruction.

10. List the flags of 8085?

Ans There are five flags in 8085.They are sign flag, zero flag, auxiliary carry flag, parity flag and carry flag.

# EXPERIMENT NO.9

**AIM :** WRITE A PROGRAM TO INTERFACE ADC & DAC WITH 8085 & DEMONSTRATE GENERATION OF SQUARE WAVE.

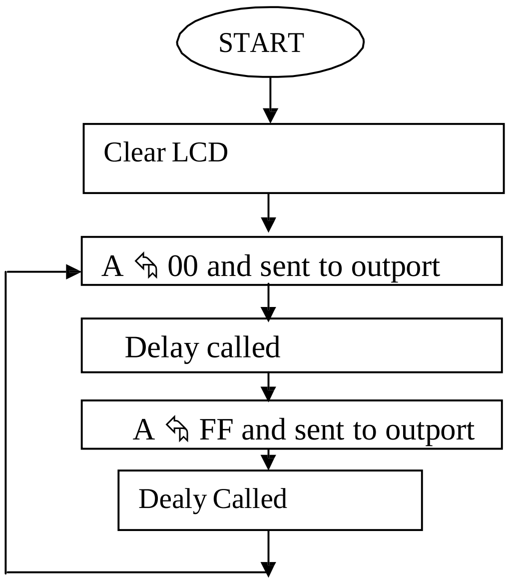
**APPARATUS :** 8085 microprocessor kit, 5V power supply, Keyboard.

**DESCRIPTION:** A D/A converter chip DAC 0800 has been provided on the board of M85-07 to enable the user to have analog output. This can be used for generating various waveforms or for any closed loop applications. The chip has been used in I/O mapped mode and has an address of (A0-A7), i.e any of A0 to A7 can be used as an address. This chip has been designed to give an output of 0 to 8 Volts. The output of DAC 0800 is coming at Pin No.13 of connector CN11.

**THEORY(Program)**

| Memory Address | Label | Machine Code | Mnemonics | Operands | Comments |
|---|---|---|---|---|---|
| 2000 | | CD 4D OF | CALL | LECHO | CLEAR LCD DISPLAY |
| 2003 | | 06 0E | MVI | B,0EH | |
| 2005 | | 21 1F 20 | LXI | H,WAVE | |
| 2008 | | CD 47 17 | CALL | PRINTF | DISPLAY MESGAE |
| 200B | DAC | 3E 00 | MVI | A,00H | |
| 200D | | D3 38 | OUT | 38H | |
| 200F | | CD 31 0F | CALL | DELAY1 | |
| 2012 | | 06 14 | MVI | B,14H | |
| 2014 | | CD 47 17 | CALL | PRINTF | DISPLAY MESSAGE |
| 2017 | | 3E FF | MVI | A,FFH | |
| 2019 | | D3 A0 | OUT | 0A0H | |
| 201B | | CD 31 0F | CALL | DELAY1 | |
| 201E | | C3 0B 20 | JMP | DAC | LOOP |
| 2021 | | 52 41 4D 50 20 | | | WAVE OUTPUT AT |
| 2026 | | 50 49 4E 20 4E | | | PIN NO. 2 CONN. C9 |

**CIRCUIT DIAGRAM / BLOCK DIAGRAM:-**




**PROCEDURE:-**

| ANSHUMAN | SCIENTECH |
|---|---|
| S | Reset |
| Enter Enter | Exmem |
| Program Address | Starting Address |
| Write Program | Next |
| | Write Program |
| **Execution Steps** | **Execution Steps** |
| Esc | Reset |
| G | GO |
| Enter-enter | Starting Address |
| Prog. Address | Fill |
| Enter | Reset |
| S | Exmem |
| Enter | Result Address |
| Any key-2 | |
| Enter-2 | |
| Register Name | |

**RESULT**: Waveform observed on the CRO from Pin No. 2 of connector 9.

**PRECAUTIONS:-**

Make sure that all the machine codes should be as per specified in the program.

**Question & Answer:**

1. What is ALE?

Ans The ALE (Address latch enable) is a signal used to demultiplex the address and data lines using an external latch. It is used to enable the external latch.

2. Where is the READY signal used?

Ans READY is an input signal to the processor, used by the memory or input/output devices to get extra time for data transfer or to introduce wait states in the bus cycles.

3. Give some examples of port devices used in 8085 microprocessor based system?

Ans The various port devices used in 8085 are 8212,8155,8156,8255,8355,8755.

4. What is the need for timing diagram?

Ans The timing diagram provides information regarding the status of various signals, when a machine cycle is executed. The knowledge of timing diagram is essential for system designer to select matched peripheral devices like memories, latches, ports etc from a microprocessor system.

5. What operation is performed during first T-state of every machine cycle in 8085?

Ans In 8085, during the first T-state of every machine cycle the low byte address is latched into an external latch using ALE signal.

6. What is interrupt acknowledge cycle?

Ans The interrupt acknowledge cycle is a machine cycle executed by 8085 processor to get the address of the interrupt service routine in order to service the interrupt device.

7. What is vectored and non-vectored interrupt?

Ans When an interrupt is accepted, if the processor control branches to a specific address defined by the manufacturer then the interrupt is called vectored interrupt. In Non-vectored interrupt there is no specific address for storing the interrupt service routine. Hence the interrupted device should give the address of the interrupt service routine.

8. List the software and hardware interrupts of 8085?

Ans Software interrupts : RST 0,RST 1,RST 2,RST 3,RST 4,RST 5,RST 6,RST 7
Hardware interrupts : TRAP,RST 7.5,RST 6.5,RST 5.5, INTR.

9. What is TRAP?

Ans The TRAP is a non-maskable interrupt of 8085. It is not disabled by processor reset or after recognition of interrupt.

10. How clock signals are generated in 8085 and what is the frequency of the internal clock?

Ans The 8085 has the clock generation circuit on the chip but an external quartz crystal or LC circuit or RC circuit should be connected at the pins X1 andX2. The maximum internal clock frequency of 8085 is 3.03MHz.

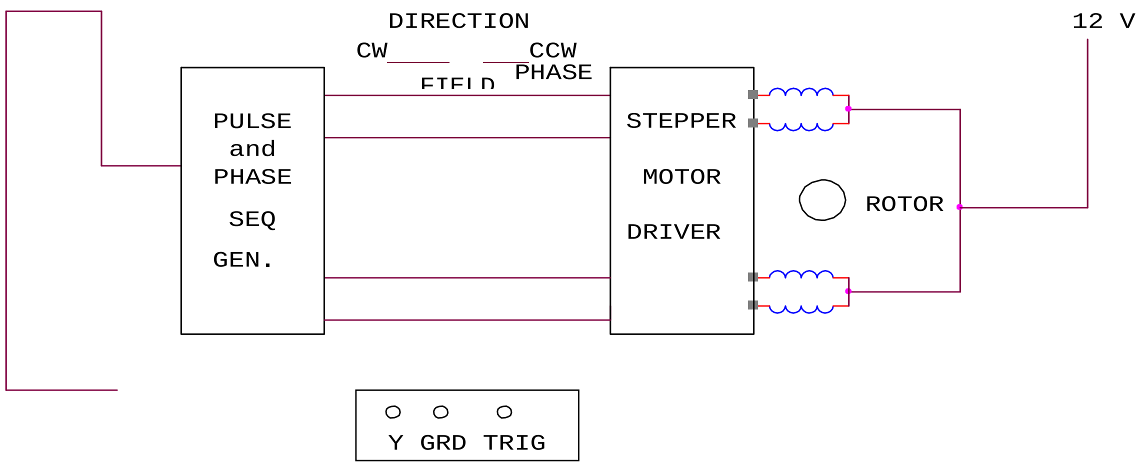
# EXPERIMENT No. 10

**AIM: -** To study the stepper motor and to execute microprocessor computer based control of the same by changing number of steps, the direction of rotation and speed.

**APPARATUS USED**:- Stepper Motor Kit, µP Kit, Interface Cord and Connecting Leads.

**THEORY:-** The stepper motor is a special type of motor which is designed to rotate through a specific angle called step for each electrical pulse received from its control unit. It is used in digitally controlled position control system in open loop mode. The input command is in form of a train of pulses to turn the shaft through a specified angle. the main unit is designed to interface with µP 8085 kit. The stepper motor controller card remains active while the pulse sequence generator disabled as given plug is connected with µp interface socket . Following programme enables the stepper motor to run with µp 8085 kit. For two phase four winding stepper motor only four LSB signals are required.

**CIRCUIT DIAGRAM**:-




**PROCEDURE:-**
Connect the stepper motor with µp 8085 kit as shown in fig. press EXMEM key to enter the address as given then press NEXT to enter data .

| ADDRESS | DATA | | | |
|---|---|---|---|---|
| 2000 | 3E 80 | MVI | A,80 | Initialize port A as output port. |
| 2002 | D3 03 | OUT | 03 | OB |
| 2004 | 3E F9 | Start MVI | | AFA |
| 2006 | D3 00 | OUT | 00 | Output code for step o. |
| 2008 | CD 3020 | call delay | | delay between two steps. |
| 200B | 3E F5 | MVI | A, F6 | Location reserve for current Delay |
| 200D | D3 OO | OUT | OO | Output code for step 1. |

| | | | |
|---|---|---|---|
| 200F | CD 3020 | Call delay | delay between two steps. |
| 2012 | 3E F6 | MVI A, F5 | |
| 2014 | D3 OO | OUT OO | Output code for step 2. |
| 2016 | CD 3020 | calls delay | between two steps. |
| 2019 | 3E FA | MVI A, F9. | |
| 201B | D3 OO | OUT OO | Output code for step 3. |
| 201D | CD 3020 | call delay | delay between two steps. |
| 2020 | C3 04 20 | JMP START | Start. |

Press FILL key to store data in memory area. This will complete the pulse sequence generation. To delay programme route, first press EXMEM to start, a dot sign will appear in address field then enter the start address. Press NEXT to enter data.

**ADDRESS DATA**

| | | | |
|---|---|---|---|
| 2030 | 11 00 00 | LXI D 00 00 | Generates a delay. |
| 2033 | CD BC 03 | CALL DELAY | |
| 2036 | 11 00 00 | LXI D 00 00 | Generates a delay. |
| 2039 | CD BC 03 | CALL DELAY | |
| 203C | C9 | RET | |

Press FILL to save data.to execute the programme press the key GO .The above programme is to rotate the motor at a particular as defined by the given address. Changing the following contents will change the motor speed.

**ADDRESS DATA**

| | | | |
|---|---|---|---|
| 2030 | 11 00 20 | AND 2036 TO SIMILAR | 11 00 20 |
| CHANGE | 11 00 10 | TO | 11 00 10 |
| CHANGE | 11 00 05 | TO | 11 00 05 |
| CHANGE | 11 00 03 | TO | 11 00 03. |

The motor direction depends upon codes FA, F6 ,F5 AND F9.Change in following codes will change the motor direction.

| ADDRESS | DATA | | |
|---|---|---|---|
| 2005 | 3E F9 | TO | 3E FA |
| 200C | 3E F5 | TO | 3E F6 |
| 2012 | 3E F6 | TO | 3E F5 |
| 2019 | 3E FA | TO | 3E F9. |

**RESULT:-** The stepper motor runs as per fed programme.

**PRECAUTION:-**

1. Make the connection of motor with µp kit properly.
2. Do not change the motor direction at high speed.

,

**Question & Answer:**

1. Define stack?

Ans Stack is a sequence of RAM memory locations defined by the programmer.

2. What is program counter? How it is useful in program execution?

Ans The program counter keeps track of program execution. To execute a program the starting address of the program is loaded in program counter. The PC sends out an address to fetch a byte of instruction from memory and increments its content automatically.

3. Define opcode and operand?

Ans Opcode(operation code) is the part of an instruction that identifies a specific operation. Operand is a part of instruction that represents a value on which the instruction acts.

4. How the 8085 processor differentiates a memory access and I/O access?

Ans The memory access and I/O access is differentiated using IO/M signal. The 8085 processor asserts IO/M low for memory operation and high for I/O operations.

5. When the 8085 processor checks for an interrupt?

Ans In the second T-state of the last machine cycle of every instruction, the 8085 processor checks whether an interrupt request is made or not.

6. Why interfacing is needed for I/O devices?

Ans Generally I/O devices are slow devices. Therefore the speed of I/O devices does not match with the speed of microprocessor. And so an interface is provided between system bus and I/O devices.

7. What is interrupt I/O?

Ans If the I/O device initiate the data transfer through interrupt then the I/O is called interrupt driven I/O.

8. What is a port?

Ans The port is a buffered I/O, which is used to hold the data transmitted from the microprocessor to I/O devices and vice versa.

9. What is the need for interrupt controller?

Ans The interrupt controller is employed to expand the interrupt inputs. It can handle the interrupt request from various devices and allow one by one to the processor.

10. What is synchronous data transfer scheme?

Ans For synchronous data transfer scheme, the processor does not check the readiness of the device after commands have been issued for read/write operation. For this scheme the processor will request the device to get ready and then read/write to the device immediately after the request.

# EXPERIMENT NO. 11

**AIM :** WRITE A PROGRAM TO CONTROL THE TRAFFIC LIGHT SYSTEM USING 8085 & 8255 PPI.

**APPARATUS :** 8085 microprocessor kit, 5V power supply, Keyboard.

**DESCRIPTION:** This Program controls light of one square. By changing the delay between two signals one can change the speed of traffic. 8255 Port Address.
Port A- 00H
Port B -01H
Port C- 02H
Control Word 03H

**THEORY(Program)**

| Memory Address | Label | Machine Code | Mnemonics | Operands | Comments |
|---|---|---|---|---|---|
| 2000 | | 3E 80 | MVI | A,80H | Init PA &PB as output |
| 2002 | | D3 03 | OUT | 03H | |
| 2004 | | 3E 11 | MVI | A,11H | Stop all four ends |
| 2006 | | D3 00 | OUT | 00H | |
| 2008 | | D3 02 | OUT | 02H | |
| 200A | | CD 50 20 | CALL | DELAY1 | |
| 200D | LOOP | 3E 44 | MVI | A,44H | GO STR signal of North & South, STOP signal of East &West |
| 200F | | | OUT | 00H | |
| 2011 | | | CALL | DELAY1 | |
| 2014 | | | MVI | A,22H | Alert signal for traffic |
| 2016 | | | OUT | 00H | |
| 2018 | | | CALL | DELAY2 | |
| 201B | | | MVI | A,99H | GO LEFT signal of North & South |
| 201D | | | OUT | 00H | |
| 201F | | | CALL | DELAY1 | |
| 2022 | | | MVI | A,22H | Alert signal for traffic |
| 2024 | | | OUT | 00H | |
| 2026 | | | CALL | DELAY2 | |
| 2029 | | | MVI | A,11H | STOP signal of North & South |
| 202B | | | OUT | 00H | |
| 202D | | | MVI | A,44H | GO STR signal of East & West |
| 202F | | | OUT | 02H | |
| 2031 | | | CALL | DELAY1 | |
| 2034 | | | MVI | A,22H | Alert signal for traffic |

| | | | | | |
|---|---|---|---|---|---|
| 2036 | | | OUT | 02H | |
| 2038 | | | CALL | DELAY2 | |

| Memory Address | Label | Machine Code | Mnemonics | Operands | Comments |
|---|---|---|---|---|---|
| 203B | | | MVI | A,99H | GO Left signal of East & West |
| 203D | | | OUT | 02H | |
| 203F | | | CALL | DELAY1 | |
| 2042 | | | MVI | A,22H | Alert signal for traffic |
| 2044 | | | OUT | 02H | |
| 2046 | | | CALL | DELAY2 | |
| 2049 | | | MVI | A,11H | STOP signal of East &West |
| 204B | | | OUT | 02H | |
| 204D | | | JMP | LOOP | Jump to loop |
| 2050 | | DELAY1: | MVI | B,25H | Delay of 10 sec. |
| 2052 | | LP3: | MVI | C,0FFH | |
| 2054 | | LP2: | MVI | D, 0FFH | |
| 2056 | | LP1: | DCR | D | |
| 2057 | | | JNZ | LP1 | |
| 205A | | | DCR | C | |
| 205B | | | JNZ | LP2 | |
| 205E | | | DCR | B | |
| 205F | | | JNZ | LP3 | |
| 2062 | | | RET | | |
| 2063 | | DELAY2: | MVI | B,05H | Delay of 2 sec |
| 2065 | | LP6: | MVI | C,0FFH | |
| 2067 | | LP5: | MVI | D,0FFH | |
| 2069 | | LP4: | DCR | D | |
| 206A | | | JNZ | LP4 | |
| 206D | | | DCR | C | |
| 206E | | | JNZ | LP5 | |
| 2071 | | | DCR | B | |
| 2072 | | | JNZ | LP6 | |
| 2075 | | | RET | | |

**PROCEDURE:-**

| ANSHUMAN S | SCIENTECH |
|---|---|
| | Reset |
| | Exmem |
| Enter Enter | Starting Address |
| Program Address | Next |
| Write Program | Write Program |

| **Execution Steps** | **Execution Steps** |
|---|---|
| Esc | Reset |
| G | GO |
| Enter-enter | Starting Address |
| Prog. Address | Fill |
| Enter | Reset |
| S | Exmem |
| Enter | Result Address |
| Any key-2 | |
| Enter-2 | |
| Register Name | |

**RESULT**: Traffic Signal Timing observed for four lane.

**PRECAUTIONS:-**

Make sure that all the machine codes should be as per specified in the program.

**Question & Answer:**

1. What is asynchronous data transfer scheme?

Ans In asynchronous data transfer scheme, first the processor sends a request to the device for read/write operation. Then the processor keeps on polling the status of the device. Once the device is ready, the processor executes a data transfer instruction to complete the process.

2. What are the internal devices of 8255?

Ans The internal devices of 8255 are port-A, port-B, port-C. The ports can be programmed for either input or output function in different operating modes.

3. What is USART?

Ans The device which can be programmed to perform Synchronous or Asynchronous serial communication is called USART (Universal Synchronous Asynchronous Receiver Transmitter). Eg: INTEL 8251

4. What is scanning in keyboard and what is scan time?

Ans The process of sending a zero to each row of a keyboard matrix and reading the columns for key actuation is called scanning. The scan time is the time taken by the processor to scan all the rows one by one starting from first row and coming back to the first row again.

5. What is programmable peripheral device?

Ans If the function performed by the peripheral device can be altered or changed by a program instruction then the peripheral device is called programmable device. It have control register. The device can be programmed by sending control word in the prescribed format to the control register.

6. What is baud rate?

Ans The baud rate is the rate at which the serial data are transmitted. Baud rate is defined as (The time for a bit cell). In some systems one bit cell has one data bit, then the baud rate and bits/sec are same.

7. What are the tasks involved in keyboard interface?

Ans The tasks involved in keyboard interfacing are sensing a key actuation, Debouncing the key and generating key codes ( Decoding the key). These tasks are performed software if the keyboard is interfaced through ports and they are performed by hardware if the keyboard is interfaces through 8279.

8. How a keyboard matrix is formed in keyboard interface using 8279?

Ans The return lines, RL0 toRL7 of 8279 are used to form the columns of keyboard matrix. In decoded scan lines SL0 t0SL3 of 8279 are used to form the rows of keyboard matrix. In encoded scan mode, the output lines of external decoder are used as rows of keyboard matrix.

9. What is GPIB?

Ans GPIB is the General Purpose interface Bus. It is used to interface the test instruments to the system controller.

10. Advantages of differential data transfer?

Ans
1. Communication at high data rate in real world environment.
2. Differential data transmission offers superior performance.
3. Differential signals can help induced noise signals.

# <u>MICROCONTROLLER & EMBEDDED</u>
# <u>SYSTEM DESIGN</u>
## (EE-328-F)

# LAB MANUAL

## VI SEMESTER

# LIST OF EXPERIMENTS

## List of Experiment:

**8051/AT 89C51 microcontroller**

1. Write an Assembly language Programme (ALP) to generate 10 kHz square wave.
2. To study implementation & interfacing of Display devices Like LCD, LED Bar graph & seven segment display with Microcontroller 8051/AT89C51
3. To study implementation & interfacing of Different motors like stepper motor, DC motor & servo Motors.
4. Write an ALP for temperature & pressure measurement.
5. Write a program to interface a graphical LCD with 89C51.
6. To study Programming and Transmission & reception of data through Serial port & study of Parallel printer port.

**PIC Microcontroller**

7. To interface PWM based voltage regulator using PIC Microcontroller .
8. Study and analysis of interfacing of Graphical LCD using PIC controller
9. Study and interfacing of IR (RC5 protocol) and RF Communication using PIC controller
10. Study of SD/MMC card Interface using 18F4550

# Microcontroller & Embedded System Design
# EE-328-F

| Sr.No. | LIST OF EXPERIMENTS |
|---|---|
| 1. | To study development tools/environment for ATMEL/PIC microcontroller programme and Architecture. |
| 2. | Write an assembly language program to add, subtract, multiply, divide 16 bit data by Atmel microcontroller. |
| 3. | An assembly language program to generate 10 KHz frequency using interrupts on P1.2. |
| 4. | Study and analyze the interfacing of 16 x 2 LCD. |
| 5. | Study of implementation, analysis and interfacing of seven segment display. |
| 6. | Study of implementation of steeper motor angle control. |
| 7. | Study of implementation of DC Motor control using PWM method. |
| 8. | Study and observation of Position control of Servo Motor. |
| 9. | Study of Programming and Transmission and Reception of data through serial port. |
| 10. | To study implementation and programming of Pressure measurement. |
| 11. | To study implementation and programming of Temperature measurement. |
| 12. | Study and analysis of interfacing of graphical LCD using PIC Microcontroller. |
| 13. | To interface PWM based voltage regulator using PIC Microcontroller. |
| 14. | Study and interface of IR (RC5 Protocol) and RF Communication using PIC Microcontroller. |

# EXPERIMENT NO 1

**AIM:** To study development tools/environment for ATMEL/PIC microcontroller programme and Architecture.

**APPARATUS REQUIRED:** µ Vision Keil, ICPROG, AT89C52 Microcontroller, PIC16F877A Microcontroller.

**SOFTWARE ENVIRONMENT AND MICROCONTROLLER DESCRIPTION:**

**Procedure to write the program in µ Vision Keil:**

1. Create a **New folder** on the desktop for saving the contents of the program.
2. Double click on the icon of **Keil**.
3. Select the device for the target **(Select Atmel → Select 89C52 →Ok →No)**
4. Go in the **project menu** and click on **µVision Project** after this an edit window will appear on desktop.
5. Write the desired program in the editing window up to end.
6. Right click on **source group** and select **remove start up** in **project workspace**.
7. Go in the **file menu** and click on **save as** and **save** the program with the extinction **.asm** on desktop in the **new folder**.
8. Right click on **source group** → Select **add file to group** → All file → Select file **.asm** → Select **Add.**
9. Now go in the **project menu** and click on options for the target **"Target1"**.
10. Update the **frequency value (eg. 11.0592)** and click on **output** and enable the following.
    a. ®Create Executable
    b. √ or Ok –Debug info
    c. Select Create Hex file
    d. Select Browse info

    Now click on **Ok**
11. Go in the **project menu** and click on **built target**.
12. Go in the **project menu** and click on **Rebuild target**.
13. Go in the **project menu** and click on Run (or Ctrl +F5).
14. After this **Hex file** will be created in the **New Folder**

**ATMEL INTRODUCTION 8051 ARCHITECTURE FAMILY**

A microcontroller is a single chip microcomputer with on board program ROM and I/O that can be programmed for various control functions. Unlike a general purpose computer, which also includes all of these components, a microcontroller is designed for a very specific task to control a particular system.

The AT89C52 is a low power, high performance CMOS 8 bit microcomputer with 8K bytes of Flash Programmable and Erasable Read Only Memory. The on chip flash allows the program memory to be reprogrammed in system or by a conventional non-volatile memory programmer. The AT89C52 provides 256 Bytes of RAM, 32 I/O lines, three 16 bit timer/counters, and six vector two levels interrupt.

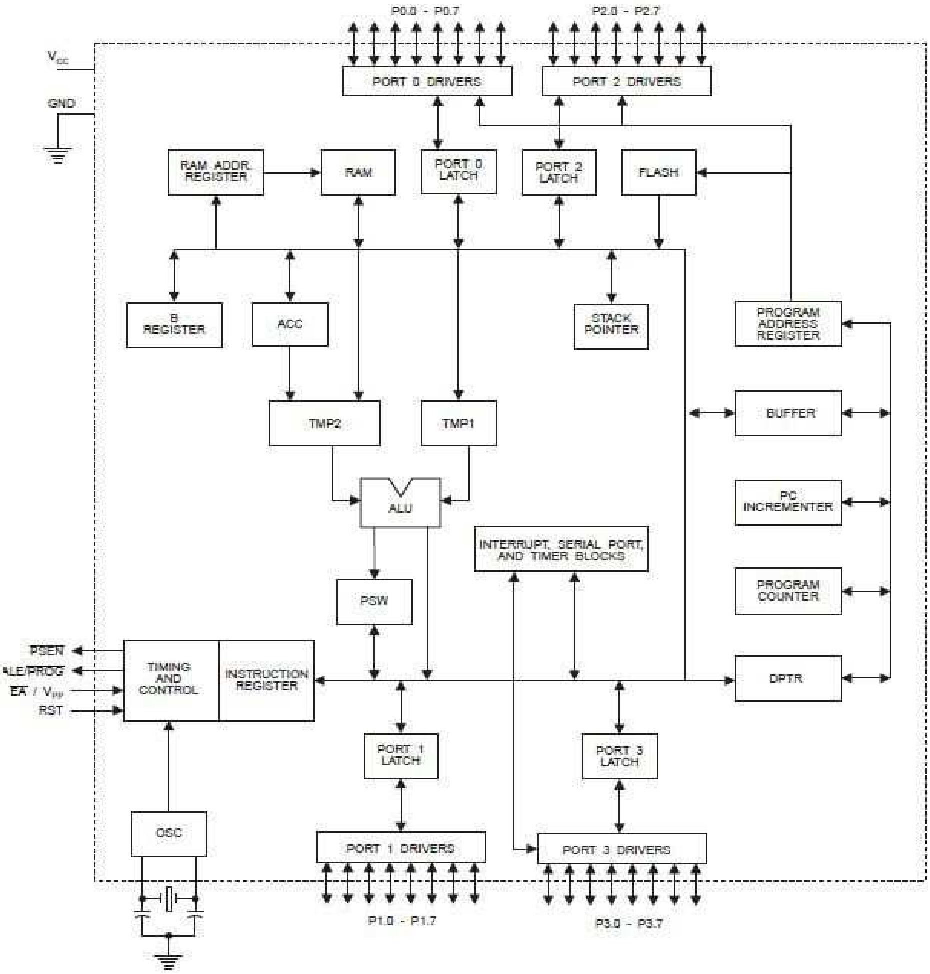



**Figure. The architecture of the 8051 family of Microcontrollers**

**Pin Diagram of AT89C52**

**Port 0 (P0.0 - P0.7):** If designated as output, each of these pins can be connected up to 8 TTL input circuits. If designated as input, they are high impedance inputs as their potential is undefined with respect to the ground. If external memory is used, these pins are used for alternate transfer of data and addresses (A0-A7) for accessing the extra memory chip. Signal on ALE pin determines the mode of transfer on port.

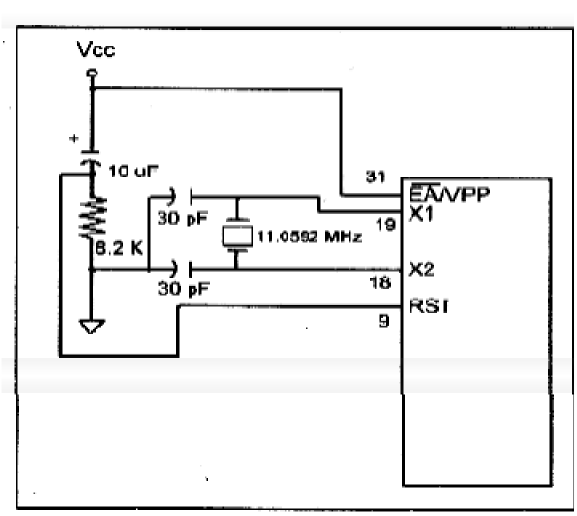
**Port 1 (P1.0 - P1.7):** If designated as output, each of these pins can be connected up to 4 TTL inputs. If designated as input, these pins act like standard TTL inputs (that is, they have an internal resistor connected to the positive supply pole and a +5V voltage). Also, pins of Port 1 have alternate functions according to the following table:

| Pin | Alternate function |
|---|---|
| P1.0 | T2 (Timer 2 input) |
| P1.1 | T2EX (Timer 2 control input) |

**Port 2 (P2.0 - P2.7):** If designated as input or output, this port is identical to Port 1. If external memory is used, Port 2 stores the higher address byte (A8-A15) for addressing the extra memory chip.

**Port 3 (P3.0 - P3.7):** Similar to Port 1, Port 3 can also be used as universal I/O, but pins of Port 3 also have alternate functions.

**RST:** Reset input: A high on this pin for two machine cycles while the oscillator is running resets the device and terminate all activities. This is often referred to as a power on reset. Activating a power on reset will cause all values in the register to be lost. Figure A and figure B shows two ways of connecting the RST pin to the power on reset circuitry.



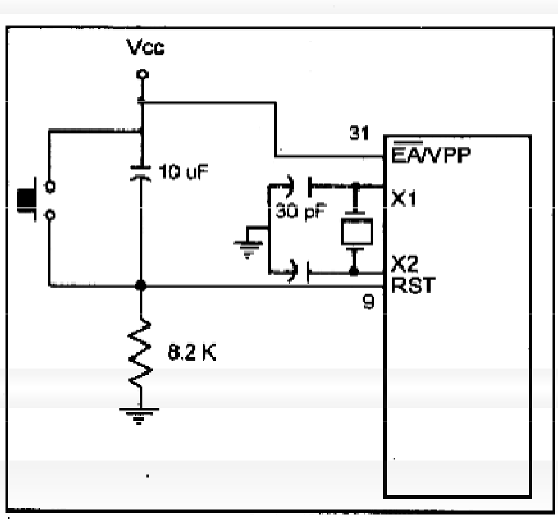




Figure A. Power On Reset Circuit

Figure B. Power On with Debounce

Positive voltage impulse on RST pin resets the MCU. In order to be detected, this impulse needs to have duration of at least two operating cycles (this cycle represents the time necessary to execute one instruction and lasts for 12 oscillator signals).

**EA/VPP:** External Access Enable; When this pin is connected to the ground, MCU gets program instructions from external program memory. In case that internal program memory is used (common case); this pin should be connected to the positive supply pole (VCC). During the loading of program to internal Flash memory, this pin is at +12V.

**ALE/PROG:** This pin emits an impulse sequence with a frequency equal to 1/6 of the frequency generated by the main oscillator. If external memory is used, signal from this pin controls the additional register for temporary storage of the lower address byte (A0 - A7). This pin also serves as a control input during the writing of program to MCU.

**PSEN:** Program Store Enable; This pin is used for reading from external program memory (ROM). When the AT89C52 is executing code from external program memory, PSEN is activated twice each machine cycle, except that two PSEN activations are skipped during each access to external data memory.

**XTAL1 and XTAL2:** XTAL1 is the Input to the inverting oscillator amplifier and input to the internal clock operating circuit. XTAL2 is Output from the inverting oscillator amplifier. AT89C52 has an on chip oscillator but requires an external clock to run it(See Figure. C). Most often quartz crystal is connected to XTAL1 and XTAL2.The quartz crystal oscillator connected to XTAL pins also needs two capacitors of 30pf value.

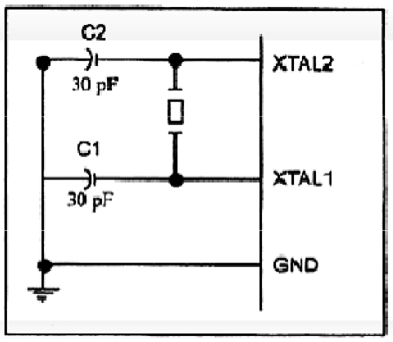



Figure. C. XTAL Connection in 8051

**VCC:** Power Supply (4 – 6V)
**GND:** Negative supply pole (ground)

## HOW TO USE ICPROG SOFTWARE FOR PIC Microcontroller

1. Click ICPROG software.
2. Select device PIC 16F877 A.
3. Click <settings> Select <Hardware> Select JDM programmer and Windows API in place of Direct I/O & click OK.
4. Click <Setting> then <options> then <programming> then select the option <verify after programming>.
5. Set configuration in ICPROG software as mentioned below:
6. Oscillator----- XT
7. Write Enable----OOOO-OFFFH
8. Deselect all Fuses.
9. Set swl in Un pressed condition for IAP mode. Jumper in 1 2 position.
10. Select <command> then Program all.

**PIC INTRODUCTION & ARCHITECTURE:**

PIC is the name for the Microchip microcontroller (MCU) family, consisting of a microprocessor, I/O ports, timer(s) and other internal, integrated hardware. The main advantages of using the PIC are low external part count, a wide range of chip sizes available, nice choice of compilers (assembly, C, Basic, etc.) good wealth of example/tutorial source code and easy programming. Once bought, the PIC's program memory is empty, and needs to be programmed with code (usually HEX files) to be usable in a circuit. For the purpose, a wide range of simple programmer hardware docs and software is downloadable from the net.

PIC is a family of Harvard architecture microcontrollers made by Microchip Technology, derived from the PIC1650 originally developed by General Instrument's Microelectronics Division.

The PIC architecture is distinctively minimalist. It is characterized by the following features:

- Separate code and data spaces (Harvard architecture)
- A small number of fixed length instructions
- Most instructions are single cycle execution (4 clock cycles), with single delay cycles upon branches and skips

- A single accumulator (W), the use of which (as source operand) is implied (i.e is not encoded in the opcode)
- All RAM locations function as registers as both source and/or destination of math and other functions.
- A hardware stack for storing return addresses
- A fairly small amount of addressable data space (typically 256 bytes), extended through banking
- Data space mapped CPU, port, and peripheral registers
- The program counter is also mapped into the data space and writable (this is used to synthesize indirect jumps).

Unlike most other CPUs, there is no distinction between "memory" and "register" space because the RAM serves the job of both memory and registers, and the RAM is usually just referred to as the register file or simply as the registers.

### PIC16F877A Specifications & Architecture:

### High-Performance RISC CPU:

- Only 35 single-word instructions to learn
- All single-cycle instructions except for program Branches, which are two-cycle
- Operating speed : DC–20 MHz clock input DC–200 ns instruction cycle
- Up to 8K x 14 words of Flash Program Memory, Up to 368 x 8 bytes of Data Memory (RAM), Up to 256 x 8 bytes of EEPROM Data Memory
- Pin out compatible to other 28-pin or 40/44-pin PIC16CXXX and PIC16FXXX microcontrollers.

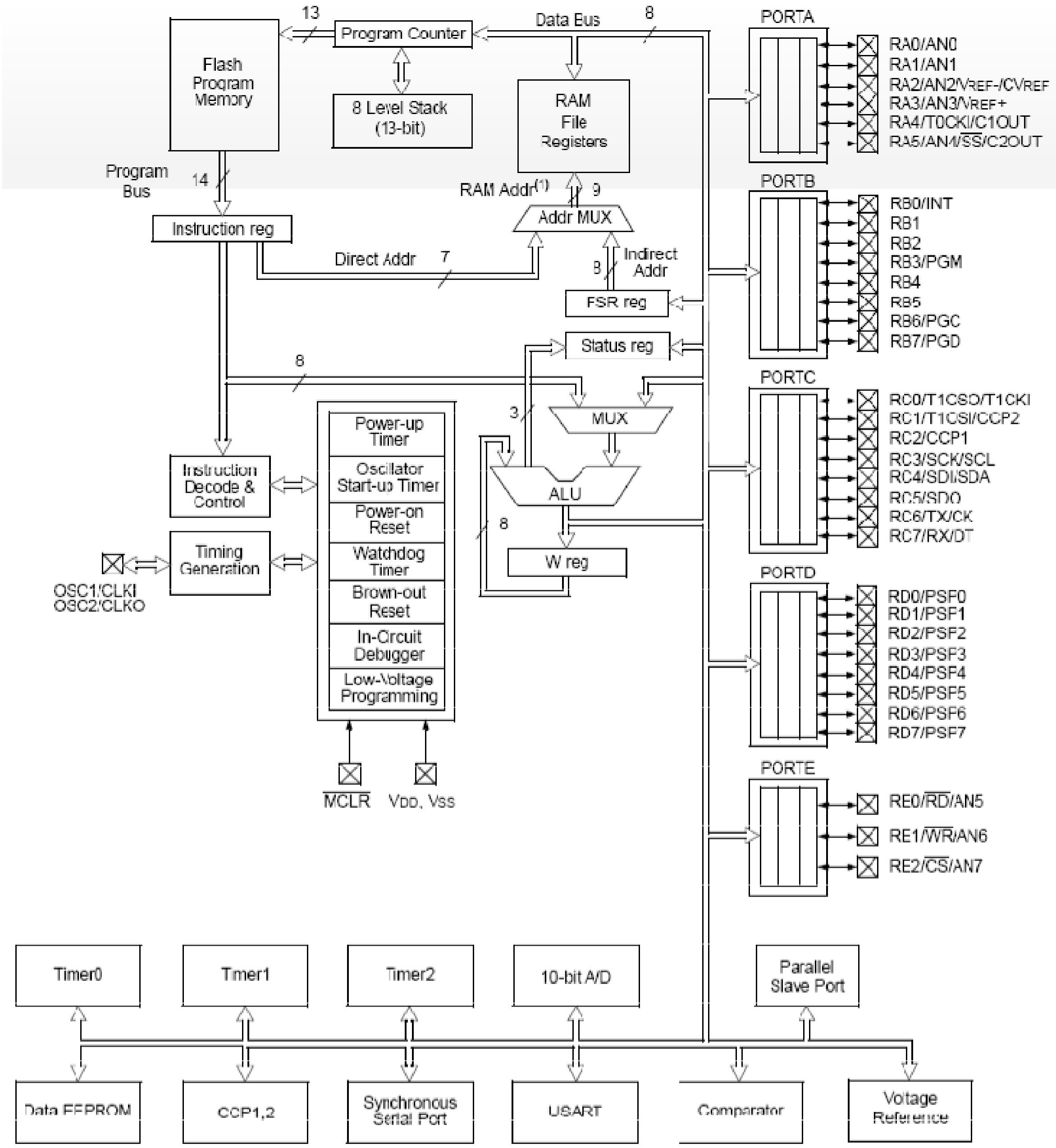
### Peripheral Features:

- Timer0: 8-bit timer/counter with 8-bit prescaler
- Timer1: 16-bit timer/counter with prescaler, can be incremented during Sleep via external crystal/clock
- Timer2: 8-bit timer/counter with 8-bit period register, prescaler and postscaler
- Two Capture, Compare, PWM modules
  **a.** Capture is 16-bit, max. Resolution is 12.5 ns
  **b.** Compare is 16-bit, max. Resolution is 200 ns
  **c.** PWM max. Resolution is 10-bit
- Synchronous Serial Port (SSP) with SPI™ (Master mode) and I2C™ (Master/Slave)
- Universal Synchronous Asynchronous Receiver Transmitter (USART/SCI) with 9-bit address detection
- Parallel Slave Port (PSP)–8 bits wide with external RD, WR and CS controls (40/44-pin only)
- Brown-out detection circuitry for Brown-out Reset (BOR)

### Analog Features:

- 10-bit, up to 8-channel Analog-to-Digital Converter (A/D)
- Brown-out Reset (BOR)
- Analog Comparator module with:
  A. Two analog comparators
  B. Programmable on-chip voltage reference (VREF) module
  C. Programmable input multiplexing from device inputs and internal voltage reference
  D. Comparator outputs are externally accessible

## Block diagram of PIC16F877A Controller




**1.**What is meant by micro controller?

Ans A device which contains the microprocessor with integrated peripherals like memory, serialports, parallel ports, timer/counter, interrupt controller, data acquisition interfaces like ADC, DAC is called micro controller.

**2.**List the features of 8051 micro controllers?

Ans
- Single supply +5v operation using HMOS technology.
- 4096 bytes program memory on-chip.
- 128 data memory on chip.

· 4 register banks
· 2 multiple modes, 16 bit timer/counter
· Extensive Boolean processing capabilities.
· 64KB external RAM size.
· 32 bi-directional I/O lines.

**3.** Explain the operating mode 0 of 8051 serial port?

Ans In this mode serial data enters and exists through RXD, TXD outputs the shift clock. 8-bits are transmitted or received:8-data bits(LSB first). The baud rate is fixed at 1/12 the oscillator frequency.

**4.** Explain the operating mode 2 of 8051 serial port?

Ans In this mode 11 bits are transmitted (through TXD) or received (through (RXD): a start bit(0), 8 data bits( LSB first), a programmable 9th data bit and a stop bit(1). On transmit, the 9th data bit can be assigned the value 0 or 1. On receive, the 9th data bit go into the RB8 in special function register SCON, while the stop bit is ignored.

The baud rate is programmable to either 1/32 or 1/64 the oscillator frequency.

**5.** Explain the mode 3 of 8051 serial port?

Ans In this mode, 11 bits are transmitted (through TXD) or (received (through RXD): a start bit(0), 8 data bits(LSB first), a programmable 9th data bit and a stop bit(1).It is same as mode 2 except the baud rate. The baud rate in mode 3 is variable.

**6.** Explain the interrupts of 8051 micro controller?

Ans · External interrupt 0 (IE0) – Highest priority,· Timer interrupt 0 (TF0)
· External interrupt 1 (IE1),· Timer interrupt 1 (TF1)
· Serial port Interrupt,Receive interrupt (RI) – lowest priority
Transmit interrupt (TI)

**7.** How many bytes of internal RAM and ROM supported by 8051 micro controller?

Ans 128 bytes of internal RAM and 4 bytes of ROM.

**8.** Define machine cycle of 8051?

Ans 8051 machine cycle consists of 6 states, S1 through S7. One state is made up of 2 clock pulses. Thus 12 clock period constitute one machine cycle. Two clock periods in a state is termed as phase 1 and phase 2.

**9.** What are the special function of port 0 of 8051?

Ans Port 0 is used as a multiplexed low order address/data bus during the external memory access. When ALE is enabled, the address on port 0 pins are latched and bus is ready to act as a data bus when ALE is low.

**10.** What are the alternative function of port 3 of 8051?

Ans Serial data input (P3.0), serial data output (P3.1), external interrupt 0 (P3.2), external interrupt 1 (P3.3), external input for timer 0(P3.4), external input for timer 1 (P3.5), external memory write pulse (P3.6), external memory read (P3.7) are the alternative functions of port 3.

# EXPERIMENT NO 2

**AIM:** Write an assembly language program to add, subtract, multiply and divide 16 bit data by Atmel microcontroller.

**APPARATUS:** M51-02 trainer kit, keyboard and power cord.

**PROGRAM:**

**Addition:**

```
        ORG 0000H
        CLR   C                 ; make CY=0
        MOV A, #0E7H            ; load the low byte now A=E7H
        ADD A, #8DH             ; add the low byte now A=74H and CY=1
        MOV R6, A               ; save the low byte of the sum in R6
        MOV A, #3BH             ; load the high byte
        ADDC A, #3BH            ; add with carry (3B+3C+1=78)
        MOV R7, A               ; save the high byte of the sum
```

**Subtraction:**

```
        ORG 3000H
        CLR C                   ; make CY=0
        MOV A, #50H             ; load the low byte now A= 50H
        MOV R1, #30H            ; load the byte now R1=30H
        SUBB A, R1              ; subtract contents of A and R1
        JNC Next
        CPL A
        INC A
Next:   MOV R2, A
        SJMP 3000H
```

**Multiply:**

```
        ORG 4000H
        MOV A, #03H             ; move the first no. into acc
        MOV B, #02H             ; move the second no. into B
        MUL AB                  ; multiply the contents of acc with B
        SJMP 4000H
```

**Divide:**

```
        ORG 5000H
        MOV A, #25H             ; move the first no. into acc.
        MOV B, #5H              ; move the second no. into B
        DIV AB                  ; divide the contents of acc with B
        SJMP 5000H
```

**RESULT:** Addition, Subtraction, Multiplication, Division of 16 bit data has been performed successfully
on the kit.

**PRECAUTIONS:** Make sure correct power supply is given to the kit/Equipment. Wrong power supplies
may cause damage to your equipments.

**Question & Answer:**

**1.**What are Pseudo instructions .

Ans. **Assembler Directives**

**2.**Number of the times the instruction sequence below will loop before coming out of loop is

```
 MOV AL, 00h
A1:  INC AL
 JNZ A1
```

:

**Ans.256**

**3.**With which instructionsDirection flag is used .

Ans. **String instruction**

**4**.A Bus cycle is equal to how many clocking period.

Ans.**4**

**5.**What is NMI input.

Ans.**Edge Sensitive**

**6.**What do the symbols [ ] indicate.

Ans.**Indirect addressing**

**7.**The internal RAM memory of the 8051 is.

Ans.**128 Bytes**

**8.**The I/O ports that are used as address and data for external memory are.

Ans.**Ports 0 and 2**

**9.**The total external data memory that can be interfaced to the 8051 is.

Ans.**64K**

**10.**What is the 8-bit address bus allows access to an address range.

Ans.**00 to FFH**

,

# EXPERIMENT NO 3

**AIM:** Write an assembly language program to generate 10 KHz frequency using interrupts on P1.2.

**APPARATUS:** E89-01 KIT, power cord, CRO and connecting leads.

**PROGRAM:**

```
          ORG 0H                      ; Wake up ROM reset Location
          LJMPMAIN                    ; Bypass interrupt vector table
          ORG 000BH                   ; ISR for Timer 0
          CPL P1.2                    ; Complement P1.2
          MOV TL0, #0D2H
          MOV TH0, #0FFH              ; Reload timer value
          RETI
          ORG 0030H                   ; starting location for program
MAIN:     MOV TMOD, #01H              ; timer 0, mode 1
          MOV THO, #0FFH
          MOV TLO, #0D2H              ; Enable timer 0 interrupt
          MOV IE, #82H
          SETB TR0                    ; Start timer 0
HERE:     SJMP HERE                   ; Stay here until interrupted
          END                         ; End of the Program
```

**RESULT**: Square wave has been generated on P1.2 and displayed on CRO.

**PRECAUTIONS:** Make sure correct power supply is given to the kit/Equipment. Wrong power supplies may cause damage to your equipments.

**Question & Answer:**

**1.**Device pins XTAL1 and XTAL2 for the 8051 are used for connections to an external oscillator or crystal.

Ans. **TRUE**

**2.**When the 8051 is reset and the $\overline{EA}$ line is HIGH, the program counter points to the first program instruction in the:

**Ans.Internal Code Memory**

**3.**An alternate function of port pin P3.4 in the 8051 is:

**Ans.Timer 0**

**4.**Bit-addressable memory locations are:

**Ans.20H through 2FH**

**5.**The number of data registers is:

**Ans.32**

**6.**The total amount of external code memory that can be interfaced to the 8051 is:\

Ans. **64 K**

**7.**An alternate function of port pin P3.0 (RXD) in the 8051 is:

**Ans.Serial Port Input**

**8**.MOV A, @ R1 will:

**Ans.copy the contents of memory whose address is in R1 to the accumulator**

**9.**The start-conversion on the ADC0804 is done by using the:

**Ans.SC**

**10.**The number of data registers is:

Ans.**32**

# EXPERIMENT NO 4

**AIM:** Study and analyze the interfacing of 16 x 2 LCD.

**APPARATUS:** NV5001 Microcontroller development Board, MC-04 Kit, power cord and connecting leads.

**PROGRAM:** for displaying 'NVIS Technologies' on LCD.

```
RS_LCD EQU P3.5
RW_LCD EQU P3.6
E_LCD EQU P3.7
------------------------------------------------------------------------------------------------------------------
ORG 0000H
JMP START
ORG 0200H
START: MOV P0, #00H
MOV A, #00H
LCALL LCDINIT
MOV A, #086H
LCALL COMMAND
MOV A, #"N"
LCALL DISPLAY
MOV A, #"v"
LCALL DISPLAY
MOV A, #"i"
LCALL DISPLAY
MOV A, #"s"
LCALL DISPLAY
MOV A, #" "
LCALL DISPLAY
MOV A, #" "
LCALL DISPLAY
MOV A, #" "
LCALL DISPLAY
MOV A, #" "
LCALL DISPLAY
MOV A, #" "
LCALL DISPLAY
MOV A, #" "
LCALL DISPLAY
------------------------------------------------------------------------------------------------------------------
LCALL DELAY_1S
```

```
LCALL DELAY_1S
LCALL DELAY_1S
-------------------------------------------------------------------------------------------------------------------------
MOV A, #082H
LCALL COMMAND

MOV A, #"T"
LCALL DISPLAY
MOV A, #"e"
LCALL DISPLAY
MOV A, #"c"
LCALL DISPLAY
MOV A, #"h"
LCALL DISPLAY
MOV A, #"n"
LCALL DISPLAY
MOV A, #"o"
LCALL DISPLAY
MOV A, #"l"
LCALL DISPLAY
MOV A, #"o"
LCALL DISPLAY
MOV A, #"g"
LCALL DISPLAY
MOV A, #"i"
LCALL DISPLAY
MOV A, #"e"
LCALL DISPLAY
MOV A, #"s"
LCALL DISPLAY
----------------------------------------------------------------------------------------------------------------------
LCALL DELAY_1S
LCALL DELAY_1S
LCALL DELAY_1S
LJMP START
----------------------------------------------------------------------------------------------------------------------
DELAY_1S:
MOV R2, #11
LOOP3: MOV R3, #98
LOOP2: MOV R4, #106
LOOP1: NOP
NOP
NOP
NOP
NOP
```

```
NOP
DJNZ R4, LOOP1
DJNZ R3, LOOP2
DJNZ R2, LOOP3
RET
-----------------------------------------------------------------------------------------------------------------------
LCDINIT: MOV A, #38H
LCALL COMMAND
MOV A, #0CH
LCALL COMMAND


MOV A, #01H
LCALL COMMAND
MOV A, #06H
LCALL COMMAND
RET
-----------------------------------------------------------------------------------------------------------------------
COMMAND:
ACALL READY
MOV P0, A
CLR RS_LCD
CLR RW_LCD
SETB E_LCD
CLR E_LCD
RET
-----------------------------------------------------------------------------------------------------------------------
DISPLAY:
ACALL READY
MOV P0, A
SETB RS_LCD
CLR RW_LCD
SETB E_LCD
CLR E_LCD
RET
-----------------------------------------------------------------------------------------------------------------------
READY: SETB P0.7
CLR RS_LCD
SETB RW_LCD
WAIT: CLR E_LCD
SETB E_LCD
JB P0.7, WAIT
RET
----------------------------------------------------------------------------------------------------------------------
END
```

**PROCEDURE:**

**1.** Insert AT89C52 Microcontroller in Programmer unit (in NV5001).
**2.** Connect serial cable between computer serial port and programmer unit serial port female connector (in NV5001).
**3.** Switch ‘On’ the programmer switch in programmer unit (in NV5001) and switch on the power supply.
**4.** Program LCD interface module.hex file (Via CD - NV5001/ Modules programs\MC-04 Display module \LCD module) in AT89C52 Microcontroller via programmer.
**5.** Switch ‘Off’ the power supply and remove the programmed controller from programmer ZIF socket.
**6.** Switch ‘Off’ the programmer switch in Programmer unit (in NV5001).
**7.** Insert programmed Microcontroller to microcontroller unit ZIF socket.
**8.** Connect 20 Pin FRC cable to LCD Interface block left side socket/connector (MC04) to Port P3 in NV5001 Trainer.
**9.** Connect 20 Pin FRC cable to LCD Interface block right side socket/connector (MC04) to Port P0 in NV5001 Trainer.

**10.** Turn contrast control potentiometer in LCD interface block to clockwise position (in MC04).
**11.** Turn Backlight control potentiometer in LCD interface block to anticlockwise position (in MC04).
**12.** Switch ‘On’ the power supply.
**13.** Observe “NVIS’’ is coming on LCD and after some delay “Technologies”.
**14.** Observe the output waveform between RS pin of LCD (P3.5) and ground, on oscilloscope.
**15.** Observe the output waveform between R/W pin of LCD (P3.6) and ground, on oscilloscope
**16.** Observe the output waveform between E pin of LCD (P3.7) and ground, on oscilloscope.
**17.** Turn contrast control potentiometer and observe the contrast change on LCD.
**18.** Turn Backlight control potentiometer and observe the change on backlight of LCD.

**RESULT:** ‘NVIS Technologies’ on displayed on 16x2 LCD.

**Question & Answer:**

1. The end-of-conversion on the ADC0804 is done by which line?
Ans. **EOC**
2. What is the difference between the 8031 and the 8051?
Ans. **The 8031 is ROM-less**.

3. Which I/O port that does not have a dual-purpose role is?

Ans. **Port 1**

4. The ADC0804 has resolution of?

Ans. **8 Bit**

5. A HIGH on which pin resets the 8051 microcontroller?

Ans. **RST**

6. An alternate function of port pin P3.1 in the 8051 is:

Ans. **Serial Port Output**

7. An alternate function of port pin P3.0 (RXD) in the 8051 is:

Ans. **Serial Port Input**

8. Magnetic tape is a

Ans. **Direct Access Storage Device**

9. Which parts of the computer perform arithmetic calculation

Ans. **ALU**

10. Vacuum tube based electronic computers are:

Ans. **Hoover generation**

# EXPERIMENT NO 5

**AIM:** Study of implementation, analysis and interfacing of seven segment display.

**APPARATUS:** NV5001 Microcontroller development Board, MC-04 Kit, power cord and connecting leads.

**PROGRAM:** for displaying "1234" on seven segment

```
SEG_A EQU P1.0
SEG_B EQU P1.1
SEG_C EQU P1.2
SEG_D EQU P1.3
-----------------------------------------------------------------------------------------------------------------
---
ORG 0000H
JMP START
-----------------------------------------------------------------------------------------------------------------
---
ORG 0200H
START: MOV P0, #00H
MOV A, #00H
CLR C
LOOP: MOV P2, #0FFH
CLR SEG_A
CLR   SEG_B
CLR   SEG_C
CLR   SEG_D
SETB SEG_A
MOV P2, #00000110B
LCALL DELAY_1S
CLR SEG_A
CLR SEG_B
CLR SEG_C
CLR SEG_D
MOV P2, #00H
SETB SEG_B
MOV P2, #01011011B
LCALL DELAY_1S
CLR SEG_B
CLR SEG_A
CLR  SEG_C
CLR SEG_D
```

```
MOV P2, #00H
SETB SEG_C
MOV P2, #01001111B
LCALL DELAY_1S
CLR SEG_C
CLR SEG_B
CLR SEG_A

CLR SEG_D
MOV P2, #00H
SETB SEG_D
MOV P2, #01100110B
LCALL DELAY_1S
CLR SEG_D
CLR SEG_B
CLR SEG_A
CLR SEG_C
MOV P2, #00H
LJMP LOOP
-----------------------------------------------------------------------------------------------------------------
-----
DELAY_1S: MOV R2, #06
DO3: MOV R3, #10
DHERE1: MOV R4, #10
DAGAIN: NOP
NOP
NOP
NOP
DJNZ R4, DAGAIN
DJNZ R3, DHERE1
DJNZ R2, DO3
RET
-----------------------------------------------------------------------------------------------------------------
-----
END
```

**PROCEDURE:**

**1.** Insert AT89C52 Microcontroller in Programmer unit (in NV5001).
**2.** Connect serial cable between computer serial port and programmer unit serial port female connector (in NV5001).
**3.** Switch ‘On’ the programmer switch in programmer unit (in NV5001) and switch on the power supply.
**4.** Program seven segment display.hex file (Via CD - NV5001/ Modules programs\MC04 Display module\Seven segment module) in AT89C52 Microcontroller via programmer.

**5.** Switch 'Off' the power supply and remove the programmed controller from programmer ZIF socket
**6.** Switch 'Off' the programmer switch in Programmer unit (in NV5001).
**7.** Insert programmed Microcontroller to microcontroller unit ZIF socket.
**8.** Connect 20 Pin FRC cable to seven segment display Interface block left side socket/connector (MC04) to Port P2 in NV5001 Trainer.
**9.** Connect 20 Pin FRC cable to seven segment Interface block right side socket/connector (MC04) to Port P1 in NV5001 Trainer.
**10.** Switch 'On' the power supply.
**11.** Observe "1234'' is coming on seven segment.
**12.** Observe the status of segment selection pins on tp28, tp29, tp30 & tp31.output waveform between RS pin of LCD (P3.5) and ground, on oscilloscope.
**13.** Observe the status of data bits on tp17 to tp24.

**RESULT:** "1234" displayed on seven segment display.

**Question & Answer:**

1. Explain how Timer2 works in a STANDARD 8051 device:
   Ans.**TIMER2 is NOT implemented in standard 8051 device. It is implemented only in 8052 devices.**
2. Give an example haw to write code memory using MOVC instruction.
   Ans. **MOVC instruction can only used to READ code memory. It cannot be used to write (use an dedicated programmer to write in code memory)**
3. What is asynchronous data transfer scheme?
   Ans.**In asynchronous data transfer scheme, first the processor sends a request to the device for read/write operation. Then the processor keeps on polling the status of the device. Once the device is ready, the processor executes a data transfer instruction to complete the process.**
4. What are the internal devices of 8255?
   Ans.**The internal devices of 8255 are port-A, port-B, port-C. The ports can be programmed for either input or output function in different operating modes.**
5. What is USART?
   Ans.The device which can be programmed to perform Synchronous or Asynchronous serial communication is called USART (Universal Synchronous Asynchronous Receiver Transmitter). Eg: INTEL 8251
6. What is scanning in keyboard and what is scan time?
   Ans.**The process of sending a zero to each row of a keyboard matrix and reading the columns for key actuation is called scanning. The scan time is the time taken by the processor to scan all the rows one by one starting from first row and coming back to the first row again.**
7. What is programmable peripheral device**?**
   Ans.**If the function performed by the peripheral device can be altered or changed by a program instruction then the peripheral device is called programmable device.**

**It have control register. The device can be programmed by sending control word in the prescribed format to the control register.**

**8.** What is baud rate?

Ans.**The baud rate is the rate at which the serial data are transmitted. Baud rate is defined as (The time for a bit cell). In some systems one bit cell has one data bit, then the baud rate and bits/sec are same.**

**9.** What is a port?

Ans.**The port is a buffered I/O, which is used to hold the data transmitted from the microprocessor to I/O devices and vice versa.**

**10.** What is the need for interrupt controller?

Ans. **The interrupt controller is employed to expand the interrupt inputs. It can handle the interrupt request from various devices and allow one by one to the processor.**

# EXPERIMENT NO 6

**AIM:** Study of implementation of stepper motor angle control.

**APPARATUS:** NV5001 Microcontroller development Board, MC-05 Kit, power cord and connecting leads.

**DESCRIPTION:** The experiment has been designed to have a clear understanding of how motors are interfaced and controlled with microcontroller. The Motor drive module is made in such a way that student can understand the whole concepts of steeper motor, DC motor and Servo system. The object is to connect and program a microcontroller to do any operation with motors. It has input and output terminals for connection of external real world applications.

**PROGRAM:** To monitor the status of switch and rotate the stepper motor.

```
ANG_SW EQU P2.5
D_ST EQU P2.3
C_ST EQU P2.2
B_ST EQU P2.1
A_ST EQU P2.0
-----------------------------------------------------------------------------------------------------------------
ORG 0000H
JMP START
-----------------------------------------------------------------------------------------------------------------
ORG 0200H
START : MOV A, #00H
BACK : LCALL DELAY
SETB ANG_SW
SETB A_ST
SETB B_ST
CLR C_ST
CLR D_ST
JNB ANG_SW, SEC_STATE
SJMP BACK
SEC_STATE : LCALL DELAY
SETB ANG_SW
CLR A_ST
SETB B_ST
SETB C_ST
CLR D_ST
JNB ANG_SW, THI_STATE
SJMP SEC_STATE
THI_STATE : LCALL DELAY
SETB ANG_SW
```

```
CLR A_ST
CLR B_ST
SETB C_ST
SETB D_ST


JNB ANG_SW, FOU_STATE
SJMP THI_STATE
FOU_STATE : LCALL DELAY
SETB ANG_SW
SETB A_ST
CLR B_ST
CLR C_ST
SETB D_ST
JNB ANG_SW, BACK
SJMP FOU_STATE
------------------------------------------------------------------------------------------------------------------------
--
DELAY : MOV R2, #20
DO3 : MOV R3, #30
DHERE1 : MOV R4, #70
DAGAIN : NOP
NOP
NOP
DJNZ R4, DAGAIN
DJNZ R3, DHERE1
DJNZ R2, DO3
RET
------------------------------------------------------------------------------------------------------------------------
--

END
```

**PROCEDURE:**

**1.** Insert AT89C52 Microcontroller in Programmer unit (in NV5001).
**2.** Connect serial cable between computer serial port and programmer unit serial port female connector (in NV5001).
**3.** Switch 'On' the programmer switch in programmer unit (in NV5001) and switch 'On' the power supply.
**4.** Program angle control.hex file (Via CD - NV5001/ \Modules programs**MC05 Drive module**\Stepper motor interface module\Angle control program) in AT89C52 Microcontroller via programmer.
**5.** Switch 'Off' the power supply and remove the programmed controller from programmer ZIF socket.

**6.** Switch ‘Off’ the programmer switch in Programmer unit (in NV5001).
**7.** Insert programmed Microcontroller to microcontroller unit ZIF socket.
**8.** Connect 20 Pin FRC cable to Stepper motor interface block socket (MC05) to Port P2 in NV5001 Trainer.
**9.** Switch ‘On’ the power supply.
**10.** Check the status of port pins on tp1 to tp 4 i.e., A to D pins.
**11.** Observe the status of Angle control switch ‘On’ SW2 line or tp 6.
**12.** Press Angle control switch and observe the direction of rotation of stepper motor.
**13.** Check the status of port pins on tp1 to tp 4 i.e., A to D pins.
**14.** Repeat steps 12 and 13 three times and observe the angle change of stepper motor.

**RESULT: Stepper motor angle is observed.**

**Question & Answer:**

1. How a keyboard matrix is formed in keyboard interface using 8279?
   Ans.**The return lines, RL0 toRL7 of 8279 are used to form the columns of keyboard matrix. In decoded scan lines SL0 t0SL3 of 8279 are used to form the rows of keyboard matrix. In encoded scan mode, the output lines of external decoder are used as rows of keyboard matrix.**
2. What is GPIB?
   Ans.**GPIB is the General Purpose interface Bus. It is used to interface the test instruments to the system controller.**
3. Advantages of differential data transfer?
   Ans.**1. Communication at high data rate in real world environment. 2. Differential data transmission offers superior performance. 3. Differential signals can help induced noise signals.**
4. Features of INTEL 8259**?**
   Ans.**1. It manages 8 interrupt request. 2. The interrupt vector addresses are programmable. 3. The priorities of interrupts are programmable. 4. The interrupt can be masked or unmasked individually.**
5. What is meant by micro controller?
   Ans.**A device which contains the microprocessor with integrated peripherals like memory, serial ports, parallel ports, timer/counter, interrupt controller, data acquisition interfaces like ADC, DAC is called micro controller**.
6. List the features of 8051 micro controllers**?**
   Ans.**Single supply +5v operation using HMOS technology.**
   · **4096 bytes program memory on-chip. · 128 data memory on chip. · 4 register banks**

· **2 multiple modes, 16 bit timer/counter · Extensive Boolean processing capabilities. · 64KB external RAM size. · 32 bi-directional I/O lines.**

7. Explain the operating mode 0 of 8051 serial port**?**

   Ans.**In this mode serial data enters and exists through RXD, TXD outputs the shift clock. 8-bits are transmitted or received:8-data bits(LSB first). The baud rate is fixed at 1/12 the oscillator frequency.**

8. Explain the operating mode 2 of 8051 serial port**?**

   Ans. **In this mode 11 bits are transmitted (through TXD) or received (through (RXD): a start bit(0), 8 data bits( LSB first), a programmable 9th data bit and a stop bit(1). On transmit, the 9th data bit can be assigned the value 0 or 1. On receive, the 9th data bit go into the RB8 in special function register SCON, while the stop bit is ignored. The baud rate is programmable to either 1/32 or 1/64 the oscillator frequency.**

9. Explain the mode 3 of 8051 serial port**?**

   Ans.**In this mode, 11 bits are transmitted (through TXD) or (received (through RXD): a start bit(0), 8 data bits(LSB first), a programmable 9th data bit and a stop bit(1).It is same as mode 2 except the baud rate. The baud rate in mode 3 is variable.**

10. Explain the interrupts of 8051 micro controller? ·

    Ans. **External interrupt 0 (IE0) – Highest priority**

    · **Timer interrupt 0 (TF0) · External interrupt 1 (IE1) · Timer interrupt 1 (TF1) · Serial port Interrupt Receive interrupt (RI) – lowest priority Transmit interrupt (TI)**

# EXPERIMENT NO 7

**AIM:** Study of implementation of Motor control using PWM method.

**APPARATUS:** NV5001 Microcontroller development Board, MC-05 Kit, power cord and connecting leads.

**PROGRAM:** To monitor the PWM status and control the speed of DC motor in 100% and 25% duty cycle pulse.

```
PWM_SW EQU P2.4
INPUT2 EQU P2.2
INPUT1 EQU P2.1
PWM_INPUT EQU P2.0
-----------------------------------------------------------------------------------------------------------
ORG 0000H
JMP START
-----------------------------------------------------------------------------------------------------------
ORG 0200H
START : MOV A, #00H
CLR C
SETB PWM_SW
SETB PWM_INPUT
SETB INPUT1
CLR INPUT2
JNB PWM_SW, FIR_ROU
SJMP START
-----------------------------------------------------------------------------------------------------------
FIR_ROU : SETB PWM_SW
CLR PWM_INPUT
LCALL DELAY_1S_2
LCALL DELAY_1S_2
LCALL DELAY_1S_2
LCALL DELAY_1S_2
SETB PWM_INPUT
-------------------------------------------------------------------------------------------------------------
LCALL DELAY_1S
LCALL DELAY_1S
LCALL DELAY_1S
LCALL DELAY_1S
LCALL DELAY_1S
LCALL DELAY_1S
LCALL DELAY_1S
LCALL DELAY_1S
```

```
LCALL DELAY_1S
LCALL DELAY_1S
LCALL DELAY_1S


LCALL DELAY_1S
LCALL DELAY_1S
LCALL DELAY_1S
LCALL DELAY_1S
SJMP FIR_ROU
--------------------------------------------------------------------------------------------------------------
DELAY_1S_2 : MOV R2, #50
DHERE1_1_1 : MOV R3, #100
DHERE1_2 : NOP
DJNZ R3, DHERE1_2
DJNZ R2, DHERE1_1_1
RET
--------------------------------------------------------------------------------------------------------------
DELAY_1S : MOV R2,#100
DO3_3 : DEC R2
DJNZ R2, DO3_3
RET
--------------------------------------------------------------------------------------------------------------
END
```

**PROCEDURE:**

**1.** Insert AT89C52 Microcontroller in Programmer unit (in NV5001).
**2.** Connect serial cable between computer serial port and programmer unit serial port female connector (in NV5001).
**3.** Switch 'On' the programmer switch in programmer unit (in NV5001) and switch 'On' the power supply.
**4.** Program PWM interface.hex file (Via CD - NV5001/ \Modules programs\MC05 Drive module \DC motor interface module\PWM Interface program) in AT89C52 Microcontroller via programmer.
**5.** Switch 'Off' the power supply and remove the programmed controller from programmer ZIF socket
**6.** Switch 'Off' the programmer switch in Programmer unit (in NV5001).
**7.** Insert programmed Microcontroller to microcontroller unit ZIF socket.
**8.** Connect 20 Pin FRC cable to DC motor /PWM interface block socket (MC05) to Port P2 in NV5001 Trainer.
**9.** Connect 2 mm patch cord between +12V DC block socket (in NV5001) to +12V DC socket in DC motor /PWM interface block (in MC05).
**10.** Switch 'On' the power supply.
**11.** Check the status of port pins on tp7 to tp11

**12.** Observe the status of PWM switch at tp11.
**13.** Observe the rotation speed of DC Motor.
**14.** Press PWM switch and repeat steps 11 to 13 one time and observe the speed change of DC motor.

**RESULT:** Wave observed on CRO and duty cycle is measured.

## Question & Answer:

1. How many bytes of internal RAM and ROM supported by 8051 micro controller?
   Ans.**128 bytes of internal RAM and 4 bytes of ROM.**
2. Define machine cycle of 8051?
   Ans.**8051 machine cycle consists of 6 states, S1 through S7. One state is made up of 2 clock pulses. Thus 12 clock period constitute one machine cycle. Two clock periods in a state is termed as phase 1 and phase 2.**
3. What are the special function of port 0 of 8051**?**
   Ans.**Port 0 is used as a multiplexed low order address/data bus during the external memory access. When ALE is enabled, the addresses on port 0 pins are latched and bus is ready to act as a data bus when ALE is low.**
4. What are the alternative function of port 3 of 8051?
   Ans.**Serial data input (P3.0), serial data output (P3.1), external interrupt 0 (P3.2), external interrupt 1 (P3.3), external input for timer 0(P3.4), external input for timer 1 (P3.5), external memory write pulse (P3.6), external memory read (P3.7) are the alternative functions of port 3.**
5. What are the use of scratch pad area of internal RAM of 8051**?**
   Ans.**In internal RAM 80 bytes constitutes the scratch pad area. The scratch pad bytes can be programmed as a general purpose registers.**
6. What are the flags supported by 8051 controller? **–**
   Ans. **Carry flag · Auxiliary carry flag · Over flow flag· General purpose user flag · Register bank select bit one · Register bank select bit zero · Parity flag**
7. What is meant by Power-on- Reset in 8051 controller?
   Ans.**When RESET pin is activated, the 8051 jumps to address location 0000H. This is called as Power-on-Reset. Reset pin is considered as a sixth interrupt source of 8051.**
8. What are the significance of SFRs**?**
   Ans. **All the controller registers such as port latches, timer register, peripheral control register, accumulator, PC and DPTR all are available in SFR region.**
9. What are the different group of instructions supported by 8051**? ·**
   Ans.**Data Transfer Group · Arithmetic Logical Branching Bit manipulation**

**10.** Write a program to mask the 0th and 7th bit using 8051?

**Ans**:

```
MOV A,#data
ANL A,#81
MOV DPTR,#4500
MOVX @DPTR,A
LOOP:  SJMP LOOP
```

# EXPERIMENT NO 8

**AIM:** Study and observation of Position control of Servo Motor.

**APPARATUS:** NV5001 Microcontroller development Board, MC-05 Kit, power cord and
connecting leads.

**PROGRAM:** To monitor the status of position control switch and control the angle of servo motor.

```
SERVO_PIN EQU P2.0
SW_PIN EQU P2.1
---------------------------------------------------------------------------------------------------------
-------
ORG 0000H
JMP START
---------------------------------------------------------------------------------------------------------
------
ORG 0200H
START : CLR SERVO_PIN
SETB SW_PIN
LOOP_S : LCALL DELAY
SETB SW_PIN
SETB SERVO_PIN
LCALL DELAY_15MS_P
CLR SERVO_PIN
LCALL DELAY_16MS
JNB SW_PIN, SW_1_1
LCALL DELAY
SJMP LOOP_S
--------------------------------------------------------------------------------------------------------------------
SW_1_1 : LCALL DELAY
SETB SW_PIN
SETB SERVO_PIN
LCALL DELAY_25MS_P
CLR SERVO_PIN
LCALL DELAY_16MS
LCALL DELAY
SJMP SW_1_1
--------------------------------------------------------------------------------------------------------------------
DELAY_16MS : MOV R2, #150
DHERE1_16 : MOV R3, #32
DAGAIN_16 : NOP
```

```
DJNZ R3, DAGAIN_16
DJNZ R2, DHERE1_16
RET
-----------------------------------------------------------------------------------------------------------------

DELAY_25MS_P : MOV R2, #20
DHERE1_25_P : MOV R3, #37
DAGAIN_25_P : NOP
DJNZ R3, DAGAIN_25_P
DJNZ R2, DHERE1_25_P
RET
-----------------------------------------------------------------------------------------------------------------
DELAY_15MS_P : MOV R2, #20
DHERE1_15_P : MOV R3, #20
DAGAIN_15_P : NOP
DJNZ R3, DAGAIN_15_P
DJNZ R2, DHERE1_15_P
RET
DELAY : MOV R5, #250
DHERE1 : MOV R4, #220
DAGAIN : NOP
NOP
DJNZ R4, DAGAIN
DJNZ R5, DHERE1
RET
------------------------------------------------------------------------------------------------------------------
END
```

**PROCEDURE:**

**1.** Insert AT89C52 Microcontroller in Programmer unit (in NV5001).
**2.** Connect serial cable between computer serial port and programmer unit serial port female connector (in NV5001).
**3.** Switch 'On' the programmer switch in programmer unit (in NV5001) and switch 'On' the power supply.
**4.** Program servo motor module.hex file (Via CD - NV5001/ \Modules programs\MC05 Drive module \DC motor interface module\Servo motor module) in AT89C52 Microcontroller via programmer.
**5.** Switch 'Off' the power supply and remove the programmed controller from programmer ZIF socket
**6.** Switch 'Off' the programmer switch in Programmer unit (in NV5001).

**7.** Insert programmed Microcontroller to microcontroller unit ZIF socket.
**8.** Connect 20 Pin FRC cable to servo motor interface block socket (MC05) to Port P2 in NV5001 Trainer.
**9.** Switch ‘On’ the power supply.
**10.** Check the status of port pins on tp12 to tp13.
**11.** Observe servo motor rotates and stop in the centre position or in 90 degree angle.
**12.** Press position control switch and repeat steps 10.
**13.** Observe servo motor rotates and stop in l80 degree angle or in a left side position.

**RESULT**: Angle rotation of the servo motor observed.

**Question & Answer:**

1. What is a Data pointer register?
   Ans.**The data pointer register (DPTR) consists of a high byte(DPH) and a low byte (DPL) functions to hold 16 bit address. It may be manipulated as a 16-bit data register or as independent 8-bit registers. It serves as a base register in indirect jumps, look up table instructions and external data transfer.**
2. What are the operating modes of 8279?
   Ans.**1. Input modes · Scanned keyboard · Scanned sensor matrix · Strobed input 2. Display modes · Left entry (Type writer mode) · Right entry (Calculator mode)**
3. What are the different functional units in 8279?
   Ans.**CPU interface section, Keyboard section, Display section, Scan section**
4. What are the priority modes in 8259?
   Ans.**a. Fully nested mode b. Special fully nested mode c. Rotating Priority mode d. Special Masked mode e. Polled mode**
5. What is IMR(Interrupt mask register)?
   Ans.**IMR stores the masking bits of the interrupt lines to be masked. This register can be programmed by an operation command word (OCW).**
6. What is priority resolver?
   Ans. **It determines the priorities of the bits set in the Interrupt request register (IRR).The bit corresponding to the highest priority interrupt input is set in the ISR during INTA input.**
7. What is the use of IRR?
   Ans.**The interrupt request register is used to store all the interrupt levels which are requesting the service. The eight interrupt inputs sets corresponding bits of the Interrupt Request Register upon the service request.**
8. What is Interrupt service register(ISR)?

Ans.**The interrupt service register stores all the levels that are currently being serviced.**

**9.** What is the difference between SHLD and LHLD?

Ans.**SHLD- Store HL register pair in memory.**

**This instruction is used to store the contents of H and L register directly in to memory.**

**LHLD- Load HL register pair from memory. This instruction copies the contents of memory location given with in the instruction in to the L register and the contents of next memory location in to the H register.**

**10.** What is the difference between STAX and LDAX?

Ans.**STAX rp – Store the contents of Accumulator register (A) in memory location whose address is specified by BC or DE register pair.**

**LDAX rp – Load Accumulator register (A) with the contents of memory location whose address is specified by BC or DE register pair.**

# EXPERIMENT NO 9 (a)

**AIM:** Study of Programming and Transmission of data through serial port.

**APPARATUS:** NV5001 Microcontroller development Board, MC-03 Kit, power cord and connecting leads.

**DESCRIPTION**: Computer interface module for Microcontroller development board with programmer trainer is an Extension module. The module has been designed to have a clear understanding of how serial port and parallel port interfaced devices are controlled and interface with microcontroller. The apparatus is connected with microcontroller unit and PC. The computer interface trainer is made in such a way that student can understand the whole concepts of serial and parallel port and how they are interfaced with microcontroller.

**INSTALLATION:**

If your computer doesn't have Hyper Terminal software please follow the below procedure.
**1.** First go to control panel and click Add/Remove Program.
**2.** Click Windows Setup.
**3.** Select Hyperterminal then press OK and click Apply.
**4.** Select Hyperterminal then press OK and click Apply.
**5.** Computer will ask for Windows CD for installing Hyperterminal.
**6.** After installing hyperterminal click cursor on
<start> <programs><Accessories><communications> <Hyperterminal> then open it.
**7.** Click on < Hyperterminal> icon give ABC in name block and click OK.
**8.** Select Communication port < Direct to COM1>.
**9.** For Trainer kit select following COM 1 properties :
Bits per second : 9600
Data bits : 8
Parity : None
Stop bits : 1
Flow control : None

**PROGRAM:** To transfer the message "YES" serially at 9600 baud, 8 bit data and 1stop bit continuously.

```
ORG 0000H
JMP START
-------------------------------------------------------------------------------------------------------
ORG 0200H
START: MOV A, #00H
MOV PSW, #00H
MOV SBUF, #00H
```

```
CLR C
SERI_TRANSMIT: MOV P3, #0FFH
MOV TMOD, #20H
MOV TH1, #0FDH
MOV TL1, #0FDH

MOV SCON, #50H
SETB TR1
CLR TI
CLR RI
MOV A, #"Y"
LCALL TRANSMIT
MOV A, #"E"
LCALL TRANSMIT
MOV A, #"S"
LCALL TRANSMIT
MOV A, #" "
LCALL TRANSMIT
LJMP SERI_TRANSMIT
TRANSMIT: MOV SBUF, A
MOV B, A
HERE_S: JNB TI, HERE_S
CLR TI
RET
--------------------------------------------------------------------------------------------------------------------
END
```

**PROCEDURE:**

**1.** Insert AT89C52 Microcontroller in Programmer unit (in NV5001).
**2.** Connect serial cable between computer serial port and programmer unit serial port female connector (in NV5001).
**3.** Switch 'On' the programmer switch in programmer unit (in NV5001) and switch 'On' the power supply.
**4.** Program Serial transmit.hex file (Via CD - NV5001/ Modules programs\ MC03 Computer Interface module\Serial port interface module\Serial transmit) in AT89C52 Microcontroller via programmer.
**5.** Switch 'Off' the power supply and remove the programmed controller from programmer ZIF socket.
**6.** Switch 'Off' the programmer switch in Programmer unit (in NV5001).
**7.** Insert programmed Microcontroller to microcontroller unit ZIF socket.
**8.** Connect 20 Pin FRC cable to Serial port Interface block socket/connector (MC03) to Port P3 in NV5001 Trainer.
**9.** Unplug the serial cable which is connected between programmer unit and PC.
**10.** Connect serial cable between computer serial port and serial port interface block

female connector (inMC03).
**11.** Click on < Hyperterminal> icon in your Pc and give ABC in name block then click OK.
**12.** Select Communication port < Direct to COM1 > ( If you connect cable to COM1)
**13.** For Module select following COM 1 properties:

Bits per second : 9600
Data bits : 8
Parity : None
Stop bits : 1
Flow control : None

**14.** Switch ‘On’ the power supply.

15. Observe transmitted data on Hyperterminal window (message “YES “).This Y, E and S character transmitted through microcontroller and received by PC through serial cable.
**16.** To see transmitted data connect CRO probe between tp1, tp2, tp3 & tp4 test points and observe it.

<u>**RESULT**</u>**:** Data ‘yes’ is checked on Hyper Terminal transferred by serial port.

# EXPERIMENT 9 (b)

**AIM:** Study of Programming and Reception of data through serial port.

**APPARATUS:** NV5001 Microcontroller development Board, MC-03 Kit, power cord and connecting leads.

**PROGRAM:** To receive bytes of data serially and put them in P0. Set the baud rate at 9600, 8- bit data and 1 stop bit.

```
RS_LCD EQU P2.5
RW_LCD EQU P2.6
E_LCD EQU P2.7
ORG 0000H
JMP START
-----------------------------------------------------------------------------------------------------------------
ORG 0200H
START: MOV PSW, #00H
CLR C
MOV P0, #00H
MOV A, #00H
LCALL LCDINIT
MOV A, #084H
LCALL COMMAND
MOV A, #" "
LCALL DISPLAY
MOV A, #" "
LCALL DISPLAY
MOV A, #"N"
LCALL DISPLAY
MOV A, #"v"
LCALL DISPLAY
MOV A, #"i"
LCALL DISPLAY
MOV A, #"s"
LCALL DISPLAY
MOV A, #" "
LCALL DISPLAY
MOV A, #" "
LCALL DISPLAY
MOV A, #" "
LCALL DISPLAY
LOOP_RECEIVE: MOV SBUF, #00H
------------------------------------------------------------------------------------------------------------------
MOV A, #00H
```

```
MOV B, #00H
MOV P0, #00H
MOV P3, #0FFH


MOV TMOD, #20H
MOV TH1, #0FDH
MOV TL1, #0FDH
MOV SCON, #50H
SETB TR1
CLR RI
--------------------------------------------------------------------------------------------------------------------------
HERE_RECEIVE: JNB RI, HERE_RECEIVE
MOV A, SBUF
MOV B, A
MOV A, #084H
LCALL COMMAND
MOV A, #" "
LCALL DISPLAY
MOV A, #" "
LCALL DISPLAY
MOV A, #" "
LCALL DISPLAY
MOV A, #" "
LCALL DISPLAY
MOV A, #" "
LCALL DISPLAY
MOV A, #" "
LCALL DISPLAY
MOV A, #" "
LCALL DISPLAY
MOV A, #" "
LCALL DISPLAY
MOV A, #" "
LCALL DISPLAY
MOV A, #084H
LCALL COMMAND
--------------------------------------------------------------------------------------------------------------------------
MOV A, B
LCALL DISPLAY
CLR RI
LJMP LOOP_RECEIVE
LCDINIT: MOV A, #38H
LCALL COMMAND
MOV A, #0CH
```

```
LCALL COMMAND
MOV A, #01H
LCALL COMMAND
MOV A, #06H
LCALL COMMAND
RET
--------------------------------------------------------------------------------------------------------
COMMAND:
ACALL READY
MOV P0, A

CLR RS_LCD
CLR RW_LCD
SETB E_LCD
CLR E_LCD
RET
--------------------------------------------------------------------------------------------------------
DISPLAY:
ACALL READY
MOV P0, A
SETB RS_LCD
CLR RW_LCD
SETB E_LCD
CLR E_LCD
RET
READY: SETB P0.7
CLR RS_LCD
SETB RW_LCD
WAIT: CLR E_LCD
SETB E_LCD
JB P0.7, WAIT
RET
--------------------------------------------------------------------------------------------------------
DELAY_1S:
MOV R2, #11
DO3: MOV R3, #98
DHERE1: MOV R4, #106
DAGAIN: NOP
NOP
NOP
NOP
NOP
NOP
DJNZ R4, DAGAIN
DJNZ R3, DHERE1
```

DJNZ R2, DO3
RET

-------------------------------------------------------------------------------------------------------------

END

**PROCEDURE:**

**1.** Insert AT89C52 Microcontroller in Programmer unit (in NV5001).
**2.** Connect serial cable between computer serial port and programmer unit serial port female connector (in NV5001).
**3.** Switch 'On' the programmer switch in programmer unit (in NV5001) and switch 'On' the power supply.
**4.** Program Serial receive.hex file (Via CD - NV5001/ Modules programs\ MC03 Computer Interface module\Serial port interface module\Serial receive) in AT89C52 Microcontroller via programmer.

**5.** Switch 'Off' the power supply and remove the programmed controller from programmer ZIF socket.
**6.** Switch 'Off' the programmer switch in Programmer unit (in NV5001).
**7.** Insert programmed microcontroller to microcontroller unit ZIF socket.
**8.** Connect 20 Pin FRC cable to Serial port Interface block socket/connector (MC03) to Port P3 in NV5001 Trainer.
**9.** Connect 20 Pin FRC cable to LCD Interface block left side socket/connector (MC04) to Port P2 in NV5001 Trainer.
**10.** Connect 20 Pin FRC cable to LCD Interface block right side socket/connector (MC04) to Port P0 in NV5001 Trainer.
**11.** Unplug the serial cable which is connected between programmer unit and PC.
**12.** Connect serial cable between computer serial port and serial port interface block female connector (inMC03).
**13.** Click on < Hyperterminal> icon in your PC and give ABC in name block then click OK.
**14.** Select Communication port < Direct to COM1 > ( If you connect cable to COM1).
**15.** For Module select following COM 1 properties:
  Bits per second : 9600
  Data bits : 8
  Parity : None
  Stop bits : 1
  Flow control : None
**16.** Switch 'On' the power supply.
**17.** "Nvis" is displayed on LCD screen.
**18.** Now press any key from keyboard (Keep cursor on hyper window).The character you pressed is displayed on LCD. The character is received by microcontroller via serial cable and displayed on LCD.
**19.** To see received data connect CRO probe between tp1 & tp3 test point and ground.

**20.** To see received data connect CRO probe between tp3 & tp4 test point and ground.

**RESULT**: Serial data is observed on port 0.

**Question & Answer**:

1. Translator for low level programming language were termed as
   Ans.**assembler.**
2. Load address for the first word of the program is called
   Ans. **load address origin.**
3. Shell is the exclusive feature of
   Ans. **UNIX.**
4. A program in execution is called
   Ans. **process.**
5. A scheduler which selects processes from secondary storage device is called
   Ans.**medium term scheduler.**
6. The term 'page traffic' describes
   Ans.**the movement of pages in and out of memory.**
7. Program 'preemption' is
   Ans. **forced de allocation of the CPU from a program which is executing on the CPU.**
8. 'LRU' page replacement policy is
   Ans.**least recently used.**
9. "Throughput" of a system is
   Ans.**number of programs processed by it per unit time.**
10. Nested Macro calls are expanded using the
    Ans.**LIFO (Last in First out).**

# EXPERIMENT NO 10

**AIM:** To study implementation and programming of Pressure measurement.

**APPARATUS:** NV5001 Microcontroller development Board, MC-15 Kit, power cord and connecting leads.

**DESCRIPTION:** Sensor module, MC15 has input and output terminals for connection of External real world applications. Pressure Sensor and Temperature Sensor Interface Module MC15 is generally used in the applications such as Monitoring and Controlling in Industries and many more.

**PROGRAM:**

```
#include <LPC214x.H>                                    /* LPC214x definitions */
#include <stdio.h>
/*************************************************************************
*  Function Prototypes
*************************************************************************/
void LCD_Init(void);                                    /* LCD Init Function  */
void LCD_Delay(unsigned int);                           /* LCD Delay Function  */
void LCD_Cmd(unsigned long);                            /* LCD Command Function */
void LCD_Data(unsigned long);                           /* LCD Data Function  */
void LCD_Disp(unsigned char, char *);                   /* LCD Display Function */
void display_lcd1 (unsigned char location, char *d);
void ADC_Init(void);                                    /* ADC Init Function */
void ADC_Convert(unsigned int);                         /* ADC Display Function */
void ADC_CALL(void);
/**************************************************************************
*  LCD Pin Out Description
**************************************************************************
/
#define RS_Set IO1SET = 0x20000000;
#define RS_Clr IO1CLR = 0x20000000;
#define EN_Set IO1SET = 0x80000000;
#define EN_Clr IO1CLR = 0x80000000;
unsigned int ADC_Val;                                   /* ADC Result (HEX)
*/
unsigned int FirstBit,SecondBit,ThrdBit,FourthBit;
/**************************************************************************

*Delay
*Description : This function provide Delay in Mili Sec.
**************************************************************************
/
```

```
void LCD_Delay(unsigned int Time)
{
   unsigned int i,j;
   for(i=0;i<=Time;i++)
   for(j=0;j<110;j++);
}



/**************************************************************************
*
* ADC initialization
* Description: This function initializes the LCD module by the following steps:
*1. Select ADC Channel
*2. Set A/D: 10-bit AIN0 @ 12MHz
* Note: This function should be called once before any of the other functions of ADC.
***************************************************************************
/
void ADC_Init()
{
PINSEL0 |= 0x00003000;                                    /* channel
AD1.0*/
AD1CR     = 0x01210400;                       /* Setup A/D: 10-bit AIN0 @ 3MHz
*/
}
/**************************************************************************
*
* ADC Conversion
* Description: This function convert ADC data into ASCII by the following steps:
* 1. Convert each byte into ASCII
* 2. Each Value will be used for LCD Display
* Arguments   : 'RADC_Value'  is the Value which needs to convert in ASCII.
***************************************************************************
/
void ADC_Convert(unsigned int ADC_Value)
{
 unsigned int X,Y,Z;                                      /* Intermidiate Variables
*/
 FirstBit=0,SecondBit=0,ThrdBit=0,FourthBit=0;
 X = ADC_Value/10;
 FirstBit = ADC_Value%10;
 FirstBit = 0x30|FirstBit;                                   /* First Byte(LSB)
*/
 Y = X/10;
```

```
 SecondBit = X % 10;
 SecondBit = 0x30|SecondBit;                                    /* Second Byte
*/
 Z = Y/10;
 ThrdBit = Y % 10;
 ThrdBit = 0x30|ThrdBit;                                        /* Third Byte */
 FourthBit = Z;                                                 /* Last Byte(MSB) */
 FourthBit=0x30|FourthBit;
}
/******************************************************************************
*
* LCD initialization
* Description : This function initializes the LCD module by the following steps:
* 1. Set 8bit : 2 Line 5x7 Dots (0x38)
* 2. Display On curser Off (0x0C)
* 3. Clear Display (0x01)
*4. Entry Mode   (0x06)
* Note: This function should be called once before any of the other functions
*****************************************************************************/
void LCD_Init(void)
{
LCD_Cmd(0x38);                          /* Function Set 8bit : 2 Line 5x7 Dots */
LCD_Cmd(0x0C);                                   /* Display On curser Off */
LCD_Cmd(0x01);                                          /* Clear Display */


LCD_Cmd(0X06);                                             /* Entry Mode */
}
/******************************************************************************
*
* LCD Command (Shifting is Done here)
* Description : This function initializes the LCD module by the following steps:
* Note : Here we have selected Pin P1.16 to P1.23 as LCD data line that’s
* why we need to shift data by 16.
*******************************************************************************
/
void LCD_Cmd(unsigned long Cmd)
{
  unsigned long Shifted_Cmd;
  Shifted_Cmd = Cmd << 16;    /* because We have selected P1.16 to P1.23 as LCD data line
*/

  RS_Clr;                                                      /* RS Pin
Clear */
  LCD_Delay(10);                                               /* Delay for
```

```
Clock*/
  EN_Set;                                                                          /* Enable Pin
SET */
  LCD_Delay(10);
  IO1SET = Shifted_Cmd;                                     /* Write Command Value to LCD Data
Pin */
  LCD_Delay(20);                                                               /* Delay for enable
Clock*/
  EN_Clr;                                                                          /* Enable Pin
Clear */
  LCD_Delay(10);
  IO1CLR = 0x00FF0000;                                                     /* Clear All pins of
LCD */
}

/***************************************************************************
*
* LCD Data
* Description: This function initializes the LCD module by the following steps:
* 1. Set Register select(RS) to High
* 2. Set enable pin high to low
* 3. Send data to LCd data pin
* Note: Here we have selected Port 1 Pin P1.16 to P1.23 as LCD data line
* thats why we need to shift data by 16.
***************************************************************************
/
void LCD_Data(unsigned long Data)
{
  RS_Set;                                                                          /* RS Pin Clear
*/
  LCD_Delay(10);                                                                 /* Delay for
Clock*/
  EN_Set;                                                                         /* Enable Pin SET
*/
  LCD_Delay(10);
  IO1SET = Data << 16;                                        /* Write Command Value to LCD Data Pin
*/
  LCD_Delay(20);                                                             /* Delay for enable
Clock*/
  EN_Clr;                                                                        /* Enable Pin Clear
*/
  LCD_Delay(10);
  IO1CLR = 0x00FF0000;                                                   /* Clear All pins of
LCD */
}
```

```
/************************************************************************
*
* LCD Display
* Description : This function initializes the LCD module by the following steps:
* 1. Send Loc from where data needs to write


* 2. Display string on LCD
************************************************************************
/
void LCD_Disp(unsigned char Loc,  char *String)
{
  LCD_Cmd(Loc);                                              /* Send Command to LCD
*/
  while(*String)                                         /*    wait untill Null char come
*/
{
        LCD_Data(*String++);                                    /* Write data to LCD
*/
        IO1CLR = 0x00FF0000;                                 /* Clear All pins of LCD
*/
        }
}

void display_lcd1 (unsigned char location,  char *d)
{
  unsigned long shift_data;
  shift_data= 0x80 | location;
  shift_data= shift_data<<16;
  LCD_Cmd(shift_data);
  LCD_Delay(100);
  while(*d)
        {
         LCD_Data(*d++);
         LCD_Delay(100);
         IO1CLR = 0x00FF0000;                   // ADDED NEW
        }
}

void ADC_CALL(void)
{
   AD1CR |= 0x01000000;                                    /* start of ADC conversion
*/
   do{
```

```
        ADC_Val = AD1DR0;                                          /* 10 bit value
*/
       }while ((ADC_Val & 0x80000000) == 0);          /* Wait ADC Conversion Complete
*/

   AD1CR &= ~0x01000000;                                    /* Again start ADC
*/
   ADC_Val = (ADC_Val >> 6) & 0x03FE;
}

/*************************************************************************
*
* Main: Initialize and start RTX Kernel
* Description : This function Initialize the LCD,RTC and ADC and RTX Kernal
*************************************************************************
/
int main (void)          /* program exec. starts here  */
{
 float volt[20],dispvolt;
char k[5];int i;
IO1DIR = 0xFFFF0000;                  /* Define Port pin P1.16 to P1.31 as Output for LCD
*/
LCD_Init();                                                  /* LCD Initialize
*/
ADC_Init();                                                   * ADC Initialize
*/

display_lcd1(0x80,"       Voltage");
while(1)
           {
             for(i=0;i<=19;i++)
             {
               ADC_CALL();
               volt[i] = (ADC_Val * 3.3) / 1023.0;
              }
dispvolt =
(volt[0]+volt[1]+volt[2]+volt[3]+volt[4]+volt[5]+volt[6]+volt[7]+volt[8]+volt[9]+volt[10]+
volt[11]       +volt[12]+volt[13]+volt[14]+volt[15]+volt[16]+volt[17]+volt[18]+volt[19])/20;
sprintf(k,"%f",dispvolt + 0.01);
LCD_Cmd(0xC6);
LCD_Data(k[0]);
LCD_Cmd(0xC7);
LCD_Data(k[1]);
LCD_Cmd(0xC8);
LCD_Data(k[2]);
```

# CONTROL SYSTEM

**(EE-324-F)**

# LAB MANUAL

**VI SEMESTER**

# CONTROL SYSTEM

## LIST OF EXPERIMENTS

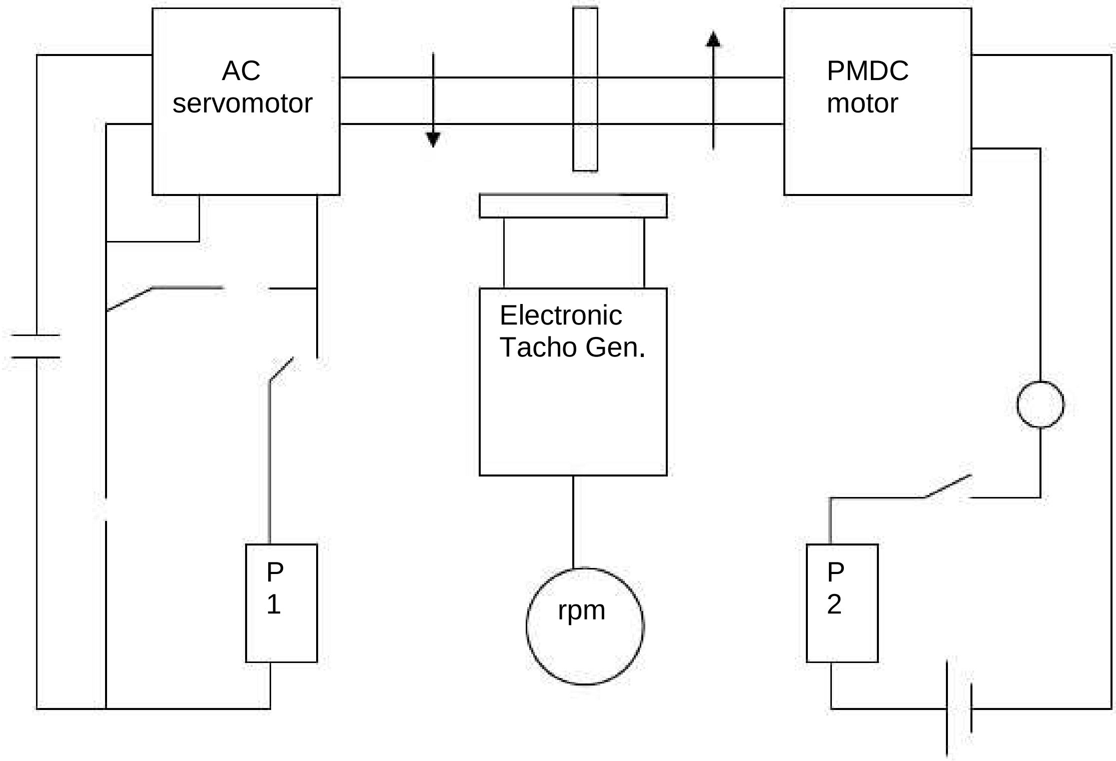
# EXPERIMENT NO: 1(a)

AIM: - To study AC servo motor and note it speed torque Characteristics.

APPARATUS REQUIRED: - AC Servo Motor Setup, Digital Multimeter and Connecting Leads.

THEORY: - AC servomotor has best use for low power control applications. Its important parameters are speed – torque characteristics. An AC servomotor is basically a two phase induction motor which consist of two stator winding oriented 90* electrically apart. In feedback application phase A is energised with fixed voltage known as "Reference" and phase B is energized with variable voltage called "Control voltage". In this setup AC servomotor is mounted and mechanically coupled a small PMDC motor loading purpose. When DC supply is fed to DC motor it runs in reverse direction of servomotor direction to impose load on servomotor. The resultant torque developed by DC motor to overcome it increase the current through it which is indicated by panel meter.

CIRCUIT DIAGRAM:-




PROCEDURE: -

1. Switch ON the power supply, switches ON S1. Slowly increase control P1 so that AC servomotor starts rotating. Connect DVM across DC motor sockets (red & black). Very the speed of servomotor gradually and note the speed N rpm and corresponding back emf Eb across DC motor.
2. Connect DVM across servo motor control winding socked (yellow) and adjust AC Servomotor voltage to 70V and note speed N rpm in table.
3. Switch On S2 to impose load on the motor due to which the speed of AC motor decreases. Increase the load current by means of P2 slowly and note corresponding speed N rpm and Ia. Calculate
   P=Ia*Eb and Torque=P*1.019*$10_4$60/2.2.14Ngm/cm

## OBSERVATION TABLE:-

TABLE-1

| S.NO | SPEED N rpm | Eb volts |
|---|---|---|
| 1. | | |
| 2. | | |
| 3. | | |
| 4. | | |
| | | |

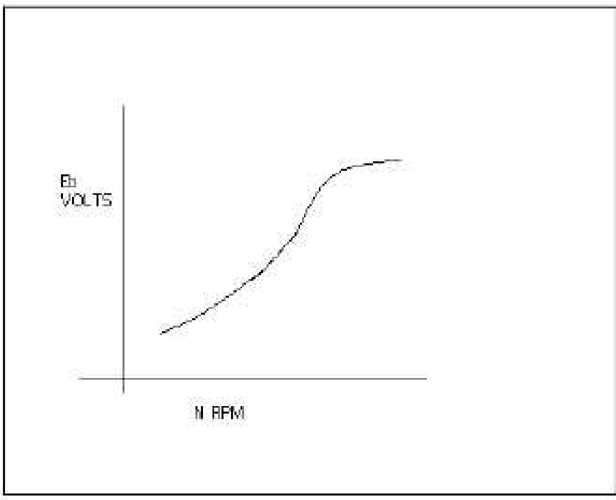
TABLE-2

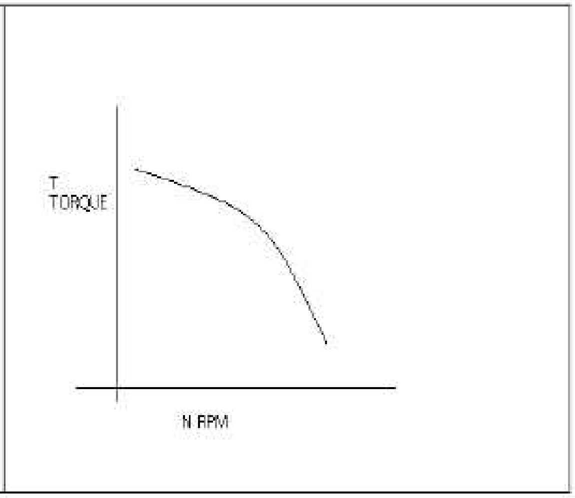
| S.NO | Ia amp | Eb ( Tab 1 ) | Speed N rpm | P watt | Torque |
|---|---|---|---|---|---|
| 1. | | | | | |
| 2. | | | | | |
| 3. | | | | | |
| 4. | | | | | |
| | | | | | |

## PRECAUTIONS: -

1. Apply voltage to servomotor slowly to avoid errors.
2. Impose load by DC motor slowly.
3. Take the reading accurately as the meter fluctuates.
4. Switch OFF the setup when note in use.

## GRAPH:-




## DISCUSSION:-

The graph is plotted between speed and torque. As we reduce the speed of the motor the torque goes on increasing therefore the graph starts with a low value and rises to a high value approximately linearly .This rise in the graph is due to the rising speed-torque characteristics of AC servo motor .

## QUIZ:-

Que 1. What is AC servo motor?
Ans.An AC servo motor is basically a two phase induction motor except for some Design feature.
Que.2 What is the use of AC servo motor?
Ans.AC servo motor has best use for low power control application.
Que.3 What are the advantages of AC servo motor?
Ans.It is rugged, light weighted, and has no brush contact as in DC servo motor.
Que4. What is the important parameter of AC servo motor?
Ans.The important parameter of AC servo motor is its speed – torque Characteristics.
Que.5 On what factor does the direction of rotation of AC servo motor Depend.
Ans.The direction of rotation of AC servo motor depends on the phase relationship of Input voltage V1 and V2 .
Que 6. What is the drawback of AC servo motor ?
Ans.The main drawback of AC servo motor is its positive slope which causes Negative damping to lead instability in control system .
Que.7 How the drawback of positive in AC servo motor is overcome ?
Ans. The drawback of positive in AC servo motor is overcome by designing the rotor With very high resistance .
Que.8 What is the input of AC servo motor in feedback control application?
Ans. In feedback control application phase A is given a fixed rated voltage called Reference voltage and phase B is given a variable voltage called

control Voltage.

Que.9 What is the phase relationship between reference voltage and control Voltage?

Ans. The reference voltage and control voltage are 90 degrees out of phase with each other.

Que.10 What are the types of AC servo motor ?

Ans.AC servo motors are of various type as squirrel cage rotor motor ,drag cup Rotor and solid iron rotor motor.

# EXPERIMENT NO: 1(b)

AIM:- To study dc servo motor and plot its speed torque characteristics.

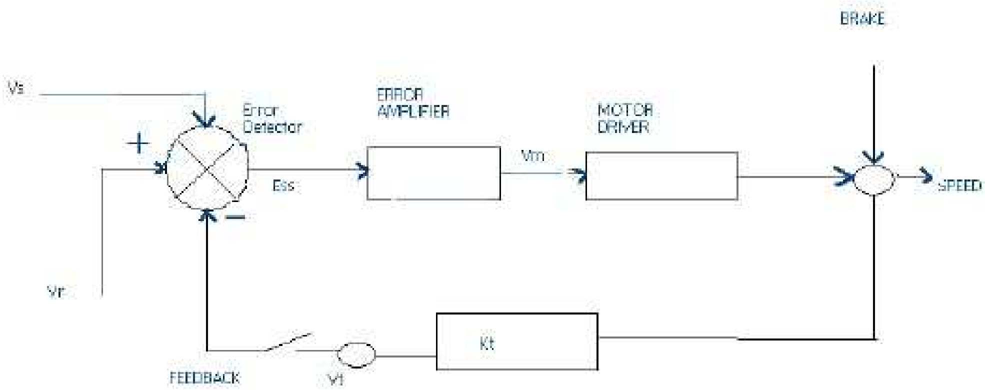
APPARATUS:- DC SERVO MOTOR KIT AND DVM.

THEORY: - The experiment is carried out in two steps.

1. Open loop performance
2. Close loop performance.

In first case the motor is run without feedback. The amplifier gain factor is kept at minimum gain = 3. motor is connected with main unit by 9 pin D Type socket. Step signal is kept off.

## CIRCUIT DIAGRAM:-




## PROCEDURE:-

OPEN LOOP PERFORMANCE:- Connect the main unit to the supply. Keep the gain switch off. Set Vr = 0.7 or 0.8. connect DVM with feedback signal socket Vt. Note the speed N rpm from display and tacho output Vt in volts from DVM. Record N rpm and Vt volts for successive gain 4-10 in observation table. Calculate Vm = Vr * Ka. Where Ka is the gain set from control 3 – 10.

Vr = 0.7 V.

Vm at gain 3 = 0.7 * 3

= 2.1 V.
Plot N vs Vt and N Vs Vm graph.

CLOSED LOOP PERFORMANCE:- In this case the gain switch is kept in on position thus feedback voltage gets subtracted from reference voltage. This is observed by decreased motor speed. Record the result between gain factor Ka and speed N. draw the graph between techo voltage Vt and speed N.

## OBSERVATION TABLE:-

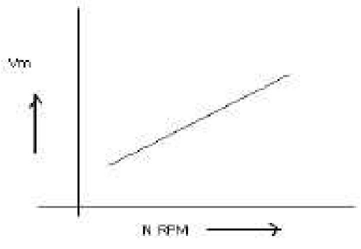
| S.NO. | GAIN(Ka) | Vt (volts) | N(rpm) | Vm=Vr×Ka |
|---|---|---|---|---|
| | | | | |

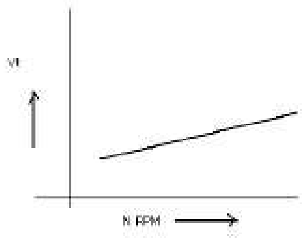
## PRECAUTIONS:-

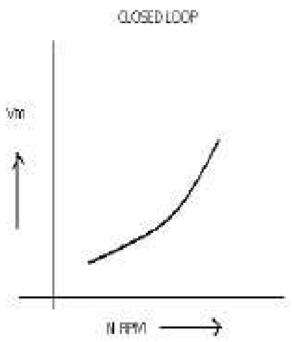
1. Apply the voltage slowly to start the motor
2. Take the reading properly.
3. Do not apply breaks for long time as the coil may get heated up.
4. Switch OFF the main power when not in use.

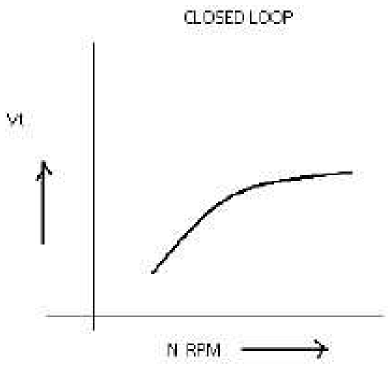
## GRAPH:-

For open loop:






## DISCUSSION:-

The graph is plotted between N (RPM) and Vt (techo voltage) and N(rpm) & Vm (motor voltage).the tacho voltage increases linearly as the RPM of DC servo motor increases. Similarly the motor voltage increases with RPM .in open loop. The slope is less but in close loop the slope is sharp and this is due to the feed back gain.

## QUIZ:-

Que.1 What are the uses of DC servo motor?

Ans. DC servo motor is widely used in radars, computers, robots, tracking systems and process controllers etc.

Que.2. What are the types of DC servo motors?

Ans. DC servo motors are separately excited or permanent magnet type.

Que.3. How the speed of DC servo motor is controlled?

Ans. The speed of DC servo motor is controlled by varying the armature voltage.

Que.4. What is the relation between torque and speed of DC servo motor?

Ans. The torque of DC servo motor decreases with increase in speed.

Que.5. Why the speed torque characteristics of DC servo motor has large Negative Slope?

Ans. The speed – torque characteristics of DC SERVO MOTOR has a large Negatives Slope due to large armature resistance.

Que.6. What is the effect of negative slope?

Ans. The negative slope provides viscous damping for the servo drive system.

Que.7. In which wattage the DC servo motors are available?

Ans. DC servo motors are available in fraction of a watt to a few hundred watts.

Que.8. What are the special features of DC SERVO MOTORS?

Ans. High torque to inertia ratio, High torque to value ratio, Low inductance of Winding and efficient heat dissipation is the special features of DC servomotor

Que.9. How the direction of rotation of DC servo motor can be changed?

Ans. The direction of rotation of DC servo motor can be changed by reversing the Phase difference from leading to lagging and vice versa between control voltages and reference voltage.

Que.10. What is transfer function of DC SERVO MOTOR?

Ans.The ratio of Laplace transform of output to the laplace transform of input.

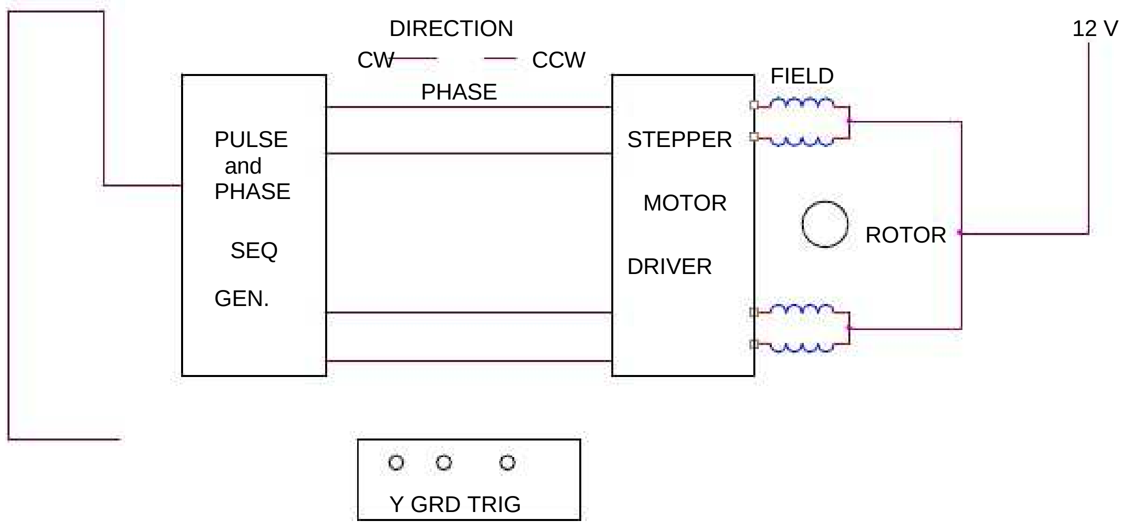
# EXPERIMENT – 2

AIM: - To study the stepper motor and to execute microprocessor computer based control of the same by changing number of steps, the direction of rotation and speed.

APPARATUS USED: - Stepper Motor Kit, µP Kit, Interface Cord and Connecting Leads.

THEORY:- The stepper motor is a special type of motor which is designed to rotate through a specific angle called step for each electrical pulse received from its control unit. It is used in digitally controlled position control system in open loop mode. The input command is in form of a train of pulses to turn the shaft through a specified angle. the main unit is designed to interface with µP 8085 kit. The stepper motor controller card remains active while the pulse sequence generator disabled as given plug is connected with µp interface socket . The following programme enables the stepper motor to run with µp 8085 kit. For two phases four winding stepper motor only four LSB signals are required.

CIRCUIT DIAGRAM:-




PROCEDURE:-
Connect the stepper motor with µp 8085 kit as shown in fig. press EXMEM key to enter the address as given then press NEXT to enter data .

ADDRESS DATA

| | | |
|---|---|---|
| 2000 | 3E 80 MVI A, 80 | Initialize port A as output port. |
| 2002 | D3 03 OUT 03 | OB |
| 2004 | 3E F9 Start MVI | AFA |
| 2006 | D3 00 OUT 00 | Output code for step o. |
| 2008 | CD 3020 call delay | delay between two steps. |

200B 3E F5 MVI A, F6 Location reserve for current Delay.
200d D3 OO OUT OO Output code for step 1.
200F CD 3020 Call delay delay between two steps.
2012 3E F6 MVI A, F5
2014 D3 OO OUT OOOutput code for step 2.
2016 CD 3020 calls delay between two steps.
2019 3E FA MVI A, F9.
201B D3 OO OUTOO Output code for step 3.
201D CD 3020 call delaydelay between two steps.
2020 C3 04 20 JMP START Start.

Press FILL key to store data in memory area. This will complete the pulse sequence generation. To delay programme route, first press EXMEM to start, a dot sign will appear in address field then enter the start address. Press NEXT to enter data.

| ADDRESS | DATA |
|---|---|
| 2030 | 11 00 00 LXI D 00 00 Generates a delay. |
| 2033 | CD BC 03 CALL DELAY |
| 2036 | 11 00 00 LXID 00 00 Generates a delay. |
| 2039 | CD BC 03 CALL DELAY |
| 203C | C9RET |

Press FILL to save data to execute the programmed press the key GO .The above programme is to rotate the motor at a particular as defined by the given address. Changing the following contents will change the motor speed.

| ADDRESS | DATA |
|---|---|
| 2030 | 11 00 20 AND 2036 TO SIMILAR 11 00 20 |
| CHANGE | 11 00 10 TO11 00 10 |
| CHANGE | 11 00 05 TO11 00 05 |
| CHANGE | 11 00 03 TO11 00 03. |

The motor direction depends upon codes FA, F6 ,F5 AND F9.Change in following codes will change the motor direction.

| ADDRESS | DATA | | |
|---|---|---|---|
| 2005 | 3E F9 | TO | 3E FA |
| 200C | 3E F5 | TO | 3E F6 |

| | | | |
|---|---|---|---|
| 2012 | 3E F6 | TO | 3E F5 |
| 2019 | 3E FA | TO | 3E F9. |

## OBSERVATION TABLE:-

| Sr No. | No. of Pulses | Displacement | Step Angle |
|---|---|---|---|
| | | | |

RESULT:- The stepper motor runs as per fed programme.

PRECAUTION:-

1. Make the connection of motor with µp kit properly.
2. Feed the programme carefully and correctly.
3. Do not change the motor direction at high speed.

QUIZ:-

Que.1.Why the application of stepper motor is increasing?
Ans. The use of stepper motor is increasing due to availability in large power rating and reducing cost.
Que.2. What is stable condition of rotor in stepper motor ?
Ans. It is that angle at which torque is zero and is positive for smaller angle and negative for larger angle.
Que.3. What are the modes of operation of stepper motor?
Ans. There are two modes of operation of stepper motor, open loop and close loop mode.
Que.4. What are the types of stepper motor?
Ans. There are three types of stepper motors, VR stepper motor, P stepper motor and hybrid stepper motor.
Que.5. How the windings of stepper motor are wound?
Ans. The windings of stepper motor are wound in such a way that there are only two phases.

Que.6. How many logics are there in each sequence?
Ans. There are two logics in each sequence, 0 and 1.
Que.7. In how many phases does the motor run?

Ans. The stepper motor runs in four phases, A,AB, B and AB.
Que.8. Why the stepper motor is run in four phases?
Ans. The stepper motor is run in four phases to avoid over stepping and to improve the response
Que.9. On what factor does the settling time of stepper motor depend?
Ans. The settling time of stepper motor depends upon loading and input sequence.
Que.10. What is use of µp kit?
Ans. The µp kit is used to run the stepper motor as per the fed programme.

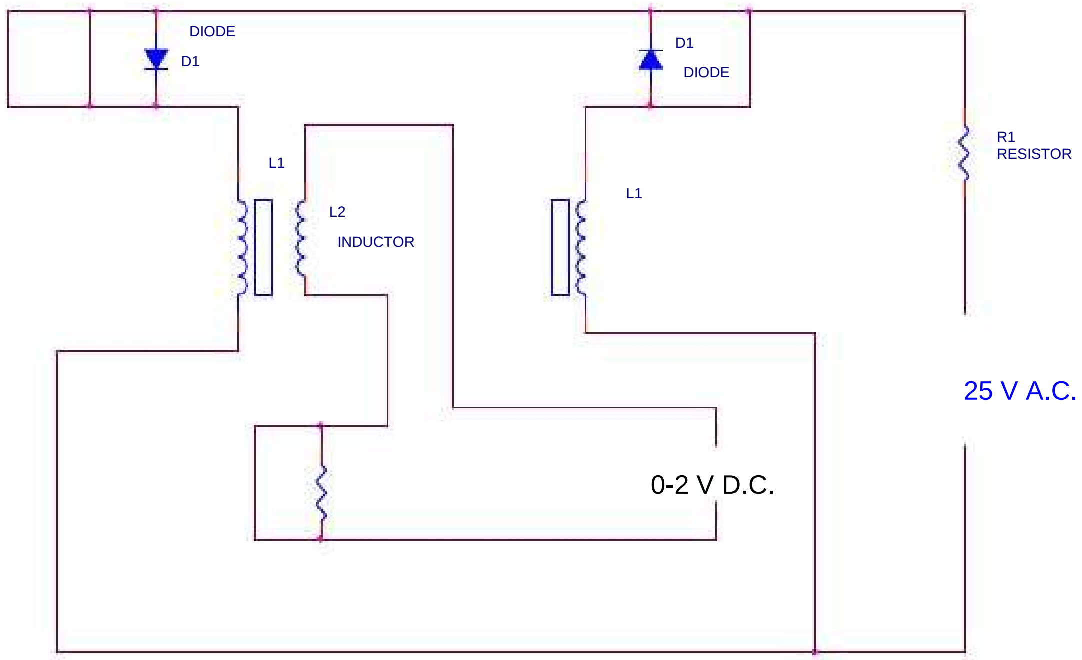
## EXPERIMENT NO:3

AIM: - To study magnetic amplifier & plot its load current (IL) V/S control current (IC). Characteristics for parallel mode.

APPARATUS REQUIRED: - Magnetic amplifier set up, digital multimeter & connecting leads.

THEORY: - Amplification is the control of larger output by variation of a smaller input. Such amplification can be performed by a magnetic device called magnetic amplifier. This set up is designed to study basic characteristics of such amplifier. To set up consists of magnetic amplified A.C & D.C power supply, to meters for load & control current & fixed value resistance of 50 ohms.

CIRCUIT DIAGRAM:-




PROCEDURE: - Connect the circuit as shown in fig. keep D.C. supply to minimum. Selects positive direction. Connect DVM across D.C. input socket. Increase the D.C. voltage slowly & note IL, IC& VC in observation & repeat the experiment. Plot the character tics curve between IL & IC in both direction. Calculate power gain = pout/pin=ΔIL*RL/Δ IC*VC.

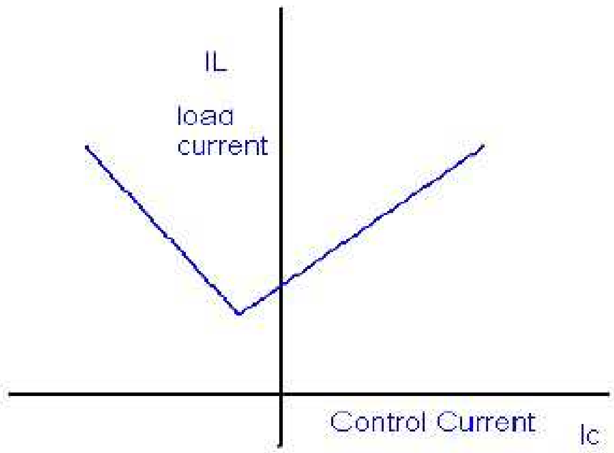
OBSERVATION TABLE:-

| SNO. | IC(mA) | IL(mA) | Vc(+ve) |
|---|---|---|---|
| | | | |
| | | | |
| | | | |
| | | | |

PRECAUTIONS:-

1. Apply voltage slowly to control winding as the coil may get heated up & burn.
2. Take the reading carefully & accurately.
3. Switch off the set up when not in use.

GRAPH:-




DISCUSSION: - The graph is plotted between control current(IC) and load current (IL)For positive polarity the control current increases linearly with load current in forward Direction but for negative polarity the control current increases load current in reverse direction. This change in direction of control current is due to change in polarity of control voltage.

QUIZ:-

Que.1. What is amplification?
Ans. Amplification is the control of a larger output quantity by the variation of a smaller input quantity.
Que.2.What is magnetic amplifier?
Ans. Magnetic amplifier is a device which amplifies a small input quantity to a large output quantity.

Que.3. What is the working principle of magnetic amplifier?
Ans. A magnetic amplifier works on the principle of linkage of induced magneto Motive Force (mmf).

Q4. What is magneto-motive force?
Ans. Magneto- motive force in a magnetic circuit is similar to EMF in an electrical Circuit.
Que.5. What is the basis of selection of core of transformer and number of turns.
Ans. The basis of selection of core of transformer and number of turns is the slope B-H loop.
Que.6. What is saturable reactor?
Ans. The saturable reactor is a specially wound transformer with three winding instead of two windings like a common transformer .
Que.7 What is drawback of a magnetic amplifier?
Ans. The main drawback of magnetic amplifier is to control small DC current a Large number of turns are required which has a greater resistance requires large DC voltage.
Que.8. How this problem is overcome in a magnetic amplifier?
Ans. This problem is overcome in a magnetic amplifier by self saturation mode.
Que.9. What is the nature of saturable reactor?
Ans. The saturable reactor is inductive nature.
Que.10. What is effect of sudden current application to control winding ?
Ans. If a sudden current is applied to the control winding the current and ampere Turns of control winding decreases slowly since it has large inductance .

## EXPERIMENT NO-4

AIM: To study magnetic amplifier and plot its load current and control current characteristics for self .

ERROR: syntaxerror
OFFENDING COMMAND: --nostringval--

STACK:

889
13742
11

# DIGITAL SYSTEM DESIGN
## (EE-326-F)

# LAB MANUAL

## VI SEMESTER

# LIST OF EXPERIMENTS

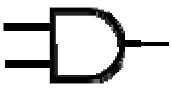
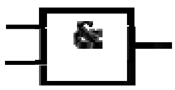
| S.NO. | NAME OF THE EXPERIMENT |
|---|---|
| **PERFORM ANY FIVE EXPERIMENT USING VHDL** | |
| 1 | Design all gates using VHDL. |
| 2 | Write VHDL programs for the following circuits, check the wave forms and the hardware generated<br>a. Half adder b. Full adder |
| 3 | Write VHDL programs for the following circuits, check the wave forms and the hardware generated<br>a. Multiplexer b. Demultiplexer |
| 4 | Write VHDL program for encoder and check the wave forms and the hardware generated. |
| 5 | Write a VHDL program for a decoder and check the wave forms and the hardware generated. |
| 6 | Write a VHDL program for a Down counter and check the wave forms and the hardware generated. |
| 7 | Write a VHDL program for a BCD to GRAY code converter and check the wave forms and the hardware generated. |
| 8 | Write a VHDL program for a T FLIP-FLOP and check the wave forms and the hardware generated. |
| **PERFORM ANY FIVE EXPERIMENT USING FPGA AND CPLD** | |
| 9 | Implement Half Adder using FPGA & CPLD. |
| 10 | Implement Full Adder using FPGA & CPLD. |
| 11 | Implement Delay Flip flop using FPGA & CPLD. |
| 12 | Implement BCD to 7 segments Decoder using FPGA& CPLD. |
| 13 | Implement an Up Counter using FPGA & CPLD. |
| 14 | Implement 1-bit Comparator using FPGA & CPLD . |
| 15 | Implement ALU using FPGA & CPLD. |

# EXPERIMENT No. 1

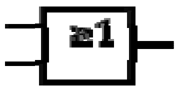
## Aim:- To Design Logic Gates using VHDL

**LOGIC GATES:**

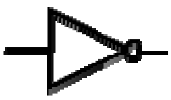
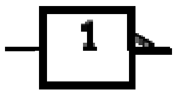
A logic gate performs a logical operation on one or more logic inputs and produces a single logic output. The logic normally performed is Boolean logic and is most commonly found in digital circuits. Logic gates are primarily implemented electronically using diodes or transistors,but can also be constructed using electromagnetic relays (relay logic), fluidic logic, pneumatic logic, optics, molecules, or even mechanical elements.

**AND**   $A \cdot B$

| INPUT | | OUTPUT |
|---|---|---|
| A | B | A AND B |
| 0 | 0 | 0 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

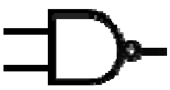
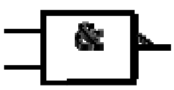
**OR**   $A + B$

| INPUT | | OUTPUT |
|---|---|---|
| A | B | A OR B |
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 1 |

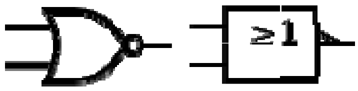
**NOT**   $\overline{A}$

| INPUT | OUTPUT |
|---|---|
| A | NOT A |
| 0 | 1 |
| 1 | 0 |

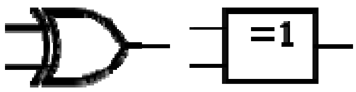
In electronics a NOT gate is more commonly called an inverter. The circle on the symbol is called a *bubble*, and is generally used in circuit diagrams to i dicate an inverted (active-low) input or output.

**NAND**   $\overline{A \cdot B}$

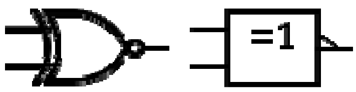
| INPUT | | OUTPUT |
|---|---|---|
| A | B | A NAND B |
| 0 | 0 | 1 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

**NOR**  $\overline{A+B}$

| INPUT | | OUTPUT |
|---|---|---|
| A | B | A NOR B |
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 0 |

**XOR**  $A \oplus B$

| INPUT | | OUTPUT |
|---|---|---|
| A | B | A XOR B |
| 0 | 0 | 0 |
| 0 | 1 | 1 |
| 1 | 0 | 1 |
| 1 | 1 | 0 |

**XNOR**  $\overline{A \oplus B}$ or $A \odot B$

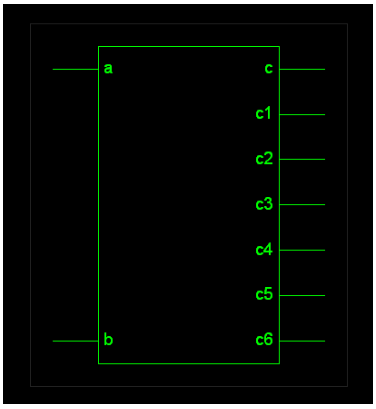
| INPUT | | OUTPUT |
|---|---|---|
| A | B | A XNOR B |
| 0 | 0 | 1 |
| 0 | 1 | 0 |
| 1 | 0 | 0 |
| 1 | 1 | 1 |

**Program:**

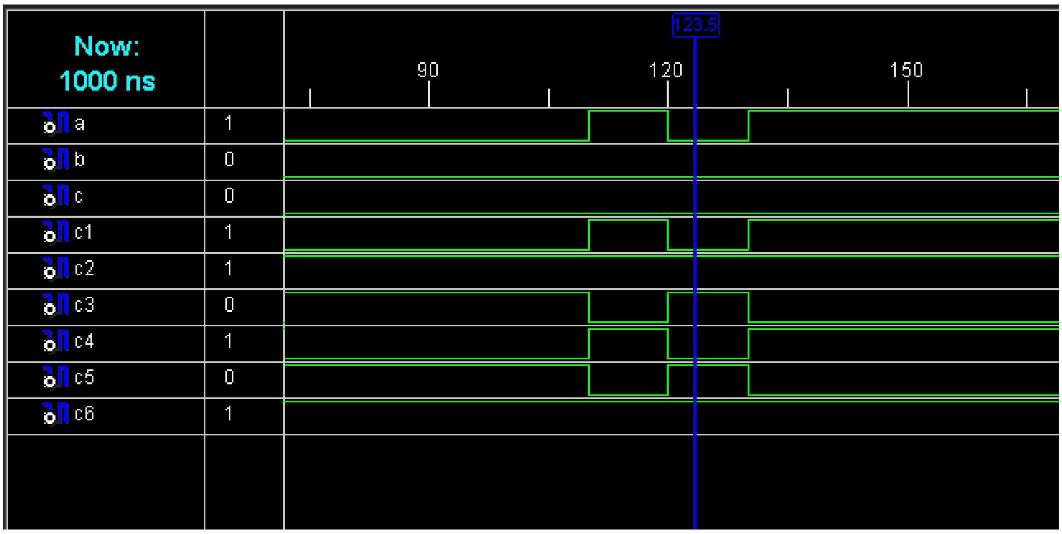
```
--------------------------------------------------------------------------------
library IEEE;
use  IEEE.STD_LOGIC_1164.ALL;
use  IEEE.STD_LOGIC_ARITH.ALL;
use  IEEE.STD_LOGIC_UNSIGNED.ALL;

entity all_ga is
   Port ( a : in  STD_LOGIC;
          b : in  STD_LOGIC;
          c : out  STD_LOGIC;
          c1 : out  STD_LOGIC;
          c2 : out  STD_LOGIC;
          c3 : out  STD_LOGIC;
          c4 : out  STD_LOGIC;
          c5 : out  STD_LOGIC;
          c6 : out  STD_LOGIC);
end all_ga;

architecture Behavioral of all_ga is

begin
c  <= a and b;
c1 <= a or b;
c2 <= a nand b;
c3 <= a nor b;
c4 <= a xor b;
c5 <= a xnor b;
c6 <= not b;

end Behavioral;
```

**OUTPUT:**

RTL View



Simulation Waveform




**Quiz Questions with answer.**

Q.1What is VHDL?
Ans. VHDL is the VHSIC Hardware Description Language. VHSIC is an abbreviation for Very High Speed Integrated Circuit.
Q.2How many truth table entries are necessary for a four-input circuit?
Ans.16
Q.3What input values will cause an AND logic gate to produce a HIGH output?
Ans. All inputs of AND gate must be HIGH.
Q.4 Name all the basic gates.
Ans. i) AND ii) OR iii) NOT
Q.5 Name all the universal gates.
Ans .i) NAND ii) NOR
Q.6 What is the full form of IEEE?
Ans Institute of Electrical and Electronic Engineering.
Q7. What is the full form of ASCII?
Ans. American Standard Code for information Interchange.
Q8. Define Entity.
Ans. It is an external view of a design unit.
Q9. Why NAND and NOR are called universal gates?
Ans. Because all the basic gates can be derive from them.
Q10. How many architectures are present in VHDL.
Ans. 4, behavior, dataflow, structural and mixed.

# EXPERIMENT No. 2 (A)

## Aim:- To Design a Half Adder using VHDL

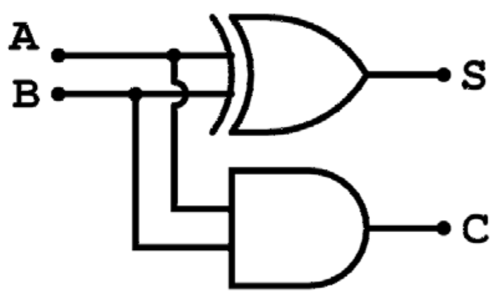
**Half adder**

A **half adder** is a logical circuit that performs an addition operation on two one-bit binary numbers often written as *A* and *B*.
The half adder output is a sum of the two inputs usually represented with the signals $C_{out}$ and *S* where

$$sum = 2 \times C_{out} + S.$$

Following is the logic table and circuit diagram for half adder:

| Inputs | | Outputs | |
|---|---|---|---|
| ***A*** | ***B*** | ***C*** | ***S*** |
| 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 1 |
| 1 | 0 | 0 | 1 |
| 1 | 1 | 1 | 0 |

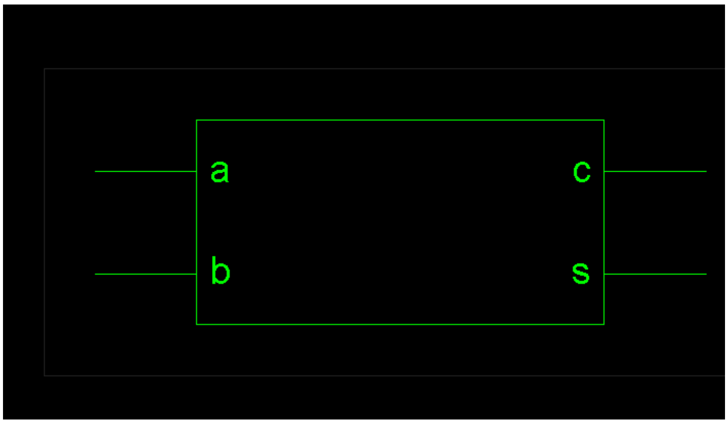


## Program:

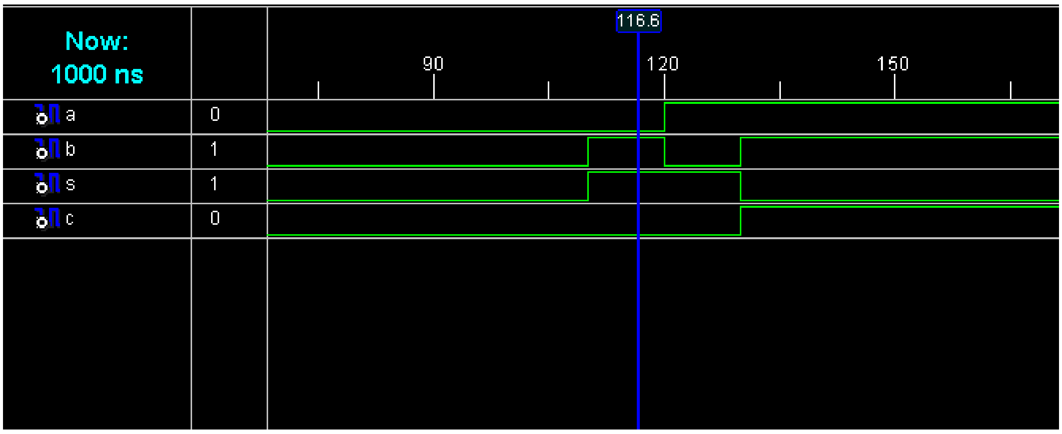
```
--------------------------------------------------------------------------------
library IEEE;
use IEEE.STD_LOGIC_1164.ALL;
use IEEE.STD_LOGIC_ARITH.ALL;
use IEEE.STD_LOGIC_UNSIGNED.ALL;

---- Uncomment the following library declaration if instantiating
---- any Xilinx primitives in this code.
--library UNISIM;
--use UNISIM.VComponents.all;

entity ha is
    Port ( a : in  STD_LOGIC;
           b : in  STD_LOGIC;
           s : out  STD_LOGIC;
           c : out  STD_LOGIC);
end ha;

architecture Behavioral of ha is
begin
s <= a xor b;
c <= a and b;
end Behavioral;
```

## OUTPUT:

RTL View



Simulation Waveform



# EXPERIMENT No. 2 (B)

## Aim:- To Design a Full Adder using VHD

### Full adder

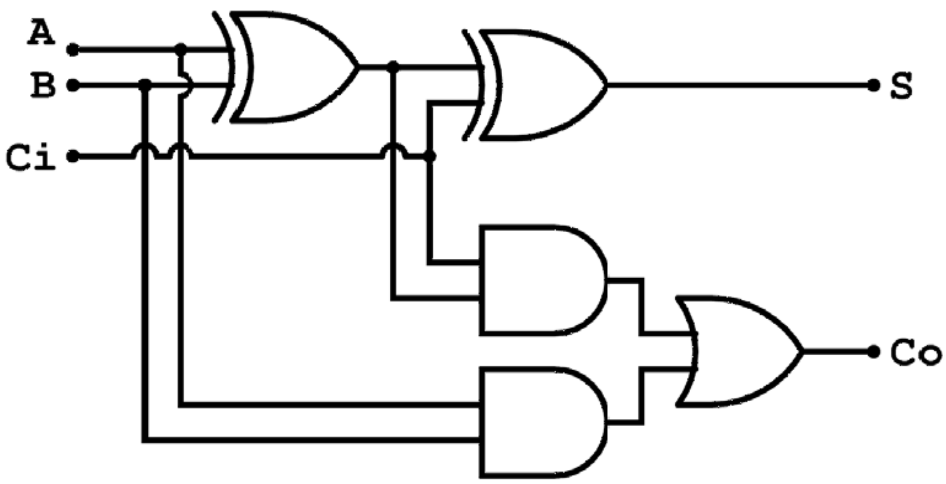
A **full adder** is a logical circuit that performs an addition operation on three one-bit binary numbers often written as *A*, *B*, and $C_{in}$. The full adder produces a two-bit outp t sum typically represented with the signals $C_{out}$ and *S* where

$$sum = 2 \times C_{out} + S.$$

The full adder's truth table is:

Truth Table:

| Inputs | | | Outputs | |
|---|---|---|---|---|
| ***A*** | ***B*** | $C_i$ | $C_o$ | ***S*** |
| 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 1 |
| 0 | 1 | 0 | 0 | 1 |
| 1 | 1 | 0 | 1 | 0 |
| 0 | 0 | 1 | 0 | 1 |
| 1 | 0 | 1 | 1 | 0 |
| 0 | 1 | 1 | 1 | 0 |
| 1 | 1 | 1 | 1 | 1 |

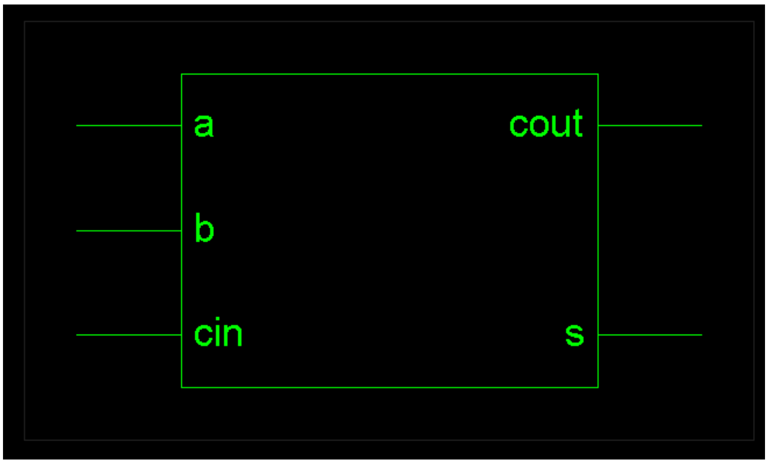


**Program:**

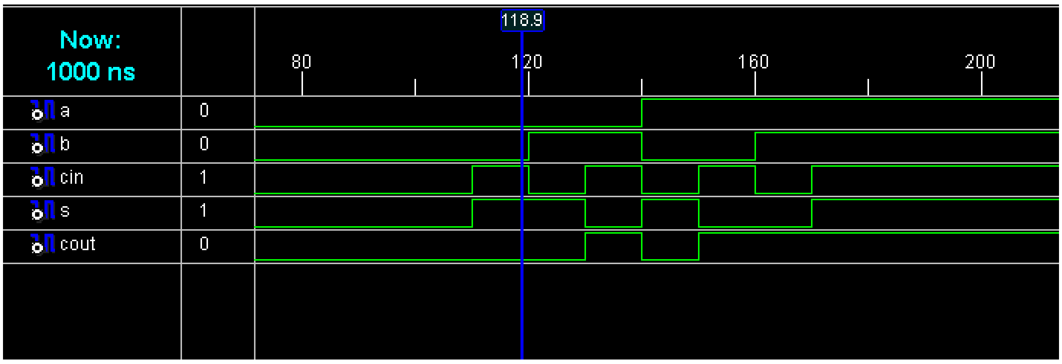
```
--------------------------------------------------------------------------------
library IEEE;
use  IEEE.STD_LOGIC_1164.ALL;
use  IEEE.STD_LOGIC_ARITH.ALL;
use  IEEE.STD_LOGIC_UNSIGNED.ALL;

---- Uncomment the following library declaration if instantiating
---- any Xilinx primitives in this code.
--library UNISIM;
--use  UNISIM.VComponents.all;

entity fa is
   Port ( a : in  STD_LOGIC;
          b : in  STD_LOGIC;
          cin : in  STD_LOGIC;
           s : out  STD_LOGIC;
          cout : out  STD_LOGIC);
end fa;

architecture Behavioral of fa is

begin
s <= (a xor b) xor cin;
cout <= (a and b) or (b and cin) or (a and cin);

end Behavioral;
```

**OUTPUT:**

RTL View



Simulation Waveform




## Quiz Questions with answer.

**Q.**1 Who is the father of **VHDL**?

Ans. John Hines, Wright Patterson AFB, Daton Ohio.

Q.2 What is a test bench in **vhdl**?

Ans.A Test Bench in VHDL is code written in VHDL that provides stimulus for individual modules (also written in VHDL). Individual modules are instantiated by a single line of code showing the port.

Q.3How many inputs and output are used in Full adder?

Ans. Three inputs and two output.

Q.4 What are the advantages of designing?

Ans. Advantages of Designing:

1. Designing is useful in quick implementation, testing and useful in complex circuits.

2. Designing reduces the design cycle.

Q.5 Why HDL is used?

Ans.HDL is used because it is easy to design, implement, test and document increasingly complex digital system.

Q6. How many types of architecture in VHDL?

Ans: 4

Q7. What is the difference between sequential and combinational ckts.?

Ans: Seq ckts have memory cell inside it and combinational has no memory in it.

Q8. Is it possible to construct full adder using half adder?

Ans: Yes, by using two half adders.

Q9. How many i/ps required for half subtractor?

Ans: Two, difference and a borrow.

Q10. Is it possible to construct full subtractor using half subtractor?

Ans: Yes, by using two half subtractor.

# EXPERIMENT No. 3(A)

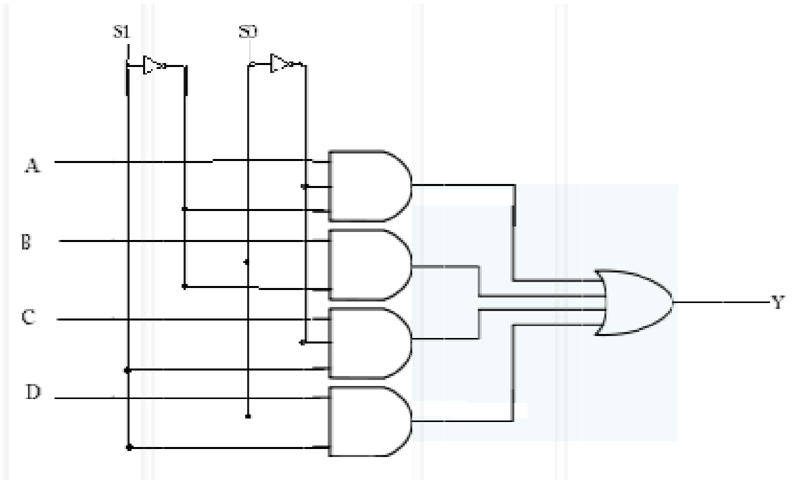
## Aim:- To Design a Multiplexer using VHDL

### Multiplexer

In digital circuit design, the selector wires are of digital value. In the case of a 2-to-1 multiplexer, a logic value of 0 would connect $I_0$ to the output while a logic value of 1 would connect $I_1$ to the output. In larger multiplexers, the number of selector pins is equa to $\lceil \log_2(n) \rceil$ where $n$ is the number of inputs.

A 4-to-1 multiplexer has a boolean equation where A, B, C and D are the two inputs, $S$1and S0 are the select lines, and Y is the output:

| S1 | S0 | Y |
|---|---|---|
| 0 | 0 | A |
| 0 | 1 | B |
| 1 | 0 | C |
| 1 | 1 | D |

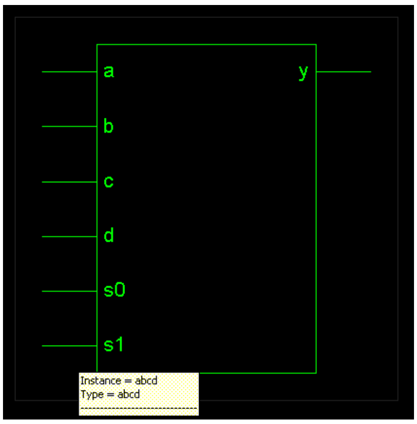


**Program:**

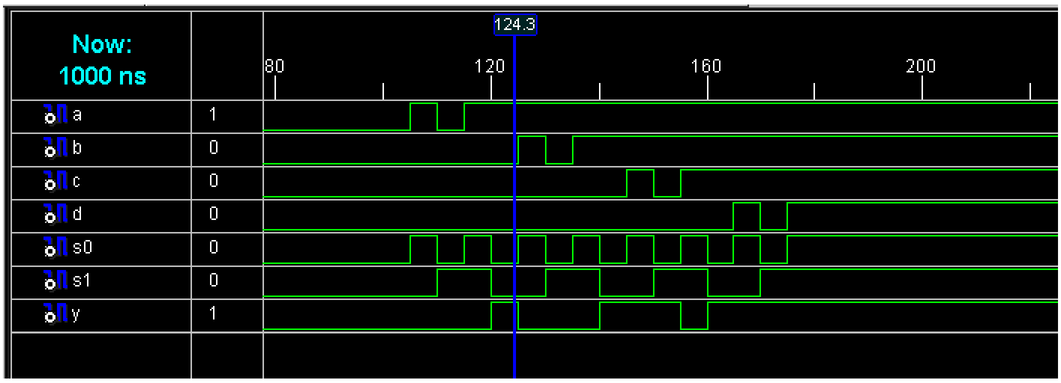
```
library IEEE;
use  IEEE.STD_LOGIC_1164.ALL;
use  IEEE.STD_LOGIC_ARITH.ALL;
use  IEEE.STD_LOGIC_UNSIGNED.ALL;

---- Uncomment the following library declaration if instantiating
---- any Xilinx primitives in this code.
--library UNISIM;
--use  UNISIM.VComponents.all;

entity abcd is
    Port ( a : in  STD_LOGIC;
           b : in  STD_LOGIC; c
           : in  STD_LOGIC;
           d : in  STD_LOGIC;
           s0 : in  STD_LOGIC;
           s1 : in  STD_LOGIC;
           y : out  STD_LOGIC);
end abcd;

architecture Behavioral of abcd is

begin
y <= a when s0 ='0' and s1 = '0' else
b when s0 ='0' and s1 = '1' else
c when s0 ='1' and s1 = '0' else
d;

end Behavioral;
```

**OUTPUT:**

RTL View



Simulation Waveform



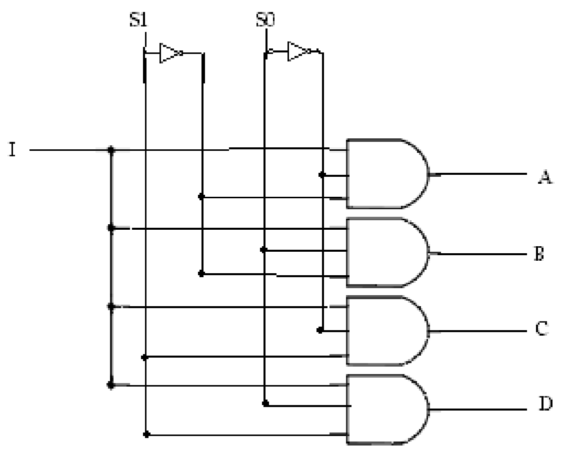
# EXPERIMENT No. 3 (B)

## Aim:- To Design a Demultiplexer using VHDL

**Demultiplexer**

Demultiplexers take one data input and a number of selection inputs, and they have several outputs. They forward the data input to one of the outputs depending on the values of the selection inputs. Demultiplexers are sometimes convenient for designing general purpose logic, because if the demultiplexer's input is always true, the demultiplexer acts as a decoder.

| I | S1 | S0 | ABCD |
|---|---|---|---|
| 0 | X | X | 0000 |
| 1 | 0 | 0 | 1000 |
| 1 | 0 | 1 | 0100 |
| 1 | 1 | 0 | 0010 |
| 1 | 1 | 1 | 0001 |

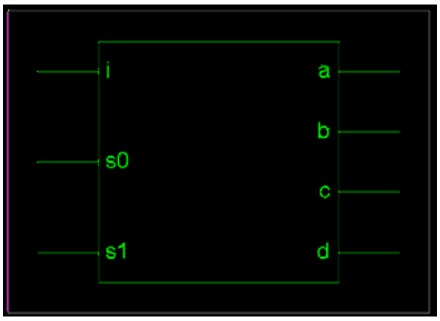


**Program:**

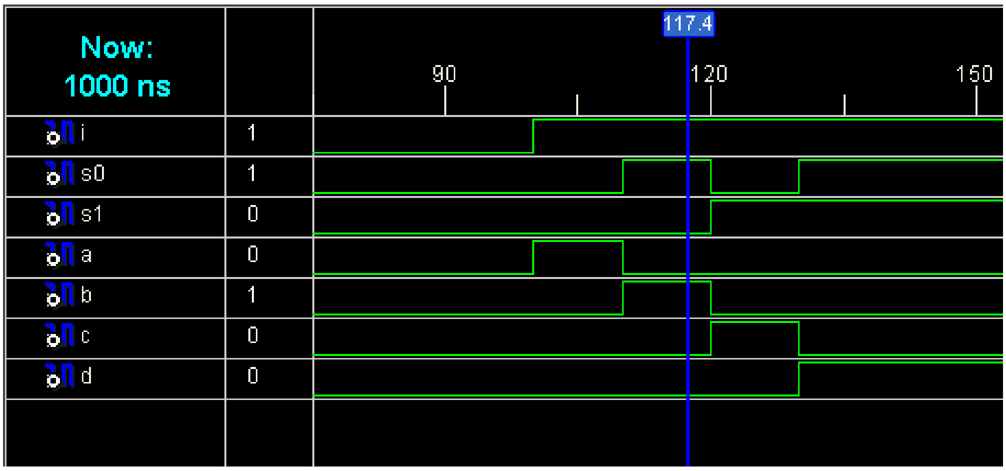
```
library IEEE;
use  IEEE.STD_LOGIC_1164.ALL;
use  IEEE.STD_LOGIC_ARITH.ALL;
use  IEEE.STD_LOGIC_UNSIGNED.ALL;

entity dm is
   Port ( i : in STD_LOGIC;
          s0  :  in  STD_LOGIC;
          s1 : in  STD_LOGIC;
          a  :  out   STD_LOGIC;
          b  :  out   STD_LOGIC;
          c  :  out   STD_LOGIC;
          d : out  STD_LOGIC);
end dm;

architecture Behavioral of dm is
signal p,q : STD_LOGIC;
begin
p <= not s0;
q <= not s1;

a<= i and p and q;
b<= i and q and s0;
c<= i and p and s1;
d<= i and s1 and s0;

end Behavioral;
```

**OUTPUT:**

RTL View



Simulation Waveform




## Quiz Questions with answer.

Q.1 Name combinational logic circuit which sends data coming from a single source to two or more separate destinations.

Ans: Demultiplexer

Q.2 What is the another name of Multiplexer.

Ans. Data Selector.

Q.3 How many control lines will be used for a 8 – to – 1 multiplexer?

Ans. The number of control lines for an 8 to 1 Multiplexer is 3.

Q.4 Which device changes serial data to parallel data .

Ans. The device which changes from serial data to parallel data is demultiplexer.

Q.5 How many select lines will a 16 to 1 multiplexer will have?

Ans. 4

Q6. Is it possible to construct 4:1 mux using two 2:1 mux?

Ans. Yes

Q7. How many outputs are there in 1:8 mux?

Ans 8.

Q8: What is the difference between sequential and combinational ckts.?

Ans: Seq ckts have memory cell inside it and combinational has no memory in it.

Q9: What is the function of select line in mux?

Ans It selects the particular input to go on output.

A10: What is the function of enable pin?

Ans: It enables the IC.

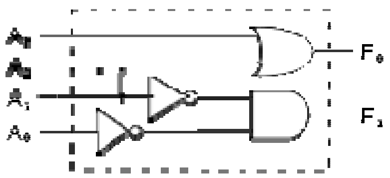
# EXPERIMENT No. 4

## Aim:- To Design an Encoder using VHDL

**Encoder** :

An **encoder** is a device, circuit, transducer, software program, algorithm or person that converts information from one format or code to another, for the purposes of standardization, speed, secrecy, security, or saving space by shrinking size.

| A3 | A2 | A1 | A0 | F1 | F0 |
|---|---|---|---|---|---|
| 0 | 0 | 0 | 1 | 0 | 0 |
| 0 | 0 | 1 | 0 | 0 | 1 |
| 0 | 1 | 0 | 0 | 1 | 0 |
| 1 | 0 | 0 | 0 | 1 | 1 |

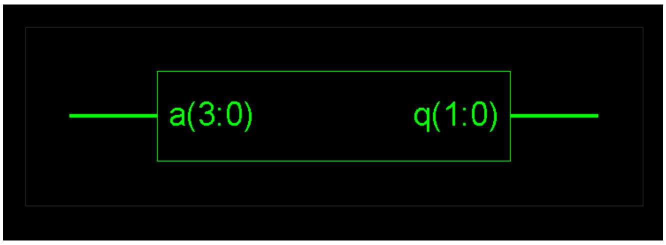


**Program:**

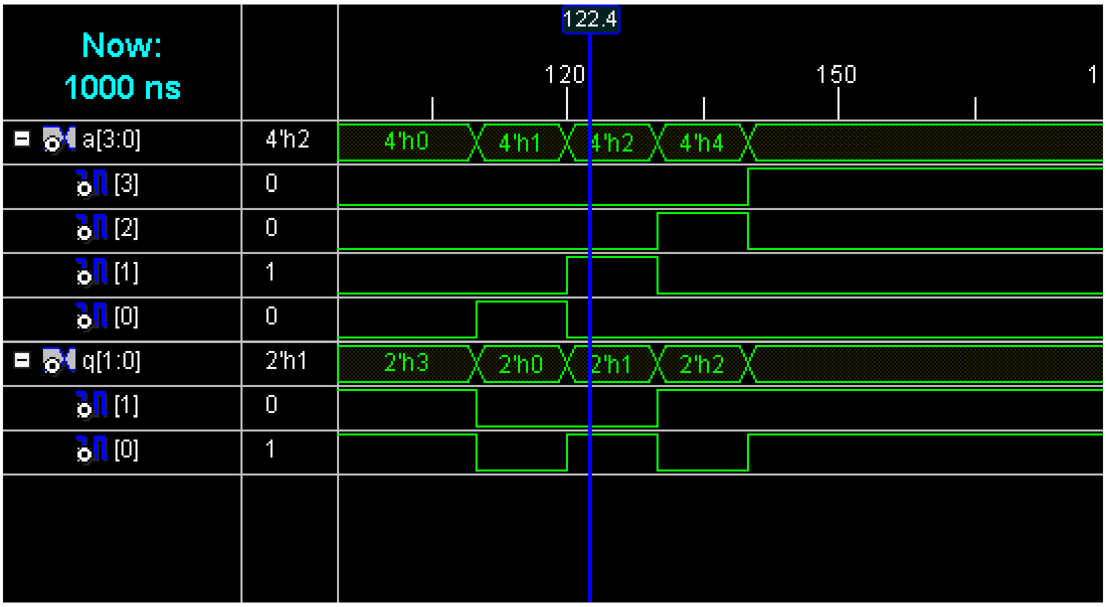
```
--------------------------------------------------------------------------------
library IEEE;
use  IEEE.STD_LOGIC_1164.ALL;
use  IEEE.STD_LOGIC_ARITH.ALL;
use  IEEE.STD_LOGIC_UNSIGNED.ALL;

entity encod1 is
    Port ( a : in  STD_LOGIC_VECTOR (3 downto 0);
           q : out  STD_LOGIC_VECTOR (1 downto 0));
end encod1;

architecture Behavioral of encod1 is

begin
q<="00" when a="0001" else
   "01" when a="0010" else
   "10" when a="0100" else
   "11";


end Behavioral;
```

**OUTPUT:**

RTL View



Simulation Waveform of Encoder




## Quiz Questions with answer.

Q.1 Name the examples of combinational logic circuits.

Ans. Examples of common combinational logic circuits include: half adders, full adders, multiplexers, demultiplexers, encoders and decoders.

Q.2 What do you mean by Digital Encoder?

Ans. Digital Encoder is a combinational circuit that generates a specific code at its outputs such as binary or BCD in response to one or more active inputs.

Q.3 How many encoder are there in Digital Electronics?

Ans. There are two main types of digital encoder. The Binary Encoder and the Priority Encoder.

Q.4 What is Combinational Logic?

Ans. Combinational Logic: A logic circuit in which the outputs are a function of the inputs. At any time, if you know the inputs, you can determine the outputs.

Q.5 What is stable state?

Ans. Stable State: An internal or external signal maintains a constant magnitude (or specified range or function) for a period of time determined by external input signals.

Q6. Write the applications of Encoder and decoder.

Ans: They are used in communication systems.

Q7: Name some encoders.

Ans Priority encoder , 4:2 encoder and etc.

Q8: How many i/ps are in 4:2 encoder?

Ans 4 i/ps and 2 o/ps.

Q9: How many select lines are present in 2:4 decoder?

Ans none.

# EXPERIMENT No. 5

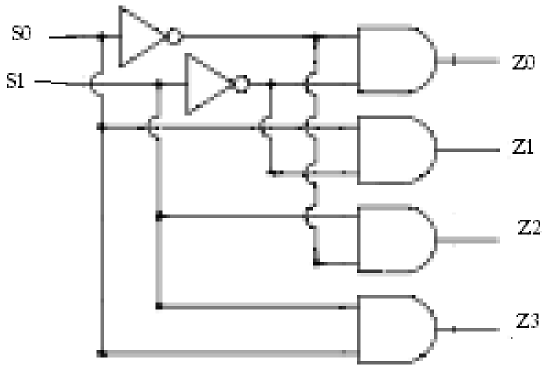
## Aim:- To Design a 2 to 4 Line Decoder using VHDL

**Decoder:**

A **decoder** is a device which does the reverse of an encoder, undoing the encoding so that the original information can be retrieved. The same method used to encode is usually just reversed in order to decode.

In digital electronics, a decoder can take the form of a multiple-input, multiple-output logic circuit that converts coded inputs into coded outputs, where the input and output codes are different.Decoding is necessary in applications such as data multiplexing, 7 segment display and memory address decoding.

| EN | S1 | S0 | Z0 | Z1 | Z2 | Z3 |
|---|---|---|---|---|---|---|
| 0 | X | X | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 1 | 0 | 0 | 0 |
| 1 | 0 | 1 | 0 | 1 | 0 | 0 |
| 1 | 1 | 0 | 0 | 0 | 1 | 0 |
| 1 | 1 | 1 | 0 | 0 | 0 | 1 |



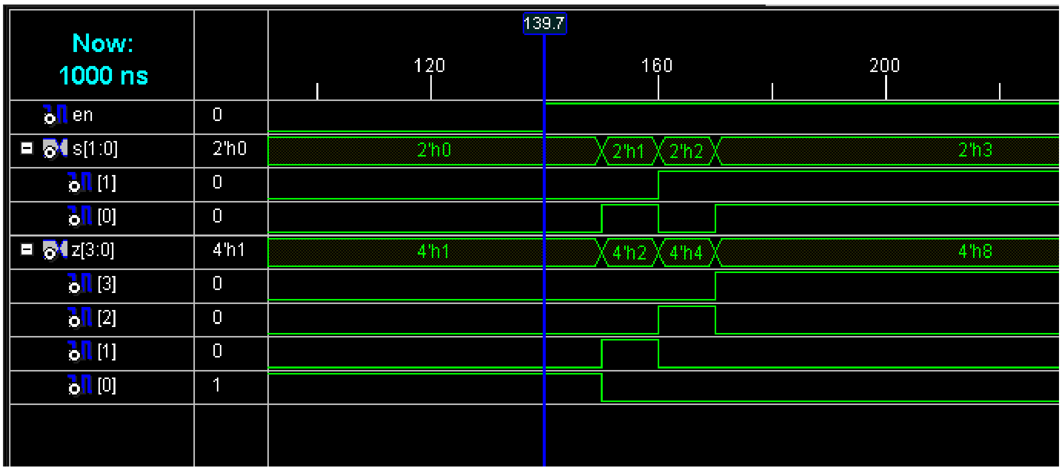
**Program:**

```
library IEEE;
use  IEEE.STD_LOGIC_1164.ALL;
use  IEEE.STD_LOGIC_ARITH.ALL;
use  IEEE.STD_LOGIC_UNSIGNED.ALL;

--library UNISIM;
--use  UNISIM.VComponents.all;

entity decoder is
   Port ( en : in  STD_LOGIC;
          s : in  STD_LOGIC_VECTOR (1 downto 0);
          z : out  STD_LOGIC_VECTOR (3 downto 0));
end decoder;

architecture arch of decoder is
signal p,q : STD_Logic; begin
p <= not s(1);
q <= not s(0);

z(0) <= p and q;
z(1) <= p and s(0);
z(2) <= q and s(1);
z(3) <= s(0) and s(1);

end arch;
```

**OUTPUT:**

RTL View

Simulation Waveform




# Quiz Questions with answer.

Q.1 Name the examples of combinational logic circuits.

Ans. Examples of common combinational logic circuits include: half adders, full adders, multiplexers, demultiplexers, encoders and decoders.

Q.2 How many two-input AND and OR gates are required to realize Y=CD+EF+G ?

Ans Y=CD+EF+G

Number of two input AND gates=2

Number of two input OR gates = 2

One OR gate to OR CD and EF and next to OR of G & output of first OR gate.

Q.3 Which device converts BCD to Seven Segment ?

Ans. A device which converts BCD to Seven Segment is called DECODER.

Q.4 What is a testbench in **vhdl**?

Ans. A Test Bench in VHDL is code written in VHDL that provides stimulus for individual modules (also written in VHDL). Individual modules are instantiated by a single line of code showing the port.

Q.5 What are the advantages of designing?

Ans. Advantages of Designing:

1. Designing is useful in quick implementation, testing and useful in complex circuits.
2. Designing reduces the design cycle.

Q6: Write the applications of Encoder and decoder.

Ans: They are used in communication systems.

Q7: Name some encoders.

Ans Priority encoder , 4:2 encoder and etc.

Q8: How many i/ps are in 4:2 encoder?

Ans 4 i/ps and 2 o/ps.

Q9: How many select lines are present in 2:4 decoder?

Ans none.

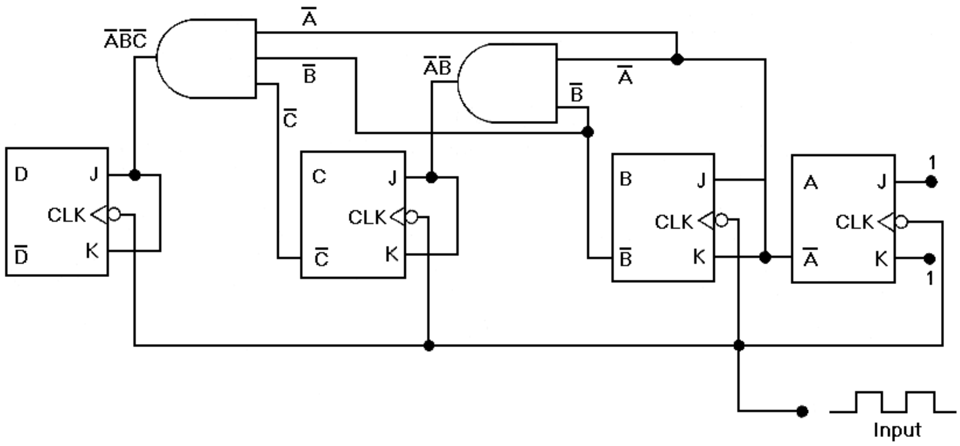
# EXPERIMENT No. 6

## Aim:- To Design a Down Counter using VHDL.

**Down Counter:**

In a binary up counter, a particular bit, except for the first bit, toggles if all the lower-order bits are 1's. The opposite is true for binary down counters. That is, a particular bit toggles if all the lower-order bits are 0's and the first bit toggles on every pulse.

Taking an example, $A_4$ $A_3$ $A_2$ $A_1$ = 0100. On the next count, $A_4$ $A_3$ $A_2$ $A_1$ = 0011. $A_1$, the lowest-order bit, is always complemented. $A_2$ is complemented because all the lower-order positions ($A_1$ only in this case) are 0's. $A_3$ is also complemented because all the lower-order positions, $A_2$ and $A_1$ are 0's. But $A_4$ is not complemented the lower-order positions, $A_3$ $A_2$ $A_1$ = 011, do not give an all 0 condition.

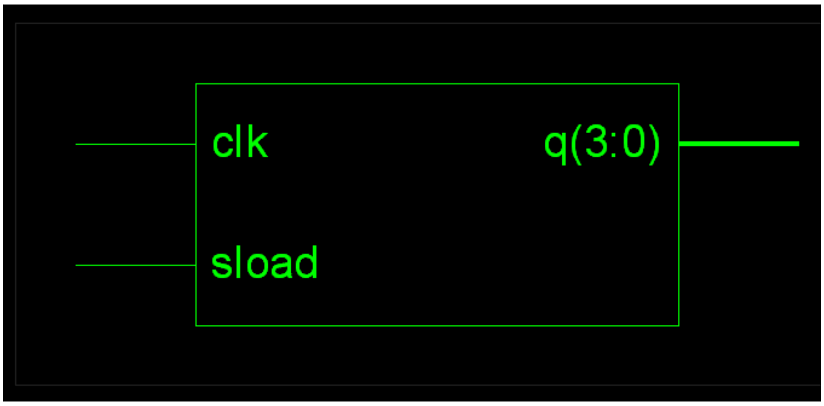


**Program:**

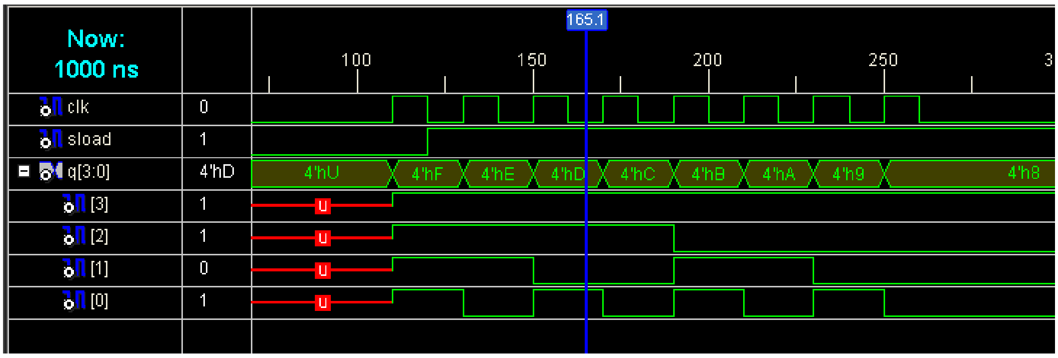
```
library IEEE;
use  IEEE.STD_LOGIC_1164.ALL;
use  IEEE.STD_LOGIC_ARITH.ALL;
use  IEEE.STD_LOGIC_UNSIGNED.ALL;

---- Uncomment the following library declaration if instantiating
---- any Xilinx primitives in this code.
--library UNISIM;
--use  UNISIM.VComponents.all;

entity up_counter is
   Port ( clk : in  STD_LOGIC;
          sload : in  STD_LOGIC;
          q : out  STD_LOGIC_VECTOR (3 downto 0));
end up_counter;

architecture Behavioral of up_counter is
signal tmp : std_logic_vector(3 downto 0);
begin
process(clk)
begin
if(clk' event and clk = '1') then
            if sload = '0' then
                        tmp <= "1111";
             else tmp <= tmp -1;

             end if;
             end if;
end process;
            q <= tmp;

end Behavioral;
```

**OUTPUT:**

RTL View




Simulation Waveform




## Quiz Questions with answer.

Q.1 What is sequential logic?

Ans. Sequential Logic: A logic circuit in which the outputs are a function of the present, and past inputs. The memory of past inputs involves the "state" of the system. At any time, if you know the present inputs, and state of the circuit, you can determine the outputs.

Q.2 How many Flip-Flops are required for mod–16 counter?

Ans. The number of flip-flops is required for Mod-16 Counter is 4.

Q.3 A 4-bit synchronous counter uses flip-flops with propagation delay times of 15 ns each. How much maximum possible time required for change of state?

Ans. 15 ns because in synchronous counter all the flip-flops change state at the same time.

Q.4 How many flip flops are required to construct a decade counter?

Ans. Decade counter counts 10 states from 0 to 9 ( i.e. from 0000 to 1001 ) .Thus four Flip Flop's are required.

Q.5 How many flip-flops are required to construct mod 30 counter?

Ans 5

Q6: What is a flip flop?

Ans. It is memory element which stores previous data.

Q7: What is the function of clock in counter ckt?

Ans: It synchronize the operation of flip flops in counter ckt.

Q8: What is the maximum count for decade counter?

Ans. From 0 to 9.

Q9: What is down counter?

Ans. When the qbar signal of previous ff is connected to clock of next ff.

Q10. What is the count for decade down counter?

Ans. From 9 to 0.

# EXPERIMENT No. 7

## Aim:- To Design a BCD to GRAY converter using VHDL

**BCD to GRAY Converter:**

It is a digital circuit that converts BCD numbers into Gray codes.

```
2-bit Gray code

00
01
11
10
```

```
3-bit Gray code

000
001
011
010
110
111
101
100
```

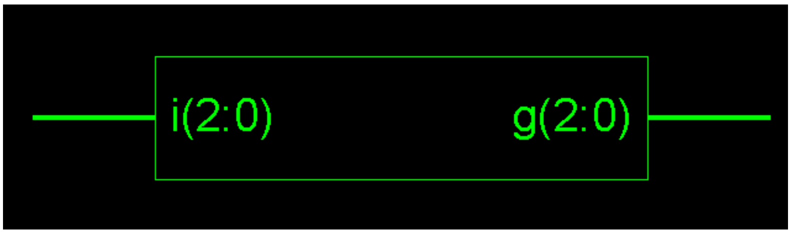
```
4-bit Gray code

0000
0001
0011
0010
0110
0111
0101
0100
1100
1101
1111
1110
1010
1011
1001
1000
```

**Program:**

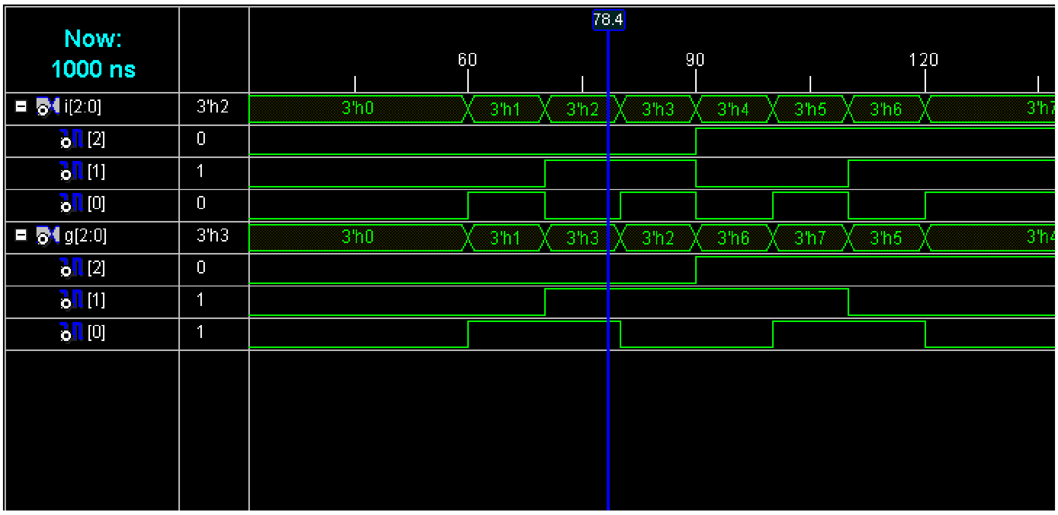
```
--------------------------------------------------------------------------------
library IEEE;
use  IEEE.STD_LOGIC_1164.ALL;
use  IEEE.STD_LOGIC_ARITH.ALL;
use  IEEE.STD_LOGIC_UNSIGNED.ALL;

---- Uncomment the following library declaration if instantiating
---- any Xilinx primitives in this code.
--library UNISIM;
--use  UNISIM.VComponents.all;

entity bg is
   Port ( i : in  STD_LOGIC_VECTOR (2 downto 0);
          g : out  STD_LOGIC_VECTOR (2 downto 0));
end bg;

architecture Behavioral of bg is

begin
process(i)
begin
case i is

when "000" => g <= "000";
when "001" => g <= "001";
when "010" => g <= "011";
when "011" => g <= "010";
when "100" => g <= "110";
when "101" => g <= "111";
when "110" => g <= "101";
when others => g <= "100";

end case;

end process;

end Behavioral;
```

.

**OUTPUT:**RTL View




Simulation Waveform




## Quiz Questions with answer.

Q.1 What is VHDL?

Ans. VHDL is the VHSIC Hardware Description Language. VHSIC is an abbreviation for Very High Speed Integrated Circuit.

Q.2 How many truth table entries are necessary for a four-input circuit?

Ans. 16

Q.3 How many bits are there in BCD code?

Ans. 4

Q.4 What is Combinational Logic?

Ans. Combinational Logic: A logic circuit in which the outputs are a function of the inputs. At any time, if you know the inputs, you can determine the outputs.

Q.5 What is stable state?

Ans. Stable State: An internal or external signal maintains a constant magnitude (or specified range or function) for a period of time determined by external input signals.

Q6. What is BCD to Gray converter?

Ans: The converter which converts bcd code into gray code.

Q7: What is the application of above code converter?

Ans We use in communication systems.

Q8. BCD to Gray converter is a combinational or sequential ckt?

Ans. Combinational ckt.

Q9: Write down the method of Binary to Gray conversion.

Ans: Using the Ex-Or gates

Q10: Convert 0101 to Decimal.

Ans; 5

# EXPERIMENT No. 8

## Aim:- To Design a Toggle Flip Flop using VHDL.

**T(Toggle) Flip Flop:**

If the T input is high, the T flip-flop changes state ("toggles") whenever the clock input is strobed. If the T input is low, the flip-flop holds the previous value. This behavior is described by the characteristic equation:

$$Q_{next} = T \oplus Q = T\overline{Q} + \overline{T}Q$$

| **T Flip-Flop operation** | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **Characteristic table** | | | | **Excitation table** | | | | |
| ***T*** | ***Q*** | ***$Q_{next}$*** | **Comment** | ***Q*** | ***$Q_{next}$*** | ***T*** | **Comment** | |
| 0 | 0 | 0 | hold state (no clk) | 0 | 0 | 0 | No change | |
| 0 | 1 | 1 | hold state (no clk) | 1 | 1 | 0 | No change | |
| 1 | 0 | 1 | Toggle | 0 | 1 | 1 | Complement | |
| 1 | 1 | 0 | Toggle | 1 | 0 | 1 | Complement | |

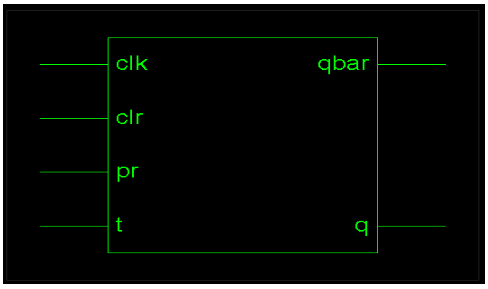
**Program:**

```
--------------------------------------------------------------------------------
library IEEE;
use  IEEE.STD_LOGIC_1164.ALL;
use  IEEE.STD_LOGIC_ARITH.ALL;
use  IEEE.STD_LOGIC_UNSIGNED.ALL;

---- Uncomment the following library declaration if instantiating
---- any Xilinx primitives in this code.
--library UNISIM;
--use  UNISIM.VComponents.all;

entity t_ff is
   Port ( pr : in  STD_LOGIC;
          clr : in  STD_LOGIC;
          clk : in  STD_LOGIC;
          t : in  STD_LOGIC;
          q : inout  STD_LOGIC;
          qbar : out  STD_LOGIC);
end t_ff;

architecture Behavioral of t_ff is
begin
process(clk,clr,pr)
begin
if( pr='0' and clr ='1') then
q <= '1';
elsif ( pr ='1' and clr ='0') then
q <='0';
elsif(pr = '1' and clr ='1' and clk = '0' and clk' event)then
q <= (not t and q) or (not q and t);
end if;
end process;
qbar <= not q;

end Behavioral;
```

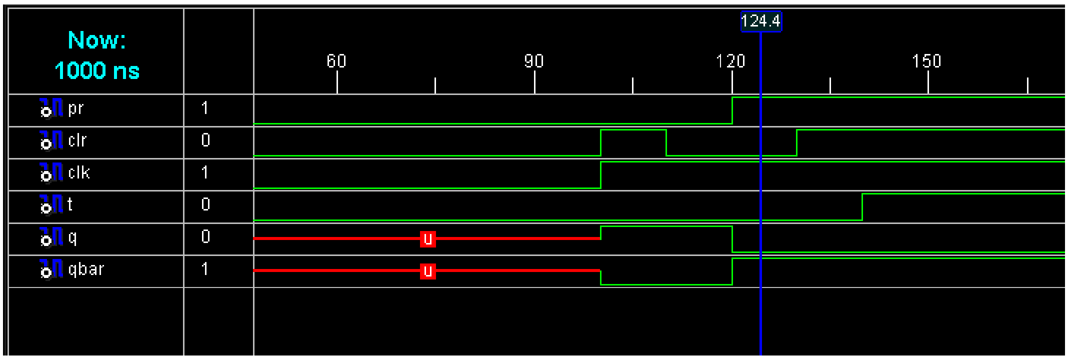
**OUTPUT:**

RTL View

.




Simulation Waveform




## Quiz Questions with answer.

Q.1 Define flip-flop.
Ans. A flip-flop is a device that can maintain binary information until it is directed by an input signal to change its state. There are several different types of flip-flops, the more commonly used are the D-FF and the JK-FF. Flip-flops are used in sequential circuit design.
Q. 2The MSI chip 7474 is
Ans. MSI chip 7474 dual edge triggered D Flip-Flop.
Q. 3 How many flip-flops are required to construct mod 30 counter?
Ans 5
Q.4The output of SR flip flop when S=1, R=0 is
Ans As for the SR flip-flop S=set input R=reset input ,when S=1, R=0, Flip-flop will be set.
Q.5 The number of flip flops contained in IC 7490 is
Ans 2.
Q6 What are the I/Ps of JK flip–flop where this race round condition occurs?
Ans; .Both the inputs are 1
Q7: .Flip flop is astable or bistable?
Ans Bistable.
Q8: When RS flip-flop is said to be in a SET state?
Ans. When the output is 1
Q9: What is the function of clock signal in flip-flop?

Ans. To get the output at known time.

Q10: What is the advantage of JK flip-flop over RS flip-flop?
Ans. In RS flip-flop when both the inputs are 1 output is undetermined.

# EXPERIMENT No. 9

**Aim:-Implement Half Adder using FPGA & CPLD.**

**Program:**

```
--------------------------------------------------------------------------------
library IEEE;
use  IEEE.STD_LOGIC_1164.ALL;
use  IEEE.STD_LOGIC_ARITH.ALL;
use  IEEE.STD_LOGIC_UNSIGNED.ALL;

---- Uncomment the following library declaration if instantiating
---- any Xilinx primitives in this code.
--library UNISIM;
--use  UNISIM.VComponents.all;

entity ha is
   Port ( a : in  STD_LOGIC;
          b : in  STD_LOGIC;
          s : out  STD_LOGIC;
          c : out  STD_LOGIC);
end ha;

architecture Behavioral of ha is
begin
s <= a xor b;
c <= a and b;
end Behavioral;
```

# Output

| **Inputs** | | **Outputs** | |
|---|---|---|---|
| ***A*** | ***B*** | ***C*** | ***S*** |
| 0 | 0 | 0 | 0 |
| 0 | 1 | 0 | 1 |
| 1 | 0 | 0 | 1 |
| 1 | 1 | 1 | 0 |

**Quiz Questions with answer.**

Q.1 Who is the father of VHDL?

Ans. John Hines, Wright Patterson AFB, Daton Ohio.

Q.2 What is a testbench in vhdl?

Ans.A Test Bench in VHDL is code written in VHDL that provides stimulus for individual modules (also written in VHDL). Individual modules are instantiated by a single line of code showing the port.

Q.3 How many inputs and output are used in Full adder?

Ans. Three inputs and two output.

Q.4 What are the advantages of designing?

Ans. Advantages of Designing:

1. Designing is useful in quick implementation, testing and useful in complex circuits.
2. Designing reduces the design cycle.

Q.5 Why HDL is used?

Ans. HDL is used because it is easy to design, implement, test and document increasingly complex digital system.

Q6. Give the basic rules for binary addition?

Ans. 0+0 = 0; 0+1 = 1 ; 1+1 = 1 0 ; 1+0 = 1.

Q7: What is the drawback of half adder?

Ans: We can't add carry bit from previous stage.

Q8: What is the difference b/w half adder& half sub tractor?

Ans: Half adder can add two bits & half sub tractor can subtract two bits.

Q9: Define Nibble?

Ans. Combination of four bits

# EXPERIMENT No. 10

## Aim:-Implement Full Adder using FPGA & CPLD.

**Full adder**

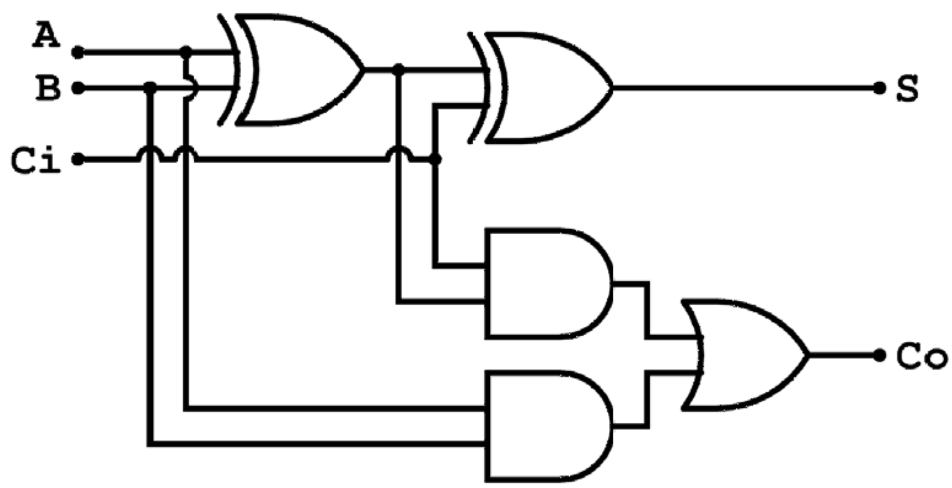
A **full adder** is a logical circuit that performs an addition operation on three one-bit binary numbers often written as $A$, $B$, and $C_{in}$. The full adder produces a two-bit outp t sum typically represented with the signals $C_{out}$ and $S$ where

$$sum = 2 \times C_{out} - S.$$

The full adder's truth table is:

Truth Table:

| Inputs | | | Outputs | |
|---|---|---|---|---|
| ***A*** | ***B*** | ***$C_i$*** | ***$C_o$*** | ***S*** |
| 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 1 |
| 0 | 1 | 0 | 0 | 1 |
| 1 | 1 | 0 | 1 | 0 |
| 0 | 0 | 1 | 0 | 1 |
| 1 | 0 | 1 | 1 | 0 |
| 0 | 1 | 1 | 1 | 0 |
| 1 | 1 | 1 | 1 | 1 |



**Program:**

```
--------------------------------------------------------------------------------
library IEEE;
use  IEEE.STD_LOGIC_1164.ALL;
use  IEEE.STD_LOGIC_ARITH.ALL;
use  IEEE.STD_LOGIC_UNSIGNED.ALL;

---- Uncomment the following library declaration if instantiating
---- any Xilinx primitives in this code.
--library UNISIM;
--use  UNISIM.VComponents.all;

entity fa is
   Port ( a : in  STD_LOGIC;
          b : in  STD_LOGIC;
          cin : in  STD_LOGIC;
           s : out  STD_LOGIC;
          cout : out  STD_LOGIC);
end fa;

architecture Behavioral of fa is

begin
s <= (a xor b) xor cin;
cout <= (a and b) or (b and cin) or (a and cin);

end Behavioral;
```

**OUTPUT:**

| **Inputs** | | | **Outputs** | |
|---|---|---|---|---|
| ***A*** | ***B*** | $C_i$ | $C_o$ | ***S*** |
| 0 | 0 | 0 | 0 | 0 |
| 1 | 0 | 0 | 0 | 1 |
| 0 | 1 | 0 | 0 | 1 |
| 1 | 1 | 0 | 1 | 0 |
| 0 | 0 | 1 | 0 | 1 |
| 1 | 0 | 1 | 1 | 0 |
| 0 | 1 | 1 | 1 | 0 |
| 1 | 1 | 1 | 1 | 1 |

## Quiz Questions with answer.

**Q.**1 Who is the father of **VHDL**?

Ans. John Hines, Wright Patterson AFB, Daton Ohio.

Q.2 What is a testbench in **vhdl**?

Ans. A Test Bench in VHDL is code written in VHDL that provides stimulus for individual modules (also written in VHDL). Individual modules are instantiated by a single line of code showing the port.

Q.3 How many inputs and output are used in Full adder?

Ans. Three inputs and two output.

Q.4 What are the advantages of designing?

Ans. Advantages of Designing:

1. Designing is useful in quick implementation, testing and useful in complex circuits.
2. Designing reduces the design cycle.

Q.5 Why HDL is used?

Ans. HDL is used because it is easy to design, implement, test and document increasingly complex digital system.

Q6. Give the basic rules for binary addition?

Ans. 0+0 = 0; 0+1 = 1 ; 1+1 = 1 0 ; 1+0 = 1.

Q7: What is the drawback of half adder?

Ans: We can't add carry bit from previous stage.

Q8: What is the difference b/w half adder& half sub tractor?

Ans: Half adder can add two bits & half sub tractor can subtract two bits.

Q9: Define Nibble?

Ans. Combination of four bits

# EXPERIMENT No. 11

## Aim:- Implement Delay Flip-Flop using FPGA & CPLD.

**Flip-Flops:**

In digital circuits, a **flip-flop** is a term referring to an electronic circuit (a bistable multivibrator) that has two stable states and thereby is capable of serving as one bit of memory. Today, the term *flip-flop* has come to mostly denote *non-transparent* (*clocked* or *edge-triggered*) devices

A flip-flop is usually controlled by one or two control signals and/or a gate or clock signal. The output often includes the complement as well as the normal output.

**D(Delay) Flip-Flop:**

The D flip-flop is the most common flip-flop in use today. It is better known as *delay* flip-flop
The Q output always takes on the state of the D input at the moment of a positive edge (or negative edge if the clock input is active low).[7] It is called the **D** flip-flop for this reason, since the output takes the value of the **D**input or *Data* input, and *Delays* it by maximum one clock count. The D flip-flop can be interpreted as a primitive memory cell, zero-order hold, or delay line. Whenever the clock pulses, the value of $Q_{next}$ is D and $Q_{prev}$otherwise.

Truth table:

| **Clock** | **D** | **Q** | **$Q_{prev}$** |
|---|---|---|---|
| Rising edge | 0 | 0 | X |
| Rising edge | 1 | 1 | X |
| Non-Rising | X | $Q_{prev}$ | |

**Program:**

```
--------------------------------------------------------------------------------
library IEEE;
use  IEEE.STD_LOGIC_1164.ALL;
use  IEEE.STD_LOGIC_ARITH.ALL;
use  IEEE.STD_LOGIC_UNSIGNED.ALL;

---- Uncomment the following library declaration if instantiating
---- any Xilinx primitives in this code.
--library UNISIM;
--use  UNISIM.VComponents.all;

entity d_ff is
   Port ( clk : in  STD_LOGIC;
          clr : in  STD_LOGIC;
          d : in  STD_LOGIC;
          pr : in  STD_LOGIC;
          q : out  STD_LOGIC);
end d_ff;

architecture Behavioral of d_ff is
begin
process(clk,clr,pr)
begin
if( pr='0' and clr ='1') then
q<= '1';
elsif ( pr ='1' and clr ='0') then
q<='0';
elsif(pr = '1' and clr ='1'and falling_edge(clk))then
q<= d;
end if;
end process;

end Behavioral;
```

# OUTPUT:

| Clock | D | Q | $Q_{prev}$ |
|---|---|---|---|
| Rising edge | 0 | 0 | X |
| Rising edge | 1 | 1 | X |
| Non-Rising | X | $Q_{prev}$ | |

### Quiz Questions with answer.

Q.1 Define flip-flop.
Ans. A flip-flop is a device that can maintain binary information until it is directed by an input signal to change its state. There are several different types of flip-flops, the more commonly used are the D-FF and the JK-FF. Flip-flops are used in sequential circuit design.
Q. 2The MSI chip 7474 is
Ans. MSI chip 7474 dual edge triggered D Flip-Flop.
Q. 3 How many flip-flops are required to construct mod 30 counter?
Ans 5
Q.4The output of SR flip flop when S=1, R=0 is
Ans As for the SR flip-flop S=set input R=reset input ,when S=1, R=0, Flip-flop will be set.
Q.5 The number of flip flops contained in IC 7490 is
Ans 2.
Q6 What are the I/Ps of JK flip–flop where this race round condition occurs?
Ans; .Both the inputs are 1
Q7: .Flip flop is astable or bistable?
Ans Bistable.
Q8: When RS flip-flop is said to be in a SET state?
Ans. When the output is 1
Q9: What is the function of clock signal in flip-flop?
Ans. To get the output at known time.

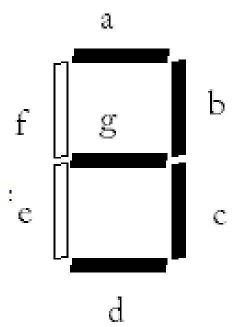
Q10: What is the advantage of JK flip-flop over RS flip-flop?
Ans. In RS flip-flop when both the inputs are 1 output is undetermined.

# EXPERIMENT No. 12

**Aim:- Implement BCD to 7 segment Decoder using FPGA & CPLD.**

**BCD to 7 segment Decoder:**

It is a digital circuit that decodes BCD numbers into7 segment numbers that can be used for 7 segment displays and other applications.




| INPUTS | OUTPUT | | | | | | |
|---|---|---|---|---|---|---|---|
| ABCD | A | B | C | d | e | f | G |
| 0000 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 0001 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 0010 | 1 | 1 | 0 | 1 | 1 | 0 | 1 |
| 0011 | 1 | 1 | 1 | 1 | 0 | 0 | 1 |
| 0100 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| 0101 | 1 | 0 | 1 | 1 | 0 | 1 | 1 |
| 0110 | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| 0111 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 1000 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1001 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |

**Program:**

```
library IEEE;
use  IEEE.STD_LOGIC_1164.ALL;
use  IEEE.STD_LOGIC_ARITH.ALL;
use  IEEE.STD_LOGIC_UNSIGNED.ALL;

---- Uncomment the following library declaration if instantiating
---- any Xilinx primitives in this code.
--library UNISIM;
--use  UNISIM.VComponents.all;

entity bs is
   Port ( i : in  STD_LOGIC_VECTOR (3 downto 0);
          o : out  STD_LOGIC_VECTOR (6 downto 0));
end bs;

architecture Behavioral of bs is

begin

o <= "1111110" when i ="0000" else
          "0110000" when i ="0001" else
          "1101101" when i ="0010" else
          "1111001" when i ="0011" else
          "0110011" when i ="0100" else
          "1011011" when i ="0101" else
          "1011111" when i ="0110" else
          "1110000" when i ="0111" else
          "1111111" when i ="1000" else
          "1111011" when i ="1001";
end Behavioral;
```

OUTPUT:

| INPUTS | OUTPUT | | | | | | |
|---|---|---|---|---|---|---|---|
| ABCD | A | B | C | d | e | f | G |
| 0000 | 1 | 1 | 1 | 1 | 1 | 1 | 0 |
| 0001 | 0 | 1 | 1 | 0 | 0 | 0 | 0 |
| 0010 | 1 | 1 | 0 | 1 | 1 | 0 | 1 |
| 0011 | 1 | 1 | 1 | 1 | 0 | 0 | 1 |
| 0100 | 0 | 1 | 1 | 0 | 0 | 1 | 1 |
| 0101 | 1 | 0 | 1 | 1 | 0 | 1 | 1 |
| 0110 | 1 | 0 | 1 | 1 | 1 | 1 | 1 |
| 0111 | 1 | 1 | 1 | 0 | 0 | 0 | 0 |
| 1000 | 1 | 1 | 1 | 1 | 1 | 1 | 1 |
| 1001 | 1 | 1 | 1 | 1 | 0 | 1 | 1 |

**QUIZ QUESTIONS WITH ANSWERS.**

Q.1 Name the examples of combinational logic circuits.
Ans. Examples of common combinational logic circuits include: half adders, full adders, multiplexers, demultiplexers, encoders and decoders.
One OR gate to OR CD and EF and next to OR of G & output of first OR gate.
Q.2 Which device converts BCD to Seven Segment ?
Ans. A device which converts BCD to Seven Segment is called DECODER.
Q.3 What is BCD to Seven segment decoder?
Ans. A binary coded decimal (BCD) to 7-segment display decoder such as the TTL 74LS47 or 74LS48, have 4 BCD inputs and 7 output lines, one for each LED segment. This allows a smaller 4-bit binary number (half a byte) to be used to display all the ternary numbers from 0 to 9 and by adding two displays together; a full range of numbers from 00 to 99 can be displayed with just a single byte of 8 data bits.
Q.4 What is decoder?
Ans. A Decoder IC, is a device which converts one digital format into another and the most commonly used device for doing this is the Binary Coded Decimal (BCD) to 7-Segment Display Decoder.
Q5: Q.5 What are the advantages of designing?
Ans. Advantages of Designing:
1. Designing is useful in quick implementation, testing and useful in complex circuits.
2. Designing reduces the design cycle.

Q6: Write the applications of Encoder and decoder.
Ans: They are used in communication systems.
Q7: Name some encoders.
Ans Priority encoder , 4:2 encoder and etc.
Q8: How many i/ps are in 4:2 encoder?
Ans 4 i/ps and 2 o/ps.
Q9: How many select lines are present in 2:4 decoder?
Ans none.
Q10: How many outputs are present in 3:8 decoder?
Ans. 8.

# EXPERIMENT No. 13

## Aim:- Implement an Up Counter using FPGA & CPLD.

**Up Counter:**

A synchronous binary counter counts from 0 to $2^N$-1, where N is the number of bits/flip-flops in the counter. Each flip-flop is used to represent one bit. The flip-flop in the lowest-order position is complemented/toggled with every clock pulse and a flip-flop in any other position is complemented on the next clock pulse provided all the bits in the lower-order positions are equal to 1.

Take for example $A_4 A_3 A_2 A_1$ = 0011. On the next count, $A_4 A_3 A_2 A_1$ = 0100. $A_1$, the lowest-order bit, is always complemented. $A_2$ is complemented because all the lower-order positions ($A_1$ only in this case) are 1's. $A_3$ is also complemented because all the lower-order positions, $A_2$ and $A_1$ are 1's. But $A_4$ is not complemented the lower-order positions, $A_3 A_2 A_1$ = 011, do not give an all 1 condition.

To implment a synchronous counter, we need a flip-flop for every bit and an AND gate for every bit except the first and the last bit. The diagram below shows the implementation of a 4-bit synchronous up-counter.

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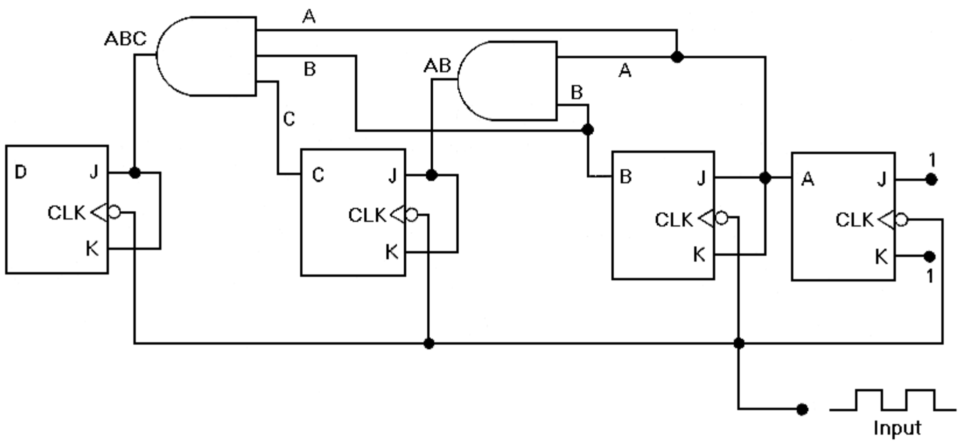


**Program:**

```
library IEEE;
use  IEEE.STD_LOGIC_1164.ALL;
use  IEEE.STD_LOGIC_ARITH.ALL;
use  IEEE.STD_LOGIC_UNSIGNED.ALL;

--library UNISIM;
--use  UNISIM.VComponents.all;

entity up_counter is
   Port ( clk : in  STD_LOGIC;
          sload : in  STD_LOGIC;
          clr : in  STD_LOGIC;
          q : out  STD_LOGIC_VECTOR (3 downto 0));
end up_counter;

architecture Behavioral of up_counter is
signal tmp : std_logic_vector(3 downto 0);
begin
process(clk)
begin
if(clk' event and clk = '1') then
             if clr = '0' then
               tmp <= "0000";
              elsif sload = '1' then
               if tmp = "1010" then
               tmp <= "0000";
               else tmp <= tmp +1;

               end if;
               end if;
               end if;
end process;
             q <= tmp;

end Behavioral;
```

# MICROWAVE AND RADAR
## (EE-326-F)

# LAB MANUAL

## VI SEMESTER

# LIST OF EXPERIMENTS

# EXPERIMENT NO. 1

**AIM: -** To study wave guide components.

**APPARATUS REQUIRED :-** Flanges, Twisted wave guide, wave guide tees, Directional Coupler, Attenuator, Isolators, Circulators, Matched terminator, Slide screw tuner, Slotted Section, Tunable probe, Horn antennas, Movable Short, Detector mount.

**THEORY: -** A pipe with any sort of cross- section that could be used as a wave guide or system of conductors for carrying electromagnetic wave is called a wave guide in which the waves are truly guided.

(1) **FLANGES: -** Flanges are used to couple sections of wave guide components. These flanges are designed to have not only mechanical strength but also desirable electric characteristics.

(2) **TWISTED WAVEGUIDE: -** If a change in polarization direction is required, twisted section may be used. It is also called rotator.

(3) **WAVE GUIDE TEE: -** Tees are junctions which are required to combine or split two signals in a wave guide. Different type of tees are :-

  (a) **H - PLANE TEE: -** All the arm of the H- plane Tee lies in the plane of the magnetic field which divides among the arm. This is thus a current or parallel junction.

  (b) **E- PLANE TEE: -** It lies in the plane of electric field. It is voltage or series junction. In this signal is divided in to two parts having same magnitude but in opposite phase.

  (c) **MAGIC TEE: -** If another arm is added to either of the T-junction. Then a hybrid T-junction or magic tee is obtained. The arm three or four is connected to arm 1&2 but not to each other.

(4) **DIRECTION COUPLER :-** The power delivered to a load or an antenna can be Measured using sampling technique in which a known fraction of the power is Measured so that the total may be calculated. A number of coupling units used for such purpose are known as directional coupler.

(5) **ATTENUATORS: -** It consists of a resistive wane inside the wave guide to absorb microwave power according to its position w.r.t side wall of the wave guide. Attenuation will be maximum if the wane is placed at center.

(a) **Fixed Attenuators:** In this the position of resistive wane is fixed, it absorbs constant amount of power.

(b) **Variable Attenuators: -** In this the position of resistive wane can be changed with the help of micrometer.

(6) **ISOLATORS: -** Ferrite is used as the main material in isolator. Isolator is a microwave device which allows RF energy to pass through in one direction with very little loss, while RF power in the reverse direction is absorbed.

(7) **CIRCULATORS: -** A microwave circulator is a multi port junction device where the power may flow in the direction from 1 to 2, 2 to 3, & so on...

(8) **MATCHED TERMINATION: -** A termination producing no reflected wave at any transverse section of the wave guide. It absorbs all the incident wave. This is also equivalent to connecting the line with its characteristic impedance.

(9) **SLOTTED SECTION: -** A length of wave guide in which a non radiating slot is cut on the broader side. This is used to measure the VSWR.

(10) **SLIDE SCREW TUNER:-** A screw or probe inserted at the top of wave guide (parallel to E) to develop susceptance the magnitude & sign of which is controlled by depth of penetration of screw and it can be moved along the length of wave guide.

(11) **H – PLANE BEND: -** An H-plane bend is a piece of wave guide smoothly bends in a plane parallel to magnetic field for the dominant mode (Hard bend).

(12) **E – PLANE BEND: -** An E-plane bend is a piece of wave guide smoothly bends in a plane of electric field (Easy bend).

(13) **HORN ANTENNAS: -** The components which radiates & intercept EM energy is of course the antenna. The open-ended wave guide, in which the open end is flared so that it looks like a horn, is called horn antenna. There are several types of horns – Sectional E-plane horn, Sectional H- plane horn and Pyramidal horn.

(14) **MOVABLE SHORT: -** It is adjustable load which moves along the length of wave guide and adjusted to get SWR.

**RESULT: -** Students have been able to appreciate the purpose and usage of various Components.

**PRECAUTIONS:-**

1. Handle all components with care and do not allow any damage to take place.
2. Do not rub/scratch the inner polished surfaces of the components with any sharp edged body.
3. If demonstrating any assembly of components, ensure that there is no cross threading and proper tightening.

**QUIZ**:-

Q.1 What is the purpose of wave guide flange?
Q.2 What is a wave guide?
Q.3 Why the wave guide is air filled?
Q.4 What is a wave guide bend?
Q.5 What is isolator?
Q.6 What is circulator?
Q.7 What is Attenuator?
Q.8 What are Tees. How many types of Tees are there?
Q.9 What is slotted line?
Q.10 What is tunable detector?

**ANSWERS**:-

Ans.1 It is used to connect two similar types of wave guides or wave guide components.
Ans.2 It is a metallic structure of any cross-section highly polished & silver plated from inside. It is used for flow of electromagnetic energy.
Ans.3 The wave guide is filled with dry air under pressure to remove any moisture from the wave guide that might cause corrosion. It also increases the power handling capacity of the wave guide.
Ans.4 It is a bend, which is used to change the path of flow of EM energy in the wave guide.
Ans.5 It is a device, which allows the flow of EM energy in one direction but does not permit energy to travel in the opposite direction.
Ans.6 It is a multi port device. It has a property that energy entering in one port is permitted to come out from the next port only and not from any other port.
Ans.7 It is a device that is used to reduce the strength of signal.
Ans.8 Junction of wave guide in different configurations is called Tee. Following type of Tees are there: - E plane Tee, H plane Tee, Magic Tee, Rat Race.
Ans.9 It is a wave guide in which a slot is made on the broader side, in the center of the side along the axis of the wave guide. It is used to facilitate movement of traveling probe along the wave guide to detect & measure the standing wave ratio.
Ans.10 It is a device that is used to detect microwave signal. Detector diode can be Point Contact Diode or Schottky Barrier Diode

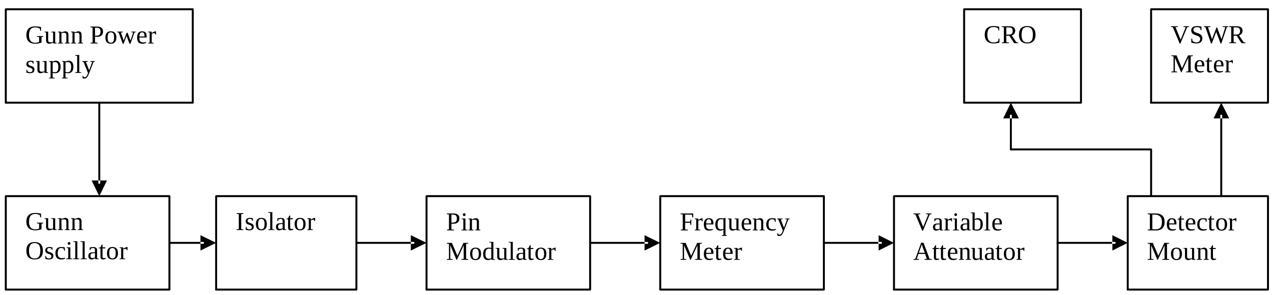
# EXPERIMENT NO.2

**AIM: -** To study the characteristics of Gunn oscillator Gun diode as modulated source

**APPARATUS REQUIRED** :- Gunn Diode, Gunn power supply, PIN Modulator, Isolator, Frequency meter, Variable Attenuator, Detector mount, Wave guide stand, VSWR meter, Cables and accessories.

**THEORY**: - The Gunn Oscillator is based on negative differential conductivity effect in bulk semiconductor which has two conduction bands, minima separated by an energy gap. A disturbance at the cathode gives rise to high field region which travel towards the anode. When this high field domain reaches the anode, it disappears and another domain is formed at the cathode and starts moving towards anode and so on. The time required for domain to travel from cathode to anode gives oscillation frequency. In a Gunn Oscillator, the Gunn diode is placed in a resonant cavity, the Oscillation frequency is determined by cavity dimension than by diode itself.

**BLOCK DIAGRAM**:-




**PROCEDURE: -**

(1) Set the components and equipments as shown in block diagram.
(2) Initially set the variable attenuator for minimum attenuation.
(3) Keep the control knob of Gunn Power Supply as below:

| | | |
|---|---|---|
| Meter Switch | - | 'OFF' |
| Gunn bias knob | - | Fully anti-clockwise |
| Pin bias knob | - | Fully anti-clockwise |
| Pin Mod frequency | - | Any position |

(4) Keep the control knob of VSWR meter as below:

| | | |
|---|---|---|
| Meter Switch | - | Normal |

| | | |
|---|---|---|
| Input Switch | - | Low Impedance |
| Range db Switch | - | 40 db |
| Gain Control knob | - | Fully clockwise |

(5) Set the micrometer of Gunn oscillator for required frequency of operation.

(6) Switch 'ON' the Gunn Power Supply, VSWR meter and Cooling Fan

**VOLTAGE – CURRENT CHARACTERISTIC**

(1) Turn the meter switch of Gunn power supply to voltage position.

(2) Measure the Gunn diode current Corresponding to the various voltages

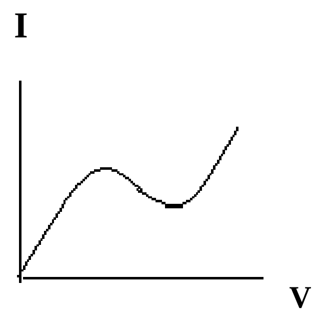
(3) Plot the voltage and current reading on the graph

(4) Measure the threshold voltage, which corresponds to the graph.

**OBSERVATIONS:-**

| S.NO | Voltage | Current |
|---|---|---|
| | | |

**GRAPH: -**




**RESULTS: -** The values of voltage and current is measured and the graph is drawn.

**PRECAUTIONS:-**

1. Use fan to keep the Klystron temperature low.
2. Ensure tight connections of the apparatus
3. Avoid cross connections of the threads.
4. Use stabilized power supply.

**QUIZ:-**

Q.1 What are the basis of classification of microwave devices?
Q.2 What is Gunn Effect?
Q.3 What are the applications of Gunn diode?
Q.4 What is negative resistance?
Q.5 What are the advantages of Gunn diode.
Q.6 What are the disadvantages of Gunn diode
Q.7 What is threshold voltage?
Q.8 What is the role of PIN diode in the test setup?
Q.9 What is the role of Isolator in the test setup?
Q.10 In a Gunn oscillator, Gunn diode is placed in a resonant cavity. In your opinion what shall be the effect of this.

**ANSWERS:-**

Ans.1 - Based on electrical behavior.
- Based on conduction.

Ans.2 There are periodic fluctuations of current passing through N type Ga As when applied voltage exceeded certain critical voltage.
Ans.3 Used as amplifier and oscillators.
Ans.4 In negative resistance devices, voltage and current phases are 180˚ out of phase. Voltage drop across it is negative and ($- I^2 R$) power is generated.
Ans.5 It has very less noise.
Ans.6 It is very temperature dependent. Frequency of oscillations changes with change in temperature.
Ans.7 It is that voltage on curve, which corresponds to maximum current.
Ans.8 PIN diode is used to square modulate the output of Gunn oscillator.
Ans.9 To avoid the flow of reflected energy back to Gunn oscillator. This reflected energy shall destabilize the frequency, phase & amplitude of output wave from oscillator.
Ans.10 The frequency of oscillations shall be determined by the dimensions of the cavity, rather than by the diode itself.

# EXPERIMENT NO. 3

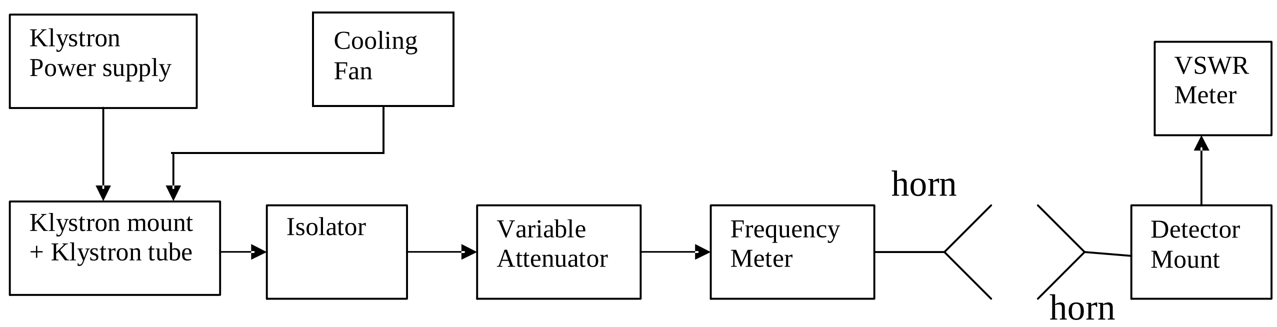
**AIM: -** Study of wave guide horn and its radiation pattern and determination of the Beam width

**APPARATUS REQUIRED: -** Klystron tube, Klystron power supply, Klystron mount, Isolator, Frequency Meter, Two horn antennas, Detector mount, Radiation pattern table, Cooling fan, VSWR meter, Cables and accessories.

**THEORY: -** If a transmission line propagating energy is left open at one end, there will be radiation from this end. In case of a rectangular wave guide this antenna presents a mismatch of about 2:1 and it radiates in many directions. The match will improve if the open wave guide is a horn shape.

The radiation pattern of an antenna is a diagram of field strength or more often the power intensity as a junction of the aspect angle at constant distance from the radiating antenna. An antenna pattern consist of several lobes, the main lobe, side lobe, and back lobe. The major power is concentrated in the main lobe and it is normally to keep the power in the side lobes and back lobe as low as possible.

**BLOCK DIAGRAM: -**




**PROCEDURE: -**

(1) Set the equipment as shown in fig. Keeping the axis of both antennas in same line.
(2) Initially set the variable attenuator for maximum position.
(3) Keep the control knobs of Klystron Power Supply as below:

| | | |
|---|---|---|
| Meter Switch | - | ‘OFF’ |
| Mod Switch | - | AM |

| | | |
|---|---|---|
| Beam voltage knob | - | Fully anti-clockwise |
| Reflector voltage | - | Fully clockwise |
| AM- amplitude knob and frequency knob | - | Around mid position. |

(4) Keep the control knob of VSWR meter as below:

| | | |
|---|---|---|
| Meter Switch | - | Normal |
| Input Switch | - | Low Impedance |
| Range db Switch | - | 40 db |
| Gain Control knob | - | Mid position |

(5) 'ON' the Klystron Power Supply, VSWR meter and Cooling Fan

(6) Turn the meter switch of power supply to beam voltage position and set beam voltage at 300V with the help of beam voltage knob.

(7) Adjust the reflector voltage to get some deflection in VSWR meter.

(8) Maximize the deflection with AM amplitude and frequency control knob of power supply.

(9) Turn the receiving horn to the left in $5^{\circ}$ steps up to 40°- 50° and note the corresponding VSWR db reading in normal db range.

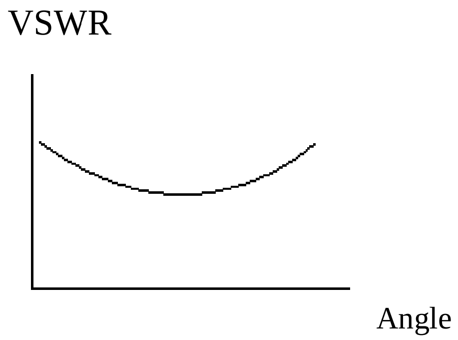
(10) Repeat the above step but this time turn the receiving horn to the right and note down the readings.

(11) Draw a relative power pattern, i.e., output vs. angle.

**OBESERVATIONS AND CALCULATIONS:-**

| S.NO | Angle | VSWR |
|---|---|---|
| | | |

**GRAPH: -**




**RESULT: -** The radiation pattern is drawn using the values of angle and VSWR.

**PRECAUTIONS:-**

1. Use fan to keep the Klystron temperature low.
2. Ensure tight connections of the apparatus
3. Avoid cross connections of the threads.
4. Use stabilized power supply.

**QUIZ:-**

Q.1 What is Horn antenna?
Q.2 What is radiation pattern?
Q.3 What are various types of lobes.
Q.4 Where in the lobe the intensity is maximum.
Q.5 Are side lobes / back lobes desirable. Discuss?
Q.6 What are the disadvantages of side lobes / back lobes?
Q.7 What is beam width?
Q.8 What is antenna gain?
Q.9 What are the advantages of flaring?
Q.10 What are the various type of microwave antennas?

**ANSWERS:-**

Ans.1 This is an open ended wave guide, in which open end is flared so that it looks like horn. It can be H plane, E plane, Pyramid horn or Conical horn.
Ans.2 It is a diagram of field strength or power intensity.
Ans.3 These are main lobe, side lobe, back lobe.
Ans.4 At the center of the lobe.
Ans.5 These are not desirable but at the same time it is not possible to design an antenna without side lobes / back lobes. Through proper design, these can be reduced.
Ans.6 Loss of energy and susceptible to interference & jamming.
Ans.7 The angle between two points on a main lobe where power intensity is half of the maximum power intensity.
Ans.8 It is a measure of increased power radiated in the direction of target as compared with the power that would have been radiated from an isotropic antenna.
Ans.9 Flaring improves directivity, increases efficiency and reduces VSWR.
Ans.10 Horn antenna, Lens antenna, Slot antenna and Micro strip antenna.

# EXPERIMENT NO. 4 (a)

**AIM: -** To study isolation and coupling coefficient of a magic Tee

**APPRATUS REQUIRED: -** Klystron tube, Klystron power supply, Klystron mount, Isolator, Frequency Meter, Variable Attenuator, Detector mounts, Magic Tee, Wave guide stand, Cooling fan, VSWR meter, Cables and accessories.

**THEORY: -** The Magic Tee is a four port device & it is a combination of the E & H plane Tee. If the power is fed into arm 3 (H- arm), the electric field divides equally between arm 1 and 2 with same phase, and no electric field exists in arm 4. If the power is fed in arm 4 (E- arm), it divides equally into arm 1 and 2 but out of phase with no power to arm 3. Further, if the power is fed from arm 1 and 2, it is added in arm 3 (H-arm), and it is subtracted in E-arm, i.e., arm 4.The basic parameters to be measured for magic Tee are defined below:

**A. Isolation: -** The isolation between E and H arms is defined as the ratio of the power supplied by the generator connected to the E-arm (port 4) to the power detected at H-arm (port3) when side arms 1 and 2 are terminated in matched load.

Hence, Isolation 3-4 = $10 \log_{10} P_4 / P_3$

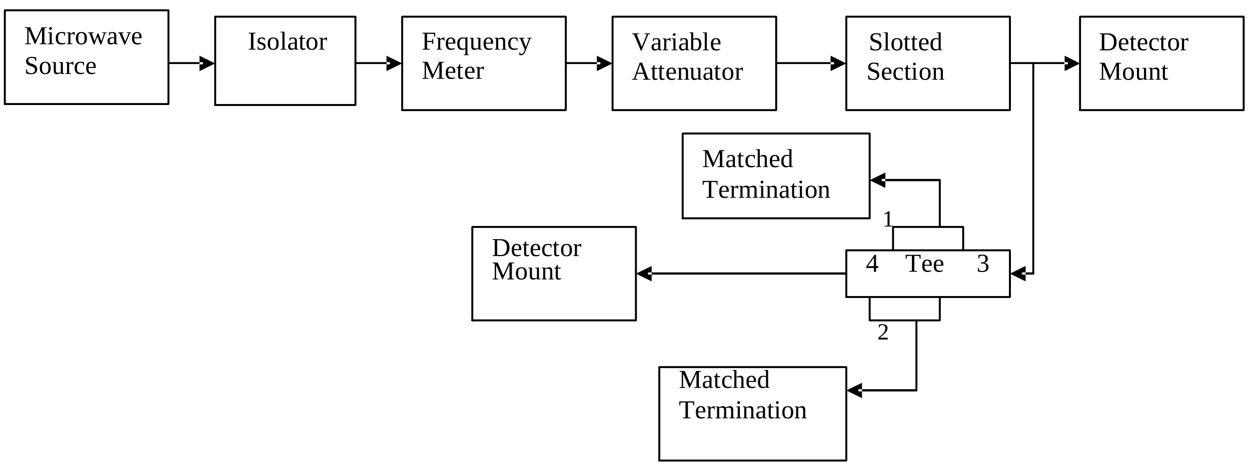
**B. Coupling Coefficient :-** It is defined as $C_{ij} = 10^{-\alpha / 20}$

Where α is attenuation / isolation in db when i is input arm and j is output arm.

Thus $\alpha = 10 \log Pi / Pj$

Where Pi is the power delivered to arm i and Pj is power detected at j arm.

**BLOCK DIAGRAM: -**



**PROCEDURE: - Measurement of Isolation and Coupling Coefficient**

(1) Set the equipments as shown in fig.
(2) Remove the tunable probe and magic Tee from the slotted line and connect the detector mount to the slotted line.
(3) Energize the microwave source for particular operation of frequency and Tune the detector for max. Output.
(4) Set any reference level of power on VSWR meter with the help of variable attenuator; gain control knob of VSWR meter and note down the reading (let it be $P_{3)}$.
(5) Without changing the position of variable attenuator and gain control knob of VSWR meter, carefully place the magic Tee after slotted line keeping H-arm to slotted line, detector to E-arm and matched termination to arm1 and 2. note down the reading of VSWR meter (let it be $P_{4)}$.
(6) Determine the isolation between port 3 and 4 as $P_3 – P_4$ in db.
(7) Determine the coupling coefficient from equation given.
(8) The same experiment may be repeated for other ports also.
(9) Repeat the same for other frequencies.

**OBSERVATIONS AND CALCULATIONS:-**

$P_3 =$

$P_4 =$

Calculate Isolation and coupling coefficient using

Isolation 3-4 = $10 \log_{10} P_4 / P_3$

$\alpha = 10 \log Pi / Pj$

**RESULT: -** Measured values for Isolation and coupling coefficient are

I =

〈 =

**PRECAUTIONS:-**

1. Use fan to keep the Klystron temperature low.
2. Ensure tight connections of the apparatus
3. Avoid cross connections of the threads.
4. Use stabilized power supply.

**QUIZ**:-

Q.1 What are the various type of Tees.
Q.2 What is H - plane Tee?
Q.3 What is E - plane Tee?
Q.4 What is Magic Tee?
Q.5 What is the electric property of H-plane Tee?
Q.6 What are the properties of E-plane Tee?
Q.7 What are the properties of Magic Tee?
Q.8 What are the applications of Magic Tee?
Q.9 What is the isolation between E & H arm?
Q.10 Define Coupling Coefficient?

**ANSWERS**:-

Ans.1 E - plane Tee, H – plane Tee, Magic Tee, and Rat Race etc.

Ans.2 An H-plane Tee is formed by cutting a rectangular slot along the width of a main wave guide and attaching another wave guide on the slot. It is3-port device.

Ans.3 A rectangular slot is cut along the broader dimension of a wave guide and a side arm is attached. This is a three-port device.

Ans.4 Rectangular slots are cut along the breadth and width of a long wave guide and side arms are attached. It is a Four-port device.

Ans.5 If equal input are given at ports 1&2 (collinear ports), the output at the port 3 shall be the sum of these two inputs.

Ans.6 If equal, in phase inputs are given at collinear ports, the output at port 3 shall be difference of the two i.e. zero. Similarly if same input is given at port 3, there shall be equal but opposite outputs at ports 1&2.

Ans.7 It has got the properties of both H & E plane Tees. However if some input is given to port 1, nothing comes out of 2.

Ans.8 - Used for measurement of impedance, Used as duplexer. Used as mixer.

Ans.9 It is defined as ratio of power supplied by generator connected to E-arm (port4) to the power detected at H-arm (port3) side arms 1&2 are terminated in matched load. Isolation 3-4 = $10 \log_{10} P_4 / P_3$

Ans.10 $C_{ij} = 10^{-\alpha / 20}$

Where α is attenuation / isolation in db when i is input arm and j is output arm

Thus $\alpha = 10 \log Pi / Pj$

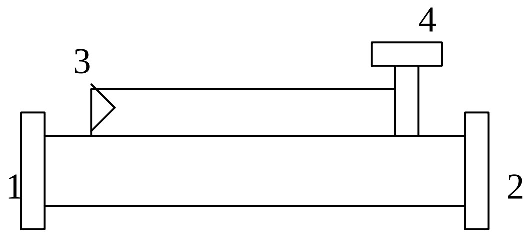
Where Pi is the power delivered to arm i and Pj is power detected at j arm.

# EXPERIMENT NO. 4(b)

**AIM: -** To measure coupling coefficient, Insertion loss & Directivity of a Directional coupler.

**APPARATUS REQUIRED: -** Klystron tube, Klystron power supply, Klystron mount, Isolator, Cooling fan, Frequency Meter, Detector mount, Variable Attenuator, Wave guide stand, VSWR meter, MHD coupler, Matched Termination, Cables and accessories.

**THEORY: -** A directional coupler is a device with which it is possible to measure the incident and reflected wave separately. It consist of two transmission lines, main arm and auxiliary arm, electro magnetically coupled to each other. The diagram is given below. The power entering in port 1 in the main arm divides between port 2 and port 4 almost no power comes out of port 3. Power entering in port 2 is divided between port 1 and 3.




Assuming power is entering from port 1, then

The coupling factor is defined as

$$\text{Coupling (db)} = 10 \log_{10} P_1 / P_4$$

Main line insertion loss is the attenuation introduced in transmission line by insertion of coupler. It is defined as:

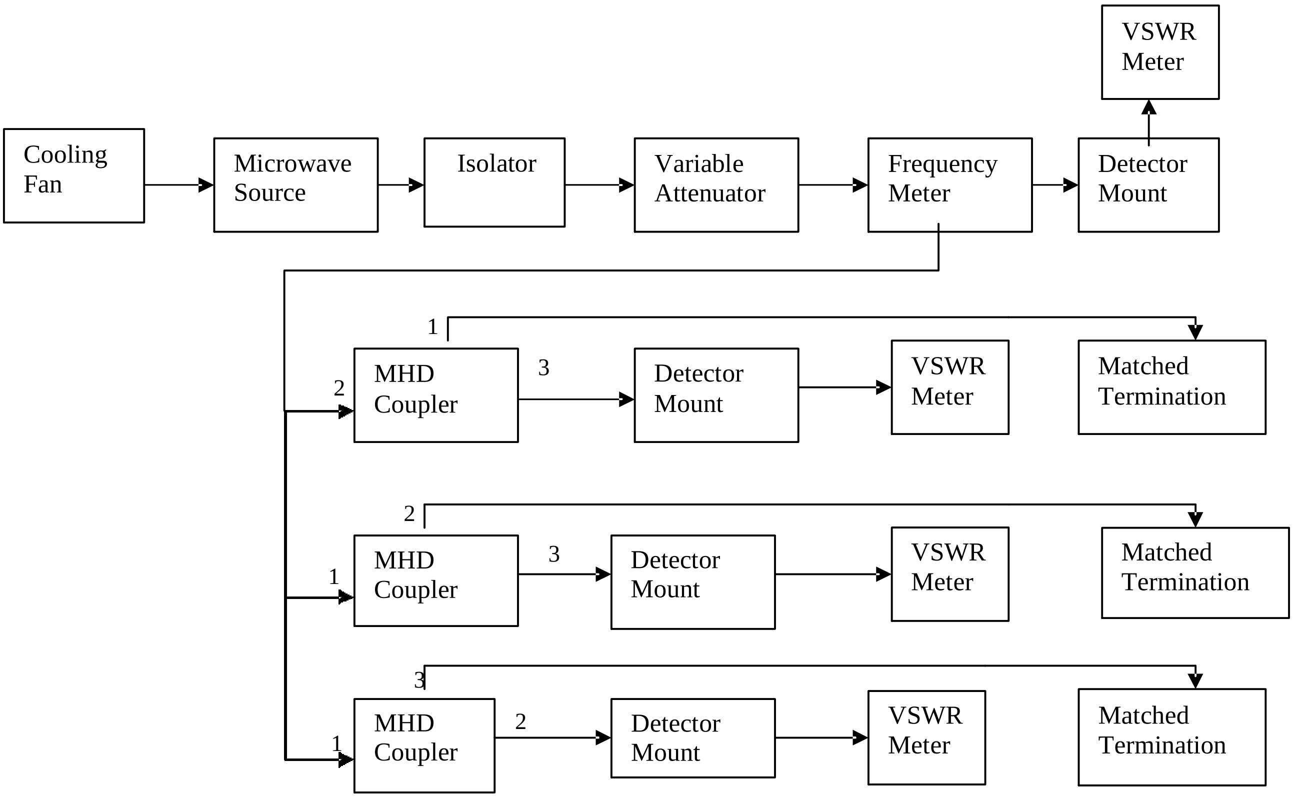
$$\text{Insertion loss} = 10 \log_{10} P_1 / P_2.$$

The directivity of the coupler is a measure of separation between incident wave and the reflected wave. It is measured as the ratio of two power outputs from the auxiliary line when a given amount of power is successively applied to each terminal of the main line with other port terminated by matched load. Hence Directivity is given by

$$D \text{ (db)} = 10 \log_{10} P_{4f} / P_{4r}$$

Where $P_{4f}$ and $P_{4r}$ are the measured powers at port 4 with equal amount of power is fed to port 1 and 2 respectively.

## BLOCK DIAGRAM:-




## PROCEDURE: - Measurement of Coupling factor, Insertion loss & Directivity

(1) Set the `equipments as shown in fig.
(2) Energize the microwave source for particular operation of frequency.
(3) Remove the MHD coupler and connect the detector mount to the frequency meter. Tune the detector for max. Output.
(4) Set any reference level of power on VSWR meter with the help of variable attenuator, gain control knob of VSWR meter and note down the reading (let it be X).
(5) Insert the D.C as shown in fig. With detector mount to the auxiliary port 4 and matched termination to port 2. Without changing the position of variable attenuator and gain control knob of VSWR meter.
(6) Note down the reading on VSWR meter (let it be Y) and calculate coupling factor using X &Y, which will be in db.

(7) Now carefully disconnect the detector from the auxiliary port 4 and match termination from port2 without disturbing the setup.
(8) Connect the matched termination to the aux. Port 4 and detector to port 2 and measure the reading on VSWR meter (let it be Z).
(9) Compute insertion loss using X & Z in db.
(10) Repeat the steps from 1 to 4.
(11) Connect the D.C in the reverse direction i.e. port 2 to frequency meter side, matched termination to port1 and detector mount to port 4, without disturbing the position of the variable attenuator and gain control knob of VSWR meter.
(12) Note down the reading and let it be $Y_0$ .Compute the directivity as Y- $Y_0$.
(13) Repeat the same for other frequency.

**OBSERVATION AND CALCULATIONS: -**

Calculate D, C and I using the equations as given above.

**RESULT: -** The measured value for MHD coupler are

Coupling coefficient =
Insertion loss =
Directivity =

.

**PRECAUTIONS:-**

1. Use fan to keep the Klystron temperature low.
2. Ensure tight connections of the apparatus
3. Avoid cross connections of the threads.
4. Use stabilized power supply.

**QUIZ:-**

Q.1 What is directional coupler?
Q.2 What is Coupling?
Q.3 What is Directivity?
Q.4 What is Isolation?
Q.5 What is Insertion loss?
Q.6 In a two hole directional coupler, what is the distance between two holes?
Q.7 What is the material of directional coupler?
Q.8 Name a few other types of directional couplers?
Q.9 In a directional coupler, are ports matched?
Q.10 How many holes can be there in a Directional coupler?

**ANSWERS:-**

Ans.1 It is a combination of two wave guides electrically connected to each other through a hole or orifice. It is used to measure the power of EM wave by taking a small fraction of it.
Ans.2 Coupling, C (db) = $10 \log_{10} P_i / P_f$
Ans.3 Directivity, D (db) = $10 \log_{10} P_f / P_b$
Ans.4 Isolation, I = $10 \log_{10} P_i / P_b$.
Ans.5 Insertion loss = $10 \log_{10} Pi / Pr$.
Ans.6 The distance is $\lambda_g / 4$.
Ans.7 These are two metallic rectangular wave-guides, made of brass / copper. These are finely polished and silver plated from inside.
Ans.8
- Two hole cross guide coupler.
- Two hole branching guide coupler
- Short slot coupler
- Bifurcated coupler
- Loop directional coupler.

Ans.9 All ports are perfectly matched to the junctions
Ans.10 It can be one, two or more than two depending upon requirement. Degree of coupling shall be decided by number and location of holes.

# EXPERIMENT NO. 5 (a)

**AIM: -** To measure attenuation and insertion loss of a fixed and variable attenuator.

**APPARATUS REQUIRED: -** Microwave source, Isolator, Frequency meter, Variable attenuator, Slotted line, Tunable probe, Detector mount, Matched termination, VSWR meter, test fixed and variable attenuator and Accessories.

**THEORY: -** The attenuator are two port bidirectional devices which attenuates some power when inserted into the transmission line.

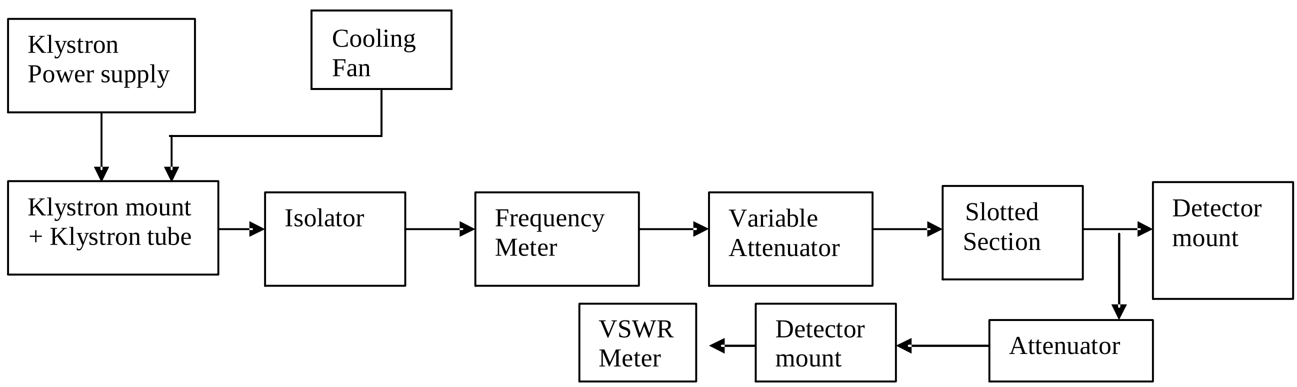
Attenuation $A$ (db) = 10 log P1/P2

Where, P1 = Power absorbed or detected by the load without the attenuator in the line. $P_2$ = Power absorbed/detected by the load with attenuator in the line. The attenuators consist of a rectangular wave guide with a resistive vane inside it to absorb microwave power according to their position with respect to side wall of the waveguide. An electric field is maximum at centre in TEIO mode; the attenuation will be maximum if the vane is placed at centre of the waveguide. Moving from centre towards the side wall, attenuation decreases in the fixed attenuator, the vane position is fixed where as in variable attenuator, its position can be changed by the help of micrometer or by other methods.

Following characteristics of attenuators can be studied:

1. Input VSWR.
2. Insertion loss (in case of variable attenuator).
3. Amount of attenuation offered into the lines.
4. Frequency sensitivity, *i.e.*, variation of attenuation at any fixed position of vane and frequency is changed.

**BLOCK DIAGRAM: -**



## PROCEDURE: -

### Insertion Loss/Attenuation Measurement

1. Remove the tunable probe, attenuator and matched termination from the slotted section in the above set up.
2. Connect the detector mount to the slotted line, and tune the detector mount also for maximum deflection on VSWR meter (Detector mount's output should be connected to VSWR meter).
3. Set any reference level on the VSWR meter with the help of variable attenuator (not test attenuator) and gain control knob of VSWR meter. Let it be P1.
4. Carefully disconnect the detector mount from the slotted line, without disturbing any position on the set up. Place the test variable attenuator to the slotted line and detector mount to other port of test variable attenuator. Keep the micrometer reading of test variable attenuator to zero and record the reading of VSWR meter. Let it be $P_2$. Then the insertion loss of test attenuator will be $P_1 – P_2$ db.
5. For measurement of attenuation of fixed and variable attenuator, after step 4 of above measurement, carefully disconnect the detector mount from the slotted line without disturbing any position obtained up to step 3. Place the test attenuator to the slotted line and detector mount to the other port of test attenuator. Record the reading of VSWR meter. Let it be P3. Then the attenuation value of fixed attenuator or attenuation value of variable attenuator for particular position of micrometer reading will be PI - P3 db.
6. In case of variable attenuator, change the micrometer reading and record the VSWR meter reading. Find out attenuation value for different position of Micrometer reading and plot a graph.
7. Now change the operating frequency and whole step should be repeated for finding frequency sensitivity of fixed and variable attenuator.

## OBSERVATION AND CALCULATIONS:-

## RESULT:-

## PRECAUTIONS:-

1. Use fan to keep the Klystron temperature low.
2. Ensure tight connections of the apparatus
3. Avoid cross connections of the threads.
4. Use stabilized power supply.

**QUIZ:-**

Q1. A loss-less line having characteristic impedance Zo is terminated in a pure reactance of value -jZo. The VSWR of the line will be

(a) 10 (b) 2

(c) 1 (d) infinite

Q2. A cylindrical cavity resonator has a diameter of 16 mm. What is the dominant resonant mode when the cavity length is i) 20 mm and ii) 15mm

(i) (ii)

(a)TEll1 M11l (c) TEl1l TMolO

(i) (ii)

(b) TMolO TE111

(d) TM11l TEo

Q3. In a circular waveguide with radius *'r'*, the dominant mode is

*(a)* TMol *(b)* TEol

*(c)* TMl1 *(d)* TEl1

Q4. Consider the following statements:

In a magic tee,

The collinear arms are isolated from each other.

One of the collinear arms is isolated from the E-arm.

One of the collinear arms is isolated from the H-arm.

E-arm and H-arm are isolated from each other. Of these statements

*(a)* 1 and 2 are correct *(b)* 1 and 3 are correct

*(e)* 1 and 4 are correct *(d)* 2 and 3 are correct

Q5. Radiation from a helical antenna is

*(a)* plane-polarized *(b)* partially plane polarized

*(e)* Circularly polarized *(d)* elliptically polarized

**ANSWERS:**

Q1:d

Q2: a

Q3: d

Q4: c

Q5: c

# EXPERIMENT NO. 5(b)

**AIM :-** To measure isolation and insertion loss of a three port Circulators/Isolator.

**APPARATUS REQUIRED** :- Klystron tube, Klystron power supply, Klystron mount, Isolator, Circulator, Slotted Section, Tunable probe, Frequency Meter, Variable Attenuator, Detector mount, Wave guide stand, Cooling fan, VSWR meter, Cables and accessories.

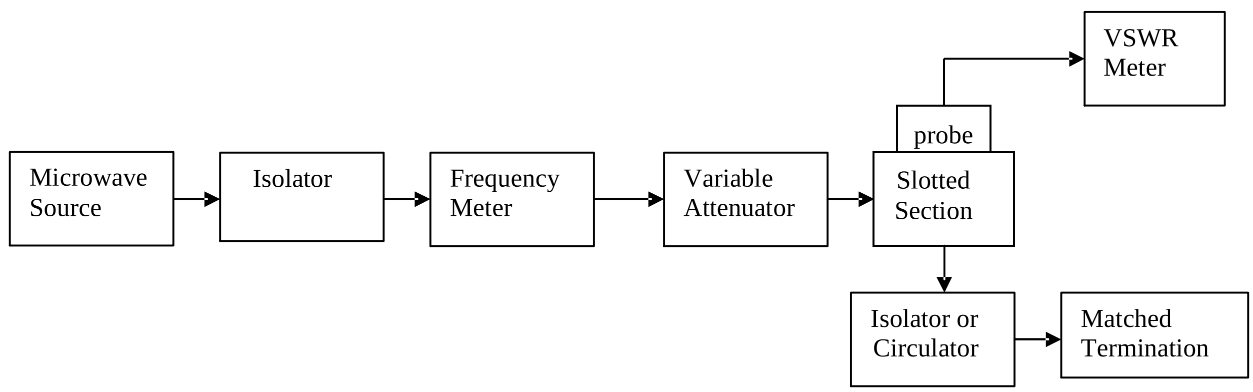
**THEORY :-**

**ISOLATOR :-** The isolator is a two-port device with small insertion loss in forward direction and a large in reverse attenuation.

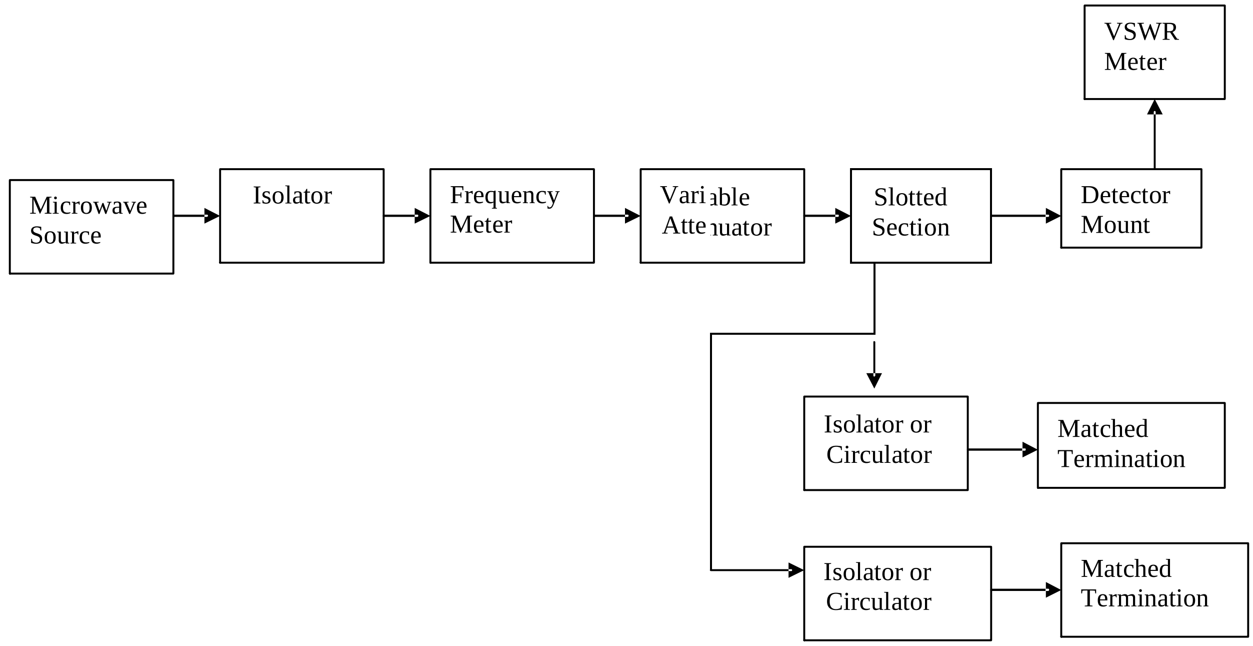
**CIRCULATOR :-** the circulator is a multi port junction that permits transmission in certain ways. A wave incident in port 1 is coupled to port 2 only, a wave incident at port 2 is coupled to port3 only and so on . Following is the basic parameters of isolator and circulator for study.

A. **Insertion loss :-** The ratio of power supplied by a source to the input port to the power detected by a detector in the coupling arm, i.e., output arm with other port terminated in the matched load, is defined as insertion loss or forward loss.
B. **Isolation :-** It is the ratio of power fed to input arm to the input power detected at not coupled port with other port terminated in the matched load..
C. **Input VSWR :-** The input VSWR of an isolator or circulator is the ratio of voltage maximum to voltage minimum of the standing wave existing on the line, when one port of it terminates the line and others have matched termination.

**BLOCK DIAGRAM :- Measurement of VSWR**



## Measurement of Insertion loss and Isolation




**PROCEDURE :-**

**(a) Input VSWR Measurement :**

(1) Set up the components and equipments as shown above with input port of isolator or circulator towards slotted line and matched load on other ports of it.

(2) Energize the microwave source for particular operation of frequency.

(3) With the help of slotted line, probe and VSWR meter, find out SWR of the isolator or circulator as describe earlier for low and medium SWR measurements.

(4) The above procedure can be repeated for other ports or for other frequencies.

**(b) Measurement of Insertion loss & Isolation :**

(1) Remove the probe and isolator or circulator from slotted line and connect the detector mount to the slotted section. The output of the detector mount should be connected with VSWR meter.

(2) Energize the microwave source for max. output for a particular frequency of operation. Tune the detector mount for max. output in VSWR meter.

(3) Set any reference level of power in VSWR meter with the help of variable attenuator, gain control knob of VSWR meter and note down the reading (let it be $P_1$).
(4) Carefully remove the detector mount from slotted line without disturbing the position of set up. Insert the isolator / circulator between slotted line and detector mount. Keeping input port to slotted line and detector at its output port. A matched termination should be placed at third port in case of circulator.
(5) Record the readings in the VSWR meter. If necessary change range – db switch to high or lower position and taking 10 db changes for one set change of switch position (let it be $P_2$).
(6) Compute insertion loss on $P_1$-$P_2$ in db.
(7) For measurement of isolation, the isolator or circulator has to be connected reverse, i.e., output port to slotted line and detector to input port with other port terminated by matched termination. After setting a reference level without isolator or circulator in the set up as described in insertion loss measurement. Let same $P_1$ level is set.
(8) Record the reading of VSWR meter after inserting the isolator or circulator (let it be $P_3$).
(9) Compute isolation as $P_1 – P_3$ in db.
(10) The same experiment can be done for other ports of circulator.
(11) Repeat the same for other frequency.

**OBSERVATIONS AND CALCULATIONS:-**

Calculate VSWR, Insertion Loss and Isolation as per formulas given above.

**RESULT:-** Measured values are follows :

VSWR =

Insertion loss =

Isolation =

## PRECAUTIONS :-

1. Use fan to keep the Klystron temperature low.
2. Ensure tight connections of the apparatus
3. Avoid cross connections of the threads.
4. Use stabilized power supply.

**QUIZ :-**

Q.1 What is an Isolator?
Q.2 What is Circulator?
Q.3 What is Insertion loss?
Q.4 What is Isolation?
Q.5 What is input VSWR of a circulator or isolator?
Q.6 What is Faraday rotation in Ferrites?
Q.7 If direction of travel of wave reverses, does the direction of polarization change?
Q.8 What is the function of resistive card in an isolator?
Q.9 How many ports a circulator can have?
Q.10 What are the applications of circulator?

**ANSWERS :-**

Ans.1 It is a two port device which have low insertion loss in forward direction and very high insertion loss in the opposite direction.
Ans.2 It is a multi port junction that permits transmission in certain ways. For example a wave incident at port 1 is coupled to port 2 only, wave incident at port 2 is coupled to port 3 only and so on.
Ans.3 It is the ratio power supplied by a source to the input port to the power detected at the output port.
Ans.4 It is the ratio of power fed to input arm to the power detected at the not coupled port, with other ports terminated in to matched loads.
Ans.5 It is the ratio of voltage max. to voltage min. of the standing wave existing on line and others have matched terminations.
Ans.6 When a linearly polarized wave along X-axis is made to travel through ferrite in the Z – direction, the plane of polarization of this wave will rotate with distance. This phenomenon is known as Faraday rotation.
Ans.7 No, the wave continues to rotate in the same direction even if the direction of travel of wave reverses.
Ans.8 Resistive card does not absorb any energy from the wave whose plane of polarization is perpendicular to its own plane and allows the wave to pass.
Ans.9 There is no restriction about number of ports. However, normally a circulator has four ports.
Ans.10 It can be used as a duplexer in radar antenna system

# EXPERIMENT NO. 6

**AIM :-** To measure the standing wave ratio and reflection coefficient in a Microwave Transmission line.

**APPARATUS REQUIRED: -** Klystron tube, Klystron power supply, Klystron mount, Isolator, Frequency Meter, Slotted section, Tunable Probe, Variable Attenuator, Wave guide stand, VSWR meter, Movable short, Matched Termination, S-S Tuner, Cables and accessories.

**THEORY :-** The electromagnetic field at any point of termination line may be considered as the sum of two traveling wave, the 'incident wave' propagates from generator and reflected wave propagates towards the generator. The reflected wave is setup by reflection of incident wave from a discontinuity on the line or from load impedance. The presence of two traveling waves, gives rise to standing wave along the line. The maximum field strength is found where two waves are in phase and minimum where the two waves adds in opposite phase. The distance between two successive minimum (or maximum) is half the guide wavelength on the line. The ratio of electric field strength of reflected and incident wave is called reflection coefficient. The voltage standing wave ratio is defined as ratio between maximum or minimum field strength along the line.

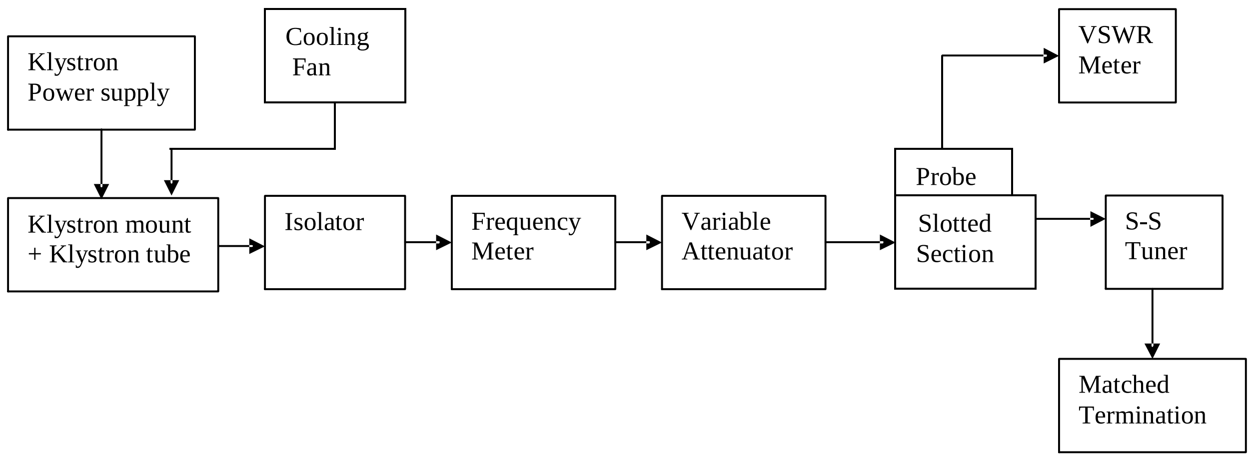
Hence, VSWR, $S = E_{max.} / E_{min}$

Reflection Coefficient, $\rho = E_r / E_i = (Z - Z_o) / (Z + Z_o)$

Where Z is the impedance at a point on line, $Z_o$ is characteristic impedance.
The above equation gives following equation:

$$|\rho| = \frac{S-1}{S+1}$$

**BLOCK DIAGRAM**: -




**P ROCEDURE :-**

(1) Set the components and equipments as shown in block diagram.
(2) Keep variable attenuator at maximum position.
(3) Keep the control knobs of Klystron Power Supply as below:

| | | |
|---|---|---|
| Meter Switch | - | 'OFF' |
| Mod Switch | - | AM |
| Beam voltage knob | - | Fully anti-clockwise |
| Reflector voltage | - | Fully clockwise |
| AM- amplitude and frequency knob | - | Mid position. |

(4) Keep the control knob of VSWR meter as below:

| | | |
|---|---|---|
| Meter Switch | - | Normal |
| Input Switch | - | Low Impedance |
| Range db Switch | - | 40 / 50 db |
| Gain Control knob | - | Mid position |

(5) 'ON' the Klystron Power Supply, VSWR meter and Cooling Fan
(6) Turn the meter switch of power supply to beam voltage position and set beam voltage at 300V with the help of beam voltage knob.
(7) Adjust the reflector voltage to get some deflection in VSWR meter.
(8) Maximize the deflection with AM amplitude and frequency control knob of power supply.

(9) Tune the plunger, reflector voltage, and probe for maximum deflection in VSWR meter.
(10) If necessary, change the range db-switch, variable attenuator position and gain control knob to get deflection in the scale of VSWR meter.
(11) Move the probe along the slotted line, the deflection will change.

**MEASUREMENT OF LOW AND MEDIUM VSWR**

(1) Move the probe along with slotted line to get max. deflection in VSWR meter.
(2) Adjust the VSWR meter gain control knob or variable attenuator until the meter indicates 1 on normal SWR scale.
(3) Keep all the control knob as it is, move probe to next minimum position and read the VSWR on scale and record it.
(4) Repeat the above step for change of S-S Tuner probe depth and record the corresponding SWR.

**OBSERVATION AND CALCULATIONS :-**

Calculate SWR and Reflection coefficient using

$E_{max.}=$

$E_{min.}=$

VSWR, $S = E_{max.} / E_{min}$

$$|\rho| = \frac{S-1}{S+1}$$

**RESULT :-** Standing wave ratio and Reflection coefficient are measured & equal to

SWR =

$\rho$ =

**PRECAUTIONS :-**

5. Use fan to keep the Klystron temperature low.
6. Ensure tight connections of the apparatus
7. Avoid cross connections of the threads.
8. Use stabilized power supply.

**QUIZ :-**

Q.1 What is Standing Wave Ratio?
Q.2 What is reflection coefficient?
Q.3 What is VSWR meter?
Q.4 What are the important controls of a VSWR meter?
Q.5 What is Full Scale Deflection?
Q.6 The values of VSWR can vary between which two extreme values.
Q.7 What are the methods to achieve impedance matching?
Q.8 What is the role of variable attenuator in the test setup?
Q.9 How many scales are there on a VSWR?
Q.10 What is guide wavelength

**ANSWER :-**

Ans.1 Any mismatched load leads to reflected waves, resulting in to standing waves along the length of line. Ratio of max. to min. voltage gives VSWR.

Ans.2 Whenever EM energy enters unmatched load, full power is not transferred to load. A part of it is reflected back.

$$\text{Reflection Coefficient} = \frac{\text{Reflected power}}{\text{Incident power}}$$

Ans.3 It is a High gain, low noise voltage amplifier. It uses detected signal out of microwave detector, amplifies the same and displays it on a calibrated voltmeter.

Ans.4 Coarse and fine gain control, Scale selection switch, Input selector switch for different currents.

Ans.5 A signal which is causing certain deflection can be increased / decreased with the help of coarse / fine gain control or by increasing / decreasing attenuators, so as to give full scale deflection on the VSWR meter. This is called FSD.

Ans.6 It can vary from 1 to ∞.

Ans.7
- Resistance of load should be equal to resistance of source.
- Reactance of load should be equal and opposite to reactance of source.
- By using half wavelength & quarter wave length lines.
- Stub matching.

Ans.8 To increase / decrease the strength of the microwave signal reaching VSWR meter.

Ans.9 Three, namely Normal SWR, Expanded SWR and db scale.

Ans.10 It is the distance traveled by EM to undergo a phase difference of 2 π radians. Also it is equal to twice the distance between two consecutive minimum points on VSWR.

# EXPERIMENT NO. 7

**AIM : -** To measure the frequency of a microwave source and demonstrate relationship among guide dimensions ,free space wavelength and guide wavelength

**APPARATUS REQUIRED :-** Klystron tube, Klystron power supply, Klystron mount, Isolator, Frequency Meter, Slotted section, Tunable Probe, Variable Attenuator, Wave guide stand, VSWR meter, Movable Short / Matched Termination, Cables and accessories.

**THEORY**: - For dominant $TE_{10}$ mode in rectangular wave guides $\lambda_o$, $\lambda_g$, and $\lambda_c$ are related as below

$$1/\lambda_o^2 = 1/\lambda_g^2 + 1/\lambda_c^2$$

Where,

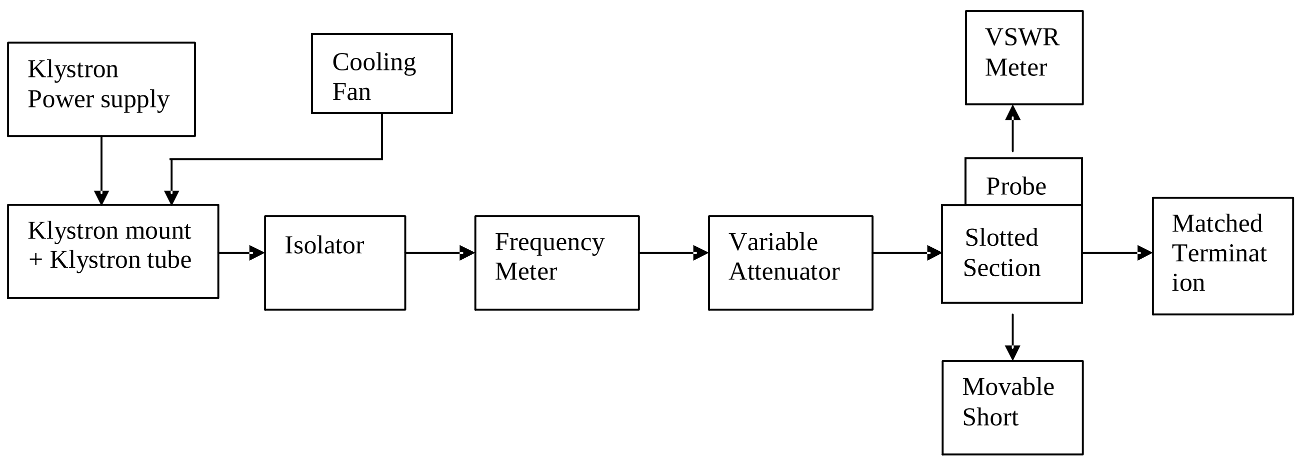
$\lambda_o$ = free space wavelength
$\lambda_g$ = Guide wavelength
$\lambda_c$ = Cut off wavelength

For dominant $TE_{10}$ mode $\lambda_c = 2a$ where a is broad dimension of wave guide .
The following relationship can be proved.

$$C = f\lambda$$

Where, C is velocity of light and f is frequency.

**BLOCK DIAGRAM**: -



**PROCEDURE: -**

(1) Set the components and equipments as shown in block diagram.
(2) Initially set the variable attenuator for maximum position.
(3) Keep the control knobs of Klystron Power Supply as below:

| | | |
|---|---|---|
| Meter Switch | - | 'OFF' |
| Mod Switch | - | AM |
| Beam voltage knob | - | Fully anti-clockwise |
| Reflector voltage | - | Fully clockwise |
| AM- amplitude knob | - | Around fully clockwise |
| AM- frequency knob | - | Around mid position. |

(4) Keep the control knob of VSWR meter as below:

| | | |
|---|---|---|
| Meter Switch | - | Normal |
| Input Switch | - | Low Impedance |
| Range db Switch | - | 50 db |
| Gain Control knob | - | Mid position |

(5) 'ON' the Klystron Power Supply, VSWR meter and Cooling Fan
(6) Turn the meter switch of power supply to beam voltage position and set beam voltage at 300V with the help of beam voltage knob.
(7) Adjust the reflector voltage to get some deflection in VSWR meter.
(8) Maximize the deflection with AM amplitude and frequency control knob of power supply.
(9) Tune the plunger, reflector voltage, and probe for maximum deflection in VSWR meter.
(10) Tune the frequency meter knob to get the 'dip' on the VSWR scale and note down the frequency directly from frequency meter.
(11) Replace the termination with movable short, and detune the frequency meter.
(12) Move probe along with the slotted line, the deflection in VSWR meter will vary. Move the probe to a minimum deflection position, to get accurate reading, it is necessary to increase the VSWR meter range db switch to higher position. Note and record the probe position.
(13) Move the probe to next minimum position and record the probe position again.
(14) Calculate the guide length wave as twice the distance between successive minimum positions obtained as above.
(15) Measure the wave guide inner broad dimension 'a' which will be around 22.86 mm for X- band.
(16) Calculate the frequency by following equation.

$$f = C / \lambda = C \sqrt{1/ \lambda_g^2 + 1/ \lambda_c^2}$$

where $C = 3 \times 10^8$ m/s i.e. velocity of light.

(17) Verify with frequency obtained by frequency meter.

(18) Above experiment can be verified at different frequencies.

**OBESERVATIONS AND CALCULATIONS :-**

Calculate frequency using the equation

$\lambda_g = 2d$

d = first min. – second min.

$\lambda_C = 2a$

$$f = C / \lambda = C \sqrt{1/ \lambda_g^2 + 1/ \lambda_c^2}$$

**RESULT :-** Measured frequency f =

**PRECAUTIONS :-**

1. Use fan to keep the Klystron temperature low.
2. Ensure tight connections of the apparatus
3. Avoid cross connections of the threads.
4. Use stabilized power supply.

**QUIZ :-**

Q.1 What is wavelength?
Q.2 What is guide wavelength '$\lambda_g$'?
Q.3 What is cut off wavelength for a wave-guide?
Q.4 What is the relationship between frequency and velocity of light?
Q.5 Name various methods that can be used to measure frequency / wavelength.
Q.6 What is wave meter?
Q.7 For $TE_{10}$ mode why $\lambda_c = 2a$
Q8 What is down frequency conversion method of measuring frequency.
Q.9 In a wave meter 'dip' indicates what?
Q10. In a wave meter, how resonant frequency can be changed.

**ANSWERS :-**

Ans.1 Amount of distance travelled by electromagnetic wave in one cycle is known as wave length .

Ans.2 Distance traveled by an EM wave to undergo a phase difference of $2\pi$ radians is called guide wave length.

Ans.3 Maximum wave length that can travel in a wave guide is called cut off wavelength.

Ans.4 $C = f \cdot \lambda$

Ans.5
- Wave meter
- Frequency down conversion method
- 2d method
- Double minimum method

Ans. 6 It is a cylindrical cavity resonator used to measure frequency.

Ans.7 $\lambda_c = 2ab / \sqrt{m^2 b^2 + n^2 a^2}$
$= 2ab / b = 2a.$

Ans. 8 With the help of local oscillator and mixer, the RF frequency is converted to low Frequency and then measured with conventional equipment.

Ans.9 It indicates that resonant frequency has been achieved and power transfer has taken place.

Ans.10 By changing the length of the cavity through movement of plunger.

# EXPERIMENT NO. 8

**AIM :-** To measure the impedance of unknown load.

**APPARATUS REQUIRED: -** Klystron tube, Klystron power supply, Klystron mount, Isolator, Frequency Meter, Slotted section, Tunable Probe, Variable Attenuator, Wave guide stand, VSWR meter, Movable short, Matched Termination, unknown load, Cables and accessories.

**THEORY :-** The waveform from generator incident on the load is reflected (if the load is not a characteristic impedance). The magnitude and hence VSWR, the phase and hence the relative position (with respect to short-circuit) of the SWR minimum, are characteristic properties of the load. Determining these, load can be determined.

The input impedance of a transmission line is given by

$$Z_m = \frac{V_s}{I_s} = \frac{V_g \cosh \gamma l + Z_0 I_g \sinh \gamma l}{I_g \cosh \gamma l + V_g/Z_o \sinh \gamma l}$$

For lossless line $\gamma = \alpha + j\beta$ ($\alpha = 0$) of $\Lambda l$ length

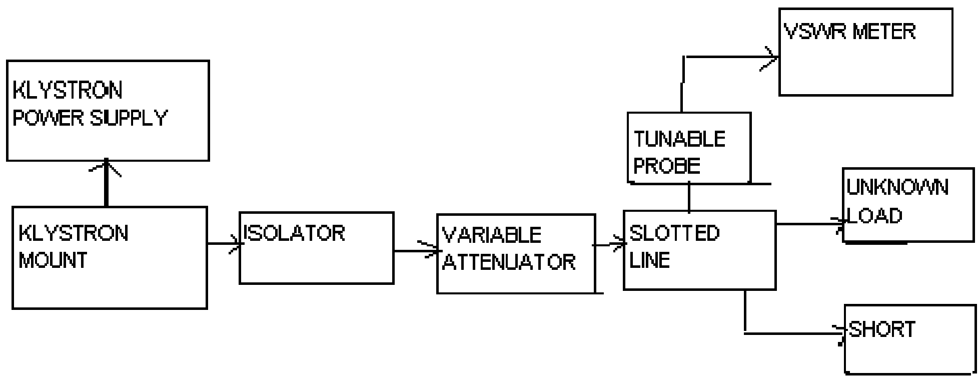
$$\text{So } Z_m = \frac{Z_0\,[Z_g + jZ_0 \tan \beta\Lambda l]}{[Z_0 + jZ_g \tan \beta \Lambda l]}$$

where Zg is, the impedance at the receiving end, Z0 is the characteristics impedance and Zm is the impedance at the input of the transmission line. $\beta \Lambda l$, being the electrical distance , is measured between position of termination and standing wave minimum.

$$\text{So } Z_g = \frac{Z_0\,[Z_{in} - jZ_0 \tan \beta\Lambda l]}{[Z_0 - jZ_{in} \tan \beta \Lambda l]}$$

$$= \frac{Z_0\,[1 - j\rho \tan \beta\Lambda l]}{[\rho - j \tan \beta \Lambda l]}$$

**Experimental setup**




Procedure

1. Set the components and equipments as shown in figure above.
2. Initially set the variable attenuator for maximum attenuation.
3. Terminate the receiving end with unknown load.
4. Keep the control knob of Klystron power supply

| | |
|---|---|
| Beam voltage | Off |
| Mod-switch | Am |
| Beam voltage knob | Full anti clockwise |
| Reflector voltage knob | Full clockwise |
| Am-amplitude knob | Full clockwise |
| Am frequency & amplitude knob | Mid position |

Switch On the klystron power supply,VSWR meter & cooling fan
Switch On the beam voltage switch and set beam voltage at 300 v
Rotate the reflector voltage knob to get deflection in VSWR meter
Tune the output by tuning the reflector voltage, amplitude and frequency of am modulation
Tune plunger of klystron mount and probe for maximum deflection in VSWR meter

5. Keep the control knob of VSWR meter as below:

| | |
|---|---|
| i. Switch | normal |
| ii. Input switch | low impedance |
| iii. Range db switch | 40db |
| iv. Gain control knob | Fully clockwise |

6. Connect detector output to SWR meter.
7. Adjust the square wave modulation frequency to approximately 1 KHz.
8. Tune the detector by adjusting short plunger for maximum meter deflection

9. Move the probe along slotted line, adjust it at standing wave minimum. Record the probe position as X,(this is the position of reference minimum) and next successive minimum position as X2.
10. Replace load by short circuit termination and move the probe carriage to new standing wave minimum and record the probe position as $X_s$ (This is known as position of reference plane)
11. Find the shift minima ($X_s \cdot X_2$ or Xs·X.). It will be positive if minimum is shifted towards load (i.e., for inductive load) and negative if minimum is shifted towards generator (for capacitive load). Shift in minimum for different loads can be easily known from the standing wave patterns given below.
12. Convert the shift in wavelength units, i.e., (X,X,). Wavelengths.
13. Position on minimum can be known more accurately if it is taken as midpoint of positions of equal responses on either side of minimum.

-

**OBSERVATIONS AND CACULATIONS:**

**PRECAUTIONS :-**

1. Use fan to keep the Klystron temperature low.
2. Ensure tight connections of the apparatus
3. Avoid cross connections of the threads.
4. Use stabilized power supply.

**QUIZ:**

Q1. For an open-ended rectangular waveguide antenna of size 0.9" *0.4" excited in the $TE_{IO}$ (dominant)-mode at λ..=3 cm, the gain is nearly

*(a)* 1.5 *(b) 2.5*
*(e)* 26.5 *(d) 36.5*

Q2. Consider the following statements regarding feed which is a key component of a reflector antenna as it has a decisive bearing on the overall performance:

(a)For a horn-food antenna, the reflector focus must coincide with horn-feed's phase centre, which for a wide-flare horn lies in the plane of the horn aperture.
(b) The feed must have minimal radiation outside the angular aperture of the reflector.
(c) In prime focus of Cassegrain systems, the main or sub reflector should be in Fraunhofer zone of the feel antennas.
Of these statements
(a) 1, 2 and 3 are correct (b) 1 and 2 correct
(c) 2 and 3 correct (d) 1 and 3 correct

Q3. On a slotted line terminated in a load, the minima of the standing wave pattern measured by a square-law device, are located at (on a cm scale) 9.5, 11.0, 12.5 and 14.0. At 10.95 and 11.05 the detected levels being twice the minimum level. The VSWR on the line is

a) 10 b) 20
c) 30 d) 50

Q4. A calorimetric measurement for average power of a signal gave a value of *400* W. The value was interpreted for peak power as 0.5 MW. Then the duty cycle of the signal is

(a) 0.08 per cent (b) 8 percent
(c) 40 percent (d) 80 percent

Q5.In microwave power measurements using bolometer, the principle of working is the variation of

*(a)* inductance with absorption of power
*(b)* resistance with absorption of power
*(c)* capacitance with absorption of power
*(d)* cavity dimensions with heat generated by the power

Q6.In wave meter the pointer is

a)oscillator b)Rotary
c)Stationary d) None

Q7.Tunnable probe exist over /in

a)VSWR meter b)Slotted section
c)Attenuator d)None

Q8.The method used to measure high VSWR is

a) Slotted line method b)Double minimum Method

c)Both d)None

Q9: In low VSWR method, in VSWR meter the pattern maximum is set to

a)One b)Zero

c) Both d)None

Q10: While measuring guided wave length the termination of the bench must be

a)Short b)Match

c) Open d) None

ANSWERS:

Q1: b
Q2: d
Q3: c
Q4: d
Q5: b
Q6: b
Q7: b
Q8: b
Q9: a
Q10: a

# EXPERIMENT NO. 9

**AIM :-**To Study working of Doppler Radar , and measure the of the velocity of the object moving in the Radar range

**APPARATUS REQUIRED:** A tripod stand, NV2001 trainer kit, SMPS supply, Trans-receiver P.C

**THEORY:-** A simple Doppler Radar sends out continuous sine waves rather than pulses. It uses the Doppler Effect to detect the frequency change caused by a moving target and displays this as a relative velocity. When the target is moving relative to Radar, an apparent shift in the carrier frequency of the received signal will result. This effect is called the Doppler Effect and it is the basis of continuous wave (CW) Radar.
The Doppler frequency is given by

$$F_d = \frac{2V_r}{\lambda} \text{Hz}$$

Or

$$F_d = \frac{2V_r F_t}{C} \text{Hz}$$

Where
Fd = Doppler frequency
Ft = transmission frequency.
Vr = Relative velocity of target with respect to Radar.
$\lambda$= Wavelength of transmitted wave.
C = Velocity of light.
The transmitter generates a continuous oscillation of frequency Fo that is radiated by the antenna. The target intercepts a portion of this radiated energy and the receiving antenna collects the reradiated energy. If the target is in motion with a velocity (Vr) relative to the Radar, the received signal will be shifted in frequency from the transmitted frequency Fo by an amount Fd. The plus sign for an approaching target and minus for a receding target. The received echo signal (Fo ± Fd) enters the Radar via the antenna and is mixed in a detector mixer with a portion of the transmitter signal 'Fo' to produce the Doppler frequency Fd. The purpose of using a amplifier is to eliminate the echo from stationary targets and to amplify the Doppler echo signal to a level where it can operate an indicating
device such as a frequency counter. Frequency from the transmitted frequency Fo by an amount Fd. The plus sign for an approaching target and minus for a receding target. The received echo signal

(Fo ± Fd) enters the Radar via the antenna and is mixed in a detector mixer with a portion of the transmitter signal 'Fo' to produce the Doppler frequency Fd

**<u>Experimental set up</u>**

**Procedure:-**

1. Fit the Trans-receiver unit on the tripod stand and adjust the suitable height for experiment.
2. Connect the SMPS supply to the trainer NV2001.
3. Connect the din connector cable from trainer board (left side of trainer) to Trans-receiver unit
4. Firstly Switch 'On' the SMPS supply and then "Power" switch on the trainer board.
5. Switch 'On' the buzzer on trainer board and set "Level" Potentiometer in fully clockwise direction.
6. Connect a CRO probe on test point of "Doppler Frequency Signal" (fd) and wave your hand or reflected in front of antenna.

7.For maximum gain detection adjust the "Detection Adjust" potentiometer in such a way that moving object in front of antenna can be detected with beep sound and also observe the signals on the Oscilloscope/DSO.

8. If any noise is observe on CRO then adjust the "Level" Potentiometer to reduce the noise.

9. Procedure for using Software

   a) Install the software and open it.

   b) Connect the audio cable from EP socket (left side of trainer) to line In/MIC in input (sound card input) of PC.

   c) Select "Start Acquisition" on the software window.

   d) If any noise is occur on software window then again adjust the "Level" potentiometer to reduce the noise.

   e) Now we can observe the waveform on PC. For measurements we have to select "Stop Acquisition" and then we can measure the frequency and time by selecting "Doppler frequency calculation".

**b)Determination of the velocity of the object moving in the Radar range**

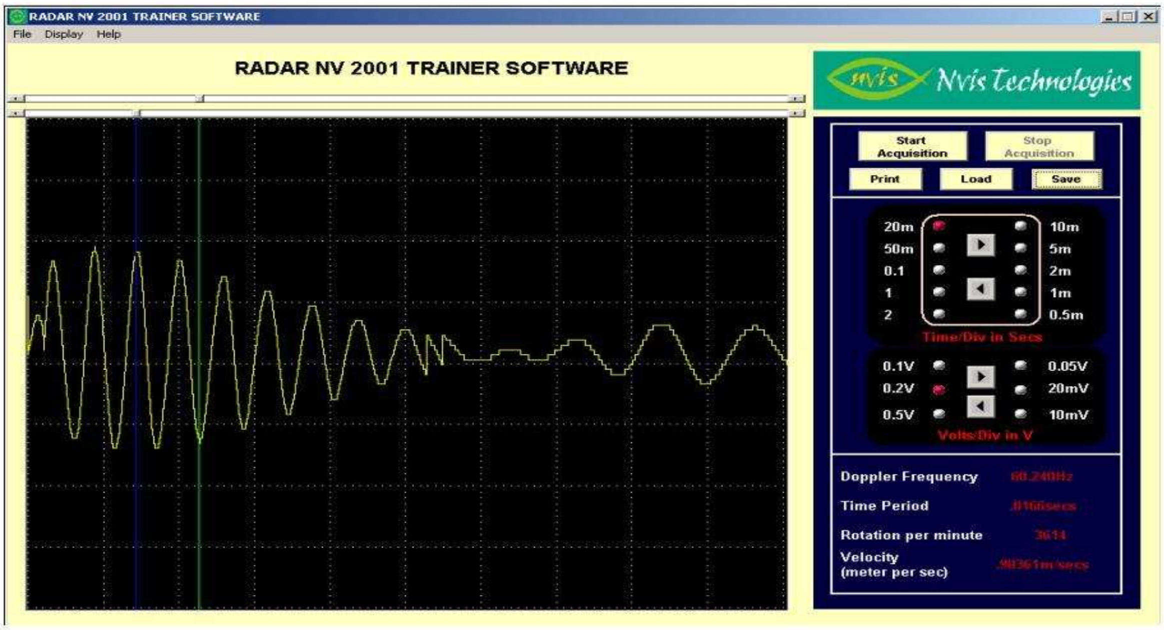
Procedure:

1. Follow the procedure as given in above from step 1 to 8
2. Connect the audio cable from EP socket (left side of trainer) to line In/MIC in input (sound card input) of PC.
3. Select "Start Acquisition" on the software window.
4. If any noise is occur on software window then again adjust the "Level" potentiometer to reduce the noise.
5. Keep the Sliding Platform for moving the object in front of Radar antenna.
6. Connect the metallic object on the sliding platform.

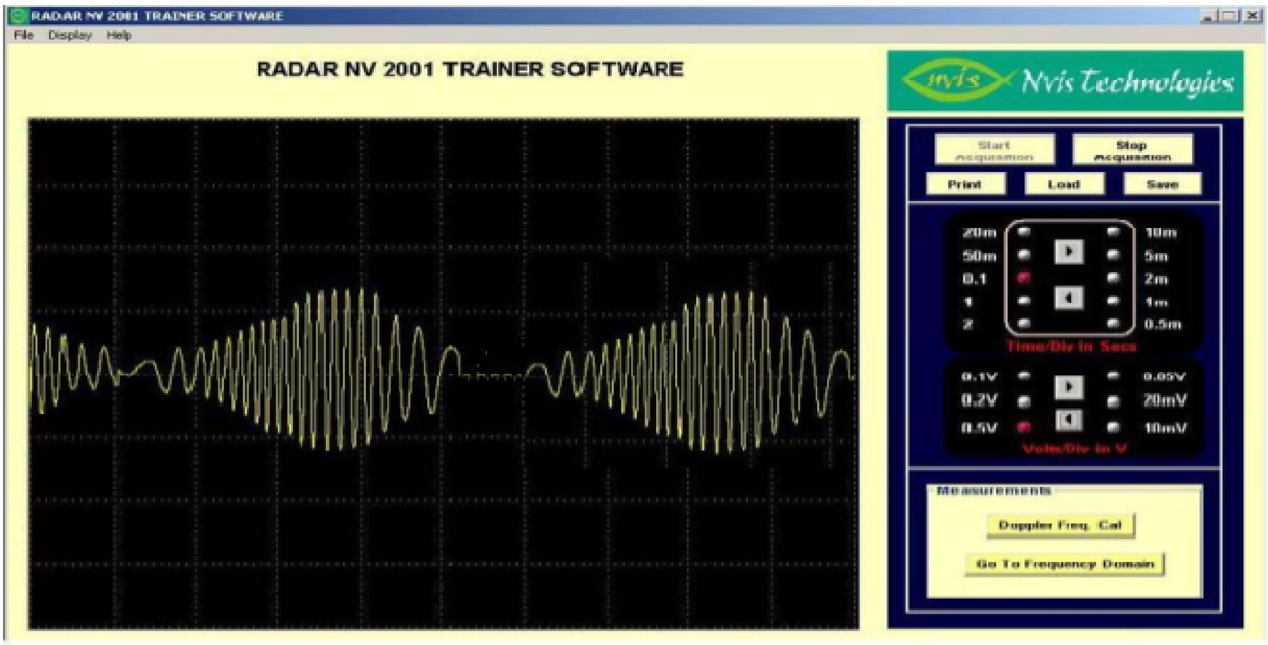
7 When object is moved slowly from right to left or left to right corresponding Doppler frequency can be observed and measured on test point '

8. Once the Doppler frequency is measured, velocity of object can be found out very easily.
9. Repeat the experiment by moving the object fast
10. Observe the change in Doppler frequency and the velocity of object.

## OBSERVATIONS




waveform in frequency and time domain is observed and calculated




Observe the change in Doppler frequency and the velocity of object.

# QUIZ

Q1.In a radar system ,the term rat –race is used in connection with

a)Modulator b)Pulse Characteristics

c) Receiver band width d)Duplexer

Q2.The type of radar that is used to eliminate clutter in navigational applications is

a) Pulse Radar b) Tracking Radar

c) MTI Radar d) Monopulse Radar

Q3.In microwave radar, pulse repetition frequency is used to resolve range and Doppler ambiguities using

a) CW Radar b) Pulsed Radar

c) Moving Target indicator d) Pulse –Doppler radar

Q4.A duplexer is used in a radar system to

1.protect the receiver when high power signal is transmitted

2. enable the use of a common antenna for transmission and reception

3. Allow antenna to only receive when the signal is arriving

4. Avoid noise interference in the radar system. Of these statements

a)1 and 2 are correct b) 3and 4 are correct

c)1 and 4 are correct d) 2 and 4 are correct

Q5.If the antenna diameter in a radar system is increased by factor of 9 , then the maximum range will increase by a factor of

a)$\sqrt{3}$ b) 3

c) 9 d) 81

Q6.The main component atmosphere for absorption of EM waves are

a)nitrogen oxygen b)Nitrogen and hydrogen

c) Oxygen and water vapor c) nitrogen and water vapor

Q7.If the minimum range is doubled in Radar ,the peak power has to be increased by a factor of

a) Two b)Four

c)Eight d) sixteen

Q8.Radiation for helical antenna is

a)Plane polarized b)Partially plane polarized

c)Circular polarized d)Elliptically polarized

Q9. The usable bandwidth of a microwave beacon transponder for 6/4 GHz Satellite communication is generally

a)360 MHz b)40MHz

c) 36 MHz d)1MHz

Q10.Radar where a single antenna is used for both transmitting and receiving is called

a) Monostatic Radar b)Bistatic Radar

b) Doppler Radar d)Pulsed Radar

A1.d
A2.c
A3.c
A4 .a
A5.c
A6.c
A7.d
A8.c
A9. c
A10.a

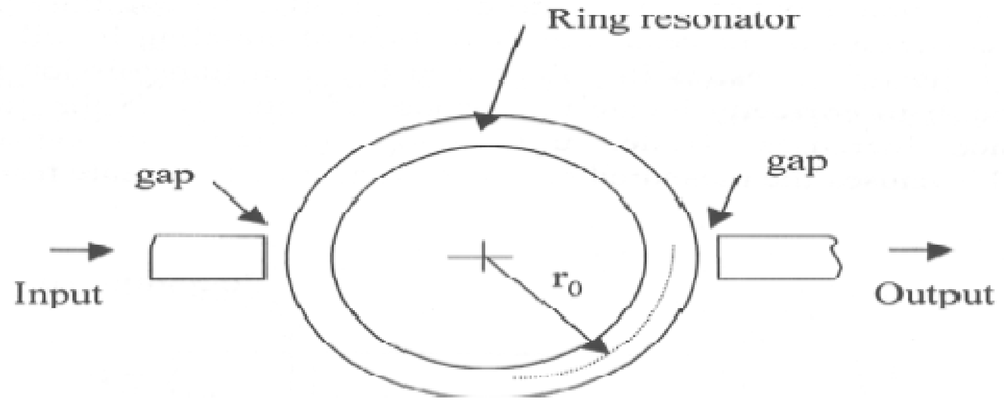
# EXPERIMENT NO. 10

**AIM :**Measurement of the resonance characteristics of a micro strip ring resonator

**APPARATUS REQUIRED:-** Microwave signal source (2.2 GHz) with modulation (1 KHz) Attenuator pad, VSWR meter, Micro strip ring resonator (DUT), Directional coupler, Detector, Matched load Cables and adapters

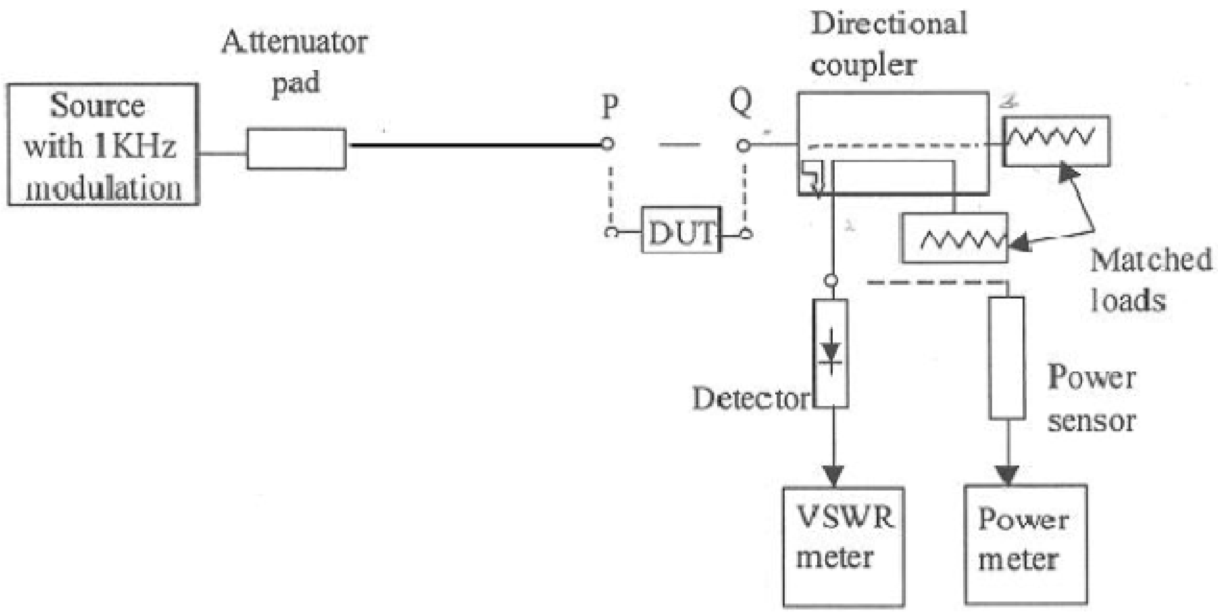
**THEORY:-**

The open-end effect encountered in a rectangular resonator at the feeding gaps can be minimized by forming the resonator as a closed loop. Such a resonator is called a ring resonator. The layout of a ring resonator along with the input and output feed lines. The coupling can be loose or tight depending on the gap width. Resonance is established when the mean circumference of the ring is equal to integral multiples of guide wavelength.




$$2\pi r_0 = n\lambda = \frac{n v_0}{f_0\sqrt{\varepsilon_{ef}}}, \qquad \text{For } n = 1, 2, 3$$

## EXPERIMENT SET UP




**PROCEDURE :-**

1. Assemble the set up as shown in above figure.
2. First connect P to Q directly.
3. Switch 'On' the source and the VSWR meter. (Before switching 'On' the source, ensure that there is sufficient attenuation to keep the RF output low)
4. Set the frequency of the source to 2.2 GHz. Adjust the power output of the source for a reasonable power indication on the VSWR meter. Note the reading of the VSWR meter. Increase the frequency of the source in steps of 0.1 GHz to 3 GHz and note the corresponding readings of the VSWR meter.
5. Now insert micro strip line ring resonator between P and Q.
6. Tabulate the results as per Table given below at frequencies from 2.2 to 3 GHz in steps of 0.1GHz.
7. Plot the transmission loss in dB as a function of frequency.
8. Identify a smaller frequency span of about 200 MHz around the minimum transmission loss. In this frequency range, repeat the measurements in smaller frequency steps (steps of 20 MHz) and locate the frequency at which the transmission loss reaches a minimum.

**OBSERVATIONS :-**

.

| Frequency F (GHz) | VSWR meter reading without ring resonator Pin(dB) | VSWR meter reading without ring resonator Pout(dB) | Transmission Loss S21(dB) |
|---|---|---|---|
| 2.2 -- 3.0 | | | |

## RESULT:-

The transmission loss response of the ring resonator is measured

**PRECAUTION:-**

**1.** Before switching 'On' the source set the RF attenuation to maximum so that the detector (or the sensor) does not receive the maximum power directly.

**2.** When using the VSWR meter, the 1 KHz modulation on the source must be 'On' and the frequency of modulation (1 KHz) must be adjusted precisely to maximize the output on the VSWR meter.

**3.** Power meter with sensor can be used in place of VSWR meter with detector. Modulation of the source is not required when using the power meter. In this case, it is important to ensure that the power applied to the sensor does not exceed the maximum rated power of the sensor.

.

## QUIZ

Q1.What is does MIC stand for?
Q2.Name the different transmission system utilized in MIC ?
Q3 What are the different categories of basic materials for MMICs.
Q4.Write the equation for the phase velocity of microwave strip line?
Q5.What are the ideal characteristics of substrate used for the fabrication of MMIC's?
Q6. Name the elements that can be used as conductor in MMIC's?
Q7.What are the desirable properties of Dielectric material?
Q8. What are the desirable properties of Resistive material?
Q9.Which element is used as a resistive materials for the fabrication MMIC's
Q10.What is the Disadvantage of MIC's

Ans 1: Microwave integrated circuits
Ans2: Micro strip line, lumped element circuits, thin film circuits
Ans3: Substrate material, conductor material, Dielectric films, resistive films
Ans 4: /√
Ans 5: high dielectric constant, low dissipation factor ,high purity ,surface smoothness.
Ans 6:Alumima, copper ,gold silver
Ans 7: Good reproductively, ability to undergo processes without developing pin holes, low RF dielectric losses, ability to with stand voltage
Ans 8: good stability, low temperature coefficient of resistance
Ans9: Cr,Cr-Sio,NiCr ,Ta and Ti
Ans10:MIC's have lower power handling capability

# EXPERIMENT NO. 11

**AIM :-**To study Magnetrons.

## CONSTRUCTION & BASIC OPERATION :-

*Basic Magnetron Structure*

The nucleus of the high-voltage system is the **magnetron tube**. The magnetron is a diode-type electron tube which is used to produce the required 2450 MHz of microwave energy. A magnetic field imposed on the space between the anode (plate) and the cathode serves as the grid. While the external configurations of different magnetrons will vary, the basic internal structures are the same.

The **ANODE** is a hollow cylinder of iron from which an even number of anode vanes extends inward. The open trapezoidal shaped areas between each of the vanes are resonant cavities that serve as tuned circuits and determine the output frequency of the tube. The anode operates in such a way that alternate segments must be connected, or strapped, so that each segment is opposite in polarity to the segment on either side. In effect, the cavities are connected in parallel with regard to the output.

The **FILAMENT**, which also serves as the **cathode** of the tube, is located in the center of the magnetron, and is supported by the large and rigid filament leads.

The **ANTENNA** is a probe or loop that is connected to the anode and extends into one of the tuned cavities. The antenna is coupled to the waveguide , a hollow metal enclosure, into which the antenna transmits the RF energy.

The **MAGNETIC FIELD** is provided by strong permanent magnets, which are mounted around the magnetron so that the magnetic field is parallel with the axis of the cathode.

*Basic Magnetron Operation*

The theory of magnetron operation is based on the motion of electrons under the combined influence of electric and magnetic fields. For the tube to operate, electrons must flow from the cathode to the anode. There are two fundamental laws that govern their trajectory:

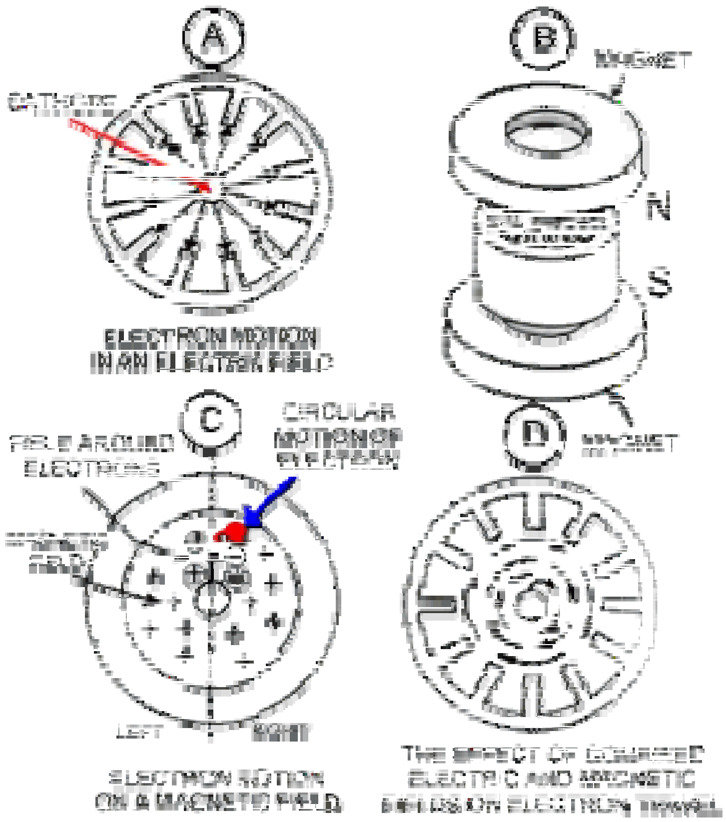



Figure 3 Electron motion in a magnetron tube
(Courtesy of Michael S. Wagner)

1. The force exerted by an electric field on an electron is proportional to the strength of the field. Electrons tend to move from a point of negative potential toward a positive potential. **Figure 3-A** shows the uniform and direct movement of the electrons in an electric field.
2. The force exerted on an electron in a magnetic field is at right angles to both the field itself, and to the path of the electron. The direction of the force is such that the electron proceeds to the anode in a curve rather than a direct path.

**Effect of the Magnetic Field**

In **Figure 3-B** two permanent magnets are added above and below the tube structure. In **Figure 3-C,** assume the upper magnet is a north pole and the lower is south pole, is located underneath the page, so that the magnetic field appears to be coming right through the page. Just as electrons flowing through a conductor cause a magnetic field to build up around that conductor, so an electron moving through space tends to build up a magnetic field around itself. On one side (left) of the electron's path, this self induced magnetic field adds to the permanent magnetic field surrounding it. On the other side (right) of its path, it has the opposite effect of subtracting from the permanent magnetic field. The magnetic field on the right side is therefore weakened, and the electron's trajectory bends in that direction, resulting in a circular motion of travel to the anode.

The process begins with a low voltage being applied to the filament, which causes it to heat up (filament voltage is usually 3 to 4 VAC, depending on the make and model). Remember, in a magnetron tube, the filament is also the cathode. The temperature rise causes increased molecular activity within the cathode, to the extent that it begins to "boil off" or emit electrons. Electrons leaving the surface of a heated filament wire might be compared to molecules that leave the surface of boiling water in the form of steam. Unlike steam, though, the electrons do not evaporate. They float, or hover, just off the surface of the cathode, waiting for some momentum.

**QUIZ:-**

Q.1 What is a magnetron?
Q.2 How many types of magnetron are there?
Q.3 What is negative resistance type magnetrons?
Q.4 What is cyclotron frequency magnetron?
Q.5 What is cavity magnetron?
Q.6 What is 'π' mode?
Q.7 What is mode jumping?
Q.8 What is strapping?
Q.9 What is frequency pushing of magnetron?
Q.10 What is pulling?

**ANSWERS :-**

Ans.1 It is a diode of cylindrical configuration, with a thick cylindrical cathode and co- axial cylindrical copper block as anode. The space between cathode & anode is used for interaction between electrons and electro magnetic field. It is an oscillator which gives output at RF frequencies and at high power.

Ans.2 Negative Resistance type, Cyclotron frequency type and Cavity type.

Ans.3 It makes use of negative resistance between two anode sections but have low efficiency.

Ans.4 It depend upon synchronism between an alternating component of electric and periodic oscillations of electrons in a direction parallel to this field.

Ans.5 It depends upon the interaction of electrons with a rotating electromagnetic field of constant angular velocity. This provides oscillations of very high peak power.

Ans.6 If relative phase shift of the AC electric field across adjacent cavities is 'π' radians, It called 'π'mode.

Ans.7 Resonant mode of magnetrons are very close to each other. There is always a possibility of mode jumping i.e. there shall be change in frequency. Mode jumping must be avoided.

Ans.8 Connection of alternate anode plates with two conducting rings of heavy gang, is called strapping. It helps in achieving dominant-mode.

Ans.9 Process of changing resonance frequency of magnetron, by changing the anode voltage, is called pushing.

Ans.10 Change in frequency of magnetron due to change in load impedance is called frequency pulling.

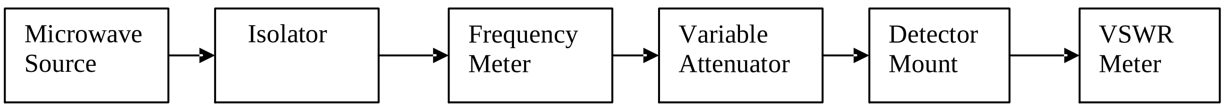
## EXPERIMENT NO:12

**AIM :-** To study the Characteristics of Reflex Klystron tube & to determine its electronic tuning range.

**APPARATUS REQUIRED** :- Klystron tube, Klystron power supply, Klystron mount, Isolator, Frequency Meter, Variable Attenuator, Detector mount, Wave guide stand, Cooling fan, VSWR meter, Cables and accessories.

**THEORY :-** The reflex Klystron makes use of velocity modulation to transform a continuous electron beam in to microwave power. Electron Beam emitted is accelerated towards the anode cavity. After passing the gap in the cavity electron travel towards the repeller electrode which is at a high negative potential ($V_r$). The electron beam never reach the repeller because of the negative field and returned back towards the gap. The accelerated electrons leave the resonator at an increased velocity and the retarded electrons leave at the reduced velocity. the electrons leaving the resonator will need different time to return, due to change in velocities. as a result, returning electrons group together in bunches. As the electron bunches pass through resonator, they interact with voltage at resonator grids. If the bunches pass the grid at such time that the electrons are slowed down by the voltage, energy will be delivered to the resonator; and klystron will oscillate. The dimension of resonant cavity primarily determines the frequency. A small frequency change can be obtained by adjusting the reflector voltage. This is called Electronic Tuning Range.

**BLOCK DIAGRAM:-**




**PROCEDURE: -MODE STUDY OF A KLYSTRON TUBE :-**

(1) Set the equipment as shown in fig.
(2) Initially set the variable attenuator for maximum position.
(3) Keep the control knobs of Klystron Power Supply as below:

| | | |
|---|---|---|
| Meter Switch | - | 'OFF' |
| Mod Switch | - | AM |
| Beam voltage knob | - | Fully anti-clockwise |

| | | |
|---|---|---|
| Reflector voltage | - | Fully anti-clockwise |
| AM- amplitude | - | Around fully clockwise |
| AM- frequency | - | Around mid position. |

(4) Keep the control knob of VSWR meter as below:

| | | |
|---|---|---|
| Meter Switch | - | Normal |
| Input Switch | - | Low Impedance |
| Range db Switch | - | 40 db |
| Gain Control knob | - | Mid position |

(5) Switch 'ON' the Klystron Power Supply, VSWR meter and Cooling Fan.
(6) Turn the meter switch of power supply to beam voltage position and set beam voltage at 300V with the help of beam voltage knob.
(7) Adjust the reflector voltage to get some deflection in VSWR meter.
(8) Maximize the deflection with AM amplitude and frequency control knob of power supply.
(9) Tune the plunger of Klystron Mount for the max. Output.
(10) Rotate the knob of frequency meter slowly and stop at that position, when there is 'dip' on VSWR meter. Read directly the frequency meter between two horizontal lines and vertical marker.
(11) Change the reflector voltage and read the frequency for each reflector voltage and plot the graph .

**OBSERVATIONS :-**

| S.NO | Repeller voltage | Frequency |
|---|---|---|
| | | |

**RESULT:-** Frequency and Repeller voltage curve is drawn and is in accordance with the stipulated curves of Klystron.

**PRECAUTIONS :-**

1. Use fan to keep the Klystron temperature low.
2. Ensure tight connections of the apparatus
3. Avoid cross connections of the threads.
4. Use stabilized power supply.

**QUESTIONS :-**

Q.1 How many cavity Reflex Klystron does have?
Q.2 On which principle Klystron tube operates?
Q.3 What are the applications of reflex klystron.
Q.4 On what principle multi cavity klystron Amplifier Works?
Q.5 What are different modes in a reflex Klystron?
Q.6 The Secondary cavity in a two-cavity klystron is called?
Q.7 What is the efficiency of Reflex Klystron?
Q.8 The single cavity in Reflex Klystron is acts as?
Q.9 What should be the transit time?
Q.10 Why negative voltage is given to the Repeller?

**ANSWERS :-**

Ans.1 Only one
Ans.2 Velocity Modulation.
Ans.3 As a Oscillator, Microwave generator.
Ans.4 Velocity modulation and Current modulation. Ans.5
They give same frequency but different transit time. Ans.6
Catcher cavity.
Ans.7 20% - 30%.
Ans.8 Both buncher and catcher cavity.
Ans.9 T = n + ¾
Ans.10 The electron beam should never reach the repeller because of the negative field and returned back towards the gap.

# EXPERIMENT NO. 13

AIM : - To measure the gain of a waveguide horn antenna.

**APPARATUS REQUIRED :-** Microwave source, Frequency meter, Isolator, Variable attenuator, Detector mount, Two horn antenna, Turn table, VSWR meter and Accessories.

**THEORY**: - If a transmission line propagating energy is left open at one end, there will be radiation from this end. In case of a rectangular waveguide this antenna presents a mismatch of about 2 : 1 and it radiates in many directions. The match will improve if the open waveguide is a horn shape.
The radiation pattern of an antenna is a diagram of field strength or more often the power intensity as a function of the aspect angle at a constant distance from the radiating antenna. The power intensity at the maximum of the main lobe compared to the power intensity achieved from an imaginary Omni directional antenna (radiating equally in all direction) with the same power fed to the antenna is defined as in gain of the antenna.

## 3 db Beam Width

The angle between the two points on a main lobe where the power intensity is half the maximum power intensity.
When measuring an antenna pattern, it is normally most interesting to plot the pattern far from the antenna.

Far field pattern is achieved at a minimum distance of

$$\frac{2D^2}{\lambda_0} \quad \text{(for rectangular Horn Antenna)}$$

where D is size of the broad wall of horn aperture in free space wave length.

It is also very important to avoid disturbing reflection. Antenna measurement are normally made at outdoor rangers or in so called anechoic chambers made of absorbing materials. Antenna measurements are mostly made with unknown antenna as receiver. There are several methods to measure the gain of antenna. One method is to compare the unknown antenna with a standard gain antenna with known gain. An another method is to use two identical antennas, as transmitter and other as receiver from following formula the gain can be calculated.

$$P_r = \frac{P_t \lambda_0 G_1 G_2}{(4 \pi S)^2}$$

Where, $P_t$ = transmitted power

$P_r$ = received power

$G_1$ , $G_2$ = gain of transmitting and receiving antenna,

S = radial distance between two antenna

$\lambda_0$ = free space wave length.

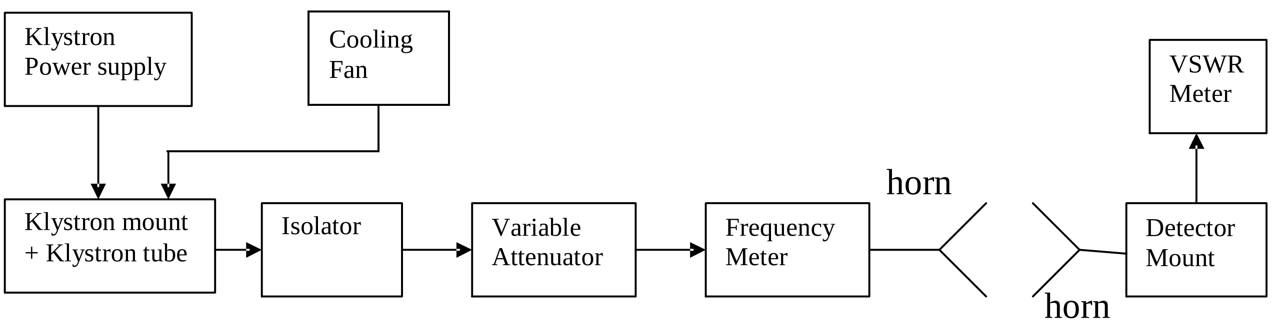
If both transmitting and receiving antenna are identical having gain G, then

$$P_r = \frac{P_t \lambda_0 G^2}{(4 \pi S)^2}$$

$$G = \frac{4 \pi S}{\lambda} \sqrt{P_r / P_t}$$

In the above equation $P_t$ , $P_r$ , S and $\lambda_0$ can be measured and gain can be computed. As from the above equation it is not necessary to know the absolute value of $P_t$ and $P_r$ only ratio is required, which can be measured by VSWR meters.

BLOCK DIGRAM:




**PROCEDURE: -**

GAIN MEASUREMENT

1. Set up the equipments as shown in Fig. Both horns should be in line.
2. Keep the range db switch of VSWR meter at 50 db position with gain control full.
3. Energize the Gunn Oscillator for maximum output at desired frequency with modulating amplitude and frequency of Gunn Power Supply and by tuning of detector.

4. Obtain full scale deflection in VSWR meter with variable attenuator.
5. Replace the transmitting horn by detector mount and change the appropriate range db position to get the deflection on Scale (do not touch the gain control knob). Note and record the range db position and deflection of VSWR meter.
6. Calculate the difference in db between the power measured in step 4 and 5.
7. Convert G into db in above example

   G db = 10 log 318 = 15.02 db

8. The same set up can be used for other frequency of operation.

## OBSERVATIONS AND CALCULATIONS:

## CONCLUSIONS AND RESULT:

## PRECAUTIONS :-

1. Use fan to keep the Klystron temperature low.
2. Ensure tight connections of the apparatus
3. Avoid cross connections of the threads.
4. Use stabilized power supply.

**QUIZ:**

Q1. In satellite communication, highly directional antennas are used to
*(a)* direct the spot beam to a particular region of space on Earth
*(b)* strengthen the beam to overcome the cosmic noise
*(c)* make corrections in change of polarization of the beam
*(d)* select a particular channel in transmission and reception

Q2. Which one of the following is caused by reflection from stratified atmosphere from the surface or land conditions along the path?
*(a)* Multipath fading *(b)* Selective fading
*(c)* Fast fading *(d)* Reflection fading

Q3.The transit time (in cycles) for the electrons in the repeller- space of a reflex klystron oscillator for sustaining oscillations is (*n* is any integer including zero)
*(a)* $2(n - 1)$ *(b)* $2n - 1$

*(c)* $n+1/2$ *(d)* $n+3/4$

Q4. Which one of the following can be used for amplification of microwave energy ?
*(a)* Travelling wave tube *(b)* Magnetron
*(c)*· Ref1ex klystron *(d)* Gunn diode

Q5. In the case of a cubic cavity resonator, the degenerate modes would include
*(a)* TMlll, TEoll and TElOl
*(b)* TMllO, TEoll and TElll
*(c)* TMllO, TEo12 and TE102
*(d)* TMllO , TEoll and TElOl

Q6.In the bench the source is modulated by a frequency
a)1 KHz b)10KHz
c)100KHz d)None

Q7.Guide wave length does not depend upon
a)termination b)frequency
c)mode of wave d) none

Q8. Klystrons are modulated by square waves because
a) It is easy generative a square wave b) It prevents frequency modulation
c) Detector circuit is easy to design d) The termination is less complicated.

Q9.The main component atmosphere for absorption of EM waves are

a)nitrogen oxygen b)Nitrogen and hydrogen

c) Oxygen and water vapor c) nitrogen and water vapor

Q10.If the minimum range is doubled in Radar ,the peak power has to be increased by a factor of

b) Two b)Four

c)Eight d) sixteen

**ANSWERS:** Q1:a
Q2: a
Q3: d
Q4: a
Q5: a
Q6 :a
Q7 :a
Q8 :a
Q9 :c
Q10:d

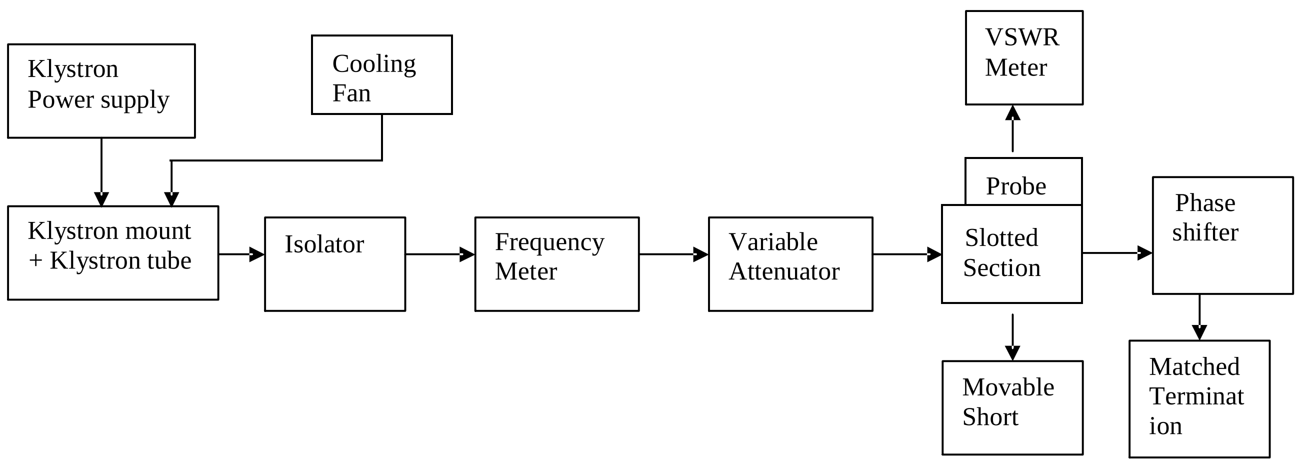
# EXPERIMENT NO. 14

**AIM : -** To study the phase shifter.

**APPARATUS REQUIRED :-** Microwave source, Isolator, Variable attenuator, Frequency meter, Slotted line, Tunable probe, Phase shifter, Movable short, VSWR meter, Cables and Accessories.

**THEORY**: - A phase shifter consists of a piece of waveguide and a dielectric material inside the waveguide placed parallel to Electric vector of TElO mode. The phase changes, as a piece of dielectric material is moved from edge of waveguide towards the centre of the waveguide.

## BLOCK DIAGRAM: -




## PROCEDURE: -

1. Set up the equipment as shown in the Fig.
2. First movable short is placed at the end of slotted line.
3. Energize the microwave source for maximum output at particular frequency of operation.
4. Find out the $\lambda g$ with the help of tunable probe slotted line and VSWR meter. It is the twice the distance between two minima on the slotted line.
5. Find out the operating frequency for frequency meter or by relation of $\lambda g$.
6. Find out $\lambda$ as

$$\lambda = c/f \quad \text{or} \quad 1/\lambda^2 = 1/\lambda_g^2 + 1/\lambda_c^2$$

7. Note and record a reference minima position on the slotted line. Let it is X.
8. Remove carefully the movable short from the slotted line without disturbing any position on the set up, place the phase shifter to the slotted line with its micrometer reading zero and then place the movable short to the other port of phase shifter.
9. Find out a new minima position let it is *Y*.
10. Change the position of micrometer of phase shifter and find out the corresponding position of new minima, let it is Yi.

## CALCULATION :

Since new minima is multiple of half wave-length from the short, it should be possible to calculate the exact electrical length of phase shifter. For example suppose at 10 GHz a reference minima is found at X = 16.08 cm.
Now suppose that phase shifter is two wave-lengths long and placed on the line as in step 8, the new minima $y$ = 14.90 cm is obtained.
Hence, short has apparently moved 16.08 - 14.90 = 1.18 cm. This can be written in form of as

$$\lambda\,(.393) = (1.18)\,\lambda/3$$

Since the apparent movement is in the direction the short actually moved, it is added to the approximate number of half wave length in the phase shifter. The total electrical length is 2.393 wave lengths. The phase shift in radians is found as below:
Multiply by 2 $\pi$ to give phase shift in radius or by $360^0$ to give phase shift in degrees.
Phase shift in above example
= 2 $\pi$ x 2.393 radians
= 360 x 2.393 degrees
The phase shift for other micrometer reading position can be found as above.

## RESULTS:

## PRECAUTIONS :-

1. Use fan to keep the Klystron temperature low.
2. Ensure tight connections of the apparatus
3. Avoid cross connections of the threads.
4. Use stabilized power supply.

## QUIZ:

Q1. In a hollow rectangular waveguide, the phase velocity
*(a)* increases with increasing frequency
*(b)* decreases with increasing frequency
*(c)* is independent of frequency
*(d)* will vary with frequency depending 'Upon the frequency range

Q2. A hollow cubic cavity resonator has a dominant resonant frequency of 10 GHz. The length of each side is

(a) √3 cm (b) √3/2
(c) √2 (d) 3/√2

Q3. In a rectangular waveguide, with *a = 2b*, if the cut- off frequency for $TE_{zo}$ mode is 16 GHz, then the cut-off frequency for the $TM_{ll}$ mode will be
*(a)* 32 GHz *(b)* 8 GHz
*(c)* 4 √3 GHz *(d)* 8√5 GHz

Q4. Evanescent mode attenuation in a waveguide depends upon the
*(a)* conductivity of the dielectric filling the waveguide
*(b)* operating frequency
*(c)* conductivity of the guide walls
*(d)* standing waves in the guide

Q5. A transmitter in free space radiates a mean power *of 'P'* Watts uniformly in all directions. At a distance '*d*'', sufficiently far from the source, in order that the radiated field is considered as plane, the electric field *'E'* should be related to *'P'* and 'd'*'* as

(a) E ∞ Pd (b) E ∞ P/d
(c) E ∞ √Pd (d) E ∞ √P/d

Q6. A loss-less line having characteristic impedance Zo is terminated in a pure reactance of value -jZo. The VSWR of the line will be
(a) 10 (b) 2
(c) 1 (d) infinite

Q7. A cylindrical cavity resonator has a diameter of 16 mm. What is the dominant resonant mode when the cavity length is i) 20 mm and ii) 15mm

(i) (ii)
(a)TEll1 M11l (c) TEl1l TMolO
(i) (ii)
(b) TMolO TE111
(d) TM11l TEo

Q8. In a circular waveguide with radius *'r'*, the dominant mode is
*(a)* TMol *(b)* TEol
*(c)* TMl1 *(d)* TEl1
Q9: The input impedance of a short circuited loss less line of length λ/8 is
a) Zero b)Resistive
c)Inductive d)Capacitive
Q10:Which of the following is capable giving highest data speed?
a)Coaxial cable link b)Microwave LOS link
c)Microwave satellite System d)Optical Fiber system

**ANSWERS:** Q1: b
Q2: a
Q3: d
Q4: a
Q5: d
Q6:d
Q7 :a
Q8:d
Q9 :c
Q10:d

# EXPERIMENT NO. 15

**AIM : -** To determine the dielectric constant of a material.

**APPARATUS REQUIRED :-** Klystron power supply, Klystron tube, Isolator, Frequency meter, Variable attenuator, Detector mount, Waveguide containing sample material.

**THEORY**: The most general description for electromagnetic purposes of a given homogeneous material is given by complex permittivity (Dielectric constant) together with complex magnetic permittivity.

By Maxwell's equation

$\nabla \times E = -\partial B/\partial t, \quad \nabla \times H = \partial D/\partial t + \sigma E, \quad (1)$

Since $B = \mu * H, D = \varepsilon E \quad (2)$

where σ = conductivity of materials

$\nabla \times E = -j\omega\mu^* H, \quad \nabla \times H = j\omega\varepsilon E + \sigma E \quad ... (3)$

where $\mu^*$ = complex permeability

$\varepsilon$ = (Real) Dielectric Constant

The equation (3) can be written

$XH = j\omega (\varepsilon - j\sigma/\omega)E$

where E" = $\varepsilon - j\sigma/\omega$ is complex dielectric constant.

The above equation can also be written as $\varepsilon = \varepsilon_o (\varepsilon ' - j \varepsilon '')$

where $\varepsilon '' = \sigma / \omega\varepsilon$ and $\varepsilon ' = \varepsilon / \varepsilon_0$

"

E , .

$\varepsilon_r = \varepsilon / \varepsilon_o = \varepsilon' - j\varepsilon''$

In the above terms $\varepsilon ''$ is called loss factor and $\varepsilon '$ associated with ability of material to store electric energy.

It is also useful to write the relative dielectric constant as

$\varepsilon_r = \varepsilon ' (1 - j \tan \delta)$

where $\tan \delta = \varepsilon '' / \varepsilon '$

The tan δ is referred as loss tangent.

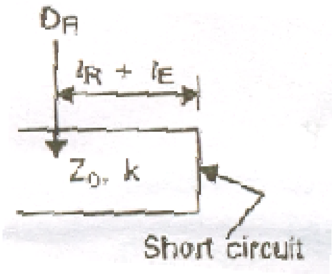
The dielectric constant is not independent of frequency and stays constant only over small portion of frequency spectrum. In many cases E $r$ is effected by temperature and humidity. So that the above should be held reasonably constant during measurements.

The accuracy of measurement largely depends on the smoothness of the sample, that fit of sample in waveguide and care which has been taken to insure that its surfaces are properly 'squared' w.r.t. each other. It is therefore, advisable to machine samples very carefully for smoothness, size, and squared surface.

*Dielectric Measurement Method*

The Fig1. shows an empty short circuited waveguide with a probe located as voltage minimum DR, Fig. 2 shows the same waveguide containing sample of length IE with a probe located at new voltage minimum D. The sample is adjacent to short circuit. We know

tan *I*K (DR - D - IE) tan *I*K *I*E kE
k/E kE /E



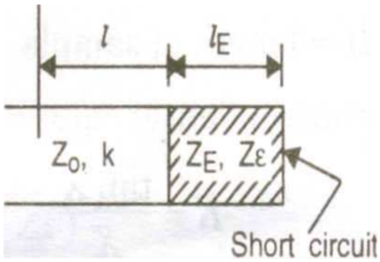
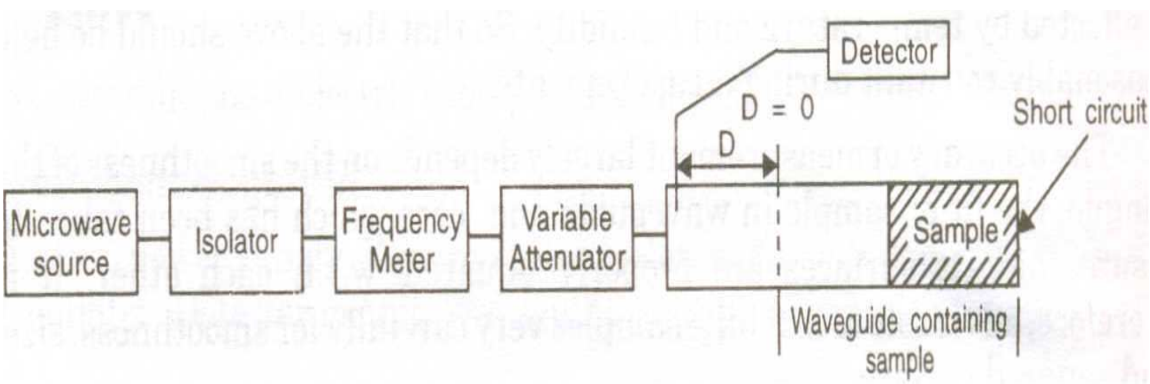




fig 1 fig 2

**BLOCK DIAGRAM**: -



We find that all the quantities associated with left hand are measurable. While right hand is of the form tan z/z, so that once the measurement has been performed, the complex number, Z = kE /E can be found by solution of transcendental equation and from it kE. Of-course E r follows readily from kE. In view of periodic nature of tangent function, there exist a infinite solution for εr• Hence it is necessary to know E r approximately in order to pick up write solution or to perform a second identical experiment with other sample of different length. The proper solution in the latter case are, common to the two sets of solution.

**PROCEDURE: -** The basic arrangement of equipment is as in Fig.

1. With no sample in short circuited line find position of voltage minima *DR* w.r.t. an arbitrarily chosen reference. With the help of slotted section and probe.
2. Measure the guide wave length $\lambda g$ by measuring the distance between two adjacent minima in slotted line.
3. Remove short circuit, insert a sample and replace the short circuit in such a manner that it touches the end of sample.
4. Measure *D,* the position of minima in slotted line with respect to same reference as in 2.
5. Measure VSWR *(r)* in the slotted line.

Case 1 : Analysis Case-Dielectric Sample (Loss less)

1. Compute propagation constant

$$k=2\pi/\lambda g$$

2. Compute

K=tan[k(Ie+Dr-D)]/k/e

where le = length of sample

3. Solve transcendental equation for X

$$K- \frac{\tan X}{-\ X}$$

If dominant mode is propagating through waveguide the dielectric, constant ε' is as follows

$$\varepsilon' = \frac{(a/\pi)^2 (X'/Le)^2 + 1}{(2a/\lambda g)^2 + 1}$$

where, *a* = width of waveguide

λg = guide wave length

$$X'/Le = \frac{X \text{ (determined earlier)}}{\text{length of sample}}$$

$X'/Le=X/L1e=X/L2e$

Case 2: Complex Dielectric Sample (Lossy)

If dielectric constant is complex, *i.e.*, *V* not=∞, compute as follows:

1. determine $k=2\pi/\lambda g$
2. compute

   $$\varphi=2k\,(D-DR-Le)$$

3. Compute

   $$[T]=r-1/r+1$$

4. Determine the complex number $C<\psi$

   $$C<-\psi=1/jkle\frac{(1-[T]e^{j\varphi})}{(1+[T]e^{j\varphi})}$$

5. solve the complex eq. for T and t

   $$C<-\psi=\frac{\tan h(T<t)}{T<t}$$

   The admittance ye is given from

   $$Ye=(T/kle)^2<2(t-90^0)$$

6. Compute εr as follows

   $$Ye=Ge+j\beta e$$

   $$\varepsilon'=\frac{Ge+(\lambda g/2a)^2}{1+(\lambda g/2a)^2}$$

   $$\varepsilon''=\frac{-\beta e}{1+(\lambda g/2a)^2}$$

## OBSERVATIONS AND CALCULATION :

## PRECAUTIONS :-

1. Ensure tight connections of the apparatus
2. Avoid cross connections of the threads.
3. Use stabilized power supply.

.

**QUIZ:**

Q1. A micro strip line on alumina substrate (E *r* = 9) has a zero thickness strip of width, *W* = 3 mm. Substrate thickness *h* = 0.5 mm. Assuming TEM wave propagation and negligible fringing field, the characteristic impedance of the line will be approximately

*(a)* 10 Q *(b)* 21 Q
*(c)* 26 Q *(d)* 50 Q

Q2. If H=0.2cos(wt-bx)$a_z$ A/m is the magnetic field of a wave in free space, then the average power passing through a circle of radius 5 cm in the *x* = 1 plane will be approximately

*(a)* 30 mW *(b)* 60 mW
*(c)* 120 mW *(d)* 150 mW

Q3. An attenuator drops a 10 V signal to 50 m V In an experiment. The loss in decibels is

*(a)* - 40 dB (c) -55 dB
*(b)* - 46 dB *(d)* - 60 dB

Q4.Which of the following pairs of types of wave propagation and associated property are correctly matched?

(a) Surface wave Vertical polarization.
(b)Duct propagation Super refraction.
(c)Sky wave Critical frequency.

Select the correct answer using the codes given below:
Codes:

(a) 1, 2 and 3 (b) 1 and 2
(c) 1and 3 (d) 2 and 3

Q5. For reliable "beyond-the-horizon" microwave communication, without using repeaters, the frequency of choice would be

*(a)* 1 MHz *(b)* 30 MHz
*(C)* 2000 MHz *(d)* 30,000 MHz

Q6. What is wavelength?

Q7. What is guide wavelength '$\lambda_g$'?

Q8.What is cut off wavelength for a wave-guide?

Q9. What is the relationship between frequency and velocity of light?

Q10.Name various methods that can be used to measure frequency / wavelength.

**ANSWERS:** Q1: b
Q2: b
Q3: b
Q4: a
Q5: b

Ans.6 .Amount of distance travelled by electromagnetic wave in one cycle is known as wave length .

Ans.7 Distance traveled by an EM wave to undergo a phase difference of $2\pi$ radians is called guide wave length.

Ans.8. Maximum wave length that can travel in a wave guide is called cut off wavelength.

Ans.9 $C = f \cdot \lambda$

Ans.10
- Wave meter
- Frequency down conversion method
- 2d method
- Double minimum method