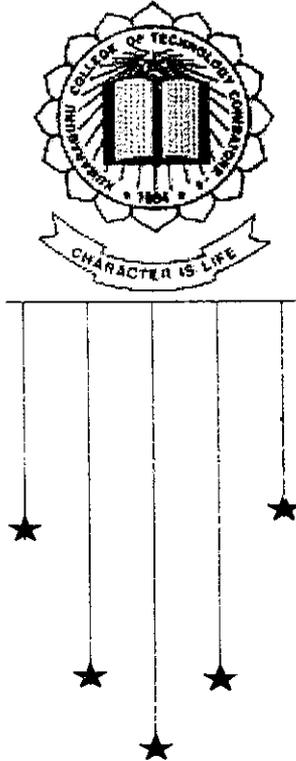


# MICROCONTROLLER BASED SYSTEM FOR MEASUREMENT OF MOTOR PERFORMANCE

P-524



**PROJECT REPORT**  
**2000 - 2001**

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**MICROCONTROLLER BASED SYSTEM FOR MEASUREMENT  
OF MOTOR PERFORMANCE.**

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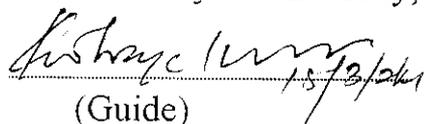
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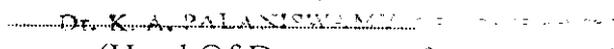
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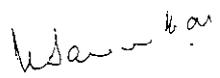
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P-524

*DEDICATED*

*TO MY*

*BELOVED PARENTS*

# *ACKNOWLEDGEMENT*

## ACKNOWLEDGEMENT

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# *SYNOPSIS*

## **SYNOPSIS**

In the conventional method of measurement of performance of a three phase induction motor different tests are to be conducted in order to calculate the desired values. This method is laborious as well as time consuming.

In this project a Micro controller based system for measurement of motor performance is proposed to measure various performance data such as torque, power and speed of the motor.

The present investigation has succeeded in overcoming all the difficulties in the conventional method.

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# *CHAPTER I*

## *INTRODUCTION*

## **CHAPTER I**

### **INTRODUCTION**

This project is designed for microcontroller based system for measurement of motor performance. The strain gauge is one type of torque transducer which is used to measure the linear mechanical displacement into electrical voltage which can be satisfactorily controlled by using signal conditioning unit. Most of the real world physical quantities are available in the form of analog. Therefore for further processing and displaying purpose, it is often convenient to express in digital form by using analog to digital converter. It employs state of art of microcontroller ATME89C51 technique for measurement and control purpose. Finally the motor output can be displayed by using seven segment LED display.

# *CHAPTER I I*

## *FUNCTIONAL DESCRIPTION*

## CHAPTER II

### FUNCTIONAL DESCRIPTION

Torque of the motor output can be directly measured by using torque transducer. The block diagram of direct measurement of motor output using torque transducer is shown in Fig.2.1

#### 2.1 Torque transducer

Transducer is a device, which converts energy from one form to another form. The type of torque transducer used is strain gauge. The force is first detected by the column and is converted into strain, which is mechanical displacement. Motor output is coupled to torque transducer, which produces linear displacement.

#### 2.2 Load cell

Strain gauges are attached to any elastic member on which their exceeds a suitable plane to accommodate them. Load cell may then be used to measure the load applied to deform the deflecting member, provided that the resultant strain is large enough to produce detectable output when the **strain gauge –elastic member** combination is used for weighing. Load cell is used to convert linear displacement into electrical voltage.

#### 2.3 Signal conditioning unit

The output of first stage has to be modified before it becomes unable and satisfactory to drive the signal presentation stage. The

signal conditioning or data acquisition equipment in many situations is an excitation and amplification system for passive transducer.

It may be amplification system for active transducer, the transducer output up to sufficient level to make it useful for conversion, processing indicating and recording.

Excitation is needed for passive transducer because the transducer does not generate their own voltage or current.

#### **2.4 Analog to digital converter**

Most of the real world physical quantities such as voltage, current, temperature, pressure and time etc are available in analog form. Therefore for processing transmission and storage purpose, it is often convenient to express this variable in digital form. Output of ADC is given to micro controller device.

#### **2.5 Display unit**

The last stage measurand system is data presentation stage, which consists of data presentation element.

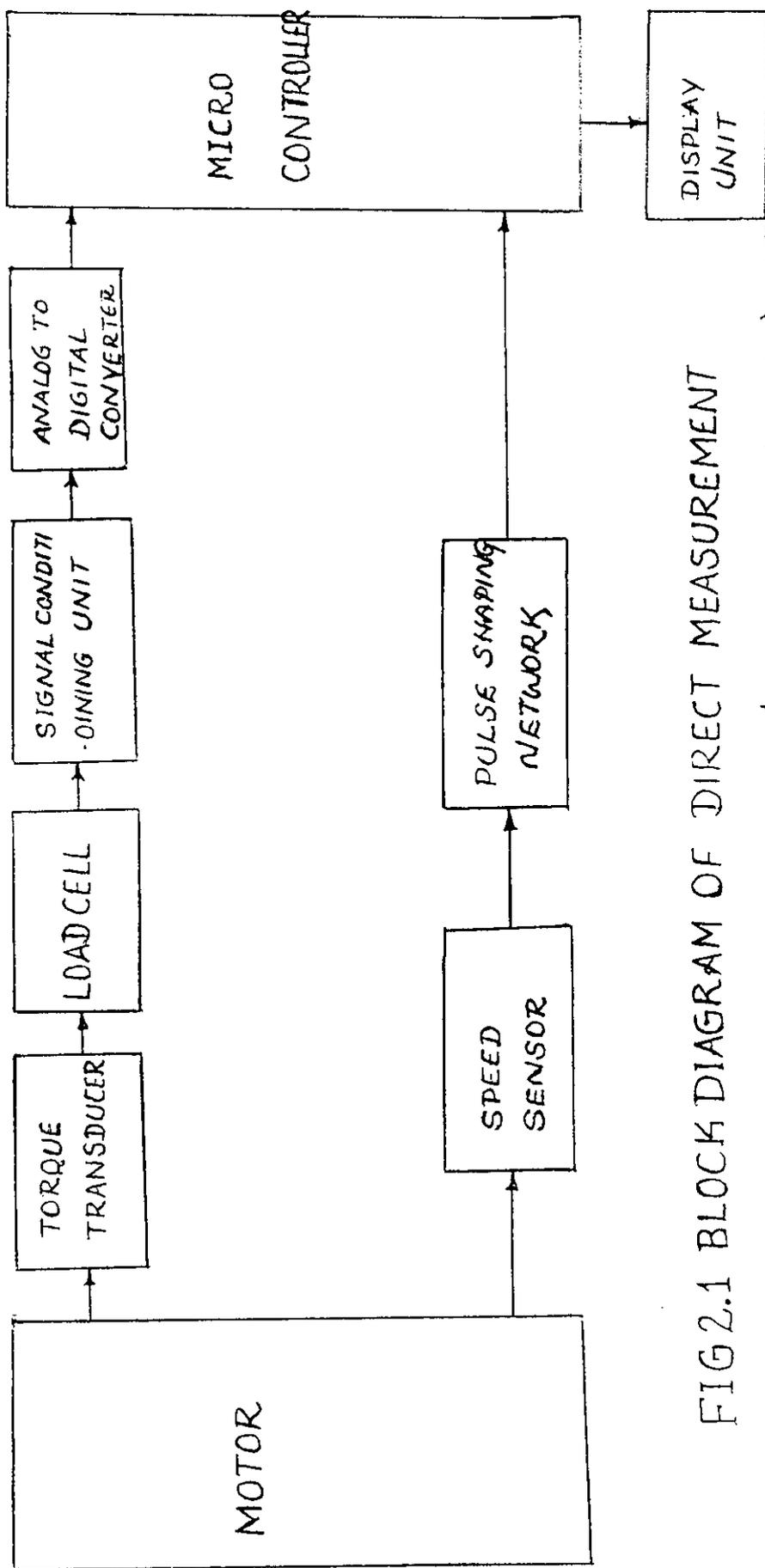


FIG 2.1 BLOCK DIAGRAM OF DIRECT MEASUREMENT OF MOTOR OUTPUT USING TORQUE TRANSDUCER

# *CHAPTER III*

## *TRANSDUCER & TORQUE MEASUREMENT*

## CHAPTER III

### TRANSDUCERS AND TORQUE MEASUREMENT

An electronic instrumentation system consists of a number of components to perform a measurement and record its results. A generalized measurement system consists of three major components

1. Input device
2. signal conditioning or processing device
3. Output device

The input device receives the measurand or quantity under measurement and delivers a proportional or analogous electrical signal to the signal-conditioning device. Here the signal is amplified, attenuated, filtered, modulated or otherwise modified in format acceptable to the output device.

The input quantity for the most instrumentation system is a non electrical quantity . In order to use electrical methods and techniques for measurement, manipulation or control, the non electrical quantity is generally converted into an electrical form by a device called “**Transducer**”. We can define a transducer as a device which, when activated transforms energy from one form to another.

### 3.1 Electrical transducer

The art of electrical measurements has been chiefly used for measurement of electrical quantities but its value in making measurement of non-electrical quantities in this new era of automation is rapidly growing. In order to measure non-electrical quantities a detector is used which usually converts the physical quantity into displacement. This displacement actuate an electrical transducers which acting as a secondary transducer, gives an output that is electrical in nature. The electrical quantity so produced is measured by standard methods used for electrical measurements. The result gives the magnitude of the physical quantity or condition being measured.

The electrical signal may be a current or a voltage or a frequency and production of this signals is based upon the electrical effects which may be resistive, capacitive, inductive etc in nature.

The first stage of measurement system may simply be called a transducer stage instead of detector transducer stage by redefining of transducer stage. However this definition has to be restricted many times especially in the field of electrical instrumentation. Keeping in restriction in view, a transducer may be defined as a device, which converts a physical quantity or a physical condition into electrical signal. Another name of transducer is “**PICKUP**”.

The transducer consists of two parts.

- 1.Sensing element.
- 2.Transduction element

### **3.1.1.Sensing (or) detector element**

A detector or sensing element is that part of transducer which responds to a physical phenomenon or change in a physical phenomenon. The responses of the sensing element must be closely related to the physical phenomenon.

### **3.1.2. Transduction element**

A transduction element transforms the output of a sensing element to an electrical output. The transduction element, in a way acts a secondary transducer.

### **3.1.3.Advantage of electrical transducer**

- Electrical amplification and attenuation can be done easily.
- The mass inertia effect is minimized.
- The effect of friction is minimized.
- The electrical or electronics system can be controlled with very small power.
- The electrical output can be easily used, transmitted and processed for purpose of measurement.

## **3.2 Classification of transducers**

- 1.On the basis of transduction form used
- 2.As primary and secondary transducer
- 3.As passive and active transducer
- 4.As analog and digital devices
- 5.As the transducer and inverse transducer

### **3.2.1 Primary transducer**

The bourdon tube acting as a primary detector sense the pressure and converts pressure into displacement.

### **3.2.2 Secondary transducer**

The secondary transducer is a device, which converts displacement into electrical output voltage.

### **3.2.3 Passive transducer**

Passive transducers derive the power required for transduction from an auxiliary power source. They also known as “**Externally Powered Transducers**”.

### **3.2.4 Active transducer**

Active transducers are those, which do not require an auxiliary power source to produce their output. They are also known as “**self generating type**” .

### **3.2.5 Resistive transducer**

It is generally seen that methods, which involve the measurement of change in resistances, are preferred to those employing other principles. This is because both alternating as well as direct current and voltages are suitable for resistances measurement.

The resistance of a metal conductor is expressed by a simple equation that involves a few physical quantities. The relationship is

$$R = \frac{\rho L}{A} \quad \text{.....(3.1)}$$

R = Resistances in ohm

L = Length of conductor in meter

A = cross sectional area of conductor in m<sup>2</sup>

Any method of varying one of the quantities involved in the above relationship can be the design basis of an **electrical resistive transducer**. There are number of ways in which resistances can be changed by a physical phenomenon. A translation and rotational potential meters which works on the basis of change in the value of resistance with change in length of the conductor. **Strain gauges** work on the principle that the resistances of a conductor or a semiconductor changes when strained. This property can be used for measurement of displacement, force and pressure. The resistivity of materials changes with changes of temperature thus causing a change of resistances.

### 3.3 Measurement of linear displacement

There is a close link between force and displacement. Every displacement transducer needs a force to operate it, while every force transducer undergoes a displacement when a force is applied. A true displacement transducer is one, which requires a negligible force, compared with the force available from the actuating system, to provide a useful output. Otherwise, if the displacement required by the

transducer for a useful output is negligible compared with the displacement of the actuating quantity, the transducer is a pure force device.

### **3.4 Theory of strain gauge**

The change in the value of resistance by straining the gauge may be partly explained by the normal dimensional behaviour of elastic material. If a strip of elastic material is subjected to tension as shown in the Fig 3.1 or in other words positively strained, its longitudinal dimension will increase while there will be a reduction in the lateral dimension. So when a gauge is subjected to a positive strain, its length increases while its area of cross section decreases as shown in the Fig 3.2.

Since the resistance of the conductor is proportional to its length and inversely proportional to its area of cross -section, the resistance of the gauge increases with positive strain. The change in the value resistance of strained conductor is more than what can be accounted for an increase in resistance due to dimensional changes. The extra change the value of resistance is attributed to a change in the value of resistivity of the conductor when strained. This property, as described earlier, is known as piezo resistive effect.

#### **3.4.1 Gauge factor**

The gauge factor is defined as the ratio of per unit change in resistance to per unit change in the length.

$$\text{Gauge Factor, Gf} = \frac{\Delta R / R}{\Delta L / L} \quad \text{..... (3.2)}$$

### 3.4.2 Poisson's ratio

The Poisson's ratio is the ratio of lateral strain to longitudinal strain.

$$\text{Poisson's Ratio, } \nu = \frac{\Delta D / D}{\Delta L / L} \quad \text{..... (3.3)}$$

If the change in the value of resistivity of a material when strained is neglected, the gauge factor is

$$\text{Gf} = 1 + 2\nu \quad \text{..... (3.4)}$$

The above equation is valid when piezoresistive effect i.e. change in resistivity due to strain is almost negligible.

### 3.4.3 Types of strain gauges

The following are the major types of strain gauges:

1. Unbonded metal strain gauges.
2. Bonded metal wire strain gauges.
3. Bonded metal foil strain gauges.
4. Vacuum deposited thin metal film strain gauges.
5. Sputter deposited thin metal strain gauges.
6. Bonded semiconductor strain gauges.
7. Diffused metal strain gauges.

### 3.4.4 Application of strain gauge

The strain gauges are broadly used for two major applications and they are

- ➔ Experimental stress analysis of machines and structures, automobiles, stress and strain in bridges. Where the output of bridge can be recorded with an oscillograph calibrated to read the instantaneous strain of stress.
- ➔ Construction of force, torque, pressure, flow and acceleration transducers.
- ➔ Strain gauges are used in load cell and proving rings to measure force by the strain produced. The proving ring is usually made of steel. The strain produced in the
- ➔ load ring is measured with a strain gauge. This strain is measure of force applied to ring.

## 3.5 Unbonded strain gauge

### 3.5.1 Construction

A typical construction for a strain gauge load cell for measuring compressive force is shown in Fig 3.3 (cells to measure both tension and compression require merely the addition of suitable mechanical fitting at the ends). The load-sensing member is short enough to prevent column buckling under the rated load and is proportional to develop about  $1,500 \mu\epsilon$  at full-scale load. Materials used include SAE 4340 steel, 17-4PH stainless steel and 2024-T4 aluminium alloy, with the last being quite popular for

“Homemade” transducers. Foil type metal gauges bonded on the all four sides; gauges 1 and 3 sends the direct stress due to  $F_i$ , and case 2 and 4 transverse due to Poisson’s ratio,  $\mu$ . This arrangement gives sensitivity  $2(1 + \mu)$  times that achieved with single active gauge in the bridge. It also provides primary temperature compensation since all four gauges are (at least for steady temperatures) at the same temperature. Further more, the arrangement is insensitive to bending stress due to  $F_i$  being applied off center or at an angle. This can be seen by replacing an off center force by an equivalent on center force and a couple. The couple can be resolved into x and y components which cause bending stresses in the gauges. If the gauges are carefully placed so as to be symmetric, the bending stresses in the cases 1 and 3 will be of opposite sign and by the rules of bridge circuit the net output  $e_o$  due to bending will be zero. Similar arguments hold for gauges 2 and 4 and for bending stresses due to  $F_i$  being at an angle. The side-force stiffener plate also reduces the effect of angular forces, since it is very stiff in the radial (x,y) direction but very soft in the z direction. The deflection under full load of such load cell is of the order of 0.001 to 0.015 in, indicating their high stiffness. Often the natural frequency is not quoted since it is determined almost entirely by the mass of force carrying elements external to the transducers. This is especially true in many applications where the load cell is used for weighing purposes. The high stiffness also implies a low sensitivity. To increase sensitivity (in low force cells where it is needed) without sacrificing column

stability and surface area for mounting gauges, a hollow load carrying member may be employed. To achieve the high accuracy (0.3 to 0.1% of full scale) required in many applications, additional temperature components are needed. This is accomplished by means of temperature sensitive resistor  $R_{gc}$  and  $R_{mc}$  shown in Fig 3.3. These resistors are permanently attached internal to the load cell so as to assume the same temperature as the gauges. The purpose of  $R_{gc}$  is to compensate for the slightly different temperature coefficient of resistance of four gauges. The purpose of  $R_{mc}$  is to compensate for temperature difference of modulus of elasticity of load sensing member. That is although we wish to measure force, the gauges sense strain; thus any change in modulus of elasticity will give difference strain even though the force is the same. Since all the metal change modulus somewhat with temperature, this effect causes sensitivity drift. The resistance  $R_{mc}$  compensate for this by changing the excitation voltage actually applied to the bridge by just the light amount to counteract the modulus effect. Two additional resistors are often found in commercial load service. There are  $R_{ss}$ , which is adjusted to standardize the sensitivity for nominal  $e_{ex}$  to a desired value, and  $R_{irs}$ , which is used to adjust the input resistance to a desired value. Fig 3.4 shows one possible design, where four gauges (only to show) oriented at 45 degree with load axis are cemented to the shear webs between the holes to pick up the tension and compression produced by the applied shear stress. With two

gauges in compression and tension, a full bridge circuit can be used. The nature of the overload stop allows, “stacking” of a high range (say 100000 lbf) and a low range (10000 lbf) cells to provide a dual range transducers whose accuracy is maintained at loads below 10% of high range. That is, at loads below 10,000 lbf we use the output of low range cell, but as load goes above 10,000 lbf, this cell “bottoms out” and we take our reading from high range. Commercial strain gauge force transducers of the various types are available for full-scale loads of few pounds to hundreds of thousands of pounds and in several accuracy grades. The lowest accuracy grade typically has an overall error of about 1% of full scale, temperature effect of  $\pm 0.005\%$  of full scale / degree F on zero shift and  $\pm 0.01\%$  of readings /degree F on span. Corresponding figure for highest accuracy grade are about 0.15% full scale overall error,  $\pm 0.0015\%$  full scale /degree F zero shift and  $\pm 0.008\%$  of readings /degree F on span. When maximum output is desired for any strain gauge transducer, one should consider low modulus materials such as aluminium to increase strain per unit force, several gauges per bridge leg, the intentional introduction of stress concentration at the gauge location, and /or use of semiconductor gauges. However, such techniques also present associated problems. Low modulus reduces stiffness and natural frequency, and some low modulus materials have excessive hysteresis and low fatigue. Stress concentration also lower fatigue life, and their effect may be difficult to calculate for design.

purposes. Semiconductor gauges present installation and temperature compensation problem.

### 3.5.2 Operation of unbonded strain gauge

An unbonded metal strain gauge is shown in Fig 3.3. This gauge consists of a wire stretched between two points in an insulating medium such as air. The wires may be made up of various copper nickel, chrome nickel or nickel iron alloys. They are about 0.003 mm in diameter, have a gauge factor of 2 to 4 and sustain a force of 2 mN. The length of wire is 25mm or less. The flexure element is connected via a rod to diaphragm width is used for sensing of pressures. The wires are tensioned to avoid buckling when they experience a compressive force.

The unbonded metal wire gauges, used almost exclusively in transducer applications, employ preloaded resistance wire connected in a wheatstone bridge. At initial preload, the strains and resistance of four arms are nominally equal, with the result the output voltage of the bridge,  $e_0=0$ . Application of pressure produces a small displacement which is about 0.004 mm (full scale), the displacement increases tension in 2 wires and decreases it in the other two, thereby increase the resistance of the two wires which are in tension and decreasing the resistance of the remaining two wires. This causes an unbalance of the bridge producing an output voltage which is proportional to the input displacement and hence to the applied pressure.

Electric resistance of each arm is  $120\Omega$  to  $1000\Omega$ , the input voltage to the bridge is 5 to 10 volts, and the full-scale output of the bridge is typically about 20 to 50 milli volt.

### 3.6 Torque measurement

#### 3.6.1 Torque

The ability of a force to rotate a body about some axis is measured by a quantity called the torque (T). The torque due to force (F) has a magnitude given by the equation

$$T = F * d \quad \text{..... (3.5)}$$

In this equation 'T' is the torque and distance 'd' is called the lever arm (or moment arm) of the force 'F'.

The lever arm is the perpendicular distance from the axis of rotation to a line drawn along the direction of force and through the point at which the force is applied.

For example, consider Fig 3.5 which represents a view looking down on to a door hinged at a point 'O'. A point perpendicular to the page and passing through 'O' is the axis about which the door rotates. When the force is applied as shown, on the other hand the same force applied at a point nearer the hinger produce a smaller torque (because 'd' is smaller) and hence result smaller rotational effect on the door.

If there are two or more force acting on an object, then each has a tendency to produce a rotation about the point 'O'. For example F2 has a tendency to rotate the object clockwise and F1 to rotate in counter clockwise.

$$\begin{aligned} \text{Net torque } \sum T &= T_1 + T_2 \\ &= (F_1 * d_1) - (F_2 * d_2) \end{aligned} \quad \text{..... (3.6)}$$

Unit of torque is Newton meter (N - m) or pound foot.

### 3.6.2 Torque in motor

By the term torque is meant the turning or twisting moment of a force about an axis. It is measured by product of force and radius at which this force acts.

$$\text{Torque } T = F * r \text{ (Nm)} \quad \text{..... (3.7)}$$

Work done by this force in one revolution = force \* distance

$$= F * 2\pi r \quad \text{..... (3.8)}$$

Power developed = F \* 2 π r \* N

$$= T * \omega$$

$$[\omega = 2 \pi N / 60 \text{ rad/sec}]$$

$$P = 2 \pi N T / 60 \text{ or } N T / 9.55$$

..... (3.9)

### 3.6.3 Shaft torque

The whole of the armature torque, as calculated above, is not available for doing useful work, because a certain percentage of it is required for supplying the iron and frictional losses in the motor.

The torque, which is available for doing useful work, is known as shaft torque  $T_{sh}$ . It is so called because it is available at the shaft. The motor output is given by

$$\text{Output} = T_{sh} * 2 \pi N \text{ watt}$$

$$\begin{aligned} T_{sh} &= \text{output in watts} / 2 \pi N \text{ in Nm rps} \\ &= \text{Output in watts} * 60 / 2 \pi N \text{ in Nm rpm} \\ &= 9.55 * \text{output} / N \text{ in Nm} \end{aligned}$$

$T_{Sh} = 9.55 * \text{OUTPUT} / N$	..... (3.10)
-------------------------------------	--------------

### 3.6.4 Torque measurements on rotating shafts

Torque transmission through a rotating shaft generally involves both a source of power and a sink (power absorber or dissipator) as shown in the Fig 3.6. Torque measurement may be accomplished by mounting either the source or sink in bearings

("cradling") and measuring the reaction force  $F$  and arm length  $L$ . Otherwise the torque in the shaft itself is measured in terms of the angular twist or strain of the shaft (or a torque sensor coupled into the shaft).

The cradling concept is the basis of the most shaft power dynamometers. These are utilized mainly for measurements of steady power and torque by using pendulum or platform scales to measure  $F$ . A free analysis of the cradled member reveals error sources resulting from friction in the cradle bearings, unbalanced of the cradled member, windage torque (if the shaft is rotating), and forces due to bending and/ or stretching of power lines (electric or hydraulic, etc.) attached to the cradled member. To reduce frictional effects and to make possible dynamic torque measurements, the cradle-bearing arrangement may be replaced by a flexure pivot with strain gauges to sense the torque as in Fig 3.7. The crossing point of the flexure plates defines the effective axis of rotation of the flexure pivot. Angular deflection under full load is typically less than 0.5. This type of cross-spring flexure pivot is relatively stiff in all directions other than the rotational one desired, just as in ordinary bearing. The strain gauge bridge arrangement also is such as to reduce the effect of all forces other than those related to the torque being measured. Speed-torque curve for the motors may be obtained quickly and automatically with such a torque sensor by letting the motor under the test accelerate an inertia from zero speed up to maximum while measuring speed with a

dc tachometer. The torque and speed signals are applied to an XY recorder to give automatically the desired curves.

Another variation (Fig 3.8) on the cradle principle is found in a null balance torque meter using feedback principles to measure small torques in the range 0 to 10 oz in. In this device the test object is mounted on hydrostatic air bearing table to reduce bearing friction to exceedingly small values. Any torque on the test object tends to cause rotation of the air-bearing table, but this rotation is immediately sensed by a differential-transformer displacement pickup. The output from this pickup is converted to direct current and amplified to provide the coil current of the torque motor, which applies opposing torque to keep displacement at zero. The amount of current required to maintain zero displacement is a measure of torque and is read on a meter. The servo loop uses integral control to give zero displacement for any constant torque. Approximate derivative control is used also to give stability. The threshold of this air-bearing system is less than 0.0005 oz in while the torque/current non linearity is 0.001 oz in. The overall system behaves approximately as a second order system with a natural frequency of about 10 Hz and damping ratio of 0.7 when no test object is present on the table.

The use of elastic deflection of the transmitting member for torque measurement may be accomplished by measuring either a gross motion or a unit strain. In either case, a main difficulty is the necessity of being able to read the deflection while the shaft is rotating.

This arrangement (given accurate gauge placement and matched gauge characteristics) is temperature-compensated and insensitive to bending or axial stresses.

The gauges must be precisely at 45 degree with the shaft axis, and gauges must be diametrically opposite, as must gauges 2 and 4.

Accurate gauge placement is facilitated by the availability of the special rosettes in which two gauges are precisely oriented on one sheet of backing material. In some cases the shaft already present in the machine to be tested may be fitted with strain gauges. In other case a different shaft or a commercial torque meter must be used to get the desired sensitivity or other properties. Of the various configurations shown in the Fig 3.9, one manufacturer uses the hollow cruciform for low-range units and the solid, square shaft for the high-range ones. Placement of the gauges on a square, rather than round, cross section of the shaft has some advantages. The gauges are more easily and accurately located and more firmly bonded on a flat surface. Also, the corners of a square section in a square section in torsion are stress-free and thus provide a good location for solder joints between lead wires and gauges. These joints are often a source of fatigue failure if located in a high-stress region. Also, for equivalent strain/torque sensitivity, a square shaft is much stiffer in bending than a round one, thus reducing effects of bending forces and rising shaft natural frequencies.

The torque of many machines, such as reciprocating engines, is not smooth even when the machine is running under "steady-state" conditions. If we wish to measure the average torque so as to calculate

power, the higher frequency response of strain-gauge torque picks up may be some what of a liability since the output voltage will follow the cyclic pulsations and some sort of averaging process must be performed to obtain average torque. If exceptional accuracy is not needed, the low-pass filtering effect of a DC meter used to read  $\epsilon_0$  may be sufficient for this purpose. In the cradled arrangements of the figure (employed in many commercial dynamometers for engine testing, etc.), the inertia of the cradled member and the low-frequency response of the platform or pendulum scales used to measure  $F$  perform the same averaging function.

Commercial strain gauge torque sensors are available with built-in slip rings and speed sensors. A family of such devices covers the range 10 oz – in to  $3 \times 10^6$  in – lbf with full-scale output of 40 mV. The smaller units may be used at speeds up to 24,000 r/min, the largest to 350 r/min. Torsional stiffness of the 10 oz – in unit is 112 in – lbf/rad while a 600,000 in – lbf unit has  $4.0 \times 10^6$  in – lbf / rad. Non linearity is 0.1% of full scale while temperature effect on zero is 0.002% of full scale/degree F and temperature effect on sensitivity is 0.002%/degree F over the range 70 to 170 degree F.

### **3.7 Shaft power measurement**

The accurate measurement of the shaft power input or output of power generating, transmitting and absorbing machinery is of considerable interest. The term dynamometer generally is used to

describe such power-measuring systems, although it is also used as a name for electric force sensors.

The type of dynamometer employed depends somewhat on the nature of the machine to be tested. If the machine is a power generator, the dynamometer must be capable of absorbing its power.

If the machine is a power absorber, the dynamometer must be capable of driving it. If the machine is a power transmitter or transformer, the dynamometer must provide both the power source and the load, unless a foursquare method is feasible.

Perhaps the most accurate and versatile dynamometer is the dc electric type. Here a dc machine is mounted in low-friction trunnion bearings and provided with field and armature control circuits. This machine can be coupled to either power-absorbing or power-generating devices since it may be connected as either a motor or a generator. When it is employed as a generator, the generated power is dissipated in resistance grids or recovered for use. The dc dynamometer can be adjusted to provide any torque from zero to the maximum design value for speeds from zero to the so-called base speed of the machine. At this speed the maximum torque develops the maximum design horsepower. At speeds above base speed, torque must be progressively reduced so as to maintain horse powerless than the design maximum. The controllability of the dc dynamometer lends it particularly to modern automatic load and speed programming applications.

By adding recent developments in variable-frequency ac motor control, a trunnion-mounted induction motor becomes a

versatile dynamometer for both driving and absorbing applications. Features include fast response, flexible control, simplified maintenance, and energy conservation, since up to 85% of the energy absorbed is returned to the ac power line.

Dynamometers capable only of absorbing power include the eddy-current brake (induction dynamometer) and various mechanical brakes employing dry friction (Prony brake) and fluid friction (air and water brakes). The eddy-current brake is easily controllable by varying a dc input, but it cannot produce any torque at zero speed and only small torques at low speeds. However it is capable of higher and speed than a dc dynamometer. The power absorbed is carried away by cooling water circulated through the air gap between stator and rotor. The prony brake is a simple mechanical brake in which friction torque is manually adjusted by varying the normal force with a hand wheel. Torque is available at zero speed, but operation may be jerky because of the basic nature of the dry friction. Water and air brakes utilize the churning action of the paddle wheels or vanes rotating inside a fluid-filled casing to absorb power. A flow of air or water through the device is maintained for cooling purposes. No torque is available at zero speed, and only small torques is available at low speeds. High speed and high power can be handled well. however, with some water brakes being rated at 10,000 hp at 30,000 r/min.

In all the power measurement applications, torque and speed are measured separately and then power is calculated manually. This calculation can be performed automatically in a number of ways

since the basic operation (multiplication) can be accomplished physically in various ways. An interesting scheme using the properties of the bridge circuit is shown in the Fig 3.10. Speed is measured with a dc tachometer generator, and this voltage is applied as the excitation of the strain gauge load cell used to measure torque. Since bridge output is directly proportional to torque, the voltage  $E_o$  is actually an instantaneous power signal.

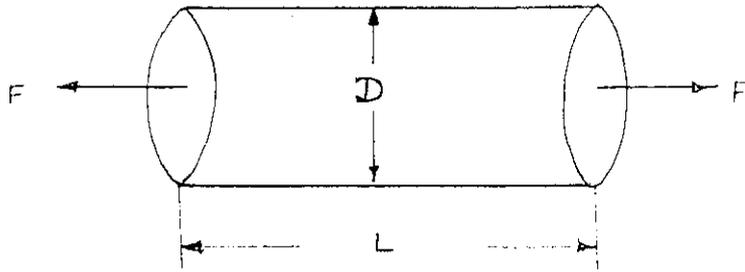


FIG 3.1 ELASTIC MATERIALS SUBJECTED TO TENSION

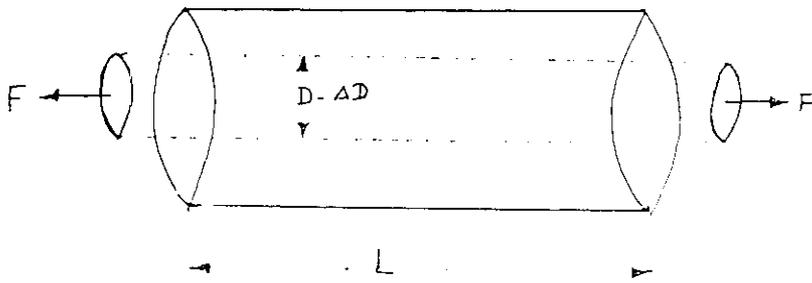


FIG 3.2 INCREASE IN LONGITUDINAL DIRECTION

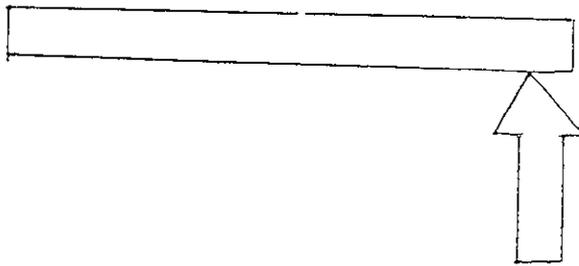


FIG 3.5 DOOR HINGED AT A POINT 'O'

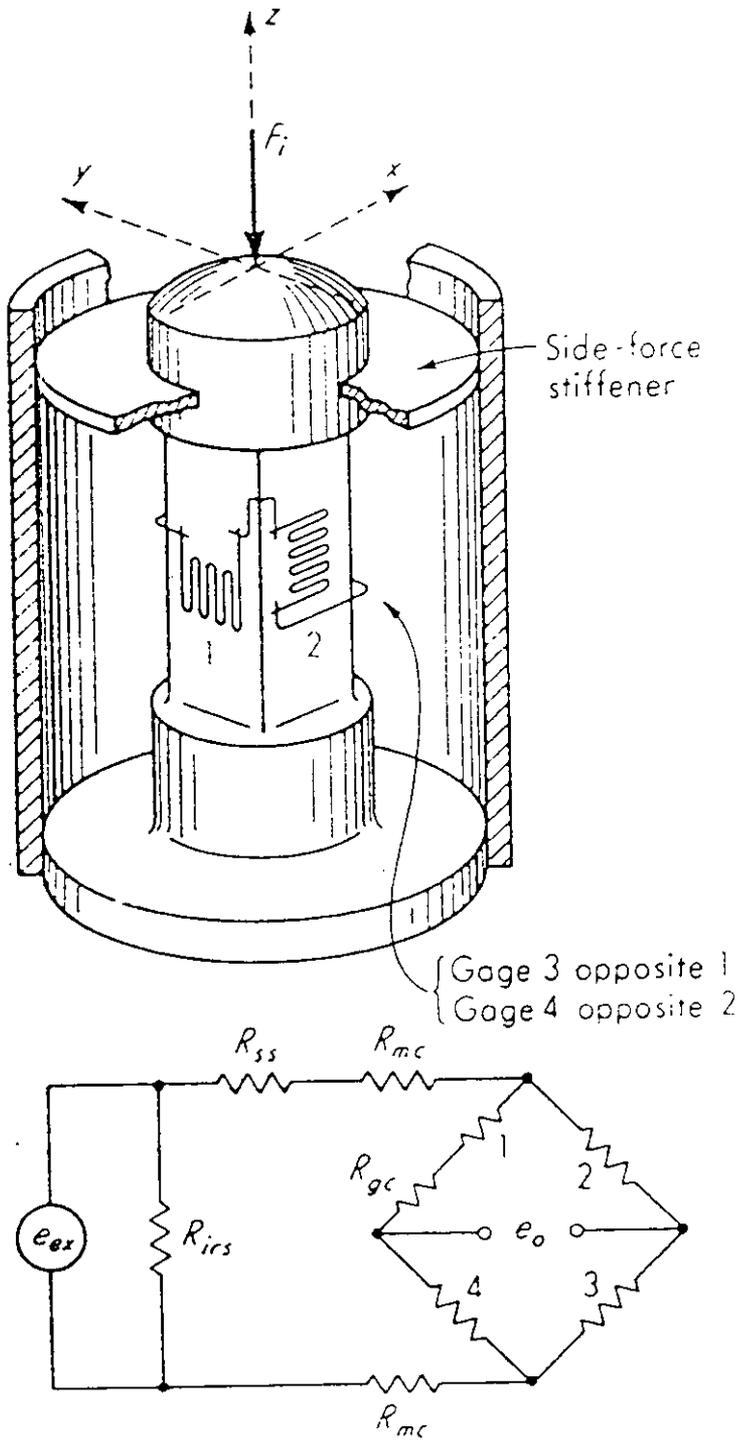


FIG 3.3. STRAIN GAUGE

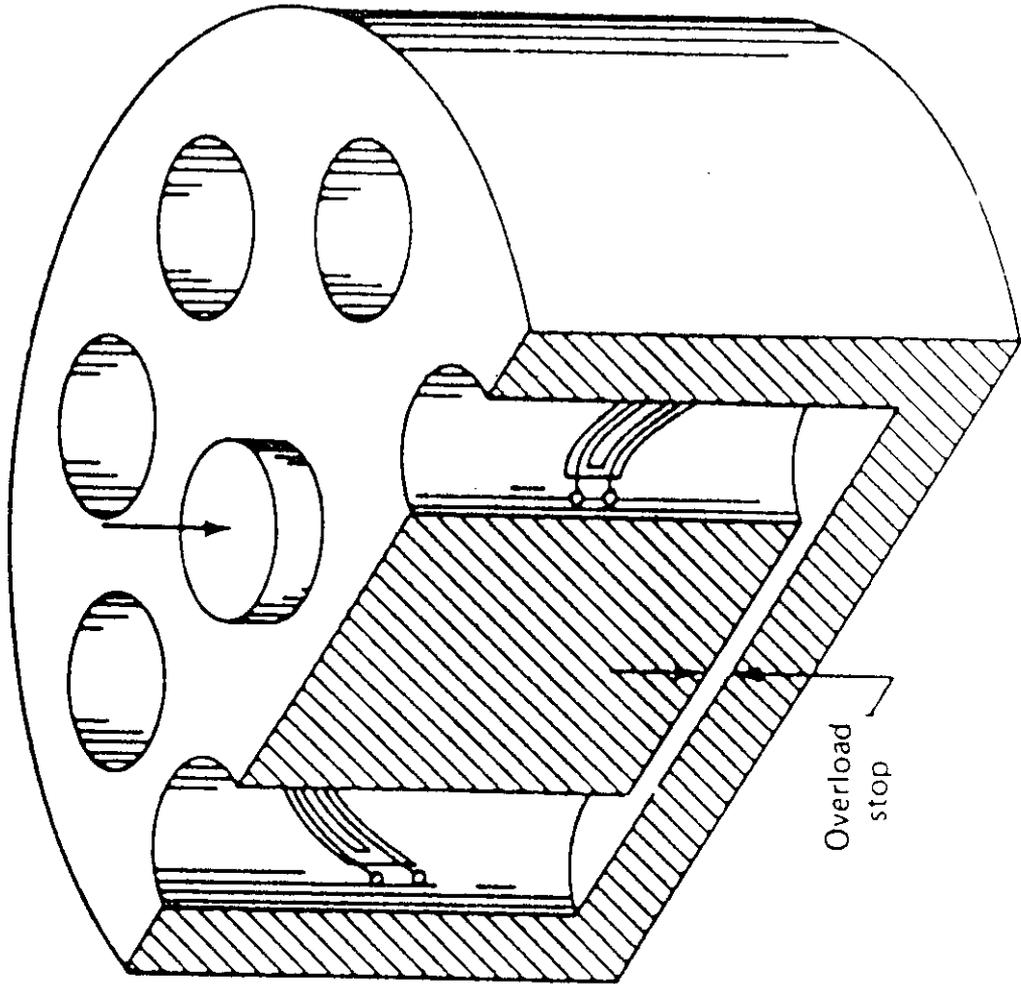


FIG 3.4 SHEAR WEB FORCE TRANSDUCER

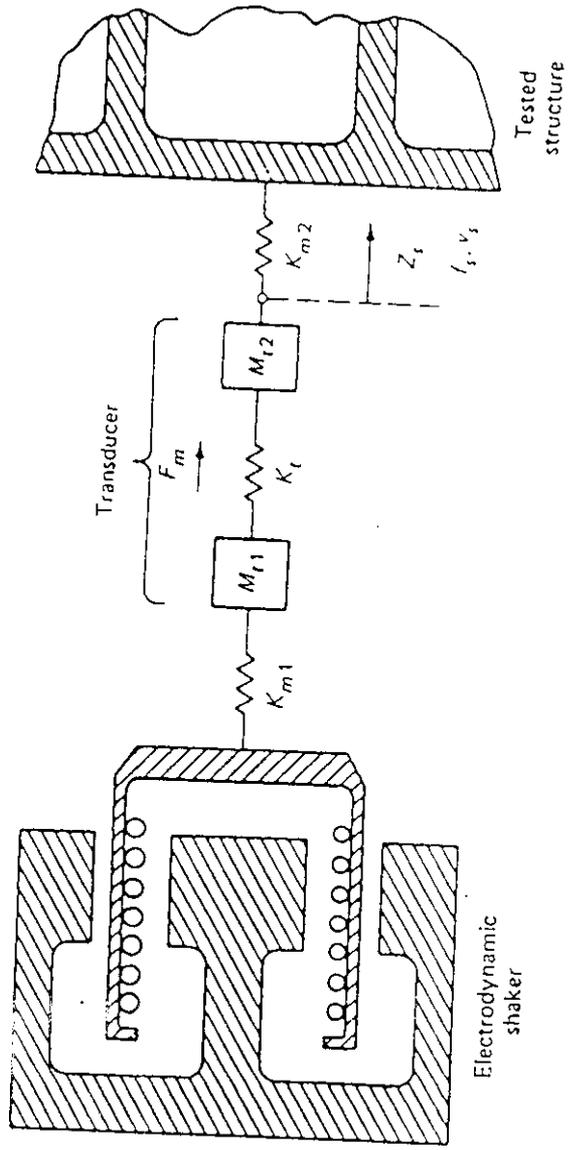
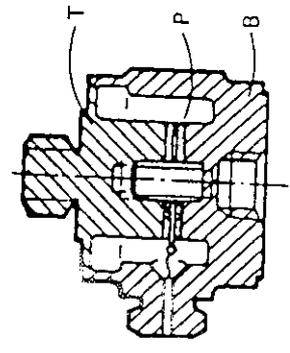
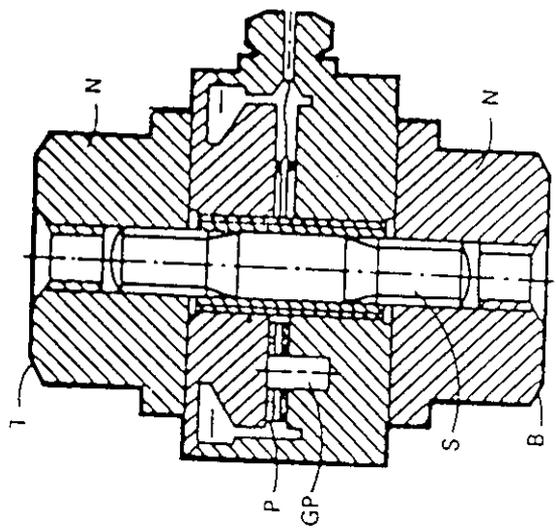


FIG 3.6. PIEZO ELECTRIC LOAD CELL

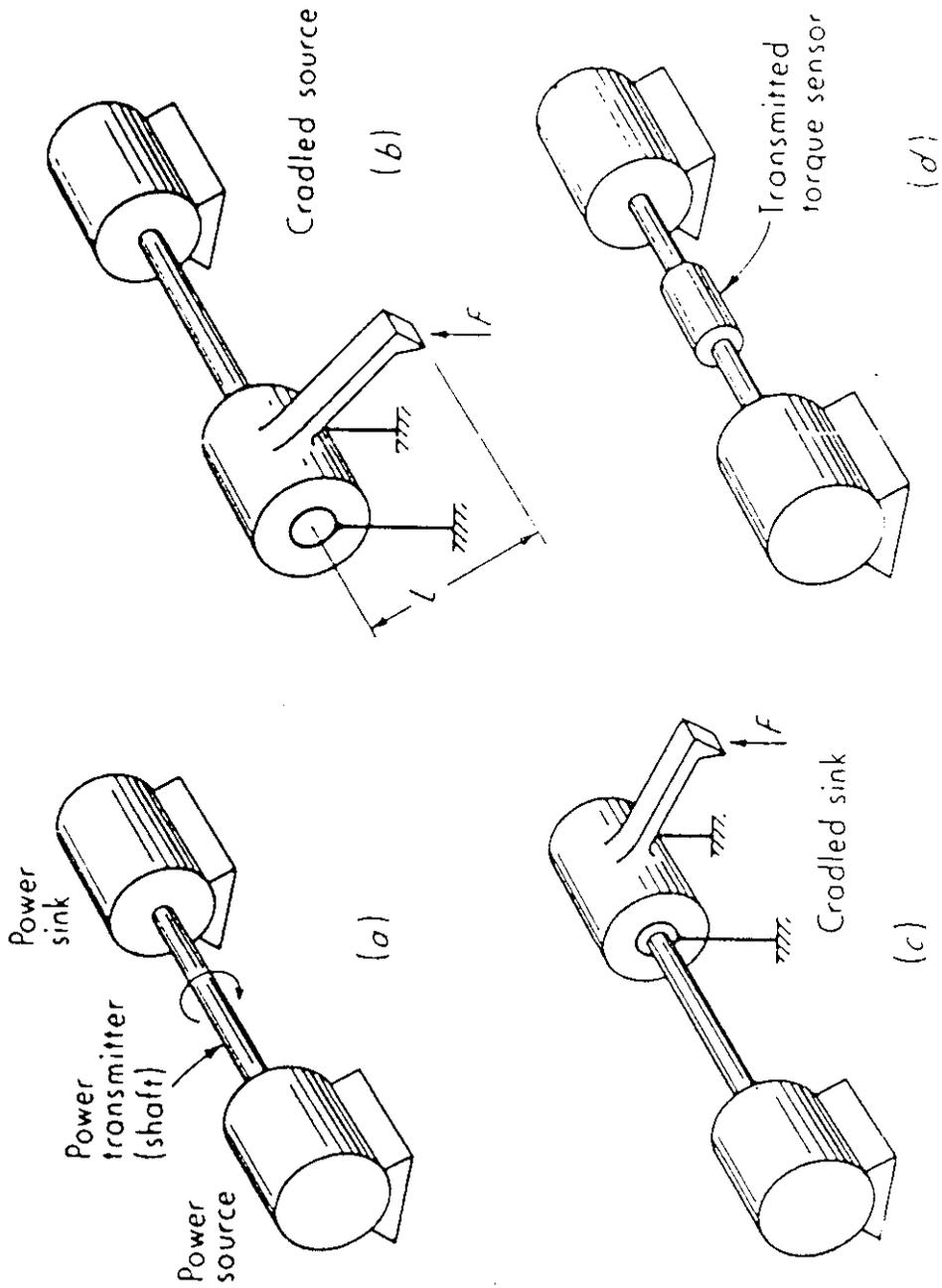


FIG 3.7 TORQUE MEASUREMENT OF ROTATING MACHINE

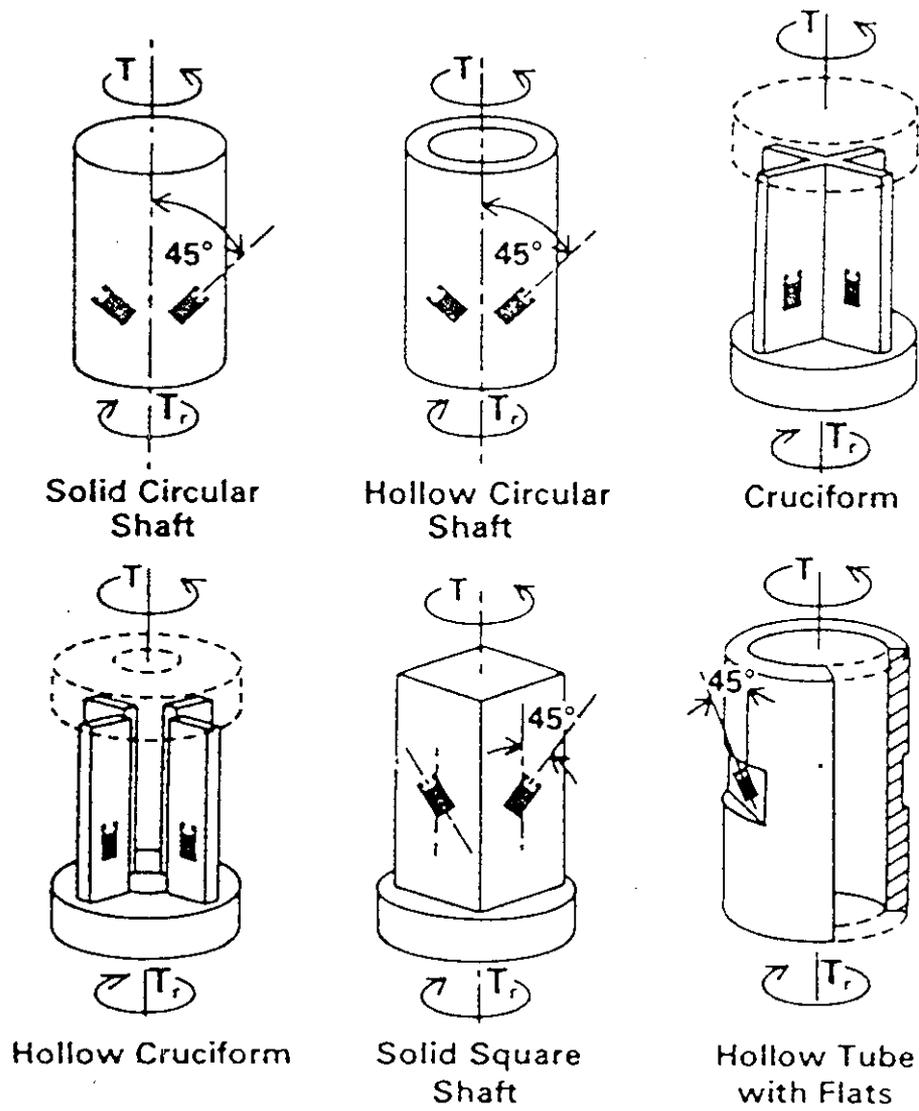


FIG 3.8. VARIOUS TORQUE SENSOR DESIGNS

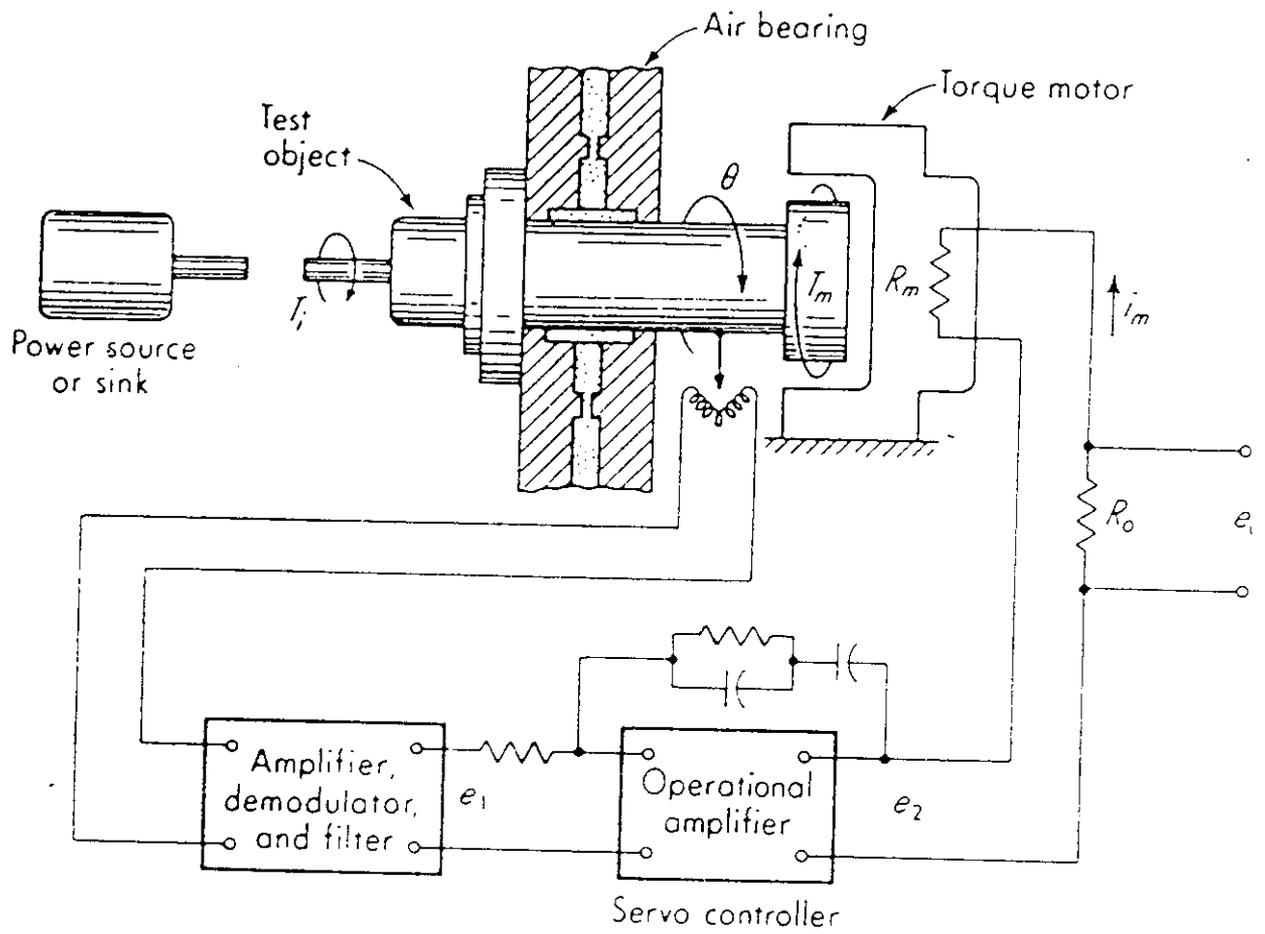


FIG 3.9 FEEDBACK TORQUE SENSOR

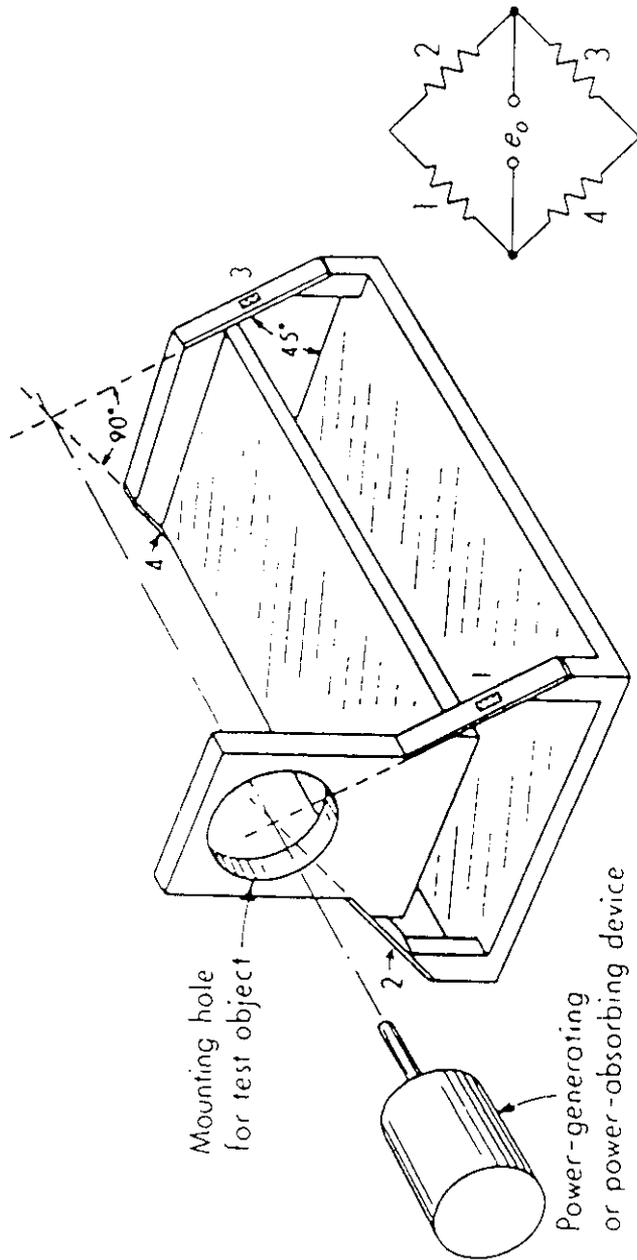


FIG 3.10 STRAIN GAUGE TORQUE TABLE

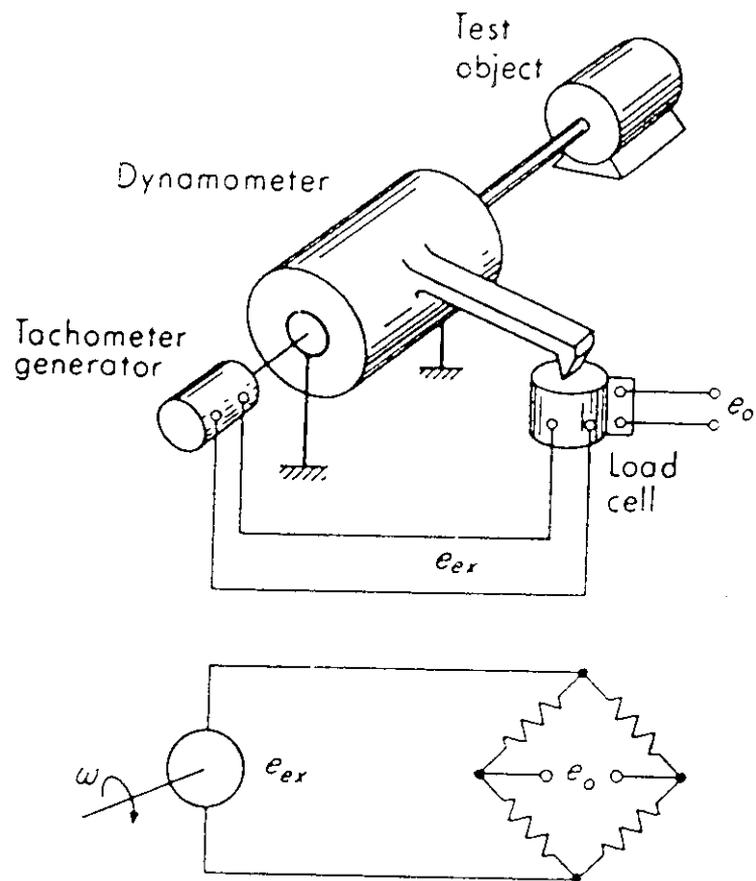


FIG 3-11. POWER MEASUREMENT

# *CHAPTER IV*

## *LOAD CELL*

## CHAPTER IV

### LOAD CELL

Load cell utilize an elastic member as the primary transducer and strain gauge as the secondary transducer as shown in the Fig 4.1. Let us analyze a simplified compressive type force measuring load cell consisting of a short column or strut with strain gauges attached. Let us assume that a force deflects or strains the block, which thereby senses the input. It converts the load into a deflection analogous to the weight or force. The unit deflection is, in turn, transformed into an electrical output by the strain gauges acting as secondary transducers. "When the **strain gauge- elastic member** combination is used for weighing it is called a **load cell**"

Load cell is a short column with resistance wire strain gauges bonded to it. The measurand in this case, is a force and is applied to the column thereby producing strain. The force is first detected by the column and is converted into strain, which is mechanical displacement. The higher the force, the higher is the strain and thus the input signal (Force) is converted into analogous output (strain). This strain changes the resistance of the strain gauges. Thus we have an output which is a changes in the value of resistance i.e., electrical in form. Hence, in this case, it takes two processes to convert an input into an analogous output. The first process involves

the conversion of force into mechanical displacement, which is done by column. While the second process involves conversion of mechanical displacement into change of resistance which is done by strain gauges.

#### 4.1 Tensile-compressive strain gauge cell

Fig 4.1 shows a tensile-compressive cell, which is a cylinder. This arrangement uses four strain gauges each mounted at 90 degree to each other. The bridge circuit is also shown. Two of strain gauges experience tensile stress while the other two are subjected to compressive stress.

The output of a bridge with equal arms and using two strain gauges mounted 90 degree to each other is :

$$\Delta e_o = (1 + \nu) \left[ \frac{\Delta R_1 / R}{4 + 2 (\Delta R_1 / R)} \right] e_i \quad \text{..... (4.1)}$$

In the present case, there are two sets of gauges mounted 90 degree to each other, with one set experiencing tensile stress while the other a compressive test.

Therefore output voltage of Wheatstone bridge is

$$\Delta e_o = 2 (1 + \nu) \left[ \frac{\Delta R_1 / R}{4 + 2 (\Delta R_1 / R)} \right] e_i \quad (4.2)$$

The above relationship is clear from the following explanation. In the case of a cylinder, an axial compressive load causes a negative strain in the vertical gauges, and a positive strain in the circumferential gauges. The two strains are not equal in this case. These two strains are related to each other by a factor,  $\nu$ , called Poisson's ratio. Since the value of strain is of no interest, the objective is to produce a force transducer. This force transducer is calibrated empirically. In case all the gauges are similar, temperature compensation is obtained as all the gauges contribute equally to unbalance the bridge.

Compression cells of this type have been used with a capacity of 300 MN. Unbonded strain gauge transducers are frequently used for force measurement, particularly if high sensitivity is required. Highest sensitivity is obtained when the gauge itself performs the function of the elastic member, i.e., all the input force is used for producing strain in the gauge.

The smaller one is permanently preloaded to measure in the range 1,000-N tension to 5,000-N compression without relaxing the built-in compressive preload. The larger unit comes with external preloading nuts, which may be adjusted to cover the range 4,000-N

tension to 16,000-N compression. An analysis by manufacturer says that such transducers may be modeled as a spring (piezoelectric elements) sandwiched between two masses. Transducer being used to measure the force applied by a vibration shaker to some structure being vibration tested ( $K_{m1}$  and  $K_{m2}$  represents the stiffness of the mounting screws). If the impedance of the structure is called as  $Z_s$ , then since  $Z_s = F_s / V_s$ , the force actually applied to the structure is  $Z_s V_s$ . The force  $F_m$  measured, however, is that in  $K_t$ , which is proportional to the relative displacement of  $M_{t1}$  and  $M_{t2}$  since this is the deflection of the piezoelectric element. Under dynamic condition  $F_m$  is not necessarily equal to  $F_s$  and a dynamic analysis as shown below is useful in developing criteria for accurate measurement.

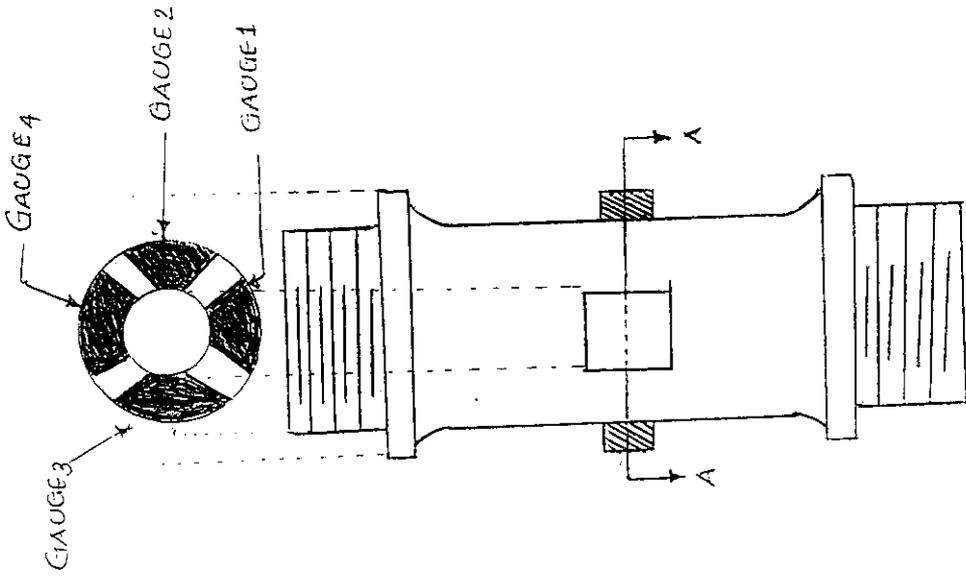
$$F_m - v_s Z_s = M_{t2} D v_s \quad \text{..... (4.3)}$$

$$\frac{F_m}{F_s} = \frac{M_{t2} D}{Z_s(D)} = 1 \quad \text{..... (4.4)}$$

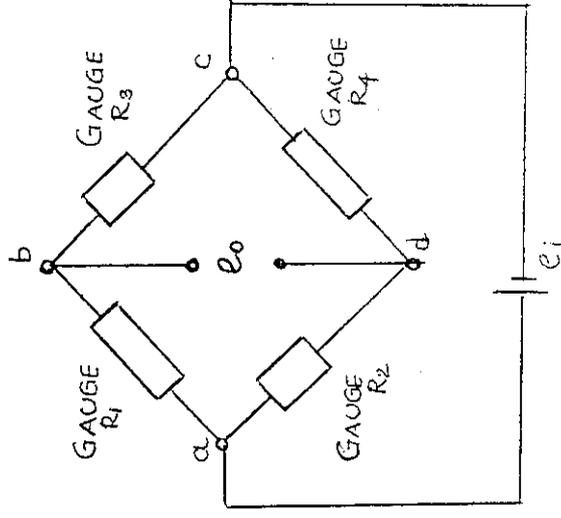
If  $M_{t2} = 0$ , there would be no error no matter what  $Z_s$  might be; thus transducers with small  $M_{t2}$  are clearly preferable for a "Spring like" structure.

$$Z_s(D) = K_s / D, \text{ and}$$

$$\frac{F_m(i\omega)}{F_s} = 1 - \frac{M_{t2}}{K_s} \omega^2 \quad \text{..... (4.5)}$$



LOAD CELL



LOAD CELL STRAIN GAUGE

FIG 4.1

# *CHAPTER V*

## *SIGNAL CONDITIONING UNIT*

## CHAPTER V

### SIGNAL CONDITIONING UNIT

The measurand, which is basically a physical quantity as is detected by the first stage of the measurement or instrumentation system. The first stage is the “**Detector Transducer Stage**”. The quantity is detected and is transduced into an electrical form in most of the cases. The output of the first stage has to be modified before it becomes usable and satisfactory to drive the signal presentation stage, which is third, and the last stage of a measurement system. The last stage may consist of indicating, recording, displaying, data processing elements or may consist of control elements.

Measurement of dynamic physical quantities require faithful representation of their analog or digital output obtained from the intermediate stage i.e. signal conditioning stage. The signal conditioning equipment may be required to do linear processes like amplification, attenuation, integration, differentiation, addition and subtraction. They are also required to do non-linear processes like modulation, demodulation, sampling, filtering, clipping and clamping, squaring, linearizing or multiplication by another function.

The signal conditioning or data acquisition equipment in many situations is an excitation and amplification system for passive transducers. It may be an amplification system for active transducers.

In the applications, the transducer output is brought up to a sufficient level to make it useful for conversion, processing, indicating and

recording. Excitation is needed for passive transducers because these transducers do not generate their own voltage or current. Therefore passive transducers like strain gauges, potentiometers, resistance thermometers, inductive and capacitive transducers require excitation from external sources. The active transducers do not require an external source of excitation since they produce their own electrical output on account of application of physical quantities. But these signals usually have a low voltage level, and hence need amplification.

The excitation sources may be an alternating or D.C. Voltage source. The D.C system is comparatively simple.

### **5.1 DC signal conditioning system**

Fig 5.1 shows the block diagram of DC signal conditioning system. The resistance transducers like strain gauges, constitute one arm or more than one arm of a wheatstone bridge which is excited by an isolated d.c.source. The bridge can be balanced by a potentiometer and can also be calibrated for unbalanced conditions.

The desirable characteristics of a D.C.amplifier are

- 1.It may need balanced differential inputs giving a high Common Mode Rejection Ratio (**CMRR**).
- 2.It should have extremely good thermal and long-term stability.

### **5.1.1 Advantage of D.C amplifier**

- 1.It is easy to calibrate at low frequency.
- 2.It is able to recover from an overload condition unlike its A.C. counterparts.

### **5.1.2 Disadvantage of D.C amplifier**

It suffers from problem of drift. Thus low frequency spurious comes out as data information. For this reason special drift D.C amplifier are used. The D.C amplifier is followed by a low pass filter, which is used to eliminate high frequency component or noise from the data signal.

In order to overcome the problem that of encountered in D.C system, A.C system is used. In A.C system carrier type A.C signal conditioning systems are used.

## **5.2 A.C signal conditioning system**

Fig 5.2 shows the block diagram of this system. The transducers are used the variable resistance or variable inductance transducer. They are employed between carrier frequencies of 50 Hz to 200KHz. The carrier frequency are much higher, they are at least 5 to 10 times the signal frequency.

Transducer parameter variations amplitude modulates the carrier frequency at the bridge output and waveform is amplified and demodulated. The demodulation is phase sensitive so that the polarity

of D.C output indicate the direction of parameter change in bridge output.

In a carrier system, amplifier drift and spurious signal are not of much important unless they modulate the carrier. However, it is more difficult to achieve a stable carrier oscillator than a comparable D.C stabilized source. In carrier systems, it is easy to obtain very high rejection of main frequency pickup. Active filters can be used to reject this frequency and prevent overloading of A.C amplifier. The phase sensitive, demodulators filter out carrier frequency component of the data signal.

D.C system are generally used for common resistance transducers such as potentiometer, strain gauge. A.C system have to be used for variable reactance transducer and for systems where signals have to be transmitted via long cable to connect the transducer to the signal conditioning equipment.

After the physical quantities like temperature, strain, pressure, acceleration etc. have been transduced into their analogous electrical form and amplified to sufficient current or voltage level (say 1 to 10 volt), they are further processed by electro=MGI PB M DBMOL B :LCC =M

applied to a variety of digital system like a digital computer, digital controller, digital data logger or digital data transmitter.

The sample and hold unit is used to sample the different input at a specified time and then hold the voltage level at their output while analog multiplexer perform the time division multiplexing (TDM) operation between different data input. TDM means that each input channel is sequentially connected to multiplexer for a certain specified time. The timing of the various input channels is controlled by a control unit. This unit controls the sample and hold circuit, the multiplexer and the analog to digital converter. The controller unit may be controller itself.

In case TDM is not used, frequency division multiplexer (FDM) may be used. In this case, the multiple data analog input can remain in analog form and are transmitted all at the same time.

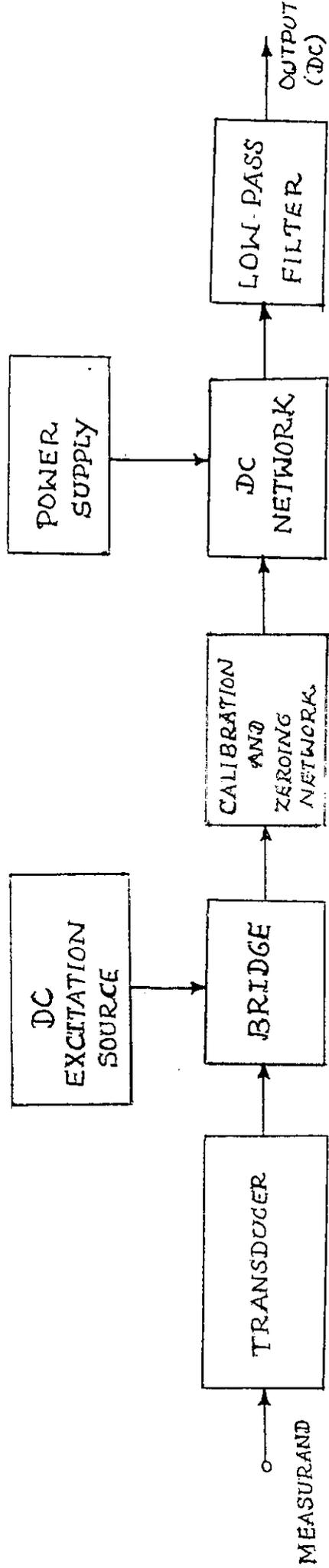


FIG 5.1 DC. SIGNAL CONDITIONING SYSTEM

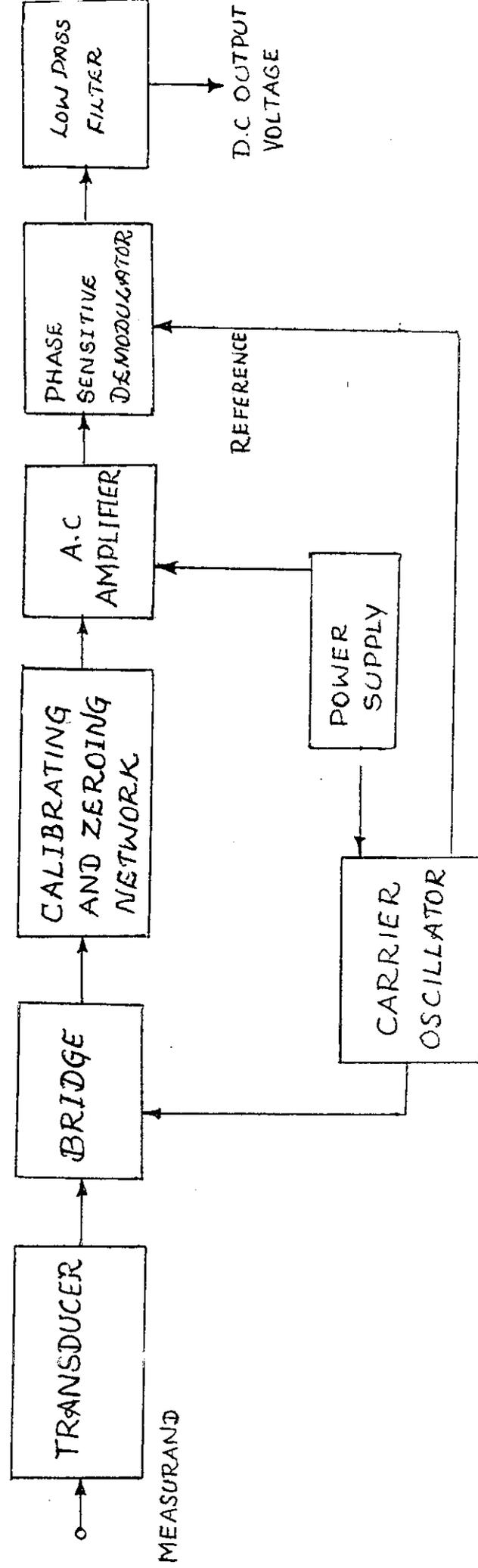


FIG 5-8 AC SIGNAL CONDITIONING SYSTEM

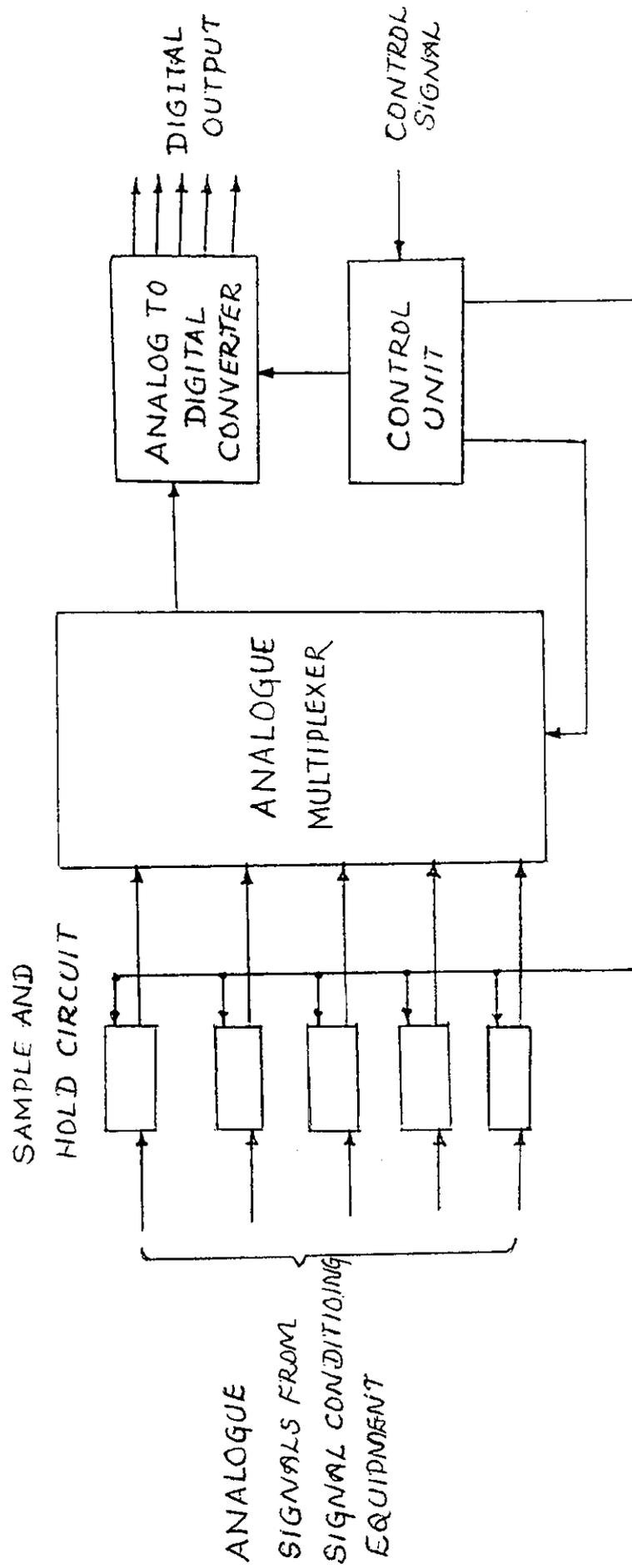


FIG5.3 DATA AQUISITION AND CONVERSION SYSTEM

# *CHAPTER VI*

## *ANALOG TO DIGITAL CONVERTER*

## CHAPTER VI

### ANALOG TO DIGITAL CONVERTER

#### 6.1 ADC 0808/0809

Fig 6.1 shows the block diagram of ADC. It can be very easily be interfaced with any of the microprocessors. This type of converter changes the analog voltage input  $V_{in}$  to an 8-bit digital output (D7-D0). A pulse applied to the ADC's START conversion terminal initiates the conversion process. The completion of conversion takes an amount of time depending upon the method of conversion time can be as large as 100ms for some ADC. During the ADC's end of conversion (EOC) output goes LOW. The EOC output returns HIGH only when the conversion is complete.

The digital output lines D7-D0 come from tri-state latches. A HIGH on the OUTPUT ENABLE (OE) terminal will enable those outputs to appear on these lines. In most of the situations, the OE input is pulsed HIGH only after the EOC output has indicated that the conversion is complete. If the OE is made HIGH during the interval, the output lines indicate the result of previous conversion.

The ADC 0808/0809 is an 8-bit digital to analog converter with 8-channel inbuilt multiplexers. It is the monolithic CMOS device manufactured by the National Semiconductors. It uses the principle of successive approximation technique for the conversion process. The 8-channel multiplexer can directly access any of the 8-single-ended analog signals. The converter features a high

impedance chopper stabilized capacitor and a successive approximation register. It is free from external zero and full-scale adjustments. Easy interfacing to microprocessors is provided by the latched and decoded multiplexer address inputs and latched TTL TIR-STATE outputs. Incorporating the most desirable aspects of several ADC techniques has optimized the design of the ADC0808/0809.

The 0808/0809 ADC offers following features

- High speed
- High accuracy
- Minimal temperature dependence
- Excellent long-term accuracy and repeatability

These features make this device ideally suited to applications from process and machine control to consumer and automotive applications. The block diagram and the internal R/2R ladder switching diagram of the ADC0808/0809 are shown in the figure. The heart of this ADC is the successive approximation register (SAR). On receipt of the 1<sup>st</sup> CLK at start of the SC cycle, the SAR outputs a high on its MSB. The DAC and the amplifier convert this to an analog voltage and apply to one of the inputs of the comparator, the comparator will go low to indicate to the SAR to turn OFF that bit because it is too large. If the output voltage from DAC is less than the input voltage, the comparator output will be high to indicate to the SAR to keep that bit ON. On receipt of the next pulse, the SAR will

turn ON the next MSB to DAC. Based on the answer, it produces from the comparator; the SAR will keep or RESET the bit. The SAR proceeds in this manner down to the LSB, adding each bit to the total in turn and using the signal from the comparator to decide whether to keep that bit in the result or not. Only 8-CLK pulse are need to do the actual conversion signal to indicate the completion of the process. The EOC signal is used to strobe the binary result into some latches where it can be read by a microcomputer.

## 6.2 Features

- Resolution ==> 8-bits
- Total adjustment errors = = >  $\pm 1/2$  LSB and  $\pm 1$  LSB.
- No missing codes
- Conversion time = = > 100 $\mu$ sec. at 640KHz.
- Supply voltage = > +5V
- 8-Channel multiplexer with latched control logic
- Easy interface to all microprocessor or operates stand alone
- Outputs meet TTL voltage level specifications
- 0V to 15V analog input voltage with single 5V dc supply
- No zero or full-scale adjustment required
- Standard hermetic or molded 28-pin DIP package
- Clock frequency 10KHz to 1280KHz
- Temperature range -40°C to +85°C or -55°C to +125°C
- Low power consumption → 15mW
- Latched TRI-STATE output
- Conversion delay time.

### 6.3 Converter

The heart of this single chip data acquisition system is its 8-bit analog –to- digital converter. The converter is designed to give:

- Fast
- Accurate, and
- Repeatable

Conversion over a wide range of temperatures. The converter is partitioned into 3-major sections:

- 256R ladder network
- Successive approximation register, and
- Comparator.

The 256R ladder network was chosen over the conventional R/2R ladder because of its inherent monotonicity, which guarantees no missing digital codes. Monotonicity, is particularly important in closed loop feed back control system. Apart from these, the 256R network does not cause load variations on the reference voltage.

The top and the bottom resistor values are different than the other resistors. The difference in these resistors causes the output characteristic to be symmetrical with the zero and full-scale points of the transfer curve. The first output transition occurs when the analog signal has reached  $+1/2\text{LSB}$  and succeeding output transitions occur every 1LSB later up to full-scale.

The successive approximation register (SAR) performs 8-iterations to approximate the input voltage. For any SAR type converter,  $n$ -iterations are required for  $n$ -bit converter. The approximation technique in ADC0808/0809 is extended to 8-bits using 256R network. The A/D converter's successive approximation register (SAR) is reset on the positive edge of the start of the conversion (SOC) pulse. The conversion begins at the falling edge of the start conversion pulse. The conversion process is interrupted by receipt of a new start of conversion pulse. The continuous conversion may be accomplished by tying the end-of-conversion (EDC) output to the SOC input. If used in this mode, an external start conversion pulse should be applied after power up. End-of-conversion will go low between 0 and 8 clock pulses after rising edge of start conversion. The most important section of the ADC is the comparator. It is this section, which is responsible for the ultimate accuracy of the entire converter. It is also the comparator drift which has the greatest influence on the repeatability of the device. A chopper-stabilized comparator provides the most effective method of satisfying all the converter requirements.

The chopper-stabilized comparator converts the DC input signal into an AC signal. This signal is then fed through a high gain AC amplifier and has the DC level restored. The technique limits the drift components, which is passed by the AC amplifier. This makes the entire ADC extremely insensitive to temperature: long term drift and input offset errors.

## 6.4 Sample and hold circuit

Fig 6.2 shows the sample and hold circuit. This ADC 0808/0809 does not contain the sample-and-hold circuit. If a sample-and-hold circuit is required, it could be connected before the multiplexers. The pin configuration of the ADC 0808/0809 where as the fig is shown in appendix. The input states for the address lines to select any particular channel. The address latched into the decoder on the low-to-high transition of the address latch enable signal.

### 6.4.1 Need of sample and hold circuit

As discussed, the ADC takes finite time, called the conversion time, to give a digital output to corresponding analog input value. If the analog input signals are not stable during conversion time, the digital output will not be the true representation of its analog value. This may lead to error in digital converted data. This error will be some function of the highest frequency and uncertainty in time. In order to overcome this problem, the sample and hold (S/H) circuit is used. This increases the system band width (BW) without change in the accuracy.

The sample and hold circuit has two modes;

- Sample mode
- Hold mode

In the sample mode, the output follows the input with unity gain. Whereas in the hold mode, it retains the last value of the sample when the switch was opened.

The basic sample and hold circuit consists of a switch and a capacitor as shown. When the switch is closed, the capacitor is charged to the instantaneous value of the input signal voltage and when it is opened, it holds the voltage. This process of charging and holding the voltage assumes very high value of load impedance. If the load impedance is not high, then the charge on the capacitor will start leaking through the low value of the load impedance and the held voltage will never be constant.

The ideal waveform of the simplest sample and hold circuit. If the time constant  $RC$  is very small, the capacitor  $C$  will be charged to the sample value very rapidly. Hence during the sample interval, the sample voltage very closely follows the input voltage and during the hold interval, the capacitor holds the sampled value. This happy situation does not hold good in practice, as capacitors and switches are not perfect. There are many types of deviations from the ideal situation. The important specifications worth mentioning for the selection of switches are

- Aperture time
- Acquisition Time

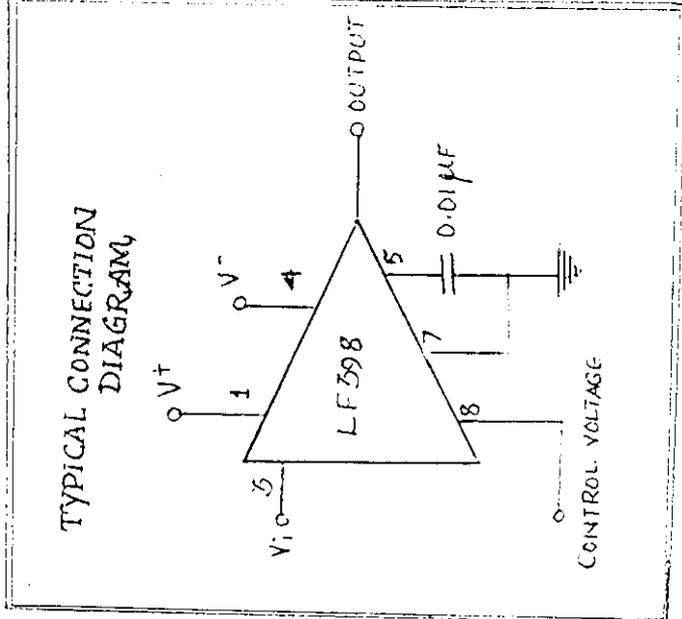
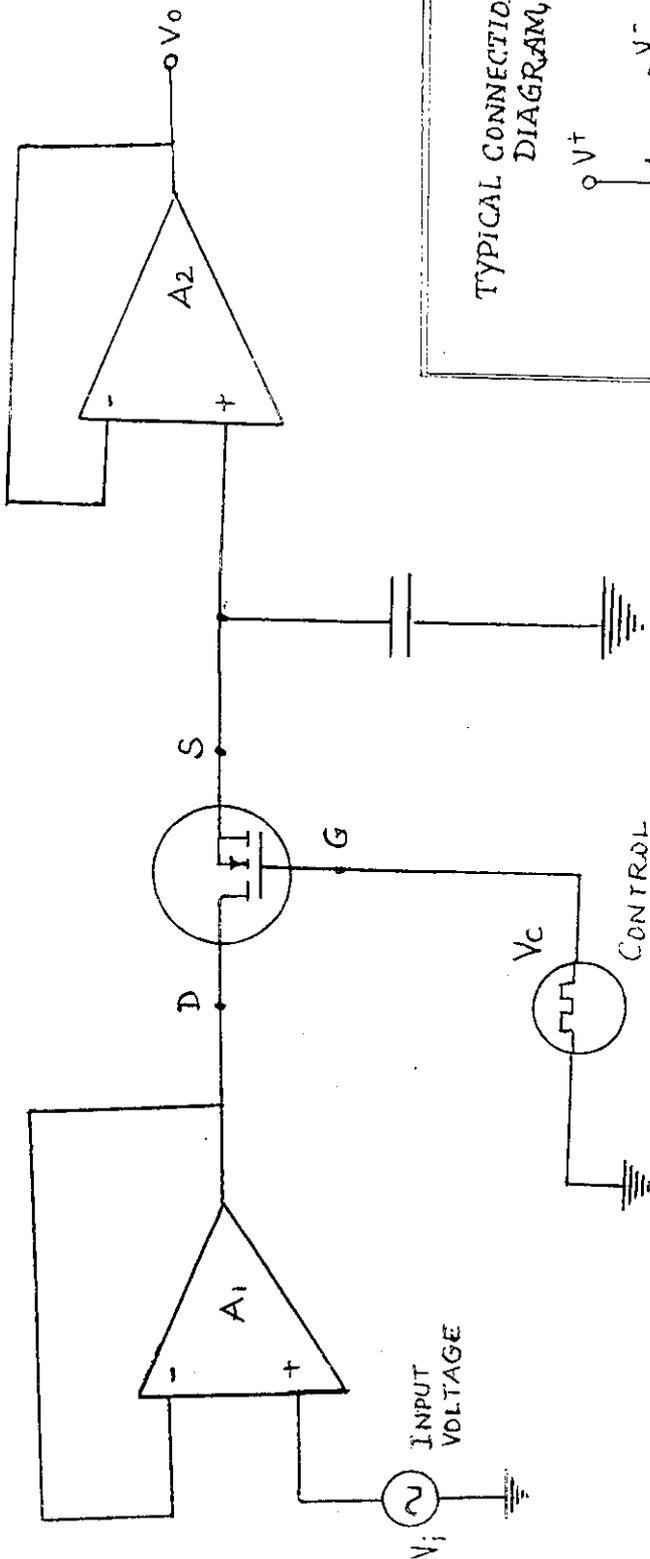


FIG 6.1 SAMPLE AND HOLD CIRCUIT

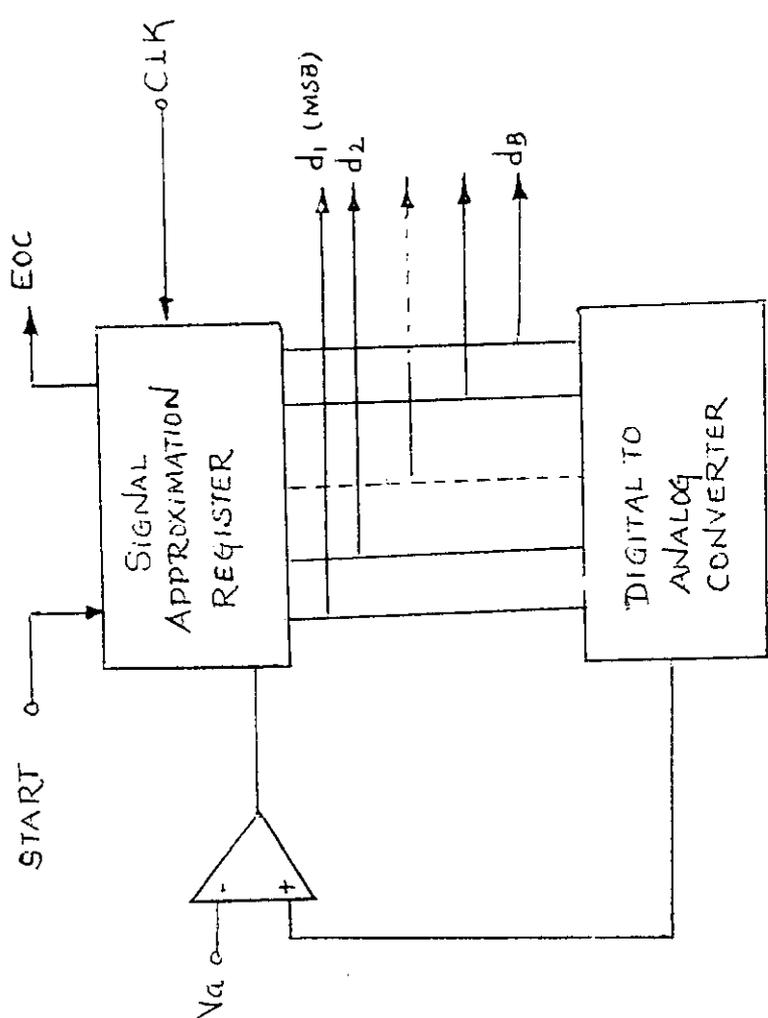


FIG 6.2 FUNCTIONAL DIAGRAM OF THE SUCCESSIVE APPROXIMATION ADC

# *CHAPTER VII*

*MICRO  
CONTROLLER  
ATMEL 89C51*

## CHAPTER VII

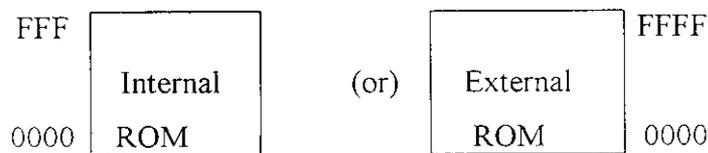
### INTRODUCTION TO MICRO CONTROLLER

The difference between Microprocessor and Micro controller is Microprocessor can only process with the data, Micro controller can control external device. That is if you want switch “ON” or “OFF” a device, you need peripheral ICs to do this work with Micro controller you can directly control the device.

Like Microprocessor, Micro controller is available with different features. It is available with inbuilt memory, I/O lines, timer and ADC. The micro controller, which we are going to use, is 89C51 it is manufactured by ATMEL, USA. This is advanced version of 8031. this Micro controller have inbuilt 4K bytes of flash ROM, 256 bytes of RAM, 32 I/O lines (4 bit ports) and 6 vectored interrupts.

#### **7.1 Flash ROM**

4-kilo byte ROM is available in the Micro controller. It can be erased and reprogrammed. If the available memory is not enough for your program, you can interface the external ROM with this IC, it has 16 address lines, so maximum of  $(2^{16})$  i.e. 64 bytes of ROM can be interfaced with this Micro controller. Both internal and external ROM cannot be used simultaneously.



\_\_\_\_\_ A pin is provided in Micro controller itself is i.e. pin no.31 EA should be high to use internal ROM, low to use external ROM.

## 7.2 RAM

Internal 256 bytes of RAM are available for user. This 256 bytes of RAM can be used along with the external RAM. Externally you can connect 64-kilo bytes of RAM with micro controller. In internal RAM first 128 bytes of RAM is available for user and the remaining 128 bytes are used as special function registers (SFR). These SFR's are used as control registers for timer, serial port etc.

## 7.3 Input/ Output Ports

There are four I/O ports available in AT89C51. They are port 0, port 1, port 2, and port 3. All these ports are eight bit ports. All these ports can be controlled as eight-bit port or it can be controlled individually. One of the main feature of this micro controller is it can control the port pins individually. For example to control a LED we need to use one I/O line in Micro processor with 8255 we have to use

an eight bit port. In micro controller we can use only. In 89C51 port 1 is available for users Port 3 is combined with interrupts. This can be used as interrupts (or) I/O ports, ports 2 & port 0 is combined with address bus & data bus.

All these port lines are available with internal pull-ups except port 0. If we want to use port 0 as I/O port we have to use pull up resistors.

This Micro controller is working in a speed of maximum of 24MHz. This micro controller is available with inbuilt oscillator: just we have to connect the crystal to its terminal.

## **7.4 ATMEL 89C51 MICRO CONTROLLER**

### **7.4.1 Features**

- Compatible with MCS-51 products.
- 4-K bytes of in-system reprogrammable flash memory- endurance:1,000 write/erase cycles.
- Fully static operations:0 Hz to 24 MHz.
- Three-level program memory lock.
- 128 x 8- bit internal RAM.
- Two 16-bit timer/counters.
- Six interrupt sources.
- Programmable serial channel.
- Low power idle and power-down modes.

### 7.4.2 Description

The block diagram of AT89C51 Microcontroller is shown in Fig 7.1. The AT89C51 is a low-power, high-performance CMOS 8-bit microcomputer with 4K bytes of Flash Programmable and Erasable Read Only Memory (PEROM). The device is manufactured using ATMEL'S high-density non-volatile memory technology and is compatible with the industry standard MCS-51 instruction set and pin out. The on-chip flash allows the program memory to be reprogrammed in-system or by a conventional non-volatile memory programmer. By combining a versatile 8-bit CPU with flash on a monolithic chip, the ATMEL AT89C51 is a powerful microcomputer, which requires a highly flexible and cost effective solution to many embedded control applications.

The AT89C51 provides the following standard features:

- 4Kbytes of flash memory.
- 128 bytes of RAM.
- 32 I/O lines.
- Two 16-bit timer/counters, a five vector two-level interrupt architecture.
- A duplex serial port.
- On-chip oscillator and clock circuitry.

In addition, the AT89C51 is designed with static logic for operation down to zero frequency and supports two software.

### **7.4.3 Pin configuration**

The AT89C51 provides the following standard features: 4K bytes of Flash, 128 bytes of RAM, 32 I/O lines, two 16-bit Timer/counters, a five vector two-level interrupt architecture, a full duplex serial port, on-chip oscillator and clock circuitry. In addition, the AT89C51 is designed with static logic for operation down to zero frequency and supports two Software selectable power saving modes. The Idle Mode stops the CPU while allowing the RAM, timer/counters, Serial port and interrupt system to continue functioning. The Power-down Mode saves the RAM contents but freezes the oscillator disabling all other chip functions until the next hardware reset.

### **7.4.4 Pin description**

#### **7.4.4.1 VCC**

Supply voltage.

#### **7.4.4.2 GND**

Ground.

#### **7.4.4.2 Port 0**

Port 0 is an 8-bit open-drain bi-directional I/O port. As an Output port, each pin can sink eight TTL inputs. When 1s are written to port 0 pins, the pins can be used as high-impedance Inputs. Port 0 may also be configured to be the multiplexed low-order address/data bus during accesses to external program and data memory. In this mode P0 has internal pull-ups.

Port 0 also receives the code bytes during Flash programming, and outputs the code bytes during program verification. External pull-ups are required during program verification.

#### **7.4.4.4 Port 1**

Port 1 is an 8-bit bi-directional I/O port with internal pull-ups. The Port 1 output buffers can sink/source four TTL inputs. When 1s are written to Port 1 pins they are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port 1 pins that are externally being pulled low will source Current(I<sub>IL</sub>) because of the internal pull-ups. Port 1 also receives the low-order address bytes during Flash programming and verification.

#### **7.4.4.5 Port 2**

Port 2 is an 8-bit bi-directional I/O port with internal pull-ups. The Port 2 output buffers can sink/source four TTL inputs.

When 1s are written to Port 2 pins they are pulled high by the internal pull-ups and can be used as inputs. As inputs, Port 2 pins that are externally being pulled low will source Current (I<sub>IL</sub>) because of the internal pullups. Port 2 emits the high-order address byte during fetches from external program memory and during accesses to external data memory that use 16-bit addresses (MOVX @DPTR). In this application, it uses strong internal pull-ups when emitting 1s. During accesses to external data memory that use 8-bit addresses (MOVX @ RI), Port 2 emits the contents of the P2 Special Function Register. Port 2 also receives the high-order address

bits and some control signals during Flash programming and verification.

#### **7.4.4.6 Port 3**

Port 3 is an 8-bit bi-directional I/O port with internal pull-ups. The Port 3 output buffers can sink/source four TTL inputs. When 1s are written to Port 3 pins they are pulled high by the internal pull-ups and can be used as inputs. As inputs,

Port 3 pins that are externally being pulled low will source current ( $I_{IL}$ ) because of the pullups. Port 3 also serves the functions of various special features of the AT89C51 as listed below:

Port 3 also receives some control signals for Flash programming and verification.

#### **7.4.4.7 RST**

Reset input. A high on this pin for two machine cycles while the oscillator is running resets the device.

#### **7.4.4.8 ALE/PROG**

Address Latch Enable output pulse for latching the low byte of the address during accesses to external memory. This pin is also the program pulse input (PROG) during Flash programming. In normal operation ALE is emitted at a constant rate of 1/6 the oscillator frequency, and may be used for external timing or clocking purposes. Note, however, that one ALE pulse is skipped during each access to external Data Memory. If desired, ALE

operation can be disabled by setting bit 0 of SFR location 8EH. With the bit set, ALE is active only during a MOVX or MOVC instruction. Otherwise, the pin is weakly pulled high. Setting the ALE-disable bit has no effect if the microcontroller is in external execution mode.

#### **7.4.4.9 PSEN**

Program Store Enable is the read strobe to external program memory. When the AT89C51 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.

#### **7.4.4.10 EA/VPP**

External Access Enable. EA must be strapped to GND in order to enable the device to fetch code from external program memory locations starting at 0000H up to FFFFH. Note, however, that if lock bit 1 is programmed, EA will be internally latched on reset. EA should be strapped to V<sub>CC</sub> for internal program executions. This pin also receives the 12-volt programming enable voltage (V<sub>PP</sub>) during Flash programming, for parts that require 12-volt V<sub>PP</sub>.

#### **7.4.4.11 XTAL1**

Input to the inverting oscillator amplifier and input to the internal clock operating circuit.

#### **7.4.4.12 XTAL2**

Output from the inverting oscillator amplifier.

#### **7.4.5 Oscillator characteristics**

XTAL1 and XTAL2 are the input and output, respectively, of an inverting amplifier which can be configured for use as an on-chip oscillator. Either a quartzcrystal or ceramic resonator may be used. To drive the device from an external clock source, XTAL2 should be left unconnected while XTAL1 is driven. There are no requirements on the duty cycle of the external clock signal, since the input to the internal clocking circuitry is through a divide-by-two flip-flop, but minimum and maximum voltage high and low time specifications must be observed.

#### **7.4.6 Port pin alternate functions**

- P3.0 RXD (serial input port)
- P3.1 TXD (serial output port)
- P3.2 INT0 (external interrupt 0)
- P3.3 INT1 (external interrupt 1)
- P3.4 T0 (timer 0 external input)
- P3.5 T1 (timer 1 external input)
- P3.6 WR (external data memory write strobe)
- P3.7 RD (external data memory read strobe).

### 7.4.7 IDLE MODE

In idle mode, the CPU puts itself to sleep while all the on-chip peripherals remain active. The mode is invoked by software. The content of the on-chip RAM and all the special functions registers remain unchanged during this mode. The idle mode can be terminated by any enabled interrupt or by a hardware reset.

It should be noted that when idle is terminated by a hardware reset, the device normally resumes program execution, from where it left off, up to two machine cycles before the internal reset algorithm takes control. On-chip hardware inhibits access to internal RAM in this event, but access to the port pins is not inhibited. To eliminate the possibility of an unexpected write to a port pin when Idle is terminated by reset, the instruction following the one that invokes Idle should not be one that writes to a port pin or to external memory.

### 7.4.8 Power-down mode

In the power-down mode, the oscillator is stopped, and the instruction that invokes power-down is the last instruction Executed. The on-chip RAM and Special Function Registers retain their values until the power-down mode is terminated. The only exit from power-down is hardware reset. Reset redefines the SFRs but does not change the on-chip RAM. The reset should not be activated before  $V_{CC}$  is restored to its normal operating level and must be held active long enough to allow the oscillator to restart and Stabilize.

#### 7.4.9 Program memory lock bits

On the chip are three lock bits which can be left unprogrammed (U) or can be programmed (P) to obtain the additional features listed in the table below. When lock bit 1 is programmed, the logic level at the EA pin is sampled and latched during reset. If the device is powered up without a reset, the latch initializes to a random value, and holds that value until reset is activated. It is necessary that the latched value of EA be in agreement with the current logic level at that pin in order for the device to function properly.

#### 7.4.10 Programming the flash

The AT89C51 is normally shipped with the on-chip Flash memory array in the erased state (that is, contents = FFH) and ready to be programmed. The programming interface accepts either a high-voltage (12-volt) or a low-voltage ( $V_{CC}$ ) program enable signal. The low-voltage programming mode provides a convenient way to program the AT89C51 inside the user's system, while the high-voltage programming mode is compatible with conventional third-party Flash or EPROM programmers.

The AT89C51 is shipped with either the high-voltage or low-voltage programming mode enabled.

The AT89C51 code memory array is programmed byte by-byte in either programming mode. To program any non-blank byte in the on-chip Flash Memory, the entire memory must be erased using the chip erase mode.

#### 7.4.11 Programming algorithm

Before programming the AT89C51, the address, data and control signals should be set up according to the Flash programming mode table and Figure 3 and Figure 4. To program the AT89C51, take the following steps.

1. Input the desired memory location on the address lines.
2. Input the appropriate data byte on the data lines.
3. Activate the correct combination of control signals.
4. Raise EA/V PP to 12V for the high-voltage programming mode.
5. Pulse ALE/PROG once to program a byte in the flash array or the lock bits. The byte-write cycle is self-timed and typically takes no more than 1.5ms. Repeat steps 1 through 5, changing the address and data for the entire array or until the end of the object file is reached.

#### 7.4.12 Data polling

The AT89C51 features Data Polling to indicate the end of a write cycle. During a write cycle, an attempted read of the last byte written will result in the complement of the written datum on PO.7. Once the write cycle has been completed, true data are valid on all outputs, and the next cycle may begin. Data Polling may begin any time after a write cycle has been initiated.

#### **7.4.13 Ready/Busy**

The progress of byte programming can also be monitored by the RDY/BSY output signal. P3.4 is pulled low after ALE goes high during programming to indicate BUSY. P3.4 is pulled high again when programming is done to indicate READY.

#### **7.4.14 Program verify**

If lock bits LB1 and LB2 have not been programmed, the programmed code data can be read back via the address and data lines for verification. The lock bits cannot be verified directly. Verification of the lock bits is achieved by observing that their features are enabled.

#### **7.4.15 Chip erase**

The entire Flash array is erased electrically by using the proper combination of control signals and by holding ALE/PROG low for 10 ms. The code array is written with all "1"s. The chip erase operation must be executed before the code memory can be re-programmed.

#### **7.4.16 Reading the signature bytes**

The signature bytes are read by the same procedure as a normal verification of locations 030H, 031H, and 032H, except that P3.6 and P3.7 must be pulled to a logic low. The values returned are as follows. (030H) = 1EH indicates manufactured by Atmel

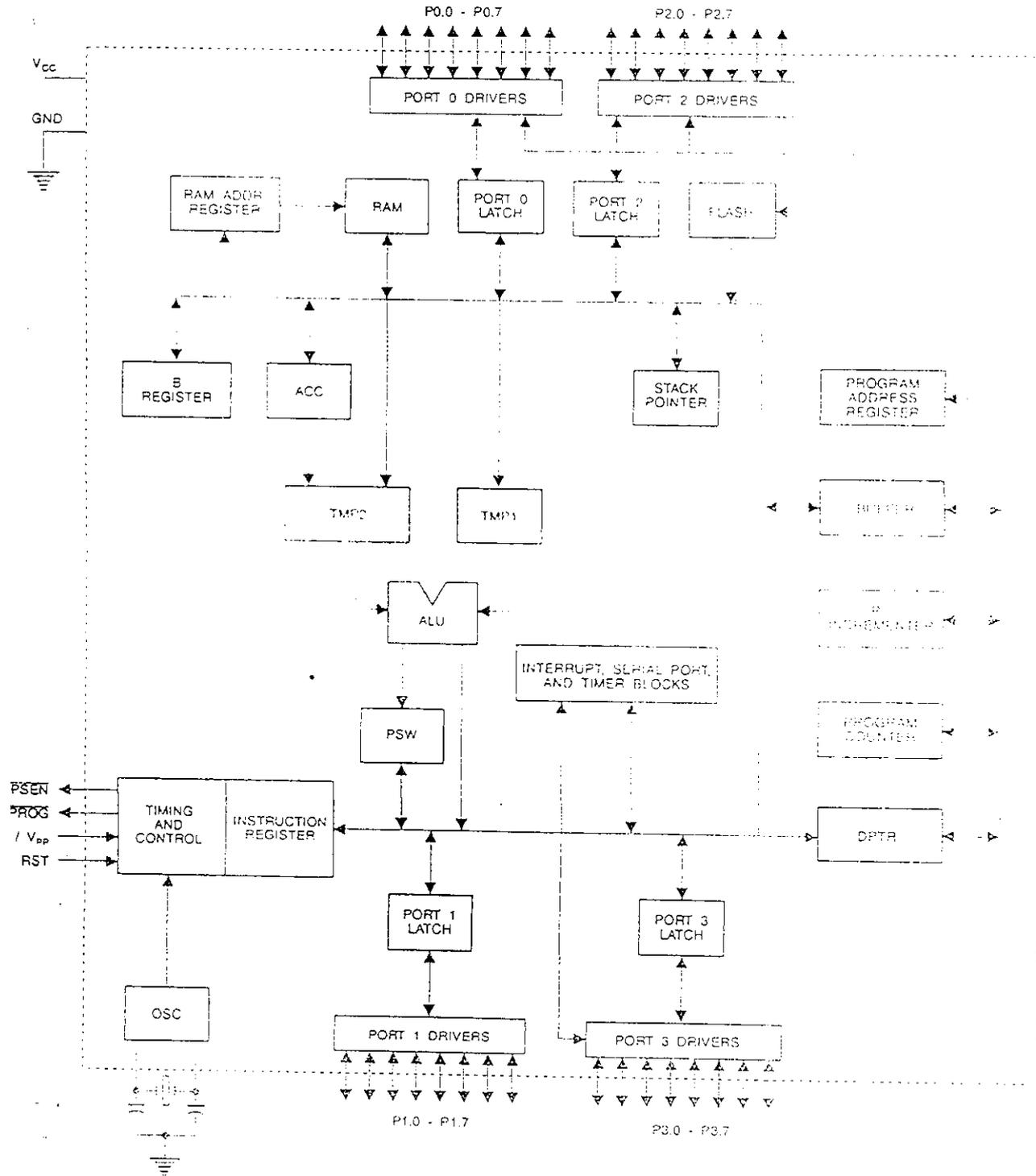
(031H) = 51H indicates 89C51

(032H) = FFH indicates 12V programming

(032H) = 05H indicates 5V programming

#### **7.4.17 Programming interface**

Every code byte in the Flash array can be written and the entire array can be erased by using the appropriate combination of control signals. The write operation cycle is self-timed and once initiated, will automatically time itself to Completion.



# *CHAPTER VIII*

## *POWER SUPPLY UNIT*

## CHAPTER VIII

### POWER SUPPLY UNIT

#### 8.1 Introduction

Block diagram of power supply unit is shown in Fig 8.1. Since all electronic circuits work only with low D.C. voltage we need a power supply unit to provide the appropriate voltage supply. This unit consists of transformer, rectifier, filter and regulator. A.C. voltage typically 230V RMS is connected to a transformer which steps that AC voltage down to the level to the desired AC voltage. A diode rectifier then provides a full-wave rectified voltage that is initially filtered by a simple capacitor filter to produce a DC voltage. This resulting DC voltage usually has some ripple or AC voltage variations. A regulator circuit can use this DC input to provide DC voltage that not only has much less ripple voltage but also remains the same DC value even the DC voltage varies some what, or the load connected to the output DC voltages changes.

#### 8.2 Transformer

A transformer is a static (or stationary) piece of which electric power in one circuit is transformed into electric power of the same frequency in another circuit. It can raise or lower the voltage in a circuit but with a corresponding decrease or increase in current. It works with the principle of mutual induction. In our project we are using step down transformer for providing a necessary supply for the

electronic circuits. In our project we are using a 15-0-15 center tapped transformer.

### **8.3 Rectifier**

The DC level obtained from a sinusoidal input can be improved 100% using a process called full-wave rectification. It uses 4 diodes in a bridge configuration. From the basic bridge configuration we see that two diodes (say D2 & D3) are conducting while the other two diodes (D1 & D4) are in "off" state during the period  $t = 0$  to  $T/2$ . Accordingly for the negative of the input the conducting diodes are D1 & D4. Thus the polarity across the load is the same.

### **8.4 Filter**

The filter circuit used here is the capacitor filter circuit where a capacitor is connected at the rectifier output, and a DC is obtained across it. The filtered waveform is essentially a DC voltage with negligible ripples, which is ultimately fed to the load.

### **8.5 Voltage regulator**

The output voltage from the capacitor is more filtered and finally regulated. The voltage regulator is a device, which maintains the output voltage constant irrespective of the change in supply variations, load variation and temperature changes. Here we use two fixed voltage regulators namely LM 7812, LM 7805 and LM7912.

The IC 7812 is a +12V regulator IC 7912 is a -12V regulator and IC 7805 is a +5V regulator. The circuit diagram of 12 V and 5V supply IC voltage regulators are shown in Fig 8.2 and Fig 8.3.

### 8.5.1 Characteristics of IC voltage regulator

There are four characteristics of three IC regulators, which must be mentioned.

1.  $V_0$ : The regulated output voltage is fixed at value as specified by the manufacture. There are number of models available for different output voltages, for example, 78XX series output voltage must be 5,6,8 etc.,
2.  $V_{in} \geq V_0 + 2$  volts: the unregulated output voltage must be at least 2V more than the regulated output voltage. For example, if  $V_0 = 5V$  then  $V_{in} = 7V$ .
3.  $I (o) \max$ : the load current may be varying from 0 to rated maximum output current. The IC is usually provided with heat sink, otherwise it may not provided the maximum output current.
4. Thermal shutdown: The IC has a temperature sensor, which turns of the IC when it becomes too hot. The output current will drop and remain there until the IC has cooled significantly.

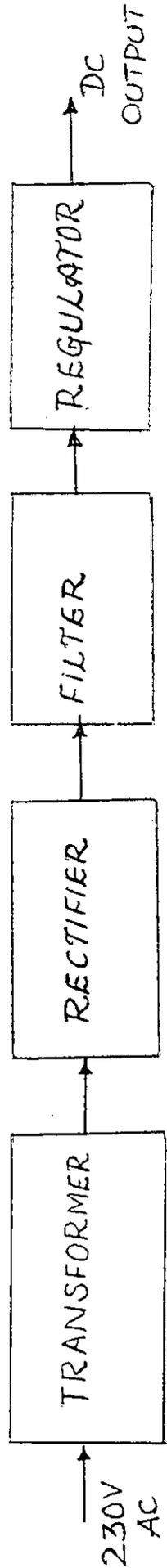


FIG 8.1 POWER SUPPLY UNIT

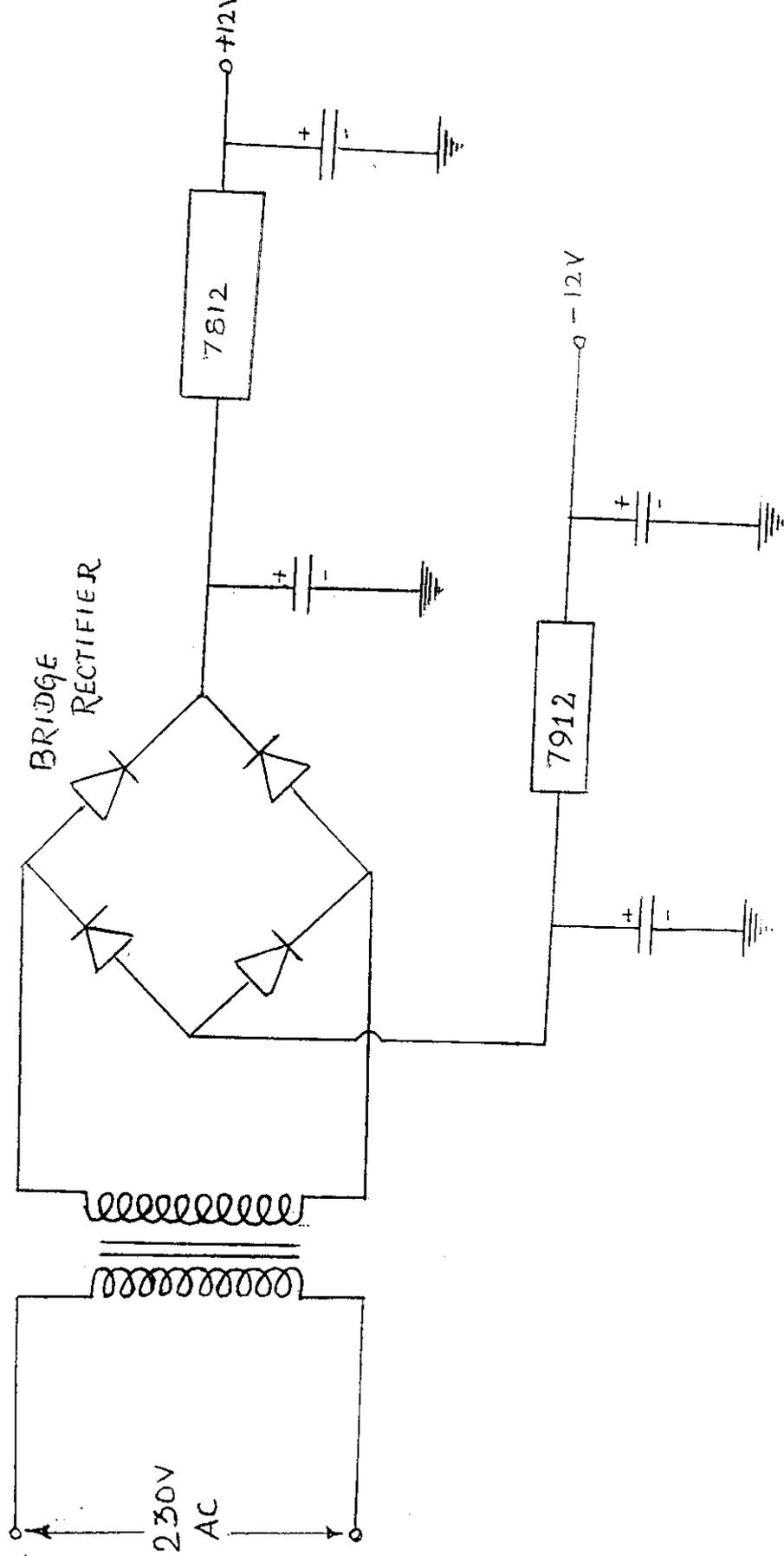


FIG 8.2 12V-IC VOLTAGE REGULATOR.

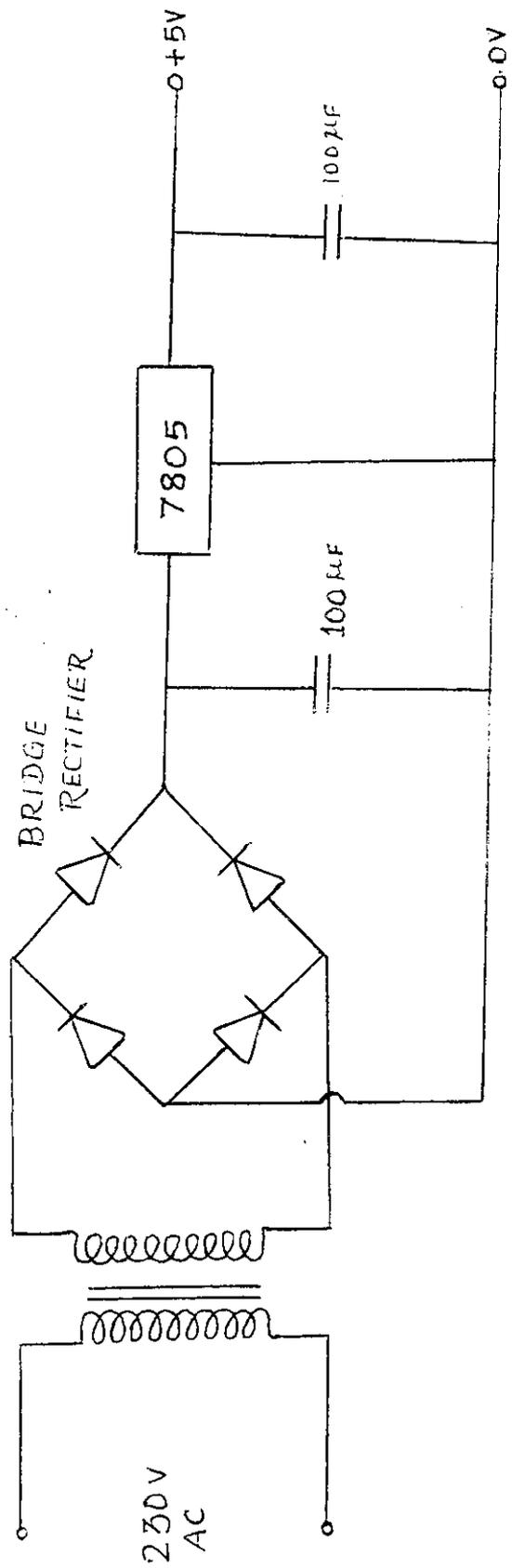


FIG 8.3 5V- IC VOLTAGE REGULATOR

# *CHAPTER IX*

## *SOFTWARE DESCRIPTION*

## CHAPTER IX

### PROGRAM

```

        org      000h
        ljmp     start
        org      00bh
        ljmp     count
start:   setb     p3.7
        mov      3bh,#00h
        mov      8ch,#0bh      ;
th0(timer\counter0 high byte)
        mov      8ah,#0d0h     ; t10(
,,      low byte)
        setb     0afh          ; enable the
interrupt source
        setb     0a9h          ; enable timer0
overflow interrupt
        mov      89h,#11h     ;
tmod(timer\counter0 mode control reg)
        setb     8ch          ; to turn
timer\counter0 on
        lcall    hex_dec
        lcall    display
main:   jb       p3.7,main
loop2:  jnb      p3.7,loop2
        inc      30h          ;30h=r7

```

```
        mov     a,30h
        cjne   a,#0ffh,loopt
        inc    31h      ;31h=r6
        mov    30h,#00h
loopt:   ;lcall  hex_dec
        ;lcall  display
        ljmp   main
jretiz:  ljmp   jreti
count:   push   psw
        mov    a,3bh
        inc   a
        mov    3bh,a
        subb  a,#0aah
        jc    jretiz
        lcall  mul
        mov    70h,30h
        mov    71h,31h
        lcall  hex_dec
        setb  p3.6
        lcall  display
        lcall  delay
        lcall  delay
        lcall  delay
        lcall  delay
        lcall  delay
        lcall  delay
```







```
lcall    delay
lcall    cal
```

```
jret_i:  mov     30h,#00h
         mov     31h,#00h
         mov     3bh,#00h
jreti:   lcall   t_load
         pop     psw
         reti
```

```

                                                                    87
init_ser: mov      tmod,#21h      ; auto reload
mode
          mov      th1,#0aah      ; count
          setb     8eh
          mov      scon,#58h      ; receive
enable and start
          lcall    delay
          ret

```

```

t_load:  mov      8ch,#0bh
          mov      8ah,#0dbh
          ret

```

```

cal:

```

```

hex_dec: mov      r7,30h
          mov      r6,31h
          mov      a,r6          ;r6 msb

```

```
        mov     r1,#00h
        mov     r3,#00h
        mov     r4,#00h
        mov     r5,#00h
loop_m2:  cjne   a,#03h,loop_m1
        mov     a,r7
        subb   a,#0e8h
        jc     loop_h
        inc    r1                ;1000's count
        mov    r7,a
        mov    a,r6
        subb   a,#03h
        mov    r6,a
        ljmp   loop_h
loop_m1:  jc     loop_h
        inc    r1                ;1000's count
        mov    a,#0e8h
        mov    r5,a
        mov    a,r7
        clr    c
        subb   a,r5
        mov    r7,a
        mov    a,#03h
        addc   a,#00h
        mov    r5,a
        mov    a,r6
```

```
        subb    a,r5
        mov     r6,a
        ljmp   loop_m2
loop_h:  mov     a,r6
        cjne   a,#00h,loop_y
        ljmp   loop_x
loop_y:  clr     c
        mov    a,r7
        inc    r3
        subb   a,#64h
        mov    r7,a
        jnc   loop_y
        mov    a,r6
        dec    a
        mov    r6,a
        ljmp   loop_h
loop_x:  mov    a,r7
        cjne   a,#64h,loop_m
        inc    r3
        mov    a,r7
        subb   a,#64h
        ljmp   loop_d1
loop_m:  jc     loop_111
        inc    r3                ;100's count
        subb   a,#64h
        mov    r7,a
```

```
                ljmp    loop_x
loop_111:      cjne    a,#0ah,loop_d10
                subb    a,#0ah
                mov     r7,a
                inc     r4                ;10's
count
                mov     a,#00h
                ljmp    loop_d1
loop_d10:     jc      loop_d1
                inc     r4
                mov     a,r7
                subb    a,#0ah
                mov     r7,a
                ljmp    loop_111
loop_d1:      mov     r5,a                ;1s
                mov     50h,a
                mov     a,r4
                mov     51h,a
                mov     a,r3
                mov     52h,a
                mov     a,r1
                mov     53h,a
                ret
delay:        mov     r0,#0ffh
del_1:        mov     r1,#0ffh
delx:         djnz    r1,delx
```

```
                djnz    r0,del_1
                ret
display:        mov     a,51h
                swap    a
                orl     a,50h
                mov     p0,a
                mov     a,53h
                swap    a
                orl     a,52h
                mov     p2,a
                ret
display0:       mov     a,51h
                swap    a
                orl     a,50h
                mov     p0,a
                mov     a,#01h
                swap    a
                orl     a,52h
                mov     p2,a
                ret
display1:       mov     a,51h
                swap    a
                orl     a,50h
                mov     p0,a
                mov     a,#02h
```

```
        swap    a
        orl     a,52h
        mov     p2,a
        ret
adc_in0:  clr     p3.2
         clr     p3.3
         clr     p3.4
         setb    p3.5
         nop
         nop
         nop
         nop
         nop
         clr     p3.5
         lcall   delay
         mov     a,p1
         mov     30h,a
         mov     70h,a
         ret
adc_in1:  setb    p3.2
         clr     p3.3
         clr     p3.4
         setb    p3.5
         nop
         nop
         nop
```

```
nop
nop
clr    p3.5
lcall  delay
mov    a,p1
mov    30h,a
mov    71h,a
ret
```

```
mul:   mov    a,30h                ;20a2h
        mov    b,#06h
        mul    ab
        mov    40h,a
;2130h
        mov    a,b
        mov    41h,a
        mov    a,31h
;20a3h
        mov    b,#06h
        mul    ab
        mov    b,a
```

```
mov     a,41h
add     a,b
mov     41h,a
mov     30h,40h
mov     31h,41h
mov     20h,40h
mov     21h,41h

ret
```

# *CHAPTER X*

## *CIRCUIT DIAGRAM*



# *CHAPTER XI*

*CONCLUSION*

## CHAPTER XI

### CONCLUSION

A Microcontroller Based System For Measurement Of Motor Performance has been designed, fabricated and tested successfully. This system has the following features.

- Less time consumption.
- No calculations needed.
- Digitalized output

The project will be very useful in industries to measure the performance data such as torque, speed and power of the motor.

# *REFERENCES*

## REFERENCES

1. "A COURSE IN ELECTRICAL AND ELECTRONICS MEASUREMENT AND INSTRUMENTATION" by A.K.Shawney, Dhanpat Rai & Co (P) Ltd, Delhi-1998.
2. "A TEXT BOOK OF ELECTRICAL TECHNOLOGY" by B.L.Theraja and A.K.Theraja, S.Chand & Company Ltd, NewDelhi-1998.
3. "LINEAR NITEGRAED CIRCUITS" by D.RoyChoudhary, New Age International (P) Ltd, NewDelhi-1999.
4. "INDUATRIAL MOTOR CONTROL" by Stephen L. Herman and Walter N. Alerich, Chennai-1998.

# *APPENDIX*

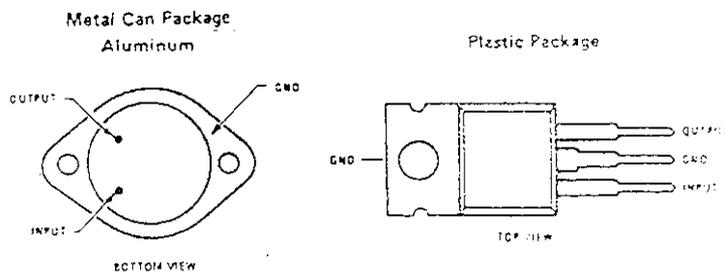
Table 6.1. Electrical characteristics of 7805 voltage regulator

<b>Absolute Maximum Ratings</b>	
Input Voltage (5 V through 18 V) (24 V)	35 V 40 V
Internal Power Dissipation	internally limited
Storage Temperature Range	-65°C to +150°C
Operating Junction Temperature Range	-55°C to +150°C
μA7800	0°C to +125°C
μA7800C	

7805C

Electrical Characteristics  $V_{IN} = 10\text{ V}$ ,  $I_{OUT} = 500\text{ mA}$ ,  $0^\circ\text{C} \leq T_J \leq 125^\circ\text{C}$ ,  $C_{IN} = 0.33\ \mu\text{F}$ ,  $C_{OUT} = 0.1\ \mu\text{F}$ , unless otherwise specified.

Characteristic	Condition	Min	Typ	Max	Unit
Output Voltage	$T_J = 25^\circ\text{C}$	4.8	5.0	5.2	V
Line Regulation	$T_J = 25^\circ\text{C}$	$7\text{ V} \leq V_{IN} \leq V$	3	100	mV
		$8\text{ V} \leq V_{IN} \leq 12\text{ V}$	1	50	mV
Load Regulation	$T_J = 25^\circ\text{C}$	$5\text{ mA} \leq I_{OUT} \leq 1.5\text{ A}$	15	100	mV
		$250\text{ mA} \leq I_{OUT} \leq 750\text{ mA}$	5	50	mV
Output voltage	$7\text{ V} \leq V_{IN} \leq 20\text{ V}$ $5\text{ mA} \leq I_{OUT} \leq 1.0\text{ A}$ $P \leq 15\text{ W}$	4.75		5.25	V
Quiescent Current	$T_J = 25^\circ\text{C}$		4.2	8.0	mA
Quiescent Current Change	with line	$7\text{ V} \leq V_{IN} \leq 25\text{ V}$		1.3	mA
	with load	$5\text{ mA} \leq I_{OUT} \leq 1.0\text{ A}$		0.5	mA
Output Noise Voltage	$T_A = 25^\circ\text{C}$ , $10\text{ Hz} \leq f \leq 100\text{ kHz}$		40		$\mu\text{V}$
Ripple Rejection	$f = 120\text{ Hz}$ , $8\text{ V} \leq V_{IN} \leq 18\text{ V}$	62	78		dB
Dropout Voltage	$I_{OUT} = 1.0\text{ A}$ , $T_J = 25^\circ\text{C}$		2.0		V
Output Resistance	$f = 1\text{ kHz}$		17		$\text{m}\Omega$
Short-Circuit Current	$T_J = 25^\circ\text{C}$ , $V_{IN} = 35\text{ V}$		750		mA
Peak Output Current	$T_J = 25^\circ\text{C}$		2.2		A
Average Temperature Coefficient of output voltage	$I_{OUT} = 5\text{ mA}$ , $0^\circ\text{C} \leq T_J \leq 125^\circ\text{C}$		1.1		$\text{mV}/^\circ\text{C}$



## Absolute Maximum Ratings\*

Operating Temperature	-55°C to +125°C
Storage Temperature	-65°C to +150°C
Voltage on Any Pin with Respect to Ground	-1.0V to +7.0V
Maximum Operating Voltage	6.6V
DC Output Current	15.0 mA

\*NOTICE: Stresses beyond those listed under "Absolute Maximum Ratings" may cause permanent damage to the device. This is a stress rating only and functional operation of the device at these or any other conditions beyond those indicated in the operational sections of this specification is not implied. Exposure to absolute maximum rating conditions for extended periods may affect device reliability.

## DC Characteristics

$T_A = -40^\circ\text{C}$  to  $85^\circ\text{C}$ ,  $V_{CC} = 5.0\text{V} \pm 20\%$  (unless otherwise noted)

Symbol	Parameter	Condition	Min	Max	Units
$V_{IL}$	Input Low-voltage	(Except $\overline{EA}$ )	-0.5	$0.2 V_{CC} - 0.1$	V
$V_{IL1}$	Input Low-voltage ( $\overline{EA}$ )		-0.5	$0.2 V_{CC} - 0.3$	V
$V_{IH}$	Input High-voltage	(Except XTAL1, RST)	$0.2 V_{CC} + 0.9$	$V_{CC} + 0.5$	V
$V_{IH1}$	Input High-voltage	(XTAL1, RST)	$0.7 V_{CC}$	$V_{CC} + 0.5$	V
$V_{OL}$	Output Low-voltage <sup>(1)</sup> (Ports 1,2,3)	$I_{OL} = 1.6\text{ mA}$		0.45	V
$V_{OL1}$	Output Low-voltage <sup>(1)</sup> (Port 0, ALE, $\overline{PSEN}$ )	$I_{OL} = 3.2\text{ mA}$		0.45	V
$V_{OH}$	Output High-voltage (Ports 1,2,3, ALE, $\overline{PSEN}$ )	$I_{OH} = -60\ \mu\text{A}$ , $V_{CC} = 5\text{V} \pm 10\%$	2.4		V
		$I_{OH} = -25\ \mu\text{A}$	$0.75 V_{CC}$		V
		$I_{OH} = -10\ \mu\text{A}$	$0.9 V_{CC}$		V
$V_{OH1}$	Output High-voltage (Port 0 in External Bus Mode)	$I_{OH} = -800\ \mu\text{A}$ , $V_{CC} = 5\text{V} \pm 10\%$	2.4		V
		$I_{OH} = -300\ \mu\text{A}$	$0.75 V_{CC}$		V
		$I_{OH} = -80\ \mu\text{A}$	$0.9 V_{CC}$		V
$I_{IL}$	Logical 0 Input Current (Ports 1,2,3)	$V_{IN} = 0.45\text{V}$		-50	$\mu\text{A}$
$I_{TL}$	Logical 1 to 0 Transition Current (Ports 1,2,3)	$V_{IN} = 2\text{V}$ , $V_{CC} = 5\text{V} \pm 10\%$		-650	$\mu\text{A}$
$I_U$	Input Leakage Current (Port 0, $\overline{EA}$ )	$0.45 < V_{IN} < V_{CC}$		$\pm 10$	$\mu\text{A}$
RRST	Reset Pull-down Resistor		50	300	$\text{K}\Omega$
$C_{IO}$	Pin Capacitance	Test Freq. = 1 MHz, $T_A = 25^\circ\text{C}$		10	pF
$I_{CC}$	Power Supply Current	Active Mode, 12 MHz		20	mA
		Idle Mode, 12 MHz		5	mA
	Power-down Mode <sup>(2)</sup>	$V_{CC} = 6\text{V}$		100	$\mu\text{A}$
		$V_{CC} = 3\text{V}$		40	$\mu\text{A}$

Notes: 1. Under steady state (non-transient) conditions,  $I_{OL}$  must be externally limited as follows:

- Maximum  $I_{OL}$  per port pin: 10 mA
- Maximum  $I_{OL}$  per 8-bit port: Port 0: 26 mA
- Ports 1, 2, 3: 15 mA
- Maximum total  $I_{OL}$  for all output pins: 71 mA

If  $I_{OL}$  exceeds the test condition,  $V_{OL}$  may exceed the related specification. Pins are not guaranteed to sink current greater than the listed test conditions.

- 2. Minimum  $V_{CC}$  for Power-down is 2V.

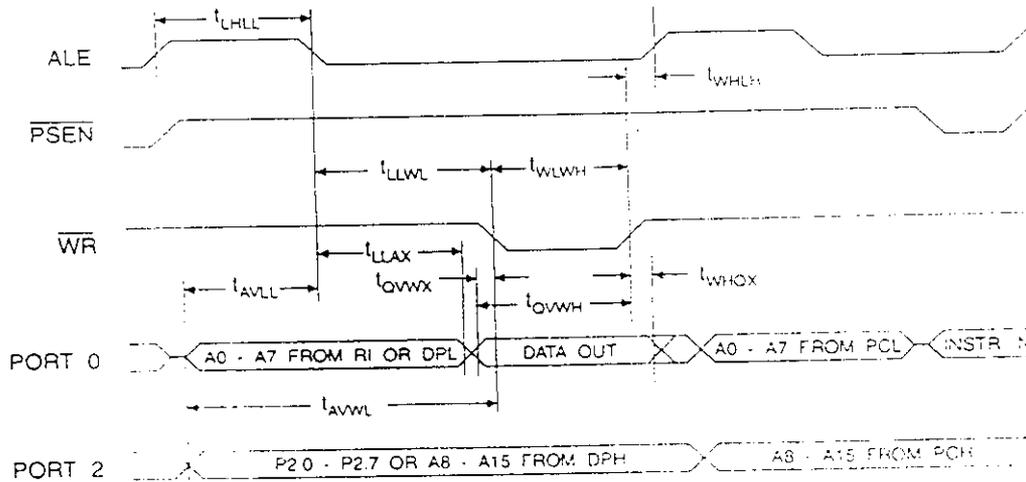
## AC Characteristics

Under operating conditions, load capacitance for Port 0, ALE/ $\overline{\text{PROG}}$ , and  $\overline{\text{PSEN}}$  = 100 pF; load capacitance for all other outputs = 80 pF.

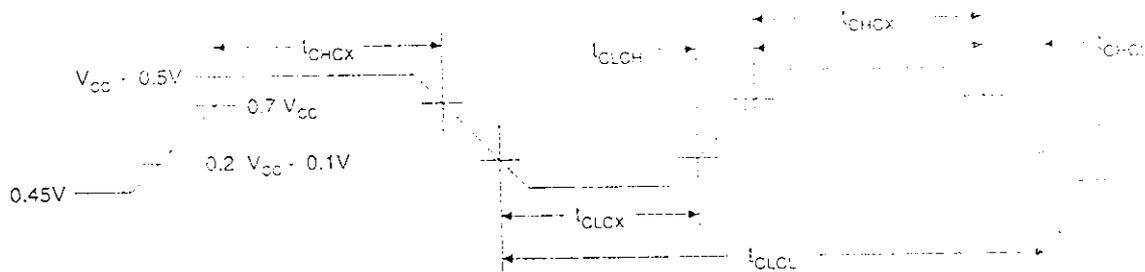
### External Program and Data Memory Characteristics

Symbol	Parameter	12 MHz Oscillator		16 to 24 MHz Oscillator		Units
		Min	Max	Min	Max	
$1/f_{\text{CLOCK}}$	Oscillator Frequency			0	24	MHz
$t_{\text{AHL}}$	ALE Pulse Width	127		$2t_{\text{CLOCK}}$ -40		ns
$t_{\text{AVLL}}$	Address Valid to ALE Low	43		$t_{\text{CLOCK}}$ -13		ns
$t_{\text{LLAX}}$	Address Hold After ALE Low	48		$t_{\text{CLOCK}}$ -20		ns
$t_{\text{LLV}}$	ALE Low to Valid Instruction In		233		$4t_{\text{CLOCK}}$ -65	ns
$t_{\text{LLPL}}$	ALE Low to $\overline{\text{PSEN}}$ Low	43		$t_{\text{CLOCK}}$ -13		ns
$t_{\text{PLPH}}$	$\overline{\text{PSEN}}$ Pulse Width	205		$3t_{\text{CLOCK}}$ -20		ns
$t_{\text{PLIV}}$	$\overline{\text{PSEN}}$ Low to Valid Instruction In		145		$3t_{\text{CLOCK}}$ -45	ns
$t_{\text{PXIX}}$	Input Instruction Hold After $\overline{\text{PSEN}}$	0		0		ns
$t_{\text{PXIZ}}$	Input Instruction Float After $\overline{\text{PSEN}}$		59		$t_{\text{CLOCK}}$ -10	ns
$t_{\text{PXAV}}$	$\overline{\text{PSEN}}$ to Address Valid	75		$t_{\text{CLOCK}}$ -8		ns
$t_{\text{AVIV}}$	Address to Valid Instruction In		312		$5t_{\text{CLOCK}}$ -55	ns
$t_{\text{PLAZ}}$	$\overline{\text{PSEN}}$ Low to Address Float		10		10	ns
$t_{\text{RLRH}}$	$\overline{\text{RD}}$ Pulse Width	400		$6t_{\text{CLOCK}}$ -100		ns
$t_{\text{WLWH}}$	$\overline{\text{WR}}$ Pulse Width	400		$6t_{\text{CLOCK}}$ -100		ns
$t_{\text{RLDV}}$	$\overline{\text{RD}}$ Low to Valid Data In		252		$5t_{\text{CLOCK}}$ -90	ns
$t_{\text{RHDX}}$	Data Hold After $\overline{\text{RD}}$	0		0		ns
$t_{\text{RHDX}}$	Data Float After $\overline{\text{RD}}$		97		$2t_{\text{CLOCK}}$ -28	ns
$t_{\text{LLDV}}$	ALE Low to Valid Data In		517		$8t_{\text{CLOCK}}$ -150	ns
$t_{\text{AVDV}}$	Address to Valid Data In		585		$9t_{\text{CLOCK}}$ -165	ns
$t_{\text{LLWL}}$	ALE Low to $\overline{\text{RD}}$ or $\overline{\text{WR}}$ Low	200	300	$3t_{\text{CLOCK}}$ -50	$3t_{\text{CLOCK}}$ -50	ns
$t_{\text{AVWL}}$	Address to $\overline{\text{RD}}$ or $\overline{\text{WR}}$ Low	203		$4t_{\text{CLOCK}}$ -75		ns
$t_{\text{QVWX}}$	Data Valid to $\overline{\text{WR}}$ Transition	23		$t_{\text{CLOCK}}$ -20		ns
$t_{\text{QVWH}}$	Data Valid to $\overline{\text{WR}}$ High	433		$7t_{\text{CLOCK}}$ -120		ns
$t_{\text{WHDX}}$	Data Hold After $\overline{\text{WR}}$	33		$t_{\text{CLOCK}}$ -20		ns
$t_{\text{RLAZ}}$	$\overline{\text{RD}}$ Low to Address Float		0		0	ns
$t_{\text{WRH}}$	$\overline{\text{RD}}$ or $\overline{\text{WR}}$ High to ALE High	43	123	$t_{\text{CLOCK}}$ -20	$t_{\text{CLOCK}}$ -25	ns

## External Data Memory Write Cycle



## External Clock Drive Waveforms

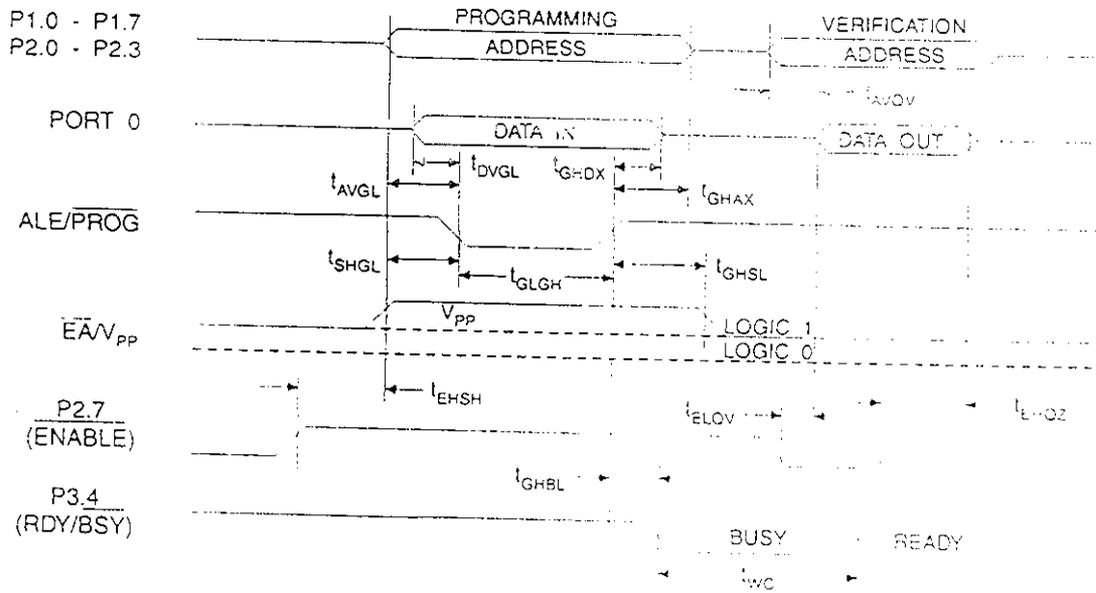


## External Clock Drive

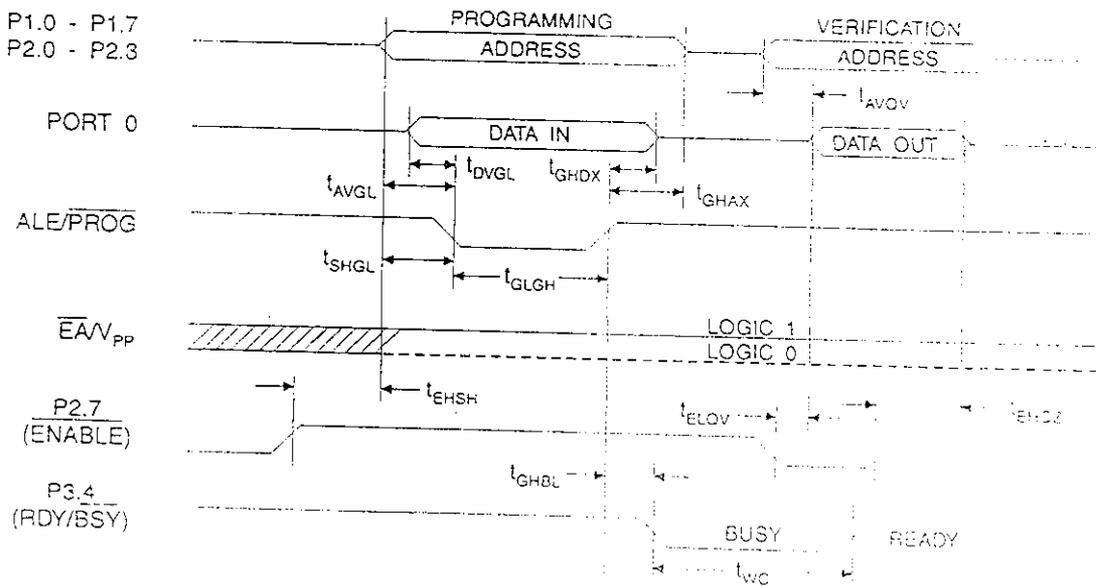
Symbol	Parameter	Min	Max	Units
$1/t_{CLCL}$	Oscillator Frequency	0	24	MHz
$t_{CLCL}$	Clock Period	41.6		ns
$t_{CHCX}$	High Time	15		ns
$t_{CLCX}$	Low Time	15		ns
$t_{CLCH}$	Rise Time		20	ns
$t_{CHCL}$	Fall Time		20	ns



### Flash Programming and Verification Waveforms - High-voltage Mode ( $V_{PP} = 12V$ )



### Flash Programming and Verification Waveforms - Low-voltage Mode ( $V_{PP} = 5V$ )



## Flash Programming and Verification Characteristics

$T_A = 0^\circ\text{C}$  to  $70^\circ\text{C}$ ,  $V_{CC} = 5.0 \pm 10\%$

Symbol	Parameter	Min	Max	Units
$V_{PP}^{(1)}$	Programming Enable Voltage	11.5	12.5	V
$I_{PP}^{(1)}$	Programming Enable Current		1.0	mA
$1/t_{CLCL}$	Oscillator Frequency	3	24	MHz
$t_{AVGL}$	Address Setup to $\overline{\text{PROG}}$ Low	$48t_{CLCL}$		
$t_{GHAX}$	Address Hold After $\overline{\text{PROG}}$	$48t_{CLCL}$		
$t_{DVGL}$	Data Setup to $\overline{\text{PROG}}$ Low	$48t_{CLCL}$		
$t_{GHDX}$	Data Hold After $\overline{\text{PROG}}$	$48t_{CLCL}$		
$t_{EHS}$	P2.7 (ENABLE) High to $V_{PP}$	$48t_{CLCL}$		
$t_{SHGL}$	$V_{PP}$ Setup to $\overline{\text{PROG}}$ Low	10		$\mu\text{s}$
$t_{GHS}^{(1)}$	$V_{PP}$ Hold After $\overline{\text{PROG}}$	10		$\mu\text{s}$
$t_{GLGH}$	$\overline{\text{PROG}}$ Width	1	110	$\mu\text{s}$
$t_{AVQV}$	Address to Data Valid		$48t_{CLCL}$	
$t_{ELOW}$	ENABLE Low to Data Valid		$48t_{CLCL}$	
$t_{EHOZ}$	Data Float After ENABLE	0	$48t_{CLCL}$	
$t_{GHSL}$	$\overline{\text{PROG}}$ High to $\overline{\text{BUSY}}$ Low		1.0	$\mu\text{s}$
$t_{WC}$	Byte Write Cycle Time		2.0	ms

Note: 1. Only used in 12-volt programming mode.