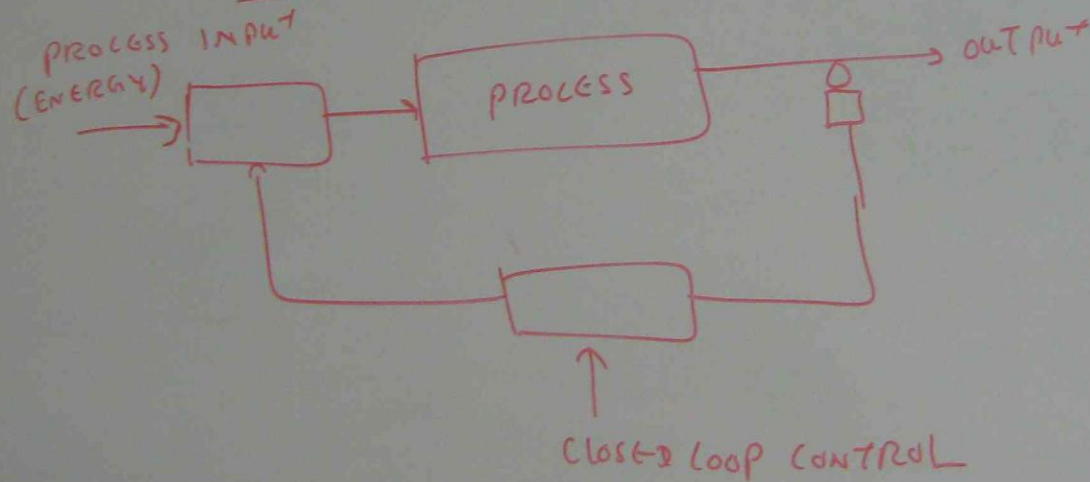


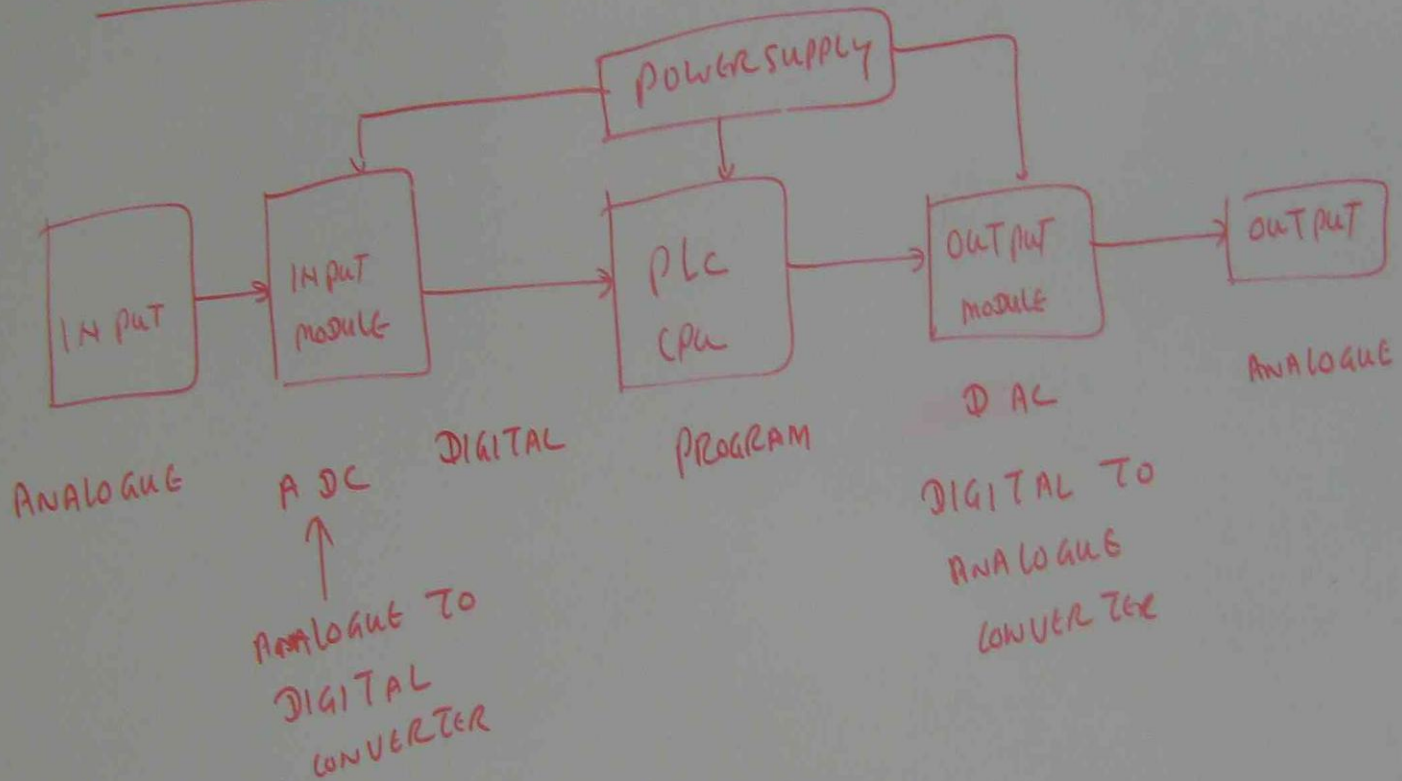
## INDUSTRIAL TRANSDUCERS

TRANSducers FORM AN IMPORTANT COMPONENT IN ANY CLOSED LOOP CONTROL SYSTEM (OR) PROGRAMMABLE CONTROL SYSTEM USED IN INDUSTRIAL CONTROL.

### CLOSED LOOP CONTROL SYSTEM



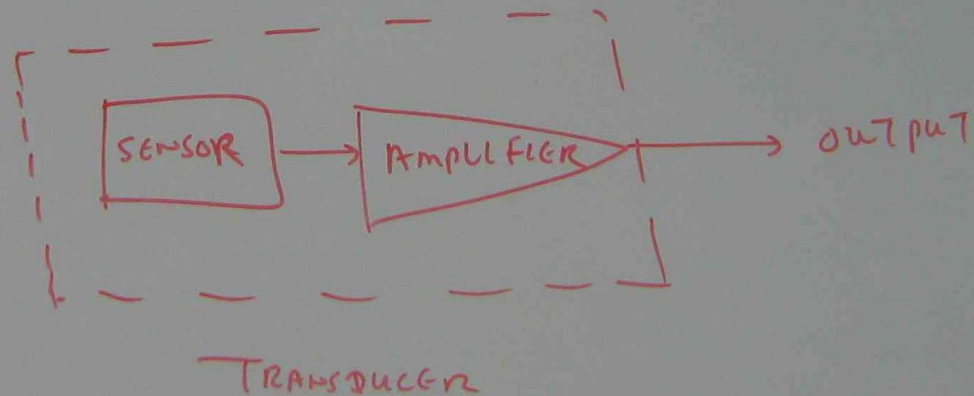
## BLOCK DIAGRAM OF PLC SYSTEM



## TRANSDUCES AND SENSORS

A TRANSDUCER CONSISTS OF THE SENSOR AND ITS ASSOCIATED CIRCUITRY TO PRODUCE AN OUT PUT SIGNAL

A SENSOR IS A DEVICE THAT DETECTS A CHANGE IN PHYSICAL STIMULUS AND CONVERT THIS CHANGE TO A SIGNAL THAT CAN BE MEASURED.



Length, Time, mass, Temperature, Current  
Amount of substance, Luminous intensity  
To be measured

### Forms of Energy

THERE ARE SIX GENERAL TYPES OF SIGNAL  
THAT CAN BE MEASURED.

RADIANT → ULTRA VIOLET LIGHT, X RAY

MECHANICAL → DISPLACEMENT, VELOCITY, FORCE, PRESSURE, Flow, Sound

THERMAL → TEMPERATURE, CONDUCTION, HEAT Flow

ELECTRICAL → VOLTAGE, CURRENT, RESISTANCE, DIELECTRIC CONSTANT

MAGNETIC → MAGNETIC FLUX, FIELD STRENGTH

CHEMICAL → COMPOSITION, PH, ACIDITY ETC

## TERMINOLOGY

RANGE  $\rightarrow$  OPERATING RANGE

SPAN - LOWER & UPPER RANGE

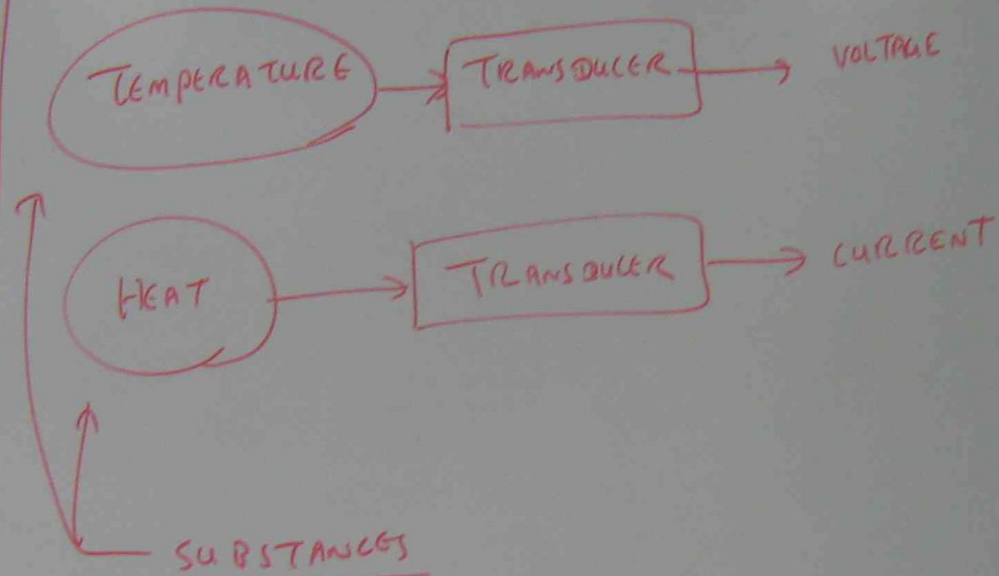
LINEARITY - OUTPUT OF TRANSDUCER  
IS PROPORTIONAL TO INPUT

SENSITIVITY - THE AMOUNT OF OUTPUT SIGNAL  
IN RELATION TO THE TRANSDUCER  
INPUT SIGNAL

RESOLUTION - THIS IS THE SMALLEST CHANGE OF  
INPUT SIGNAL THAT THE TRANSDUCER  
CAN RESPOND TO.



## TEMPERATURE MEASUREMENT



SOLID, LIQUID, GAS  
HEAT IS GENERATED & TRANSMITTED BY  
CONDUCTION, CONVECTION & RADIATION.

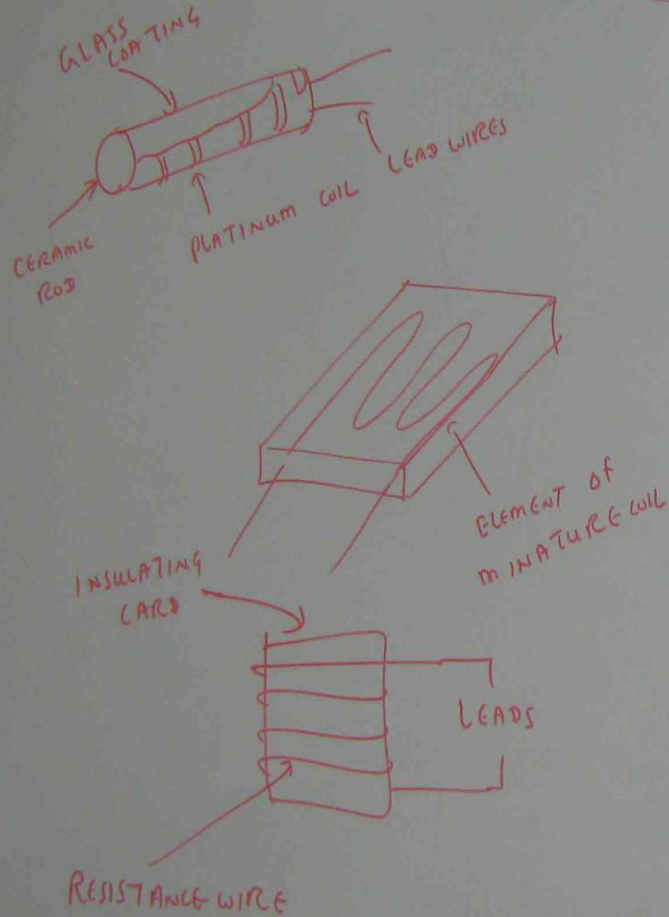
## TRANSDUCERS

THERMOCOUPLES (500C → 1500C)

OUTPUT IS GENERATED IN MILLIVOLT

RTD RESISTANCE TEMPERATURE DETECTOR

## RESISTANCE TEMPERATURE DETECTOR (RTD) CONSTRUCTION



THE RESISTANCE TEMPERATURE DETECTOR DEPENDS ON THE PROPERTY THAT THE RESISTANCE OF PURE METALLIC CONDUCTOR INCREASES WITH TEMPERATURE RISE.

THE RTD CONSISTS OF A LENGTH OF METAL WIRE WITH KNOWN REPRODUCIBLE AND STABLE TEMPERATURE/RESISTANCE CHARACTERISTICS WOUND ON A NON CONDUCTIVE FORMER.

$$R_2 = R_1 + \alpha \Delta t$$

$$\Delta t = t_2 - t_1$$

## THERMISTOR

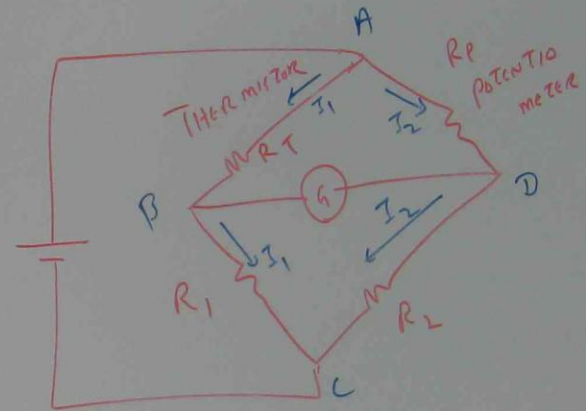
CHANGE IN INPUT TEMPERATURE CAN PRODUCE CHANGE IN OUTPUT SIGNAL.

THERMISTORS ARE RESISTORS MADE FROM METALLIC OXIDE AND CAN EITHER BE POSITIVE TEMPERATURE COEFFICIENT (PTC) <OR> NEGATIVE TEMPERATURE COEFFICIENT (NTC)

$-100^{\circ}\text{C} \rightarrow +300^{\circ}\text{C}$  (RANGE)



## THERMISTOR BRIDGE



WHEN THE BRIDGE IS BALANCED

NO  
CURRENT  
FLOW INTO

(1)

$$V_{AB} = V_{AD}$$

$$I_1 R_T = I_2 R_P \quad \text{--- (1)}$$

$$V_{BC} = V_{CD}$$

$$I_1 R_1 = I_2 R_2 \quad \text{--- (2)}$$



G - GALVANOMETER



$$(1) \div (2) \Rightarrow$$

$$\frac{I_1 R_T}{I_1 R_1} = \frac{I_2 R_P}{I_2 R_2}$$

$$\boxed{\frac{R_T}{R_1} = \frac{R_P}{R_2}}$$

THE BRIDGE IS CALIBRATED TO HAVE BALANCE AT PARTICULAR TEMPERATURE BY ADJUSTING  $R_P$ .

WHEN TEMPERATURE CHANGE, THE CHANGE OF  $R_T$  CAUSES UNBALANCE AND GALVANOMETER INDICATE UNBALANCE VALUE.

INSTEAD OF GALVANOMETER, THE CONTROL CIRCUIT CAN BE UTILIZED.

## FORCE MEASUREMENT

### (THE STRAIN GAUGE)

THE STRAIN, LOAD, ACCELERATION AND VIBRATION ON AN OBJECT CAN BE DETERMINED BY MEASURING THE DISPLACEMENT OF PRE-DETERMINED POINTS.

WHEN THE FORCE IS APPLIED  $\rightarrow$  THE OBJECT DISTORT SLIGHTLY

IF THE STRAIN GAUGE IS STRETCHED, ITS RESISTANCE INCREASES

IF THE STRAIN GAUGE IS COMPRESSED, ITS RESISTANCE DECREASES

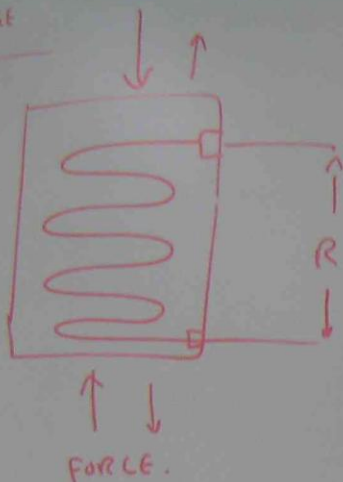
$$R = \frac{\rho L}{A}$$

$R$  = RESISTANCE ( $\Omega$ )  
 $\rho$  = RESISTIVITY ( $\Omega\text{-m}$ )  
 $A$  = C.S.A OF WIRE ( $\text{m}^2$ )

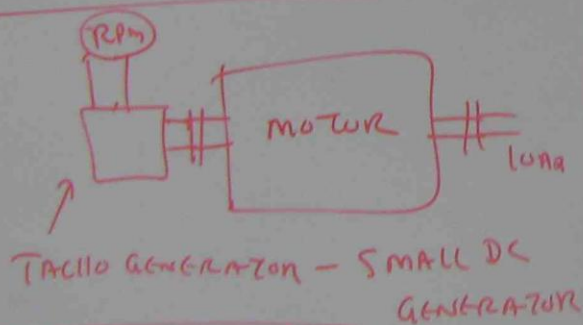
THE STRAIN GAUGE RESISTANCE IS INCLUDED IN BRIDGE SO THAT UNBALANCE CONDITION CAUSES THE CURRENT FLOWS IN GALVANOMETER.

STRAIN

## STRAIN GAUGE



## TACHO GENERATOR



$$E_g = \frac{\phi z N}{60} \times \frac{P}{a}$$

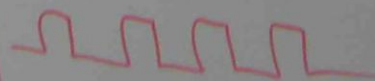
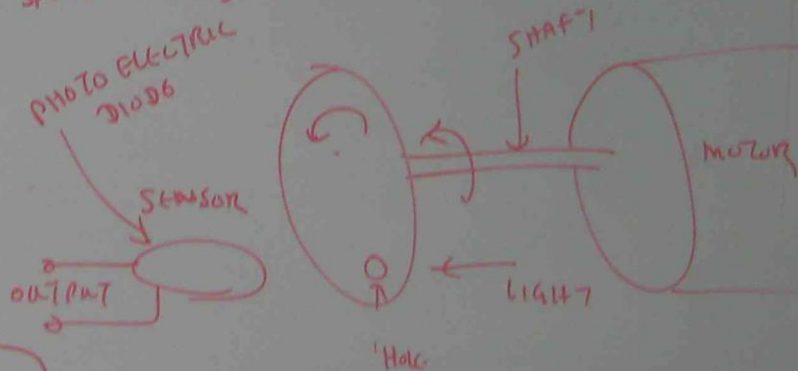
$\phi$  = flux,  $z$  = NO. OF CONDUCTORS IN WINDINGS  
 $N$  = SPEED,  $P$  = NO. OF POLES  
 $a$  = NO. OF ARMATURE PATHS

Eg  $\propto N$

TACHO GENERATOR VOLTAGE IS PROPORTIONAL TO MOTOR SPEED WHICH IS SENSED BY IT  
 AS TACHO GENERATOR IS COUPLED WITH MOTOR SHAFT

## ENCODERS

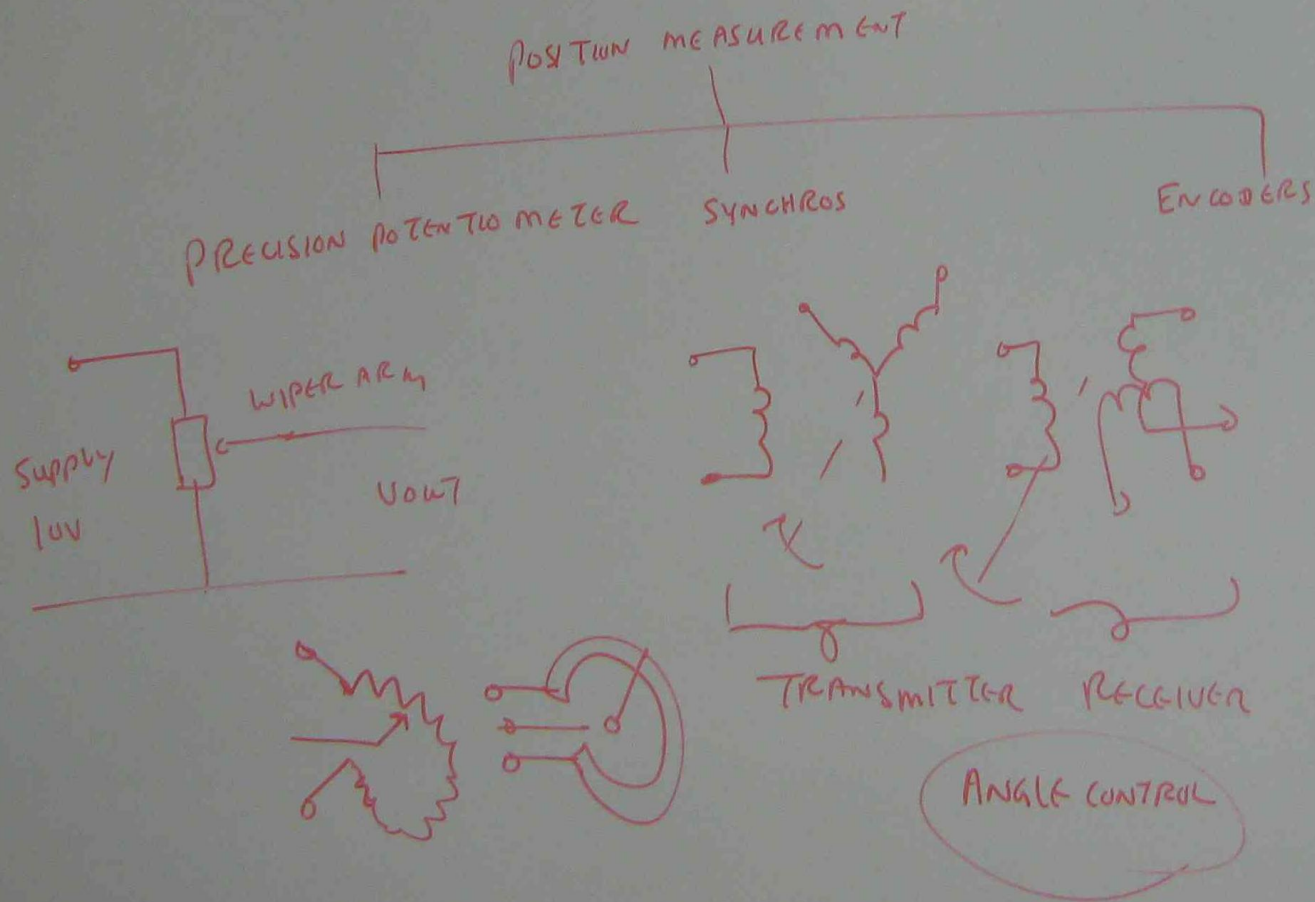
SPEED  $\rightarrow$  DIGITAL PULSE



NO OF PULSES  $\propto$  SPEED

## POSITIONAL MEASUREMENT

POSITION TRANSDUCERS ARE WIDELY USED IN CONTROL SYSTEMS TO MEASURE SHAFT POSITION, POSITION OF OBJECTS, CONTROL VALVE POSITION, LEVELLING OF LIFT CARS ETC.

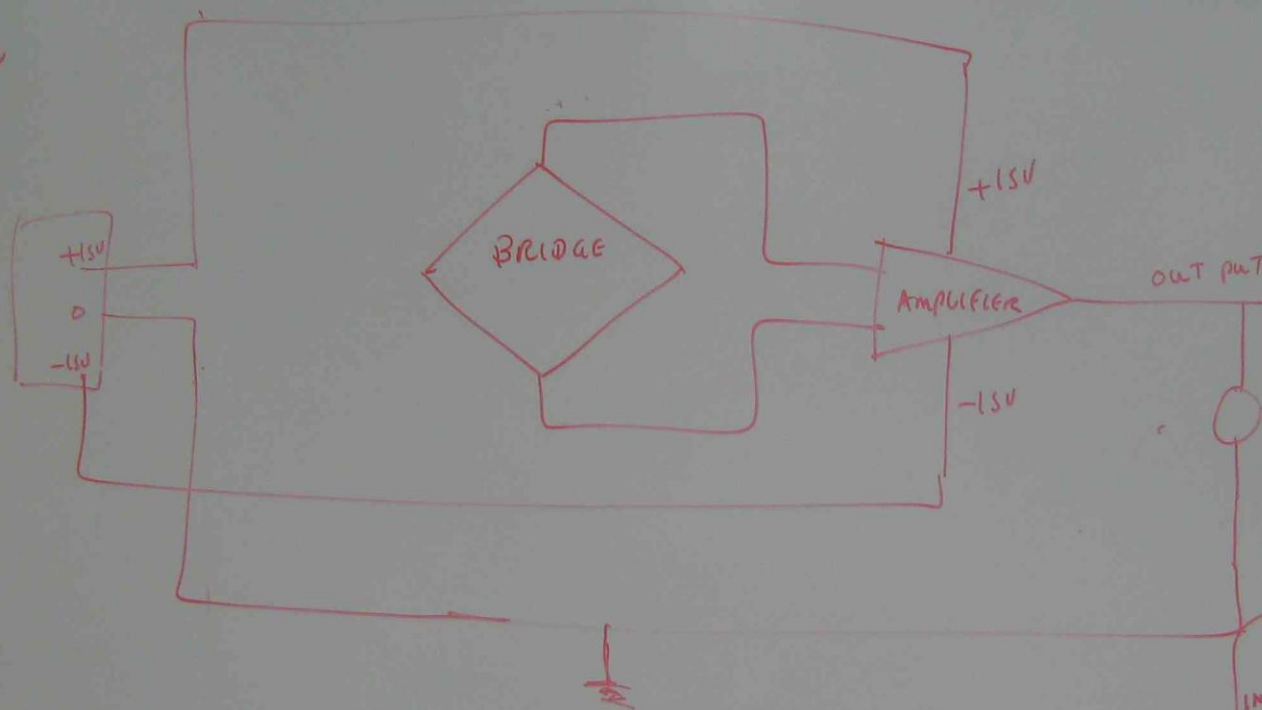




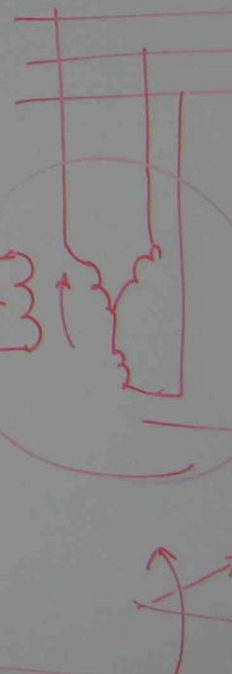
FT position

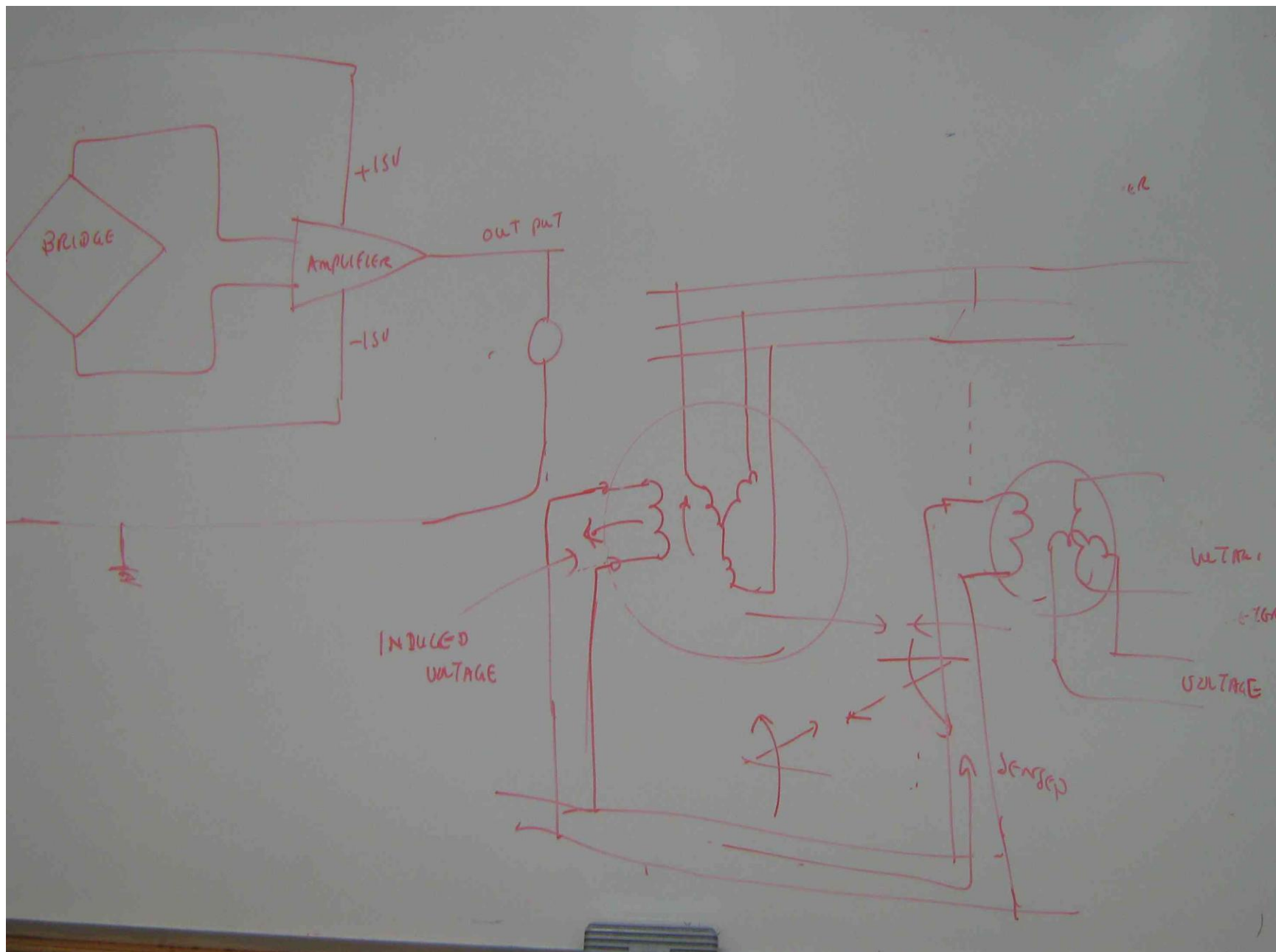
etc.

Power  
Supply.



INDUCTOR





## FINAL CONTROL ELEMENTS

### ELECTRO MECHANICAL DEVICES USED IN CONTROL SYSTEM

- SOLENOIDS
- RELAYS
- CONTACTORS

### PROTECTION METHODS USED WITH ELECTRO-MECHANICAL DEVICES

- CONTACT PROTECTION
- INTERFACE CIRCUIT PROTECTION
- CONTACT BOUNCE PROTECTION

## VALVES

- ELECTRICAL SOLENOIDS
- MOTOR DRIVEN
- PNEUMATIC
- HYDRAULIC

## SOLID STATE SWITCHES

- BIPOLAR JUNCTION TRANSISTORS (BJT)
- THYRISTORS (SCR AND TRIACS)

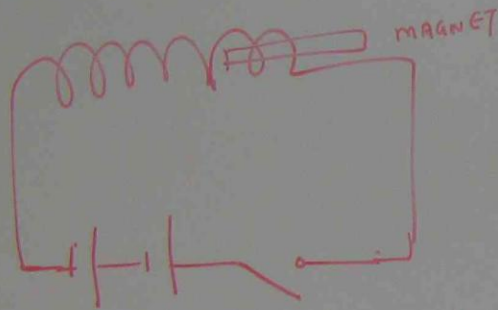
## FINAL CONTROL ELEMENTS (F.C.E)

FINAL CONTROL ELEMENTS (F.C.E) ARE IMPORTANT COMPONENTS IN ANY CONTROL SYSTEM AS THESE ELEMENTS CONVERT THE OUTPUT SIGNALS FROM THE CONTROLLERS TO CONTROL THE ACTUAL PROCESS SUCH AS TEMPERATURE, HEAT, PRESSURE, FLOW, LEVEL, POSITION ETC.





## SOLENOID



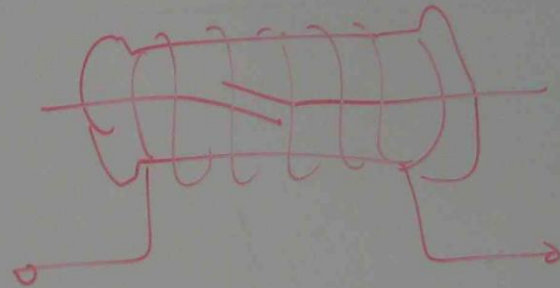
THE SOLENOID IS AN ELECTROMAGNETIC DEVICE THAT PRODUCES A STRAIGHT LINE MECHANICAL FORCE.

THE SOLENOID CONVERTS ELECTRICAL SIGNAL TO ELECTROMAGNETIC FIELD.

A MOVABLE CORE OF FERROMAGNETIC MATERIAL LOCATED WITHIN THE FIELD CAN BE DRAWN INTO THE CENTRE OF THE COIL.

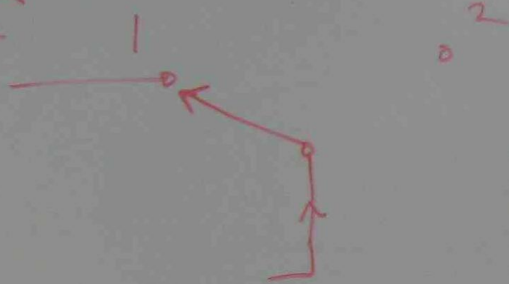
RELAYS AND CONTACTORS ARE BASED ON SOLENOID PRINCIPLE.

## REED RELAY



REED RELAYS CONTACTS ARE MAGNETIZED BY MAGNETIC COIL. TWO OPPOSITE POLES ATTRACT EACH OTHER TO CLOSE THE RELAY CONTACT.

CHANGE OVER



NORMALLY OPEN  
(NO)



NORMALLY CLOSED



TIMER



CONTACTOR FUNCTION

CARRY THE LOAD  
MAKING  
BREAKING

THEY CAN CARRY AC OR DC.



WHEN THE CONTACTS ARE OPEN, THE ELECTRIC ARC NEEDS TO BE ELIMINATED BY

- (a) EXTINGUISHING METHOD — COMPRESSED AIR EXTINGUISHES THE SPARK
- (b) ABSORPTION METHOD — THE ELECTRIC CHARGE THAT PRODUCES THE ARC IS ABSORBED BY RESISTOR & CAPACITOR
- (c) SEVERAL CONTACTS — CONTACTS ARE CONNECTED IN SERIES. THIS WILL DIVIDE THE VOLTAGE SURGE ACROSS EACH CONTACT AND REDUCED THE ARC.

