SPEED MEASUREMENT

SPEED MEASUREMENT IS WIDELY USED IN INDUSTRIAL CONTROL APPLICATIONS FOR DC AND AC MOTOR SPEED CONTROL. IE TACHO FEEDBACK, POSITIONAL CONTROL TO PROVIDE VELOCITY FEEDBACK SIGNALS, SETTING ALTERNATORS SPEED TO ENABLE SYNCHRONISATION OF THE ALTERNATORS TO EACH OTHER AND THE SYSTEM.

ANALOG TACHOMETERS

DC PERMANENT MAGNET TACHO GENERATOR

- PERMANENT MAGNET FIELD
- ARMATURE WITH COMMUTATOR SEGMENTS
- DC OUTPUT VOLTAGE $\propto$ ANGULAR VELOCITY

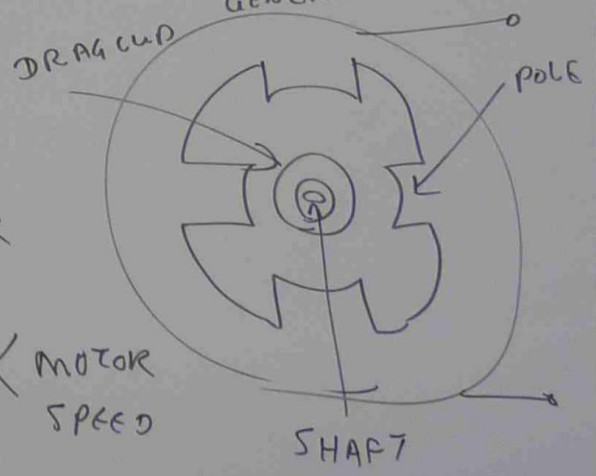
AC PERMANENT MAGNET TACHO GENERATOR

- PERMANENT MAGNET ROTOR
- POLY PHASE STATOR WINDING

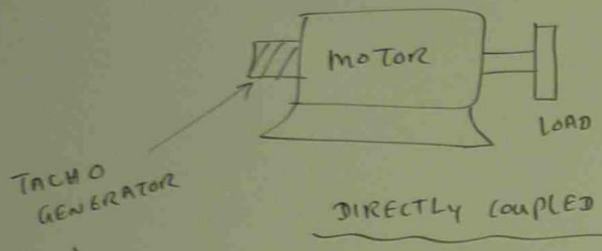
OUTPUT VOLTAGE / FREQUENCY $\propto$ MOTOR SPEED

OUTPUT AC → RECTIFIER → DC

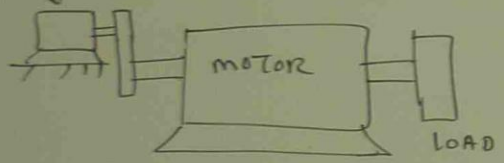
AC INDUCTION TACHO GENERATOR



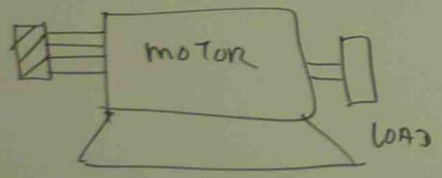
MOUNTING OF TACHO GENERATORS



DIRECTLY COUPLED



BELT COUPLED



GEAR COUPLED

pb

A TACHO GENERATOR HAS AN OUTPUT VOLTAGE OF 2 VOLTS / 1000 RPM. IF IT'S OUTPUT VOLTAGE IS 3.3 V WHEN CONNECTED TO A MOTOR SHAFT, DETERMINE THE MOTOR SHAFT SPEED.

$2\ V \longrightarrow 1000\ RPM$

$3.3\ V \longrightarrow ? = \frac{1000 \times 3.3}{2}$

$= 1000 \times 1.65$

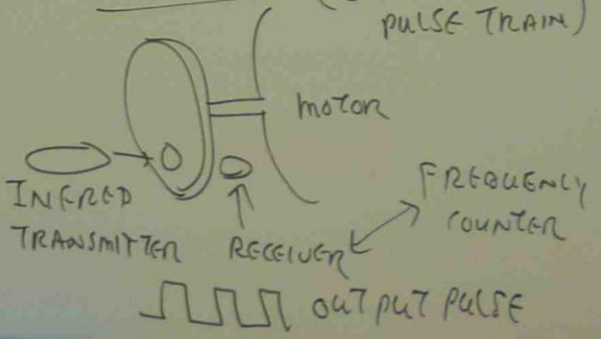
$= 1650\ RPM$

DIGITAL TACHO METER

OPTICAL (ENCODER PULSE TRAIN)

MAGNETIC

USE MAGNETIC PICK UP AND TOOTH GEAR WHEEL



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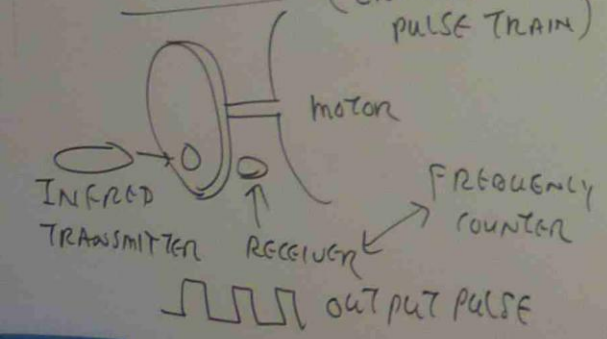
$= 1650$ RPM

DIGITAL TACHO METER

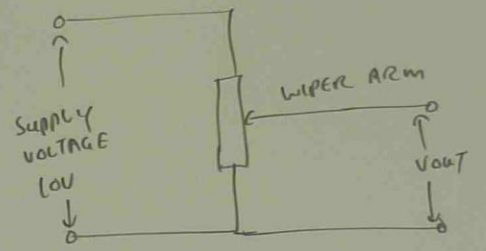
- OPTICAL (ENCODER PULSE TRAIN)
- MAGNETIC



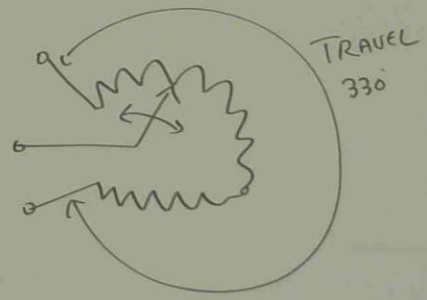
USE MAGNETIC PICKUP AND TOOTH GEAR WHEEL

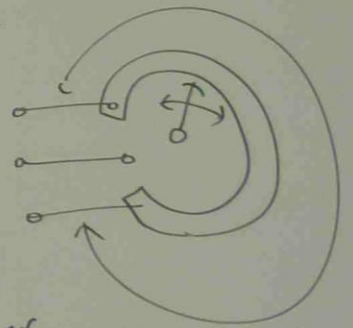
POSITION MEASUREMENT

PRECISION POTENTIO METERS



WIPER ARM POSITION ⟶ OUT PUT VOLTAGE



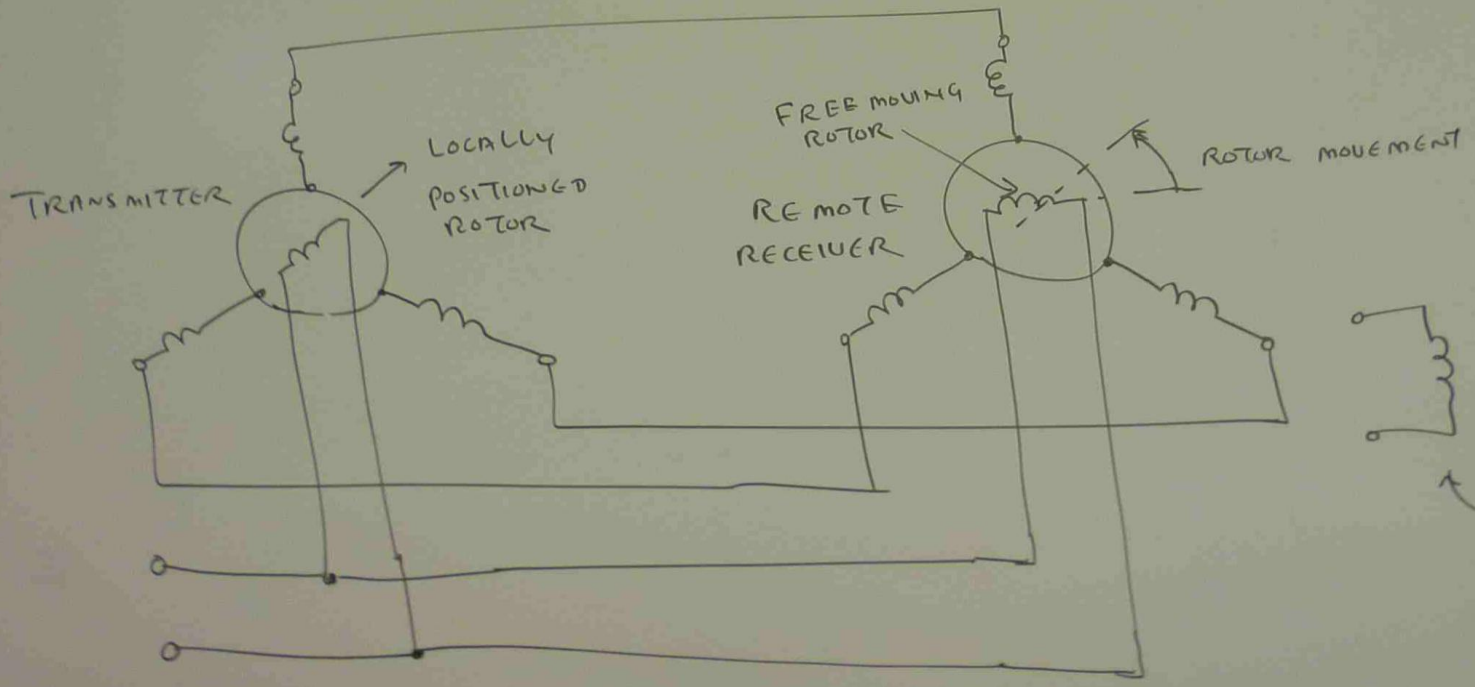


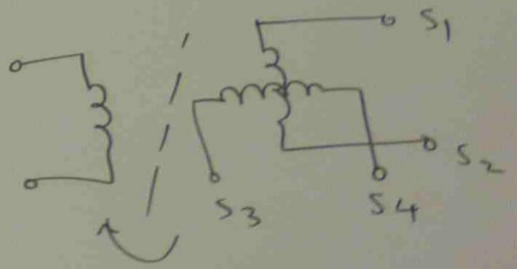
VOLTAGE ∝ ANGLE of TRAVEL

SYNCHROS

THESE ARE SELF SYNCHRONOUS MACHINES COMMONLY CALLED SYNCHROS (OR) SELSYNS.

A SYNCHRO (AND A RESOLVER) ARE A SIMPLE ROTARY TRANSFORMER WHERE THE RELATIONSHIP BETWEEN THE PRIMARY (ROTOR) AND THE SECONDARY (STATOR) IS CONTROLLED BY THE SHAFT ANGLE. THEREFORE THE VOLTAGE INDUCED IN THE STATOR VARIES AS A FUNCTION OF THE SHAFT ANGLE.



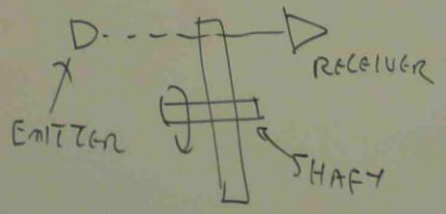


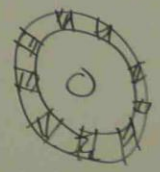
THE RESOLUCR IS CONSIDERED A SUB CLASSIFICATION OF A SYNCHRO AND IS BASED ON THE SAME PRINCIPLE. THE DIFFERENCE IS THAT THE SYNCHRO HAS THREE STATOR WINDING DISPLACED 120 ELECTRICAL DEGREE APART WHERE THE RESOLUER HAS TWO STATOR WINDING DISPLACED 90 ELECTRICAL DEGREE APART

SHAFT ANGLE ENCODER

- INTERNAL
- ABSOLUTE

AN INCREMENTAL ENCODER (PULSE GENERATOR) PROVIDES A DIGITAL OUTPUT THAT INDICATES CHANGE IN SHAFT POSITION WHILE ABSOLUTE ENCODER INDICATES ACTUAL SHAFT POSITION



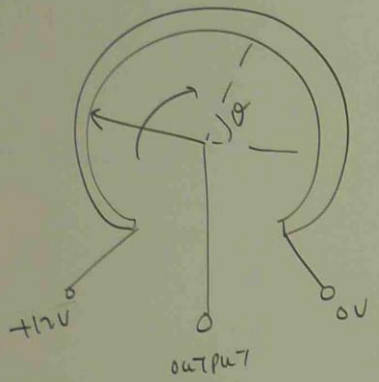


INCREMENTAL

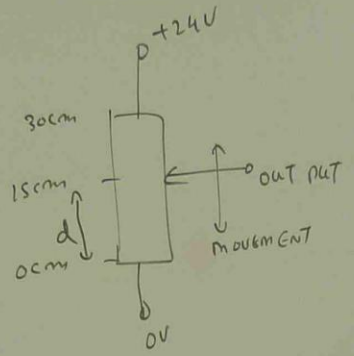
ABSOLUTE

POSITION TRANSDUCERS

CIRCULAR



LINEAR

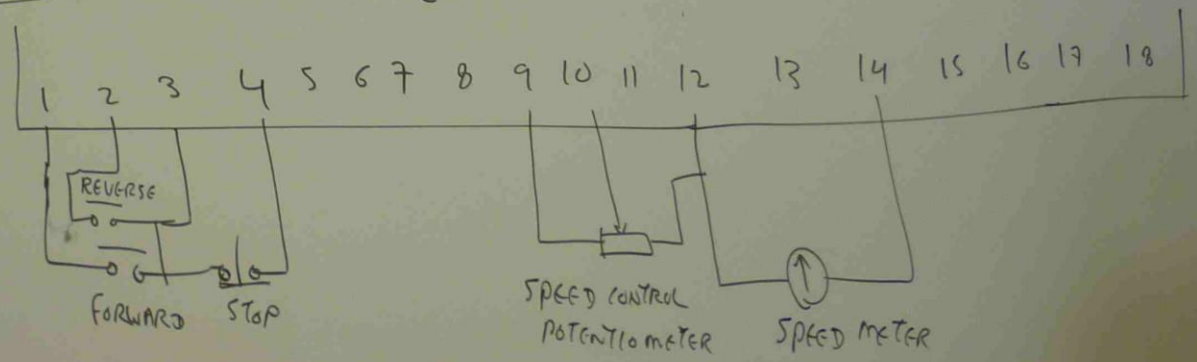


OUT PUT VOLTAGE ∠ ANGLE (θ)

OUT PUT VOLTAGE ∠ DISTANCE (d)

PRACTICAL APPLICATION

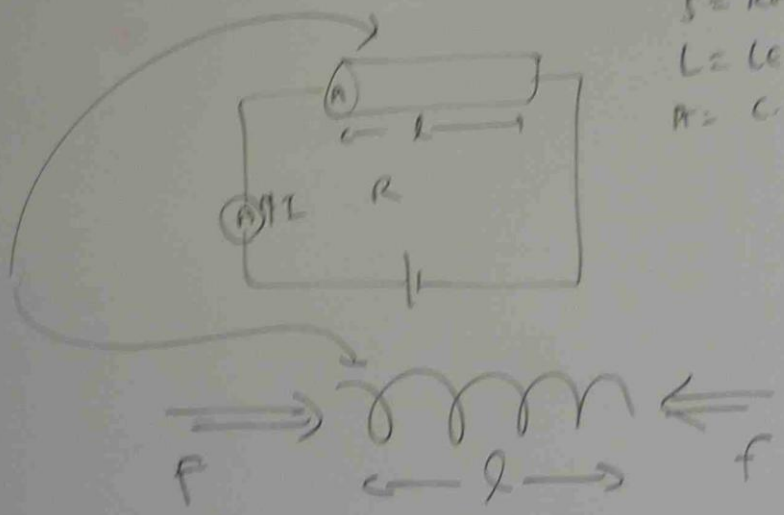
ZENAR



FORCE MEASUREMENT (STRAIN GAUGE)

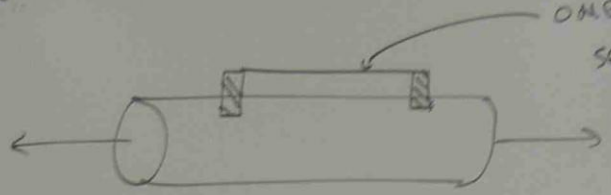
$$R = \frac{\rho L}{A}$$

R = RESISTANCE
ρ = RESISTIVITY
L = LENGTH
A = C.S.A



THE RESISTANCE OF MATERIAL IS DIRECTLY PROPORTIONAL TO IT'S LENGTH AND INVERSELY PROPORTIONAL TO C.S.A

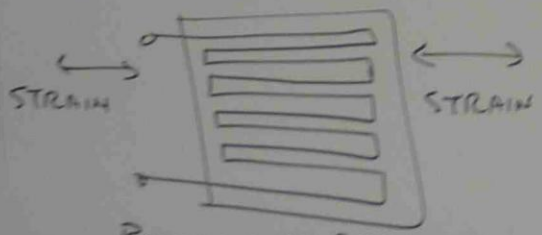
A STRAIN GAUGE IS RESISTIVE MATERIAL WHICH CAN BE DIRECTLY ATTACHED TO THE SURFACE (OR) INDIRECTLY CONNECTED TO THE SURFACE



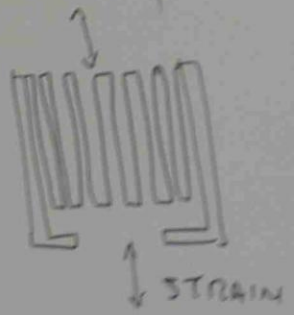
UNBONDED WIRE STRAIN GAUGE

THE STRAIN GAUGE IS A TRANSDUCER USED TO SENSE OR MONITOR CHANGES IN SURFACE SHAPE CAUSED BY

- STRESS
- STRAIN
- VIBRATION
- WEIGHT
- FORCE
- EXPANSION
- ACCELERATION



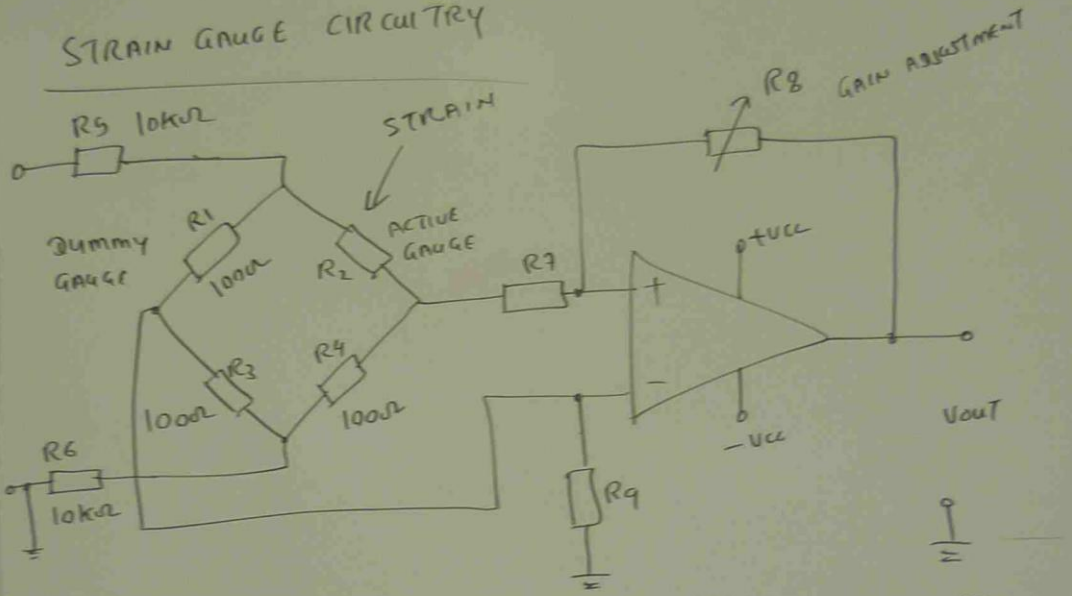
BONDED WIRE STRAIN GAUGE



FOIL STRAIN GAUGE

THE STRAIN GAUGE IS CONSTRUCTED AS PER DIAGRAM SO THAT THE STRESS CHANGES THE RESISTANCE & FLOW OF CURRENT.

STRAIN GAUGE CIRCUITRY



R5, R6 PROVIDES CONSTANT CURRENT SOURCE TO BRIDGE

AIN GAUGE IS CONSTRUCTED AS PER DIAGRAM SO THAT
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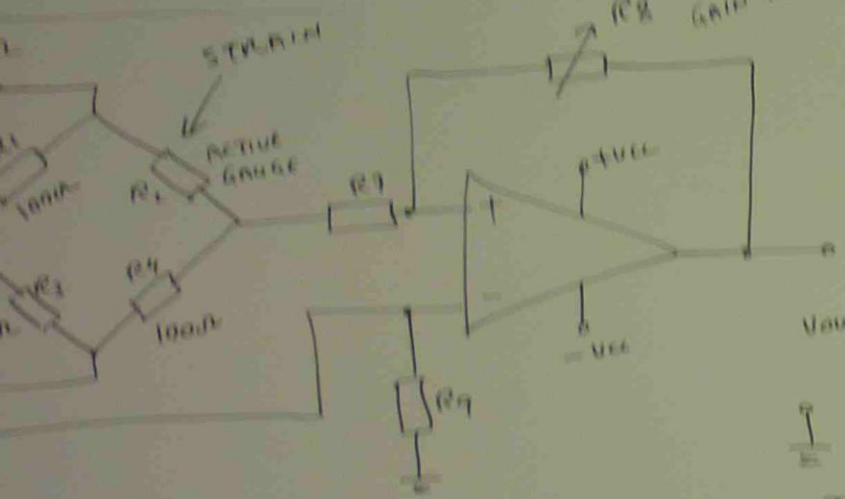
GAUGE CIRCUITRY



, R6 PROVIDES CONSTANT CURRENT SOURCE TO
RIDGE

GAUGE FACTOR

GAUGE FACTOR IS THE CONSTANT FOR ANY STRAIN GAUGE MATERIAL FOR THE AMOUNT OF RESISTANCE CHANGE FOR A GIVEN STRAIN (OR) FORCE

$$\frac{\Delta L}{L} = \frac{\Delta R}{R} = K E$$

$$K = \frac{\Delta R / R}{E}$$

Δ = CHANGE

R = RESISTANCE (Ω)

L = LENGTH (m)

E = FORCE

K = GAUGE FACTOR

RESISTIVE GAUGE

GAUGE FACTOR = 2 → 4.5

TYPICAL RESISTANCE = 50 → 1000Ω

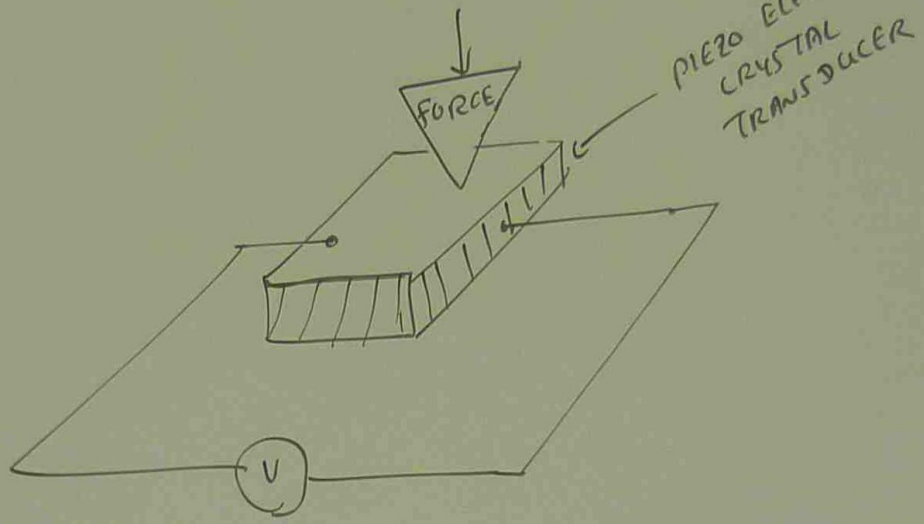
SEMICONDUCTOR GAUGE

GAUGE FACTOR = 100

RESISTANCE = 50 ↓ 10kΩ

PIEZO ELECTRIC DEVICES

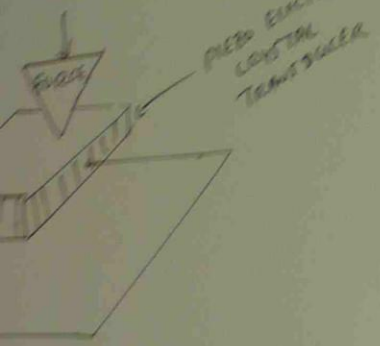
VIBRATION / FORCE PRODUCES VOLTAGE AND CURRENT FLOW IN PIEZO ELECTRIC DEVICE.



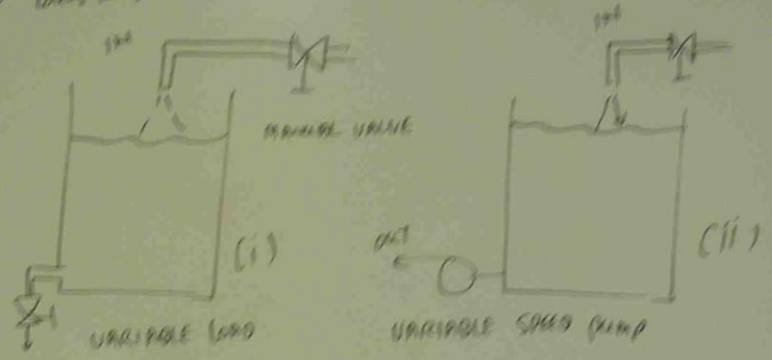
ELECTRIC DEVICES

/ FORCE PRODUCES VOLTAGE AND CURRENT FLOW

ELECTRIC DEVICE.



Q/ REFER THE DIAGRAM BELOW AND ANSWER THE FOLLOWING QUESTIONS



(a) WHICH PROCESS IS SELF REGULATING, WHY?

(b) WHICH PROCESS IS NOT SELF REGULATING, WHY?

(c) WHICH PROCESS HAS A LINEAR RESPONSE, WHY?

(a) (i)

(b) (ii)

(c) (ii) → LEVEL ∝ (PUMP IN − PUMP OUT)

Q/ DEFINE THE TERMS "RANGEABILITY" AND "TURNDOWN"

RANGEABILITY

THE RATIO OF MAXIMUM CONTROLLABLE FLOW TO MINIMUM CONTROLLABLE FLOW

TURNDOWN

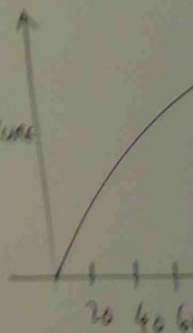
THE RATIO OF THE MAXIMUM
SITUATION TO MINIMUM C

Q/ A TYPICAL
A RANGEABILITY OF
A CONTROL VALVE RAN
200:1 DISCUSS HO

PROVIDE THE COMBINATIO

(50:1) ×(

Q/ A TEMPERATURE
VARIES AS SHOWN



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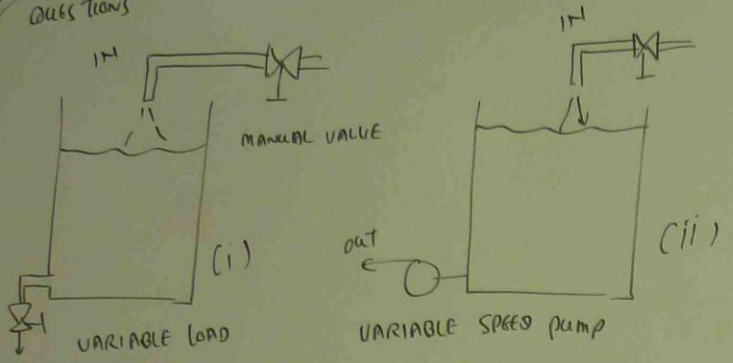

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(a) (i)
(b) (ii)
(c) (ii) → LEVEL ∝ (PUMP IN − PUMP OUT)

Q/ DEFINE THE TERMS "RANGEABILITY" AND "TURN DOWN"

RANGEABILITY

THE RATIO OF MAXIMUM CONTROLLABLE FLOW TO MINIMUM CONTROLLABLE FLOW

TURN DOWN

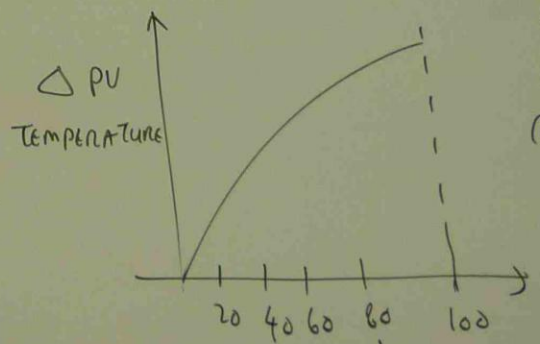
THE RATIO OF THE MAXIMUM CONTROLLED FLOW IN THE INSTALLED SITUATION TO MINIMUM CONTROLLABLE FLOW.

Q/ A TYPICAL EQUAL PERCENTAGE CONTROL VALVE HAS A RANGEABILITY OF 50:1. A PROCESS REQUIRES A CONTROL VALVE RANGEABILITY OF A MINIMUM OF 200:1 DISCUSS HOW THIS MAY BE ACHIEVED.

PROVIDE THE COMBINATION OF TWO VALVES

$(50:1) \times (50:1) = 2500:1$

Q/ A TEMPERATURE PROCESS HAS A GAIN THAT VARIES AS SHOWN BELOW



COMMENT ON THE PERFORMANCE OF

(a) A LINEAR CONTROL VALVE USED ON THE ABOVE PROCESS

(b) EQUAL % CONTROL VALVE USED ON (FUEL FLOWRATE) PROCESS

AXIMUM CONTROLLED FLOW IN THE INSTALLED
NUM CONTROLLABLE FLOW.

UAL PERCENTAGE CONTROL VALVE HAS
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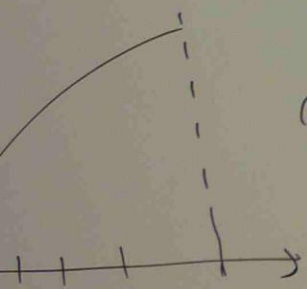
RANGE ABILITY OF A MINIMUM OF
SS HOW THIS MAY BE ACHIEVED.

INATION OF TWO VALVES

$\times (50:1) = 2500:1$

TURE PROCESS HAS A GAIN THAT
SHOWN BELOW



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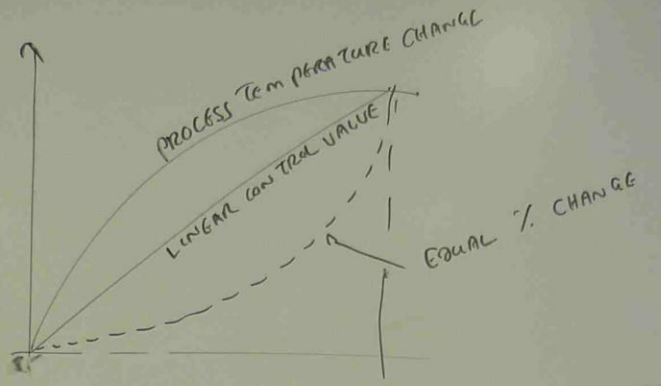

Q EXPLAIN THE APPLICATION OF QAD (MINIMUM AREA AND MINIMUM DISTURBANCE) RESPONSE.

QAD (QUARTER AMPLITUDE DAMPING)

QAD RESPONSE IS COMMONLY USED ON MOST CONTROL LOOPS.

QAD RESPONSE RETURNS THE PROCESS VARIATION (P.V) BACK TO THE SET POIN IN MINIMUM POSSIBLE TIME WITH THE LEAST WASTE OF ENERGY. HOWEVER THE QAD RESPONSE CYCLES FOR 3 TO 4 CYCLES BEFORE P.V STABILISES AGAIN.

MINIMUM DISTURBANCE — IF CYCLING IS UNDESIRABLE, THE MINIMUM DISTURBANCE RESPONSE MAY BE USED. THE MINIMUM DISTURBANCE RESPONSE IS ACHIEVED BY USING LESS GAIN THAN REQUIRED FOR QAD.

Q SIMPLY EXPLAIN THE PRINCIPLE USED BY SELF TUNING CONTROLLERS TO SELF TUNE.

SELF TUNING (MICROPROCESSOR - BASED) CONTROLLERS COMMONLY USE THE PROCESS REACTION CURVE (STEP RESPONSE) METHOD TO CALCULATE THE REQUIRED PID SETTINGS.

THE CONTROLLER DOES THIS BY MAKING A SMALL CHANGE TO IT'S OUTPUT AND MEASURING THE RESULTING PROCESS REACTION CURVE PARAMETERS. FROM THESE, THE CONTROLLER THEN CALCULATES THE APPROPRIATE PID SETTINGS.

Q

COMMENT ON THE EFFECT OF AN INCORRECTLY SIZED VALVE ON CONTROL LOOP PERFORMANCE.

(a) UNDER SIZED VALVE (b) OVER SIZED VALVE.

UNDER SIZED VALVE

THE VALVE IS TOO SMALL FOR THE APPLICATION. IT CAN NOT PROVIDE THE MAXIMUM DEMAND REQUIRED BY THE PROCESS

OVER SIZED VALVE

THE VALVE IS TOO LARGE FOR THE APPLICATION.

- IT WILL NORMALLY OPERATE NEAR IT'S CLOSED POSITION CAUSING POSSIBLE DAMAGE TO THE VALVE TRIM DUE TO THE HIGH VELOCITY OF FLOW THROUGH THE SMALL VALVE OPENING.
- IT OPERATES (STROKE) OVER A RESTRICTED PART OF THE AVAILABLE VALVE TRAVEL LEADING TO POOR CONTROL.