CBCS SCHEME

Approved 18EC36

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Third Semester B.E. Degree Examination, Dec.2019/Jan.2020
Power Electronics and Instrumentation

Time: 3 hrs. Max. Marks: 100

Note: *Answer any FIVE full questions, choosing ONE full question from each module.*

Module-1

1 a. Name the power semiconductor devices along their circuit symbols and maximum Ratings. **(04 Marks)**

b. Explain the operation of SCR, interms of two transistor model and derive anode current and gate currents relation. Discuss how a small gate current can trigger the device into condition. **(08 Marks)**

c. The latching current of a thyristor circuit is 60m Amp. The duration of the firing pulse is 50μsec. Given $V_s = 100V$, $R = 20\Omega$ and $L = 0.5H$ are connected in series.
   i) Derive the expression for circuit current i(t)
   ii) Draw variation of current i(t) with reference to time
   iii) Will the thyristor device gets turned ON? **(08 Marks)**

OR

2 a. Enumerate the applications of power electronics. (04 Marks)

b. Explain the operation of self commutation by resonating load [class A] with relevant circuit and waveforms. **(08 Marks)**

c. **What are the gate triggering schemes? Explain with circuit diagram and wave forms, now RC triggering circuit turns ON (triggers) SCRs. (08 Marks)**

Module-2

3 a. Explain the control strategies used to operate choppers. **(06 Marks)**

b. Explain with the help of neat circuit diagram and waveforms, the operation of a single phase half wave controlled rectifiers with resistive load. Derive an expression for the :
   i) Average load voltage ii) RMS load voltage. **(08 Marks)**

c. For the ideal type A [step down] chopper circuit, following conditions are given : V = 220V, Duty cycle = 0.3, Chopping frequency f = 500Hz, $R = 1\Omega$, L = 3mH and $E_b = 23$ volts. Determine the following :
   i) Minimum value of output current (load)
   ii) Maximum value of output current (load)
   iii) Average output (load) current. **(06 Marks)**

OR

4 a. Explain the effect of free wheeling diode used in controlled rectifiers. **(04 Marks)**

b. **With the circuit diagram and circuit waveforms, explain the principle of operation of step-up chopper. (08 Marks)**

c. A single phase fully controlled bridge rectifier is feeding to a RL load, to obtain a regulated DC output voltage. The RMS value of the AC voltage is 230V, at 50Hz and the firing angle is maintained at $\pi/3$, so that the load current is 4Amp.
   i) Calculate the DC average output voltage
   ii) Active power and reactive power input
   iii) Assuming the load resistance remains the same, determine DC average output voltage. If a freewheeling diode is used at output with all the conditions remains same. **(08 Marks)**

Module-3

5 a. Define the terms : i) instrument ii) Accuracy iii) Absolute error iv) Relative errors? (04 Marks)

b. Explain the operation of single – phase half bridge inverter connected to RL load, with the help of circuit and waveforms. (08 Marks)

c. A basic D' arsonval movement with a null scale deflection of 2mAmp and having an internal resistance of 50Ω is available. It is to be converted into a 0–10V, 0–1000V, 0–100V and 0–250V multi range voltmeter. Determine the value of resistance to extend? (08 Marks)

OR

6 a. What are inverters? Classify the inverters according to commutation and connections? (04 Marks)

b. What are the static errors? Explain them in detail with examples. (08 Marks)

c. A single phase half bridge inverter, has resistive load of R = 3Ω and DC input voltage V_{dc} = 50 volts. Calculate :

i) RMS output voltage at fundamental frequency
ii) The output power (P_0)
iii) The average and peak current of each thyristor
iv) The peak – reverse blocking voltage of each thyristor. (08 Marks)

Module-4

7 a. Explain how a simple AC bridge circuit operates and derive an expression for the unknown parameters. (04 Marks)

b. With the aid of diagram, explain the working of unbalanced wheat stone bridge and derive for a galvanometer current expression. (08 Marks)

c. Explain the principle of operation of digital time measurement with basic block diagram. (08 Marks)

OR

8 a. What are the advantages of digital instruments over analog instruments? (04 Marks)

b. Determine the equivalent parallel resistance and capacitance that causes a Wein's bridge to null condition with the following values : R_1 = 3.1KΩ, C_1 = 5.2μF, R_2= 55KΩ, R_4 = 100KΩ, ff = 2.5KHz. Derive the balanced expressions. (08 Marks)

c. With neat block diagram, explain the operating principle of a Ramp type DVM. (08 Marks)

Module-5

9 a. Define transducers. What are advantages of electrical transducers? (04 Marks)

b. Explain instrumentation Amplifier using transducer bridge with the help of circuit diagram. (08 Marks)

c. Explain with neat diagram the PLC structure. (08 Marks)

OR

10 a. What are features of instrumentation Amplifiers? How it differs from the ordinary opAmp. (04 Marks)

b. Describe the operation of resistive position transducer with constructional diagram and typical circuit used. (08 Marks)

c. With the aid of Bridge circuit, explain the working of resistance thermometer. Mention limitations of it. (08 Marks)

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Clarification indicated in the Note dated 22/01/202 - 18EC36

message

Suresh Delampady <sureshd1230@gmail.com>
To: pmanjunath p <pmanjunathvtu@gmail.com>

Wed, Jan 22, 2020 at 12:59 PM

Sir 22/01/2020
Please find the attachment for the clarification sought for the subject code:18EC36.
Please go through the Note dated 22/01/2020 given in the letter.
Thanks and Regards

Dr. Suresh. D
Chairman - BOE
ECE/TCE/MT boards
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RNS INSTITUTE OF TECHNOLOGY

(AICTE Approved, VTU Affiliated and NAAC 'A' Accredited)

Department of Electronics & Communication Engineering.

Program is Accredited by NBA for the Academic years 2018-19, 2019-20 and 2020-2021

From
Chairman
BOE – EC/TE/TC/MT Board
VTU, Belagavi.

Date : 22/01/2020

I hereby informed that the following Question paper, Scheme, and Solutions in the following subjects are found to be in order with a note on minor incorporations.

Sl. No	Subject Code	Name of the Subject	Remarks
1.	18EC36	Power Electronics and Instrumentation	i) Q1a: Marks can be awarded even without Ratings also. ii) Q1b: Marks can be awarded for the explanation of any type of SCR operation.(Even without two transistor model) iii) Q3a: Marks can be awarded even if the candidate writes answer for Step up, Step down and Step up –down operation. iv) Marks can be awarded for the calculation and answers shown with R load also. v) Missing answers of Q9 and Q10 are included

Note dated 22/01/2020: * For the question Q1a, marks can be awarded for any answer written on power semiconductor devices used for power electronic converters and applications which is indicated in the syllabus.* Clarification for Q1b is already given. * Q3c Whoever attemps the question grace marks can be awarded.

Thanking you,

Dr. SURESH. D
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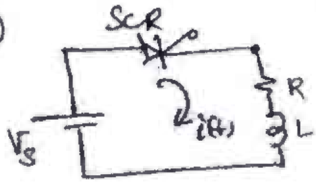
18EC36

Scheme & Solution

Signature of Scrutinizer

Subject Title : PE&I Subject Code : 18EC36

Question Number	Solution	Marks Allocated
Q 1	(a) (*) Marks can be awarded even without the ratings. Mentioning any 4 devices with their symbol & ratings (1×4) m	04
note →	(b) → (*) Marks can be awarded for any type of SCR operation (Even without two transistor model). Two transistor model circuit (1) m. Explaining & deriving $I_A = \frac{I_g(\alpha_1+\alpha_2) - I_{CBO}}{1-(\alpha_1+\alpha_2)}$ (5) m. Discussing I_A with & without I_g → (2) m	08
	(c)  $V_S = 100$ V, $R = 20$, $L = 0.5$ H, Pulse = 50 μsec, $i_L(t) = 60$ mAmp.	
	Using KVL $V_S = Ri(t) + L\frac{di(t)}{dt}$ → (1) m	
	Deriving for current $i(t) = \frac{V_S}{R}\left[1 - e^{-\frac{R}{L}t}\right]$ Amps (4) m	08.
	 $i(t) = \frac{100}{20}\left[1 - e^{-\frac{20}{0.5}\times t}\right]$ at t = 50 μsec, $i(50\mu sec) = 9$ mA → (3) m	
	Since calculated value 9 mA is less than the latching current (60 mA), SCR doesn't turned ON. (1) m	
(OR) 2 (a)	Any 5 to 6 applications of power electronics	04
(b)	Class A commutation : Circuit diagram (2), Explaining (2), Deriving for current & volt (2), waveforms (2)	08

Subject Title : P E & I **Subject Code :** 18EC36

Question Number	Solution	Marks Allocated
2 (a)	Gatting triggering senues → R triggering, RC triggering, UJT triggering (2)m RC triggering: circuit diagram (1), Explanation (3), waveforms (2)	08
Q 3 (a)	Control strategies of chopper → Time ratio control (fixed f, variable f) (2)m; → Current limit control Note (*) Marks can be awarded → Step up, step down & step up down can be considered - 2x3 Explaining cases with waveform 2x3 - (4)m	6
(b)	Single phase half wave controlled Rectifier with R load circuit diagram → (1) Explanation → (2) waveform → (2) Deriving $V_{o(av)} = \frac{V_m}{2\pi}[1+\cos\alpha]$, $V_{o(RMS)} = V_m\sqrt{\frac{\pi-\alpha}{4\pi}+\frac{\sin 2\alpha}{8\pi}}$ } (03)	8
(c)	Given: $V = 220V$, Duty cycle $= K = 0.3$, $f = \frac{1}{T} = 500Hz$ $R = 1$, $L = 3\times10^{-3}$, $E_b = 23$ volts. (1)m Minimum value of load current $I_{o(min)} = \frac{V}{R}\left[\frac{e^{T_{on}/\tau}-1}{e^{T/\tau}-1}\right] - \frac{E_b}{R}$ ⇒ 28.05 Amp. (2)m $K = 0.3 = \frac{T_{ON}}{T}$, $T_{on} = 600\mu s$, $T_{on}/\tau = 200\times10^{-3}$ ($\tau = \frac{L}{R}$) (1)m Maximum load current $I_{o(max)} = \frac{V}{R}\left[\frac{1-e^{-T_{on}/\tau}}{1-e^{-T/\tau}}\right] - \frac{E_b}{R}$ → 58.64 Amp. (1)m 3m Average load current $I_{o(av)} = \frac{I_{max}-I_{min}}{2}$ ⇒ 15.32 Amp. (1)m 3m	6

Note: (*) Marks can be awarded for the calculation and answer shown with R load also

Subject Title : PE 32 Subject Code : 18EC36

Question Number	OR Solution	Marks Allocated
Q 4 (a)	clearly, Explaining the effect of using free wheeling Diode with RL load, with output load voltage. Any waveform — (2) Explain → (2)	04
(b)	Step Up Chopper: circuit diagram (1)m Explaination → (3)m Deriving; output volt $V_0 = \frac{V_s}{1-K}$; (3)m Explaining change of K, & V_0. (1)m	08
(c)	Given $V_s = 230V$, $\alpha = \pi/3 = 60°$ $I_{o(av)} = 4$ Amp. 1φ fully controlled Rectifier → i) DC output volt → $V_{o(av)} = \frac{2V_m}{\pi}\cos\alpha \Rightarrow \frac{2\times\sqrt{2}\times230}{\pi}\cos(60°)$ ⇒ 103.54 V → (3)m ii) Active power input $P_{in} \Rightarrow \frac{2V_m}{\pi}\cos\alpha\,(I_{o(av)}) \Rightarrow 414$ watts; Reactive input $Q_{in} \Rightarrow \frac{2V_m}{\pi}\sin\alpha\,(I_{oav}) \Rightarrow 717.32$ VAR. } (3)m iii) $R_L = \frac{V_{oav}}{I_{oav}} = \frac{103.54}{4} \Rightarrow 25.89\,\Omega$ → (1)m When F.W.D is connected across the load, Av. load volt' $V_{o(av)} = \frac{V_m}{\pi}[1+\cos\alpha] \Rightarrow 155.3$ volts. → (1)m So, with FWD, Av. o/p volt increases → (1)m	8
Q 5 (a)	Defining the terms 1 each × 4 = (4)m	4
(b)	1φ half bridge converter → RL load diagram (2)m Explanation (3)m waveform → (3)m	8
(c)	Given $R_m = 50\,\Omega$. For a (0-10) V Range $R_t = \frac{V}{I_{fsd}} = \frac{10}{2\,mA} \Rightarrow 5\,k\Omega$ ∴ Resistance $R_4 = R_t - R_m \Rightarrow 4950\,\Omega$ (3)m	(3)

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Subject Title : PE&I Subject Code : 18 EC 36

Question Number	Solution	Marks Allocated
Q 5 (c)	→ for (0-50)V Range $R_3 = \frac{V}{I_{FSD}} - (R_4 + R_m) = 20k\Omega$ (2)m	
	for (0-100) V Range $R_2 = \frac{V}{I_{FSD}} - (R_4 + R_3 + R_m) = 25k\Omega$ (3)m	(3m)
	for (0-250) V Range $R_1 = \frac{V}{I_{FSD}} - [R_4 + R_3 + R_2 + R_m] = 75k\Omega$ (3)m	(3m) 8
(OR)		
6 (a)	Defining inverters → (1) classifying According Commutation (3) └→ connections }	04
(b)	Types of static errors → (1)m Gross error → (2)m Systematic error → (3)m Random error → (2)m	8
(c)	1 ϕ half bridge inverter ; R = 3Ω V_s = 50 volts. i) Rms value at fundamental frequency $V_1 = \frac{2V_s}{\sqrt{2}\pi} \Rightarrow 22.5$ volts. (2)m ii) Rms o/p volt : $V_{O\,Rms} = \frac{V_s}{2} = 25V$ = o/p power ⇒ $P_o = \frac{(V_{O\,Rms})^2}{R_L} = \frac{(25)^2}{3} = 208.33$ watts (2)m iii) Peak current of thyristor $I_{peak} = \frac{V_s/2}{R} \Rightarrow 8.33$ Amp and $I_{av} = \frac{50}{100} \times 8.33 \Rightarrow 4.165$ Amp. } (2)m iv) Peak reverse blocking volt is given by $V_{BR} \Rightarrow 2 \times V_s/2 = 50V$ (2)m	8
Q 7. (a)	AC bridges → operations — (2)m Balance condition (2)m	4
(b)	Unbalance Wheatstone bridge Ckt → (1) Explain → (2) Showing V_{th} (V_{oc}) → (2)m R_{th} (R_{ab}) → (2)m $I_g = \frac{V_{th}}{R_{th} + R_g}$ → (1)m	8

Subject Title : PE 32 **Subject Code :** BEC 36

Question Number	Solution	Marks Allocated
7 (c)	Digital time Measurement — Basic block diagram (4)m, Explaining function (4)m	8
OR		
8 (a)	Advantages of DI over AI — any 4 points (4)m	4
(b)	Wein's Bridge. Deriving $R_3 = \frac{R_4}{R_2}\left(R_1 + \frac{1}{\omega^2 R_1 C_1^2}\right)$, $C_3 = \frac{R_2}{R_4}\left(\frac{C_1}{1+\omega^2 R_1^2 C_1^2}\right)$ (5)m; Bridge ckt → (1)m; $R_3 = 12.4\ k\Omega$, $C_3 = 20.3\ pf$ } (3)m	8
(c)	Ramp type DVM — Block diagram → (3)m, Explanation → (5)m	8
9 (a)	Defining transducer (1)m; Advantages of Electrical transducers any (3) → (3)m	4
(b)	Inst. Amp with transducer bridge — Ckt diagram → (3), Explaining → (5)m	8
(c)	PLC diagram → (3), Explaining → (5). Solution given in page 6 & 7 & 8	8
OR		
10 (a)	features of Instrument Ampl → (2), differences with ordinary op Amp (2)	4
(b)	Resistive position transducer. Constructional diagram → (2), Typical ckt → (2), Explanation (4)m. Solution in page 8, 9 & 10	8
(c)	Resistance thermometer — Bridge circuit → (3)m, working → (4)m, limitations → (1)m	8

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9a. Transducers: An electrical transducer is a sensing device by which the physical, mechanical or optical quantity to be measured is transformed directly by a suitable mechanism into an electrical voltage/current proportional to the i/p measured.

Advantages:

- Electrical amplification & attenuation done easily
- Mass inertia effects are minimised
- The o/p can be indicated & recorded remotely
- The s/m can be controlled with a very small power.

9b. Instrumentation Amplifier

A differential Instrumentation Amp with resistive transducer is as shown in Fig. The resistive transducer is connected to one arm of the bridge.

Let R_T be the resistance of transducer & ΔR the change in resistance of the resistive transducer. Hence the total resistance is $(R_T \pm \Delta R)$

The condition for bridge balance is $V_b = V_a$

$$\frac{R_B(E)}{R_B+R_C} = \frac{R_A(E)}{R_A+R_T}$$

$$\therefore \quad \frac{R_C}{R_B} = \frac{R_T}{R_A}$$

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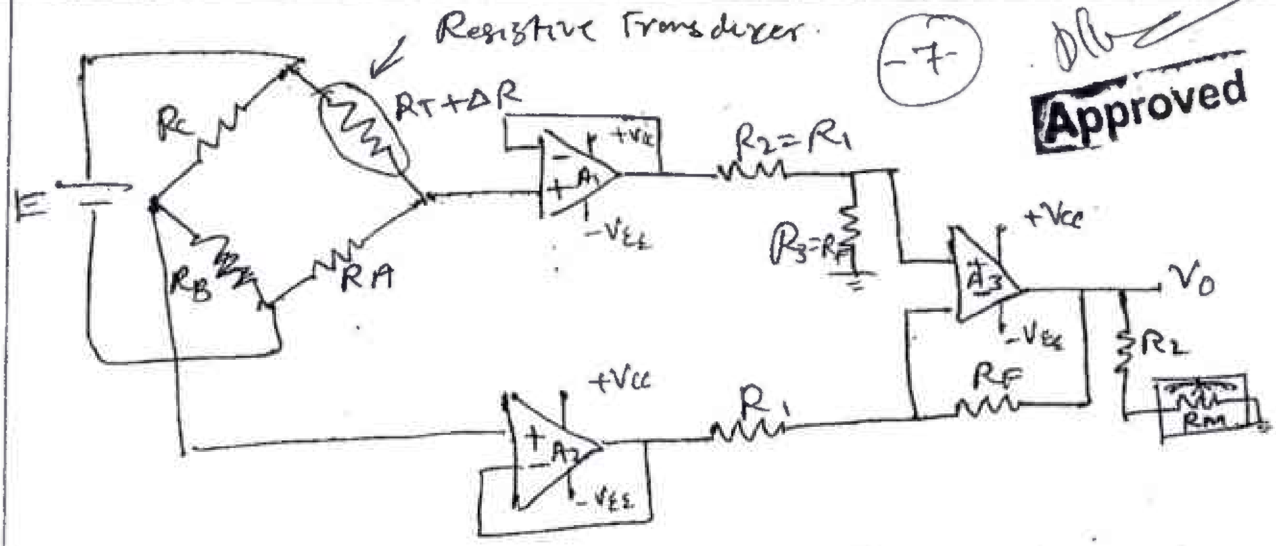
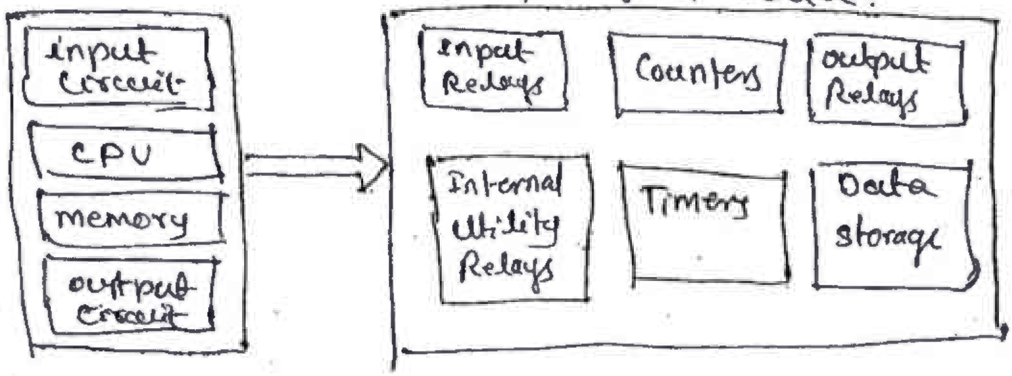


Initially the bridge is balanced at a desired reference condition. As the physical quantity to be measured changes, the resistance of the transducer also changes, causing the bridge to be unbalanced. Hence the o/p voltage of the bridge is a function of the change in the resistance of the transducer.

9c <u>PLC structure:</u>

Programmable Logic Controller structure consists of a CPU, memory areas & appropriate circuits to receive input/output data.



<u>Input Relays</u>: These are connected to the outside world. They physically exist & receive signals from switches, sensors, etc.

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Internally utility Relay: These do not receive signals from the out-side world nor do they physically exist. They are simulated relays.

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Counters: These again do not physically exist. They are are simulated counters & can be programmed to count pulses. Thypically these counters can be up-count down count or both.

Timers. These also do not physically exist. They come in many varities & increments. the most common type is an ON-state delay type. other include OFF delay. Increment vary from 1ms to 1s.

Output Relays: These are connected to the outside world. They exist physically & send ON/OFF signals to solenoid lamps etc. They can be transistors, relays or triacs depending upon the type selected.

Data storage: Typically there are registers assigned simply to store data. They are usually used as temporary storage for math or data. They can also be used to store data in case of a power failure.

10a. Features of instrumentation Amplifier

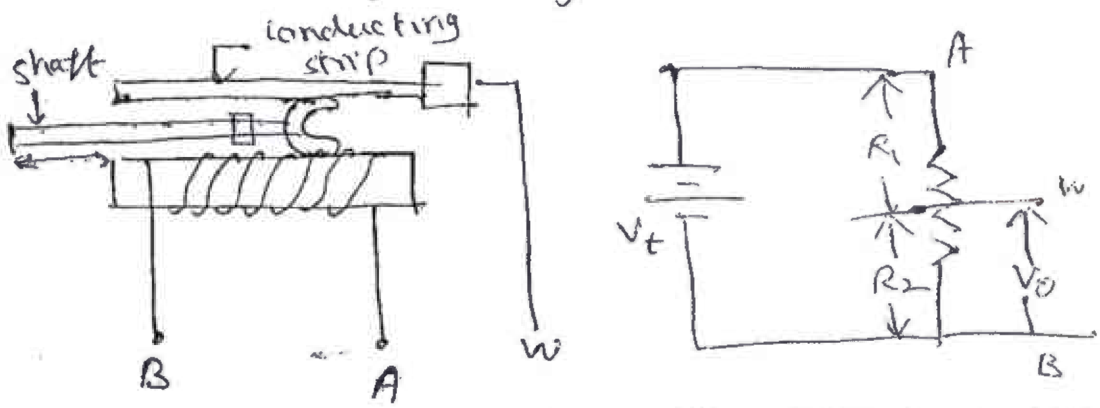
Instrumentation amplifier is a type amp. that has been equipped with input buffers, which eliminates the need to equalize the i/p impedance & makes the amplifier particularly suitable for use in measurement equipment & proof.

Additional features include very low DC offset low drift, low noise level very and CMRR

10b. operation of resistive position transducer.

Here the principle used is that the physical variable under measurement causes a resistance change in the sensing element.

One type of displacement transducer uses a resistive element with a sliding contact or wiper linked to the object being measured. Thus the resistance betn the slider & one end of the resistance element depends on the position of the object.



The output voltage depends on the wiper position & is therefore a function of the shaft position. This voltage may be applied to a voltmeter calibrated in cms for visual display.

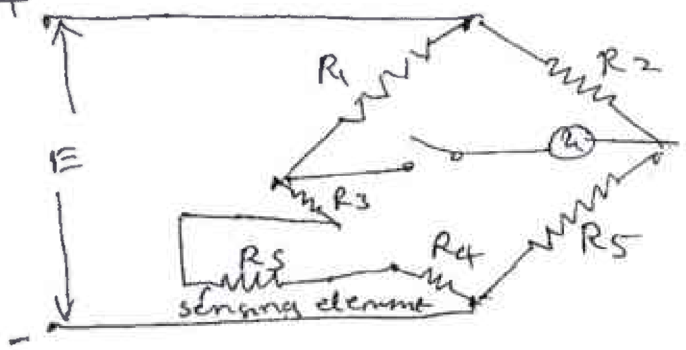
If the circuit is unloaded, the o/p voltage V_o is a certain fraction of V_t, depending upon the position of the wiper.

$$\frac{V_o}{V_t} = \frac{R_2}{R_1+R_2}$$

∴ When applied to resistive position sensors, this equation shows that o/p voltage is proportional to R_2 i.e the position of the wiper of the potentiometer. If the resistance of the transducer is distributed uniformly along the length of travel of the wiper, the resistance is perfectly linear

10c. Resistance thermometer: (10)

The resistance of the thermometer changes when its temperature is changed. This property is used for measurement of temperature. The resistance thermometer bridge circuit uses the change in electrical resistance of conductor to determine the temperature.



The main section of a Resistance thermometer bridge is its sensing element. It determines sensitivity & operating temp. range of the instrument.

The changes in resistance caused by changes in temp. as detected by a wheatstone's Bridge is as shown in Fig. The sensing element R_s is made of a material having high temp. co-eff. R_1, R_2, R_5 are made of resistance under normal temp. under balance condition

$$\frac{R_1}{R_2} = \frac{R_3}{R_5} \Rightarrow \frac{R_1}{R_2} = \frac{R_s + R_3 + R_4}{R_5}$$

when Rs changes, the bridge is going to unbalanced the galvanometer shows a deflection.

Limitations

1. High cost
2. Need to bridge & power source
3. possibility of self heating.