Date 9/4/2020

TRANSDUCERS & MEASUREMENTS
ASSIGNMENT - 1

— UMANG
2018UIC3127
ICE-2

Q1 ex 4.3 Nakra Chaudhry

ans.

$$C = \frac{\varepsilon_0 A}{d} = \frac{8.85 \times 10^{-12} \times 5 \times 10^{-4}}{1 \times 10^{-3}}$$

$$= 44.25 \times 10^{-13}\ F$$

$$\text{sensitivity} = \frac{44.25 \times 10^{-13}}{10^{-2}}$$

$$= \underline{\underline{44.25 \times 10^{-15}}}$$

Q2 ex 12.5 Nakra Chaudhry

ans.

$$\text{sensitivity} = \frac{45.14}{1100 - 0}$$

$$V = \text{sensitivity} \times \text{temp diff}$$

$$= \frac{45.14}{1100} \times (840 - 25)$$

$$\simeq \underline{\underline{33.445\ V}}$$

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Q3/ex. 8.3 Bentley

ans.

a) $C_x = \frac{\varepsilon_0 w}{d}\left(\varepsilon_2 R - (\varepsilon_2 - \varepsilon_1)x\right)$

$= 8.85 \times 10^{-12} \times 50\,(4 \times 50 - (4-1)x)$

$C_0 = 8.85 \times 10^{-12} \times 50 \; 200 \times 10^{-3}$

$= \underline{\underline{88.5 \times 10^{-12}}}\ F$

$C_{25} = 8.85 \times 10^{-12} \times 50\,(4 \times 50 - 3 \times 25)\,10^{-3}$

$= 55.3\ pF$

$C_{50} = 8.85 \times 10^{-11} \times 50\,(200 - 3 \times 50) \times 10^{-3}$

$= \underline{\underline{22.1}}\ pF$

b) $5269 = a_1(100) + a_2(100)^2$

or $10538 = 2a_1(100) + 2a_2(100)^2$

and $10779 = a_1(200) + a_2(200)^2$

$\therefore\ 241 = a_2(20000)$

$a_2 = \underline{\underline{0.01205}}$

and

$a_1 = \frac{5269 - 120.5}{100}$

$= \underline{\underline{51.485}}$

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c) $E_{T,0} = E_{T,20} , E_{20,0}$

$= 12500 + 1000$

$= 13500 \, \mu V$

and

$13500 = 51.48 (T) + 0.01205 (T)^2$

$T^2 + 4272.19T = 1120331.95$

$$T_{1,2} = \frac{-4272 \pm \sqrt{(4272.19)^2 + 4 \times 1120331.95}}{2}$$

$T = \underline{\underline{247.85}}$

Q4/ ex 8.7 Bentley

ans.

$$\text{slope} = \frac{27393 - 0}{500 - 0} = 54.786$$

at 100°C, $E_{ideal} = 54.786 \times 100$

$= 5478.6$

$E_{real} = 5269$

$$\text{non linearity}, N = \left(\frac{5269 - 5478.6}{27393} \right) \times 100$$

$N = -0.76515$

at 200°C, $E_{ideal} = 54.786 \times 200$

$= 10957.2$

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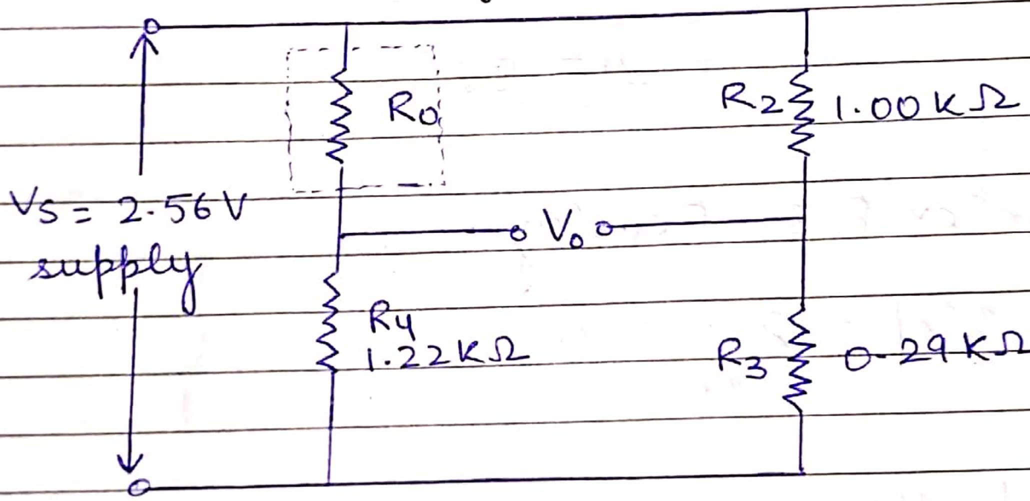
$E_{real} = 10779$

$$N = \left(\frac{10779 - 10957.2}{27393} \right) \times 100$$

$$N = -0.65053$$

Q5 ex 9.3 Bentley

ans.



a) $R_\theta = 1.68 \exp\left(3050\left(\frac{1}{\theta} - \frac{1}{298}\right)\right)$

on solving the above circuit by applying KVL & KCL we get,

$$V_{out} = V_S \left(\frac{1}{1 + \frac{R_4}{R_\theta}} - \frac{1}{1 + \frac{R_3}{R_2}} \right)$$

i) $V_{out} = V_{min}$ when R_θ is minimum

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and,

$$R_{o(max)} = 1.68\, e^{3050\left(\frac{1}{273} - \frac{1}{293}\right)}$$

$$= \underline{\underline{4.2887\ K\Omega}}$$

& $$R_{o(min)} = 1.68\, e^{3050\left(\frac{1}{323} - \frac{1}{298}\right)}$$

$$= 0.76\ K\Omega$$

So,

$$V_{out}(min) = -1.0017$$

$$V_{out}(max) = 0.0156$$

ii) $$V_{ideal} = \left(\frac{V_{max}\, I}{I_{max} - I_{min}} - \frac{V_{max}\, I_{min}}{I_{max} - I_{min}}\right)$$

$$= 0.24$$

$$V_{12°C} = 0.225$$

$$N = \frac{0.225 - 0.74}{1.03} \times 100$$

$$= -1.456\%$$

b) $$R_{T_{min}} = \frac{1}{1 + \frac{R_4}{R_{T_{min}}}} + \frac{1}{1 + \frac{R_3}{R_2}}$$

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$$R_{Tmax} = \frac{1}{1+\frac{R_4}{R_{Tmax}}} + \frac{1}{1+\frac{R_3}{R_2}}$$

$$= \frac{2}{3}$$

$$V_{L\,min} = 0 \times \frac{1}{1+R_{Tmin}} = 0$$

$$V_{L\,max} = 1.037 \times \frac{1}{1+R_{Tmin}}$$

$$\approx 0.6V$$

$$\text{Range} = \underline{\underline{0 - 0.6V}}$$

Q6. ex 9.4 Bentley

ans

$$0 = V_S\left(\frac{1}{1+\frac{R_4}{R_{0^\circ C}}} - \frac{1}{1+\frac{R_3}{R_2}}\right)$$

$$0.5 = V_S\left(\frac{1}{1+\frac{R_4}{R_{50^\circ C}}} - \frac{1}{1+\frac{R_3}{R_2}}\right)$$

$$1 = V_S\left(\frac{1}{1+\frac{R_4}{R_{50^\circ C}}} - \frac{1}{1+\frac{R_3}{R_2}}\right)$$

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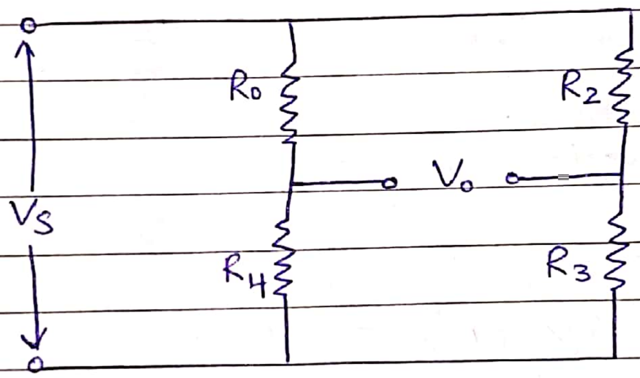
& $R_{0^\circ c} = 0.0585\, e^{\frac{3200}{273}} = 8.96\ K\Omega$

$R_{25^\circ c} = 0.0585\, e^{\frac{3200}{298}} = 3.26\ K\Omega$

$R_{50^\circ} = 0.0585\, e^{\frac{3200}{323}} = 1.40\ K\Omega$

$R_2 = \underline{\underline{1000\ \Omega}}$ $\qquad R_3 = \underline{\underline{265\ \Omega}}$

$R_4 = \underline{\underline{2370\Omega}}$ $\qquad V_s = \underline{\underline{243V}}$



Q7 A variable reluctance sensor consists of a core, variable air gap and an armature. The core is a steel rod of 1mm diameter, relative permeabbility 100, and bent to form a semicircle of diameter 4 cm. A coil of 500 turns is wound on to the core. The armature is a steel plate of thickness 0.5 cm and relative permiability of 100. Assuming relative permeability of air = 1.0, Date..................

calculate the inductance of the sensor for air gaps of 1mm and 3mm.

ans.

$$R_{core} = \frac{R}{\mu_o \mu_e r^2}$$

$$= \frac{2 \times 10^{-2}}{1.2 \times 10^{-6} \times 100 \times 25 \times 10^{-8}}$$

$$= \underline{6.66 \times 10^8}$$

$$R_{arm} = \frac{R}{\mu_o \mu_e rt}$$

$$= \frac{2 \times 10^{-2}}{1.2 \times 10^{-6} \times 100 \times 5 \times 1 \times 10^{-4}}$$

$$= 0.33 \times 10^8$$

$$R_{gap1} = \frac{2 \times 10^{-3}}{1.2 \times 10^{-6} \times \pi \times 25 \times 10^{-8}}$$

$$= 21.2 \times 10^8$$

$$R_{gap3} = 21.2 \times 3 \times 10^8$$

$$= 63.6$$

$R_{T3} = 70.59$ $R_{T4} = 28.19$

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$$L_1 = \frac{25}{28.19} \times 10^{-4}$$
$$= 0.886 \times 10^{-4}$$
$$= 88.6 \mu H$$

$$L_3 = \frac{25}{70.59} \times 10^{-4}$$
$$= 0.3541 \times 10^{-4}$$
$$= 35.41 \mu H$$

Q8. An LVDT has an output of 6V RMS when the displacement is 0.4 mm. Determine the sensitivity of this instrument in volts/mm. A 10V voltmeter with 100-scaled divisions is used to read the o/p. To tenth of a division can be estimated with ease. Determine the resolution of voltmeter. The above arrangement is used in a pressure transducer for measuring the deflection of diaphragm. The diaphrgm is deflected through half micron by a pressure of 100 N/m². Determine the scope resolution and sensitivity.

ans

i) sensitivity $= \frac{6}{4 \times 10^{-4}} = 1.5 \times 10^{4}$

$= 15000$ V/mm

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ii) resolution

$$\frac{10}{100} = 0.1\,V/\text{division}$$

total count = 100 × 10 div

$$\text{resolution} = \frac{fsd}{\text{total count}}$$

$$= \frac{10}{100 \times 10} = 0.01\,V$$

Q9. An LVDT with a secondary voltage of 5 V has arranged of ±25 mm

a) Find o/p voltage when core is −18.75 mm off the center.

b) Plot the o/p voltage v/s core position.

ans.

a) $\text{sensitivity} = \frac{5}{25} = 0.2\,V/mm$

$V = 0.2 \times 18.75 = 3.75\,V$

for 18.75 mm, V = 3.75.

for −10 mm,

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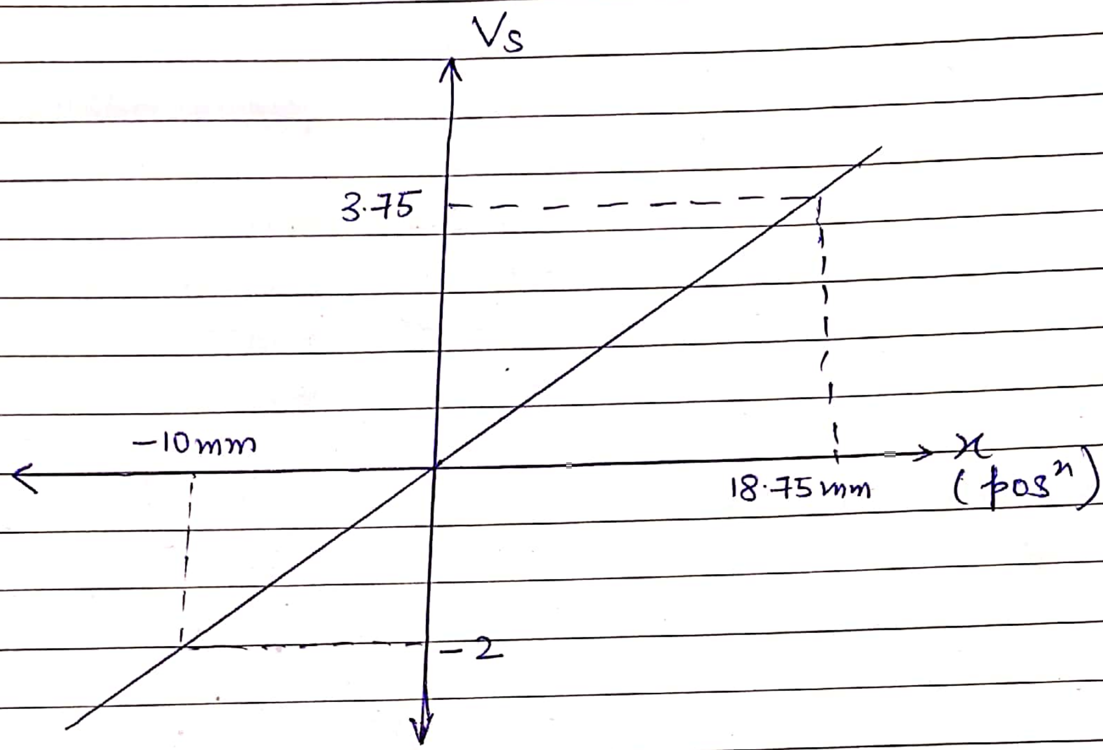
$V = 0.2 \times -10 = -2V$

b)



linear Plot.

x ———— x