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Solution Interfacing

2013/2014

جامعة بيرزيت

BIRZEIT UNIVERSITY

ANSWER BOOKLET

Student :	Number : ....
Course : Department :	Number : ....
Divsion :	Instructor : ....
Date : .... Day Month Year	

For Instructor's Use

Question	Grade
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Problem #1:

Type J TC is to be used in a measurement system that provide an output of 2 V at 200°C. A solid state sensor will be used to provide reference temp. compensation. the sensor has 3 terminals: supply voltage V_s, output V_T and ground. The output varies 8 mV/C.

Solution:

J TC with 0°C reference its output 10.78 mV @ 200°C from tables.

$$V_{J_0}(200°C) = 10.8\,mV.$$

$$\text{overall gain} = \frac{2\,V}{10.8\,mV} = \underline{\underline{185.5}}$$

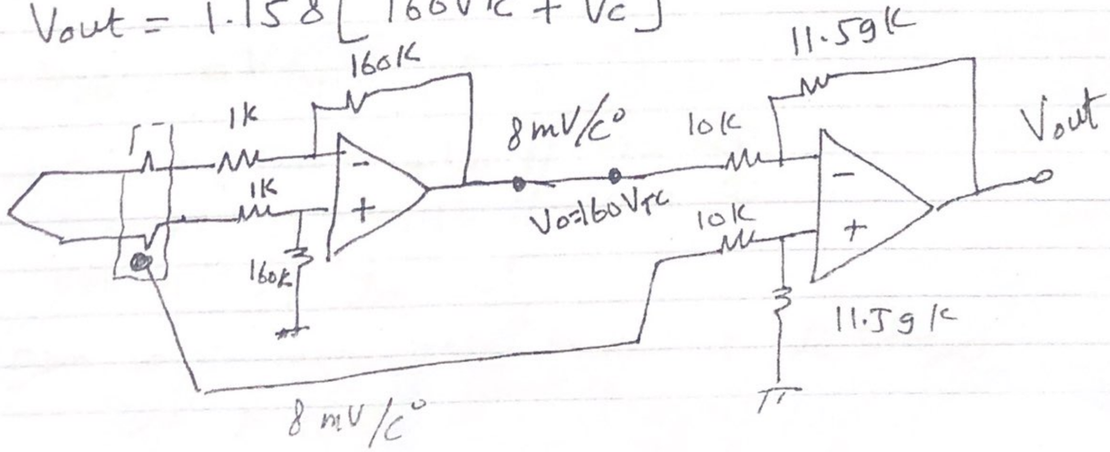
From tables of J TC slope is approx. 50 μV/C°.
slope of sensor 8 mV/C°.

$$\frac{8\,mV/C°}{50\,\mu V/C°} = 160 \text{ times larger}$$

to make the rest of the gain

$$\frac{185.5}{160} = \underline{\underline{1.159}}$$

$$V_{out} = 1.158\,[160 V_{TC} + V_c]$$



Problem 2:

Temprature for a plating operation must be measured for control within a range of 500 – 600 F°. Develop measuring system that scales this temprature into 0 to 5V for an input to 8-bit ADC ; measurement must be within ∓ 1F°.

Solution:

Range: 260 – 315.6 °C

Choosing the Sensor: TC & RTD could fit to the Problem

let us choose J TC with reference 25 ∓ 5 °C to satisfy the accuracy.
Correction circuit must be used to compensate the reference Voltage.

From tables:

For 260°C ; $V_{J_{25}}(260) = V_{J_0}(25) - V_{J_0}(25)$

$V_{J_{25}}(260) = 12.84 \text{ mV}$

$V_{J25}(315.6) = 15.9 \text{ mV}$

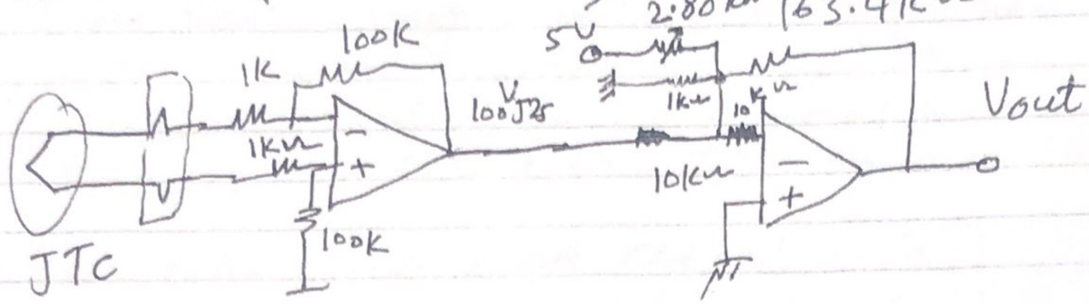
$V_{ADC} = m V_{J_{25}} + V_o$

$0 = m(12.8\text{mV}) + V_o$ // $m = 1634$
$5 = m(15.9\text{mV}) + V$ // $V_o = -21$

$V_{ADC} = 1634 V_{J_{25}} - 21$

gain is so large, we make it 2 stages
100 & 16.34

$V_{ADC} = 16.34(100 V_{J25} - 1.29)$

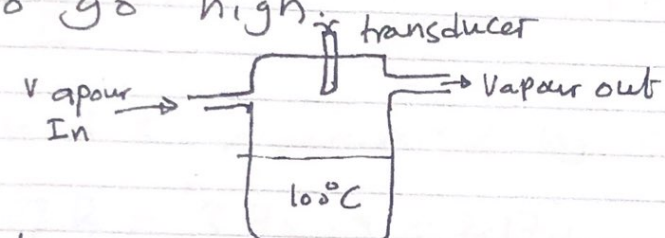


Problem #3:

Vapour flows through chamber containing liquid at 100°C. Control system will regulate the vapour temprature, so a measurement must be provided to convert 50 - 80°C into 0 to 2V.

the error should not exceed ∓1°C.

If the liquid level rises to the tip of the transducer, the temp. will suddenly rise to 100°C. The event should cause an alarm to go high.



Solution:

Selection of Sensor RTD is the best choise.

Let us choose RTD with the following spec.

$$R @ 65°C = 150\Omega$$
$$\alpha = .004/C°$$
$$P_D = 30 mW/C°$$

@ 50°C $RTD = 150[1 + .004[50-65]] = 141\Omega$

@ 80°C $RTD = 159\Omega$

@ 100°C $RTD = 171\Omega$

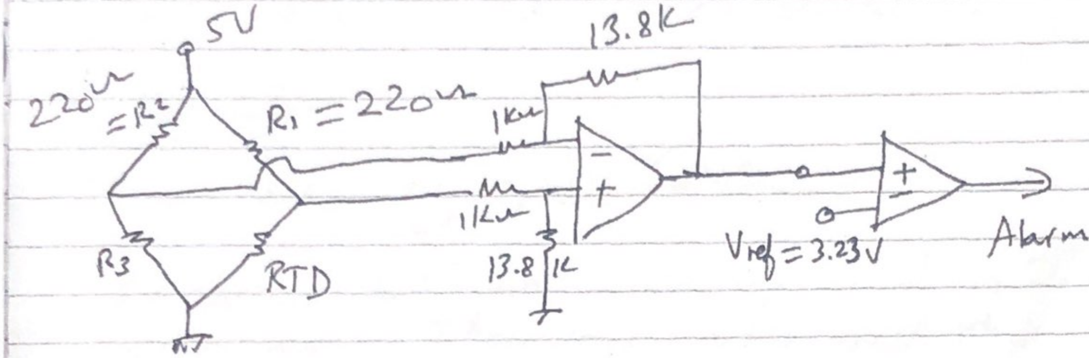
For 1°C error because of self-heating we can find max. current

$$P = P_D \Delta T = 30 mW/C° \times 1°C = 30 mW$$

max. Current

$I = \sqrt{\frac{P}{R}} = \sqrt{\frac{30}{159}} = 13.7\,mA$.

Bridge should be used for RTD



Value of R_1 is determined by current < 13.7mA

$V = IR = 13.7 \times 159 = 2.17V$

$R_1 = (5 - 2.17)/159 = 206.5\Omega$

Let us choose $R_1 = 220\Omega$

to null the bridge @ 50°C we will make
$R_2 = 220\Omega$ & $R_3 = 141\Omega$

@ 50°C ⇒ $\Delta V = 5\left(\frac{141}{220+141} - \frac{141}{220+141}\right) = 0$

@ 80°C ⇒ $\Delta V = 5\left(\frac{159}{220+159} - \frac{141}{220+141}\right) = .1447V$

@ 100°C ⇒ $\Delta V = .2338V$

gain needed $= \frac{2}{.1447} = \underline{13.8}$

$V_{ref} = 13.8 \times .2338 = 3.23V$

Problem # 4:

Develop a system that turns on alarm LED When the temprature in a champer reaches $10 \mp .5\,^\circ C$. when the temprature drops below $8\,^\circ C$; the LED should be turned off.

Solution:

it looks hystresis Comparator

because we are interested just in 2 tempratures Thermistor is the best choice.

we choose thermistor ; $P_D = 5\,mW/C^\circ$.

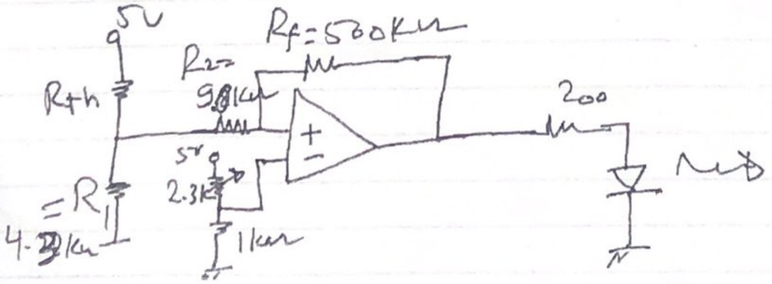
$$R_{th}\big|_{10^\circ C} = 10\,K\Omega \; ; \; R_{th}\big|_{8^\circ C} = 11\,K\Omega$$

$\mp .5\,^\circ C$ requirement means that self heating must be kept below $\mp .5\,^\circ C$.

to be sure let us use $.25\,^\circ C$.

$$P = P_D \cdot \Delta T = 5\,mW/_{C}{}^{\circ} \times .25\,^\circ C = 1.25\,mW$$

$$I = \sqrt{\frac{1.25\,mW}{10\,K\Omega}} = .354\,mA.$$



$$V_{Th} = I R_1 = .35\,mA \times 10\,K\Omega = 3.5\,V$$

$$R_1 = \frac{5 - 3.5}{.35} = 4.28\,K\Omega \quad \text{we will use } 4.3\,K\Omega$$

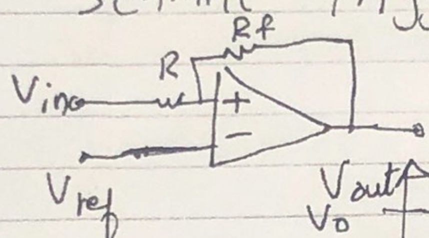
For 10°C ; $V_D = 1.5V$
" 8°C ; $V_D = 1.41V$

difference is .09V required for hystreses

hystresis: $\frac{R_2}{R_f} \times 5 = .09 \Rightarrow \frac{R}{R_f} = .018$

choose $R_f = 500k\Omega$; $\Rightarrow R_2 = 9k\Omega$

Note: Schmitt trigger



$$V_{out} = V_{ref} - \frac{R_f}{R} V_o$$