Problem #1:

Type J TC is to be used in a measurement system that provide an output of 2V 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.

$$V_{J_0}(200°C) = 10.8\,mV.$$

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

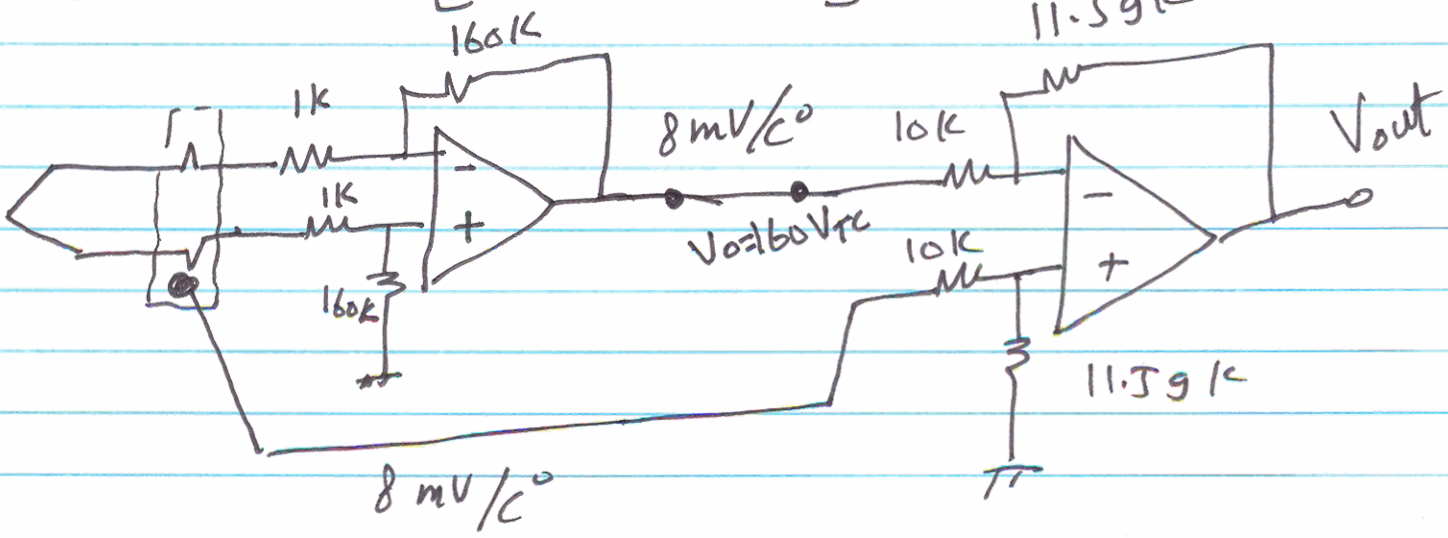
From tables of J TC slope is approx. 50 μV/C°.
slope of sensor 8 mV/C°.

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

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 ∓ 1°F.

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

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

$V_{J_{25}}(315.6) = 15.9\ mV$

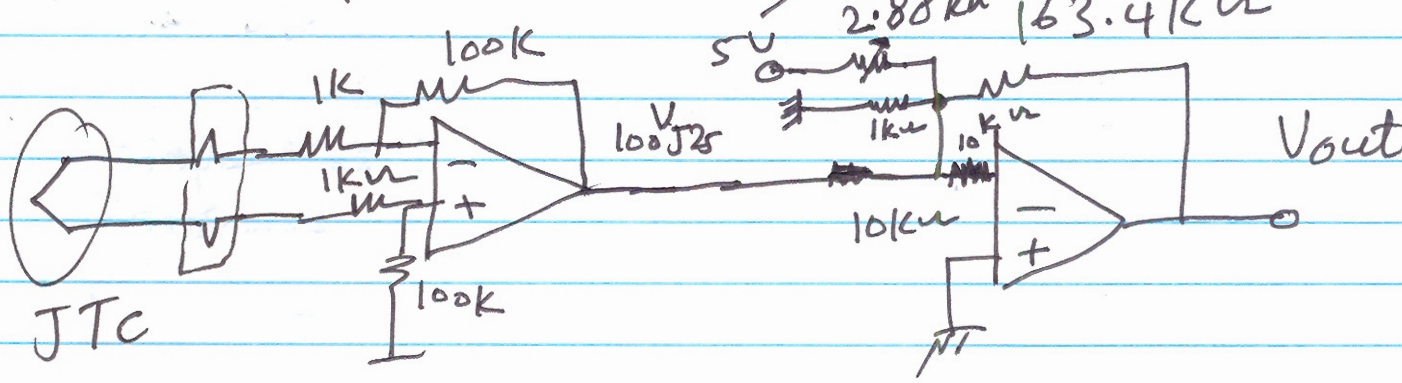
$V_{ADC} = m V_{J_{25}} + V_o$

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

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

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

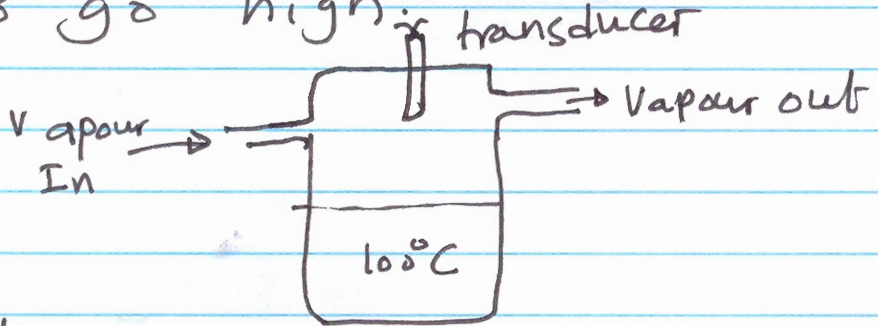
$V_{ADC} = 16.34(100 V_{j25} - 1.29)$



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 $= 171\Omega$

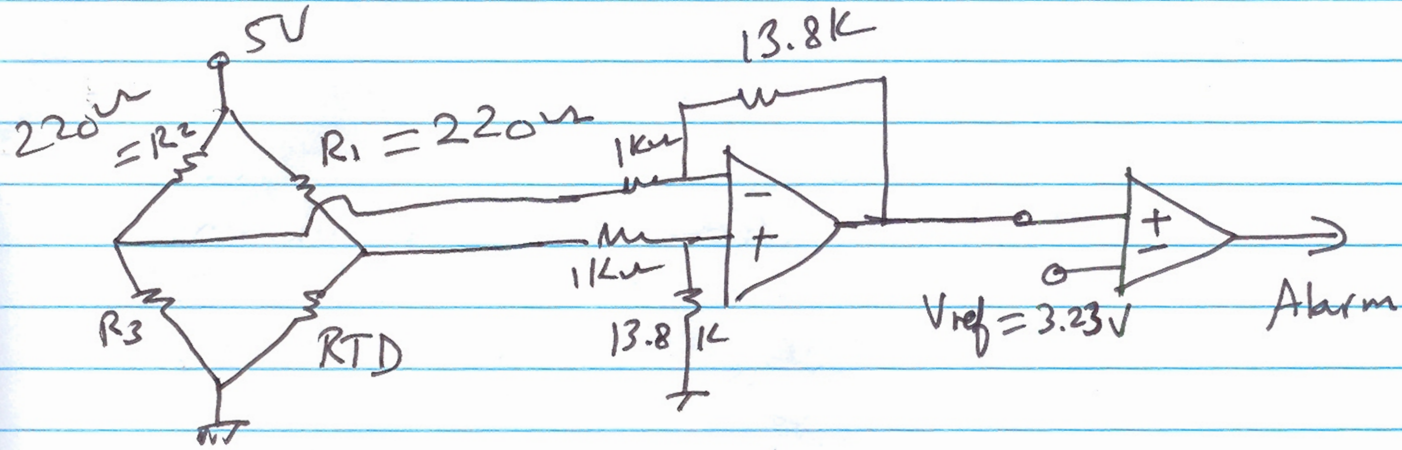
For 1°C error because of self-heating we can find max. current

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

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 $R_2 = 220\Omega$ & $R_3 = 141\Omega$

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

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

$$@\ 100°C \Rightarrow \Delta V = .2338V$$

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

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

Problem # 4:

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

Solution:

it looks hystresis Comparator

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

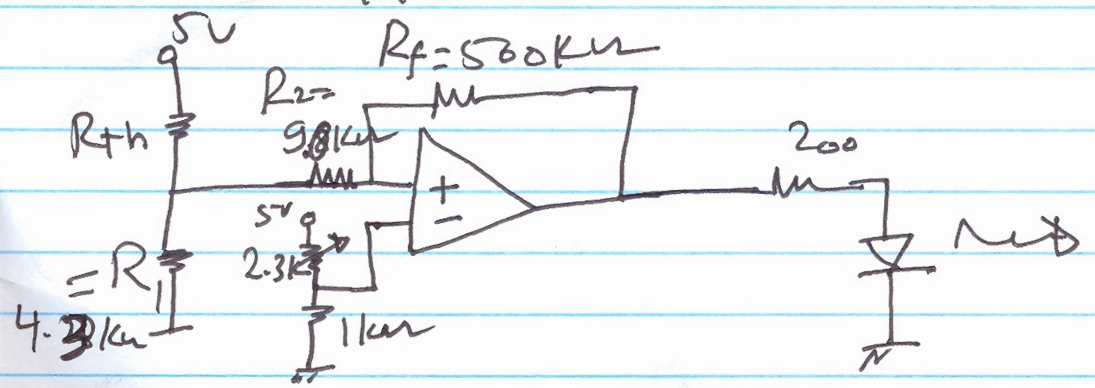
we choose thermistor; $P_D = 5 mW/C°$.

$$R_{th}\Big|_{10°C} = 10K\Omega \ ; \ R_{th}\Big|_{8°C} = 11K\Omega$$

$\mp .5°C$ requirement means that self heating must be kept below $\mp .5°C$.
to be sure let us use .25°C.

$$P = P_D \cdot \Delta T = 5 mW/C° \times .25°C = 1.25 mW$$

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



$$V_{th} = IR_1 = .35 mA \times 10K\Omega = 3.5V$$

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

For 10°C ; $V_D = 1.5V$

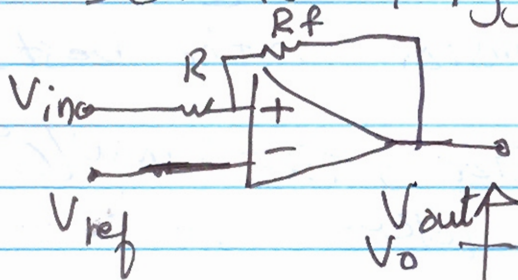
" 8°C ; $V_D = 1.41V$

difference is .09V required for hystreses

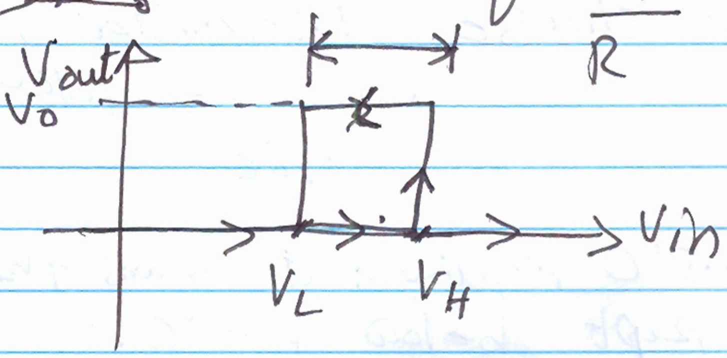
hystresis $\frac{R_2}{R_f} \times 5 = .09 \Rightarrow \frac{R}{R_f} = .018$

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

Note: Schmitt trigger



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



Solution Interfacing

2013/2014

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