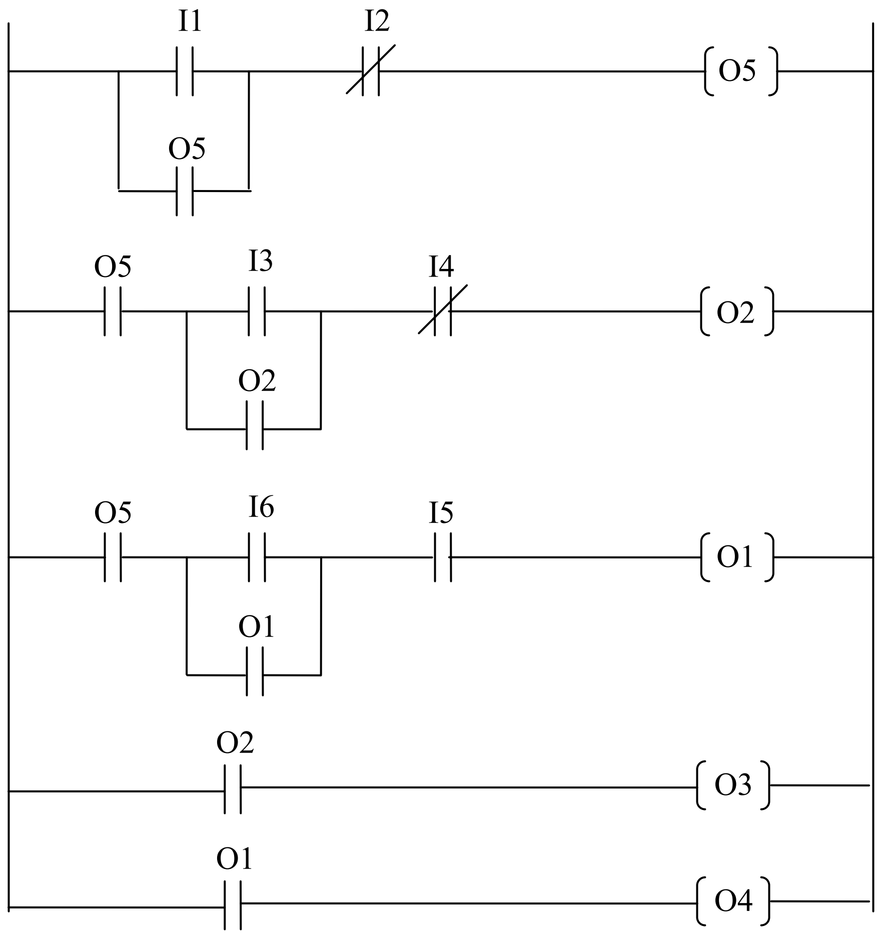
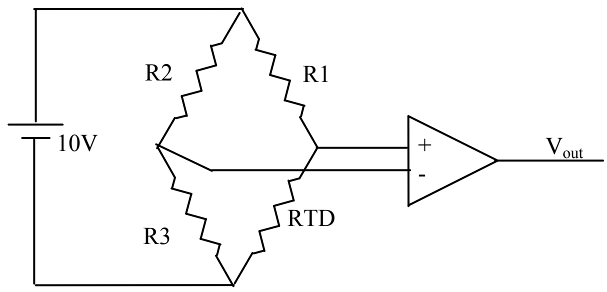
1-a)



1-b)



$RTD_{20} = RTD_5 (1+ \alpha \Delta t)$

$= 150(1+0.02*(35-5)) = 240\ \Omega$

$R2 * RTD = R1*R3$

Let $R2=20k\Omega$, $R1=15K\Omega$

$R3=R2 * RTD / R1=240/15=320\Omega$

2-a)

$V3=V1$

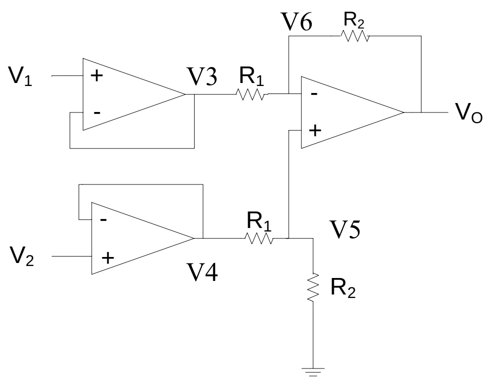
$V4=V2$

$$V6=V5=V4\frac{R2}{R2+R1} = V2\frac{R2}{R2+R1}$$

$$\frac{V3-V6}{R1} = \frac{V6-Vo}{R2}$$

$$Vo=V6+V6\frac{R2}{R1}-V3\frac{R2}{R1}$$
$$=V6\frac{R2+R1}{R1}-V3\frac{R2}{R1}$$
$$=V4\frac{R2}{R2+R1}\,\frac{R2+R1}{R1}-V3\frac{R2}{R1}$$
$$=\frac{R2}{R1}(V4-V3)$$
$$=\frac{R2}{R1}(V2-V1)$$

The voltage follower is used to make a high input impedance to avoid loading effect.



2-b)

I) 0V → 0mA

7.5V→ 10mA

I=mV

$m=I/V=10*10^{-3}/7.5=1/750=0.001333$

I=0.001333V

$I=-V_1\frac{R_2}{R_1R_3}$ $\quad$,$R_1(R_3+R_5)=R_2R_4$

Let R=1kΩ

So

$V=-V_1$

So $I=V\frac{R_2}{R_1R_3}$

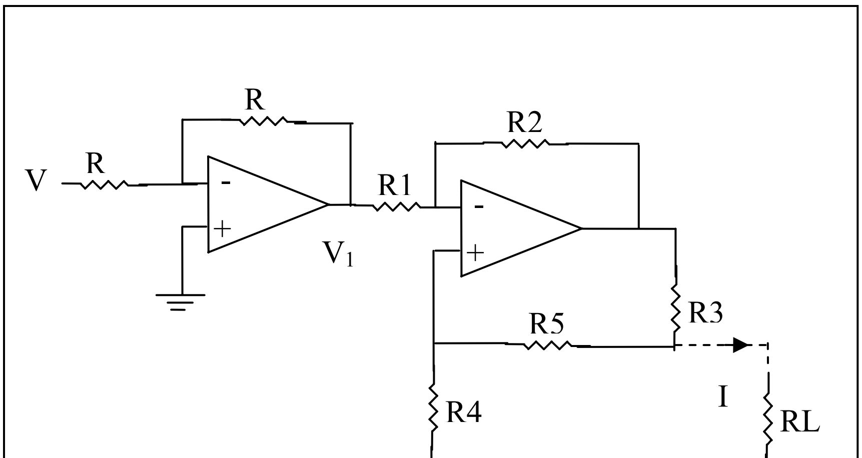
Let $R_1=R_2=1k\Omega$, $R_5=0$

S0 $I=V\frac{1}{R_3}=\frac{V}{750}$

So $R_3=750\Omega$

$R_1(R_3+R_5)=R_2R_4$

$R_3=R_4=750\Omega$



II) 0V → 4mA
7.5V→ 20mA
$I=mV+I_0$
As 0V → 4mA
$.004=m*0+ I_0$
$I_0=0.004$
As 7.5V → 20mA
$.020=m*7.5+ I_0$
$.020=m*7.5+ 0.004$
$m=0.016/7.5=0.0021333$
so $I=0.0021333V+0.004$
$=0.0021333(V+1.875)$
$=- 0.021333 V_1$
$V_1=-(V+1.875)$

$I=-V_1 \frac{R_2}{R_1R_3}$, $R_1(R_3+R_5)=R_2R_4$

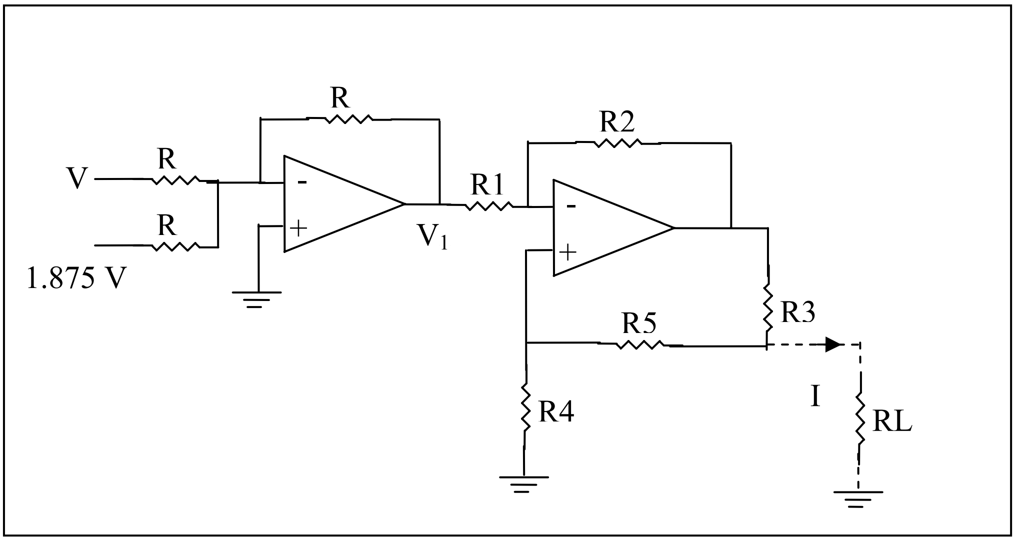
Let $R=1k\Omega$
Let $R_1=R_2=1k\Omega$, $R_5=0$

S0 $I=-V_1 \frac{1}{R_3} = -.0021333V_1$

So $R_3=468\Omega$
$R_1(R_3+R_5)=R_2R_4$
$R_3=R_4=468\Omega$

0 ft → 4mA
20ft→ 20mA
$I=m L+I_0$
As 0ft → 4mA
$.004=m*0+ I_0$
$I_0=0.004$
As 20 ft → 20mA
$.020=m*20+ I_0$
$.020=m*20+ 0.004$
$m=0.016/20=0.0008$

$I=0.0008 L+.004= 0.0008 (L+5) A=.8(L+5) mA$



3-a) Let Vmax=5V
V=m*Vi+Vo
As Vi = 2.5 → V=0
0=2.5m+Vo →1

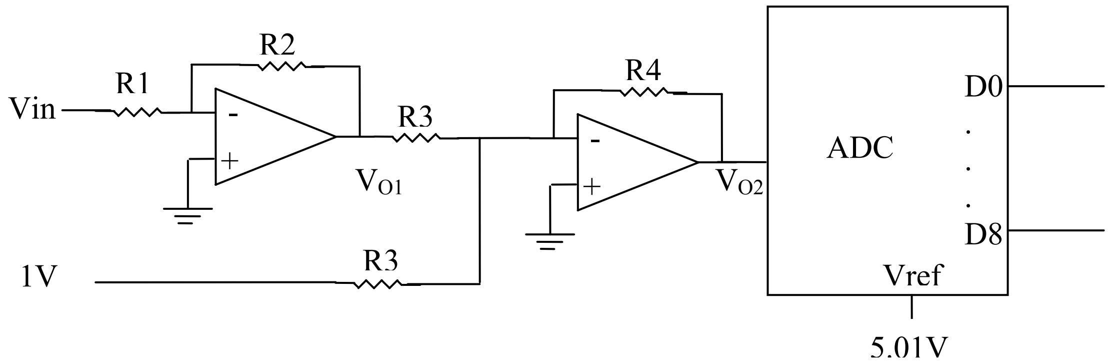
As Vi = 7 → V=5
5=7m+Vo →2

Subtract 2 from 1
4.5m=5
m= 1.111
Vo=-2.5m=-2.7775

So V=1.111Vi-2.7775=2.7775(.4Vi-1) → 3
Let Vref ≈ Vmax
$\Delta V=1.111*\Delta Vi=0.01111=2^{-n}*Vref$
$2^{-n}=0.002222$
-nlog2=log0.002222
n= 8.81= 9bit

$$Vmax=\frac{(2^n-1)}{2^n}Vref$$

Vref=5.01V



$$V_{O1}=-\frac{R2}{R1}Vin$$

$$V_{O2}=-\frac{R4}{R3}(V_{O1}+1) \quad \rightarrow 4$$

$$=\frac{R4}{R3}\left(\frac{R2}{R1}Vin-1\right)$$

Comparing 3,4

$$\frac{R2}{R1}=.4$$

So let R2=4kΩ and R1=10kΩ

And $\frac{R4}{R3}$=2.7775

So let R4=277.75KΩ and R3=100KΩ

3-a –another solution --) Let Vmax=10V

V=m*Vi+Vo

As Vi = 2.5 → V=0

0=2.5m+Vo →1

As Vi = 7 → V=10

10=7m+Vo →2

Subtract 2 from 1

4.5m=10

m= 2.222

Vo=-2.5m=-5.555

So V=2.222Vi-5.555=5.555(.4Vi-1) → 3

Let Vref ≈ Vmax

$\Delta V=2.222*\Delta Vi=0.02222=2^{-n}*Vref$

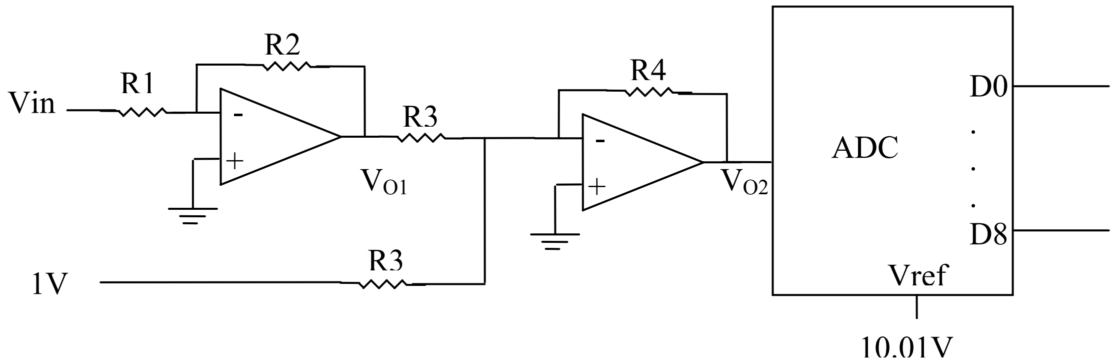
$2^{-n}=0.00222$

-nlog2=log0.00222

n= 8.81= 9bit

$$Vmax=\frac{(2^n-1)}{2^n}Vref$$

Vref=10.01V



$$V_{O1}=-\frac{R2}{R1}Vin$$

$$V_{O2}=-\frac{R4}{R3}(V_{O1}+1) \quad \rightarrow 4$$

$$=\frac{R4}{R3}\left(\frac{R2}{R1}Vin-1\right)$$

Comparing 3,4

$$\frac{R2}{R1}=.4$$

So let R2=4kΩ and R1=10kΩ

And $\frac{R4}{R3}=5.555$

So let R4=55.55KΩ and R3=10KΩ

3-b)

I) $N=\text{int}\left(2^n\left(\frac{V}{Vref}+\frac{1}{2}\right)\right)$

At V=-3.4 N=40.96≈40

At V=4 N=230.4≈230

II) $V=Vref\left(\frac{N}{2^n}-.5\right)$

For N=C6H=6+12*16=198

So V(N=198)≤ V< V(N=199)

V(N=198) = 2.734V

V(N=199) = 2.773V

So 2.734≤V<2.773