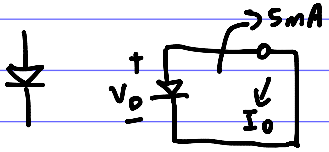
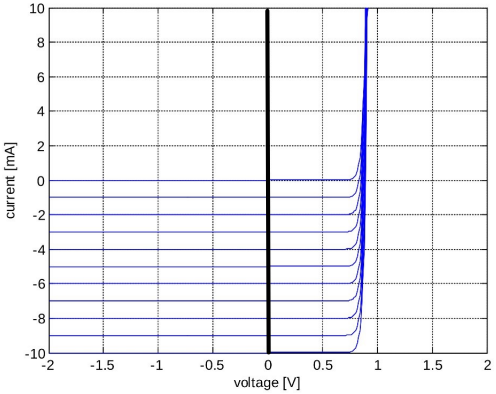
1)

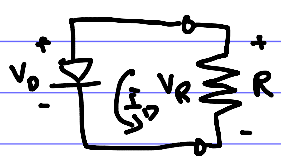


Short-circuit condition: $V_D = 0\,V$



Magnitudes: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10 mA

1a)



$V_R = I_R R$ - (1)

$V_R = V_D$, - (2)

$I_R = -I_D$ - (3)

Sub (2) and (3) into (1)

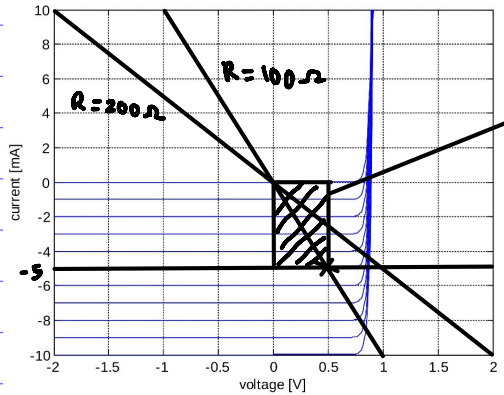
$$V_D = -I_D R$$

When $I_D = -10mA$, $R = 100\Omega$,

$$V_D = -(-10 \times 10^{-3})(100)$$
$$= 1V$$

When $I_D = -10mA$, $= R = 200\Omega$,

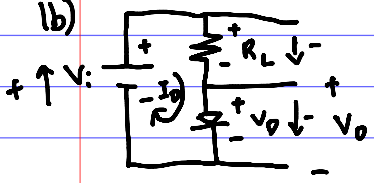
$$V_D = -(-10 \times 10^{-3})(200)$$
$$= 2V$$



Taking the current for the middle value to be 5mA, the power generated is:

$$P = VI$$
$$= 0.5(5 \times 10^{-3})$$
$$= 2.5mV$$

1b)



From the circuit:

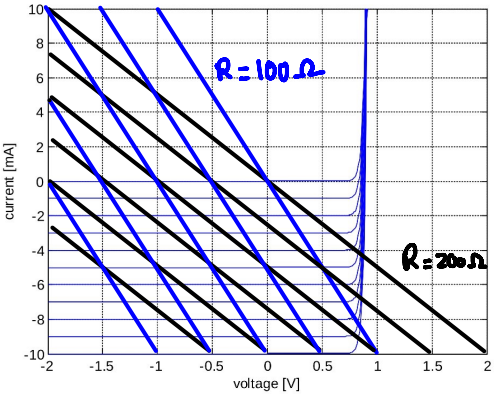
$V_o = V_D$

Using Kirchhoff's voltage law,

$V_i = V_R + V_D$

$V_R = I_D R$

$\therefore V_i = I_D R + V_D$



From the diagram above, a safe value for V_i is $-1.5V$.

2) Thermistor resistance: $R = R_0 e^{\beta\left(\frac{1}{T} - \frac{1}{T_0}\right)}$

When $T_0 = 100°C$, $R_0 = 20,000$, $\beta = 3650$, $R = 500$

$$500 = 20,000\, e^{3650\left(\frac{1}{T} - \frac{1}{100+273.15}\right)}$$

$$\frac{1}{40} = e^{3650\left(\frac{1}{T} - \frac{20}{7463}\right)}$$

$$\ln\left(\frac{1}{40}\right) = \frac{3650}{T} - \frac{73000}{7463}$$

$$\frac{3650}{T} = 6.092709714$$

$$T = 599.076629K$$

$$= 325.926629$$

$$\approx 325.9°C$$

3a) Angle per slit $= \frac{360^\circ}{180}$

$= 2^\circ$

Gear ratio is 10:1.

∴ For the encoder to move 2°, the measured shaft must move $\frac{2}{10} = 0.2^\circ$.

b) Resolution is the angle per bit of the measured shaft, which is 0.2°.

c) Decimal value of the encoder $= 87.4 \div 0.2$

$= 437$

Binary value = 0001 1011 0101

d) Binary value = 0011 0111 1010

Decimal value = 890

Encoder value $= 890 \times 0.2$

$= +178^\circ$