An industrial sensor used to measure temperature, the Rosemount 214C from Emerson, has a nominal resistance of 100 Ωat0$_o$C, witha temperature coefficient of resistance (α) equal to 3.85*10-3/ $_o$C. It is used to measure temperatures ranging from –45 $_o$Cto 455 $_o$C. An alarm is to be raised when the temperature rises above 400$_o$C – a red LED, with a cut-in voltage of 1.8 V is to light up to indicate this status. If the maximum current through the LED is to be 10 mA, while that through the RTD is limited to 100 μA, design an appropriate circuit for this purpose, so that the output voltage will not be greater than5 V. You are provided with +15V supplies and may assume that all components are ideal.

1. A current source is modelled such that the current through the RTD is limited to 100μA.

We will use a variable resistor (RTD) whose resistance varies according to temperature, which can be calculated by using the formula

$$R = R_{ref}[1 + \alpha(T - T_{ref})] \qquad (1)$$

$where\ R_{ref}$ is given as 100Ω at T_{ref} = 0^0 C.

α = $3.85*10^{-3}$ /^{0}C.

So from (1) at temperatures:

-45^0C	R = 82Ω
400^0C	R = 256Ω
455^0C	R = 272Ω

At 400^0C we calculated R = 256Ω . After measuring the voltage at the non inverting terminal of the op amp, it is found to be 4.45mV. So to provide this voltage as the reference to the inverting terminal, we use a voltage divider circuit, we assume R_4 to be 30Ω and R_3 to be 99970Ω. This voltage divider is connected to the inverting terminal. So the diode will start to conduct when the temperature reaches 400^0C. A LED diode is connected to a 1kΩ resistor to limit the current to 10mA. The output is taken across R_6=500Ω so that the output voltage doesn't exceed 5V. We can from the fig 1. that the output is high after resistor increases more than 256Ω.

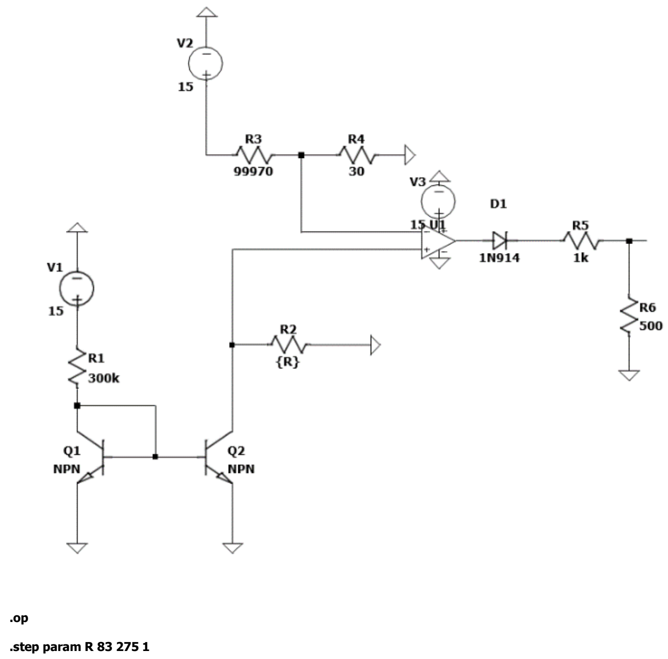

Fig 1.5

The fig 1.6 gives the relation between current through diode and the variable resistance.

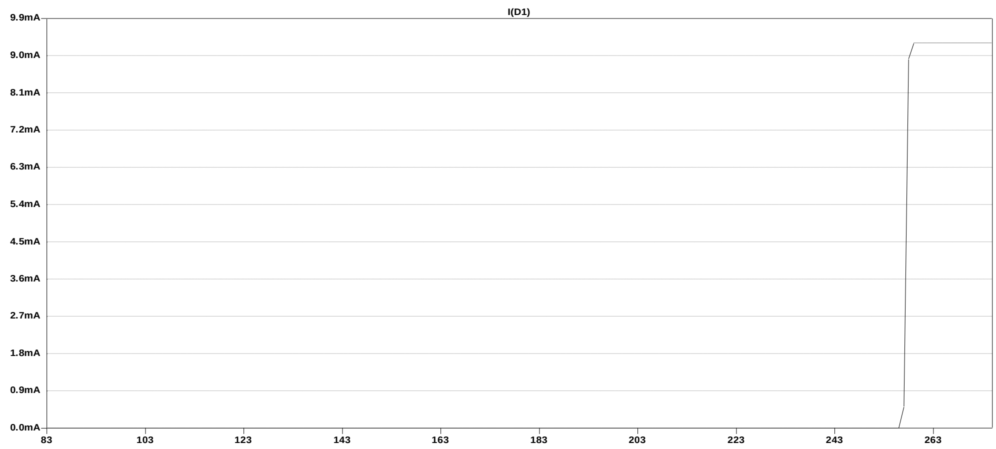

Fig 1.6

The fig 1.7 gives the relation between the output voltage and the variable resistance.

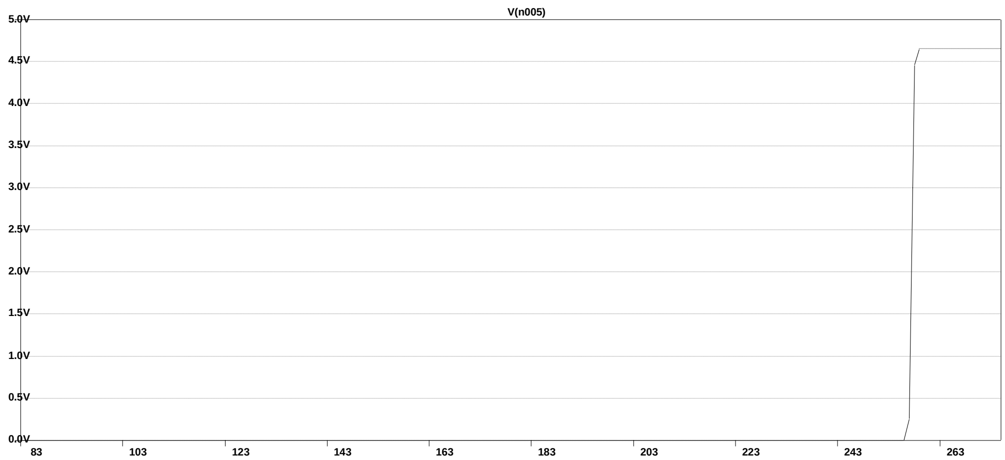

Fig 1.7

The safe range of operation of a temperature controlled chamber is to be indicated by means of a green LED which should glow when the temperature is between 25 and 45 degrees above the ambient temperature. A green LED has a typical forward cut-in voltage of 3.3 V. If the temperature sensor of choice is a Pt100 RTD, with a nominal value of resistance R_o= 100 Ω, temperature coefficient of resistance α= 3.85*10^{-3}/ $^oC$and a maximum safe current of 100 μA, design a circuit to obtain the above, provided that the maximum current through the LED is to be limited to 10 mA.

2. A current source is modelled such that the current through the RTD is limited to 100µA.

We will use a variable resistor (RTD) whose resistance varies according to temperature, which can be calculated by using the formula

$$R = R_{ref}[1 + \alpha(T - T_{ref})] \qquad 1$$

$where\ R_{ref}$ is given as 100Ω at T_{ref} = 0^0 C.

α = 3.85*10^{-3} / ^{0}C.

So from 1 at temperatures:

25^0C	109.625Ω
45^0C	117.325Ω

Since the circuit should work and light the LED diode when the temperature is between 25^0C and 45^0C, we will implement based on the logic of window comparator. Therefore at 109.625Ω and 117.325Ω , we need to find out the corresponding voltages using the simulation. The voltage is around 2.25mV at 109.625Ω and at 117.325Ω the voltage is around 2.4mV . Therefore the reference voltages are 2.25mV and 2.4mV. To provide this voltage, we use voltage divider circuits. We assume R_4 to be 160Ω and find R_3 to be 999840Ω, similarly R_5 to be 150Ω and R_6 to be 999850 Ω. An LED diode with 1kΩ resistance is connected to limit the current through the diode to 10mA. We can see that from fig 1.8 from 109.625Ω to 117.325Ω, output becomes high.

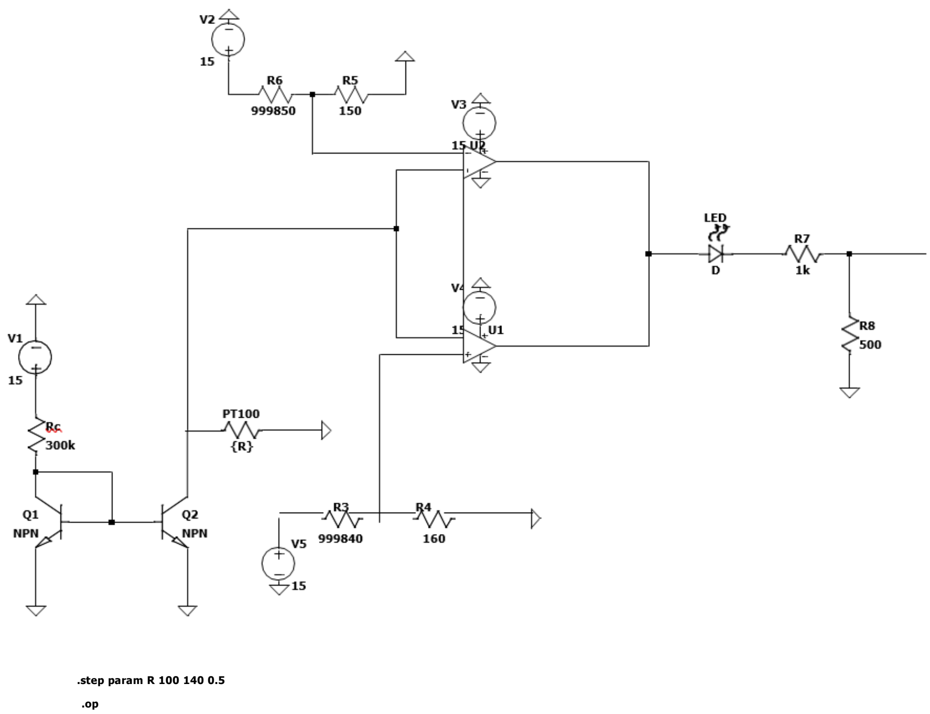

Fig 1.8

The fig 1.9 gives the relation between current through diode and the variable resistance.

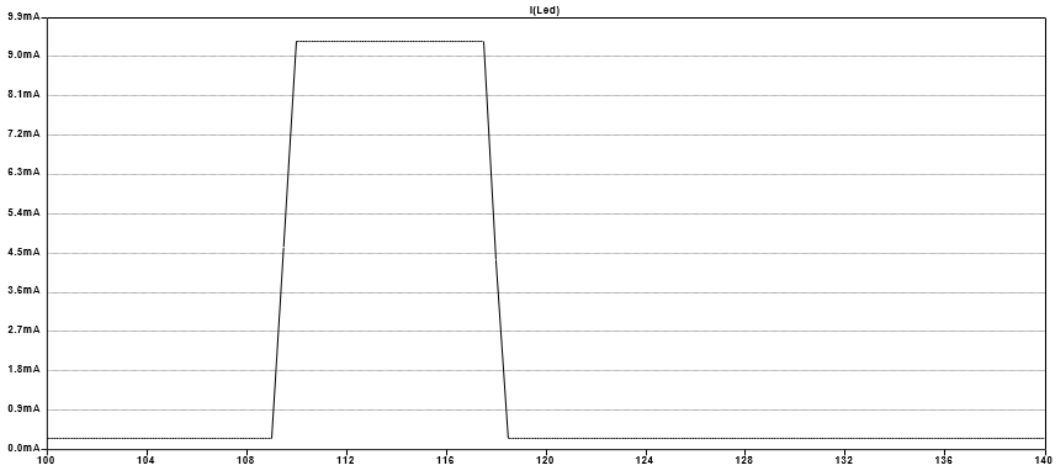

Fig 1.9

The fig 1.10 gives the relation between the output voltage and the variable resistance.

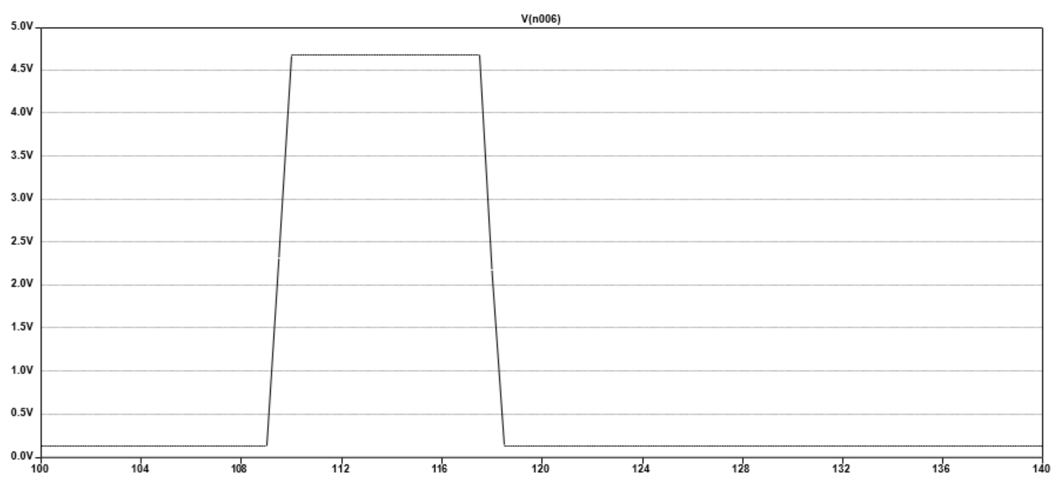

Fig 1.10