1. An industrial sensor used to measure temperature, the Rosemount 214C from Emerson, has a nominal resistance of 100Ω at0℃, with a temperature coefficient of resistance (α) equal to 3.85* /10^ − 3^0C. It is used to measure temperatures ranging from –45^0 C to455^0 C. An alarm is to be raised when the temperature rises above 400^0 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 100µA, design an appropriate circuit for this purpose, so that the output voltage will not be greater than 5 V. You are provided with + 15 V supplies and may assume that all components are ideal.

Ans:

First, we take a variable resistor (named RTD). This is the temperature dependent resistor. Next, we model a current source using active loads such that it provides a constant current within the specified range (100µA). This is done by using the equation ,

$$V_{CC} - I_C R_C - V_{BE} = 0$$

Assuming a current of 50µA, we calculate the resistance which is found out to be 300KΩ. Here we use an inverting comparator . That is, reference voltage is given to the inverting terminal. To find out the resistances corresponding to the temperatures given ,we can use the formula,

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

Where R_{ref} is given as 100Ω , α = to 3.85*10-3 /^{0} C and T_{ref}= 0^0 C .

Using this formula, we find that at -45^0 C , R is 82.675Ω , at 455^0 C , R is 275.175Ω. We need the LED to light up at 400^0 C. Therefore,by using the same formula, we get R=254Ω. Therefore at 254Ω, we need to find out the corresponding voltage using the simulation. We can see from the graph that at 254Ω, the voltage is around 4.45mV. Therefore the reference voltage is 4.45mV. To provide this voltage ,we use a voltage divider circuit. We assume R4 to be 30Ω, we find out R3 to be 99970Ω. This voltage divider is connected to the inverting terminal . An LED diode with 2KΩ resistance is connected to limit the current to 10mA. Output is taken across R6=800Ω to ensure that the output voltage doesn’texceed 5V. We can see that at 254Ω,output becomes high.

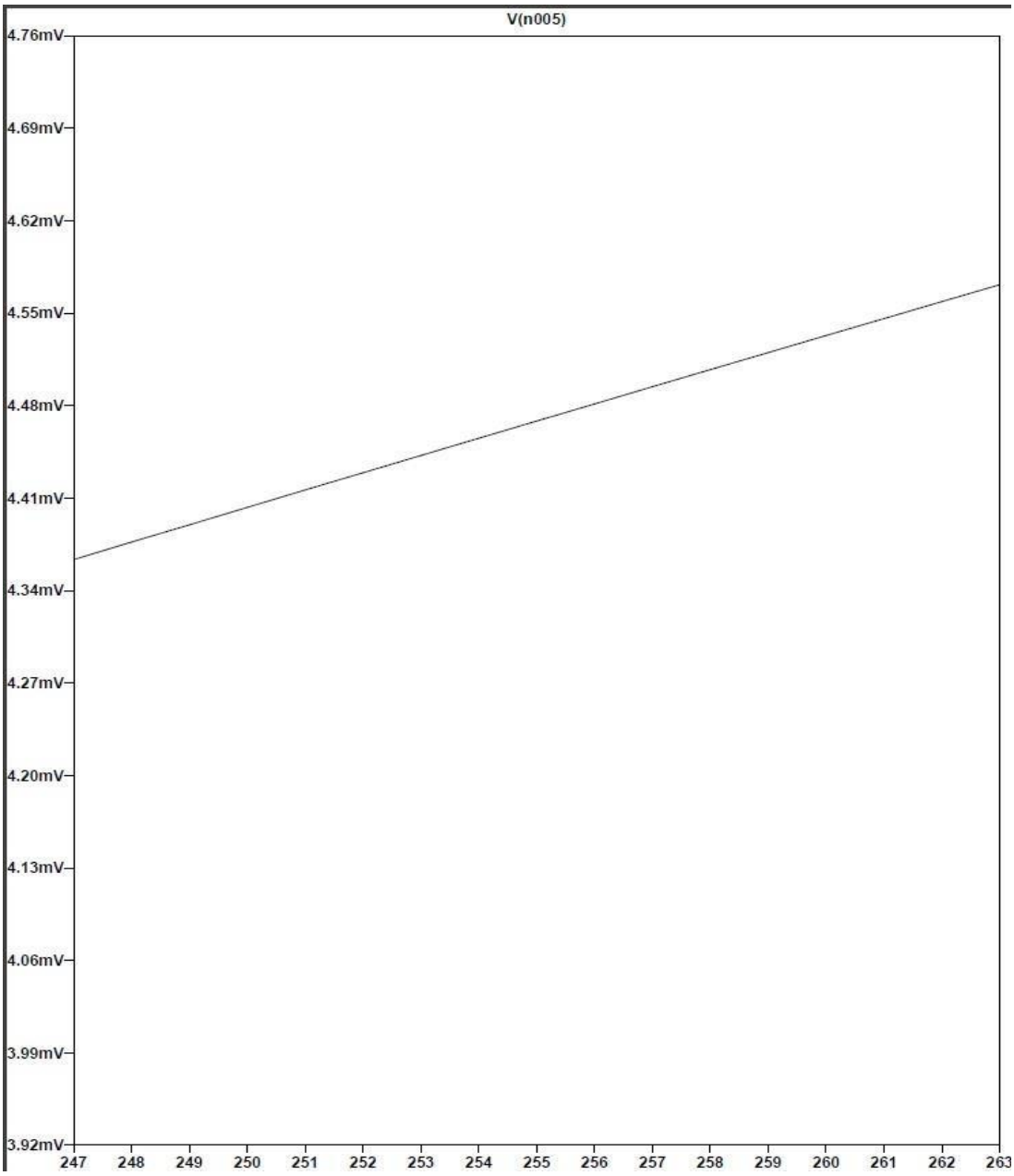

Fig. 2.1 Graph of Voltage drop across RTDsensor

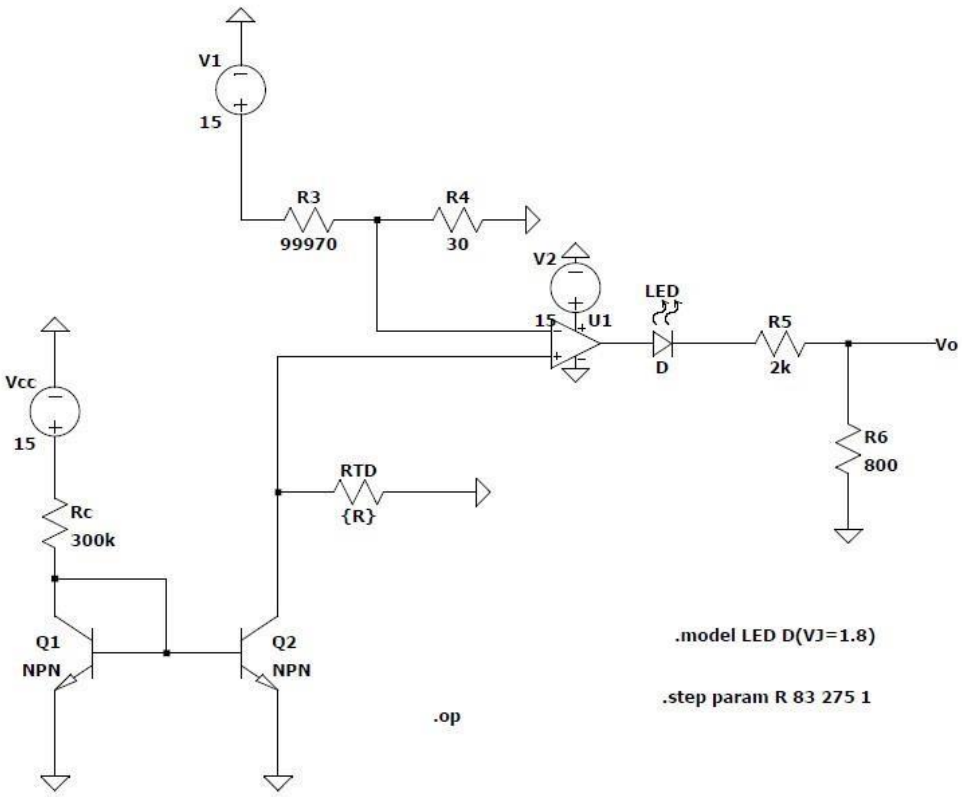

Fig. 2.2 Circuit Diagram

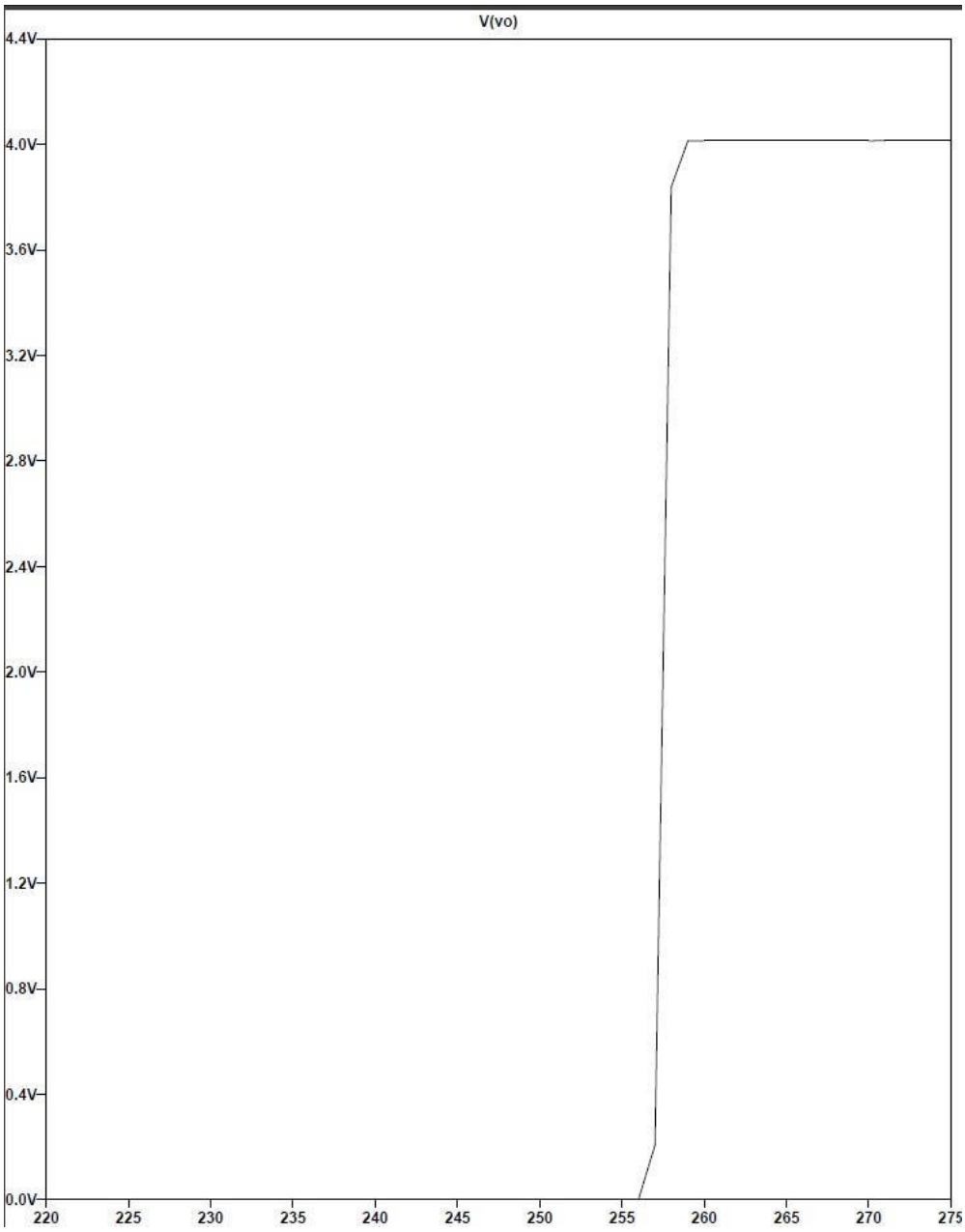

Fig. 2.3Output Voltage

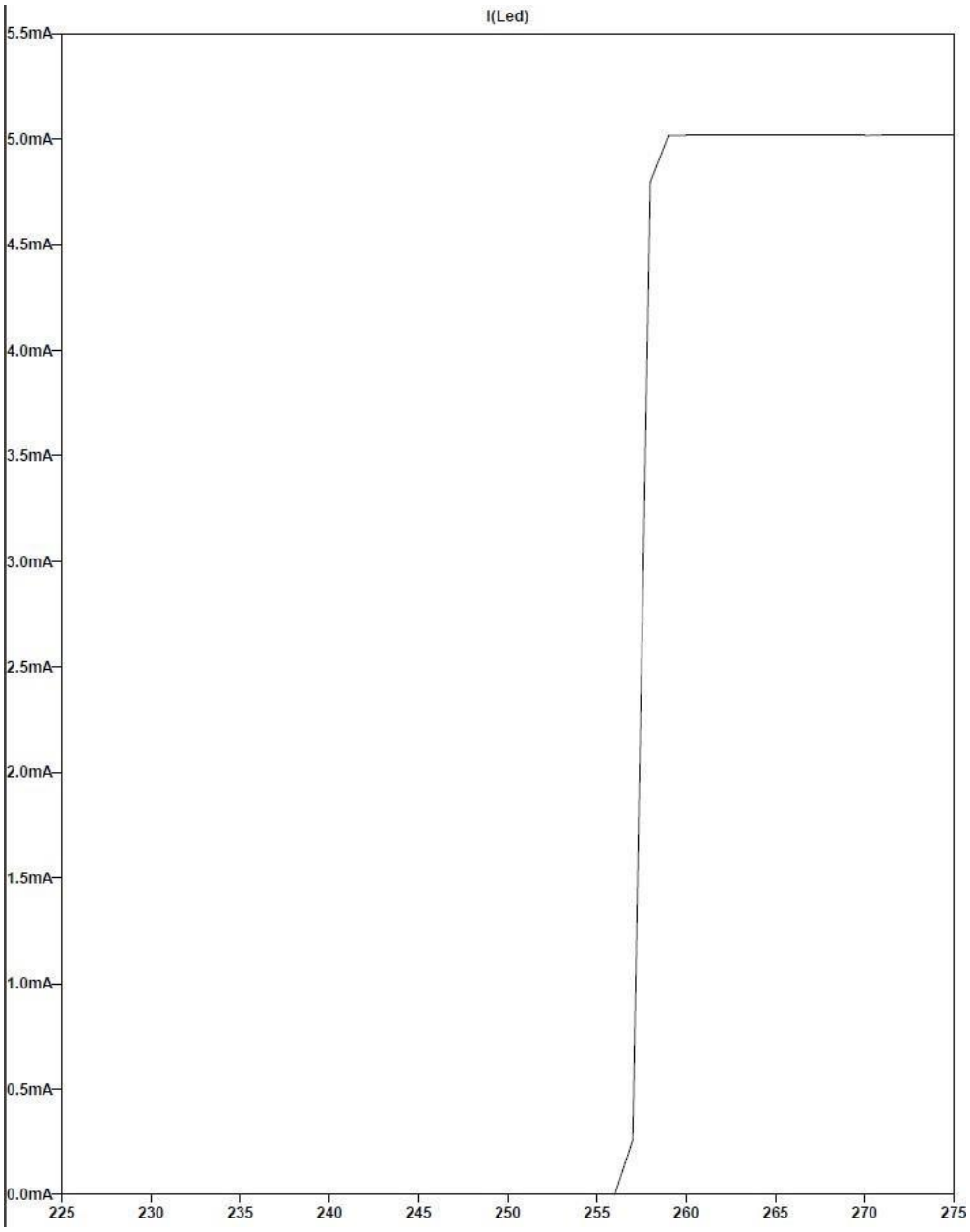

Fig. 2.4 Current through LED