Electronics

Comparators

Problem 1.- A temperature transducer from a transformer gives an analog signal between 1V and 5V corresponding to temperatures between 20º C and 150º C.
Design a warning indicator that activates when the temperature exceeds 90º C and an alarm at 95º C.
You have access to a reliable and regulated 12V source for your circuit. The warning light and alarm activate through relays whose coils require 40mA at 12V. You can use 2N3904 transistors to drive the coils.

Solution: First, we calculate the voltages that correspond to the warning and alarm. Since the voltage is linear in the temperature, we find the values by interpolation.

$$V_{warning} = 1V + \frac{90-20}{150-20}(5V - 1V) = 3.15V$$

$$V_{alarm} = 1V + \frac{95-20}{150-20}(5V - 1V) = 3.31V$$

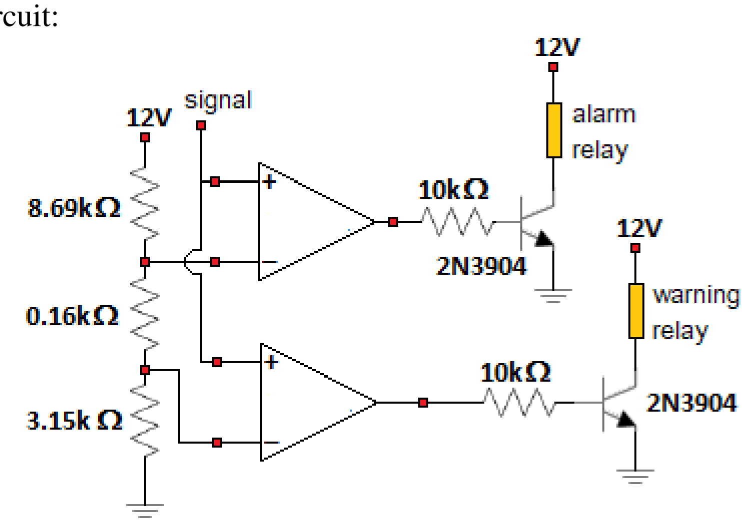
We can prepare a voltage divisor using 12kohm (1kohm per volt) and using precision resistors of values 3.15kohm, 0.16kohm and 8.69kohm to obtain the desired voltages to compare.

The output from the comparators are sent to the base of the 2N3904 using resistors that saturate the transistors. Recall that the output of a comparator is close to the source voltage minus the internal drop ~1.4V, so in our case 12V-1.4V = 10.6 V. To get 40mA for the relays with beta of 100, the base current must be 400µA. To get this, the base resistance should be:

$$R_{base} = \frac{10.6V - 0.7V}{400\mu A} = 24.8k\Omega$$

And we can use 10kohm for extra safety.

This is the final circuit:



Problem 2.- For a press to manufacture brakes, the signal from a transducer gives a voltage between 0 and 5mV approximately linear with temperature between 20º C and 120º C.
Design a circuit that turns on a relay when the temperature exceeds 60º C and turns it off when the temperature drops below 40º C.

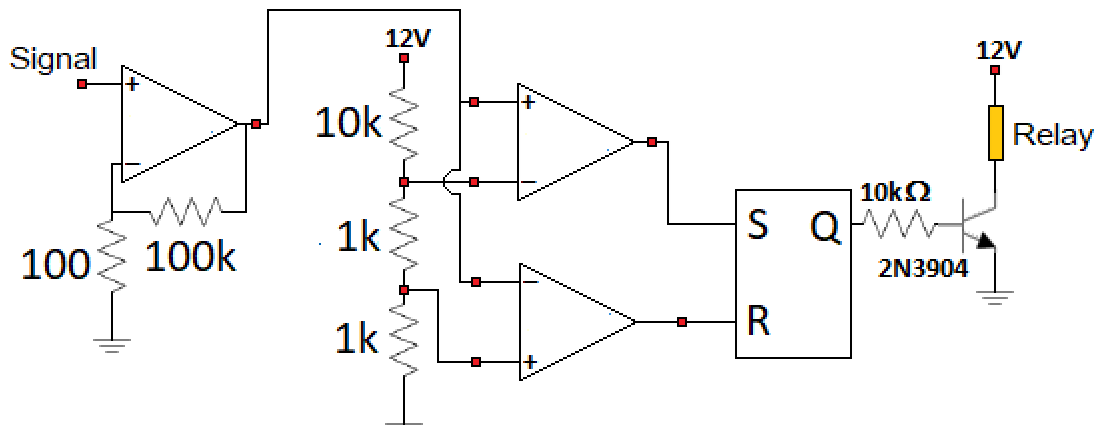
Solution: First, we calculate the signal at the two thresholds by interpolation.

$$V_{ON} = \frac{60-20}{120-20} 5mV = 2.00mV$$

$$V_{OFF} = \frac{40-20}{120-20} 5mV = 1.00mV$$

For convenience, we amplify the signal by a factor of 1000, using an opamp in the non-inverting configuration. Then, we divide the voltage source (let us assume we have a 12V source) with precision resistances of 1kom, 1kohm and 10kohm in series to get the voltages to compare.

The outputs from the comparators are then sent to a flip-flop RS and the output from this FF is connected to the base of a 2N3904 transistor to drive the relay.



Problem 3.- Design a system of alarm signal and trip for overvoltage. The alarm should occur when the signal is between 4.2V and 4.8V and the trip at 4.8V. You have access to a 10V regulated and reliable source for your circuit, which you can use as reference.

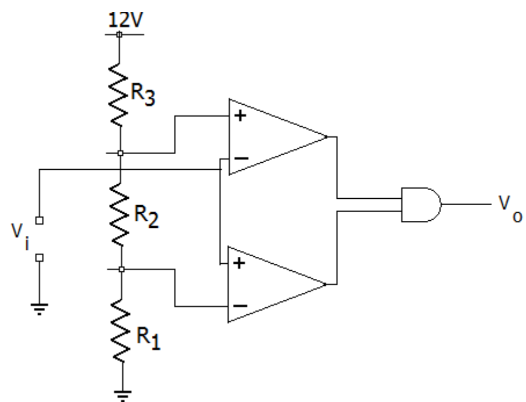
Problem 4.- A cook wants to prepare a boiled egg, but at lower temperature, so the egg keeps its elastic properties. To this end, the temperature of the water has to be kept close to 65.5º C.
Design a circuit that measures the temperature with a thermos couple and controls a heater switch that turns it on at 64º C and off at 67º C. The output of this circuit can be a relay. Assume you have a K-type thermocouple, whose voltage vs. temperature is in the table below.

T (°C)	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
60	2.436	2.477	2.519	2.56	2.601	2.643	2.684	2.726	2.767	2.809
70	2.85	2.892	2.933	2.976	3.016	3.058	3.1	3.141	3.183	3.244

Design the thermocouple reader without loading the sensor. Design the ON/OFF control.

Problem 5.- Design an indicator of good power (PG) for a signal between 4.8V and 5.2V Consider that you have access to a regulated and reliable reference at 12V for your comparators.

Solution: The solution can be based on two comparators that use a voltage divider to generate the references 4.8V and 5.2V out of the 12V source. These comparisons combine in an AND gate as shown below:



Using precision resistors, we can have for example:

$R_1 = 4.8k\Omega$
$R_2 = 0.4k\Omega$
$R_3 = 6.8k\Omega$