EE 204 - Analog Circuits
Lecture 19

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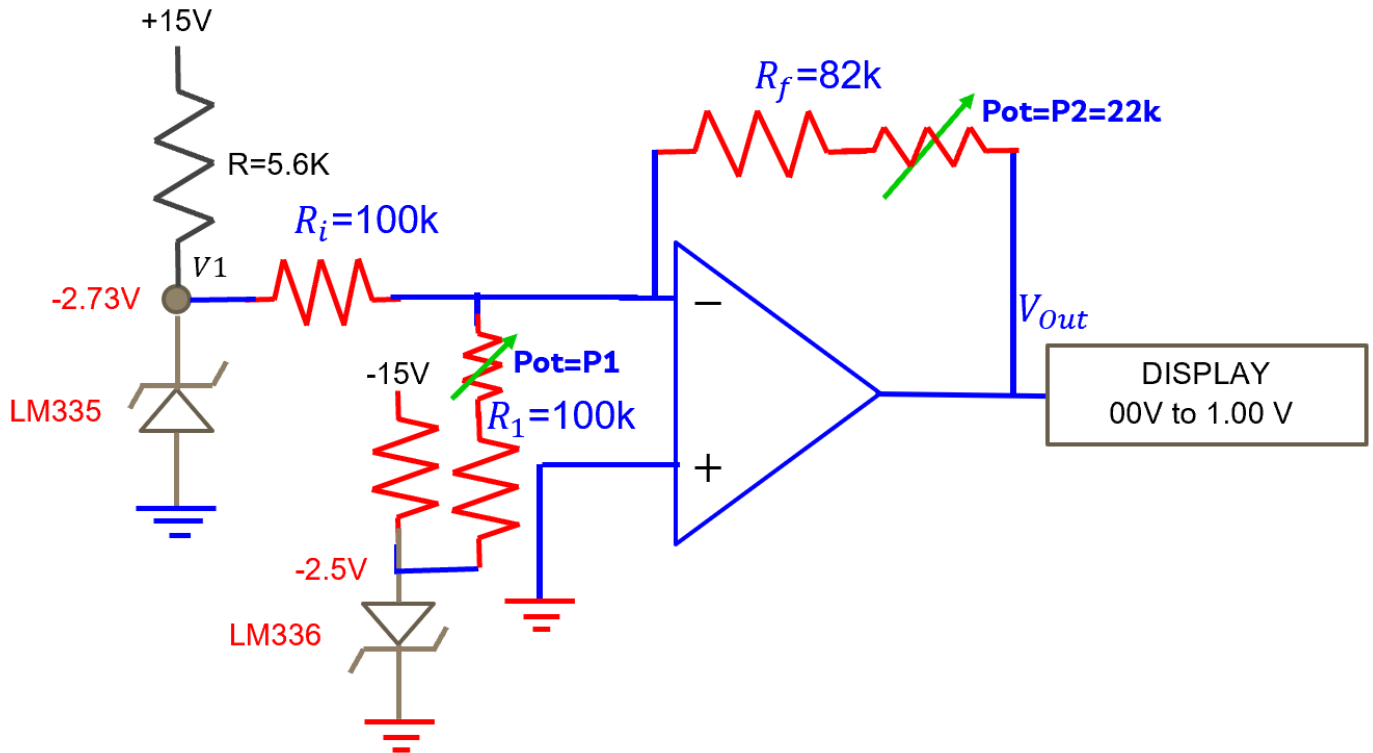October 27, 2023

Contents

1   Temperature Sensor

A temperature sensor is a device used to measure temperature. In the previous lecture, we studied about how can we make a temperature indicator and the possible circuits that can be used for the same.

The following image shows one such circuit.

In today's lecture, we use the temperature indicator circuit to make a Temperature Controller.

2   Temperature Controller

The temperature controller is used to detect and maintain the temperature at a particular value.

The basic circuit diagram showing the temperature sensing circuit connected to a heater drive which controls the heating element is shown below.
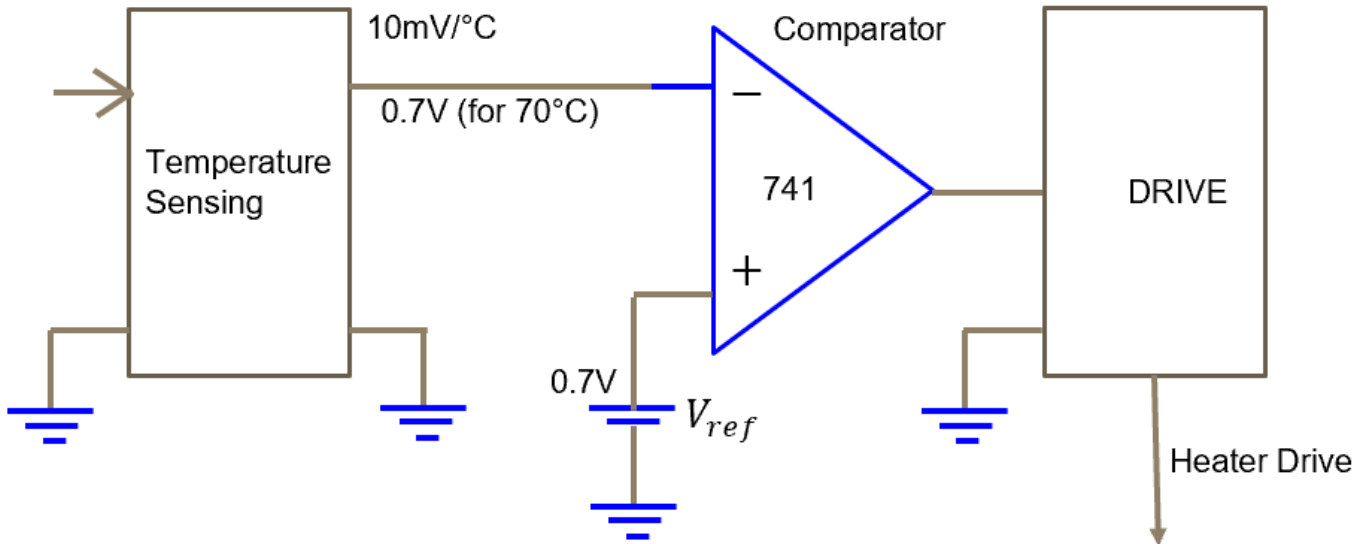
We then further check the temperature control mechanism using the temperature sensor at room temperature, which gives us an idea about the potential reading and the expected conversion required to get the same temperature reading in the display as the room temperature.

The sensor, as discussed previously has a temperature coefficient of $10\,mV\,K^{-1}$ and the base voltage is $2.73V$ at $0°C$. Hence, the voltage at room temperature can be calcuated.

A representative image is shown below -
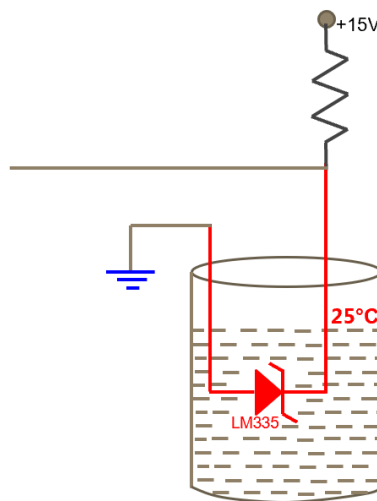
We now go back to our BJT circuits to see a new combination of BJTs which can be used for multifold amplification.

2.1 Darlington Pair

The Darlington Pair is a particular type of configuration of two BJTs joined such that the emitter of one of them acts as the base of the other transistor. This configuration helps in mutlifold amplification of the current from the transistors.
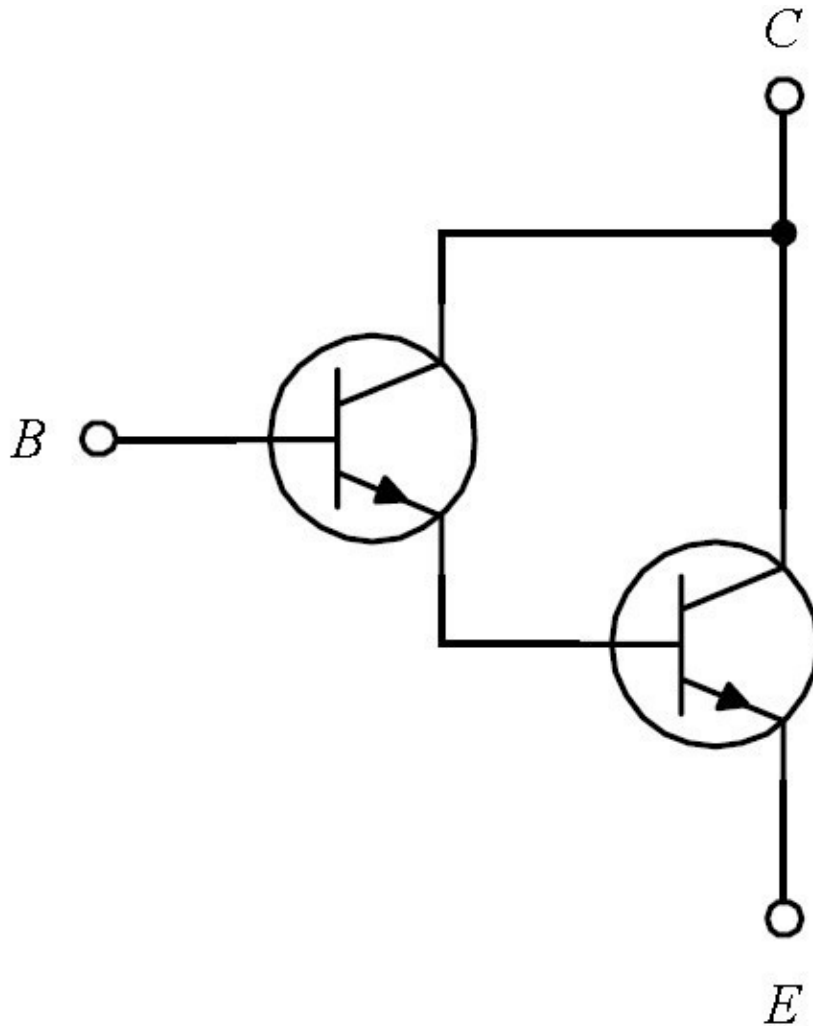
The current amplified by the first transistor is further amplified by the second transistor thus leading to manifold amplification.

A Darlington transistor has a current gain of 1000 or more, so that only a small base current is needed to make the pair switch on much higher switched currents.

Another advantage involves providing a very high input impedance for the circuit which also translates into an equal decrease in output impedance.

But a disadvantage of such a circuit is the approximate doubling of the base-emitter voltage and also an increase in the saturation voltage.

## 2.2 Temperature Controller using Darlington Pair

Now, that we have learnt about amplification using this circuit, we introduce it in our temperature controller to cause current amplification, so that the small current passing through gets amplified leading to heat generation through the heating resistor.

Therefore, the modified controller looks like the following
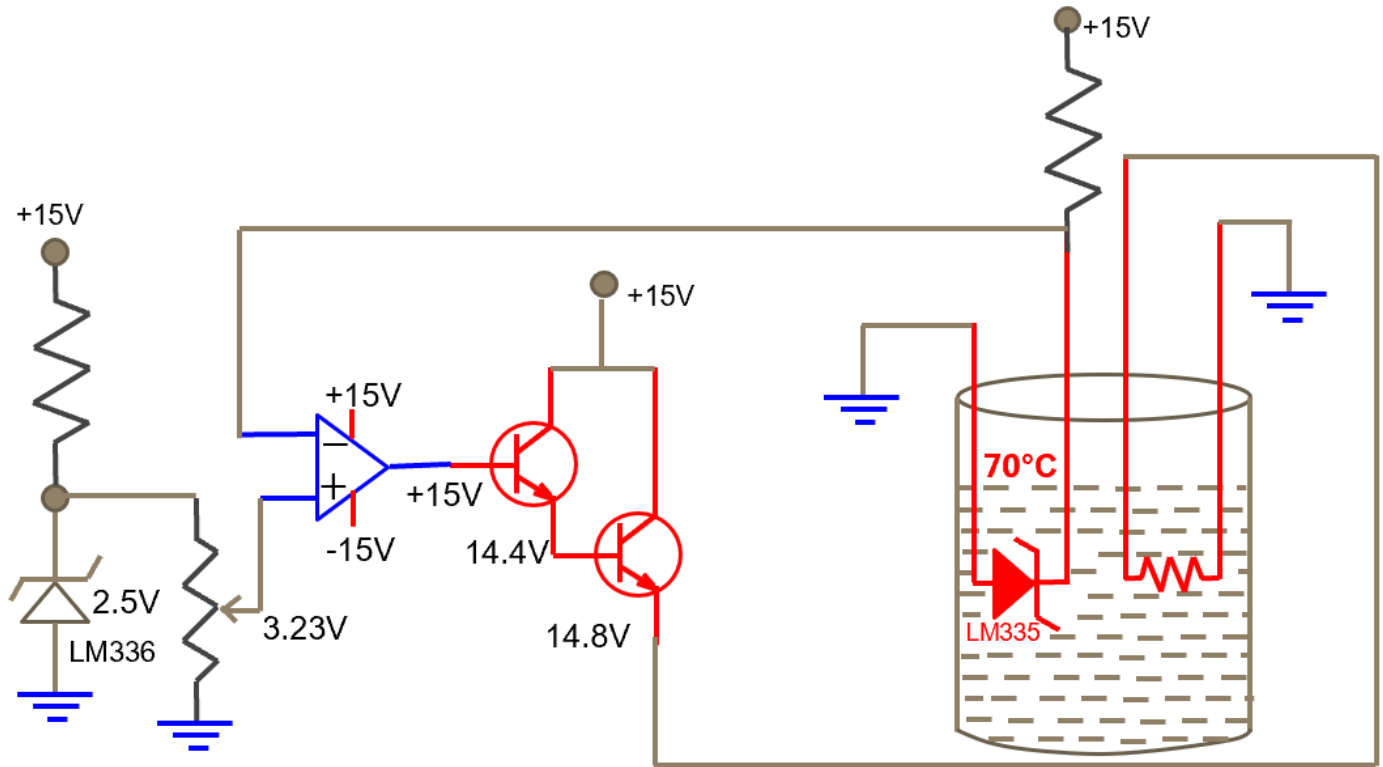
This controller is also called as an **ON/OFF controller**.

But the disadvantage of such a circuit is that there could be a negative voltage coming from the other side of the transistors, which could easily damage them leading to a loss in the circuit power. Hence, we need to attach a diode before the darlington pair setup.
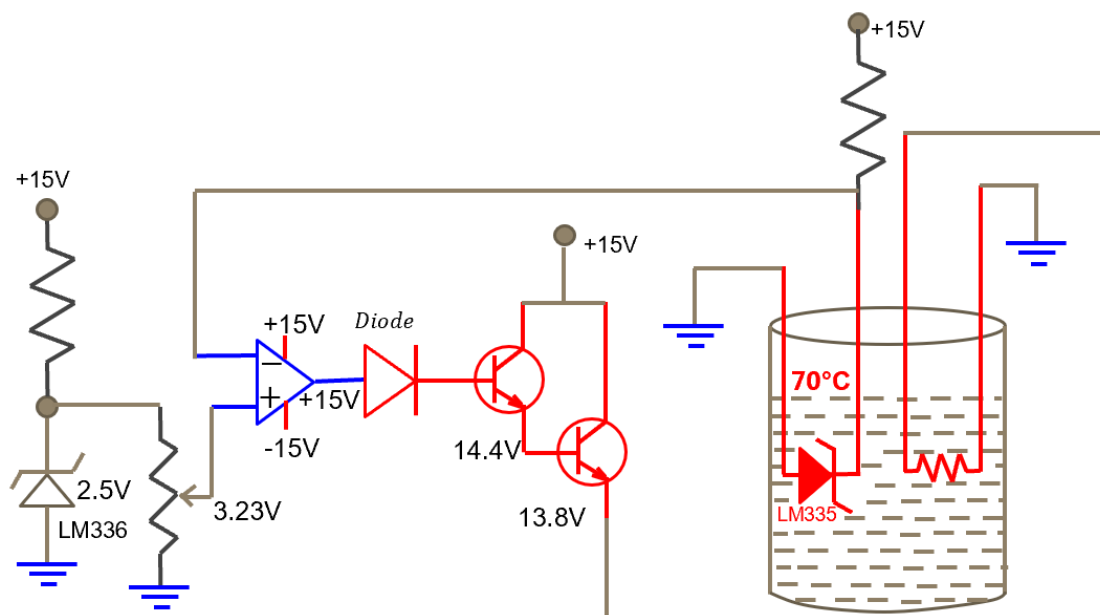
We then also connect resistors to the OpAmp to create hysteresis for the circuit.

2.3 ON/OFF Controller with hysteresis
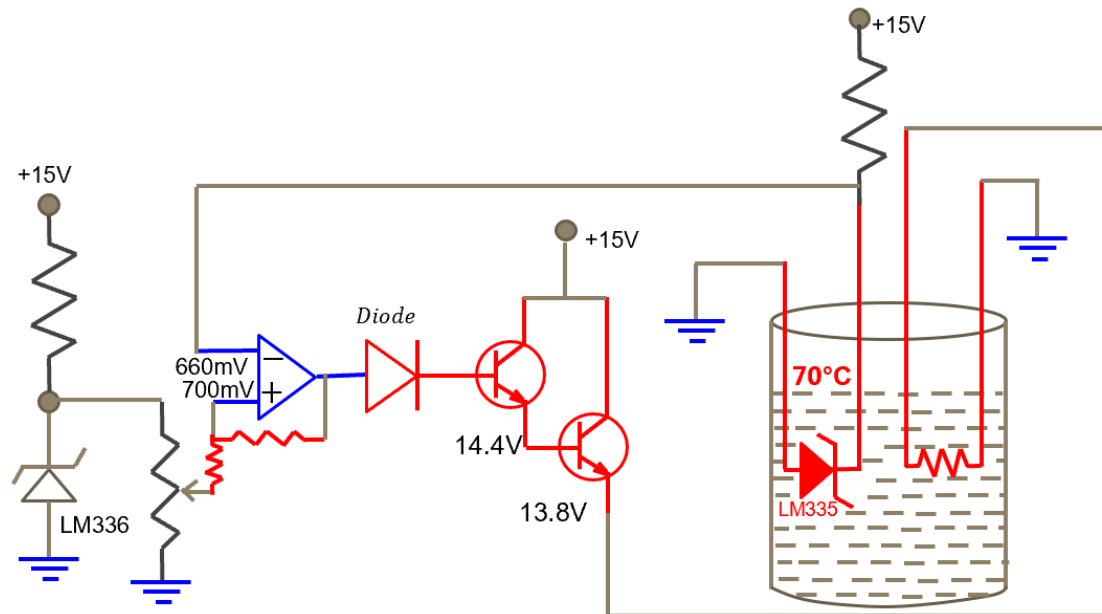
But, there is also an alternative circuit which is much safer and achieves the same objectives as the one we've landed at after the analysis. Such a circuit uses a relay mechanism instead of the darlington pair and the complex configuration. The relay mechanism by default takes care of any back currents which might occur, leading to a much safer and reliable device.

2.4 Temperature Controller using Relay