PID Temperature Controller

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Abstract

From the ancient age, humans are tying to control various parameters of various system in this Nature. Now humans have a good control of fire, wind and water (not truly). So, there are many intelligent way to control the parameters of a system. Now, temperature, level, flow, density of every fluid; motor speed; all types of vehicle speed; inclination of air ship and spaceship; direction of ships and cars etc. are needed to be controlled.

Now, there are many kinds of controlling mechanisms, i.e. on-off type controller, proportional controller, digital sensing mechanism, PID controller, and etc. Among of them, PID controller is the best known controller within affordable range.

Introduction

If one needs a smooth change of parameter quickly and without any oscillation then PID (Proportional-Integrating-Differential) controller is a good option. A PID controller can get the desired value of the parameter quickly and can hold the position with great accuracy. In this section, we will briefly discuss about the PID controller.

Now, we consider a temperature controller of a heat bath. The main disadvantage of a on-off type controller is the unstable and oscillatory control of the temperature due to the inertia of the heater. Again, if we use a proportional controller, that will lead to a temperature lower than the desired value and will reach to an equilibrium due to the heat loss of the bath. But in this case if there is a accurate calibration, one can get higher accuracy, but the 'speed' of system will be slower.

Now, if we add a Differential and Integrating circuit with the Proportional circuit, the integrator will keep integrating the input until the system reaches to the desired value. And the differential amplifier will add the slope of the curve to increase the slope and will keep the process fast.
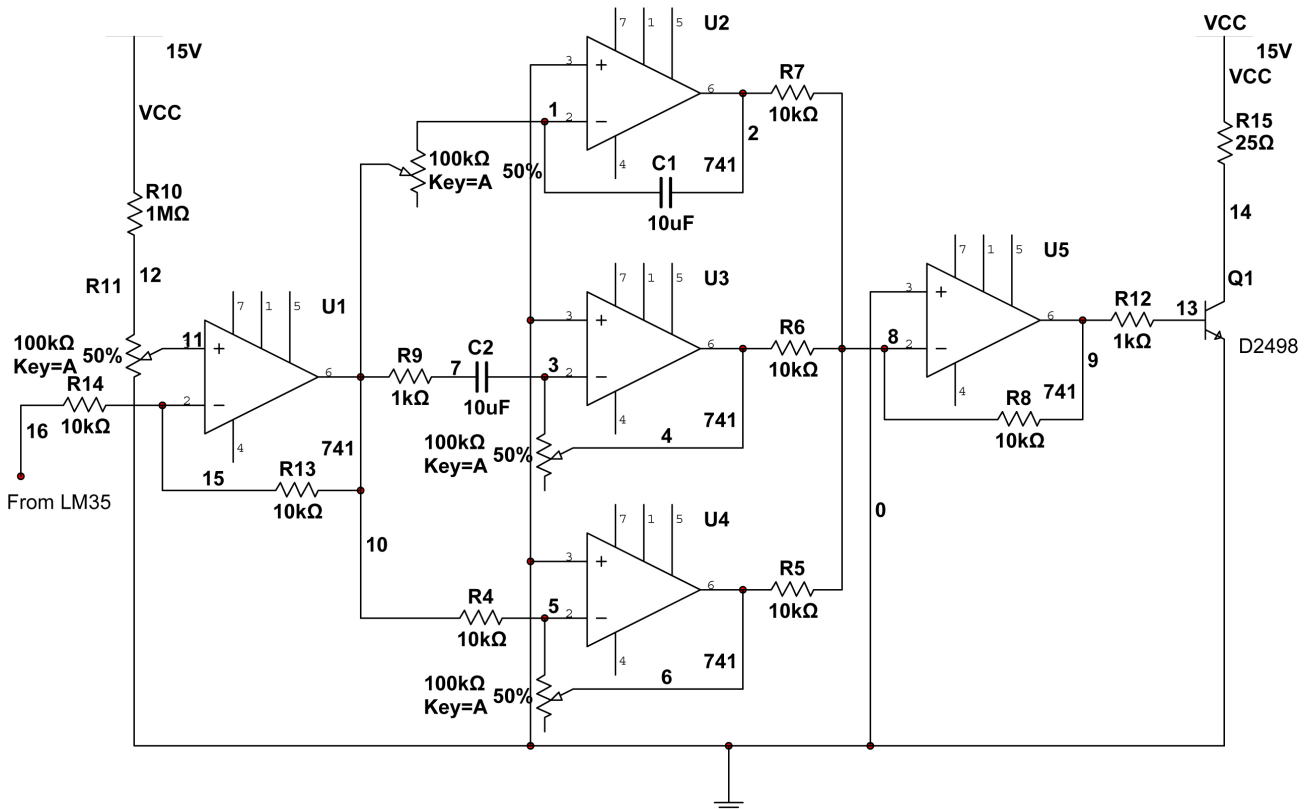
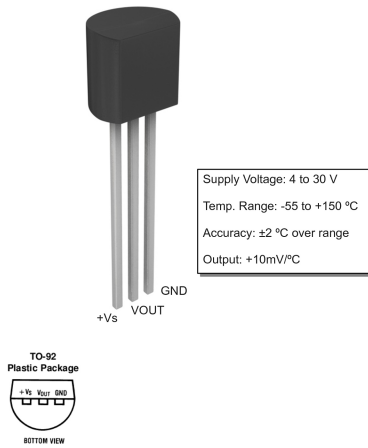

Figure 1: PID Temperature Controller Circuit

Figure 2: Temperature Sensor

Figure 1 is an example of PID Controller. Here, we used the power transistor as a heating element as we need a heating element with unknown and complicated transfer function corresponds to the current passing through it, to prove that PID can control any arbitrary heat bath . These transistor can heat upto 155^0C and its temperature is dependent on I_C as well as I_B. So, by changing the base current I_B we can control the temperature of the transistor. The 25Ω resistor is there to prevent short circuit and to limit I_C.

LM35 IC is used here as temperature sensor. The package is calibrated with 10mV$/^0$C with 0mV at 0^0C.

Observation

With the PID constants

Input=50^0C=0.25V
P=11.5
I=0.78
D=10^{-5}

and using LabJack and LabView software, we get the plots. Figure 1 is showing how the temperature is settling down to almost 51^0C with accuracy of 0.5^0C.

By choosing the proper PID constants (Tuning the PID), we can have a better control.

The resistors are not ideal, A accurate measurement of the carbon resistors can reduce the error of 1^0C.

Simulation

Now, we can simulate the whole thing using by making a model of the system in MatLab. Figure 5 is the model of the controller. There is nothing to describe, we have to demonstrate in MatLab.
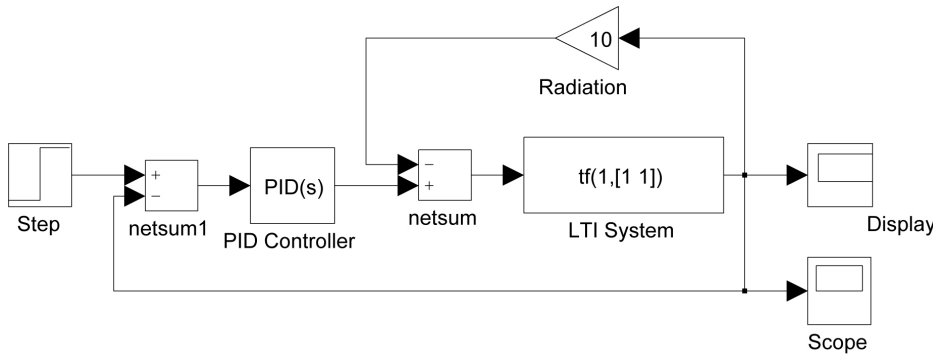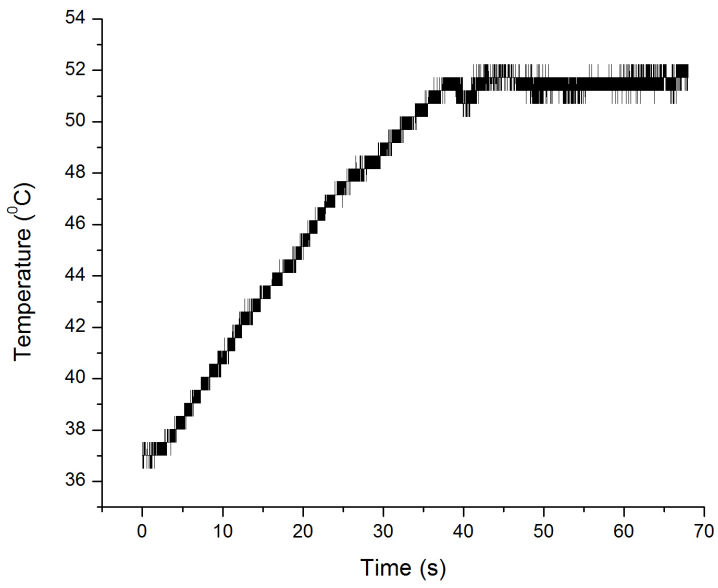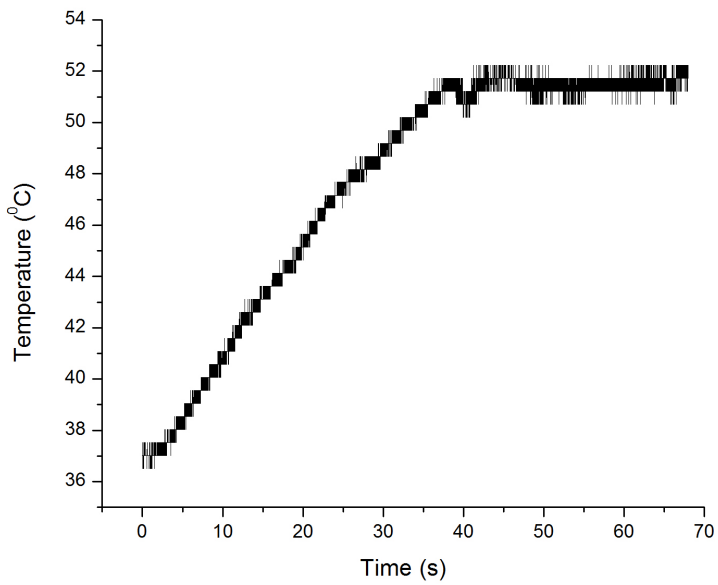

Figure 3: PID Controller Model

Figure 4: Temperature VS Time Plot

Figure 5: Output of 1st OP-Amp VS Time Plot