Lab No. 1 Temperature Control System

Objective

The process in this lab is the same as Lab 2 in ENGR 4038. Here we analyze the control of a temperature control system by an on-off relay controller. This system experiences limit cycles which can be calculated using sinusoid + bias describing functions. The experimental data is then compared against the predicted results.

Theory

In this temperature controlled system we study the behaviour of an on-off type controller as shown in figure 1 below. The relay switching point is at δ and the relay switches from D1 to D2. This type of controller has limit cycles and these limit cycles can be predicted using a sinusoid + bias describing functions.

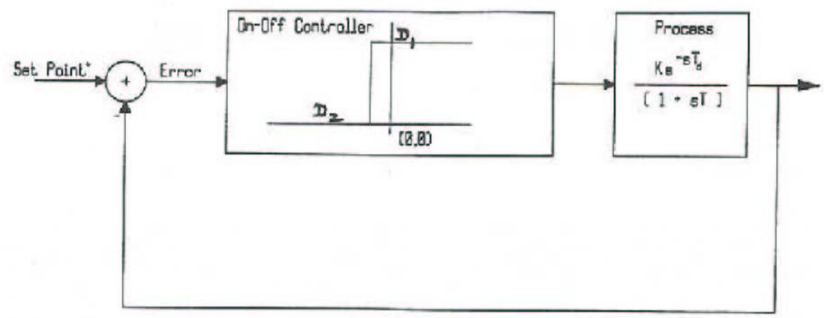


Figure 1: Block Diagram of the System

The circuit diagram for the on-off controller is shown in figure 2 below.

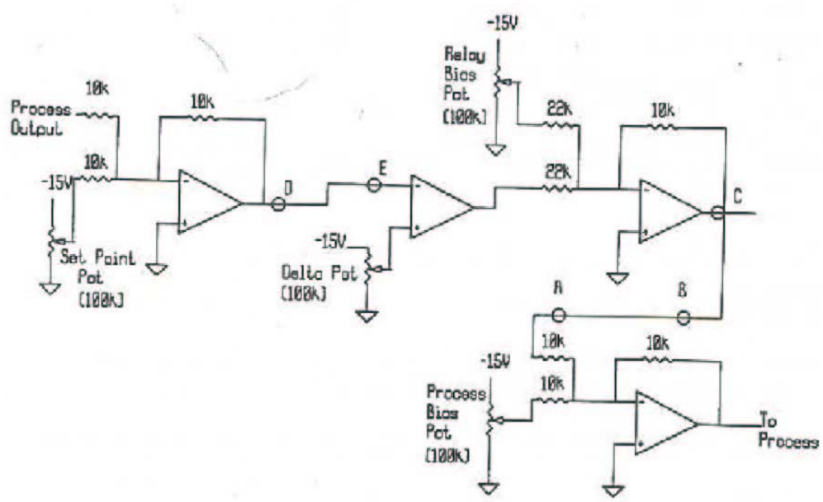


Figure 2: On-Off Controller Circuit Diagram

Procedure

As instructed, please refer to the 0138 Advanced Control II lab manual for full details of methods carried out in the experiment.

Experimental Values

Parameters of On-Off Controller

2.

- The δ pot has been set to approximately -0.3V.

3.

- The bias pot was adjusted to get 10V at the output of the op-amp.

4.

- The set point pot was adjusted as the output of the op-amp at C switches from 0 to 12.6V.

5.

- The relay bias pot was adjusted so that the lower of the two levels at C was at 0V exactly.

6.

- The upper level of the set point pot was adjusted to 12.8V.

8. The on-off controller parameters are:

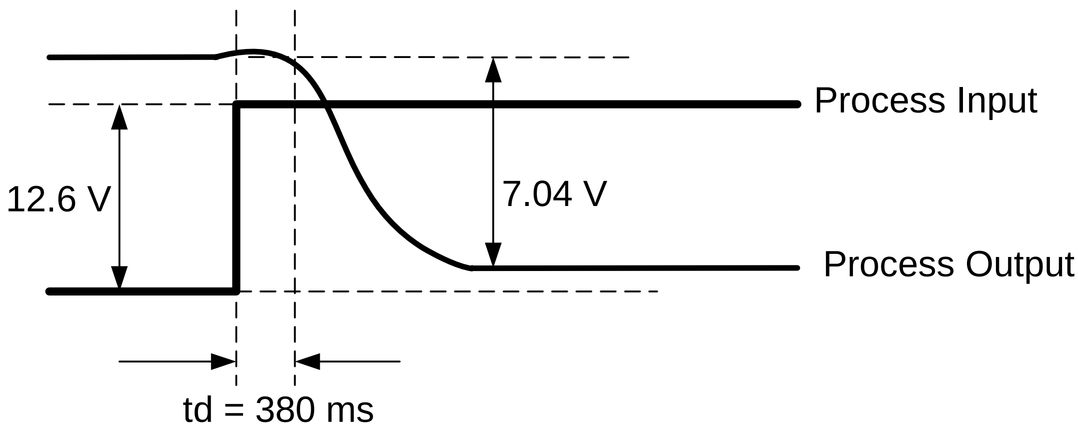
- δ = -0.3V
- D_1 = 12.8V
- D_2 = 0V

Parameters of Linear Process

4.

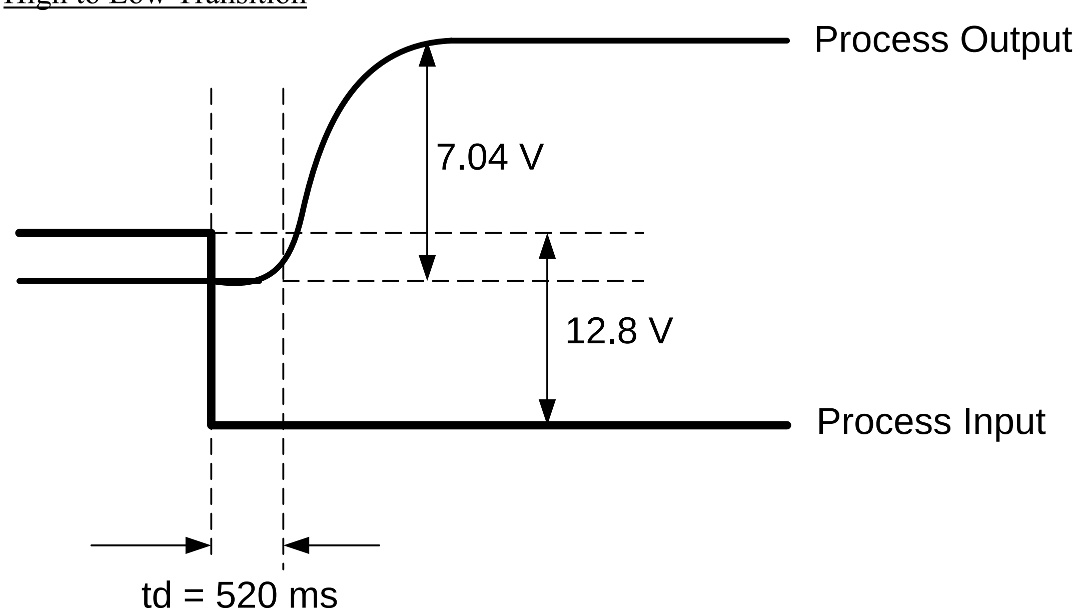
- Waveforms below show the process from the op-amp box switch from low to high and high to low. The gain K, time delay T_d, and the time constant T are obtained as follows:

Low to High Transition



$K = \frac{7.04V}{12.6V} = 0.559$ $T = 63\% \, of \; 7.04V = 2.96\,s$ measured on the scope!

High to Low Transition



$K = \frac{7.04V}{12.8V} = 0.55$ $T = 63\% \, of \; 7.04V = 1.72\,s$ measured on the scope!

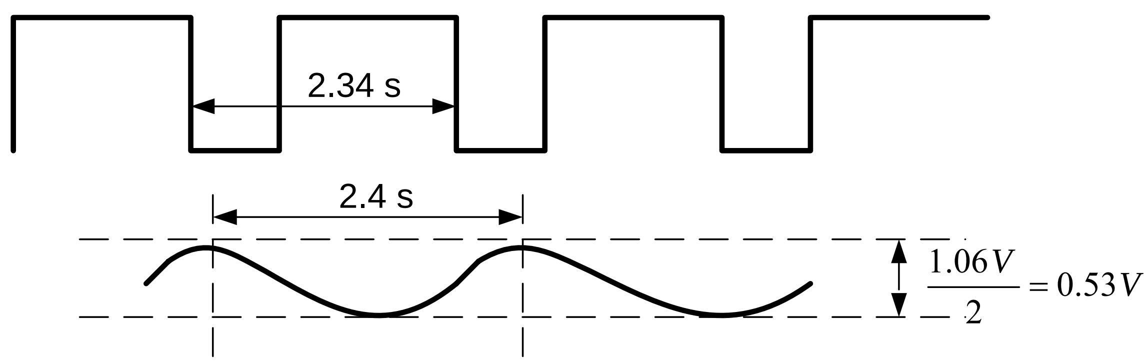
Therefore the average of the gain K, time delay T_d, and the time constant T are as follows:

$K = 0.5545$
$T_d = 450$ ms
$T = 2.34$s

Closed Loop System & Observation of Limit Cycles

2.

- The waveform below shows the oscillations (limit cycle) of the error signal and the signal going to the process. The DC bias and the amplitude measurements are also shown.



DC Offset = 1.82V – 0.53V = 1.29V
The reading of the set point pot voltage $V_{set\ point} = -1.2$ V

Conclusion

In conclusion this experiment exhibited the control of a temperature control system by an on-off relay controller. The theoretical and measured frequency of the limit cycle is obtained and verified. The low-to-high transition and high-to-low transition of the on-off controller is captured and the average values of the gain K, time delay T_d, and the time constant T are used for the frequency ($f = 2\pi\omega$) and gain (A) calculations in the theoretical section. The DC offset value is also captured and measured for the theoretical portion. Finally all results were as expected!