MIDDLE EAST TECHNICAL UNIVERSITY

DEPARTMENT OF ELECTRICAL AND ELECTRONICS ENGINEERING

EE407
PROCESS CONTROL LABORATORY

EXPERIMENT 1
THERMOCOUPLE CHARACTERISTICS

Date of the Experiment:	26/11/2018
Lab Group:	Monday Afternoon 1
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I. Results and Discussion

1. The experimental step response of compensated system obtained through experimental procedure can be seen at Figure 1.

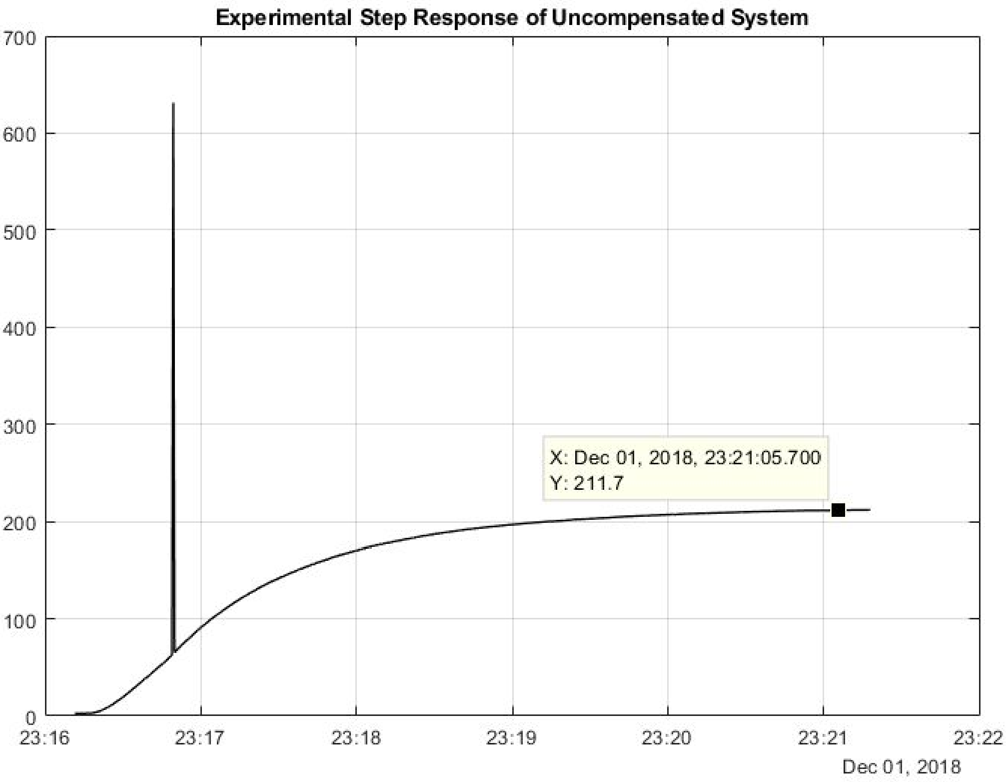

Figure 1: *Experimental Step Response of Compensated System*

The time constant of the thermocouple with compensator can be obtained from this step input. It can be seen from the Figure 1 that, the system reached its steady state at *23:21:05.700 at a steady state value of 211.7.* While, it can be observed from the Figure 2 that the system reached its $e_{ss,63.2\%} = 133.9$ value at *23:17:24:100.* Considering the heating process started at *23:16:15.500,* time interval between start and $e_{ss,63.2\%}$ point can be equated to τ_m.

$$\boxed{\tau_m = 23:17:24:100 - 23:16:15.500 = 67.600 \textit{ seconds}}$$

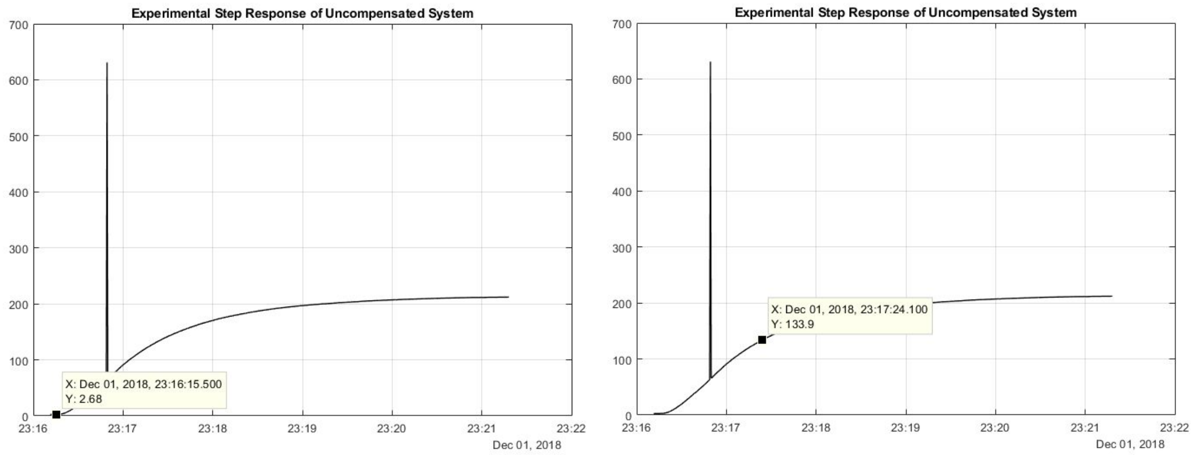

Figure 2: *Measurements for calculating* τ_m *on Step Response*

2. Assuming, very roughly, that the room temperature which is $Tref$ is at 20°C, the steady state gain, K, of the thermocouple can be found from the formula:

$$V = K * (T - T_{ref})$$

The final temperature is equal to that of the liquid bath which means T=80°C. The steady-state voltage value is $V_{ss} = 212\ mV$ from the data. The effect of the amplifier circuit should be eliminated where the gain is 100. These ratio can be eliminated by dividing the gain to voltage value.

$$\frac{V_{ss}}{100} = K * (T - T_{ref})$$

$$K = \frac{V_{ss}}{100} * \frac{1}{(T-T_{ref})} = 212 * 10^{-5} * \frac{1}{60} = 35.33 * 10^{-6}\ V/°C$$

3. The experimental step response of compensated system obtained through experimental procedure can be seen at Figure 3.

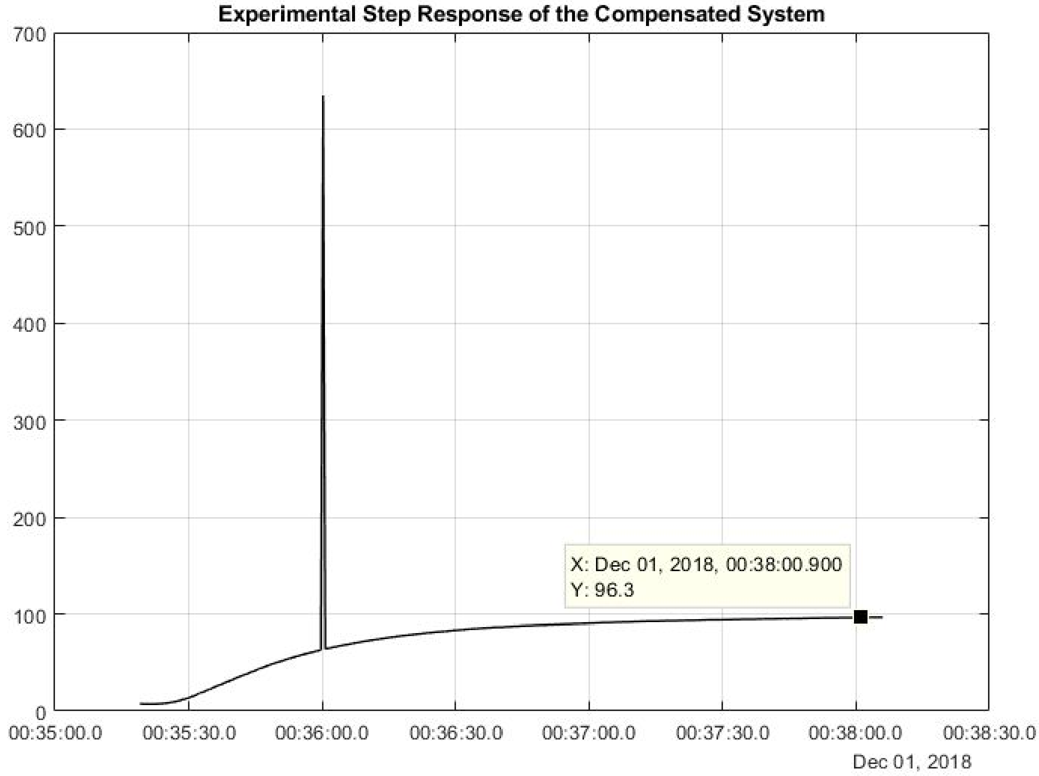

Figure 3: *Experimental Step Response of Compensated System*

The time constant of the thermocouple with compensator can be obtained from this step input. It can be seen from the Figure 3 that, the system reached its steady state at *00:38:00.900.* While, it can be observed from the Figure 4 that the system reached its $e_{ss,63.2\%}$ value at *00:35:57:700.* Considering the heating process started at *00:35:24.700,* time interval between start and $e_{ss,63.2\%}$ point can be equated to $\tau_{compensated}$.

$$\boxed{\tau_{compensated} = 00:35:57:700 - 00:35:24.700 = 33\ seconds}$$

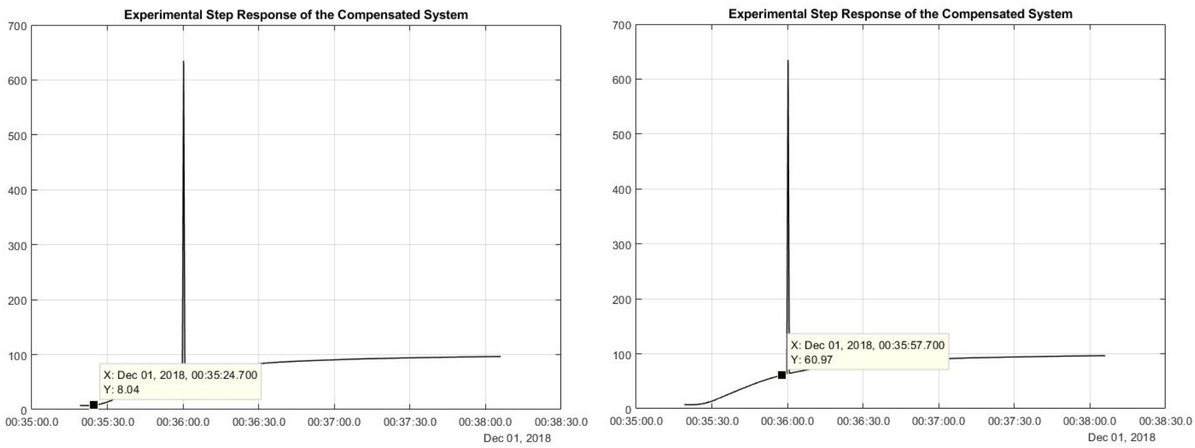

Figure 4: *Measurements for calculating* $\tau_{compensated}$ *on Step Response*

The time constant became smaller using a compensator.However, it is not quite twice as fast due to the non idealities of the components and losses in the RC circuit.

4. It is possible to use a passive compensator however the result will not be as precise as one may expect since the passive components have non idealities. Noninteracting compensator can be used since it handles the nonlinearities better considering the stability of the system. Using active compensators may make the performance of the thermocouple better but voltage protection may be needed since high voltages can damage the amplifier, and there will be noise issues.

II. Conclusions

In this experiment we used a device called a thermocouple used for measuring the temperature difference of two points by converting it to a voltage value. We observed its transient behaviour for certain inputs with and without a compensator. We observed the trade off between gain and response speed when experimented with compensator. Using a compensator made the response much faster, but the gain decreased as much.