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EE407- PROCESS CONTROL LABORATORY

EXPERIMENT 1: THERMOCOUPLE CHARACTERISTICS

FINAL REPORT

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Question 1)

The step response data for the uncompensated thermocouple system recorded in step 18 of the Experimental Procedure is plotted in Figure 1 below.

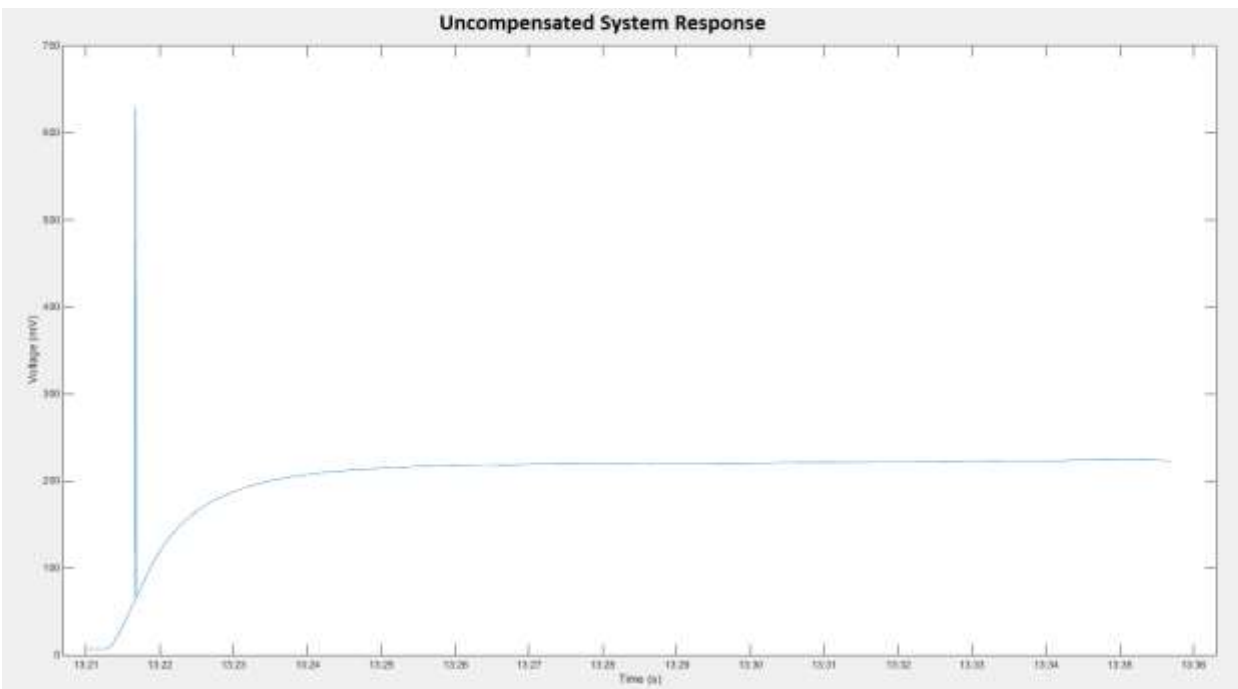

Figure 1. The response of the uncompensated thermocouple system

The time constant τm of the system is the time at which the magnitude of the response reaches **63.2%** of the difference between its initial value and steady-state value. For this system, the steady-state value is **222.9mV** and the initial value is **6.4mV** as seen from the recorded data in Figure 1.

The voltage value where τm is measured is

$$V_m = (222.9 - 6.4) * \frac{63.2}{100} = 136.8\, mV \quad (1)$$

At that value, the time difference between the point at 136.8mV and the beginning of the step response is:

$$\tau_m = 55.3s$$

Question 2)

It can be seen from Figure 1 that steady-state is reached at a value of V_{ss}=222.9mV. The amplifier gain was set to 100, so in order to eliminate it, we divide V by the gain.

Using Equation 2 below:

$$V = K\left(T - T_{ref}\right) \quad (2)$$

Where V=V_{ss}/100, T=80°C, T_{ref}=20°C

$$K = \frac{V}{T - T_{ref}} = \frac{0.2229/_{100}}{80 - 20} = 37 * 10^{-6}\,\frac{V}{°\text{C}} \quad (3)$$

So, K=37*10^{-6} V/°C

Question 3)

The step response at the compensated output is shown in Figure 2.

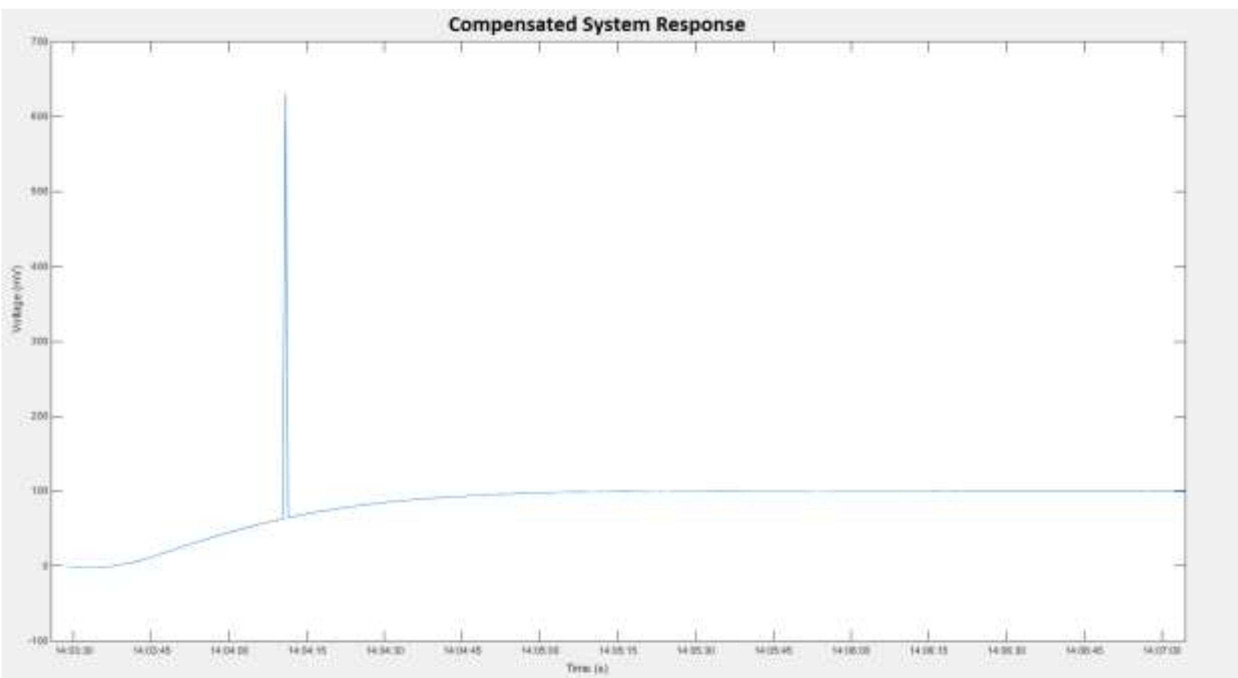

Figure 2. Response of the Compensated Thermocouple System

Following similar calculations as those in Question 1, the following values were found from the recorded data (that can be seen in Figure 2).

Steady-State Voltage: V_{ss}=101.3mV

Initial Voltage: V_0=0

Value of voltage from where τ is measured:

$$V_\tau = (101.3 - 0) * \frac{63.2}{100} = 64.02\, mV \quad (4)$$

From the plot, τ can be found to be:

$$\boldsymbol{\tau = 33.6s}$$

$\tau_{\text{compensated}}$=33.6s

$\tau_{\text{uncompensated}}$=55.3s

$$\frac{\tau_{uncompensated}}{\tau_{compensated}} = \frac{55.3}{33.6} = 1.65 \quad (5)$$

As seen from Eq. 5, the compensated system is 1.65 times faster than the uncompensated system. It is not exactly two times higher. The discrepancies might arise from any losses or noise in the RC circuit or during the amplifying process.

Question 4)

Reducing the time constant indefinitely by using passive compensators is not possible in practice. This is due to the fact that passive elements are not ideal. Cascading the compensators can make the response faster.

Conclusion

This experiment was an analysis of the transient behavior of the thermocouple and a comparison between its operation with and without a compensator. It was seen how using a compensated thermocouple system can increase response time. However, the gain of the system decreases by that same amount when using a compensator. There is a trade-off between system response speed and the system gain.