Experiment 5

Controller design on MATLAB platform by discrete frequency response.

Background:

Frequency response plots in MATLAB have no fundamental difference of usage between the analog and digital domains. Once the transfer function is defined in terms of three parameters (*numerator coefficients array, denominator coefficients array, time step*), it is automatically taken to be a digital one by virtue of the third parameter. Once this is done, a frequency response functions always yield digital domain plots of the main band with the Nyquist sampling frequency marked at the band limit.

In Expt. 4, an analog system controller was designed for a stated phase margin requirement. In the present experiment we check out the impact of gain and sampling time on digital gain and phase margins..

Objective:

The given digital OLTF is closed through *negative feedback of different gains*, examining the consequences on *gain and phase margins*.

Sensitivity to the choice of sampling time is additionally examined for the design procedure.

Tutorial:

In the MATLAB platform, go through the procedural steps as described for:

- *Frequency-Domain Characteristics on Response Plots:*
  https://www.mathworks.com/help/control/ug/system-characteristics-on-response-plots.html

- *Frequency response of a SISO system:*
  https://www.mathworks.com/help/control/ug/frequency-response-of-a-siso-system.html

- *Creating Discrete-Time Models:*
  https://in.mathworks.com/help/control/examples/creating-discrete-time-models.html

Elements of the software for familiarisation:

a. Functions/keywords: bode; bodeoptions; bodeplot; freqresp; sigma; sigmaplot; tf; zpk.

b. Tools: Plot customization:
https://www.mathworks.com/help/control/analysis-plot-customization.html

Project:

The digital OLTF of a *furnace model*, inclusive of a *first order actuator*, is given by

$$G_{OL}(z) = 10^{-5} \cdot \frac{4.711z + 4.644}{z^3 - 2.875z^2 + 2.753z - 0.8781}$$

The furnace output can be fed back to the actuator input with *different positive integer gains* in the feedback loop.

Study in detail the variation of *gain* and *phase margin* as the control is implemented as above.

The nominal sampling time for the system is 0.01s.

For observations and discussions:

Record and discuss the proximity to instability as the furnace is operated with different feedback gain settings.

For different feedback gain values that you consider, how are the margins (hence stability) affected by the choice of sampling time.