IMC Controller for Current Carrying MEMS Devices

Mohamad H. Alizade | 96109866

Supervisor: Dr. Haeri

[1] Base on the paper: Dynamic pull-in for micro-electromechanical device with a current-carrying conductor. Ji-Huan He, Daulet Nurakhmetov et al. (2019)

Review

In the previous note we derived the discrete transfer function of the system as follows:

$$G(z) = \frac{0.0891(z+0.95)}{z^2 - 1.84z + 0.861} \qquad 1$$

As we mentioned before, the zero of this transfer-function lies in the left-hand side of the unit circle and hence causes ripple. We won't include this zero in the $\tilde{G}$.

Designing the IMC Controller

$$G(z) = G_1(z)G_2(z) \qquad 2$$

$$G_1 = \frac{0.0891kz^2}{z^2 - 1.84z + 0.861} \qquad 3$$

$$D(z) = \frac{0.013z^2}{z^2 - 1.84z + 0.861} \qquad 4$$

K is chosen such that G2(1) = 1 since we want the steady-state error to be zero.

Implementation

We use the following Simulink structure in order to implement our IMC controller.

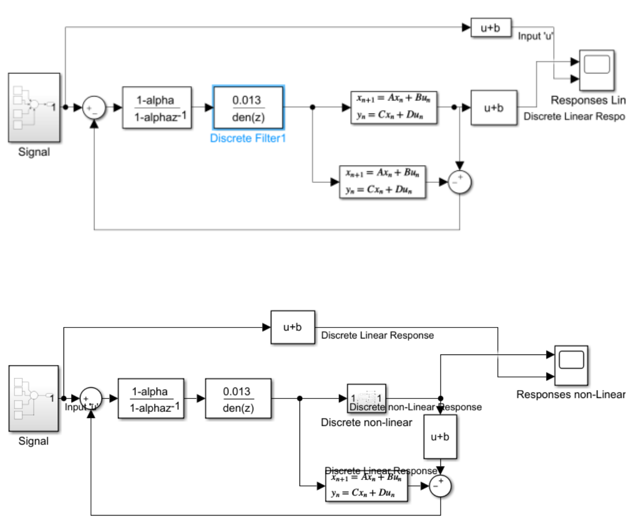

Figure 1 simulink implementation

For changing amplitude and alpha (same parameter as beta), we could change the parameters in the main.m header.

Results for Linear Discrete Sys.

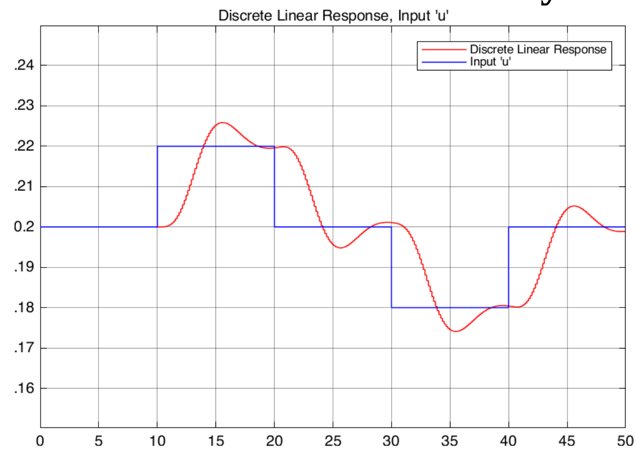

Figure 2 alpha = 0, +10%

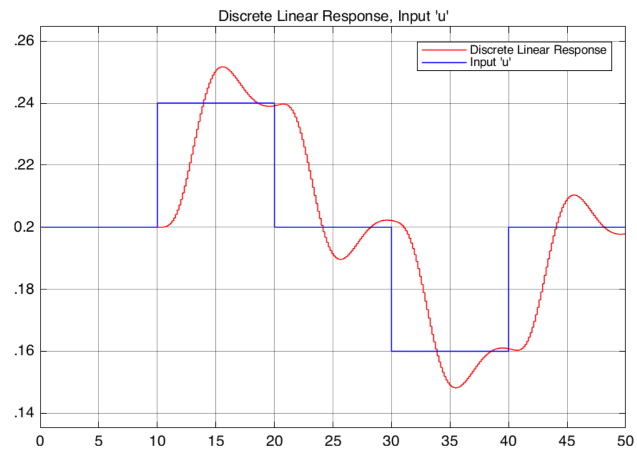

Figure 3 alpha = 0, +20%

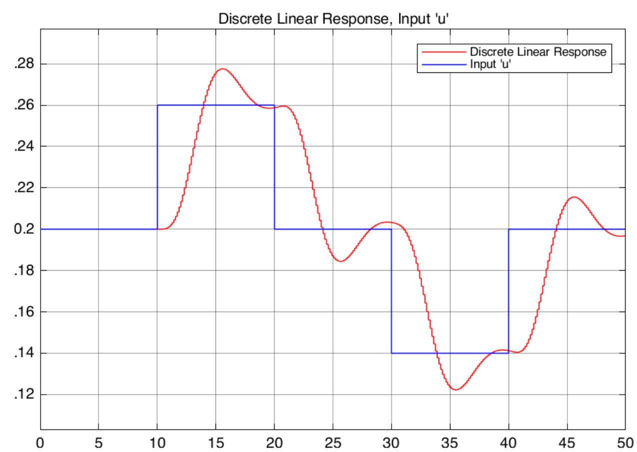

Figure 4 alpha = 0, +30%

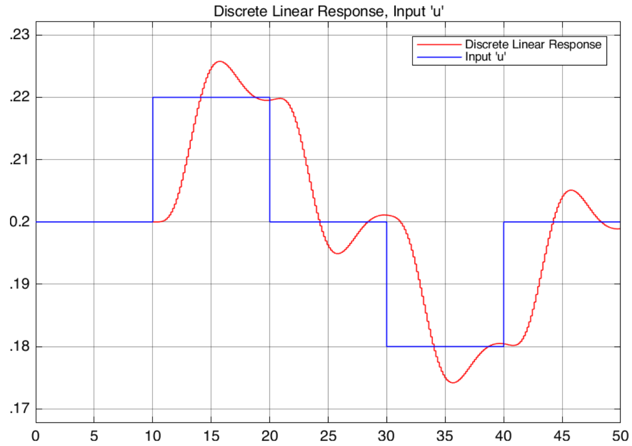

Figure 5 alpha = 0.5, +10%

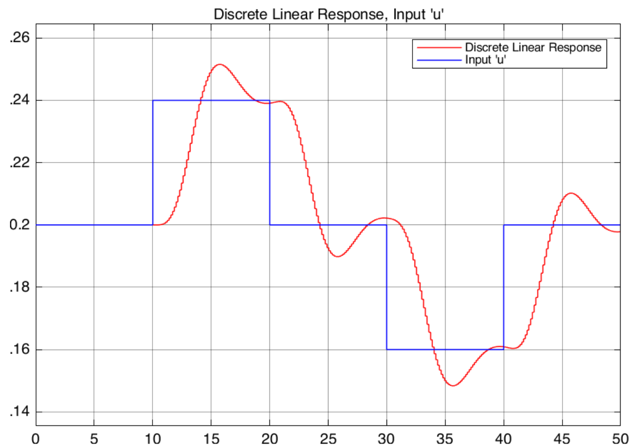

Figure 6 alpha = 0.5, +20%

Figure 7 alpha = 0.5, +30%

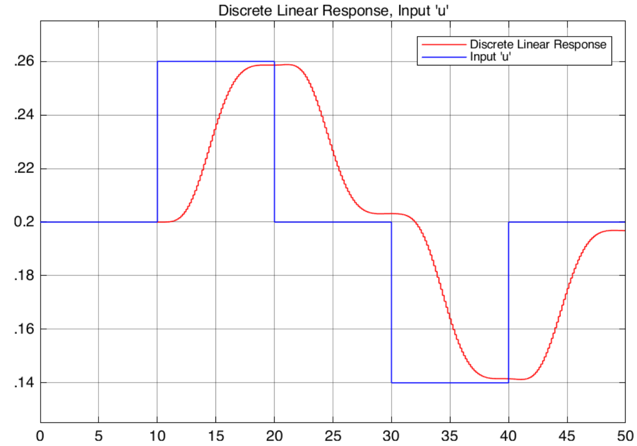

Figure 8 alpha = 0.95, +30%

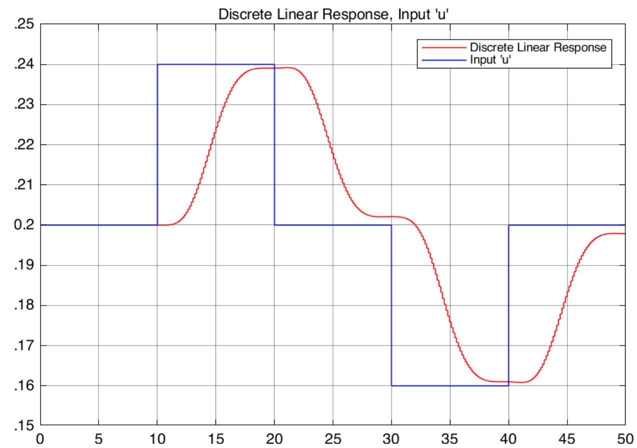

Figure 9 alpha = 0.95, +20%

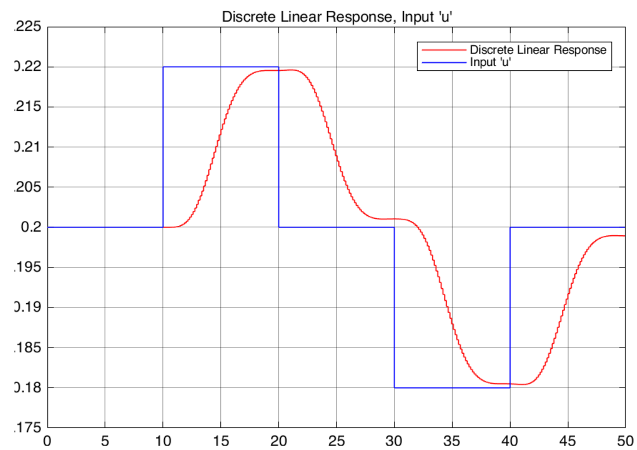

Figure 10 alpha = 0.95, +10%

All the responses for alpha = 1 are constant 0.2

Since there’s a zero in the loop.

Results for Non-linear Discrete

Figure 11 alpha = 0, +10%

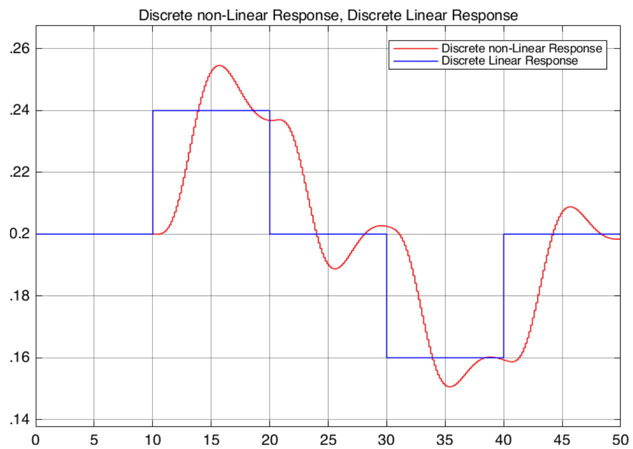

Figure 12 alpha = 0, +20%

Figure 13 alpha = 0, +30%

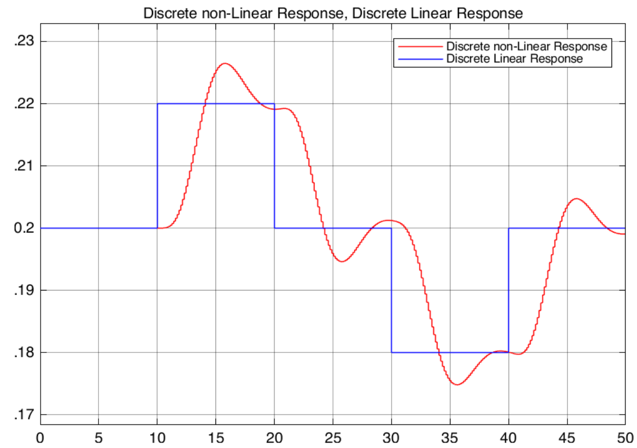

Figure 14 alpha = 0.5, +10%

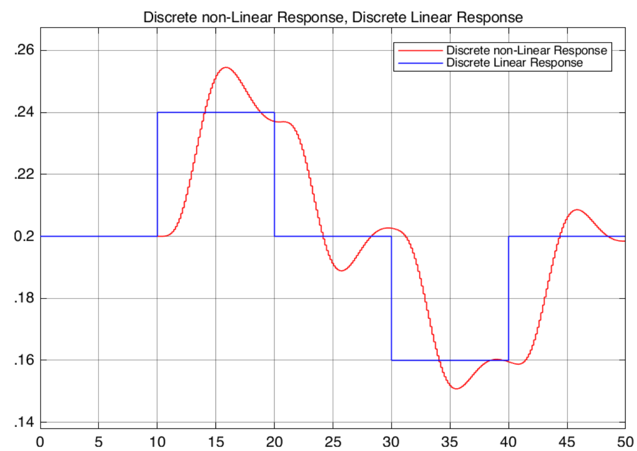

Figure 15 alpha = 0.5, +20%

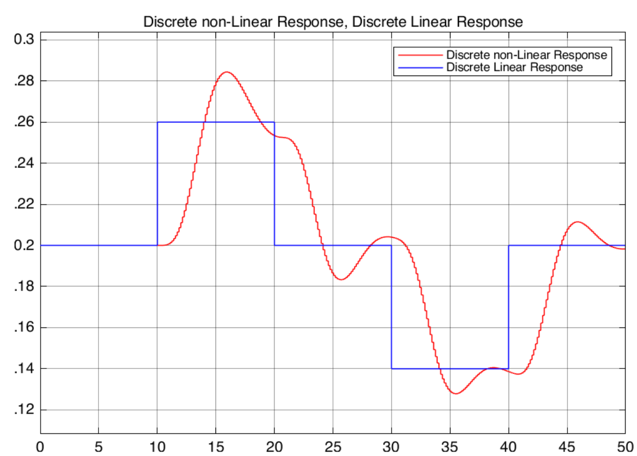

Figure 16 alpha = 0.5, +30%

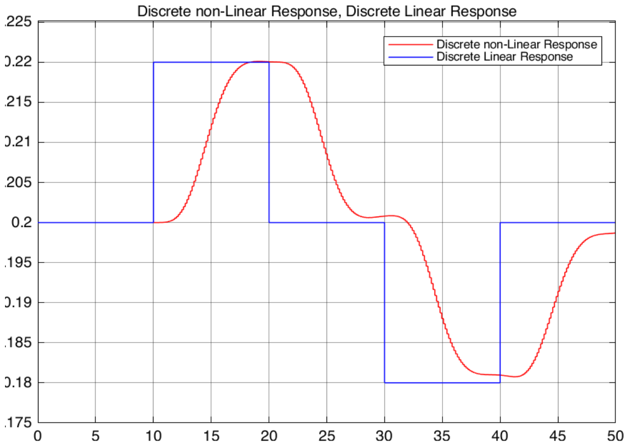

Figure 17 alpha = 0.95, +10%

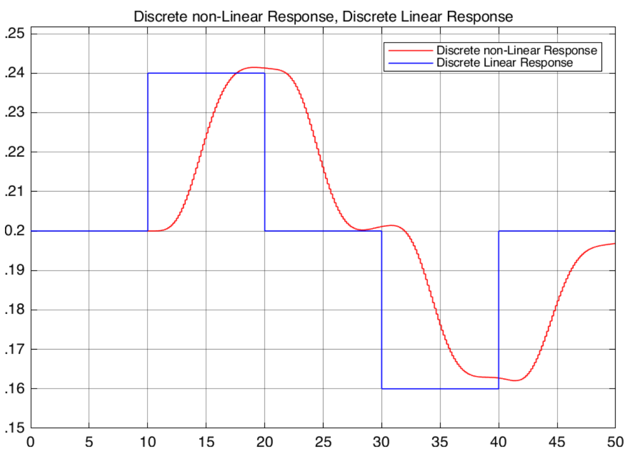

Figure 18 alpha = 0.95, +20%

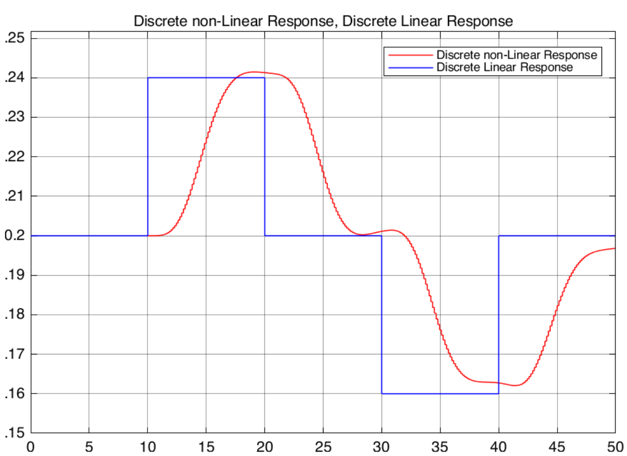

Figure 19 alpha = 0.95, +30%

Linear continuous results

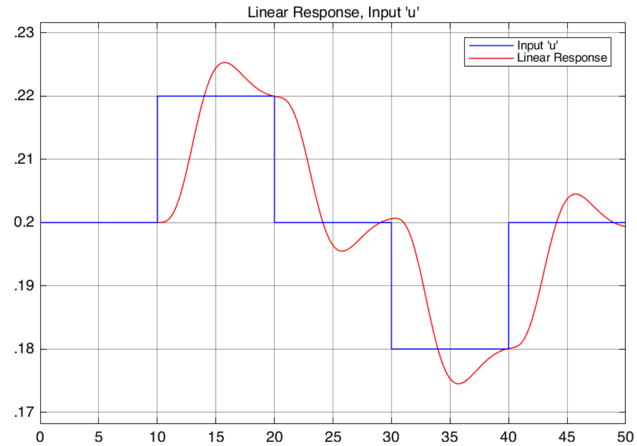

Figure 20 alpha = 0, +10%

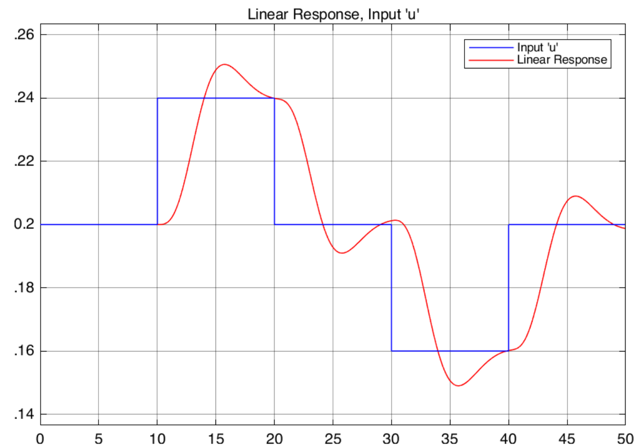

Figure 21 alpha = 0, +20%

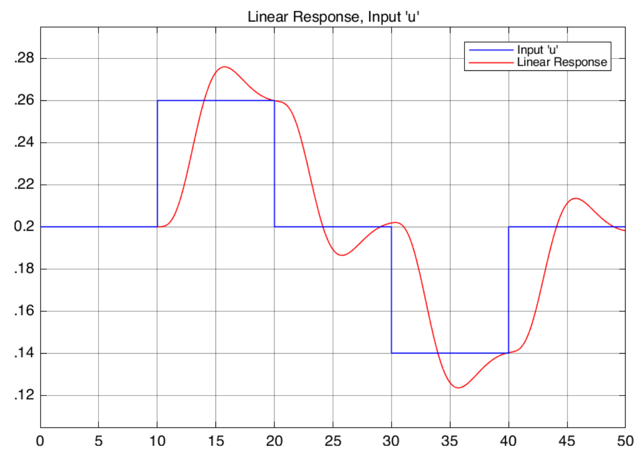

Figure 22 alpha = 0, +30%

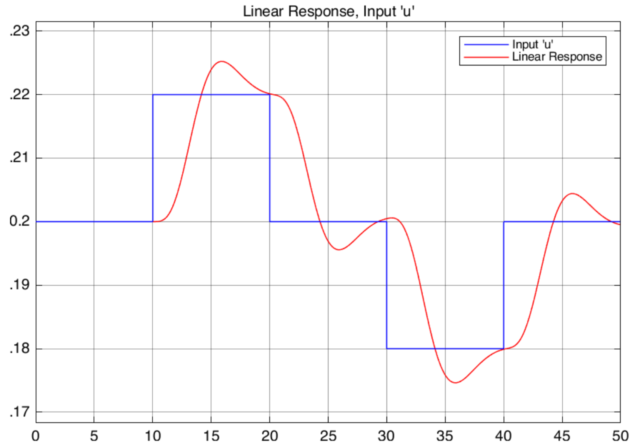

Figure 23 alpha = 0.5, +10%

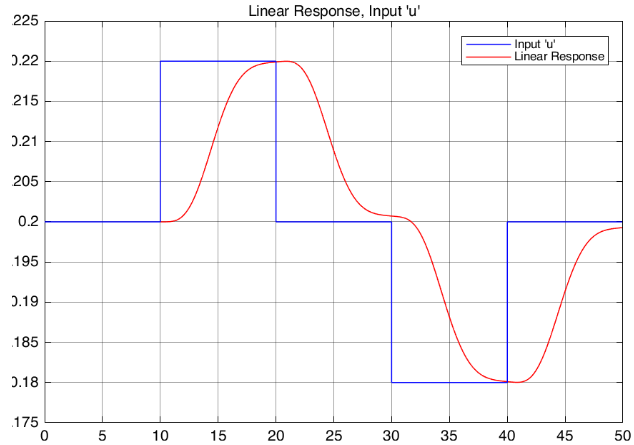

Figure 26 alpha = 0.95, +10%

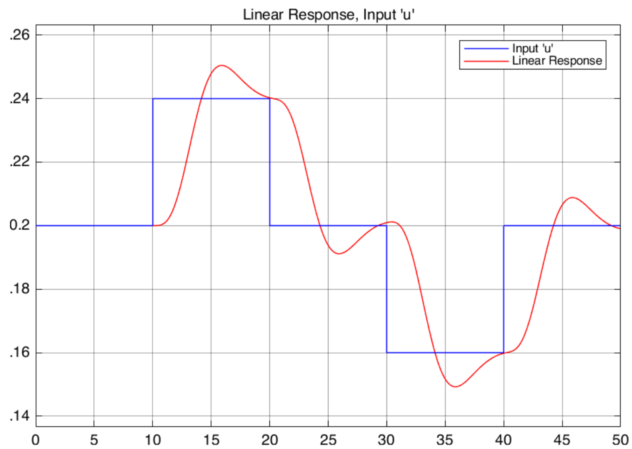

Figure 24 alpha = 0.5, +20%

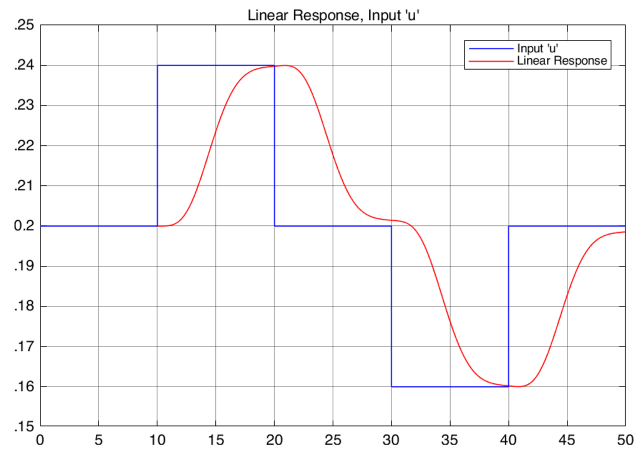

Figure 27 alpha = 0.95, +20%

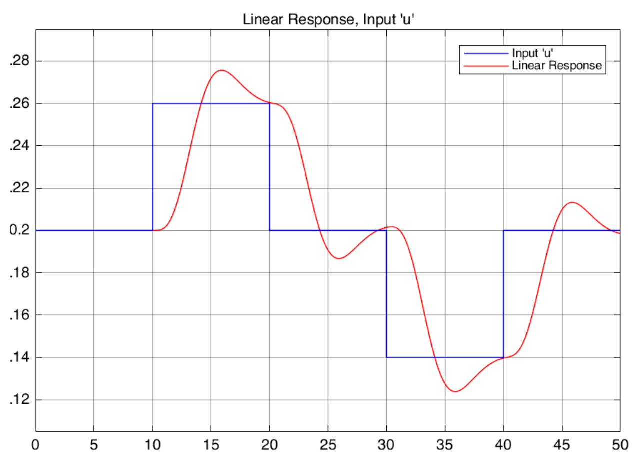

Figure 25 alpha = 0.5, +30%

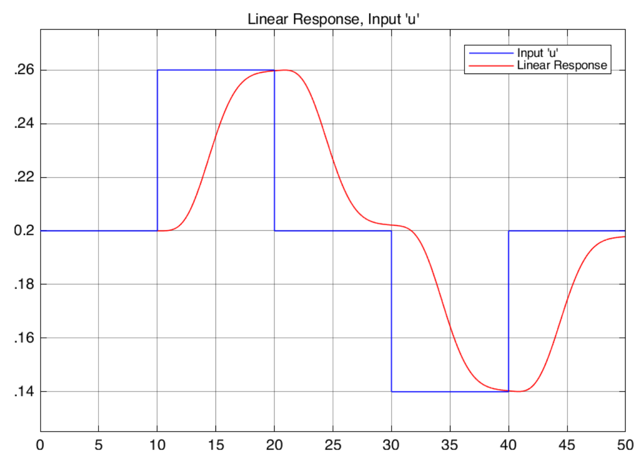

Figure 28 alpha = 0.95, +30%

Non-linear Continuous Results

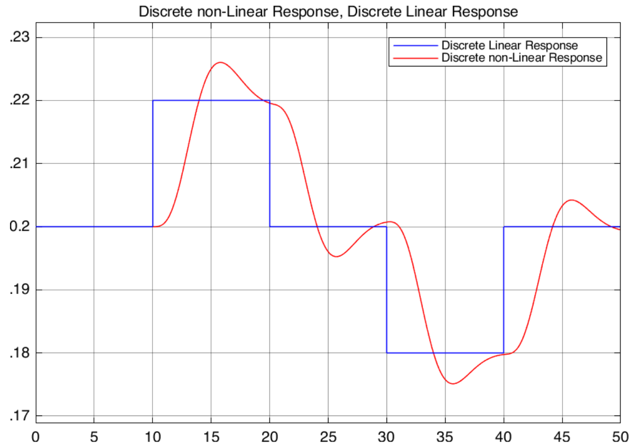

Figure 29 alpha = 0, +10%

Figure 30 alpha = 0, +20%

Figure 31 alpha = 0, +30%

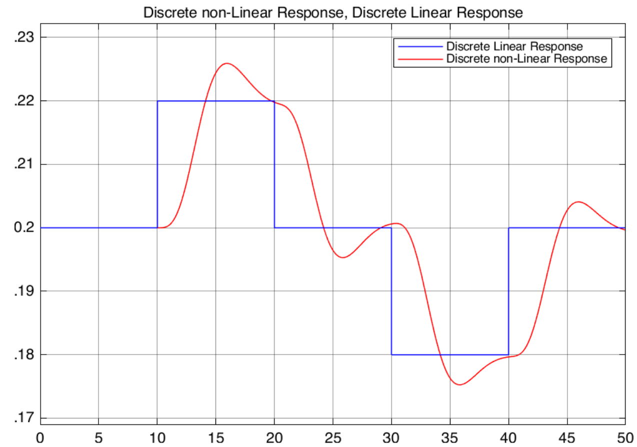

Figure 32 alpha = 0.5, +10%

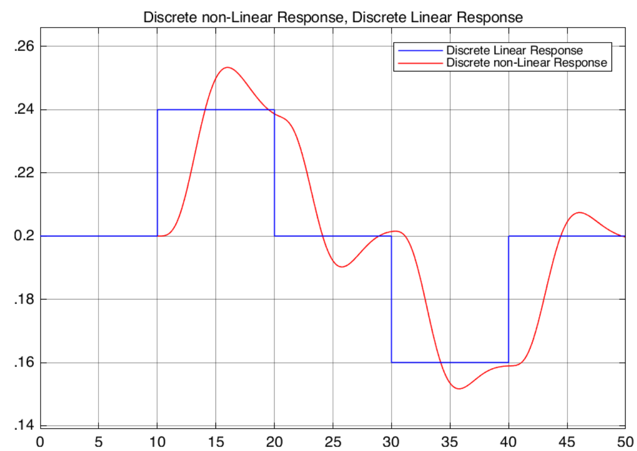

Figure 33 alpha = 0.5, +20%

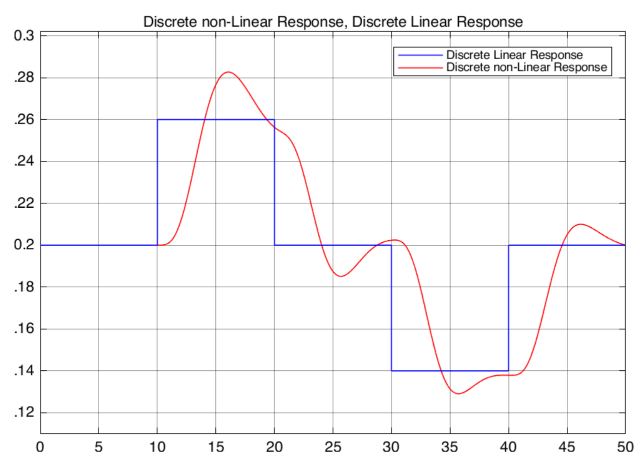

Figure 34 alpha = 0.5, 30%

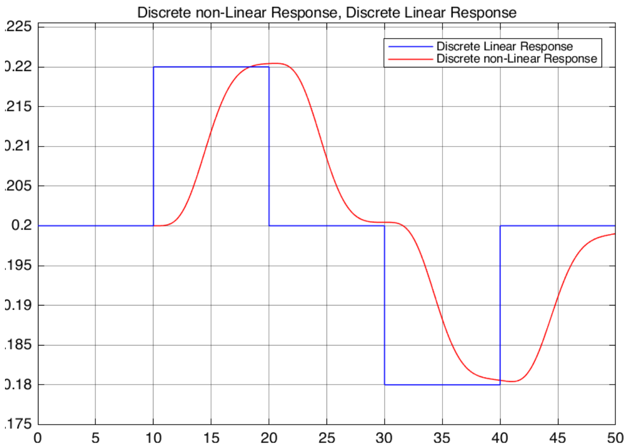

Figure 35 alpha = 0.95, +10%

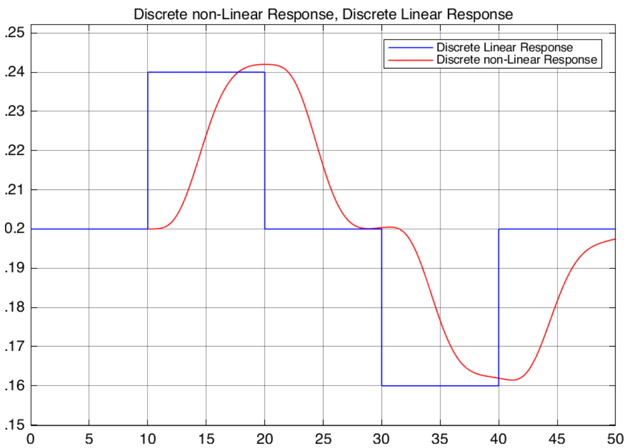

Figure 36 alpha = 0.95, +20%

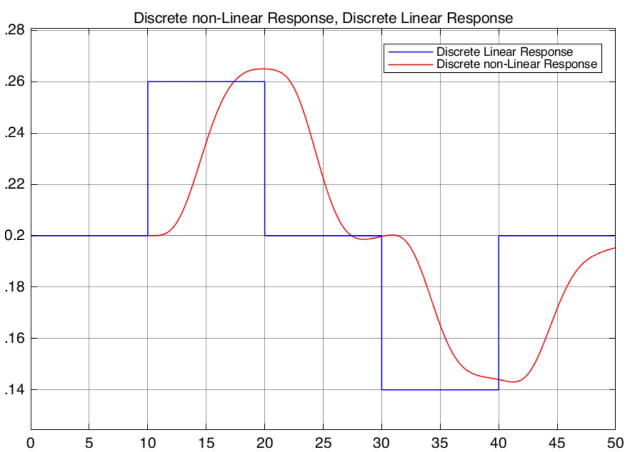

Figure 37 alpha = 0.95, +30%

Comparing the results

As we can see, All the responses for alpha = 1 are constant 0.2 Since there's a zero in the loop. Also, we can observe that alpha defines the speed of the convergence. As alpha approaches 1, the response curve is smoother. There's also less overshoot since alpha acts as a lowpass filter. IMC model is less prone to modeling error since it uses the discrete model as part of its controller structure.