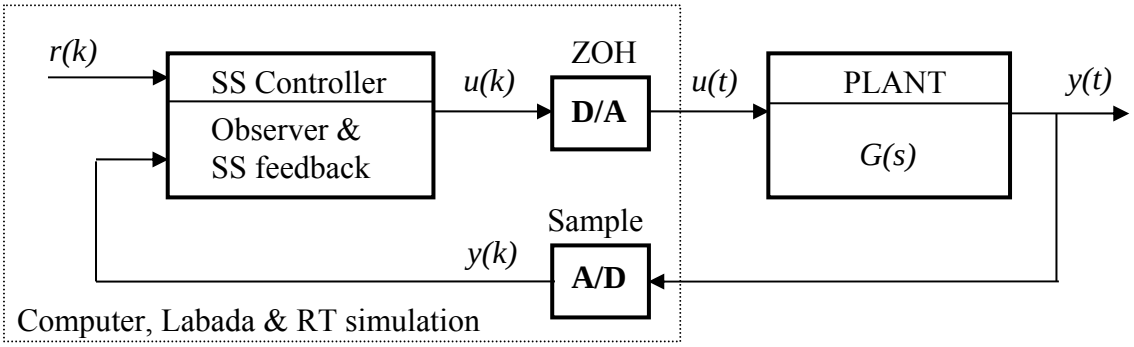
## *Control Systems 414* *Practical 1* *19th February 2016*

**SS Control of "PLANT G(s) in Labada"**

**AIM:** Practical discrete state variable controller design for a closed loop hybrid system.

**ASSIGNMENT:** For the following "PLANT" computer control system with sample period $T = 0.04$ seconds:




1. The "PLANT" must first be identified via a step and frequency response measurement as a dominant 2nd order underdamped continuous system, with transfer function:

$$G(s) = \frac{Y(s)}{U(s)} = \frac{\omega_n^2}{s^2 + 2\zeta\omega_n s + \omega_n^2} \quad , \quad \omega_n \approx 16 - 18\ rad/\sec, \quad \varsigma \approx 0.1 - 0.15$$

   Use the *"Plant_step_ID_2013b.mdl"* SimuLink simulation block diagram to accurately identify this model.

2. Design a discrete state variable controller (use a control canonical discrete SS model) with $T = 0.04$ seconds, to satisfy the following closed loop specifications:
   - Optimally damped: $\zeta = 0.707$
   - 2% Settling time: $t_s = 0.4$ second
   - Accurate tracking of a constant reference input $r(k)$, design the feedforward gain $\overline{N}$ as,

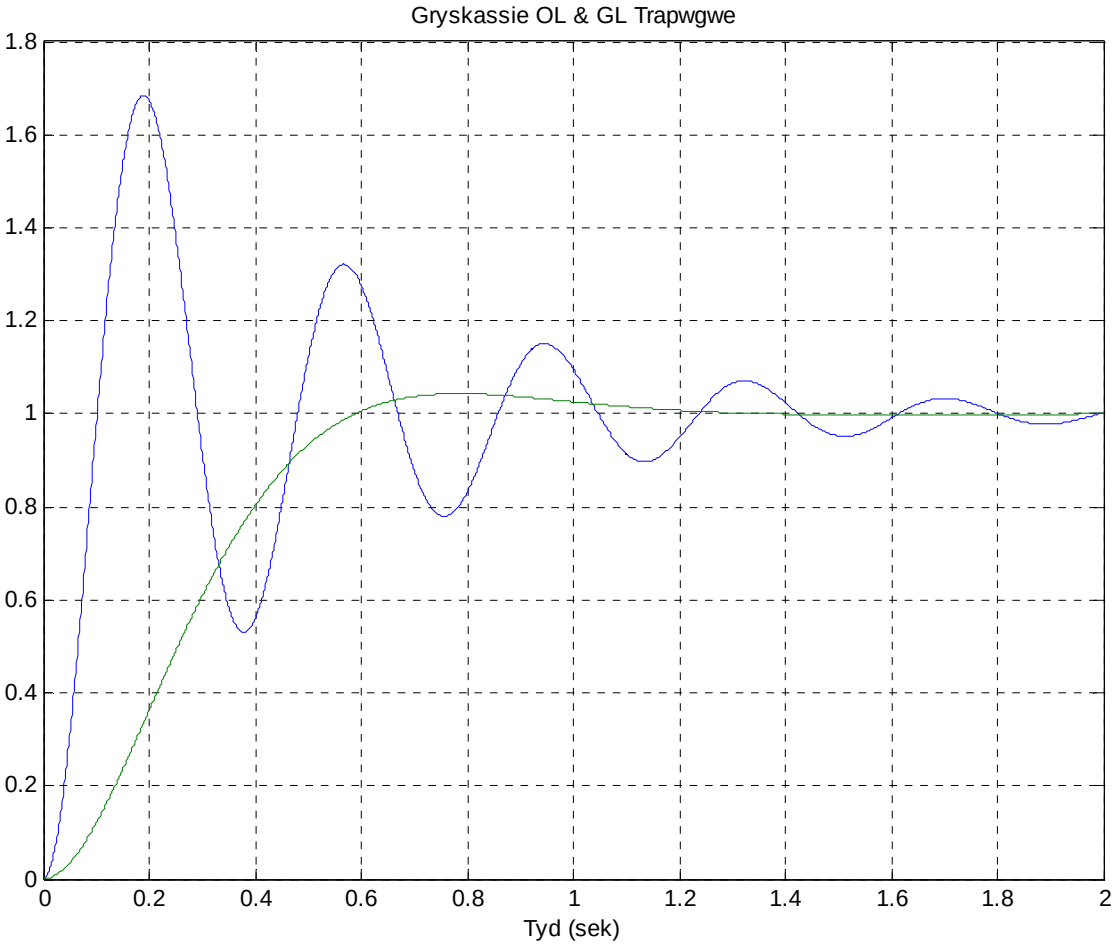
$$\begin{bmatrix} \mathbf{N_x} \\ N_u \end{bmatrix} = \begin{bmatrix} \mathbf{F} - \mathbf{I} & \mathbf{g} \\ \mathbf{c} & 0 \end{bmatrix}^{-1} \begin{bmatrix} \mathbf{0} \\ 1 \end{bmatrix} \quad , \quad \overline{N} = \mathbf{kN_x} + N_u$$

   - Current state observer, where the observer error dynamics will converge within 2 sample periods (i.e. place all observer poles at $z = 0$)

3. Verify your design in Matlab/Simulink: Simulate the "PLANT" as a continuous transfer function with a fixed time step of 0.001 seconds using numerical integration (eg. ode4 Runge-Kutta). Implement the current state observer as a discrete model and use the estimated states in the feedback control law. (See the SimuLink model *"RT_Plant_SS_2014.mdl"* on the next page with the switch toggled to the ideal TF model of the plant). Comment on whether the closed loop specifications are satisfied or not.

4. Implement the design physically in real time using SimuLink and the "Stream In/Out" blocks of the "Real-Time Windows Target" toolbox. Use the model *"RT_Plant_SS_2014.mdl"* again for the hardware-in-loop simulation, on the computer with the Labada box (AD/DA convertors). Comment on the whether the closed loop specifications are still satisfied and give reasons if not.

**Report:** Everyone writes his/her own report (design and results) and hand-in at the 10h00 lecture on Monday 22/02/2016. **Make a note of your Labada box number, you have to use the same one for the next practical !**


Gryskassie OL & GL Trapwgwe
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
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0
0.2
0.4
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0.8
1
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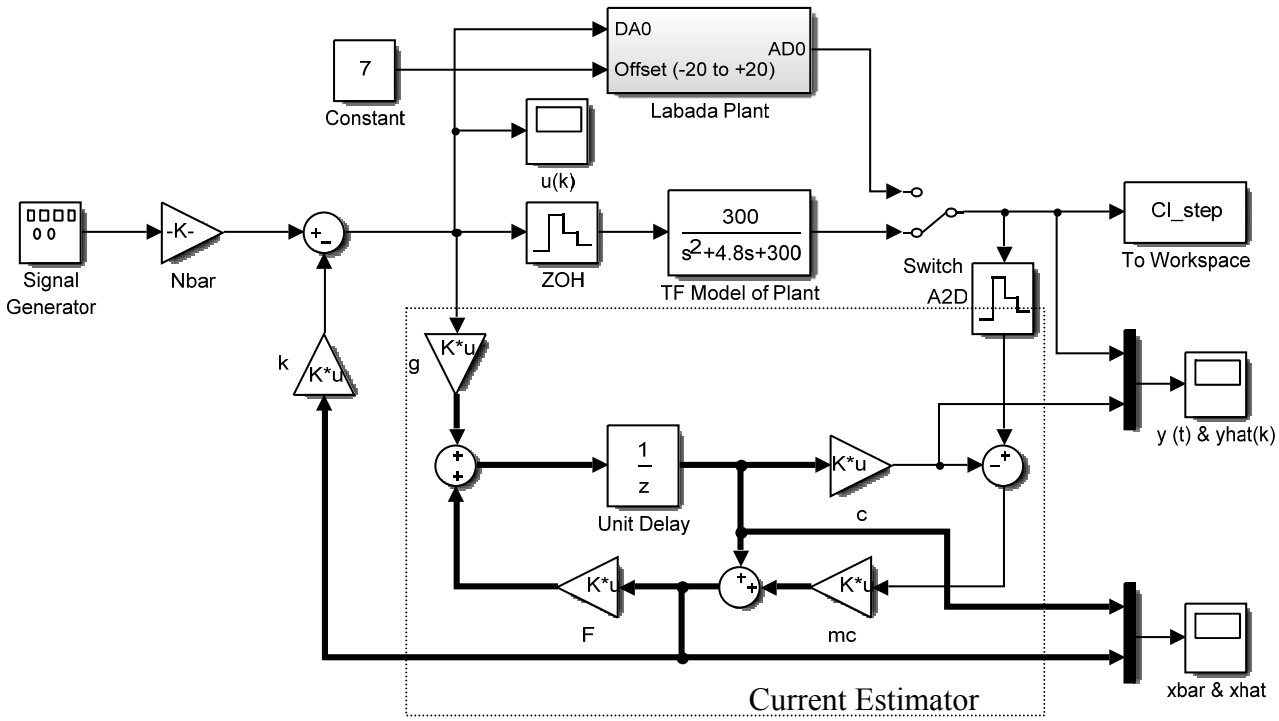
2
Tyd (sek)


7
Constant
DA0
AD0
Offset (-20 to +20)
Labada Plant
u(k)
Signal
Generator
-K-
Nbar
ZOH
300
s2+4.8s+300
TF Model of Plant
Switch
A2D
Cl_step
To Workspace
y (t) & yhat(k)
k
K*u
g
K*u
1
z
Unit Delay
K*u
c
K*u
F
K*u
mc
xbar & xhat
Current Estimator