King AbdulAziz University

College of Engineering, Chemical Engineering Dept.

Fall 2004 HW#12 Ch.E 442

(Design & Computer Application)

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1. The table below shows the experimental process reaction curve of an open-loop system with a PI controller.
   a- Approximate the process by a first-order system with dead time.
   b- One the basis of the approximation above, compute the Ziegler-Nichols settings of the PI controller.
   c- Compare them to the Cohen-coon settings which can be computed from the process reaction curve and find which settings yield the smaller ISE of the closed-loop response to a unit step change in set point.
   d- Compute the tolerance of the Ziegler-Nichols and Cohen-coon settings to errors in static gain K, time constant τ, or dead time t_d. Which settings possess larger tolerance?

Time (minutes)	Manipulated input	Measurement of output
-2	100	200
-1	100	200
0	150	200.1
0.2	150	201.1
0.4	150	204.0
0.6	150	227.0
0.8	150	251.0
1.0	150	280.0
1.2	150	302.5
1.4	150	318.0
1.6	150	329.5
1.8	150	336.0
2.0	150	339.0
2.2	150	340.5
2.4	150	341.0

2. Use Nyquist Criterion to find the ranges of K_c values that yield stable closed-loop response for:

   a- The feedback loop describe as follows:

   $G_p(s) = 10\, e^{-tds}/(2s+1)$, $G_m(s) = G_f(s) = 1$, a PI controller is to be used.

   b- $G_p(s) = 1/(s-5)$, $G_m(s) = G_f(s) = 1$, a P controller is to be used.

3. Consider the data table shown below:

Data I			Data II			Data III		
Frequency (Cycles/min)	AR	Ø (deg.)	Frequency (Cycles/min)	AR	Ø (deg.)	Frequency (Cycles/min)	AR	Ø (deg.)
.01	10	-0.63	.01	5.0	-0.23	.01	17	-1.49
.05	9.99	-6.30	.05	5.05	-1.13	.02	16.99	-2.98
.1	9.99	-3.15	.10	5.20	-2.39	.10	16.67	-14.75
1.0	9.95	-63.01	.20	5.93	-5.44	.30	14.42	-41.21
3.0	9.58	-188.6	.30	7.68	-11.62	.50	11.66	-61.90
5.0	8.94	-313.0	.40	12.69	- 23.96	.70	9.33	-77.76
7.0	8.19	-436.1	.50	25.00	-90.00	1.00	6.80	-95.73
9.0	7.43	-557.7	.60	9.98	-151.39	1.50	4.30	-117.03
10.0	7.04	-618.0	.70	5.00	-163.74	2.00	2.92	-132.42
12.0	6.40	-737.7	.80	3.25	-168.10	2.50	2.07	-144.53
15.0	5.55	-915.8	.90	2.20	-170.87	3.00	1.55	-154.04
20.0	4.47	-1209.4	1.10	1.29	-173.46	4.00	0.94	-169.23
			1.50	0.62	-175.71	8.00	0.26	-208.22
			2.0	0.33	176.95	10.00	0.17	-223.12
			3.0	0.05	178.84	20.00	0.04	-287.45

a- Draw the corresponding Nyquist plots.

b- Using the Nyquist criterion, examine the stability of the corresponding closed-loop systems.

c- Find the corresponding phase and gain margins.