Date: ________________ Name: ___________________________________

LABORATORY EXERCISE 10
PID TUNING FROM CLOSED LOOP TESTS

OBJECTIVE: To provide familiarity with closed loop testing, determination of process data and the calculation of tuning parameters from the closed loop data.

PREREQUISITE: Completion of Laboratory Exercise 9, PID Tuning from Open Loop Tests

BACKGROUND: Tuning by closed loop process testing involves putting the controller in AUTOMATIC, removing all Reset and Derivative, and setting the Gain just high enough to cause a sustained process oscillation. From this test, the relevant parameters are the period of oscillation in minutes, and the Gain which ultimately caused the sustained oscillation. These are called the "ultimate Period" and "ultimate Gain", respectively. From this data, the tuning parameters can be calculated.

NOTE: The open-loop (the subject of Exercise 9) and the closed-loop methods (the closed-loop method is the subject of this exercise) may or may not produce similar tuning values, even when using the same process model. The "Generic" process model is used in these exercises; there is some difference in the results. For demonstration purposed, is you wish to obtain similar results from t he two methods, use the Generic2" model.

1. RUNNING THE PROGRAM

Start **WINDOWS**

Run **PC-ControLAB**

2. TUNING BY CLOSED LOOP PROCESS TESTS.

2.1 Setup

Confirm the following:

Process:	GENERIC	(see the top line, left hand side)
Control Strategy	FEEDBACK	(see the top line, right hand side)

If PC-ControLAB has already running, you may have to do any or all of the following:

Select **Control | Select Strategy | Feedback**
Select **Process | Select Model**
Highlight "Generic.mdl" and press **Open**

Select **Process | Initialize** to initialize the process model.

If you are more familiar with using Proportional Band, rather than Gain, for tuning controllers, or if you are more familiar with tuning the reset (integral) mode in Repeats per Minute, rather than Minutes per Repeat, then:

Press **Tune** then select the **Options** tab to set up the program to match the system you use:

Display GAIN as:	Display RESET as:
GAIN	Mins/Repeat
PROP BAND	Repeats/Min

Press **Tune** then select the **Options** tab. Select Reset Action OFF.

2.2 Process Testing

Set:	Gain:	1.0
or	PB:	100%
	Reset:	See above
	Deriv:	0.0 minutes

Put the controller in Auto.

Make a set point change of 5% of full scale. (Press **StepIncr** once.)

If there is no oscillation, or if the oscillation dies out, increase the Gain (or decrease the Proportional Band) and repeat the set point change. (The Gain can initially be changed approximately 50% of its present value, or the PB can be changed to one-half of its present value. As the response gets closer to sustained oscillation, smaller changes should be made.) You should not have to observe the response for more than three cycles to determine whether or not the oscillation is decaying or not.)

When sustained oscillation is ultimately achieved, record the following:

Gain or PB required for sustained oscillation		K_{cu}	= ________
	or	PB_u	= ________
Period of sustained oscillation		P_u	= ________

Use the table for the closed-loop Ziegler-Nichols method (Table 1 at the back of this exercise) to calculate tuning parameters for a P, PI and PID controller. Enter these in the table below:

(First calculate Gain (K_C), Integral time (T_I) and Derivative (T_D) from the equations. Then, if your system uses PB rather than Gain, or Reset Rate rather than Reset Time, calculate those values.)

	P	**PI**	**PID**
Gain (K_C)			
Prop Band (PB)			
Integ Time (T_I) (min/rpt)	═══		
Reset Rate (rpt/min)	═══		
Deriv Time (T_D)	═══	═══	

Before testing for the closed loop response, go to **Tune | Options** tab and set Reset Action ON.

For each type of controller, enter the parameters, put the controller in Auto and test the loop for a 10% (of full scale) set point change.

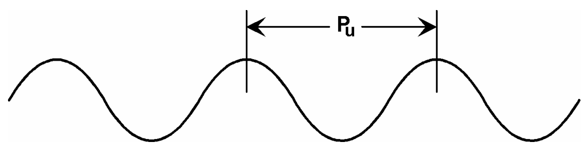
Calculate or measure the decay ratio, period and (for PI controller only) the period-to-integral time ratio. (This will be used in a subsequent exercise.)

Also, for each type of controller, make a 5% load change. (Press **StepIncr** or **StepDecr**.) Mark which controller type has the best, and the worst, response to a load change.

	P	**PI**	**PID**
Decay Ratio			
Period, mins			
Period / Integral Time	═══		═══
Load change, best and worst response			

TABLE 1
ZIEGLER-NICHOLS TUNING PARAMETER CORRELATION FOR CLOSED LOOP PROCESS DATA

CONTROLLER	PROP ONLY	PI	PID
GAIN K_C	$0.5\ K_{cu}$	$0.45\ K_{cu}$	$0.6\ K_{cu}$
RESET T_I - Mins/Repeat	----	$\frac{P_u}{1.2}$	$\frac{P_u}{2}$
DERIVATIVE T_D - Minutes	----	----	$\frac{P_u}{8}$



K_{cu} = Controller Gain that causes sustained oscillation

P_u = Period (in minutes) of sustained oscillation
= Time between any two successive peaks