| **EET 223** | **Arnold Stadlin** |
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| **PID Control Simulation Lab** | **04/28/06** |


**SUMMARY**

The PID Control Simulation Lab was performed completely in software. Three techniques were used to practice tuning and observe a simulated PID control system.

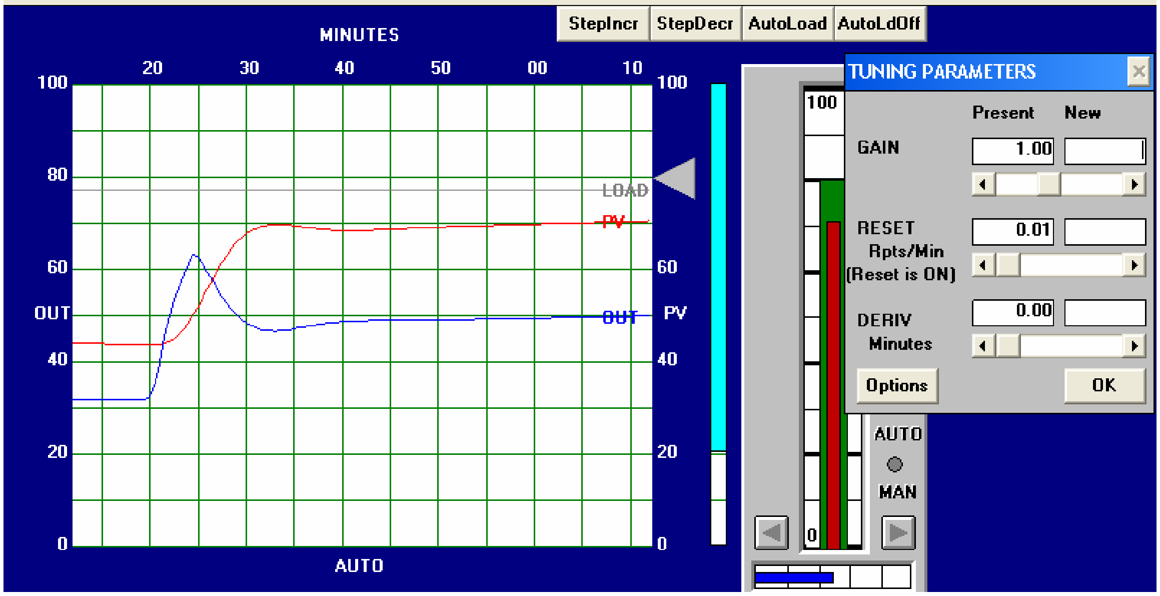
Tuning the PID control using the *Trial and Error Method* was actually the most difficult of the methods to get good results with. This may have been because it was also the first method tried with no previous experience and unfamiliar software. However, the *Trial and Error Method* did work.

The second method I used for tuning the PID control was the *Reaction Curve Method.* This method provided a relatively quick estimate of the corrective force coefficients. The reason that the method relatively quick is because the reaction curve is easy to generate with fixed parameters. Also, reasonable "close enough" estimates are easy to interpret from the curve's graphic profile and the resulting calculations are not to complex (thanks to Zieler, Nichols, and Kilian).

The *Continuous Cycle Method* gave the best results. This method seemed to provide more distinct results for the $\mathbf{K_I}$ and $\mathbf{K_D}$ coefficients compared to the same coefficients generated by the *Reaction Curve* calculations. This may have been because my estimated data for *Rise Time* and *Lag Time* in the *Reaction Curve Method* was not accurate enough. I'll do better next time.

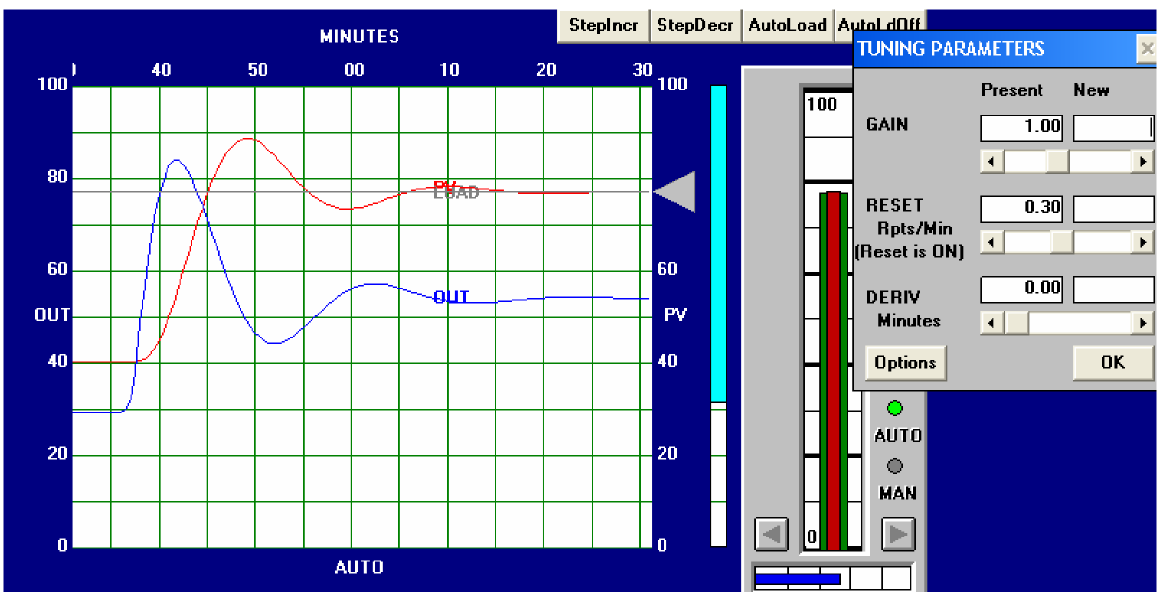
Overall, this lab gave me some practice with the tuning techniques. This helps develop confidence in the techniques and encourages me to try them out in a real world process.

## Figure 1 - Proportional Control Only



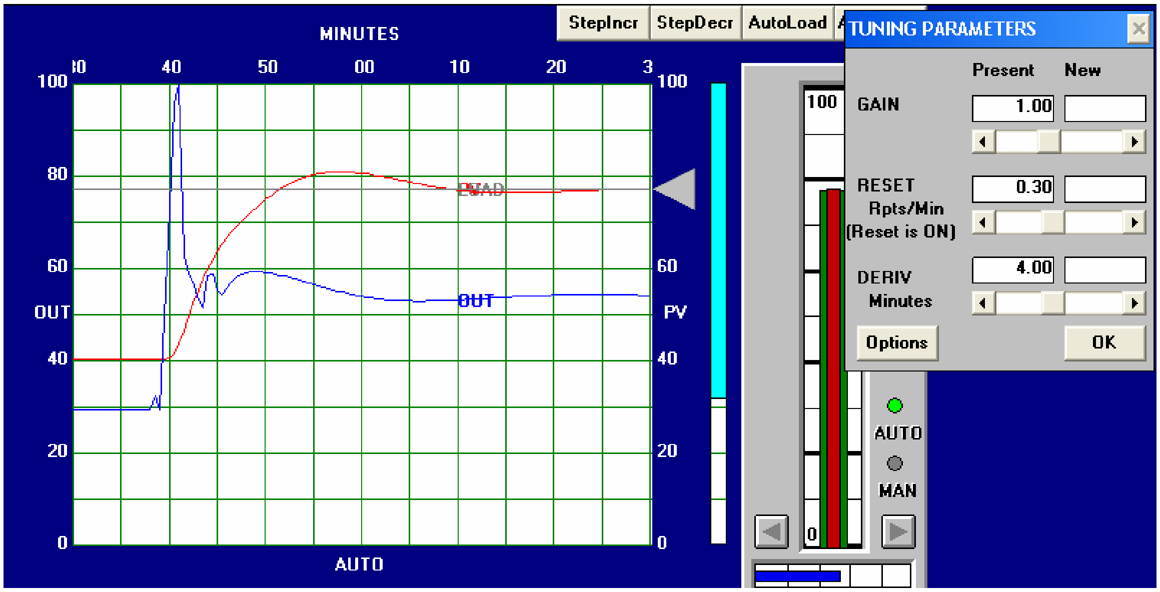

When only *Proportional Control* is used, a steady state error exists. This error can be reduced by increasing the *Gain*; but the error can never be eliminated.

## Figure 2 - Proportional Control with Integral Control



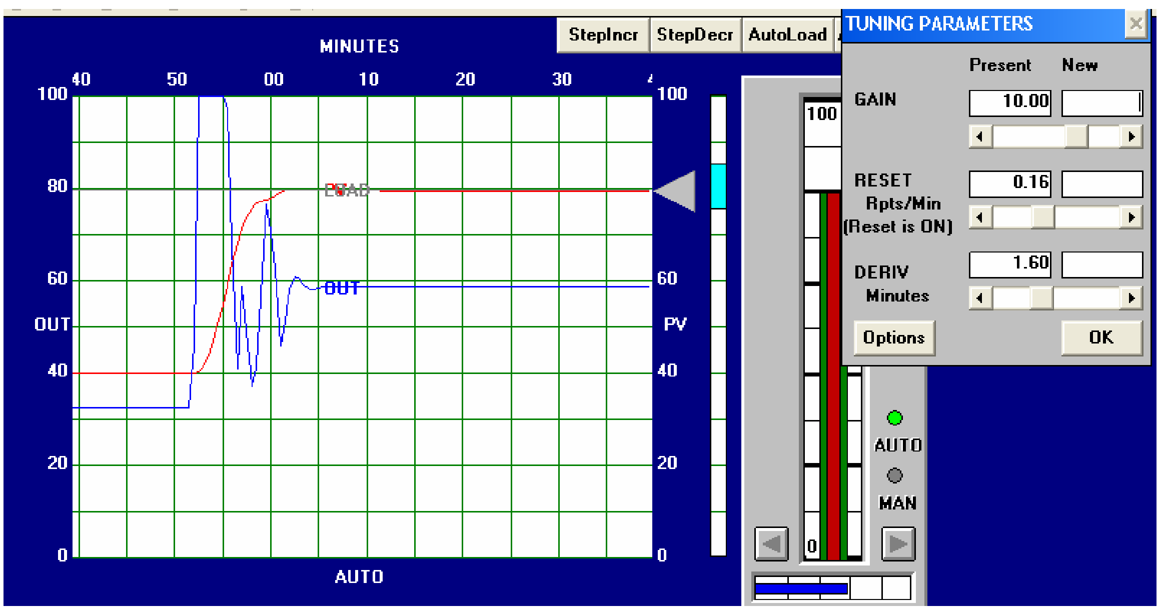

Adding *Integral Control* can eliminate the steady state error. However, *Integral Control* may cause over-shooting and system instability.

## Figure 3 - Combining Proportional, Integral, and Derivative Control



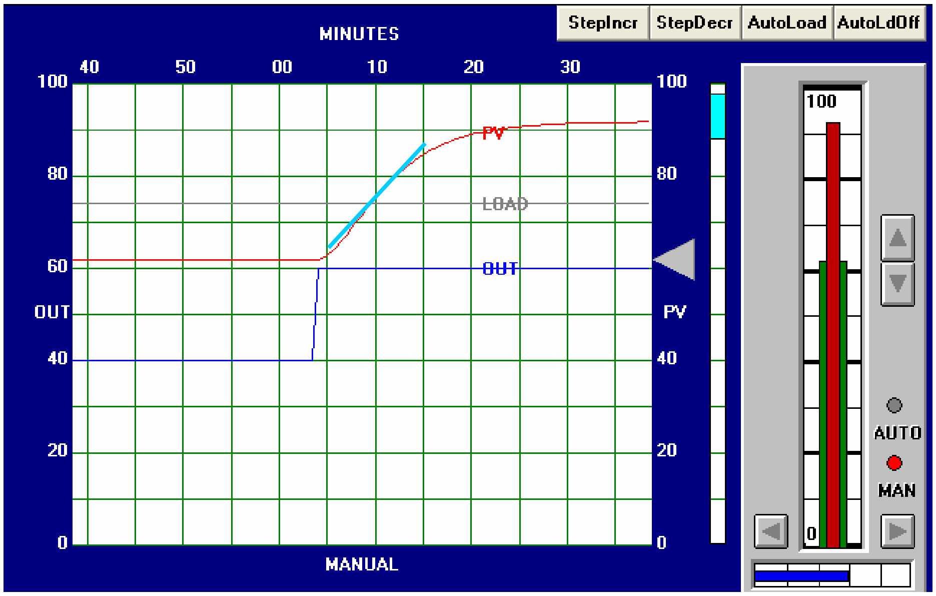

*Derivative Control* is based on the rate of change of the error with respect to time. This will improve the system response time and stability.

## Figure 4 - Manual Tuning Technique




Starting with a favorable $\mathbf{K_P}$, find the best $\mathbf{K_I}$, then continue on to find the best $\mathbf{K_D}$; repeating the procedure until adequate results are achieved. In the above example, $\mathbf{K_P = 10}$, $\mathbf{K_I = 0.16}$, and $\mathbf{K_D = 1.60}$.

## Figure 5 - Reaction Curve Method




## Calculations

$$N = \frac{\Delta PV_{\%}}{\Delta T_{min}} = \frac{20_{\%}}{10_{min}} = 2_{\%/min}$$

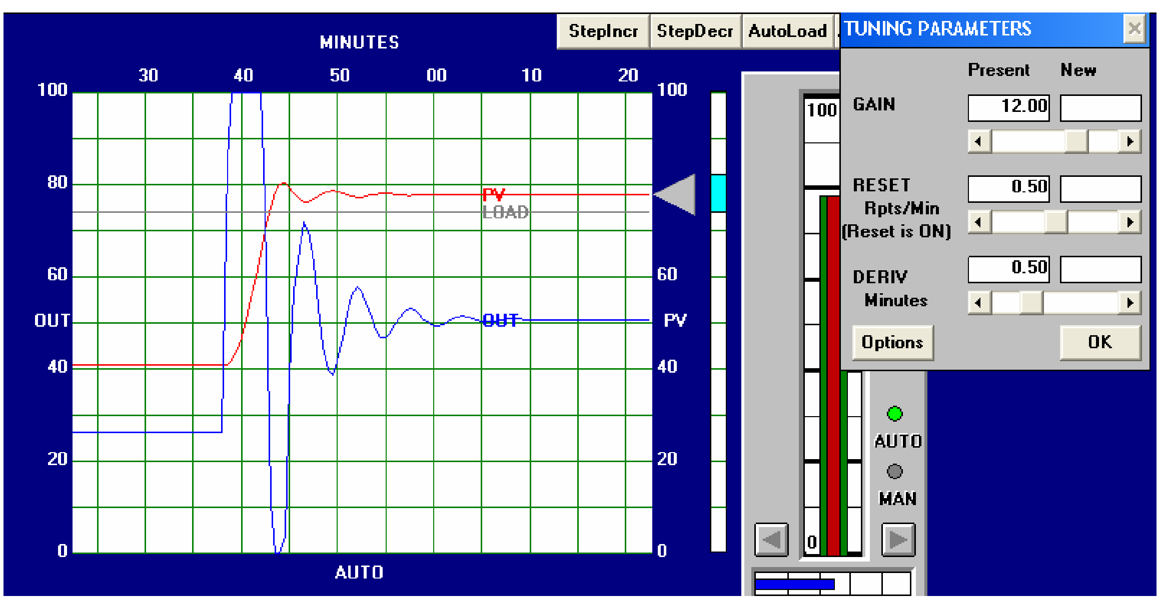
$$L = 1_{min}$$

$$K_P = \frac{1.2\Delta CV}{N*L} = \frac{1.2*20_{\%}}{2_{\%/min}*1_{min}} = 12$$

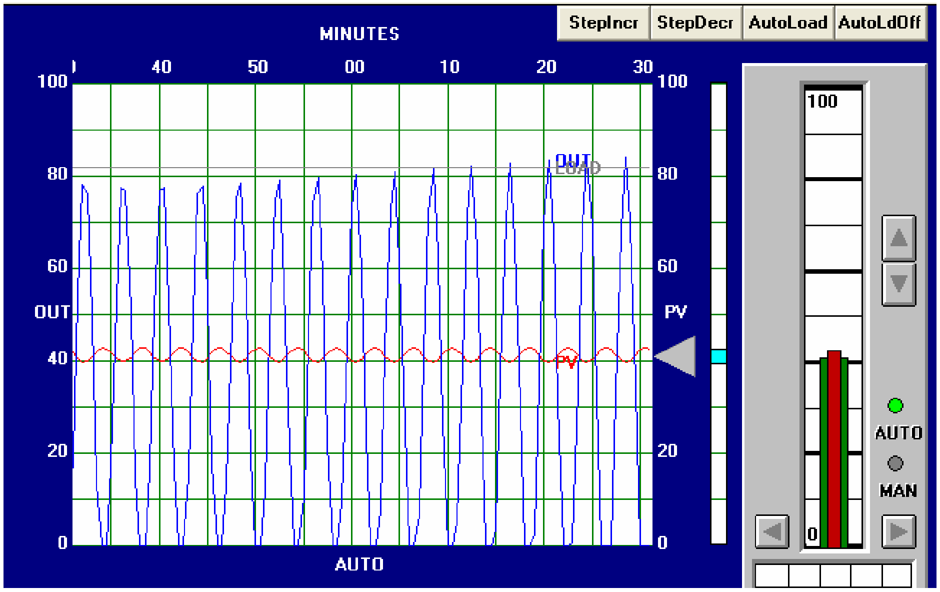
$$K_I = \frac{1}{2*L} = \frac{1}{2*1_{min}} = 0.5_{/min}$$

$$K_D = 0.5L = 0.5*1_{min} = 0.5_{min}$$

## Figure 6 - Reaction Curve Method Results



## Figure 7 - Continuous Cycle Method




## Calculations

$T_C = 5_{min}$

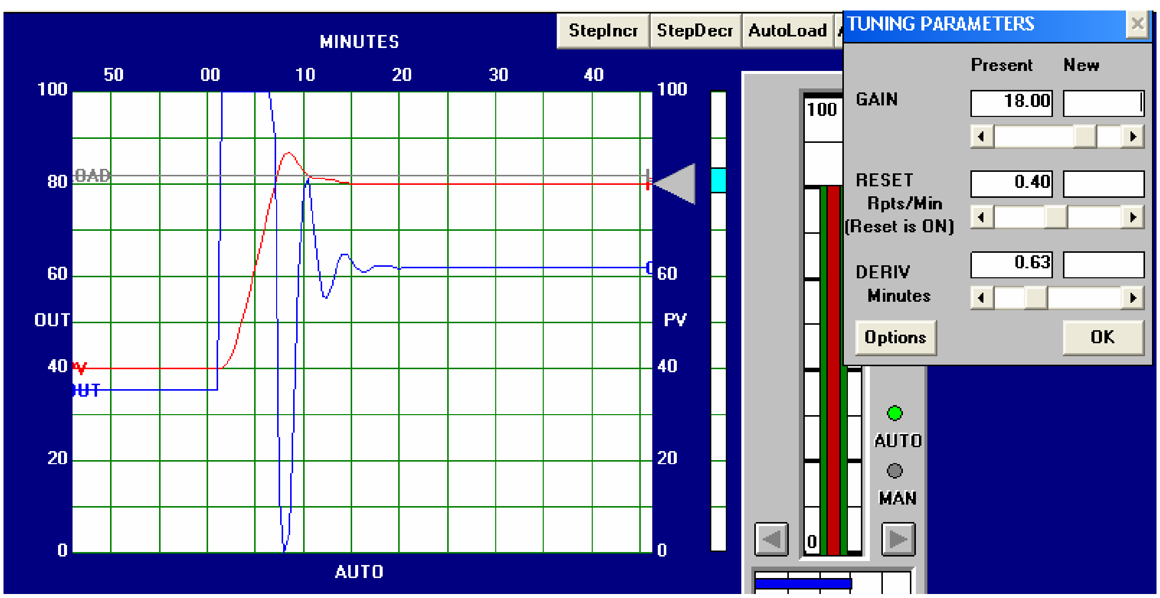
$K'_P = 30$ Note: This is a value that Continuous Oscillation is observed

$$K_P = 0.6K'_P = 0.6*30 = 18$$

$$K_I = \frac{2}{T_C} = \frac{2}{5_{min}} = 0.40_{/min}$$

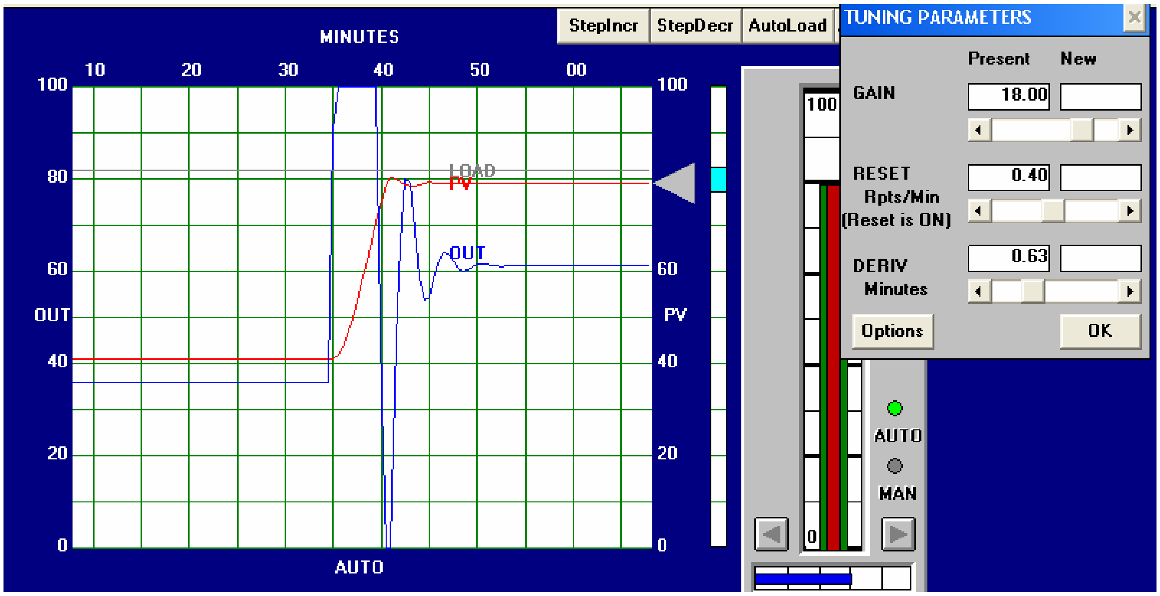
$$K_D = \frac{T_C}{8} = \frac{5_{min}}{8} = 0.63_{min}$$

## Figure 8 - Continuous Cycle Method Results with Fast Set Point Change




The above graphic was generated with a very high rate of change of the *Set Point*. This caused a little overshoot.

**Figure 9 - Continuous Cycle Method Results**




The above graphic shows the typical response when moving the *Set Point* quickly by hand. There is minimal over-shooting and relatively quick *Settling Time.*