Mechanical Control Systems (ME 4473)

Recitation - 7

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(For the best learning experience, students are encouraged to build their own simulink models as they are being worked out in the class)

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1. **Agenda:**
    - Revision
    - Problems(Discrete Time PID: evolution of output signal with a PID Controller, implementation of PID controllers in the digital electronics)

2. **Questions:**

- **PID:**

- **What is the mechanism of a PID controller?**

- **A PID controller is a trio of 3 different controllers that compliment each other's shortcomings. Based on the error functions what are the best and worst working conditions for a PID controller?**

	Pros	**Cons**
Proportional Controller		
Integral Controller		
Derivative controller		

- **On Lecture 19 and 20, Dr Schoen went in depth over the PID controller tuning techniques. What does it mean to tune a PID Controller?**

- **What are the methods used for PID Controller Tuning?**
    1. …………………....
    2. ……………………
    3. ……………………

3. **Problems:**

Because of the advent of inexpensive Digital electronics, it has become a current trend to design controllers using ‘by-wire’ controls. These controllers are also more efficient and typically have better performance than the mechanical controllers. However, digital electronics are discrete time systems and hence our continuous time systems need to be interpreted to discrete time domain in order to implement the digital controllers.

A. **For a system defined in continuous time, how do we change it to a discrete time:**

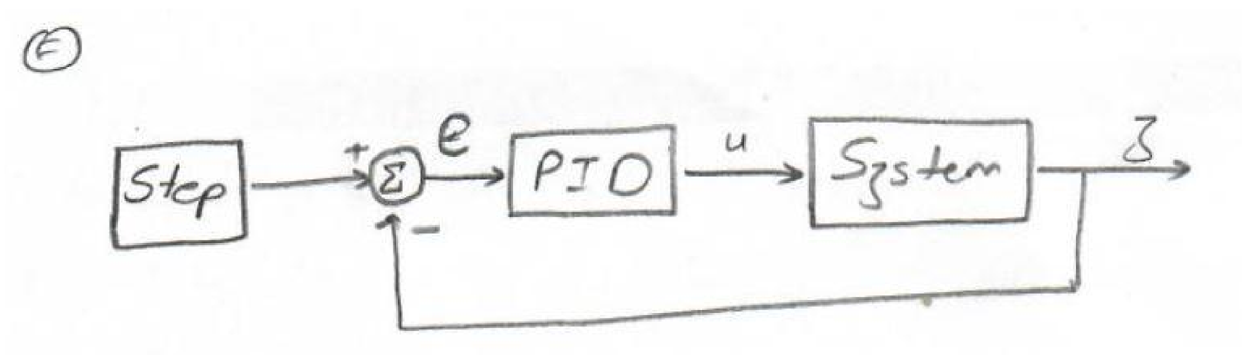
B. **For a transfer function in matlab defined in continuous-time, how do we change it to discrete time?**

C. **What is the relation between s of the Laplace transform and z of the z-transform?**

D. **In the discrete-time, what is the equation for the transfer function of a PID controller?**

E. **What is the equation for the input signal for the system generated by a discrete PID Controller?**

F. **With this information, let's build a discrete-time PID controller for a continuous time system. Consider the following system:**



Let's assume that the sampling rate is 100 Hz. Hence, The sampling time is 0.01 sec.

1. **Discrete Difference Equation: Let's assume that the transfer function for the system is ;**

    System = $\frac{s}{s^2+3s+6}$

For Ts = 0.01 sec, write the discrete transfer function using Matlab.

a. **Using this discrete transfer function, evaluate the difference equation for the system:**

b. **Discrete PID: Assuming $K_p = K_I = K_D = 1$, write down the transfer function and difference equation for the Discrete PID Controller.**

c. **Evolution of the System: Using the excel sheet, evaluate the evolution of the system.**
   @ Excel

2. **Now, let's make it a little bit fun. Lets change our system to:**

   System = $\frac{s}{s^{2} - 3s + 6}$

   What did we do here that makes our system interesting?

Changed the system such that there are poles in the right hand plane.

   a. **Discrete Time Transfer Function (T = 0.01):**

3. **Now, let's design a discrete time & Continuous time controller in Simulink.**
   @Simulink.
   1. **Step response comparison with the continuous time model**

2. **PID Controller comparisons at Kp = K_I = K_D = 1**

3. **PID Tuning of Discrete PID using Autotuner**
4. **Copy the Discrete PID coefficients and use it on the continuous PID**

5. **In the self tuner, tuning using the response time, transient behavior and controller effort**

6. ………………………………………

Conclusion:

1. …………………………..
2.
3. Process of Implementation of a Digital PID to a continuous-time system:
   a. ………………
   b. ………………
   c. ……………………
   d. For the simulation:
      i. ……………………
      ii. ……………………
      iii. …………………..
      iv. ……………………..
   e. For the controller implementation:
      i. ……………………….
      ii. ……………………….
      iii. ………………………..
      iv. ……………………….

Bibliography:

- **PID Picture: https://en.wikipedia.org/wiki/PID_controller**
- **Simple Examples of PID Control: https://www.youtube.com/watch?v=XfAt6hNV8XM**
- **Modern Control Systems, 13th ed, 13.9 Implementation of Digital Controllers**