System Identification

Lecture 4

Today's Topic

- System Identification (SI) Concepts
  - Least Square (LS) curve fitting
  - Parametric and nonparametric SI
  - LS identification
  - Vibration Measurements
- Actuators and Sensors
- Experiment # 2

SI Concepts (II)

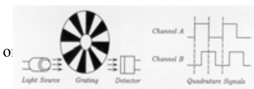
- In order to design controls for a dynamic system, it is necessary to have a model that will adequately describe the system's motion. The model can be derived basically in two ways:
  - EOM derived from first principles in Physics, Chemistry, Biology, etc..
  - Parameters derived from experimentation ⇒ System Identification
    - Parametric
    - Nonparametric

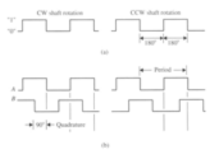
SI Concepts (II)

- Developed on the board

Sensors I

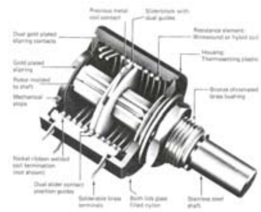
- Optical Encoders
  - Converts linear or rotary displacement into digitally coded or pulse signals
  - Measures the number of pulses – resolution
  - Can measure velocity – clock
  - In our lab, the encoders have:
  - R = 4000 pulses/rev. (or counts/rev)
  - Quadrature 4X resolution
    - R = 16000 counts/rev
    - R = 16000 counts/$2\pi r_p$
      - Where r_p is the pinion pitch radius





Sensors II

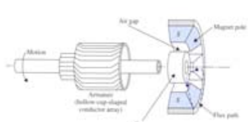
- Potentiometers

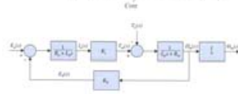


$$e(t) = K\theta(t)$$

Actuators

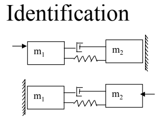
- Brushless Motor (or permanent magnet synchronous motor)
  - Elimination of the brush friction and associated wear
- In contrast to the conventional DC motor – the permanent magnets are fixed to the rotor
  - Provide continuous torque the current commutation must be done electronically, instead of a mechanical switch
  - Internal PI controller – can show that by choosing appropriated gains, the motor becomes simply a constant gain.
    - Kt = 0.1 N-m/A

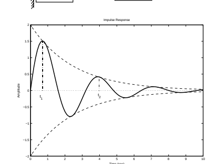


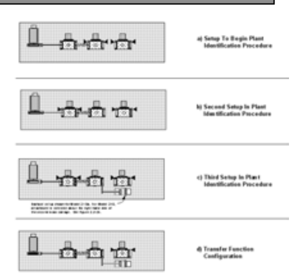


Experiment (I)

- Identification







Experiment (II)

- Perform experiments for the loaded masses and unloaded masses ⇒ determine the masses of attached elements + carriage
- Calculations for each mass
  - From the plot ⇒ T and thus ω_d
  - Approx ω_n
  - From logarithmic decrement ⇒ ζ
  - Compute $\omega^2_{n_{with\ mass}} = \frac{k}{m_w + m_c}$ and $\omega^2_{n_{without\ mass}} = \frac{k}{m_c}$
  - Find damping c
  - Change the springs and identify the stiffness for each one

Experiment (III)

- Identification of the Hardware gain

$$k_{hw} = k_c k_a k_t k_{mp} k_e k_{ep} k_s$$

where:

k_c, the DAC gain, = 10V / 32,768 DAC counts
k_a, the Servo Amp gain, = approx 2 (amp/V)
k_t, the Servo Motor Torque constant = approx 0.1 (N-m/amp)
k_{mp}, the Motor Pinion pitch radius inverse = 26.25 m-1
k_e, the Encoder gain, = 16,000 pulses / 2π radians
k_{ep}, the Encoder Pinion pitch radius inverse = 89 m-1
k_s, the Controller Software gain, = 32 (controller counts / encoder or ref input counts)

Experiment (IV)

- Hardware gain identification ⇒ Apply voltage to an open loop system and compute the acceleration and from Newton's 2nd. Law we can compute the applied force.

Experiment (V)

- All your controller designs will be based on the identified parameters
- Remember to use the same springs and masses when implementing the controller