Control Systems Lab.
(Experiment – 8)

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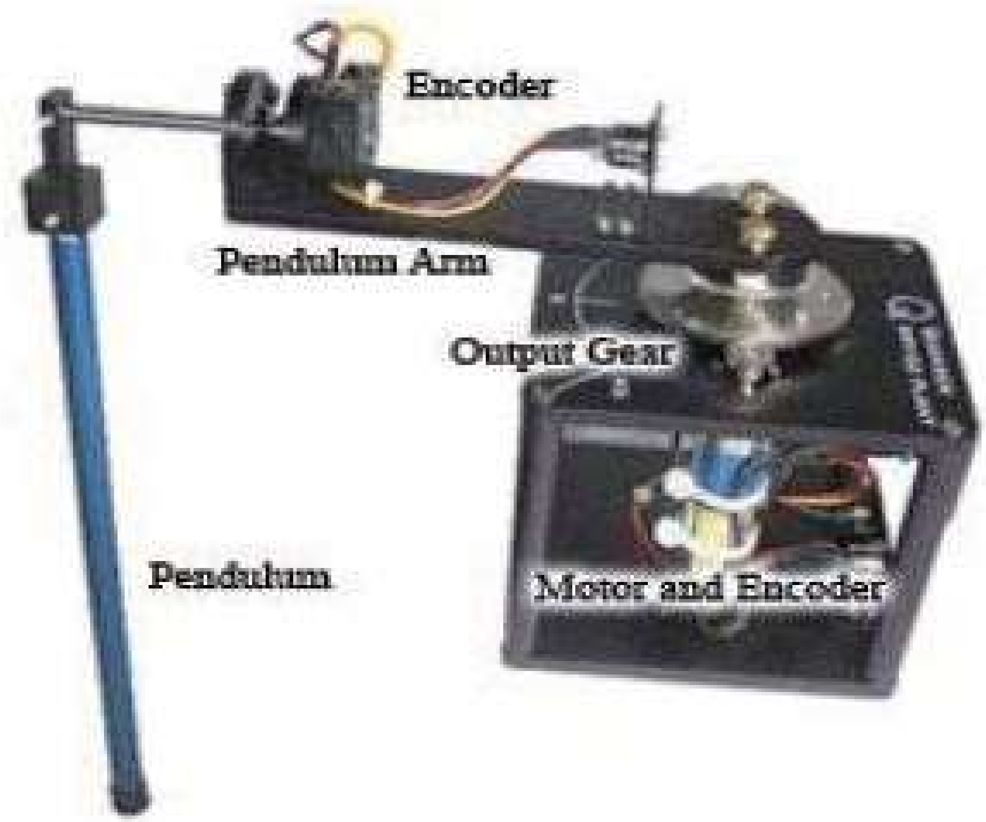
In Real Lab Exercise

MATLAB Simulink interfacing with the Servo-Pendulum system kit

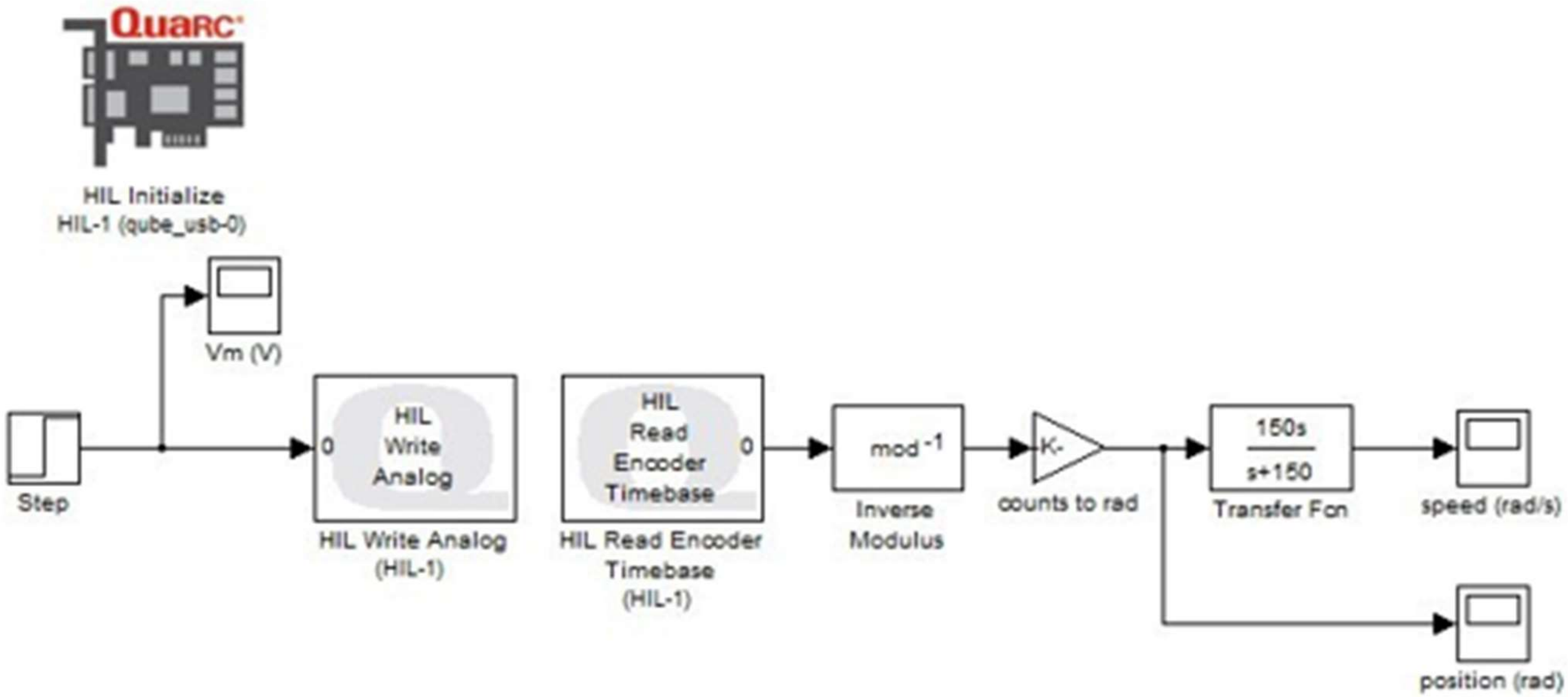
In Virtual Lab Exercise

MATLAB Simulink model and stability analysis in simulation environment

Real SERVO-PENDULUM system



Hardware-MATLAB interfacing in real lab: Design a Simulink model that applies a step voltage (DC) of 1V to the motor and reads the servo velocity and the position as shown in the figure below,



Work to be done for online/virtual lab:

Sec A. LINEARIZED 1^{ST} ORDER DYNAMIC MODEL OF DC SERVO AND PENDULUM

- Open-loop position and speed response of a servo motor.

➢Voltage-to-speed transfer function is: $P(s) = \frac{\Omega_m(s)}{V_m(s)} = \frac{K}{\tau s + 1}$ ....(i)

➢Voltage-to-position process transfer function is the same as above with an integrator in series: $$P(s) = \frac{\Theta_m(s)}{V_m(s)} = \frac{K}{s(\tau s + 1)}$$ ....(ii)

the model steady-state gain, K = 23.0 rad/(V-s) and

the model time constant, τ = 0.13 sec.

*Build a MATLAB Simulink model for the above dynamic system (ii) and check its response under unit step input (DC voltage, 1V)

The following assumptions are important in modeling of the system:

1) The system starts in a state of equilibrium meaning that the initial conditions are therefore assumed to be zero.

2) The pendulum does not move more than a few degrees away from the vertical to satisfy a linear model.

3) A small disturbance can be applied on the pendulum.

Sec. B. STABILITY ANALYSIS

➢ **Topics Covered**

- Stable, marginally stable, and unstable systems.
- Open-loop position and speed response of a servo.

Definition for Bounded-Input Bounded-Output (BIBO) stability:

- A system is stable if every bounded input yields a bounded output
- A system is unstable if any bounded input yields a unbounded output.

The stability of a system can be determined from its poles:

- Stable systems have poles only in the left-hand side of 'S' plane
- Unstable systems have at least one pole in the right-hand side of 'S' plane
- Marginally stable systems have one pole on the imaginary axis and the other poles in the left-hand side of 'S' plane

- Determine the stability of the voltage-to-position servo system from its poles based on the process transfer function given in equation is

$$P(s) = \frac{\Theta_m(s)}{V_m(s)} = \frac{K}{s(\tau s + 1)}$$

- (K = 23.0 rad/(V-s) is and τ = 0.13 sec)

- The poles are located at,

$$\begin{aligned} s(\tau s + 1) &= 0 \\ s &= \left\{0, -\frac{1}{\tau}\right\} = \{0, -7.69\}. \end{aligned}$$

**Since there is one pole in the negative real part of 'S' plane and one pole on the origin, the system is considered as stable.

You have to validate this statement by MATLAB code as an exercise.

Hint: A = tf ([23], [0.13 1 0])

pzmap(A)