Control Systems Lab
(Experiment – 9: BALANCE CONTROL)

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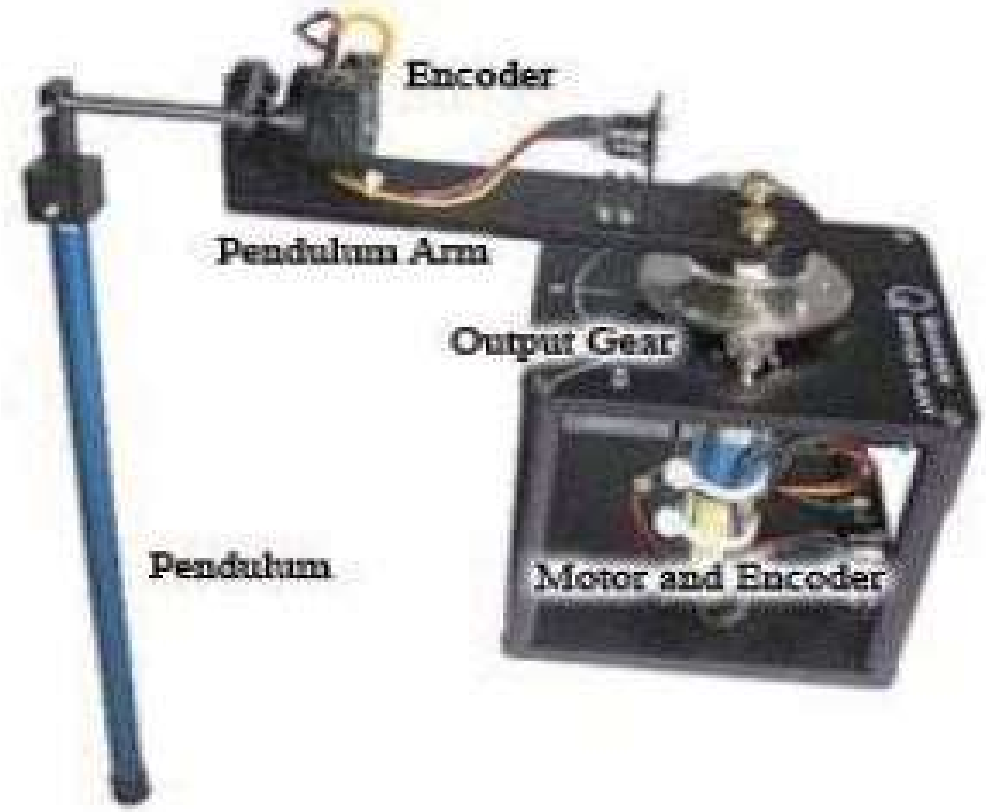
In Real Lab Exercise

MATLAB Simulink interfacing with the Servo-Pendulum system kit

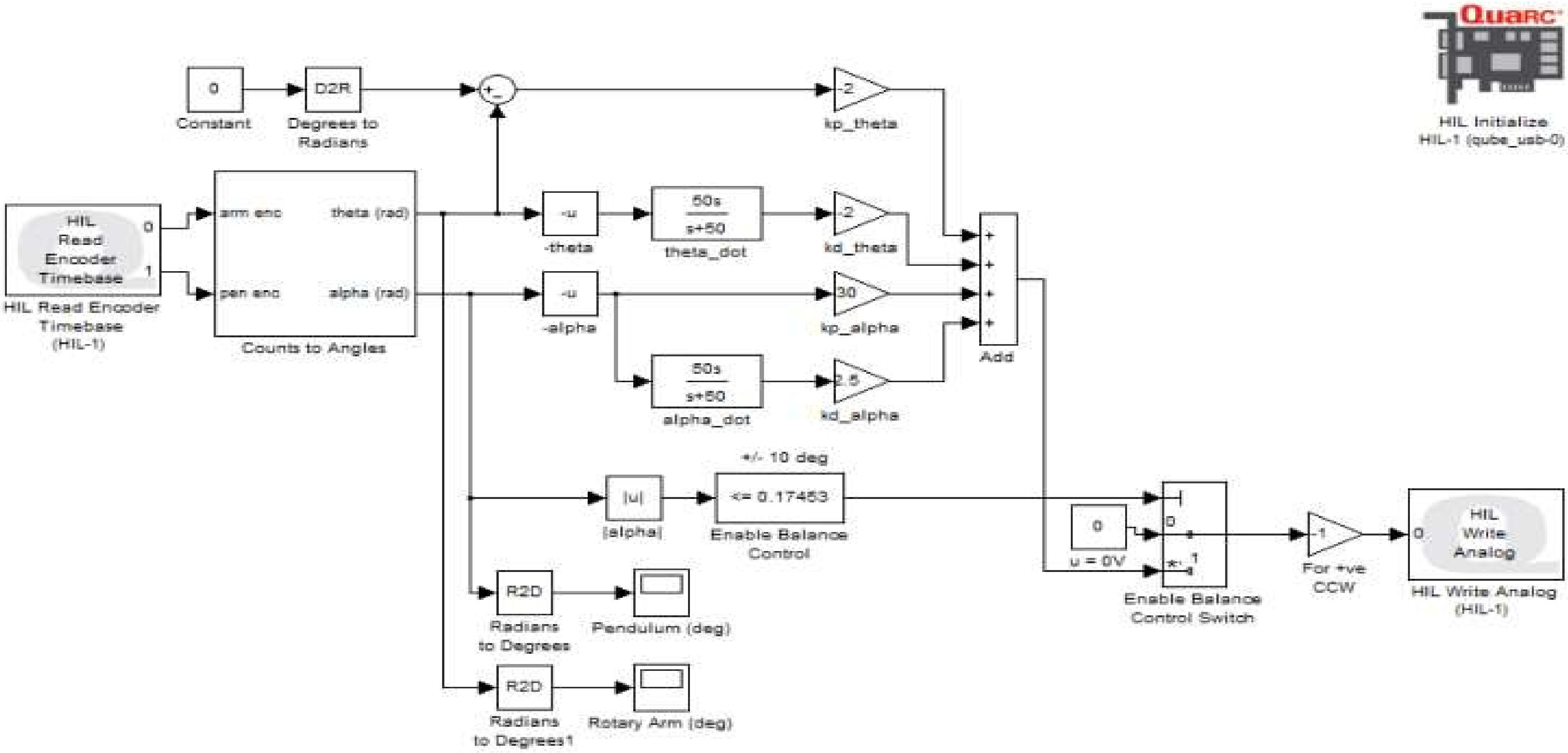
In Virtual Lab Exercise

MATLAB Simulink model and balance control in simulation environment

Real SERVO-PENDULUM system



Hardware-MATLAB interfacing in real lab:



Work to be done for online/virtual lab:

Sec A. LINEARIZED 1ST 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:

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

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

the model time constant, τ = 0.13 sec.

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.

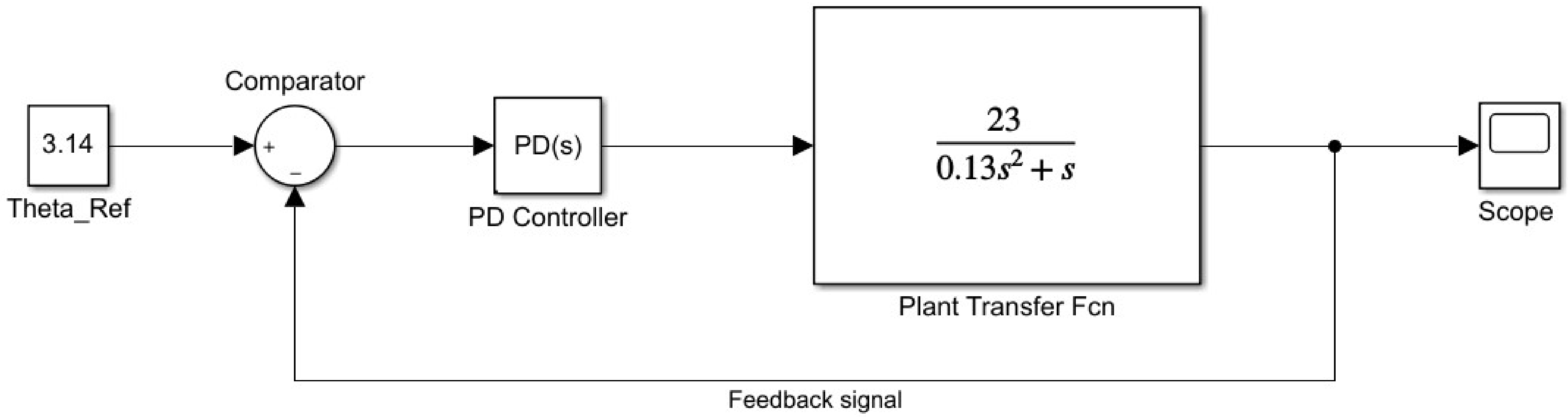
Sec B. PD Controller based balance control

For controlling the balance of the servo-pendulum system,

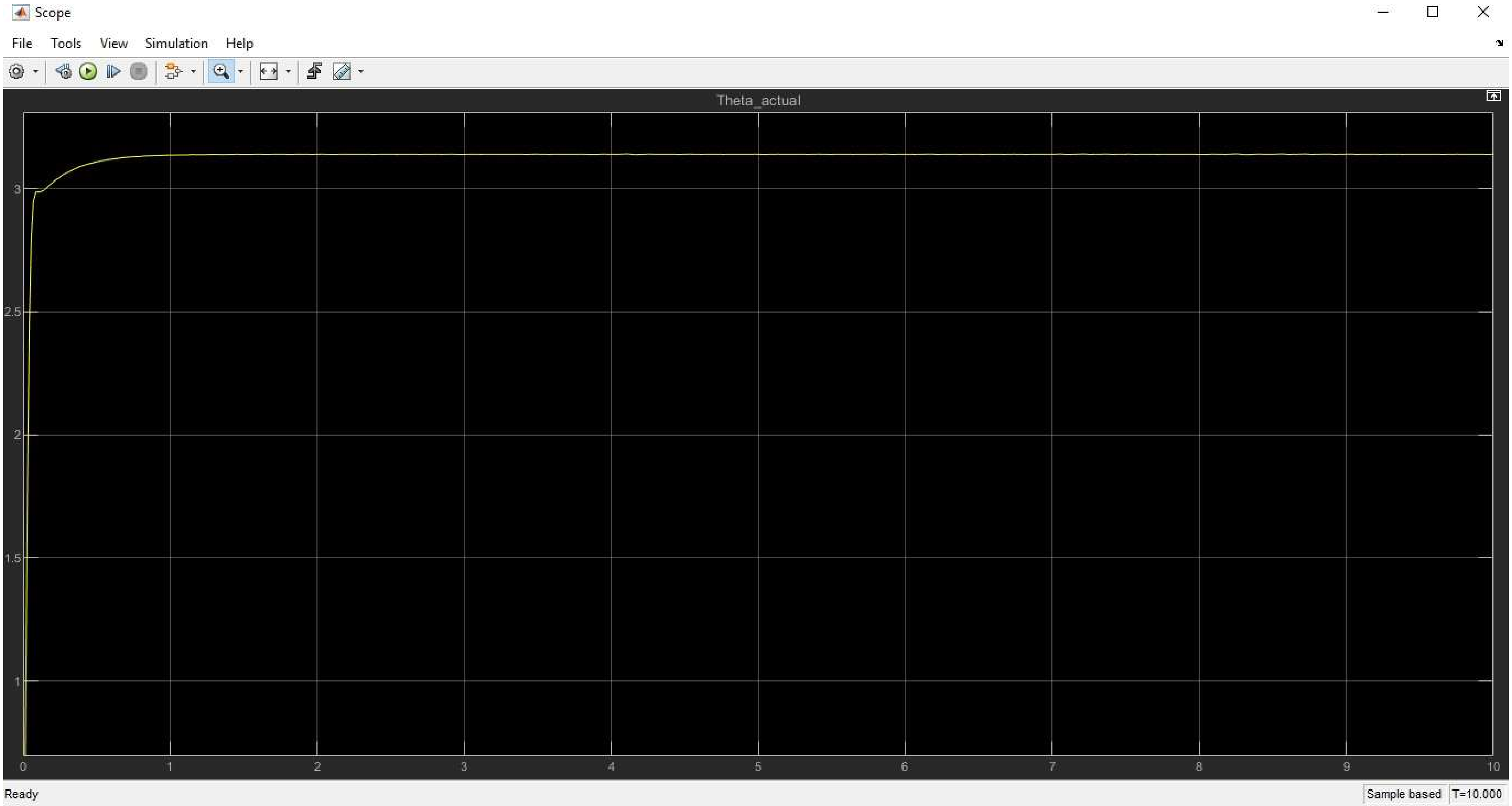
Feedback control system is required:

Reference Angular position Theta_ref = 3.14 radian, (Assuming the Inverted Pendulum shifts upward (180 Degree) from the initial downward position (0 degree), 180 deg. = 3.14 radian)

PD controller, Kp = 1, Kd= 0.2 (After tuning) in MATLAB/Simulink, observe Theta_actual



Simulation result for balancing system using PD controller



“Zoomed in” response (tracking the reference position Theta_ref =3.14 rad.)