

# Ball and Beam



The Quanser Ball and Beam module consists of a track on which the metal ball is free to roll. The track is fitted with a linear transducer to measure the position of the ball, i.e. it outputs a voltage signal proportional to the position of the ball. One side of the beam is attached to a lever arm that can be coupled to the load gear of the Quanser SRV02 unit. By controlling the position of the servo, the beam angle can be adjusted to balance the ball to a desired position. This objective is achieved by using two PD controllers in a cascade control system.

## Specifications

**Servo load shaft position**

$$M_p \leq 5\%$$

$$t_p \leq 0.15s$$

$$e_{ss} = 0$$

**Ball position**

$$M_p \leq 10\%$$

$$t_s^{4\%} \leq 3.5s$$

$$|e_{ss}| \leq 5mm$$

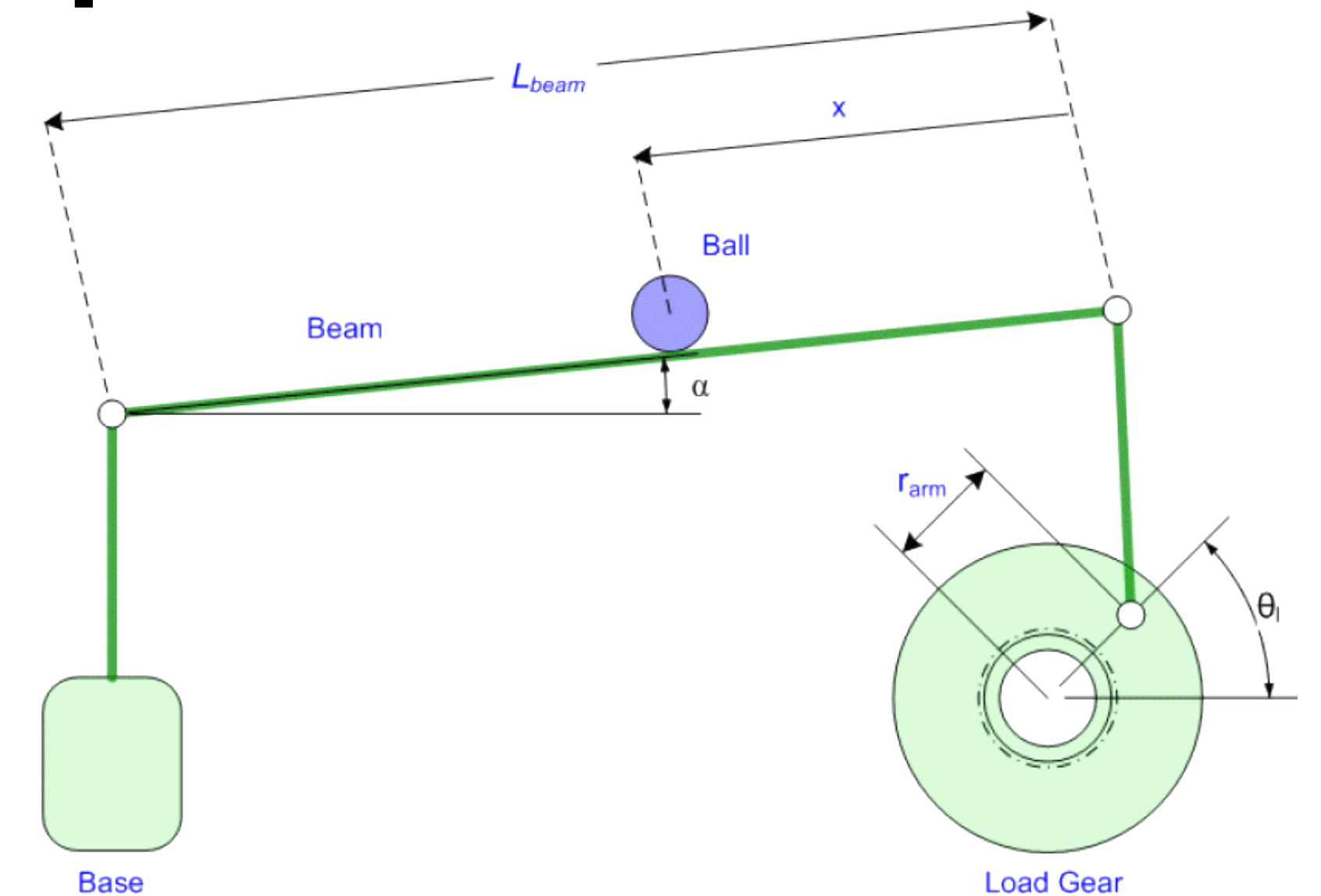
Damping ratio:  $\zeta = 0.69$

Natural frequency:  $\omega_n = 28.9 s^{-1}$

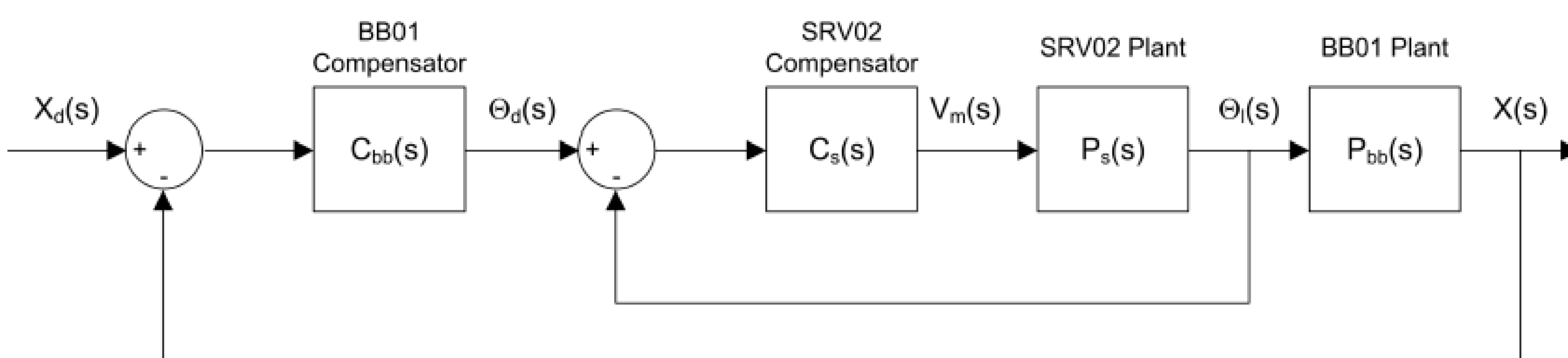
Damping ratio:  $\zeta = 0.59$

Natural frequency:  $\omega_n = 1.66 s^{-1}$

## Experiment schematics



## Cascade control



$$C_{bb}(s) = K_c(s + z) = 4.68(s + 1.41)$$

**SRV02 Servo Transfer Function**

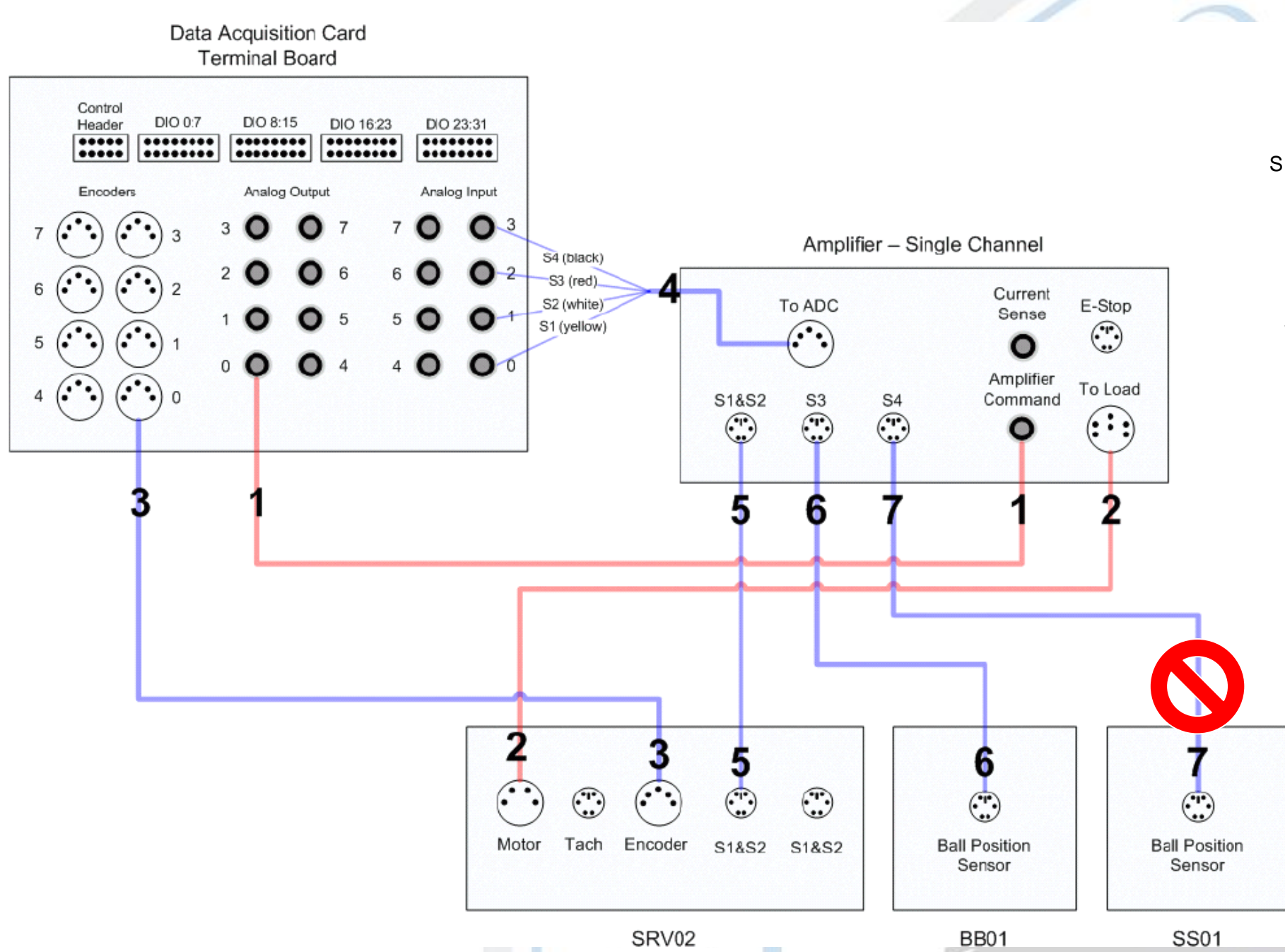
$$P_s(s) = \frac{\Theta_l(s)}{V_m(s)} = \frac{K}{s(\tau s + 1)} = \frac{1.76}{s(0.0285s + 1)}$$

**Ball Balancer Transfer Function**

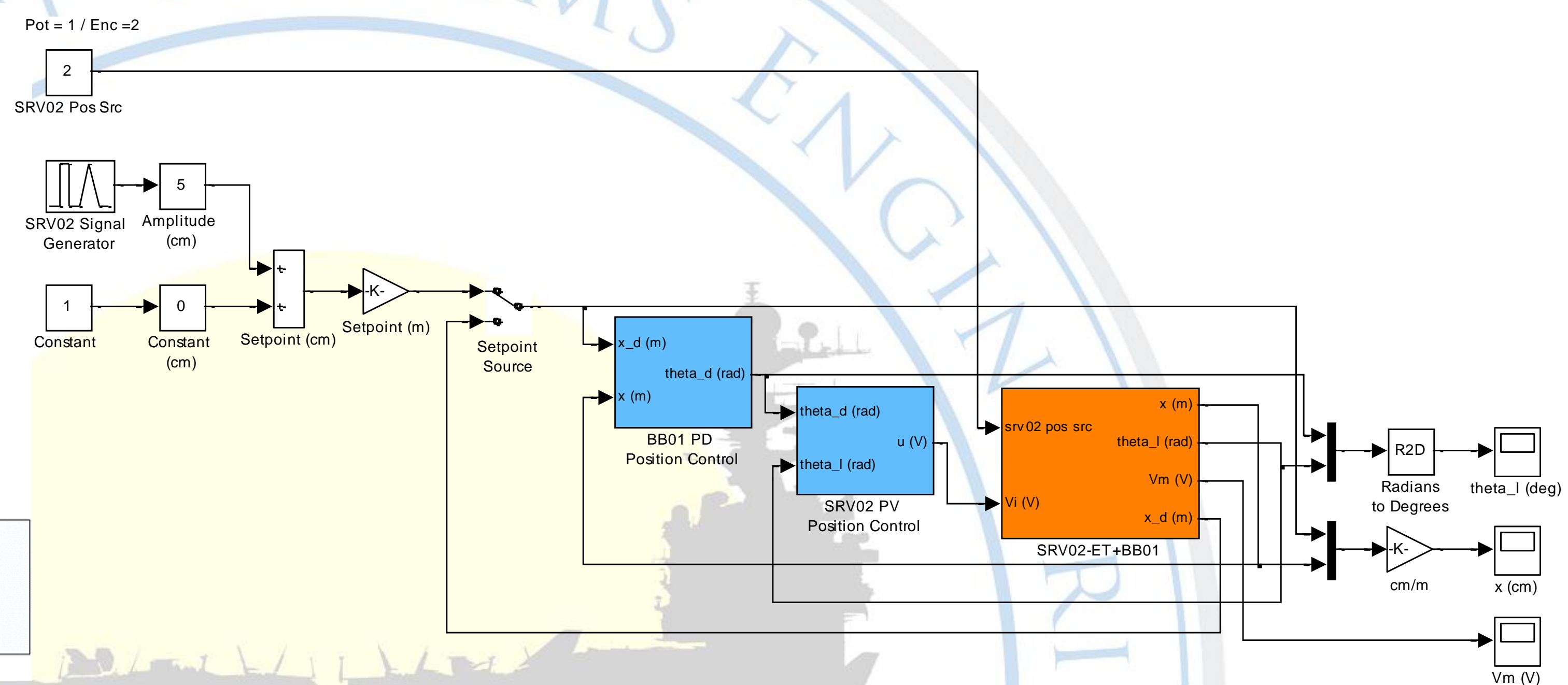
$$P_{bb}(s) = \frac{X(s)}{\Theta_l(s)} = \frac{K_{bb}}{s^2} = \frac{0.419}{s^2}$$

$$C_s(s) = K_c(s + z) = 0.078(s + 173)$$

## Wiring diagram



## Simulink block diagram



## Applications



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