ECE 461 Handout #27

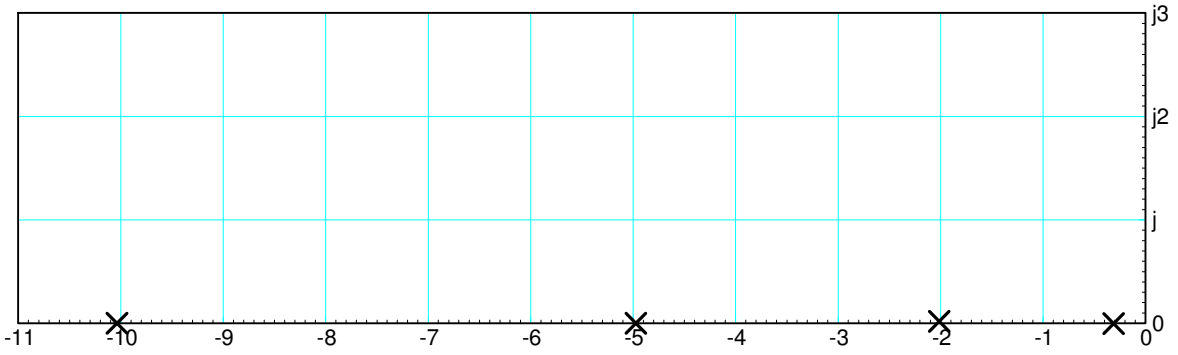
Systems with Delays

Design a gain compensator, K(s), so that the following system with a 100ms delay has

$$G(s) = \left(\frac{100}{(s+0.3)(s+2)(s+5)(s+10)} \right) e^{-0.2s}$$

to meet the following requirements:

- No error for a step input
- 2% settling time = 4 seconds
- Damping ratio = 0.707 (45 degrees)



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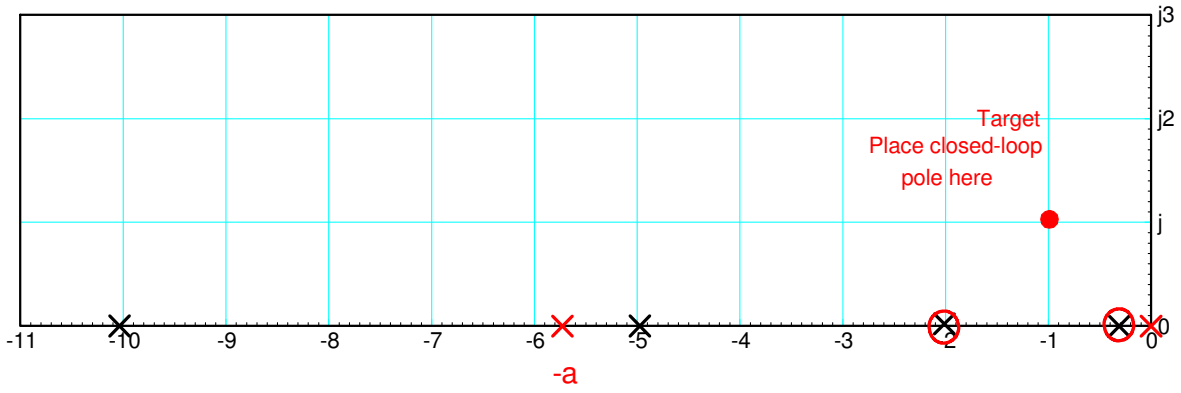
Translating the specs:

- Make it a type-1 system
- Place the closed-loop dominant pole at s = -1 + j1

Let

$$K(s) = k\left(\frac{(s+0.3)(s+2)}{s(s+a)}\right)$$



$$GK = \left(\frac{100k}{s(s+5)(s+10)(s+a)}\right) e^{-0.2s}$$

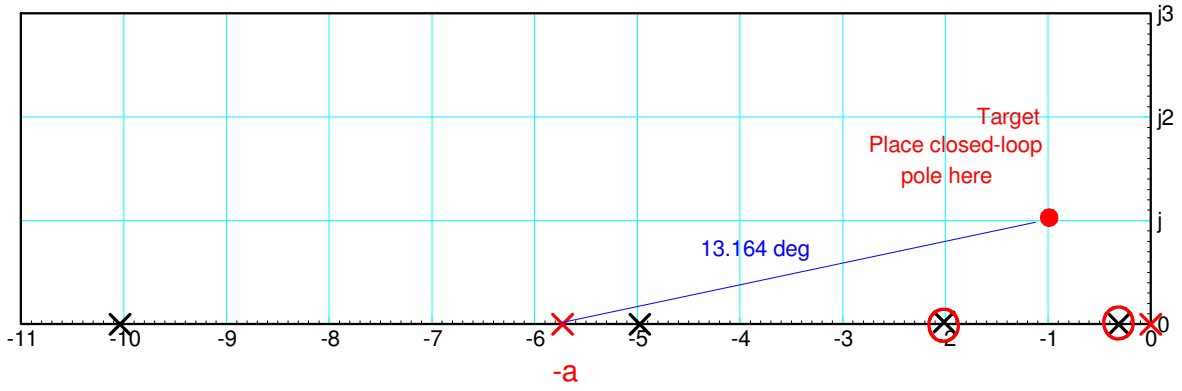
Evaluate what you know at s = -1 + j1

$$\left(\left(\frac{100}{s(s+5)(s+10)}\right) e^{-0.2s}\right)_{s=-1+j1} = 2.313\angle -166.836^0$$

To make the angle add up to -180 degrees

$$\angle(s+a) = 13.164^0$$

$$a = 1 + \frac{1}{\tan\left(13.164^0\right)} = 5.275$$



So now...

$$GK = \left(\left(\frac{100k}{s(s+5)(s+5.275)(s+10)}\right)e^{-0.2s}\right)_{s=-1+j1} = 0.527k\angle 180^0$$

$$k = \frac{1}{0.527} = 1.898$$

giving

$$K(s) = \left(\frac{1.898(s+0.3)(s+2)}{s(s+5.275)}\right)$$