

Homework #6: ECE 461/661

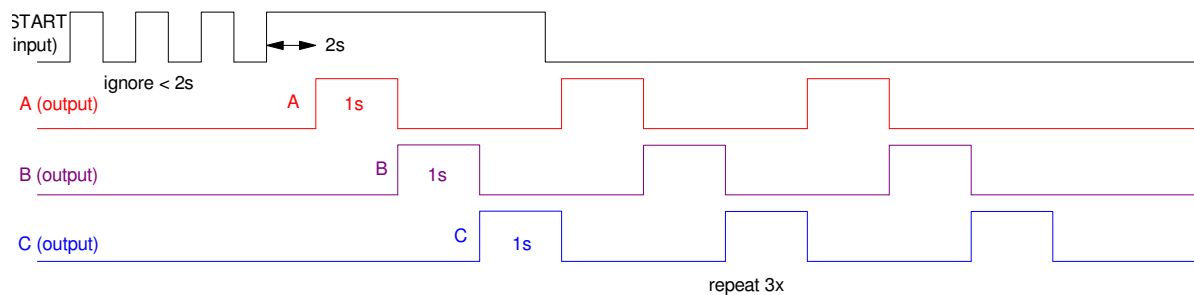
Counter Blocks, Sketching a Root Locus Plot

Ladder Logic & Counter Blocks

Write a ladder-logic program which uses timer blocks to implement a watering system

- In order to start operation, the START button has to be held down for 2 seconds.
- Once started, a counter is cleared, sprinkler A turns on for 1 second, and then turns off.
- When A turns off, sprinkler B turns on for 1 second then turns off.
- When B turns off, sprinkler C turns on for 1 second then turns off.

The process then repeats three times using a counter block. After three cycles, the process stops.

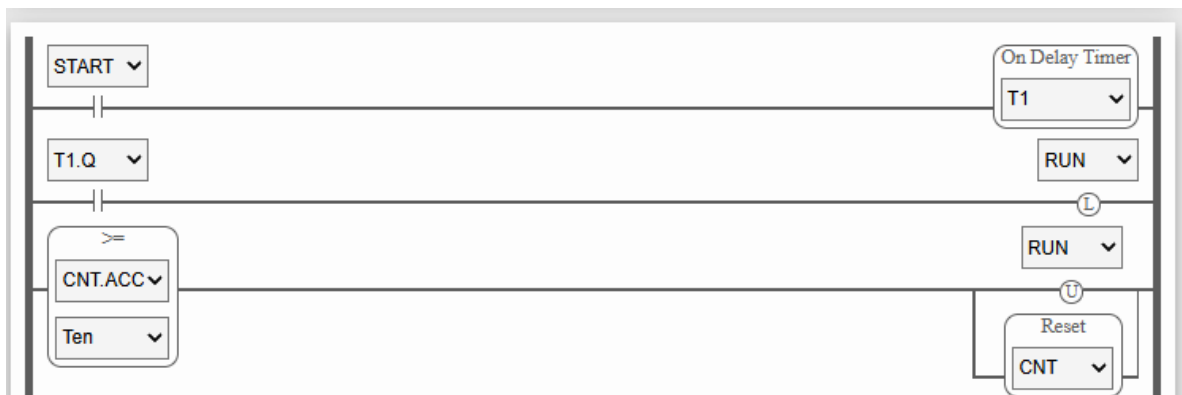


1) Write a ladder logic program using timer blocks to implement this watering system

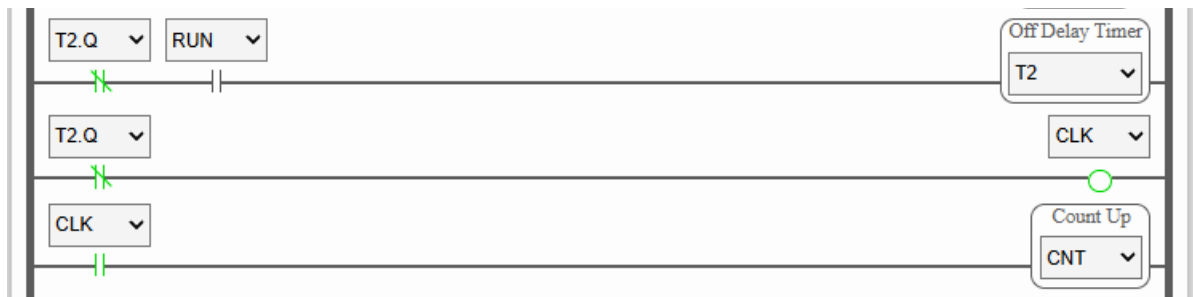
- Your pick which program
- Code Composer Workbench or PLC Fiddle recommended

Rung 1-2: When START is held down for 2 seconds, the variable RUN is set.

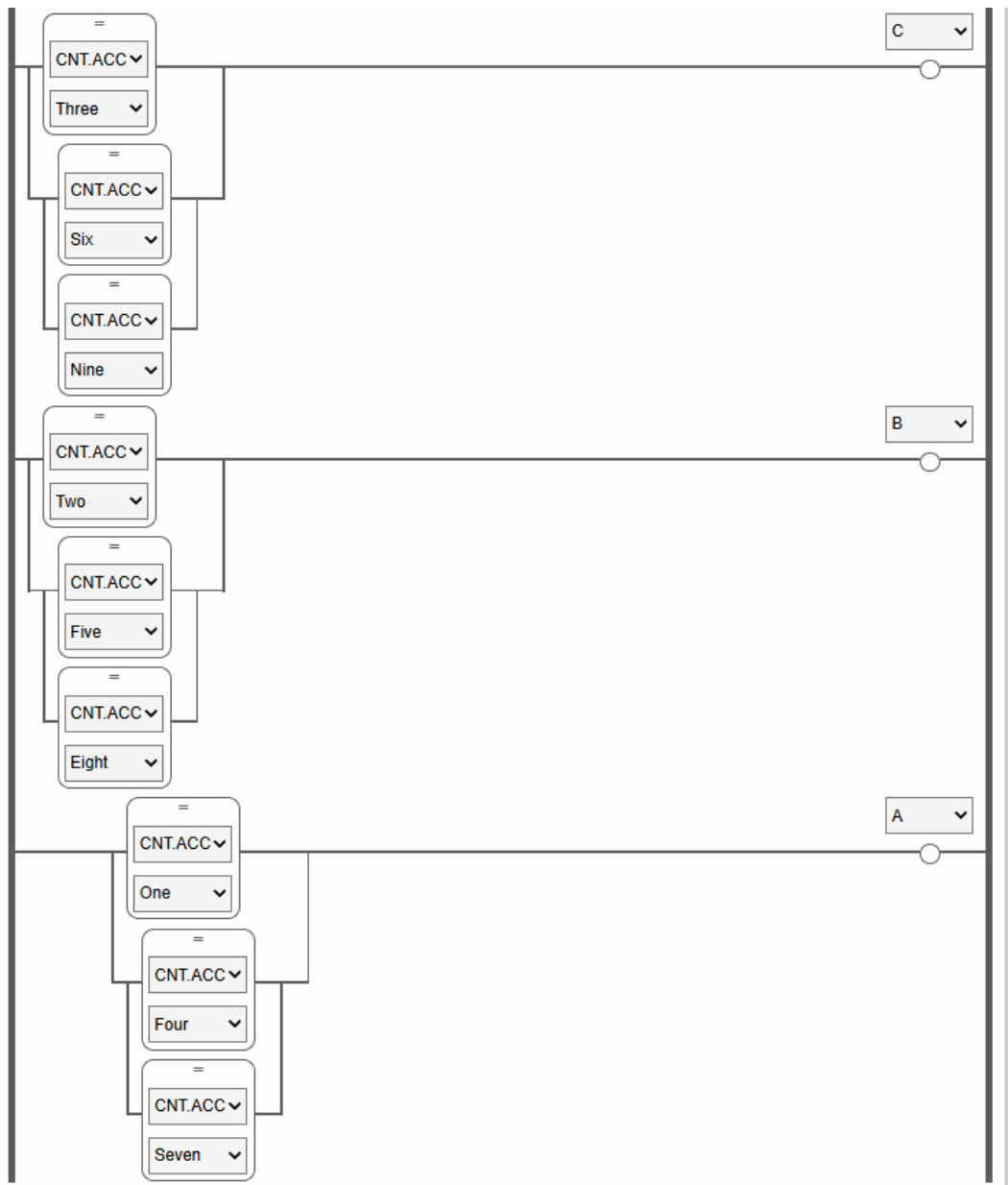
Rung 3: When the count gets to ten, the process stops (RUN is cleared, the counter resets to zero)



Rung 4-6: When running, CLK tics every 1.000 second.
Each time the clock tics, the counter counts up



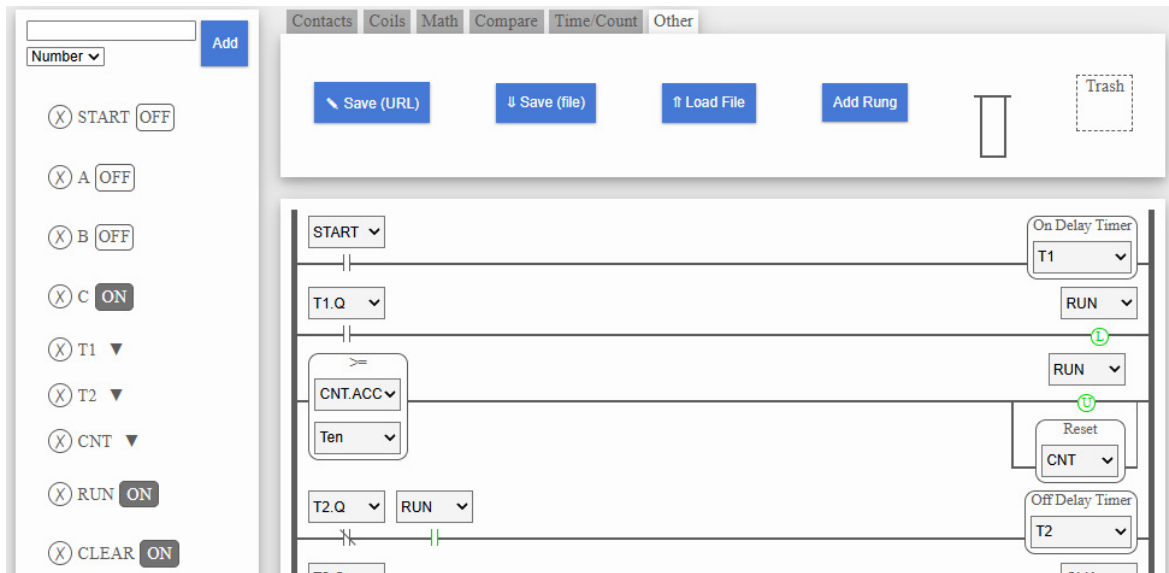
Rung 7-10: Turn on the lights at the corresponding times in the count (1, 4, 7 = A, etc)



2) Verify your code's operation

- Button presses less than 2 seconds are ignored

- Once started, the process continues turning on all three outputs, one at a time



3) Demonstrate your ladder logic program

- In-person
- Make a short video
- Over zoom

shows better in the video

Sketching a Root Locus Plot with Real Poles

4) Draw the root locus for the following system

$$G(s) = \left(\frac{2}{(s+1)(s+3)(s+7)(s+10)} \right)$$

Calculate and show the following on your root-locus plot

The real axis loci

- (-1, -3), (-7, -10)

The asymptotes (number, intersect, angles)

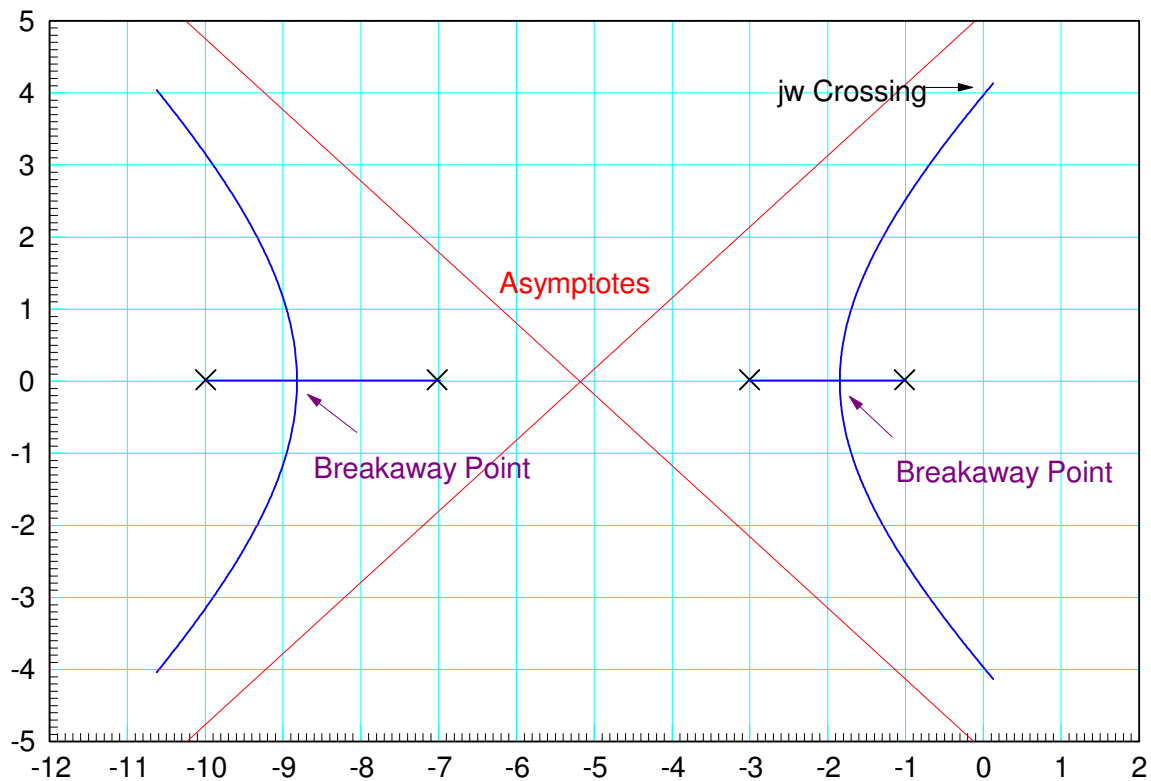
- Four asymptotes
- +/- 45 degrees, +/- 135 degrees,
- Asymptote intersect = -5.25

The breakaway points (estimate is OK)

- $s = -1.8439$ *found using numeric methods*
- $s = -8.8397$ *found using numeric methods*

The jw crossing

- $s = j3.9701$ *found using numeric methods*



5) Draw the root locus for the following system

$$G(s) = \left(\frac{2(s+1)}{(s-1)(s+2)(s+5)(s+7)} \right)$$

Calculate and show the following on your root-locus plot

The real axis loci

- (+1, -1), (-2, -5), (-7, -inf)

The asymptotes (number, intersect, angles)

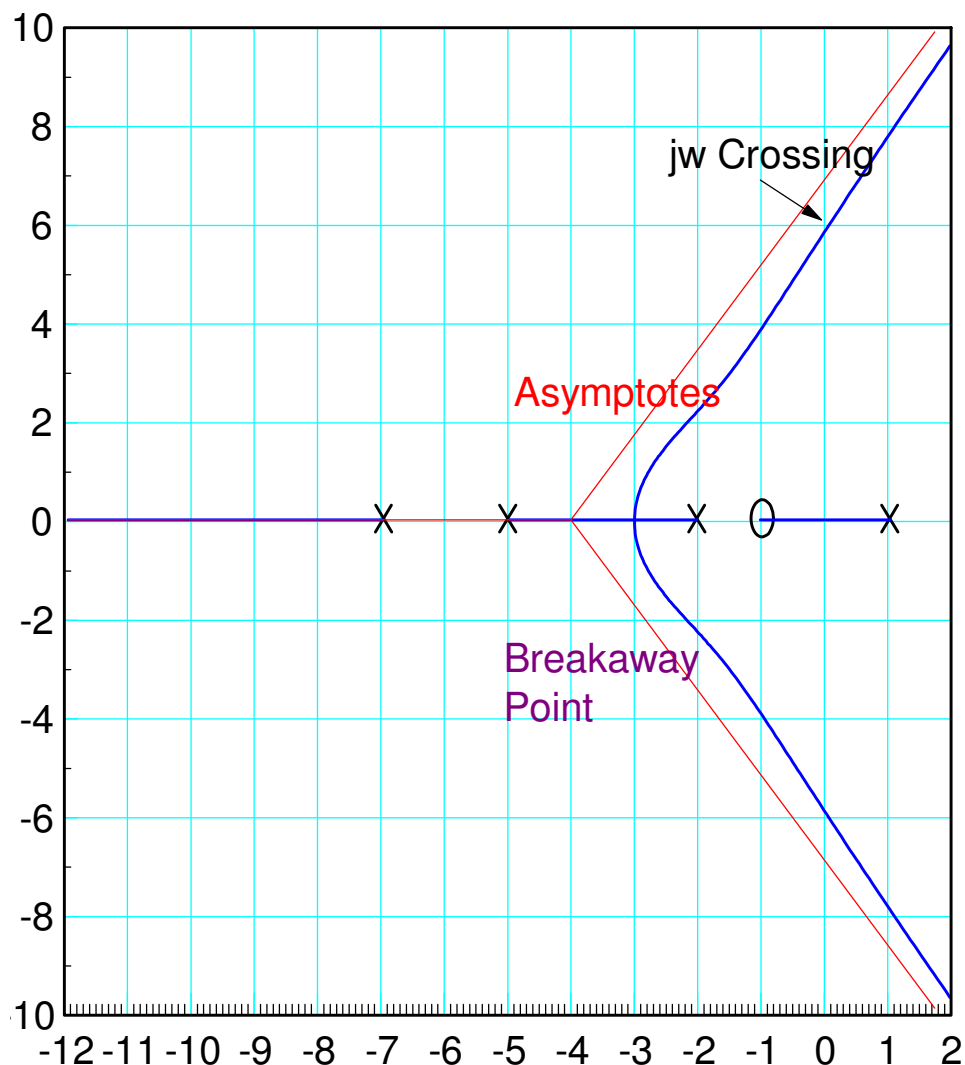
- Three (4 poles - 1 zero)
- +/- 60 degrees, 180 degrees
- Intersect = -4.000

The breakaway points (estimate is OK)

- $s = -2.9978$

The jw crossing

- $s = 0, j5.8615$



Sketching a Root Locus with Complex Poles & Zeros

6) Draw the root locus for the following system

$$G(s) = \left(\frac{100(s+3j)(s-3j)}{s(s+4)(s+2+2j)(s+2-2j)} \right)$$

Calculate and show the following on your root-locus plot

The real axis loci: (0, -4)

The breakaway point: $s = -1.0661$

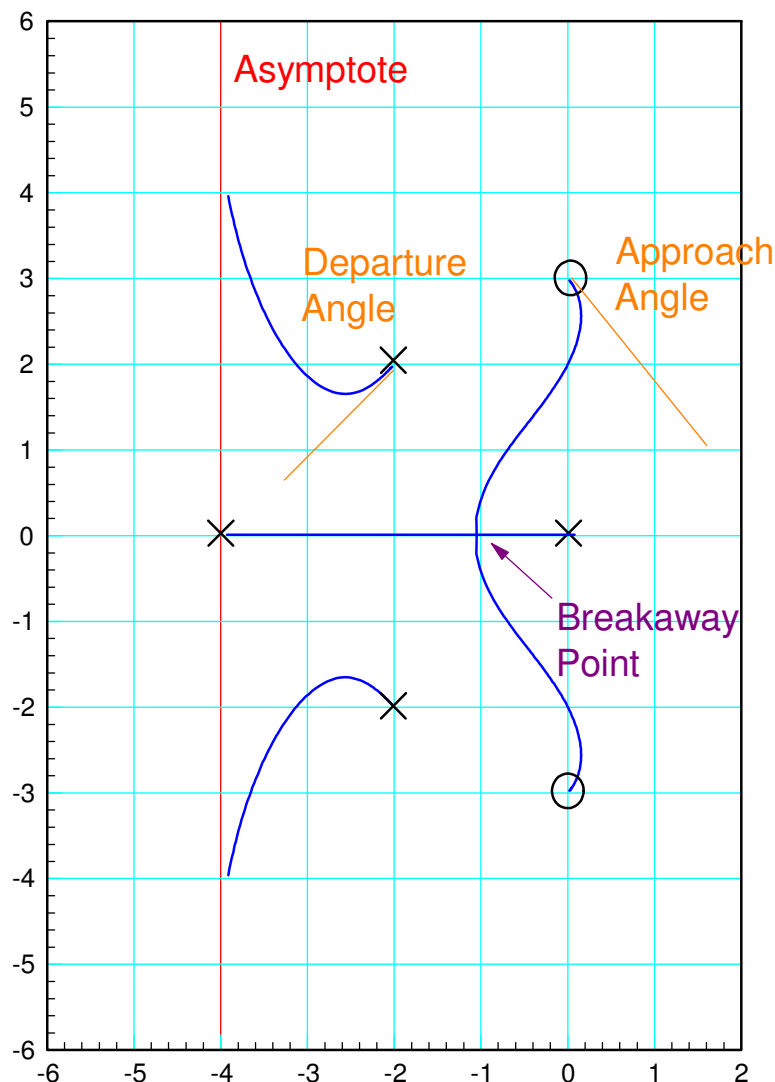
The jw crossing: $s = j2.0000$

The asymptotes (number, intersect, angles)

- Two asymptotes, ± 90 degrees, Asymptote Intersect = -4

The departure angle: -131.62 degrees

The approach angle: -48.37 degrees



7) Draw the root locus for the following system

$$G(s) = \left(\frac{10(s+1+3j)(s+1-3j)}{s(s+0.5)(s+2+2j)(s+2-2j)} \right)$$

Calculate and show the following on your root-locus plot

The real axis loci

- (0, -0.5)

The asymptotes

- Two
- +/- 90 degrees
- Intersect: -1.25
- (number, intersect, angles)

The breakaway points

- $s = -0.2378$

The jw crossing

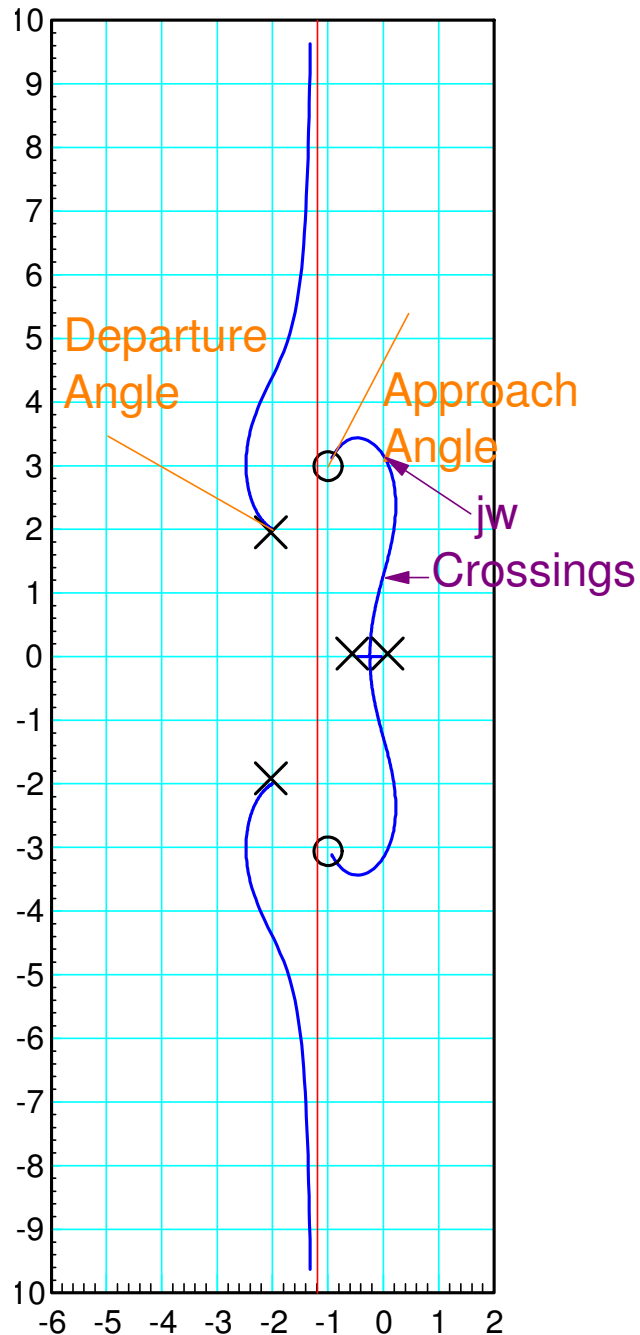
- $s = j1.2649$
- $s = j3.1623$

Departure Angle

- 154.4465 degrees

Approach Angle

- 61.5807 degrees



Note: To find the departure and approach angles, one method is to

- Pick a point ϵ to the right of the complex pole or zero
- Evaluate $G(s)$ at that point
- Find the angle needed to make the total 180 degrees
- Adjust the sign for a pole (negative) or zero (positive)

Note: You can always add or subtract 360 degrees from the answer (+311.63 degrees = -48.37 degrees)

Departure Angle: (problem #7)

```
>> G = zpk([-1+3j, -1-3j], [0, -0.5, -2+2j, -2-2j], 10)

      10 (s^2 + 2s + 10)
-----
s (s+0.5) (s^2 + 4s + 8)

>> s = -2 + 2j + 1e-4;
>> angle(evalfr(G,s)) * 180/pi

ans = -25.5535

>> -180 - ans

ans = -154.4465
```

Since this is a pole, the departure angle is +154.4465 degrees

- When you divide complex numbers, the angle subtracts (hence the minus sign)

Approach Angle (problem #7)

```
>> s = -1 + 3j + 1e-4;
>> angle(evalfr(G,s)) * 180/pi

ans = 118.4193

>> 180 - ans

ans = 61.5807
```

Since this is a zero, you don't need to add a negative sign: the approach angle is +61.5807 degrees.