rlocus.comp Generating the root locus via a computer

Matlab

In Matlab, the command `rlocus` generates a root locus plot from a linear system model object defined by `tf`, `zpk`, or `ss`. The data cursor has particularly useful information associated with it, including the gain required for the closed-loop pole of a given branch to be located at the selected point. Here are a few examples.

Example rlocus.comp–1 re: rlocus using zpk

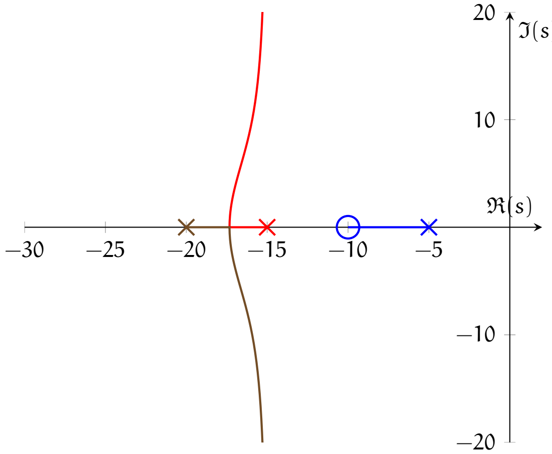
Use Matlab and `zpk` to generate a root locus plot from the open-loop transfer function

$$\frac{s+10}{(s+5)(s+15)(s+20)}.$$

The following code generates the root locus plot.

```
sys=zpk([-10],[-5,-15,-20],1);
figure
rlocus(sys)
```

The figure it generates should look something like the following.



Example rlocus.comp–2 re: rlocus using tf and custom gains

Use Matlab and `tf` to generate a root locus plot from the open-loop transfer function

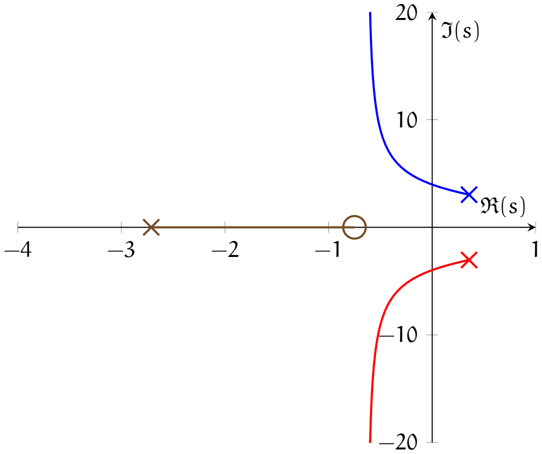
$$\frac{4s+3}{s^3+2s^2+7s+25}.$$

The following code generates the root locus plot.

```
sys=tf([4,3],[1,2,7,25]);
k=sort([3.5,logspace(-1,3,50),Inf
    ]); % custom gains
figure
rlocus(sys,k)
```

Note the use of custom gain values. Sometimes this is useful, especially if a specific gain value or range is important. In the code above, a specific gain of `3.5` is chosen; most gains (50 of them) are generated logarithmically from 10^{-1} to 10^3, `logspace(-1,3,50)`; and the final gain of ∞, `Inf`, is included. The array is sorted such that `3.5` is placed in the correct order in the array.

The figure the code generates should look something like the following.



Python

The following was generated from a Jupyter notebook with the following filename and kernel.

```
notebook filename: python_root_locus.ipynb
notebook kernel: python3
```

We begin with the usual loading of modules.

```
import numpy as np # for numerics
import control as c # the Control Systems module!
import matplotlib.pyplot as plt # for plots!
```

Let's draw the root locus for the transfer function

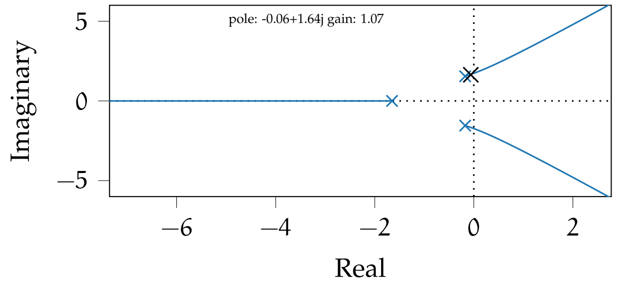
$$\frac{1}{s^3 + 2s^2 + 3s + 4}. \tag{1}$$

Defining a transfer function in Python is straightforward with the Control Systems module (documentation here).

```
transfer_function = c.TransferFunction(1,[1,2,3,4])
```

Now `transfer_function` is a transfer function object. We use the `root_locus` method of the Control Systems module.

```
p1 = c.rlocus(transfer_function) # compute root locus
plt.show() # display the plot
```



Notice that double-clicking the locus yields a data cursor that gives the complex coordinate and corresponding gain! For instance, at the coordinate $-0.10 + j1.61$, the gain is 0.67. Therefore, to place a closed-loop pole at this location, we would choose $K = 0.67$.