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CONTROLLER DESIGN ON MATLAB PLATFORM USING DISCRETE ROOT LOCI

OBJECTIVE

- To study the variations in the sustained oscillation frequency of the CL with the variation in zeroes of OLTF and sensitivity.

THE OLTF AND THE VARIATIONS

The root loci for the Closed Loop transfer function is given as:

$$z^3 + kz^2 + 1.98kz - (k+1)$$

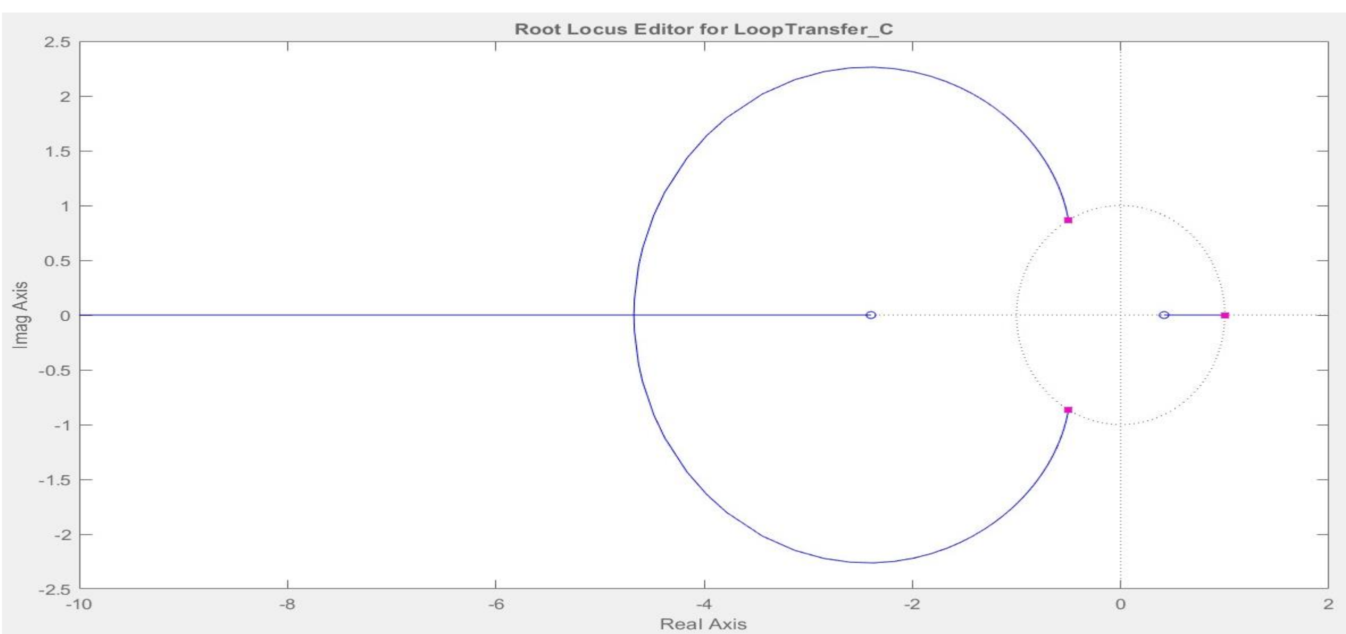
which can be converted to a general OLTF as:

$$k\frac{z^2 + 1.98z - 1}{z^3 - 1}$$

And since there are variations in the zeros of OLTF, they can be modeled by two parameters for zeros, and same as studied considering the variation of one at a time

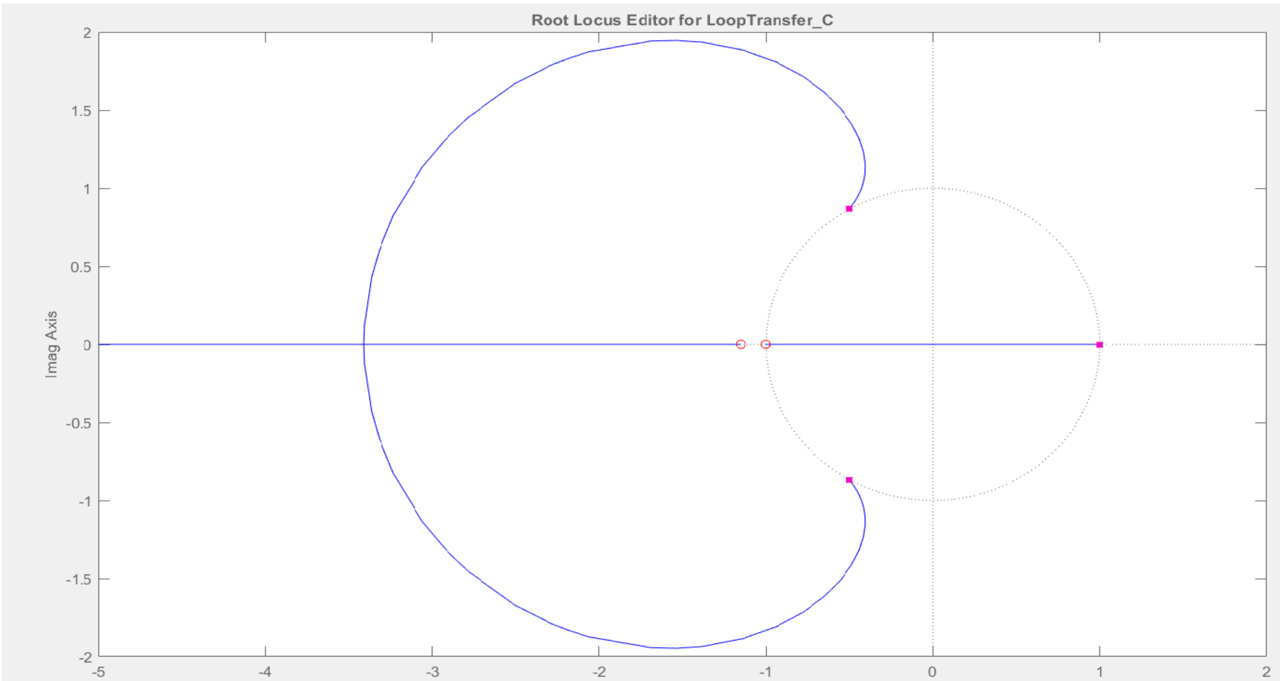
$$k\frac{(z-a)(z-b)}{z^3 - 1}$$

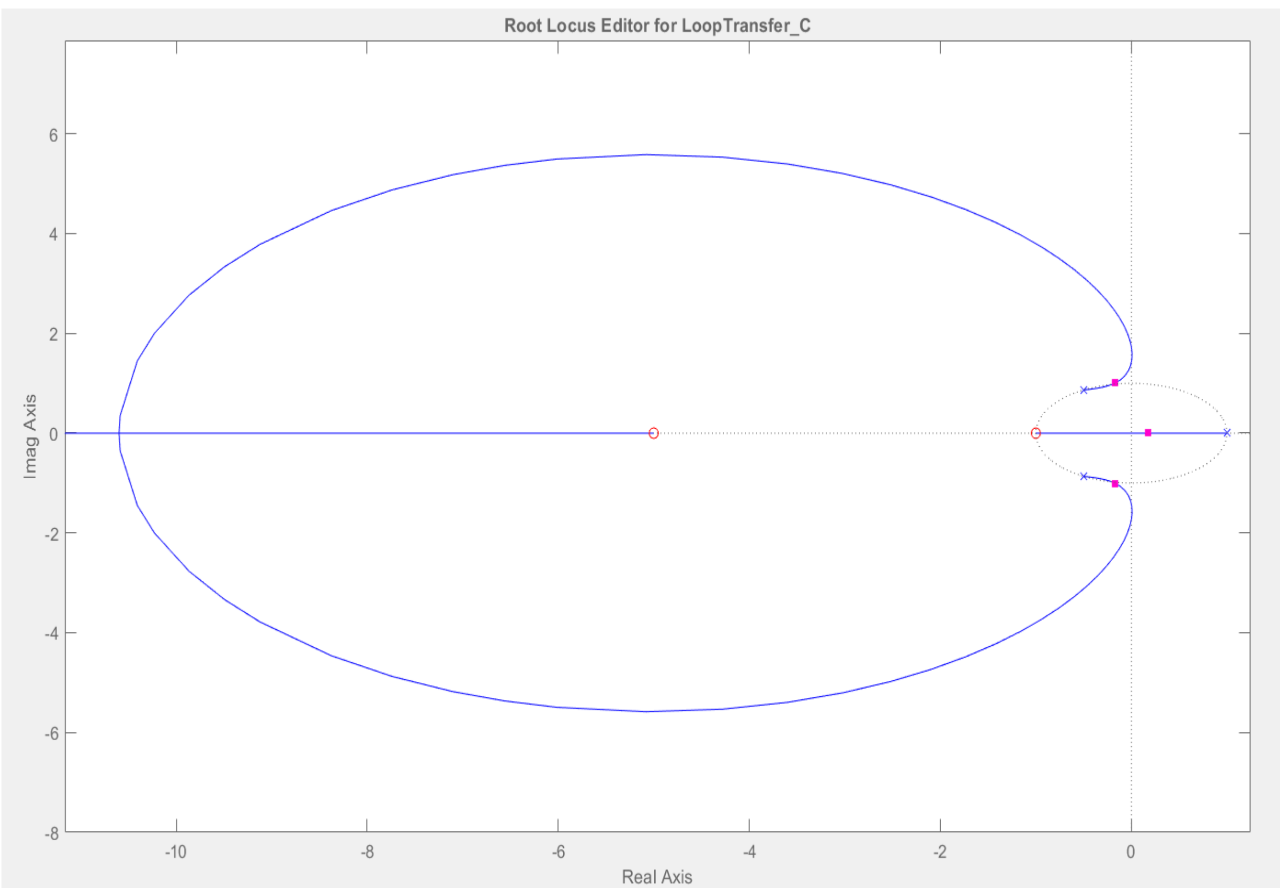
Apart from that, the root loci for OLTF is as shown below (with a natural frequency for sustained oscillations = 2.09rad/sec) :



CHARACTERISING BEHAVIOR THE VARIATION OF ZEROS

It turns out; we can reduce the number of cases made by different sets by careful inspection. Initially, assume that one zero is fixed at -1. Now we would have to consider different possibilities of variation of other zero in regions marked by the unity circle and this zero.

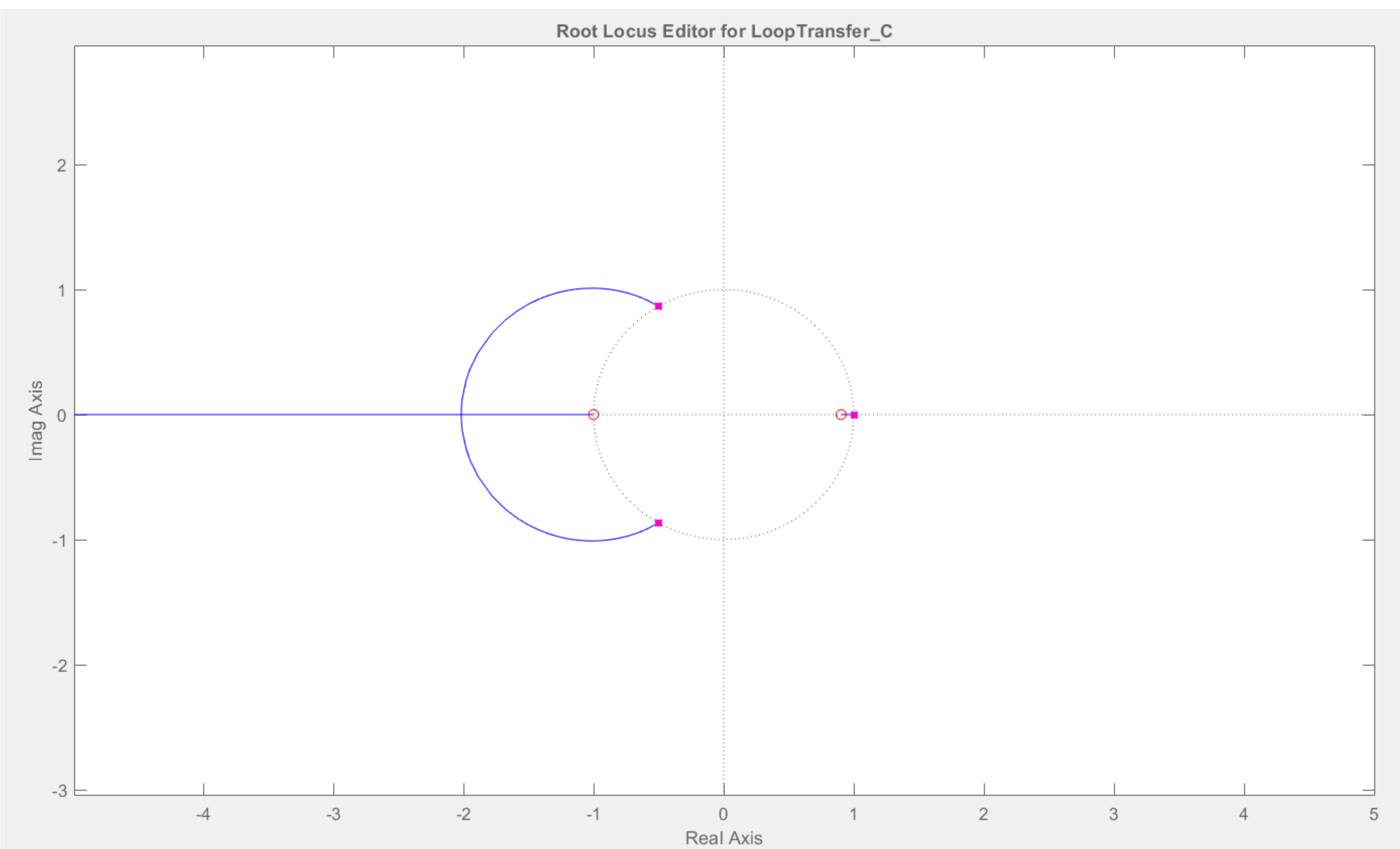




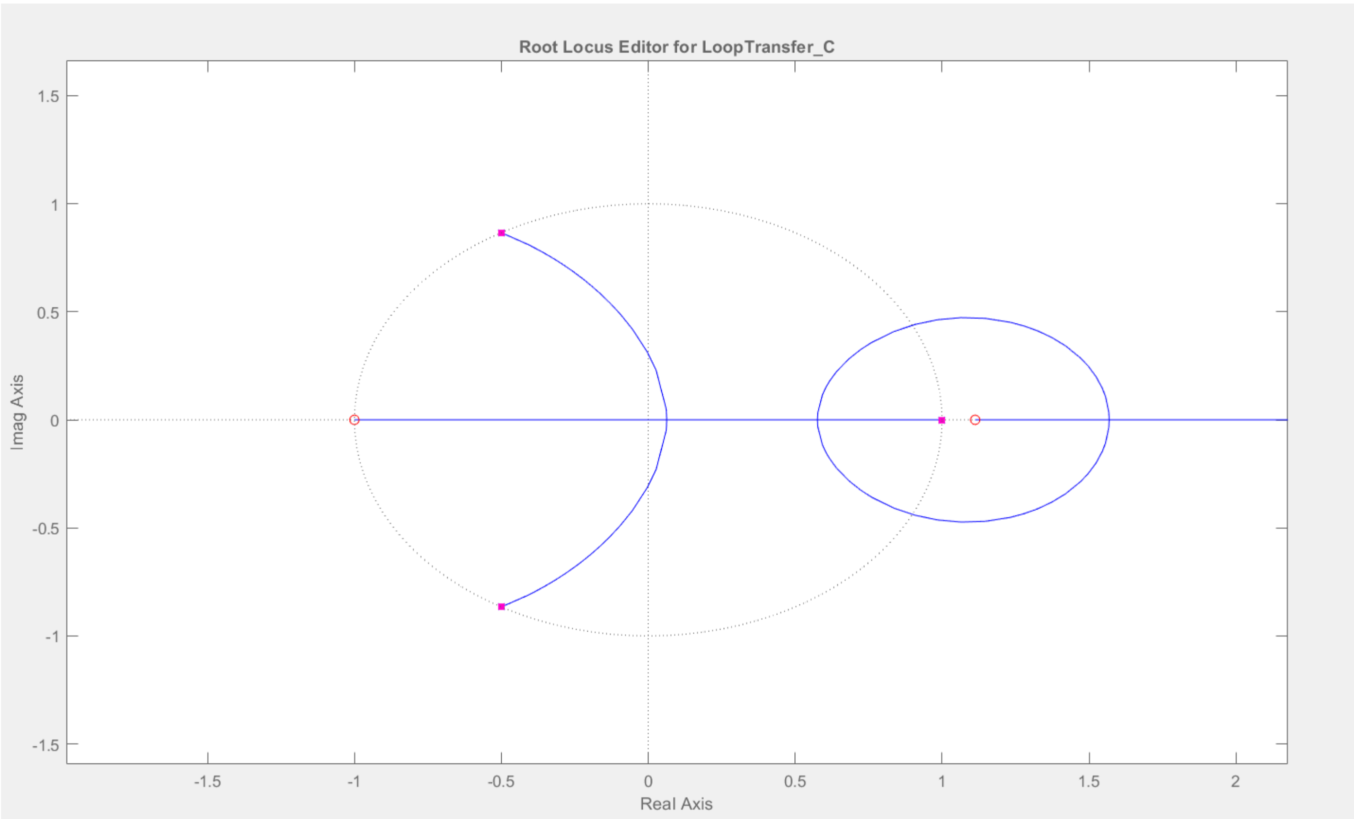
As is visible that for the small values to the left of -1, the natural frequency remains to be the same however as we move on to the larger values for zero, we get certain new frequencies too although not much different from the initial frequency

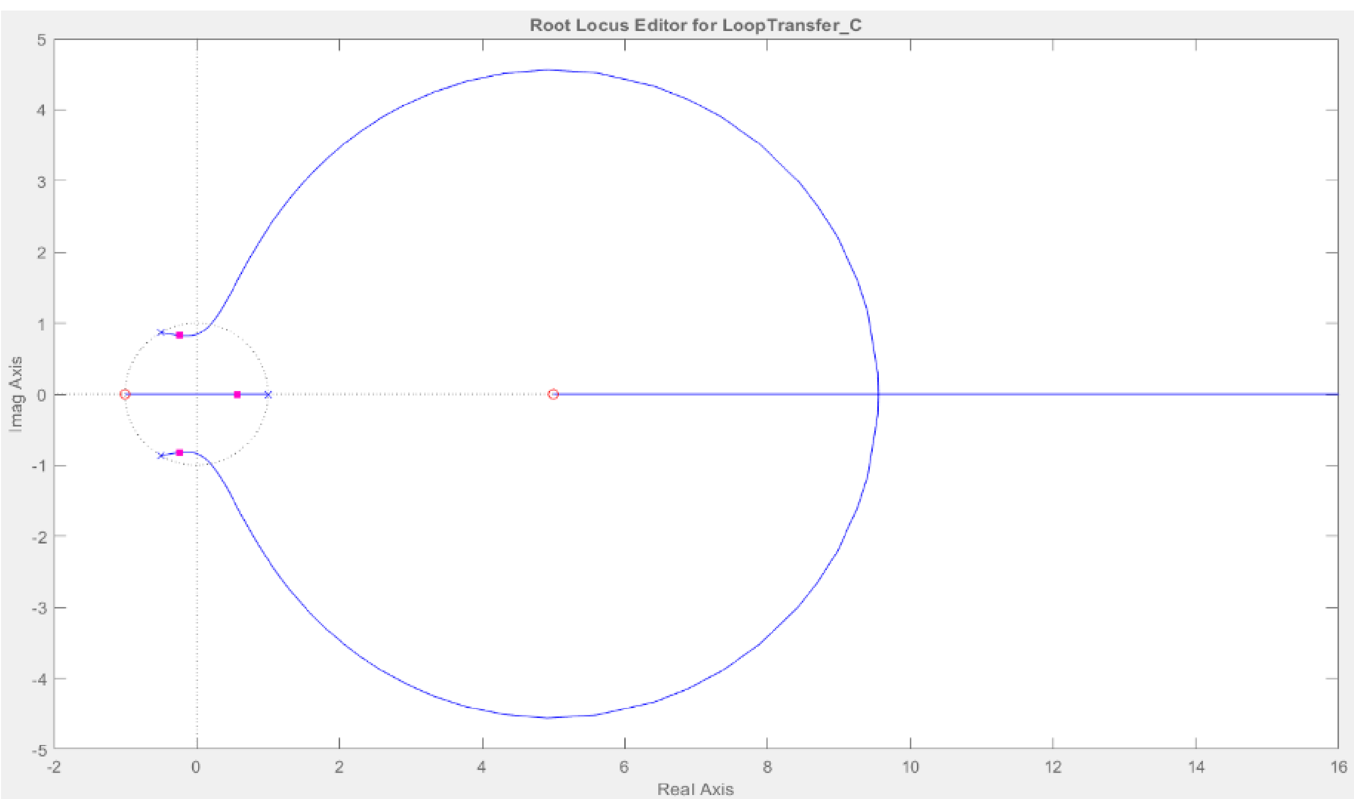
k	Zero location	Frequency (Sustained Oscillations)
0.0098971	-100	1.58
0.016381	-60	1.59
0.047356	-20	1.62
0.088879	-10	1.67
0.14991	-5	1.77
--	-2	--

Now, as the position of zero is taken inside the circle, no change in frequency is observed.



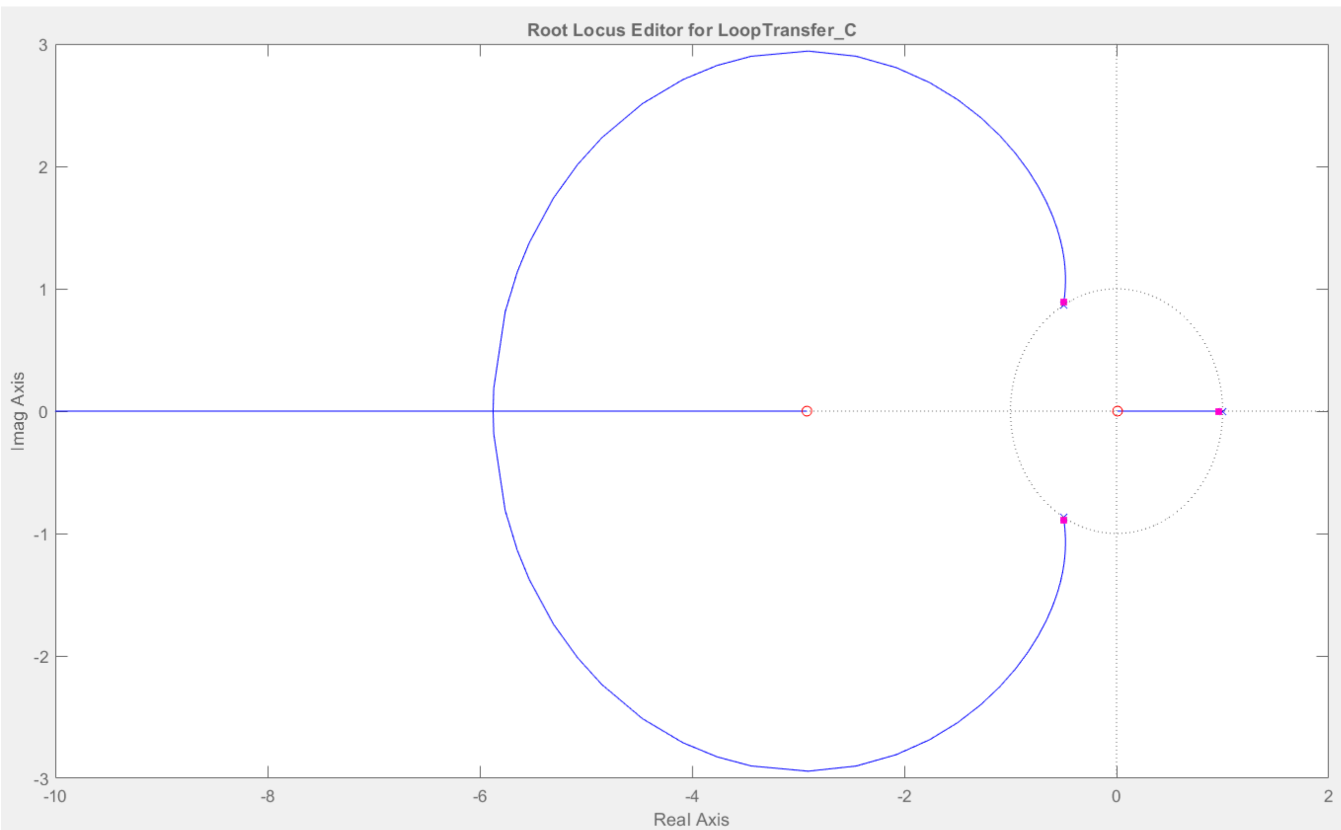
However, as soon as the position of zero goes beyond z = 1, there is a sudden change of behavior primarily because of crossing against the pole which originally was present over there. Their opposite characteristics amplify the behavioral response. Shown below is the response for a few zeros:





k	Zero Position	Frequency (Sustained Oscillations)
-1.482	1.01	0.141
-0.93314	1.5	0.841
-0.233	5	1.37
-0.10895	10	1.47
-0.052274	20	1.52
-0.016962	60	1.55

Now, if we move the position of pole from -1 and try to generalise around it, we notice that as for zeros beyond -1, its behavior is pulled out for the same as z = -1 and around it. And the opposite is true as it moves beyond z=-1



Now to complete the analysis, if we assume the zero to be fixed at z = 1, and move the poles, we realise that there is no change in the behavior of sustained oscillation frequency. Accordingly, changes can be made to manipulate the zeros to achieve the required characteristics.