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Design Project 1—Time Domain

In Case 1, we must stabilize the system with only a PD controller and a lowpass filter. This was an incredibly difficult task. Even using Matlab's automatic PID control tuning, the results are barely acceptable. In order to maintain stability, the gain must be kept very low. With such a low gain, the derivative gain must be turned way up for the controller to settle in a reasonable time.

Ultimately, I accomplished the following results using the transfer function:

with parameters  
k­1=­3.0927 x 10-5  
a­1=2.1 x 103  
b­1=10





Case 2 adds a notch filter. Since most of the natural oscillation of the system occurs at 1 rad/sec, I centered my notch filter there. Once the notch filter was in place, I was able to increase the bandwidth of the controller by increasing the corner frequency of the lowpass filter and increase my derivative gain as well. The resulting system is about two to three times as fast as the PD controller with lowpass filter.

I finally decided on a controller with the transfer function

with parameters  
k­2=2.5 x 10-5  
a­2=1 x 104  
b2=.53   
c­2=1   
d2=1



Case 3 is a very different situation than cases 1 and 2. The introduction of a complex pair of zeroes allows pole-zero cancellation to remove the dominant (1 rad/s) dynamics of the satellite. I canceled out that pole pair with a zero pair, then added four much faster poles at -100. I determined experimentally that my final zero should go at -1.9, and turned up the gain as far as I could. The resulting system is about two orders of magnitude faster than the ones designed in cases 1 and 2, and has much less overshoot.

with parameters  
k3=16  
a­3=1.9  
b3=1   
c­3=.04   
d3=10-4   
e3=.02  
f3=10-4   
g3=.02

