

16.06 Lecture 33

The Gain-Phase Plane and Nichols Charts

November 24, 2003

Today's Topics:

1. OL/CL Calculations
2. The Nichols Chart
3. Examples

Suppose we are interested in the relationship of the closed loop frequency response to the open loop frequency response. We know that for a unity feedback system they are related as follows

And with a little manipulation we can obtain the open loop frequency response as a function of the closed loop response

Then if we define-

and substitute into the expression above, we obtain

Where we have dropped the argument ω from the notation to simplify these expressions.

Finally, we can write expressions for the open loop amplitude and phase in terms of the closed loop amplitude and phase as follows

Using these expressions we can determine the amplitude and phase of the open loop system response that corresponds to the amplitude and phase for the closed loop response. In particular, these expressions result in a very useful figure called the Nichols Chart.

Example-Recall once again the example that Prof, Willcox used to illustrate the design of a phase-lead compensator. The uncompensated and compensated open loop expressions we used in the earlier comparison were-

Plotting these two on the Nichols chart yields-

And as we determined earlier the phase margin of the uncompensated system is ?? degrees and the compensated system has ?? degrees of phase margin, as can be readily determined from the Nichols chart. Furthermore, it is clear that the uncompensated system has a resonant peak of ?? db, while the compensated system peak is only ?? db