Tutorial on Using Excel Spreadsheet to Obtain Bode Plots and Nyquist Plots

(by Tom Co, tbco@mtu.edu , last revision 1/11/2010)

I. Preliminaries:

Given: $G(s)$, a transfer function in Laplace domain

Required: Frequency response plots corresponding to $G(s)$

A. Bode Plots.

- These consist of two plots. The first plot is a plot of log modulus (in decibels) versus frequency. The second plot is the phase shift (in degrees) versus frequency. Both plots usually have the frequency in logarithmic scale.
- Using the given transfer function G(s),

$$\text{Log Modulus} = 20\log\left(\left|G(i\omega)\right|\right)$$

$$\text{Phase Shift} = \phi = \arg\left(G(i\omega)\right)\frac{180°}{\pi}$$

B. Nyquist Plots.

- The Nyquist plots is obtained by simply plotting

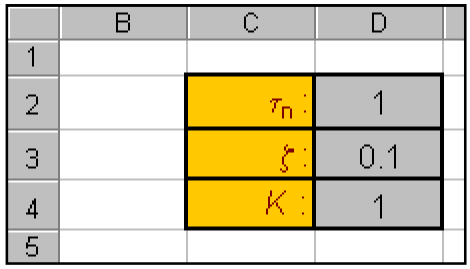
$$\text{Imaginary}\left(G(i\omega)\right) \quad \text{vs.} \quad \text{Real}\left(G(i\omega)\right)$$

II. Spreadsheet Implementation:

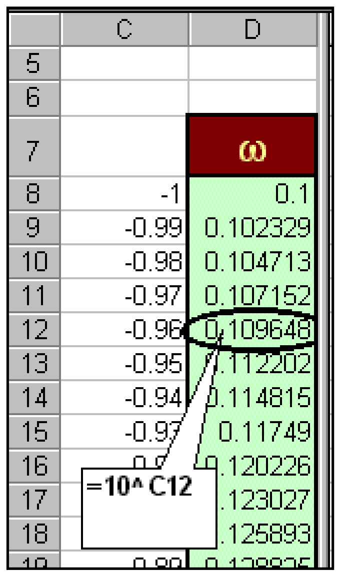
For discussion purposes, consider a second order transfer function,

$$G(s) = \frac{K}{\tau_n s^2 + 2\zeta\tau_n s + 1}$$

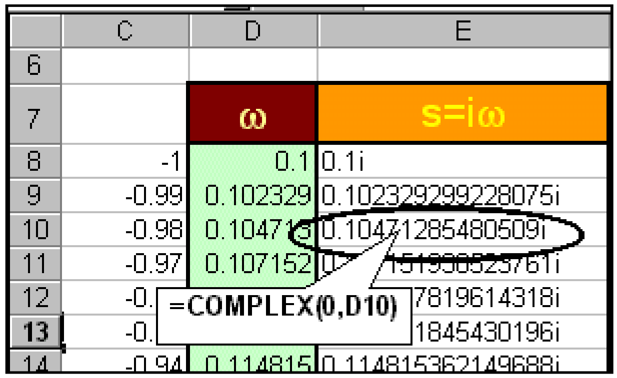
1. Set up some cells for the various parameters in the transfer function.



2. Next, determine the range of frequencies that are of interest. For example, let $10^{-1} < \omega < 10^{1}$. Since the frequency will be plotted in logarithmic scale, you can use a column to include numbers ranging linearly from -1 to 1 e.g. $-1, -0.99, \ldots, 0.98, 0.99, 1$. Then use another column to evaluate the frequency, e.g. $\omega = 10^{-1}, 10^{-0.99}, \ldots, 10^{0.98}, 10^{0.99}, 10^{1}$.

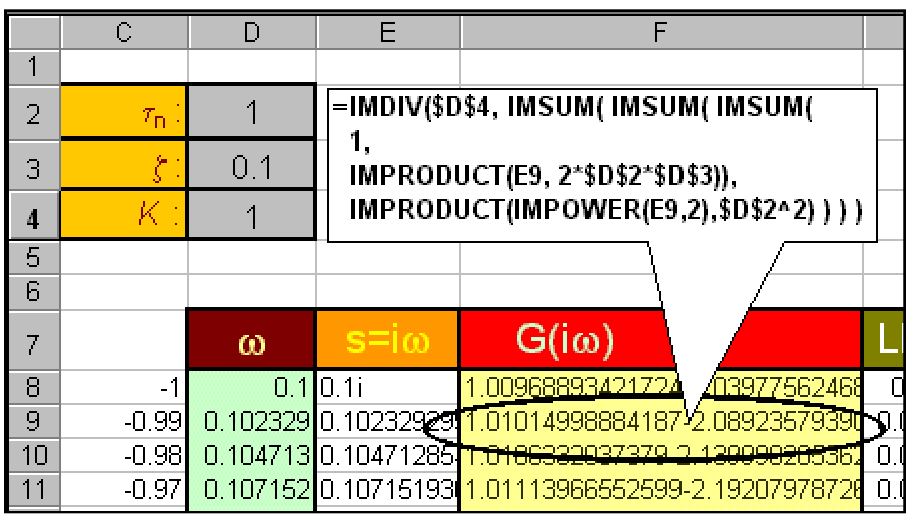


3. In the next column, build cells containing complex numbers, s=iω. This can be done by using the **COMPLEX(,)** function provided in Excel.

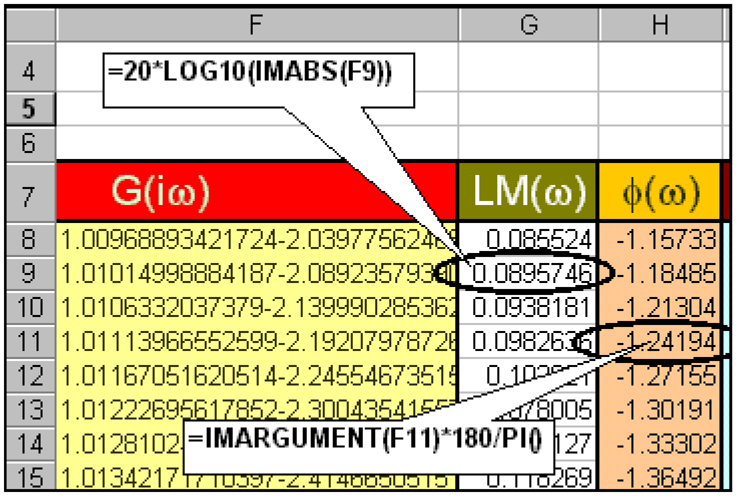


(*Note*: you may need to change the width of the column in order to see the numbers)

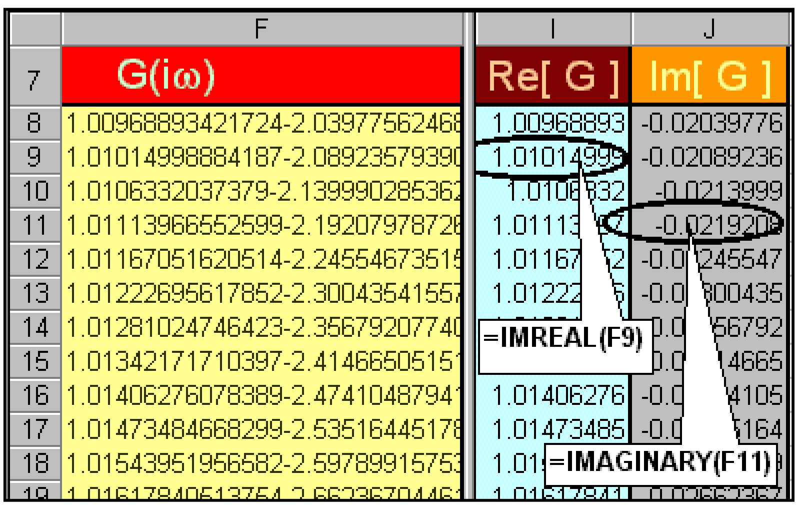
4. Now evaluate the transfer function, $G(s)$, with $s = i\omega$, using the built-in functions, **IMDIV(a,b)**, **IMSUM(a,b)**, **IMPRODUCT(a,b)**, **IMPOWER(a,n)** to perform complex division, sum, product and power operations on complex numbers **a** and **b**, with **n** as integer.



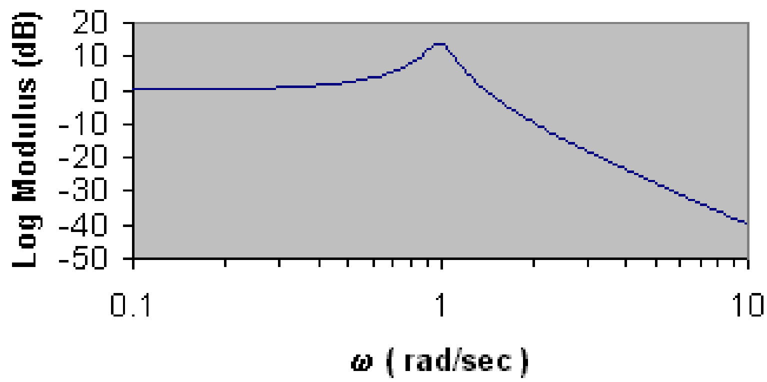
5. From the results in $G(i\omega)$, obtain the Log Modulus and Phase Shift columns:

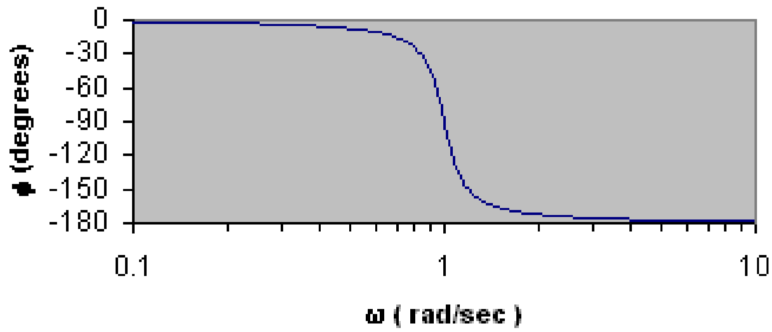


6. Also, from $G(i\omega)$, obtain columns that evaluate $Re[G]$ and $Im[G]$, respectively:



7. Using the Log modulus, Phase Shift and Frequency columns, obtains the Bode plots:





8. Using the columns for $Re[G]$ and $Im[G]$, obtain the Nyquist Plot: