

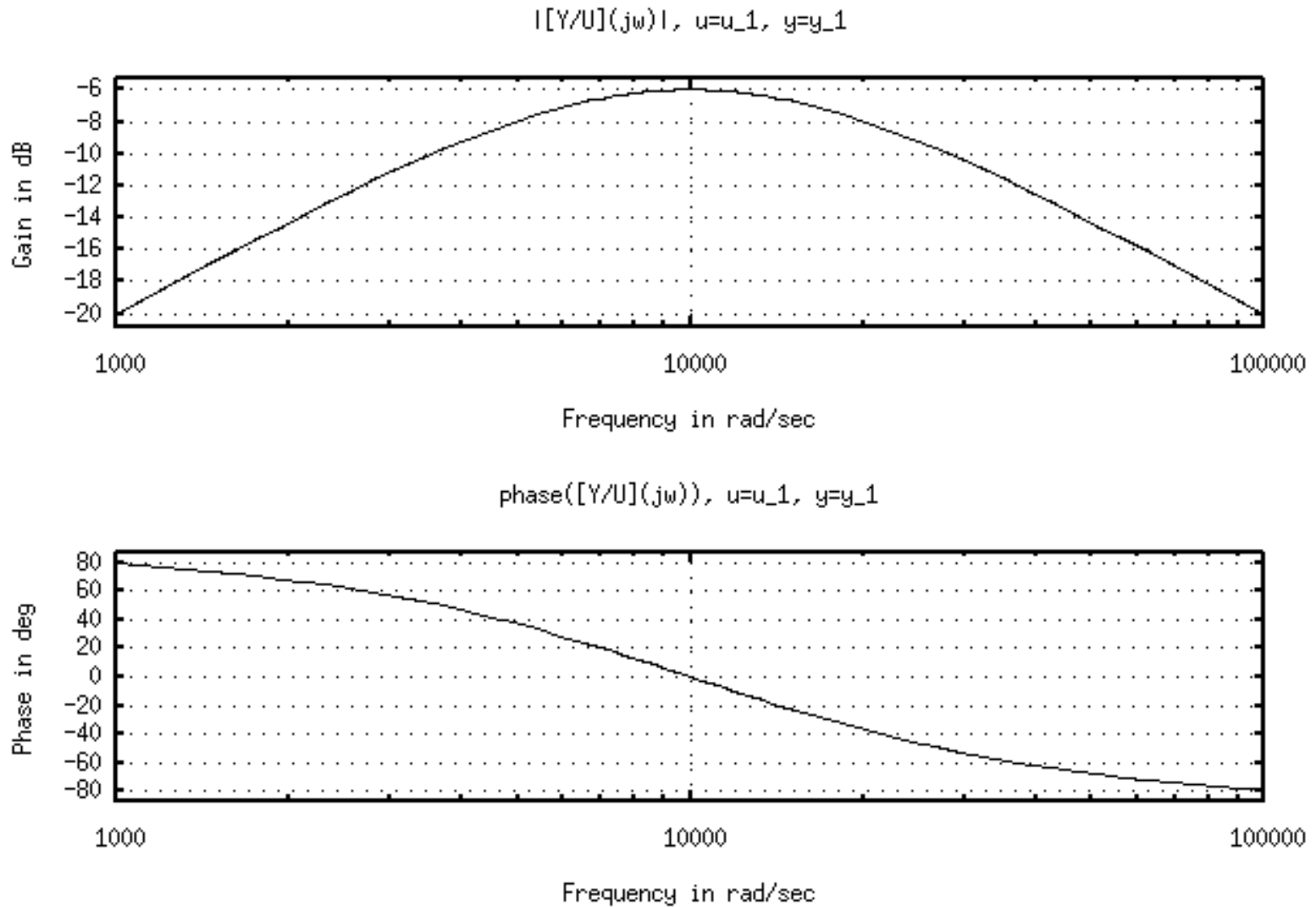
**Filter design aids**

## Tools for TF to Bode

- Matlab, Octave, Scilab and others will allow calculation of a Bode Plot
  - Example in “Octave”

```
octave:1> r=10000
r = 10000
octave:2> c=0.01e-6
c = 1.0000e-08
octave:3> tau=r*c
tau = 1.0000e-04
octave:4> den=conv([tau 1],[tau 1])
den =
  1.0000e-08  2.0000e-04  1.0000e+00
octave:5> num=[tau 0]
num =
  1.0000e-04  0.0000e+00
octave:6> tranFn=tf(num,den);
octave:7> bode(tranFn)
```

# Bode plot for simple bandpass filter



## “Q” - Quality factor

- Consider a first order band pass filter

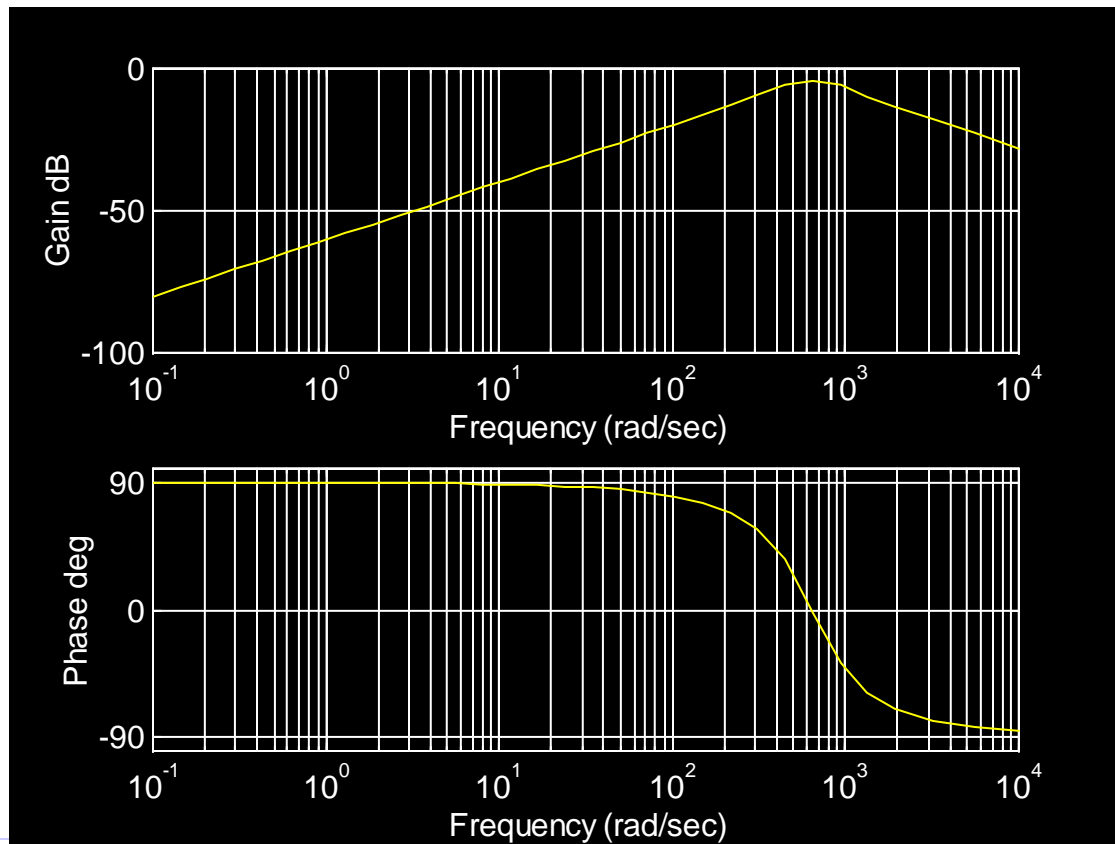
$$G(s) = \frac{As}{\left(\frac{1}{\omega_c}\right)^2 s^2 + \frac{2\zeta}{\omega_c} s + 1} = \frac{As}{\tau^2 s^2 + 2\zeta\tau s + 1}$$

$$Q = \frac{1}{2\zeta}$$

$$G(s) = \frac{As}{\tau^2 s^2 + \frac{\tau}{Q} s + 1} = \frac{As}{\left(\frac{1}{2\pi f}\right)^2 s^2 + \frac{1}{2\pi f Q} s + 1}$$

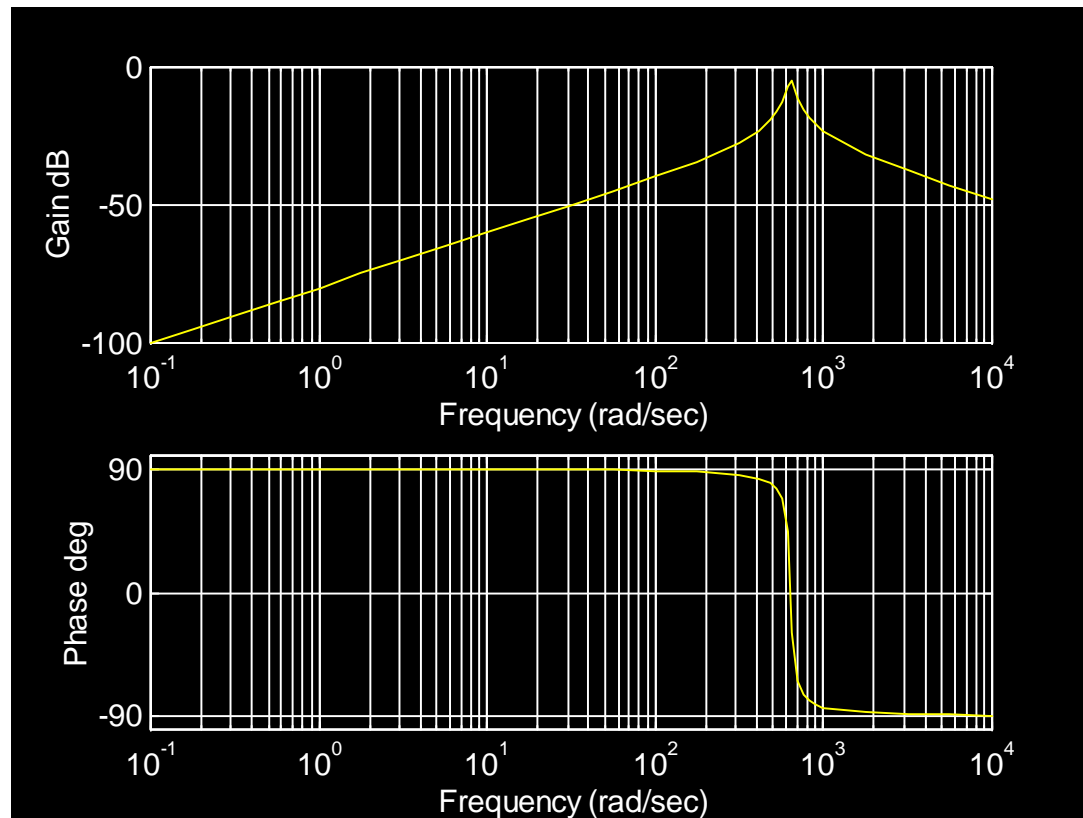
## “Q” Examples

○ •  $Q=1, \quad G(s) = \frac{As}{\left(\frac{1}{2\pi 1000}\right)^2 s^2 + \frac{1}{2\pi 1000} s + 1}$



## “Q” Examples

○ •  $Q=10, G(s) = \frac{As}{\left(\frac{1}{2\pi 1000}\right)^2 s^2 + \frac{1}{2\pi 10000} s + 1}$



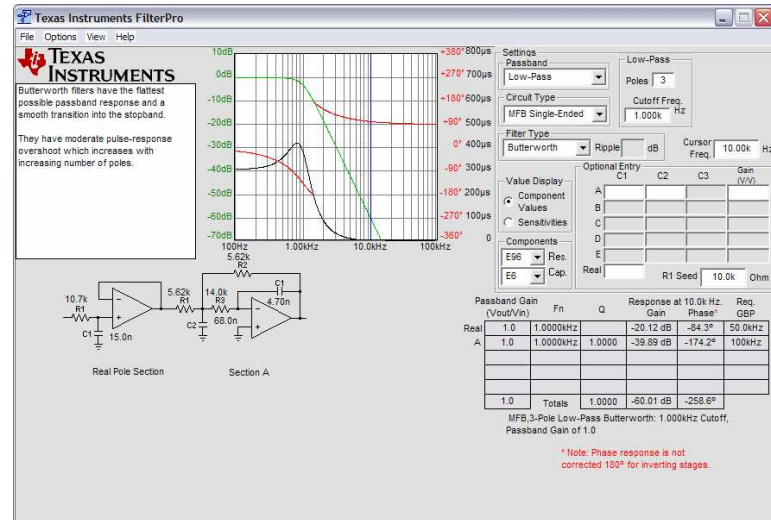
# Tools for Filter Design

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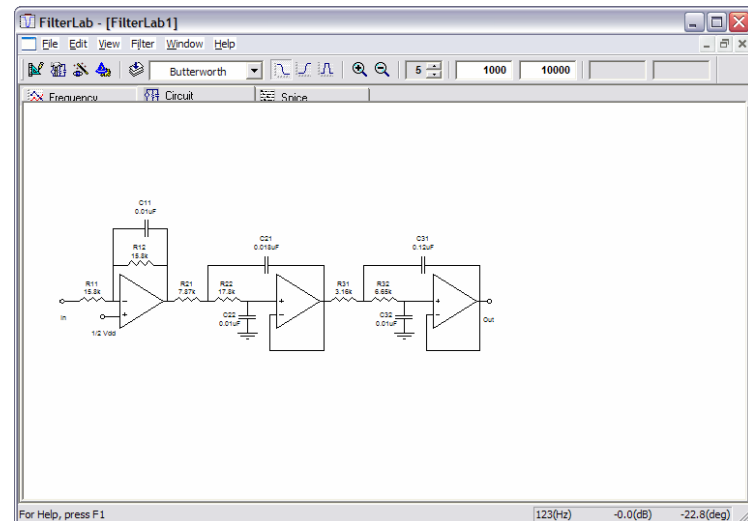
- ● Symbolic computing tools
  - Matlab
  - Octave
  - Scilab
  - require you to specify the filter transfer function
- Performance specification computing tools
  - Active filter design tools
    - Texas Instruments FilterTool
    - Microchip Filterlab
  - Digital filter design tools
- General electronic simulation tools
  - SPICE
  - TINA

# Active Filter (OpAmp based) tools

- TI Filtertool



- Microchip Filter Lab



## Filter types

- Butterworth - Ripple-free passband and a smooth stop band. Butterworth has least distortion due to almost linear phase.
- Chebyshev - Predetermined passband ripple and requires smaller order than a Butterworth filter for a desired response. Superior for applications where passband includes only one frequency of interest
- Elliptical - Equiripple pass- and stop-band, Predetermined amount of passband ripple along with ripple in the stop band. Elliptic filters require smallest order for a desired magnitude response
- Bessel -constant propagation delay across the input frequency spectrum
- Gaussian -the most gradual pass band roll-off and the lowest group delay. Low distortion across the spectrum.