Example

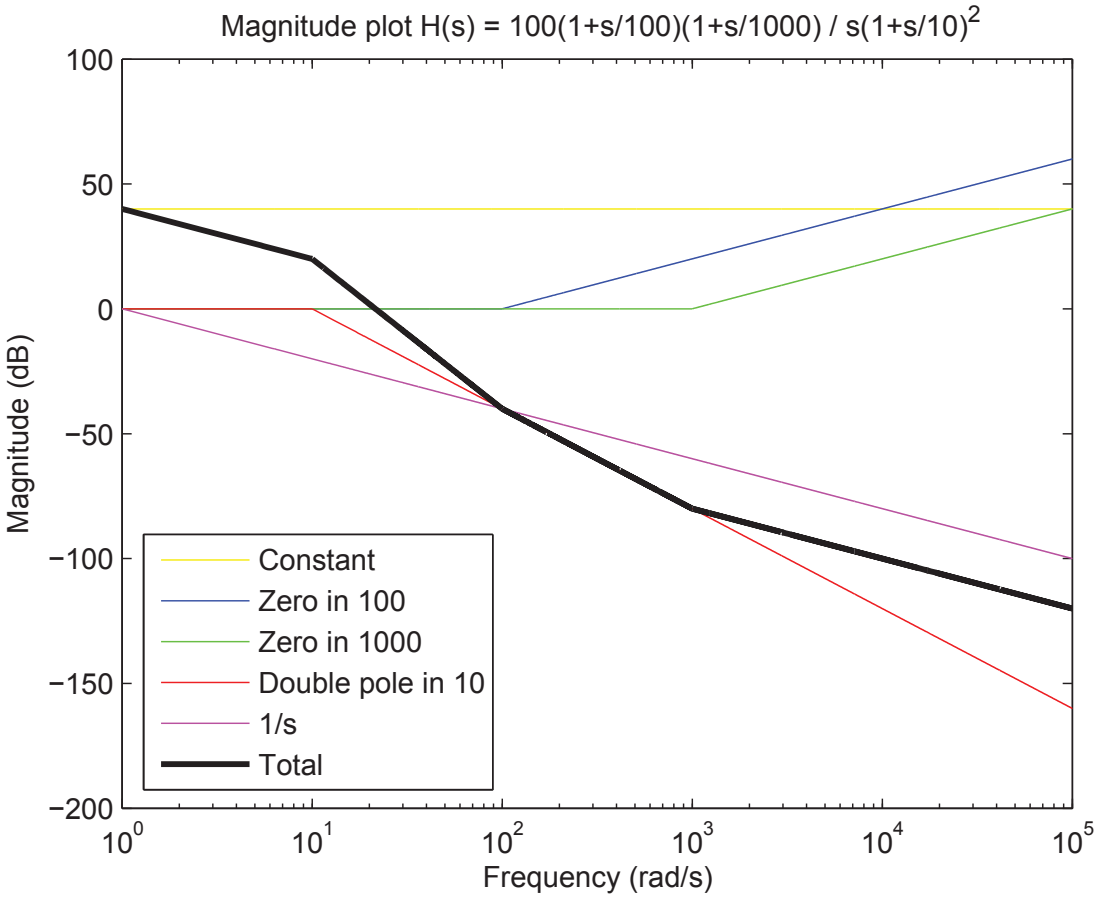
Suppose we want to construct (by hand) the bode plot of

$$H(s) = \frac{s^2 + 1100s + 100000}{10s^3 + 200s^2 + 1000s}$$

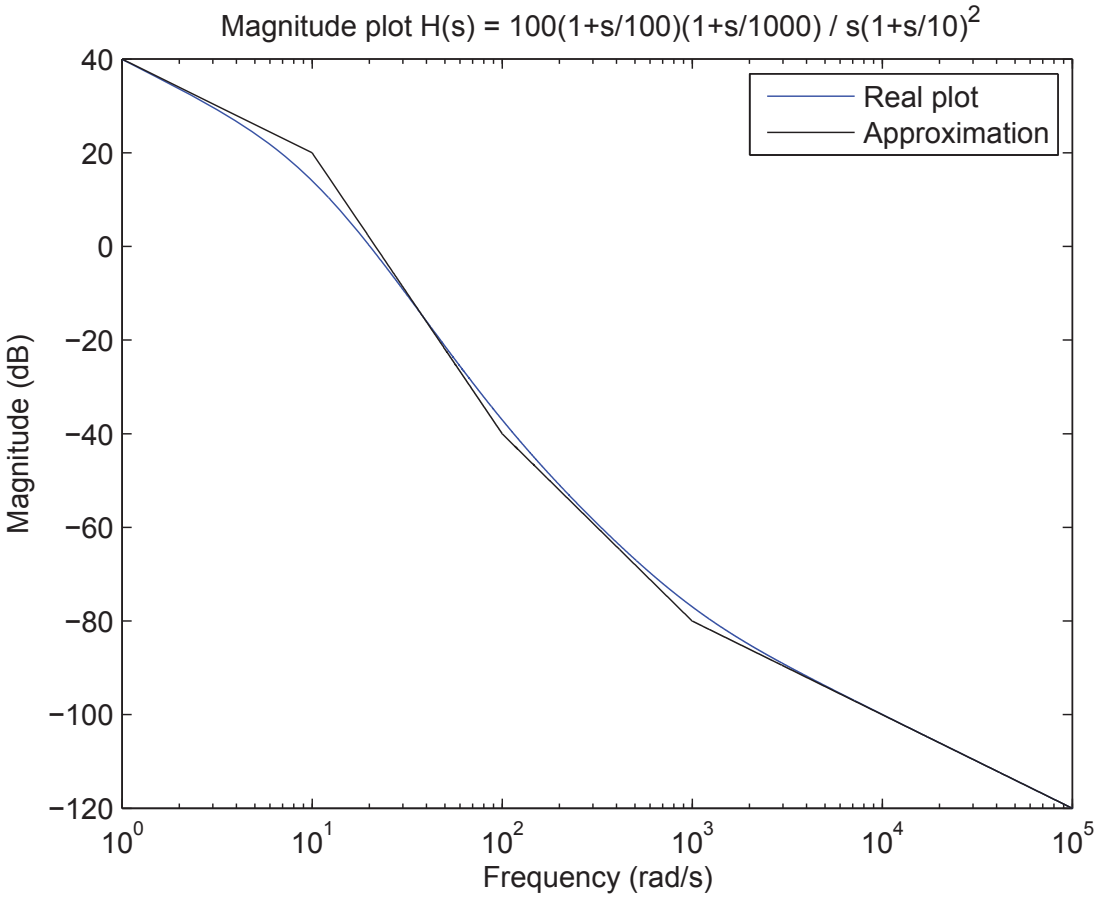
The first step is to find the representation with breakpoints.

$$\begin{aligned} H(s) &= \frac{s^2 + 1100s + 100000}{10s^3 + 200s^2 + 1000s} \\ &= \frac{(s+100)(s+1000)}{10s(s+10)^2} \\ &= \frac{100000(1+\frac{s}{100})(1+\frac{s}{1000})}{1000s(1+\frac{s}{10})^2} \quad = \frac{100(1+\frac{s}{100})(1+\frac{s}{1000})}{s(1+\frac{s}{10})^2} \end{aligned}$$

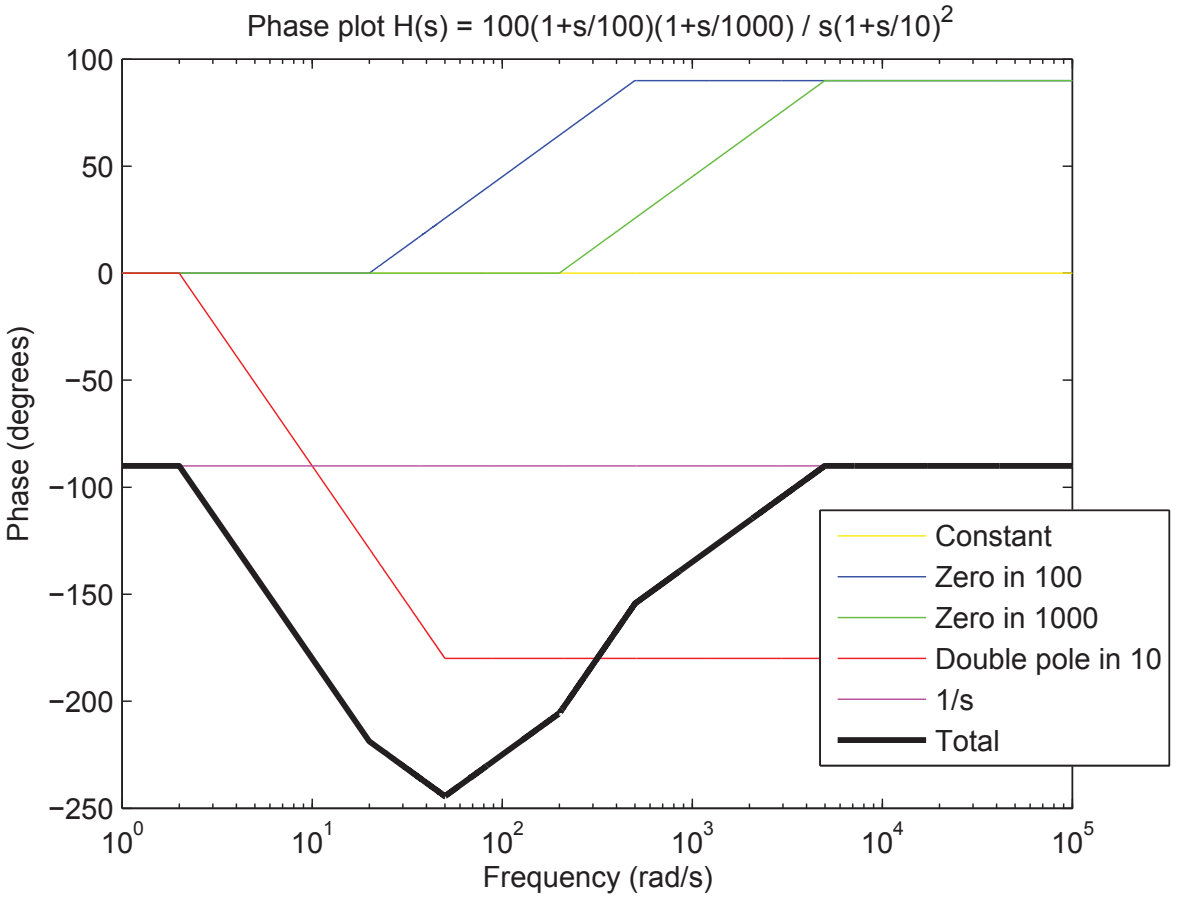
Example Magnitude plot



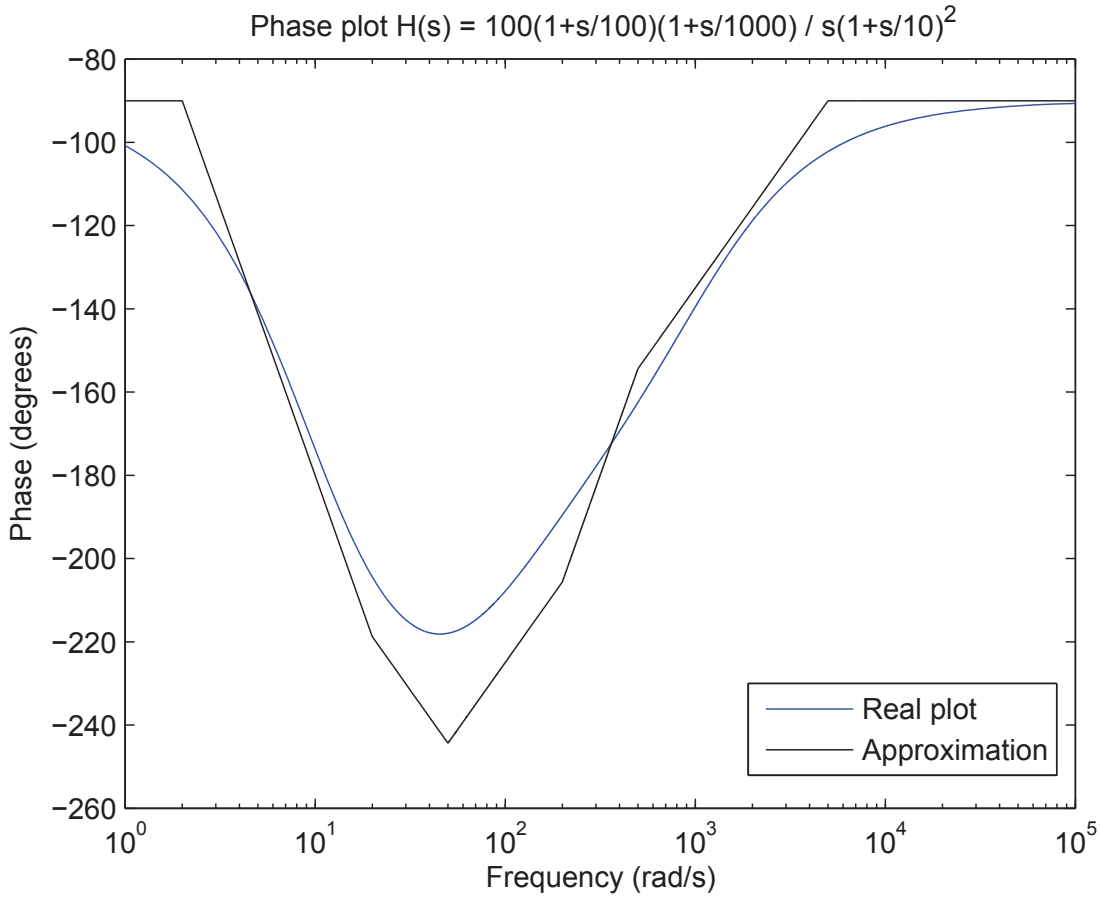
Example Magnitude plot



Example Phase plot



Example Phase plot



Outline

1 The Frequency Response

2 What Is The Bode Plot

3 How To Construct A Bode Plot (by hand)

4 Constructing The Bode Plot In Matlab

5 Introduction To Nyquist Plots

Basic commands in Matlab

In Matlab it is very easy to draw the bode plot.

- First, define the system using one of the following commands:
  - tf(num,den) (num and den are respectively the numerator and denominator of the transfer function)
  - zpk(z,p,K) (using the zeros (z), the poles (p) and the gain (K) of the transfer function)
  - ss(A,B,C,D) (using the matrices of the state-space model)
- In case of a discrete time system, Ts (the sample time) is also needed as a last parameter in these commands
- Next, use the command bode(sys)

Matlab example

```
%Examples for creating the bode plot in Matlab
%Say we have the transfer function
%H(s) = (5s^2 - 10s + 5)/(s^2 + 5s + 4)
num = [5 -10 5];
den = [1 5 4];
sys = tf(num,den);
bode(sys)
figure

%Using the same system, we first find the factorization
%H(s) = 5*(s-1)^2/[(s+1)(s+4)]
z = [1 1];
p = [-1 -4];
K = 5;
```

Matlab example

```
sys = zpk(z,p,K);
bode(sys)

figure
%If we had a discrete time system with the same transfer
%function
%H(z) = (5z^2 - 10z + 5)/(z^2 + 5z + 4)
%and sampling time Ts = 1/2 of a second

sys = tf(num,den,0.5);
bode(sys)
```

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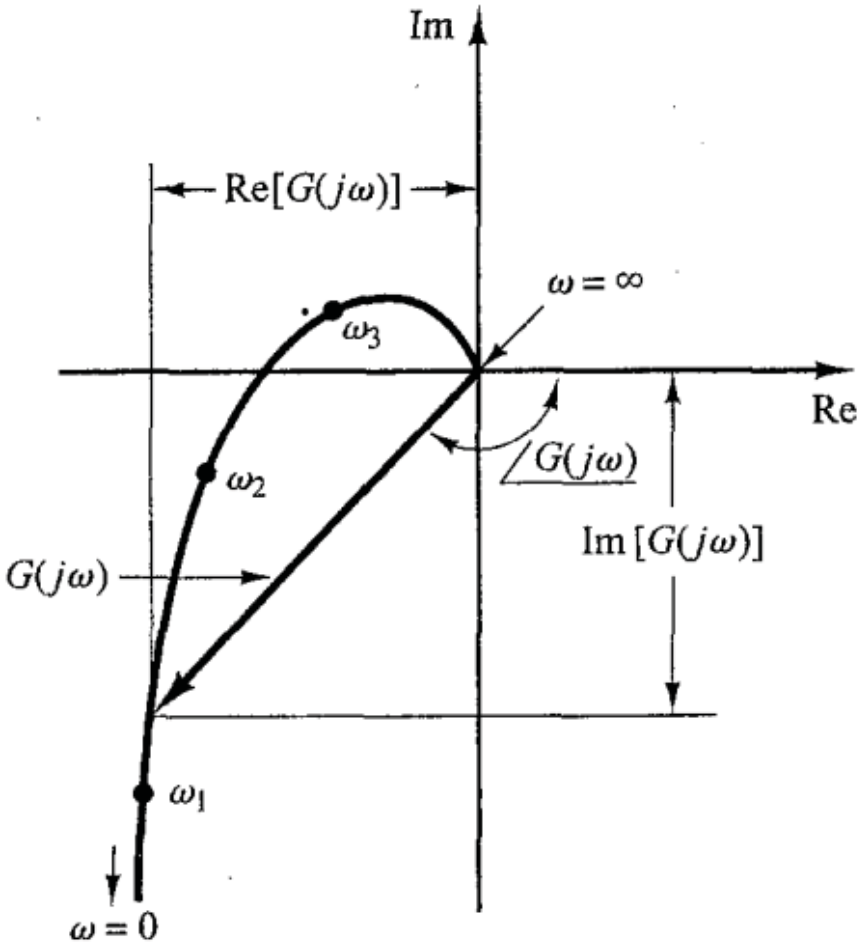
5 Introduction To Nyquist Plots

Nyquist plot

A Nyquist plot is also called a polar plot, and is another way to plot $H(j\omega)$.
In a polar plot, as ω is varied from 0 to ∞, $H(j\omega)$ is plotted as a point in the complex plane.

- $|H(j\omega)|$ is the distance between the origin and the point
- $\angle H(j\omega)$ is the angle between the vector to the point and the positive real axis, measured counterclockwise

Nyquist plot



Nyquist plot in matlab

Similar to constructing the bode plot in matlab, we first have to define the system using tf, zpk or ss.
Then we use the command nyquist(sys).

```
%How to create a Nyquist plot in matlab
sys = tf([14 7 3],[1 10 10 10 10]);
nyquist(sys)
```

Bode and Nyquist plot