Unit-3
Frequency-Response Analysis

Introduction

- Frequency response studies system behavior under sinusoidal inputs.
- Useful for stability and control design.

Relationship Between Time and Frequency Response

- Time-domain: Rise Time, Peak Time, Settling Time, Overshoot
- Frequency-domain: Bandwidth, Resonant Peak, Resonant Frequency

Time Response vs Frequency Response

- Rise Time ↔ Bandwidth
- Overshoot ↔ Resonant Peak
- Stability ↔ Gain & Phase Margins

Frequency Response of a System

- $G(s)=1/(1+sT)$
- $G(j\omega)=1/(1+j\omega T)$
- Magnitude and Phase relationships

Polar Plot


Polar plot of 1st order system
0.6
0.4
0.2
0
-0.2
-0.4
-0.6
-0.8
0
0.2
0.4
0.6
0.8
1
w = + inf
w = 0
real
DC
angle
magnitude
imaginary

Construction of Polar Plot

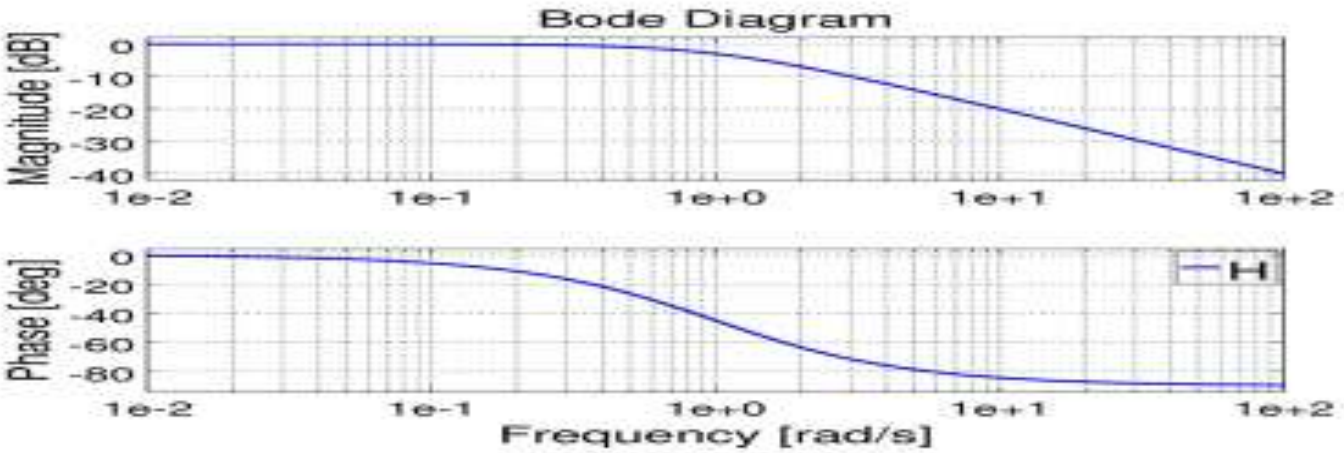
- Replace s by jω
- Compute magnitude and phase
- Plot for varying frequencies.

Example Polar Plot

- For G(s)=1/(1+s)
- Starts at (1,0) and approaches origin.

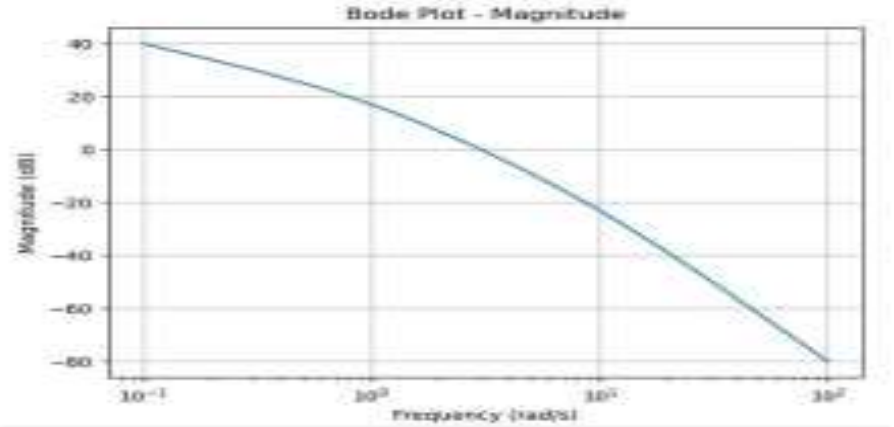
Bode Plot

- Magnitude Plot (dB vs logω)
- Phase Plot (degrees vs logω)



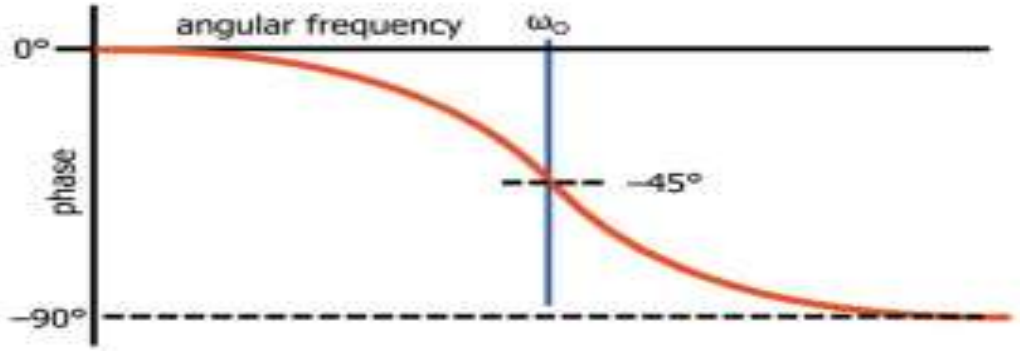
Magnitude Plot

- $20 \log|G(j\omega)|$
- Common slopes: 0, -20, -40 dB/decade



Phase Plot

- Represents phase lag/lead as frequency varies.



Nyquist Stability Criterion

- Uses open-loop frequency response to determine closed-loop stability.
- $N = Z - P$