ME451: Control Systems

Lecture 23
Bode diagram of simple systems

Dr. Jongeun Choi
Department of Mechanical Engineering
Michigan State University

Course roadmap

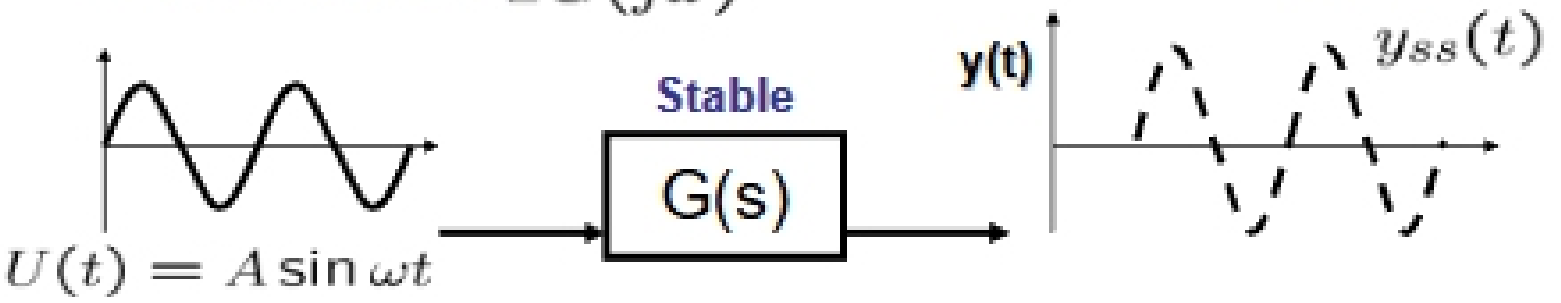
Modeling	*Analysis*	*Design*
✔ Laplace transform	✔ Time response	Design specs
✔ Transfer function	✔ Transient	✔ Root locus
✔ Models for systems	✔ Steady state	Frequency domain
✔ electrical	✔ Frequency response	✔ PID & Lead-lag
✔ mechanical	• Bode plot	Design examples
✔ electromechanical	✔ Stability	
✔ Block diagrams	✔ Routh-Hurwitz	
✔ Linearization	• Nyquist	

(Matlab simulations &) laboratories

Frequency response (review)

- Steady state output $y_{ss}(t) = A\,|G(j\omega)|\sin(\omega t + \angle G(j\omega))$
  - Frequency is same as the input frequency ω
  - Amplitude is that of input (A) multiplied by $|G(j\omega)|$
  - Phase shifts $\angle G(j\omega)$

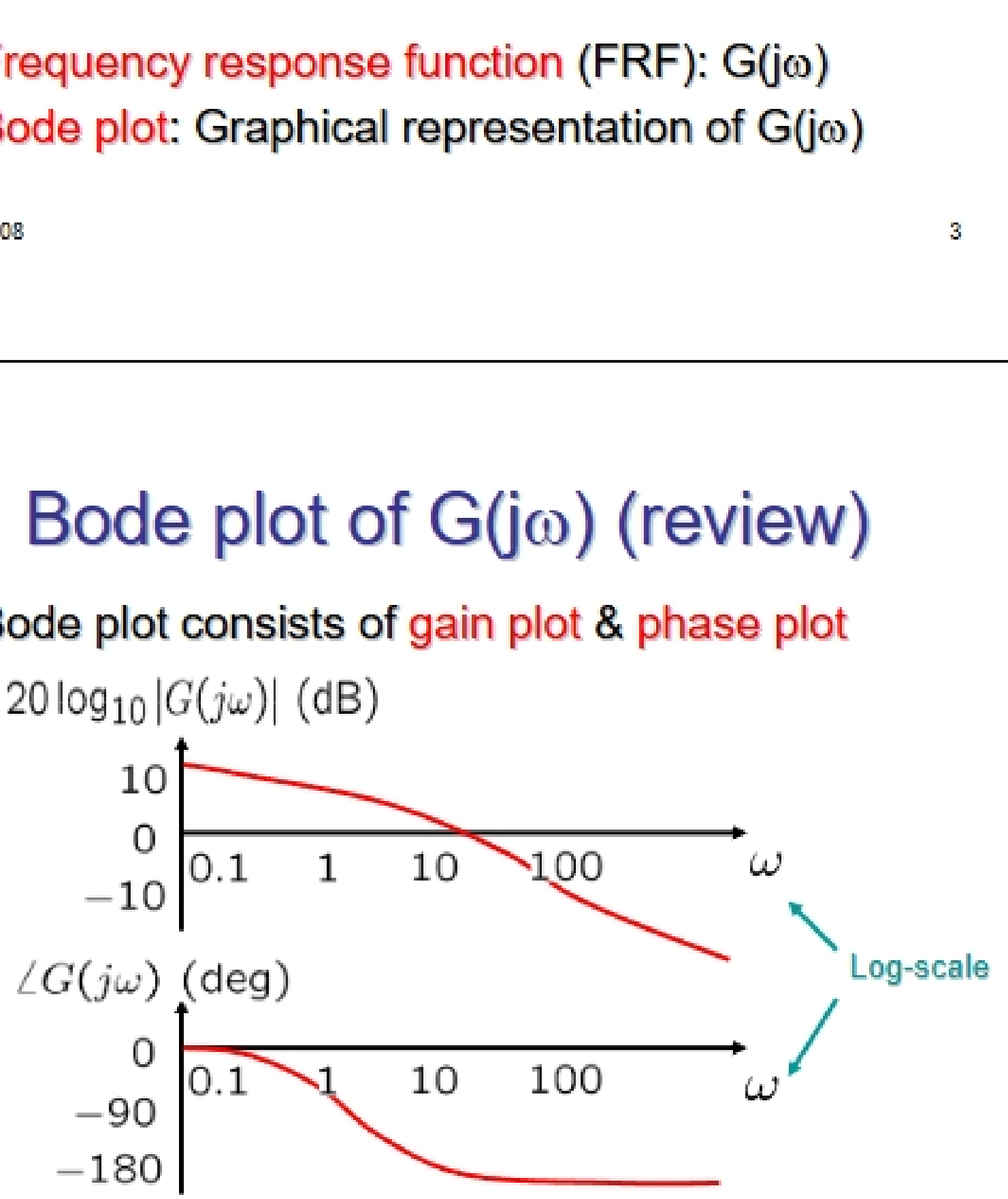
Gain



- Frequency response function (FRF): G(jω)
- Bode plot: Graphical representation of G(jω)

Bode plot of G(jω) (review)

- Bode plot consists of gain plot & phase plot



Sketching Bode plot

- Basic functions (Today)
  - Constant gain
  - Differentiator and integrator
  - Double integrator
  - First order system and its inverse
  - Second order system
  - Time delay
- Product of basic functions (Next lecture)
  1. Sketch Bode plot of each factor, and
  2. Add the Bode plots graphically.

Main advantage of Bode plot!

Bode plot of a constant gain

- TF $G(s) = K \Rightarrow |G(j\omega)| = K, \ \angle G(j\omega) = 0^\circ, \ \forall \omega$