Bode Design Guidelines (vdv 8.4)

1. Relative stability: -20 dB/dec slope at or near crossover (only if no RHP zeroes).
2. Steady-state accuracy: low-frequency asymptote
3. Accuracy in operating range: typically need at least 20dB over appropriate frequencies
4. Crossover frequency: is a measure of bandwidth and thus speed of response. $\omega_c \approx 0.635\omega_b$. Behavior away from crossover is known:

$$G_cG \; ? \; 1, \quad M_{dB} \; ? \; 0, \quad \frac{C}{R} \quad \frac{G_cG}{1+G_cG} \approx 1$$

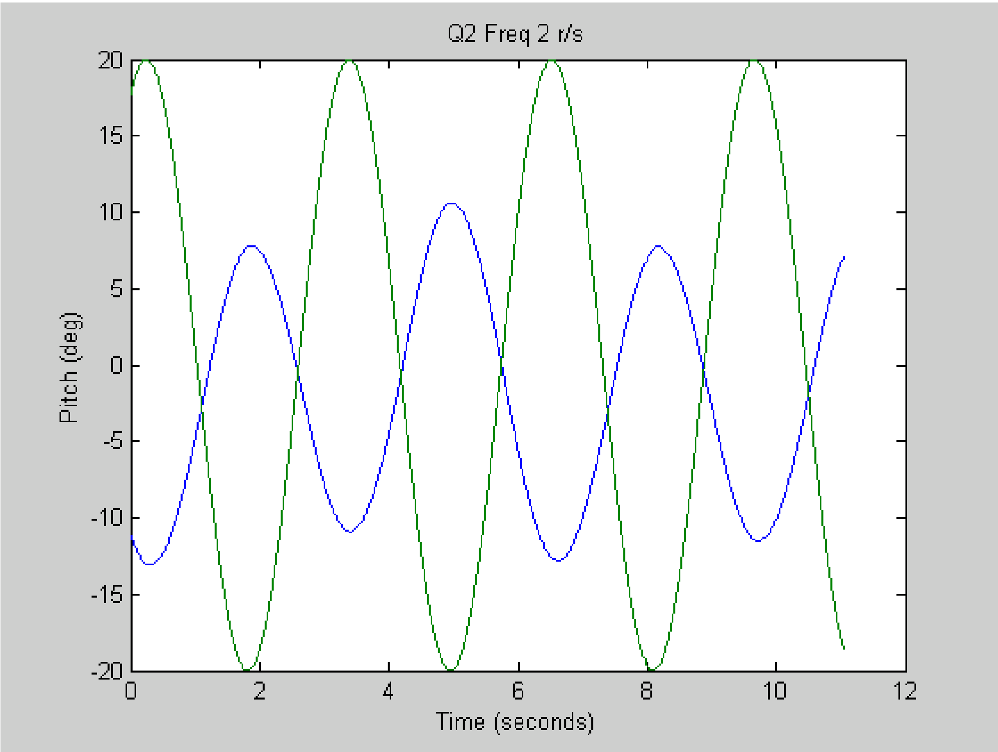
$$G_cG = 1, \quad M_{dB} = 0, \quad \frac{C}{R} \quad \frac{G_cG}{1+G_cG} \approx G_cG$$

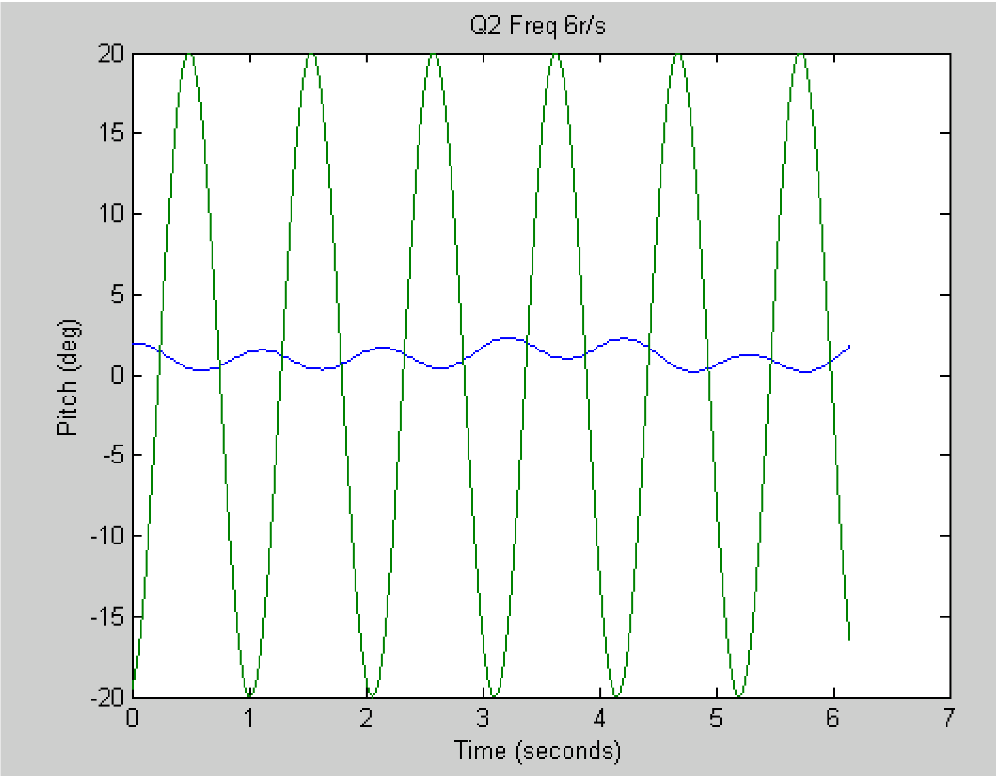
5. Noise rejection: need small M_{dB} for high frequencies, keep bandwidth low.

Control Design Methods:

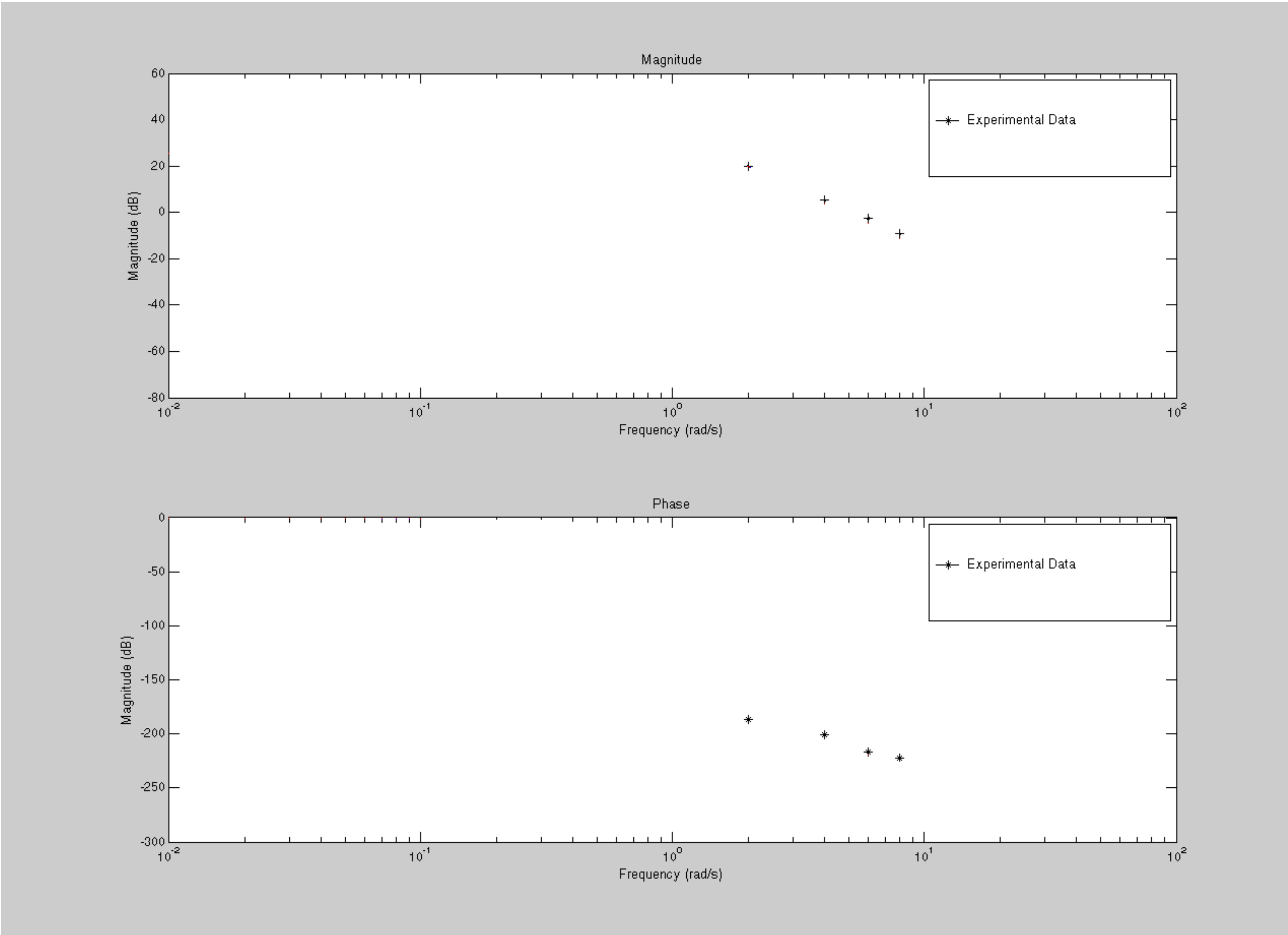
- Root Locus
    - Need system pole-zero pattern
    - Often a good place to start
    - Insight about dynamics
- Nyquist
    - Use to check stability
- State-Space
    - Full state feedback
- Nichols Chart
    - System must be open-loop stable
- Bode
    - Most commonly used
    - System must be open-loop stable

Quanser frequency response:

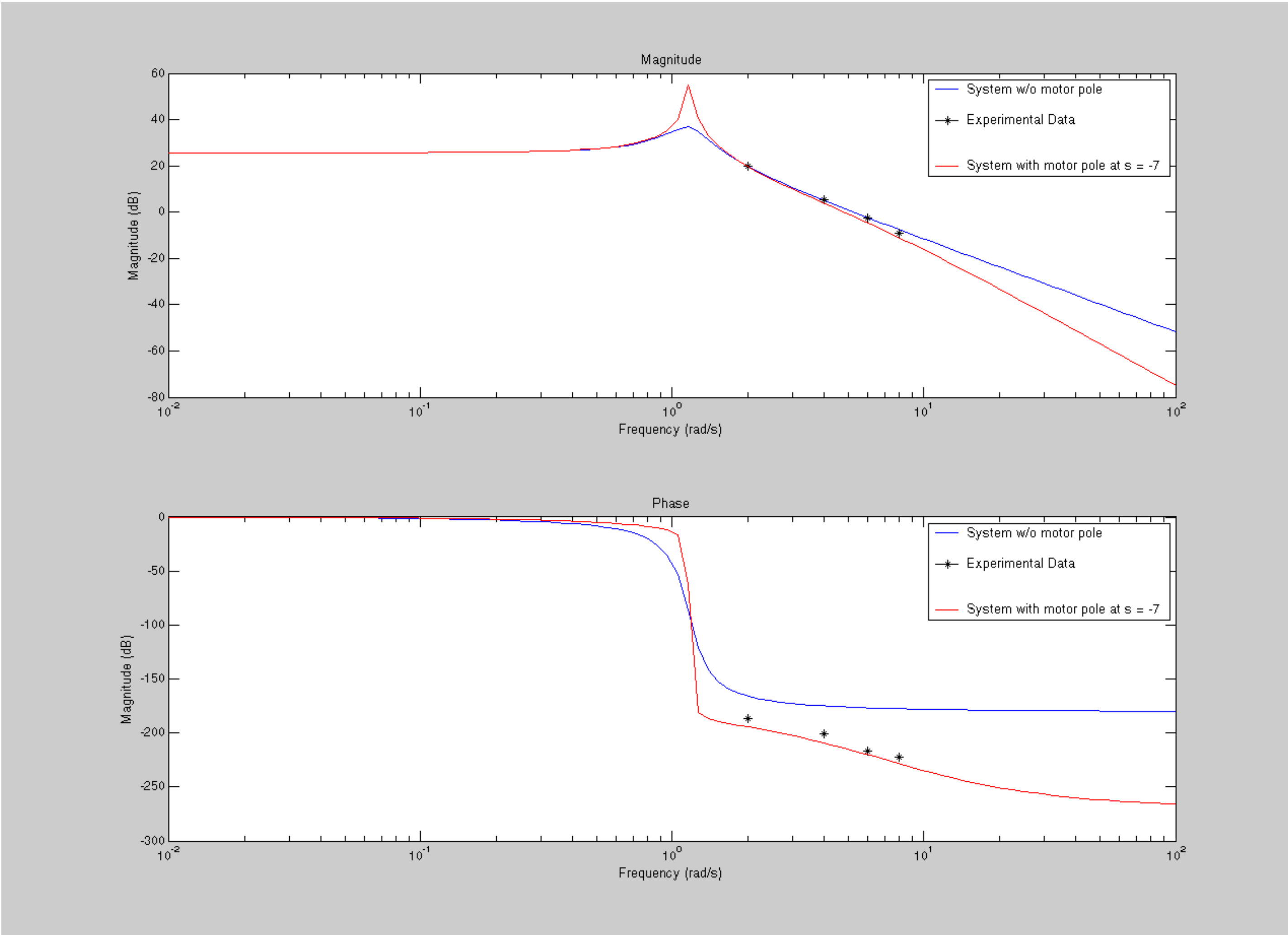




Quanser frequency response data:

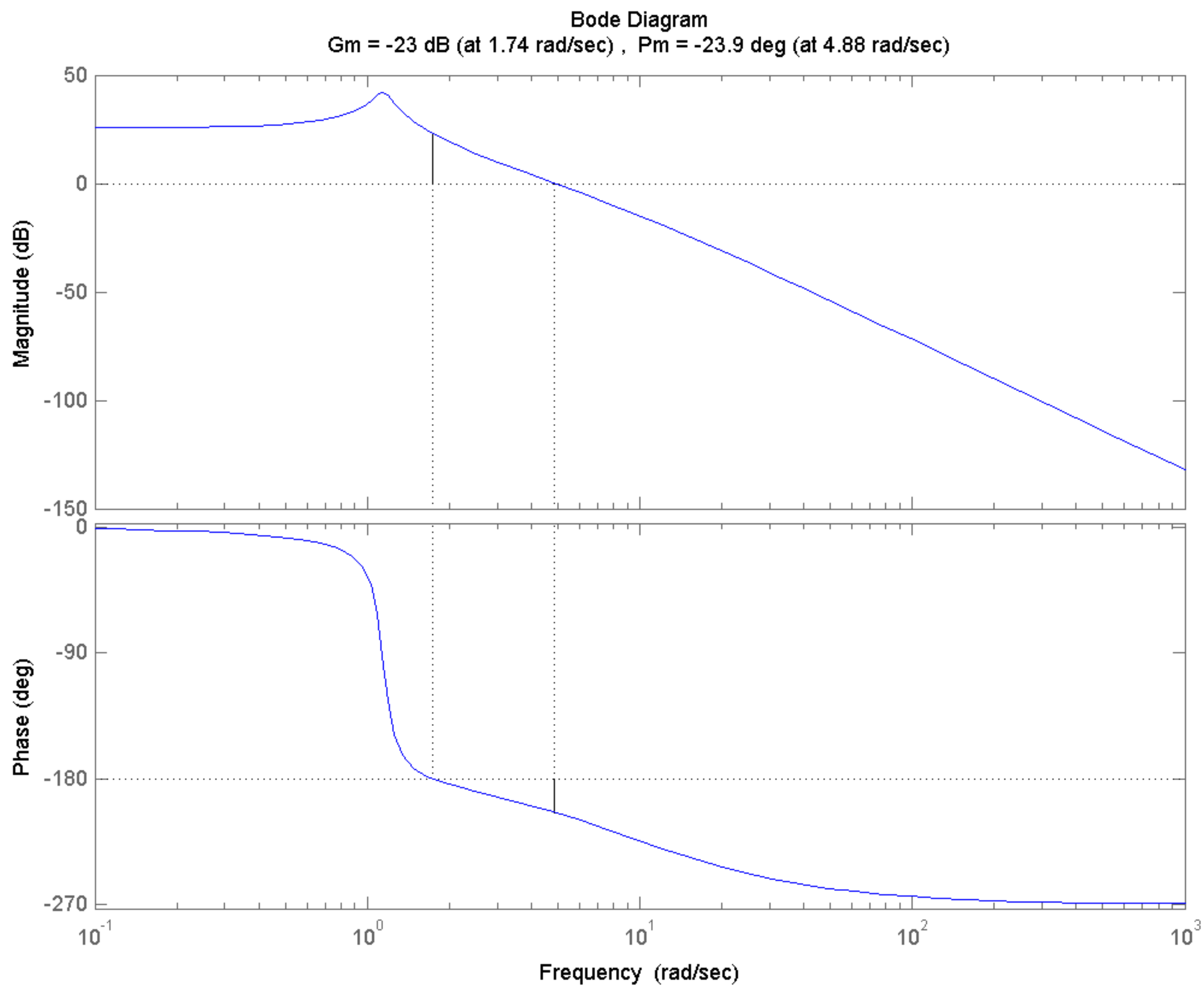


Quanser: frequency response data



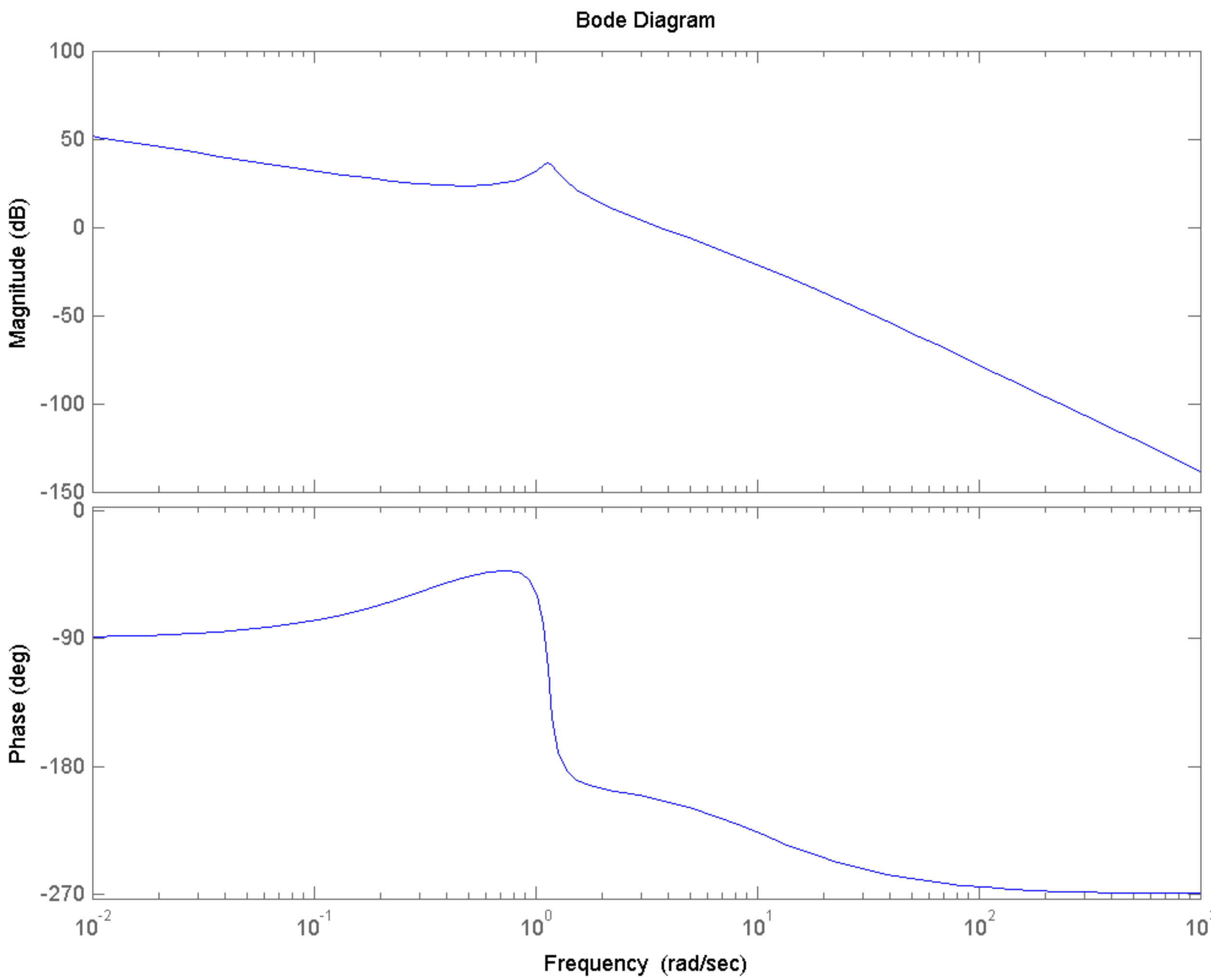
Uncompensated Quanser system

$$G(s) \quad \frac{250}{(s+10)(s+0.086-1.14j)(s+0.086+1.14j)}$$



Quanser + PI

$$G(s) \quad \frac{250}{(s+10)(s+0.086-1.14j)(s+0.086+1.14j)} \qquad G_c(s) \quad \frac{0.2(1+2.5s)}{s}$$



Quanser + PI + lag-lead

$$G(s) \quad \frac{250}{(s+10)(s+0.086-1.14j)(s+0.086+1.14j)} \qquad G_c(s) \quad \frac{0.2(1+2.5s)(1+1.2s)}{s(1+0.05s)}$$