goal: tools for analysis using transfer functions, Nyquist / Bode plots

1°. frequency domain analysis

1¹. Nyquist stability criterion [AMv2 Ch 10.1, 10.2] [Nv7 ch 10.3]

1². stability margins [AMv2 Ch 10.3] [Nv7 Ch 10.7]

1³. sensitivity functions [AMv2 ch 12.1, 12.2] [Nv7 not covered]

* general comment: these techniques were developed before we had cheap computers, so there are many graphing heuristics that are traditionally taught;
→ we'll rely on computers to graph, but still extract intuition

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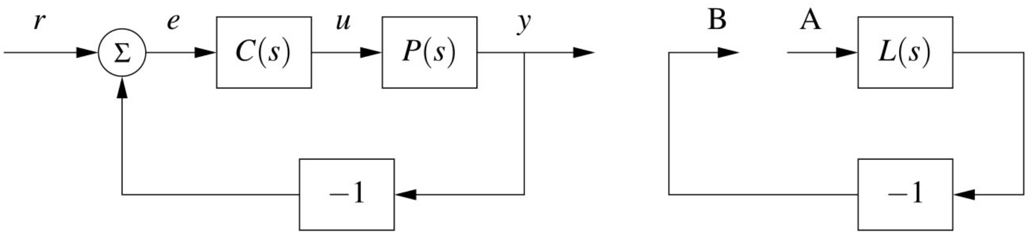
1°. frequency domain analysis

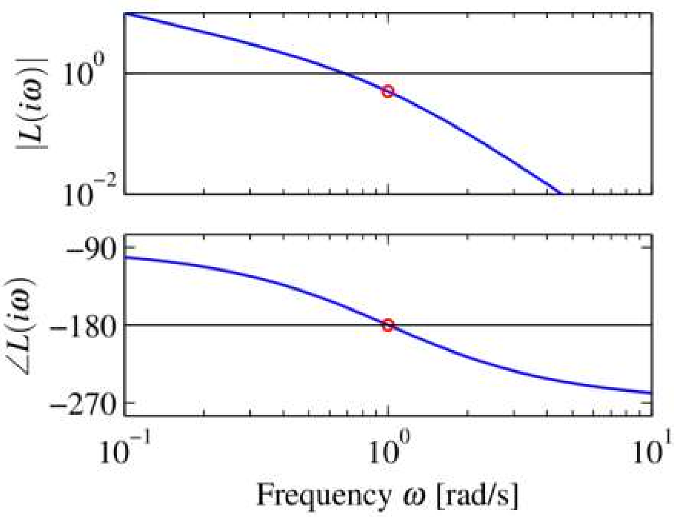
1¹. Nyquist stability criterion



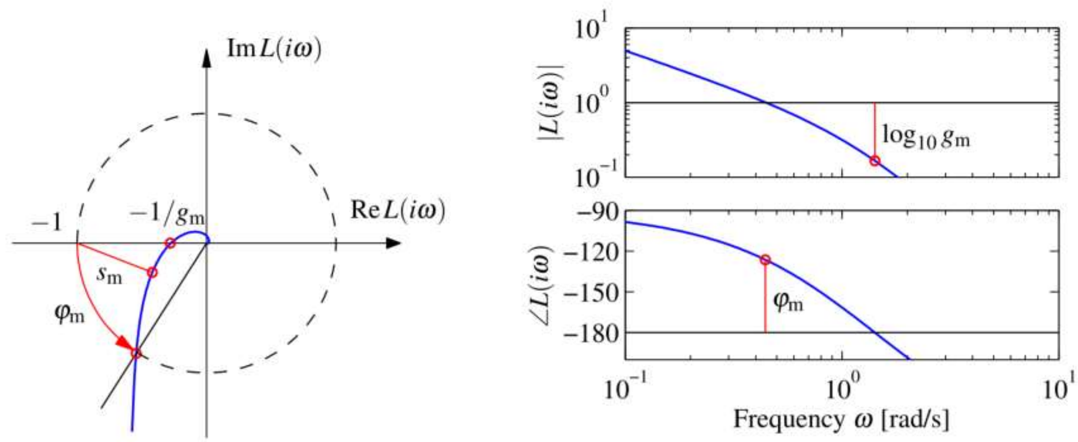
(a) Closed loop system (b) Open loop system

Figure 10.1: The loop transfer function. The stability of the feedback system (a) can be determined by tracing signals around the loop. Letting $L = PC$ represent the loop transfer function, we break the loop in (b) and ask whether a signal injected at the point A has the same magnitude and phase when it reaches point B.

→ sketch the Nyquist plot (i.e. graph Ω) of transfer function L using Bode plot (what can you say about stability of closed-loop $\frac{L}{1+L}$?)



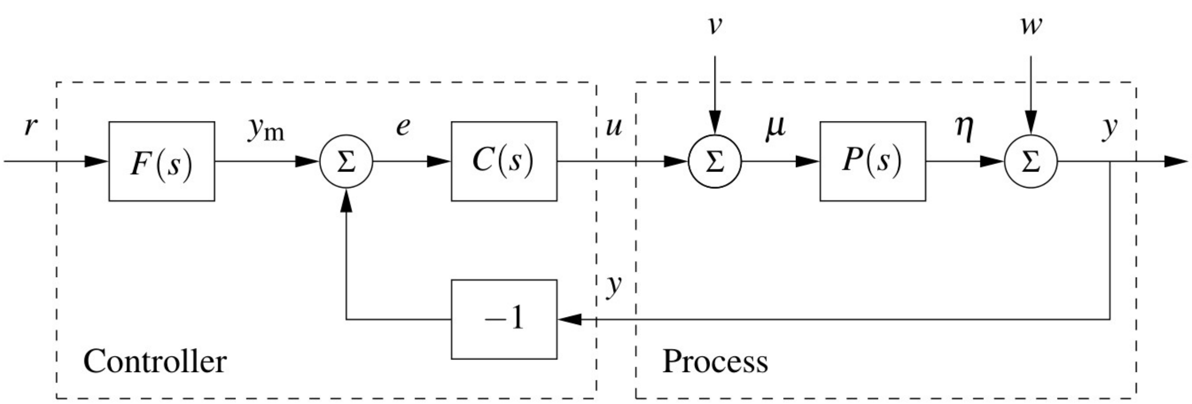
1°. stability margins

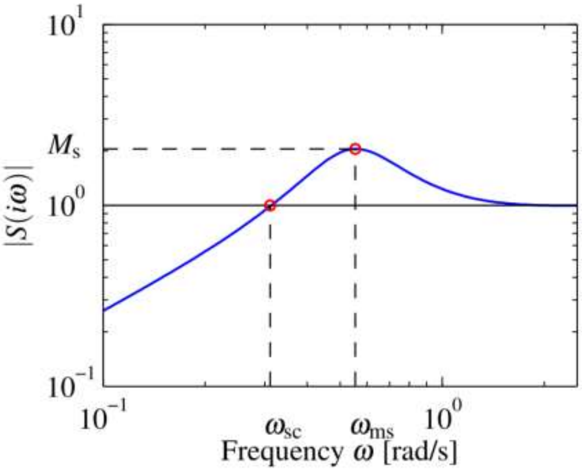


(a) Nyquist plot (b) Bode plot

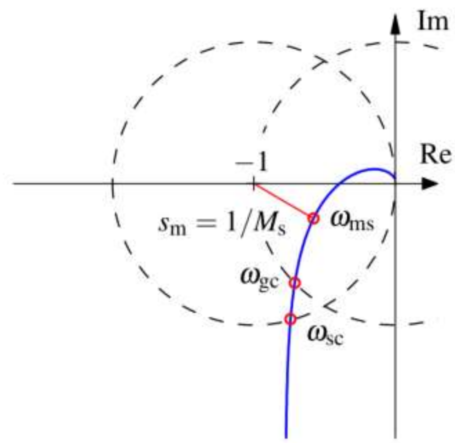
Figure 10.11: Stability margins for a third-order loop transfer function $L(s)$. The Nyquist plot (a) shows the stability margin, s_m, the gain margin g_m, and the phase margin φ_m. The stability margin s_m is the shortest distance to the critical point -1. The gain margin corresponds to the smallest increase in gain that creates an encirclement, and the phase margin is the smallest change in phase that creates an encirclement. The Bode plot (b) shows the gain and phase margins.

1^3. sensitivity functions





(a) Gain curves



(b) Nyquist plot