goal: tools for analysis using transfer functions, root locus plots

1°. frequency domain analysis

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

1². root locus [AMv2 Ch 12.5] [Nv7 Ch 9]

* 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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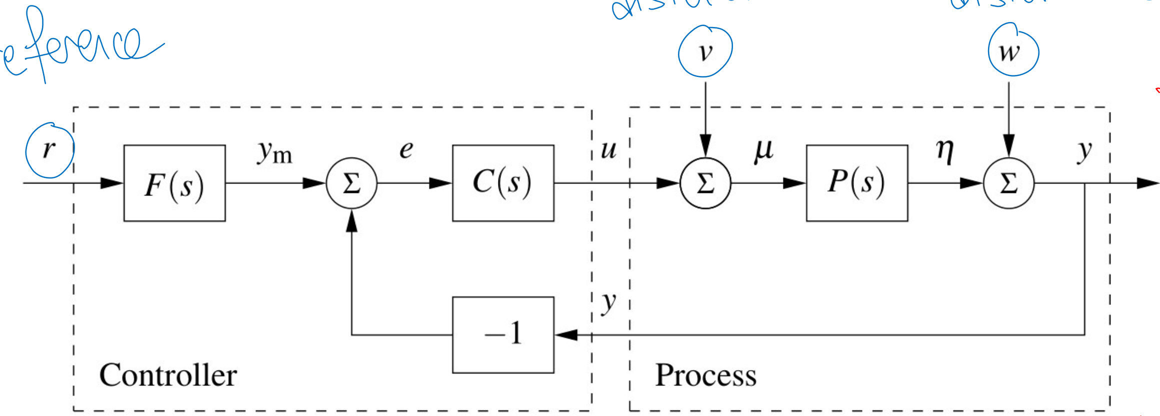
1° frequency domain analysis

1¹. sensitivity functions

input disturbance

output disturbance

reference

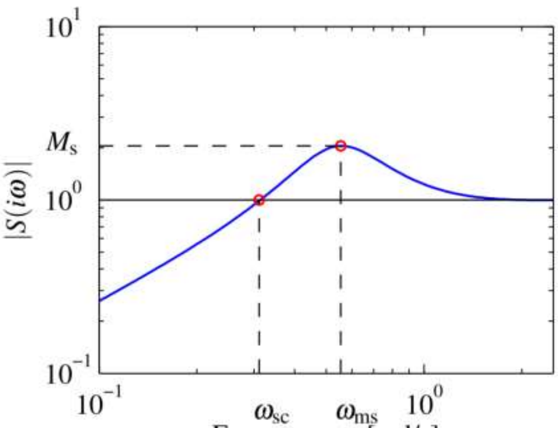


note: process input μ and output η aren't what C: commands (u) or measures (y)

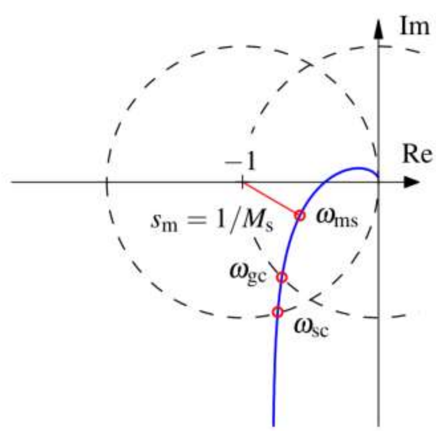
→ determine G_{uv} (how input disturbance affects input)

→ determine G_{uv} (how input disturbance affects input) ' or measures (y)'
& G_{yw} (how output disturbance affects output)

y	u	e	μ	η	
$\frac{PCF}{1+PC}$	$\frac{CF}{1+PC}$	$\frac{F}{1+PC}$	$\frac{CF}{1+PC}$	$\frac{PCF}{1+PC}$	r
$\frac{P}{1+PC}$	$\frac{-PC}{1+PC}$	$\frac{-P}{1+PC}$	$\frac{1}{1+PC}$	$\frac{P}{1+PC}$	v
$\frac{1}{1+PC}$	$\frac{-C}{1+PC}$	$\frac{-1}{1+PC}$	$\frac{-C}{1+PC}$	$\frac{-PC}{1+PC}$	w



(a) Gain curves



(b) Nyquist plot

_9-frequency-domain

1°. root locus

$$
\begin{aligned}
P_{\mathrm{a}}(s) &= k\,\frac{s+1}{s^2}, & P_{\mathrm{b}}(s) &= k\,\frac{s+1}{s(s+2)(s^2+2s+4)},\\
P_{\mathrm{c}}(s) &= k\,\frac{s+1}{s(s^2+1)}, & P_{\mathrm{d}}(s) &= k\,\frac{s^2+2s+2}{s(s^2+1)}.
\end{aligned}
\tag{12.18}
$$

start at "x", tend to "o"

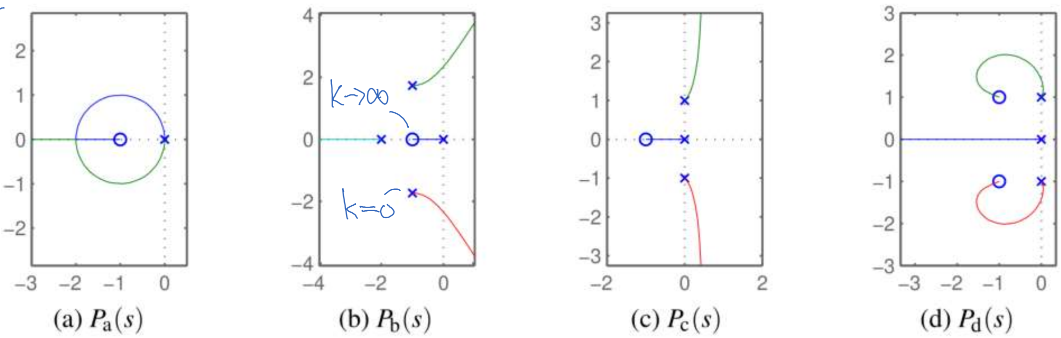


Figure 12.18: Examples of root loci for processes with the transfer functions $P_a(s)$, $P_b(s)$, $P_c(s)$, and $P_d(s)$ given by equation (12.18).

→ which of these systems can be stabilized by proportional feedback?
(can the gain be arbitrarily large?)

→ how would you use the root locus to determine whether a system can be stabilized with proportional feedback?

→ how would you use the root locus to determine whether a stable system can track a non-zero reference with integral feedback?