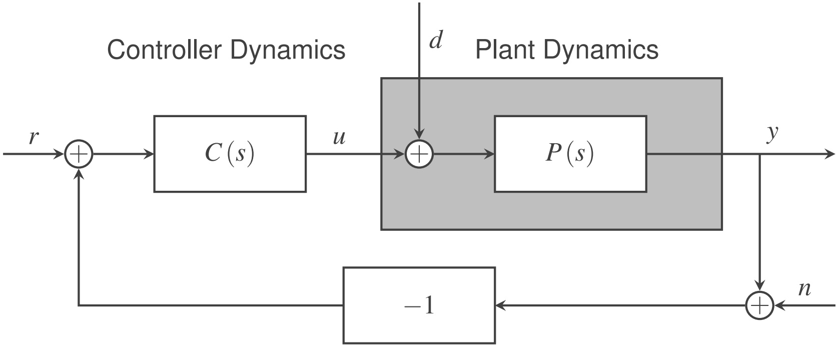
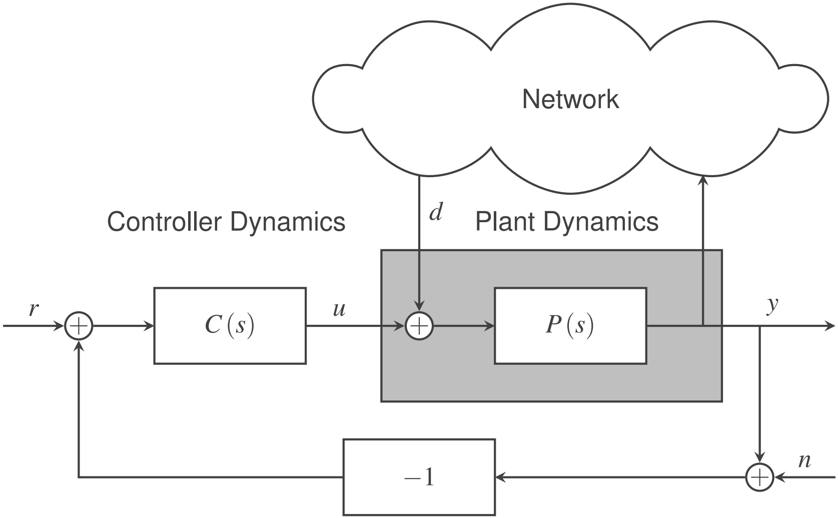
Conventional Control



Today's Talk



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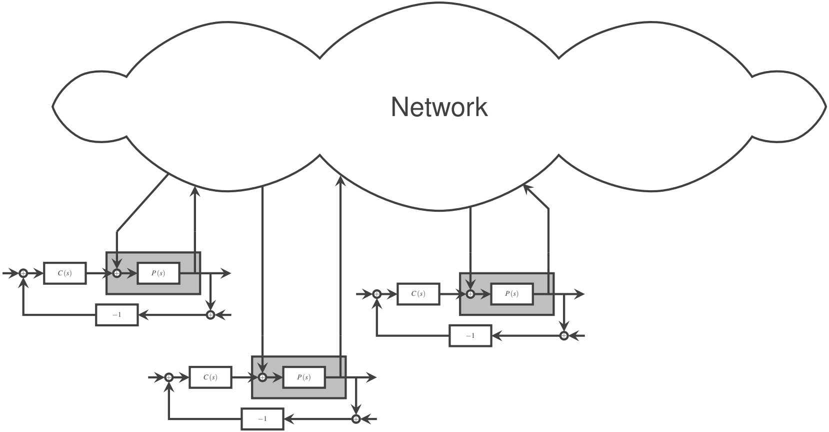

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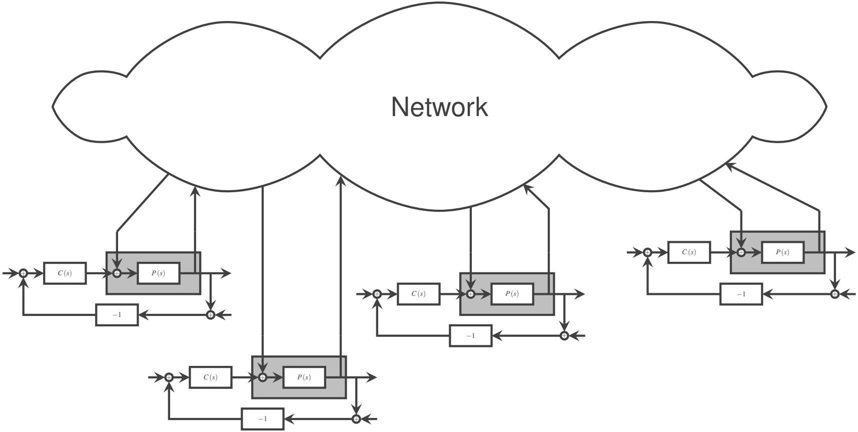

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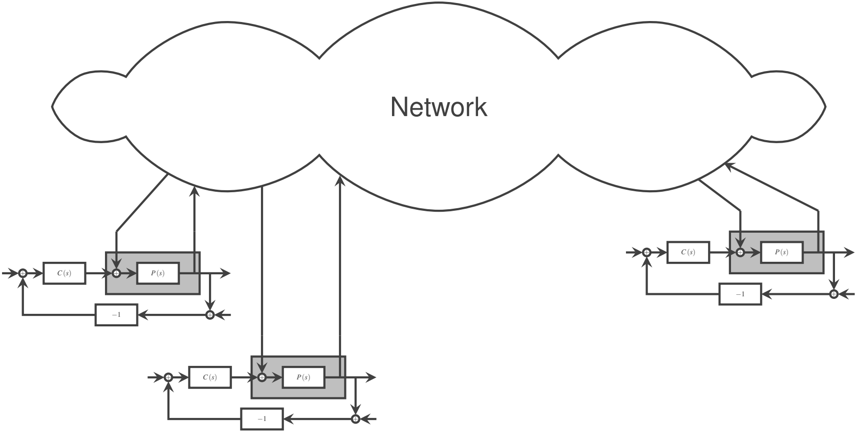
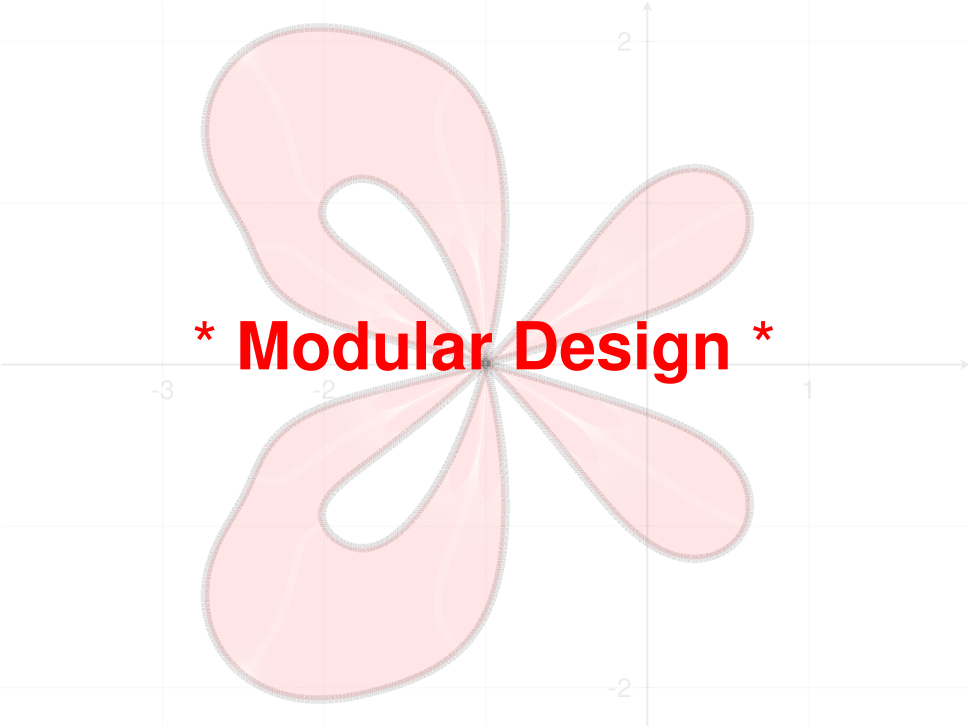
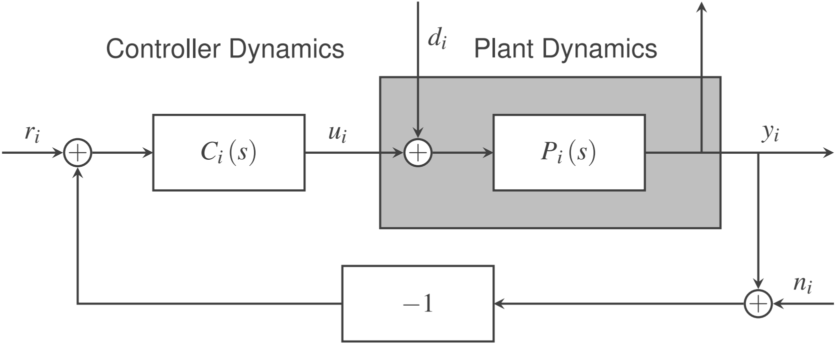


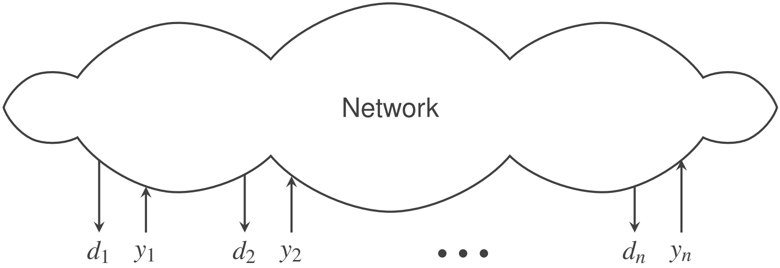

* Modular Design *
2
-3
-2
1
-2

Component Model



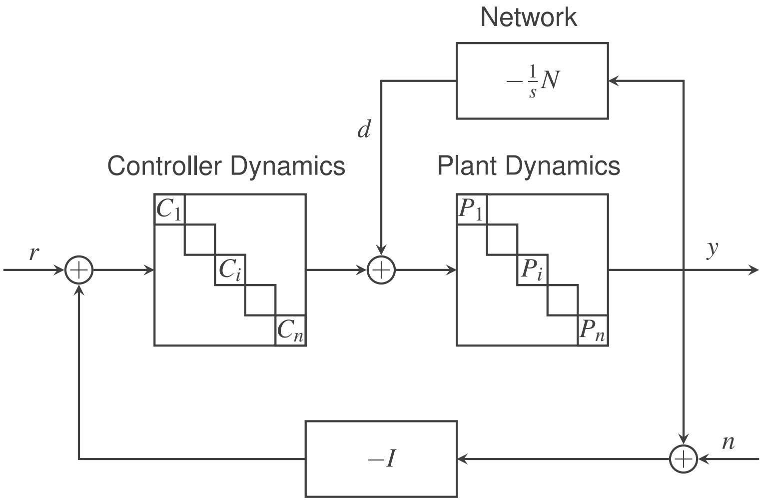
$$y_i(s) = \underbrace{\frac{P_i(s)}{1 + P_i(s)\, C_i(s)}}_{G_i(s)} d_i(s)$$

Network Dynamics



$$d(s) = -\frac{1}{s} N y(s)$$

The System Model



Modular Stability Criteria

Component test:

If for each i ***test on $G_i(s)$***

Modular Stability Criteria

Component test:

If for each i ***test on $G_i(s)$***

Modular stability guarantee:

Then the system model is stable for all ***class of matrices N***

Modular Stability Criteria

The question:

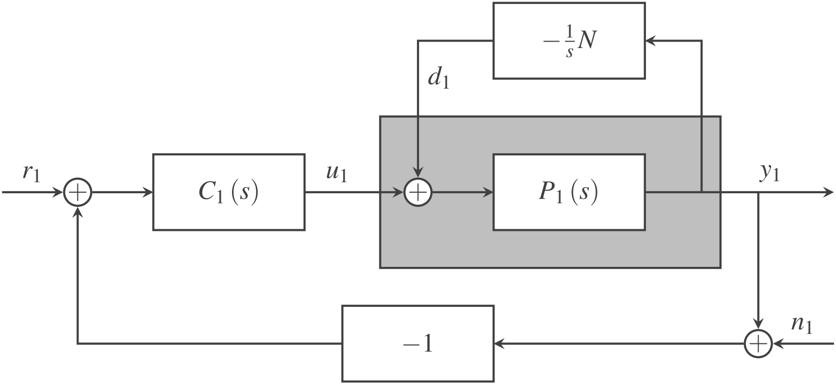
Given

modular stability guarantee,

how to construct

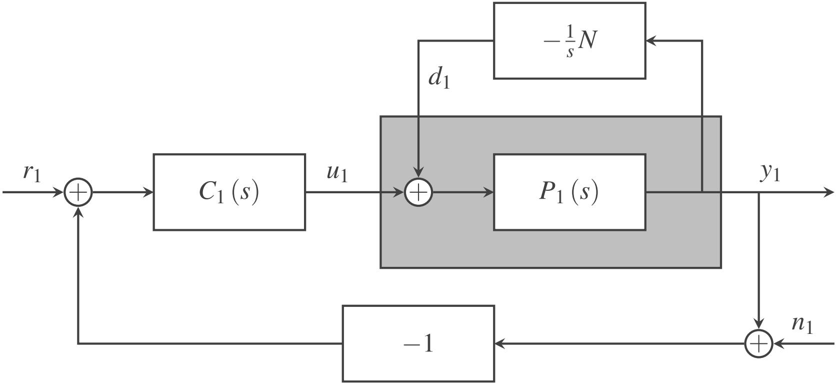
component test?

The Scalar Case



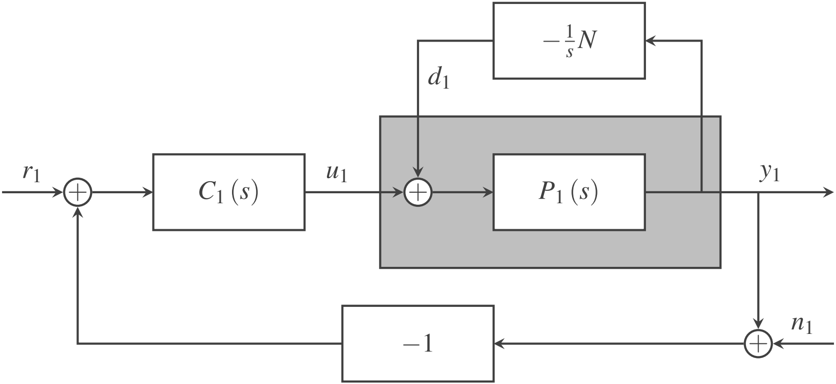
Class of matrices: $0 \leq N \leq 1$

The Scalar Case



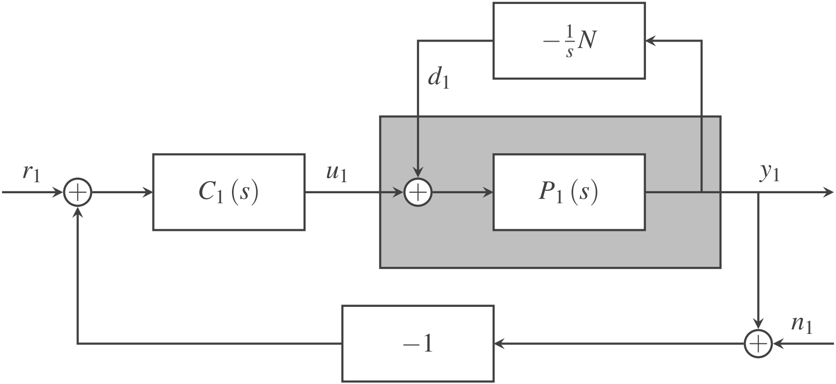
$$y_1(s) = \underbrace{\frac{P_1(s)}{1 + P_1(s)\,C_1(s)}}_{G_1(s)} d_i(s)$$

The Scalar Case



$$\left(\forall s \in \overline{\mathbb{C}}_+\right) \quad \left(1 + \frac{1}{s} N G_1(s)\right) \neq 0$$

The Scalar Case



$$\left(\forall s \in \overline{\mathbb{C}}_+\right) \quad \left(\frac{1}{N} + \frac{1}{s} G_1(s)\right) \neq 0$$

The Scalar Case

Component test:

If

$$\left(\forall s \in \overline{\mathbb{C}}_+\right) \quad \frac{1}{s} G_1(s) \notin (-\infty, -1]$$

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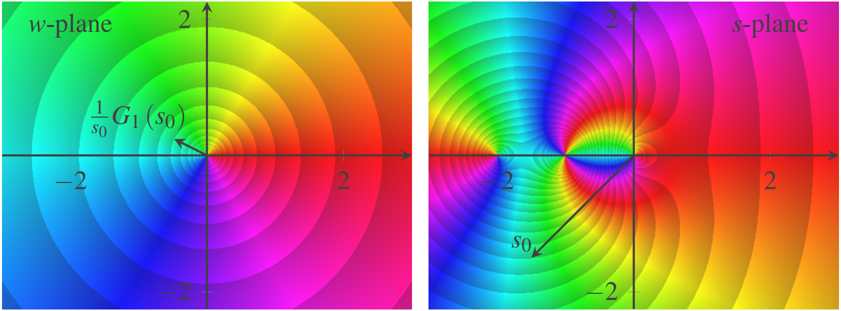
Modular stability guarantee:

Then the system model is stable for all

$$0 \leq N \leq 1$$

Component Test



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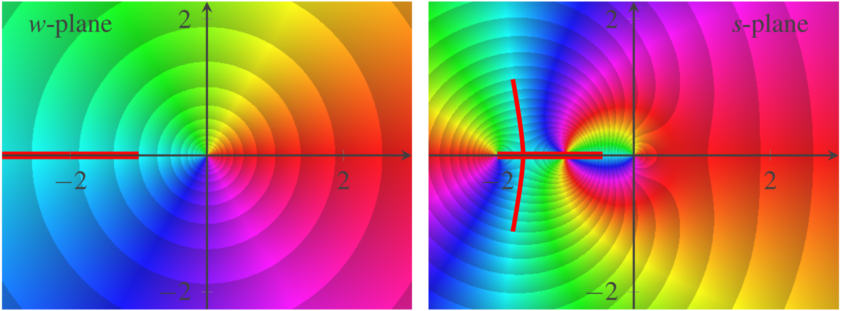

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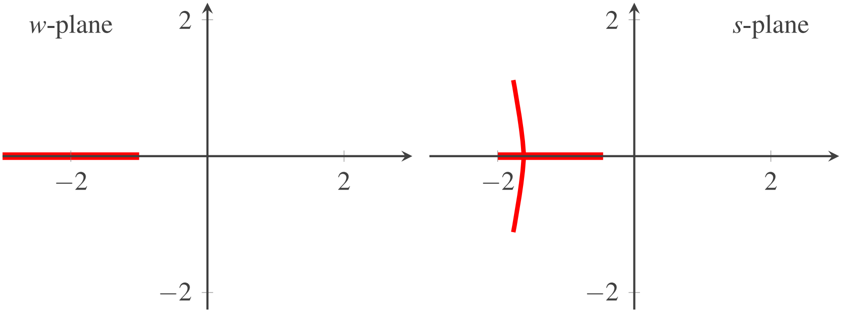
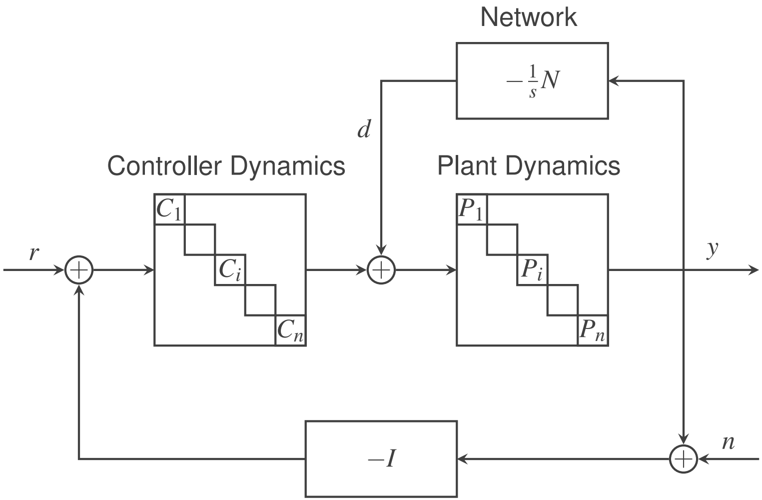


$$\left(\forall s \in \overline{\mathbb{C}}_+\right) \qquad \frac{1}{s} G_1\left(s\right) \notin \left(-\infty, -1\right]$$

The Matrix Case



The Matrix Case

Component test:

If for all i

Modular stability guarantee:

Then the system model is stable for all

$$0 \preceq N \preceq I$$

The Matrix Case

Component test:

If for all i

$$\left(\forall s \in \overline{\mathbb{C}}_+\right) \quad \frac{1}{s} G_i(s) \notin (-\infty, -1]$$

Modular stability guarantee:

Then the system model is stable for all

$$0 \preceq N \preceq I$$

The Matrix Case

Component test:

If for all i

Requires $G_1(s) = \ldots = G_n(s)$

$$\cancel{\left(\forall s \in \overline{\mathbb{C}}_+\right) \quad \frac{1}{s} G_i(s) \notin (-\infty, -1]}$$

Modular stability guarantee:

Then the system model is stable for all

$$0 \preceq N \preceq I$$

The Matrix Case

Component test:

If for all i

$$\left(\forall s \in \overline{\mathbb{C}}_+\right) \quad \operatorname{Re}\left(\frac{1}{s} G_i\left(s\right)\right) \notin \left(-\infty, -1\right]$$

Modular stability guarantee:

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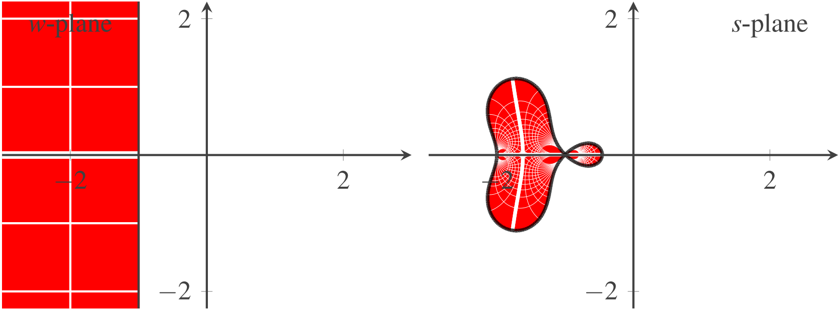
Component Test



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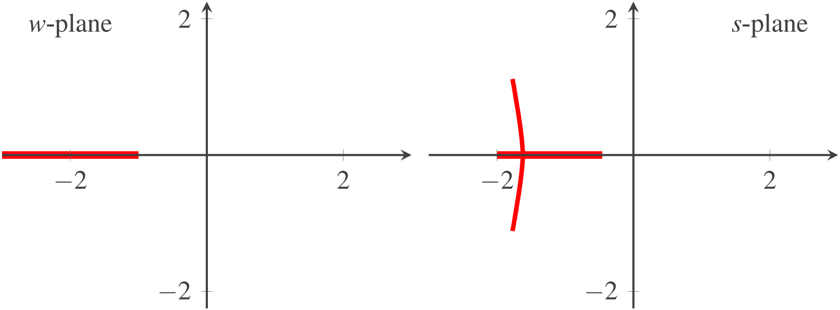

$$\left(\forall s \in \overline{\mathbb{C}}_+\right) \quad \mathrm{Re}\left(\frac{1}{s} G_i\left(s\right)\right) \notin \left(-\infty, -1\right]$$

Better Decentralised Criteria?

Component test:

If for all $i \geq 2$

$$\left(\forall s \in \overline{\mathbb{C}}_{+}\right) \quad \mathrm{Re}\left(\frac{1}{s} G_i\left(s\right)\right) \notin \left(-\infty, -1\right]$$

Modular stability guarantee:

Then the system model is stable for all

$$0 \preceq N \preceq I$$

Better Decentralised Criteria?

Component test:

If for all $i \geq 2$

$$\left(\forall s \in \overline{\mathbb{C}}_+\right) \quad \mathrm{Re}\left(\frac{1}{s} G_i(s)\right) \notin (-\infty, -1]$$

Modular stability guarantee:

Then the system model is stable for all

$$\cancel{0 \preceq N \preceq I}$$

Better Decentralised Criteria?

Component test:

Given $h(s) \in \mathbf{PR}$, if for all i

$$\left(\forall s \in \overline{\mathbb{C}}_{+}\right) \quad \operatorname{Re}\left(\frac{h(s)}{s} G_i(s)\right) \notin (-\infty, -1]$$

Modular stability guarantee:

Then the system model is stable for all

$$0 \preceq N \preceq I$$

Comments

- **Component test**
  - State-space methods
  - Nyquist criteron
  - Circuit theoretic methods
- **Controller Design:**
  - $\mathscr{H}_\infty$ optimal control
  - Frequency response methods
- **Frequency control problems:**
  - Droop control
  - Automatic Generation Control (AGC)
  - Including delays, governor and turbine dynamics, ...

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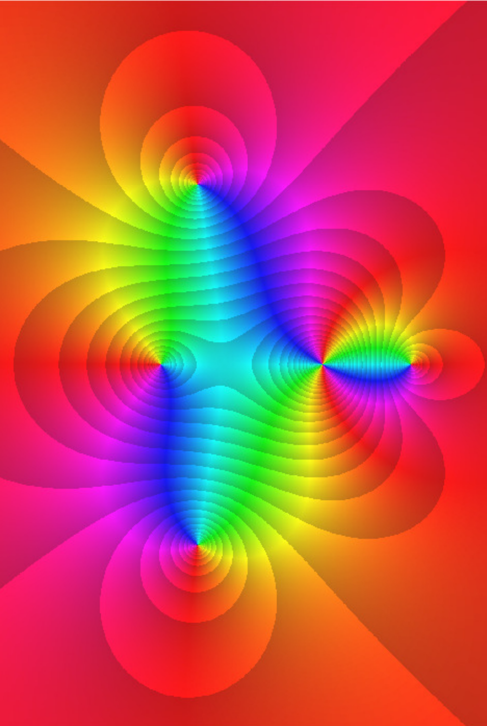

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