Lecture 1

# ENEE 765 Adaptive Control

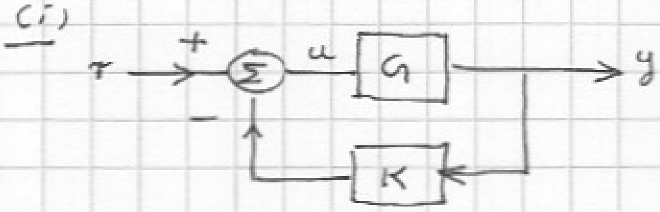
PSK
09.02.05

Some recollections of linear multivariable time-invariant systems ( $G, K, C, M, R, U, Y$ are all functions of $s$ )

Laplace transform argument

Consider the following block diagrams

(i)




$u \in \mathbb{R}^m$
$y \in \mathbb{R}^p$
$r \in \mathbb{R}^m$

Then $Y(s) = G(s)\,U(s)$

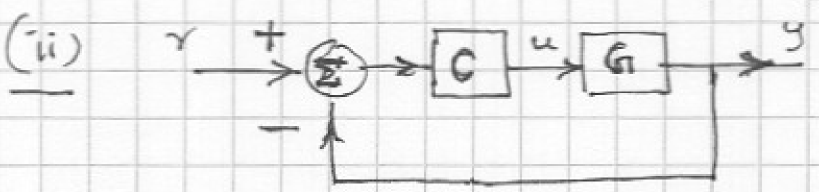
$$U(s) = R(s) - K(s)\,Y(s)$$

$$\Rightarrow \quad Y(s) = \underbrace{(\mathbb{1}_p + G(s)K(s))^{-1}\,G(s)}\;R(s) \quad = G_f(s)\,R(s)$$

$$= \underbrace{G(s)\,(\mathbb{1}_m + K(s)G(s))^{-1}}\;R(s) \quad = G_f(s)\,R(s)$$

$G_f$ is closed-loop transfer function.

(ii)

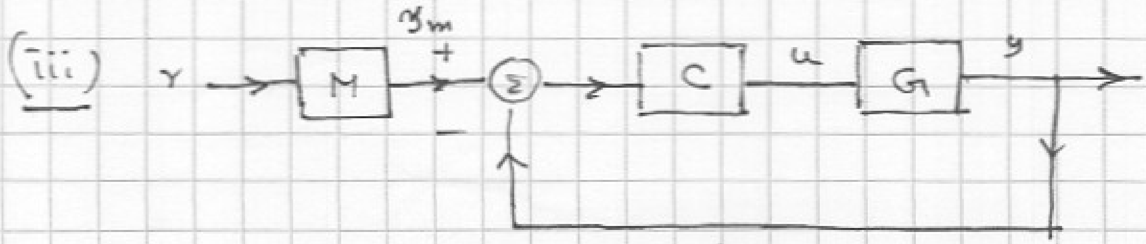



$r \in \mathbb{R}^p$

Then $Y(s) = \underbrace{G(s)\,(\mathbb{1}_m + C(s)\,G(s))^{-1}\,C(s)}\;R(s)$

$$= \underbrace{(\mathbb{1}_p + G(s)\,C(s))^{-1}\,G(s)\,C(s)}\;R(s) \quad = G_f(s)\,R(s)$$

(iii)



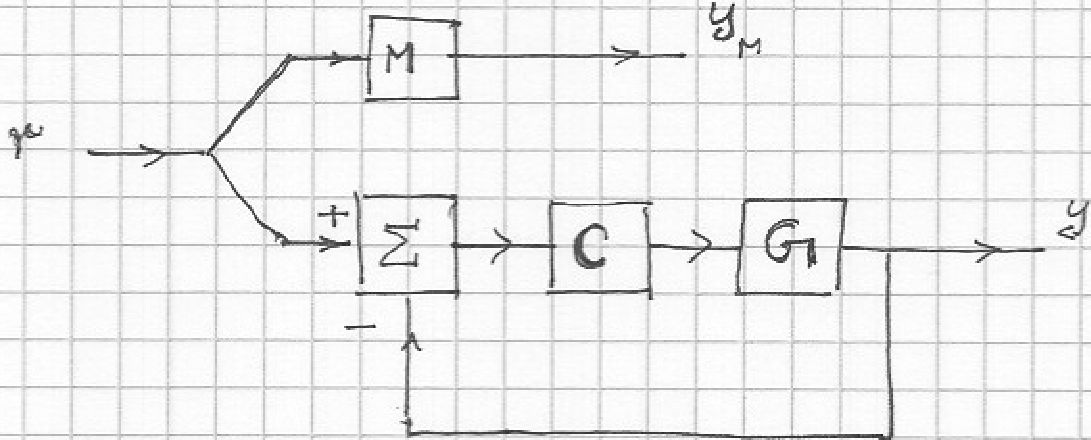

$r \in \mathbb{R}^k$

Then $Y(s) = \underbrace{(\mathbb{1}_p + G(s)\,C(s))^{-1}\,G(s)\,C(s)\,M(s)}\;R(s)$

$$= \underbrace{G(s)\left(\mathbb{1}_m + C(s)G(s)\right)^{-1} C(s)M(s)}\,R(s)$$

and

(iv)




$$\Rightarrow \qquad Y_M(s) = M(s)R(s)$$

$$Y(s) = \left(\mathbb{1}_p + G(s)C(s)\right)^{-1} G(s)C(s)R(s)$$

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In these diagrams K is a feedback compensator, C is a pre-compensator, M is a reference model and G is the physical plant.

We refer to (iii) & (iv) as series/cascade model reference control and parallel model reference control respectively, and the design goal is to find C in these cases to achieve $y_m \approx y$

In case (iii) this ~~amounts~~ to ~~choosing~~ **C** ~~such~~ that

$$\left(\mathbb{1}_p + G(s)C(s)\right)^{-1} G(s)C(s) \approx \mathbb{1}_p$$

and in case (iv) it is the matching problem:

<u>solve for $C(s)$ such that</u>

$$\left(\mathbb{1}_p + G(s)C(s)\right)^{-1} G(s)\,C(s) \approx M(s).$$

**Suppose** $p = m = 1$ (SISO system). Then, in case (iii) this amounts to asking

$$\frac{GC}{1+GC} \approx 1$$

$$\Leftrightarrow \quad \frac{G}{\frac{1}{C}+G} \approx 1$$

which can be achieved if $C(s) = C \to \infty$ (high gain)

We also recall the use of root-locus theory to design loops as in case (i), case (ii) — i.e find $K$ and $C$ so as to achieve desired stability ~~properties~~ for ~~the~~ closed-loop system. ~~It is clear that one~~