A pedagogical path from the internal model principle to Youla-Kučera parametrization

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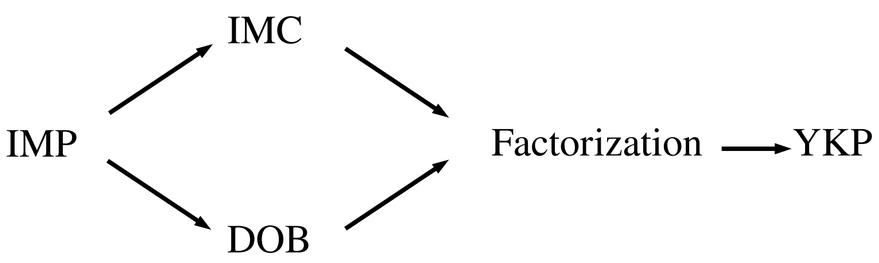
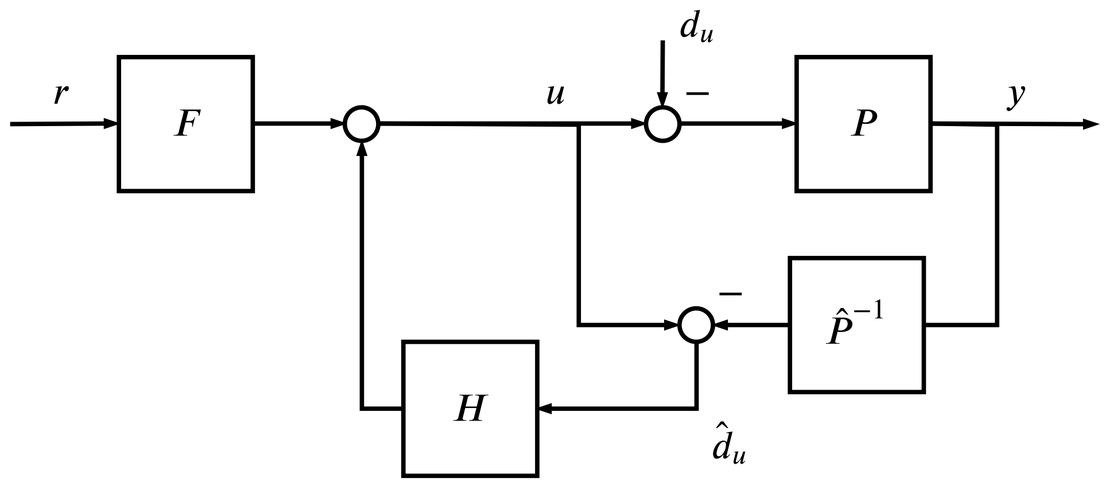
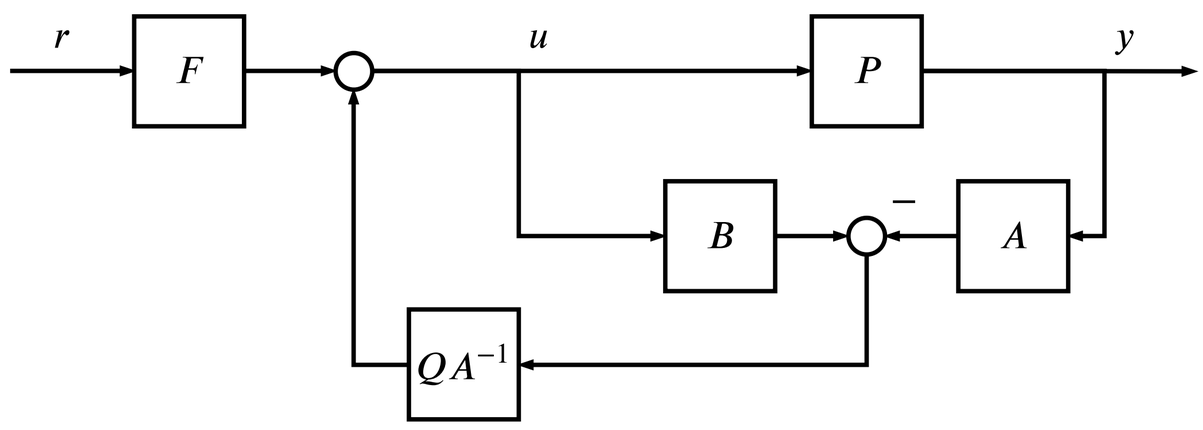


We propose a sequence of pedagogical steps for introducing the Youla-Kučera parametrization:

- Introduce the internal model principle (IMP).
- Make clear how reasonable it is.
- Introduce disturbance observer (DOB) and internal model control (IMC), supported by the IMP intuition.
- Show how they are related
- Introduce the concept of factorization to generalize
- Use IMC to introduce the stable Youla-Kučera parametrization
- Use the "Gang of Four" to derive stability criteria for IMC of unstable plant
- Introduce the parametrization, plug in to block diagram
- Reshape block diagram to show interpretations



The DOB controller structure.



The "polynomial" factorization, between IMC and DOB.

The "Gang of Four" for the closed loop system using IMC:

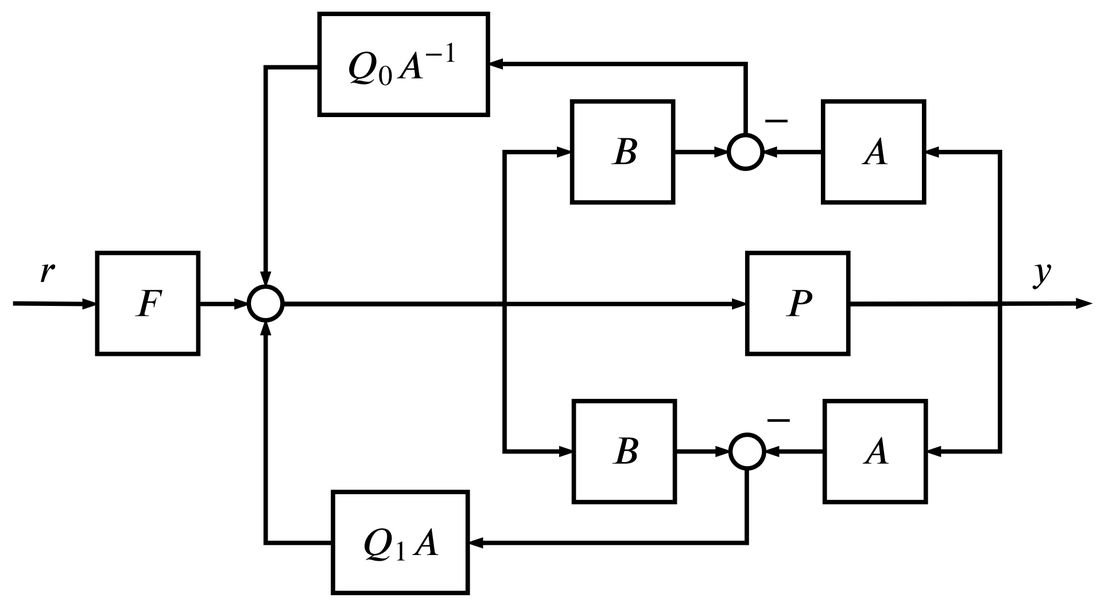
$$\begin{bmatrix} y \\ u \end{bmatrix} = \begin{bmatrix} PQ & P(1-PQ) \\ Q & 1-PQ \end{bmatrix} \begin{bmatrix} r \\ d_u \end{bmatrix}$$

Let the plant be given by: $P = \dfrac{B}{A}$

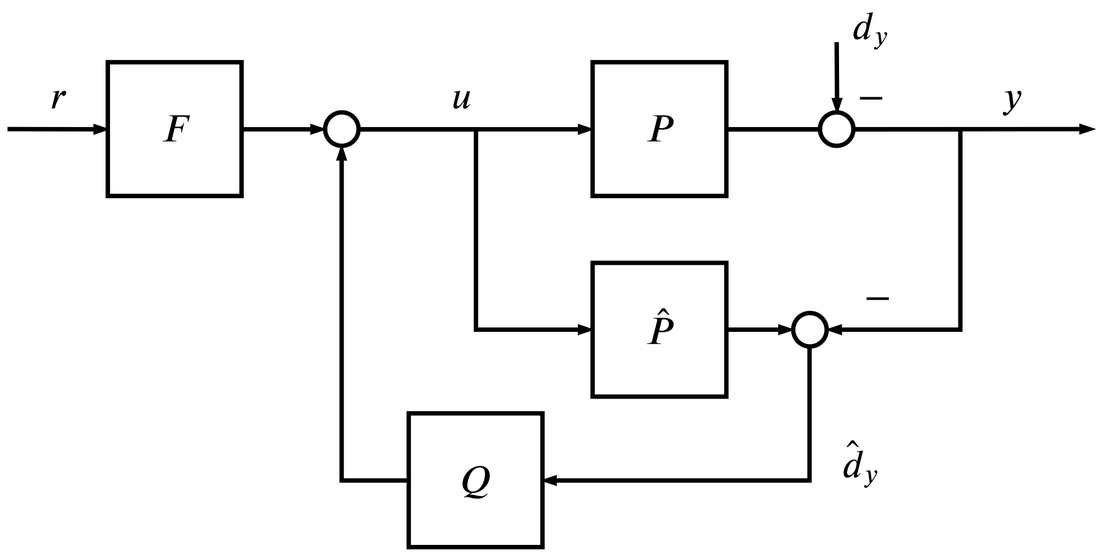
The YKP parametrization for unstable plants can be obtained by:

$$Q = Q_0 + Q_1 A^2$$

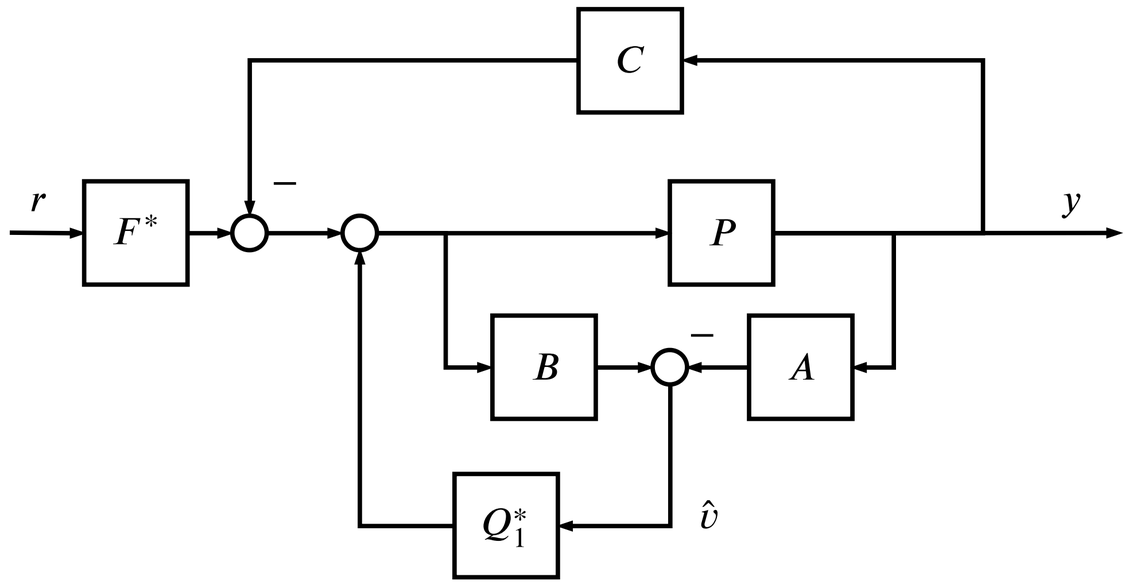
Where Q_0 is a stabilizing IMC controller, and Q_1 is a stable transfer function parametrizing all stablizing controllers.



General YKP in "IMC form".



The IMC controller structure.



General YKP in "post-stabilized form".