Modelling and control summaries

by Anthony Rossiter

Block diagrams 6 – multiple inputs

Real systems often have multiple input signals to the loop

1. **The main loop input is likely to be a target signal – often denoted by 'r' for reference.**
2. **Other loop inputs will be sensor or measurement noise and system disturbances.**

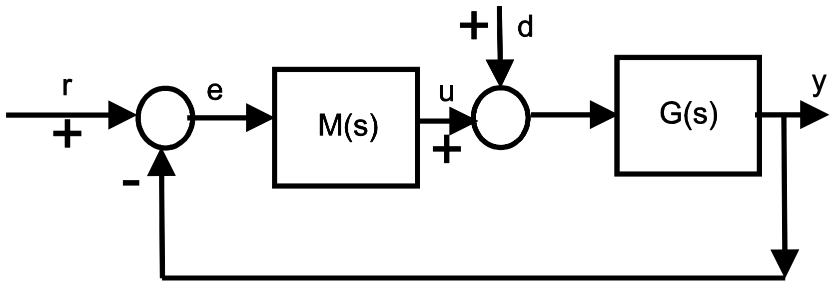
[WARNING: Do not confuse loop input with system input]

Key observations for dealing with systems with multiple loop inputs

Systems modelling with Laplace transforms must be linear and this means that **superposition** is valid. Hence once can model the impact of each loop input separately and add the result at the end. Convince yourself of this using the following example.

Derive dependence on r ignoring d.

$$y = \frac{GM}{1+GM} r$$
$$u = \frac{M}{1+GM} r$$
$$e = \frac{1}{1+GM} r$$



Same result

LONG HAND DERIVATION:

$$\left.\begin{array}{l} e = r - y \\ u = Me \\ f = d + u \\ y = Gf \end{array}\right\} \Rightarrow \begin{array}{c} e = r - Gf \\ e = r - G(d+u) \\ e = r - Gd - GMe \end{array} \Rightarrow e = \frac{1}{1+GM} r - \frac{G}{1+GM} d$$

WARNING: When using the short cut method to consider the impact of d alone, be careful because the forward path from d ➔ e and d ➔ u both include the negative sign from the summing junction and hence:

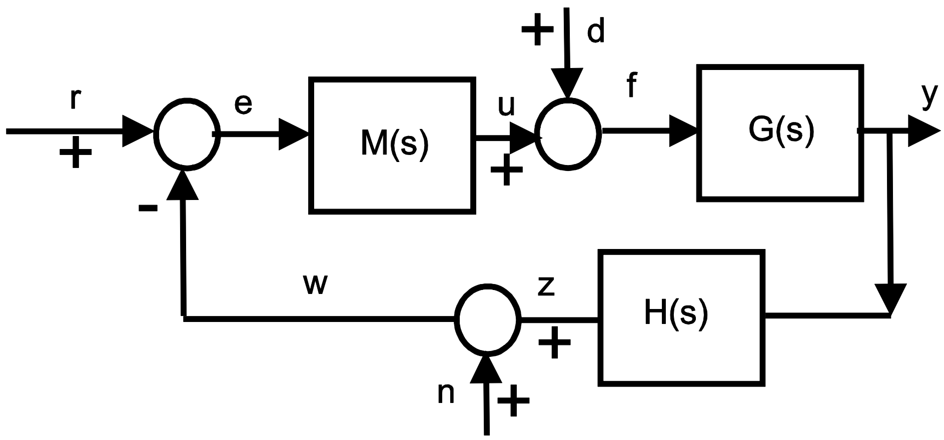
$$e = \frac{-G}{1+GM} d; \quad u = \frac{-GM}{1+GM} d; \quad y = \frac{G}{1+GM} d$$

Hence a sumary of total relationships will be:

$$e = \frac{1}{1+GM} r - \frac{G}{1+GM} d; \quad u = \frac{M}{1+GM} r - \frac{GM}{1+GM} d; \quad y = \frac{GM}{1+GM} r + \frac{G}{1+GM} d$$

EXAMPLE

Confirm the following relationships for yourself using both long hand derivations and superposition in combination with the short cut method.



$$e=\frac{1}{1+HGM}r-\frac{HG}{1+HGM}d-\frac{1}{1+HGM}n;$$
$$u=\frac{M}{1+HGM}r-\frac{MHG}{1+HGM}d-\frac{M}{1+HGM}n;$$
$$y=\frac{GM}{1+HGM}r+\frac{G}{1+HGM}d-\frac{GM}{1+HGM}n;$$

By yourself: Find the relationships for signals f,w and z.