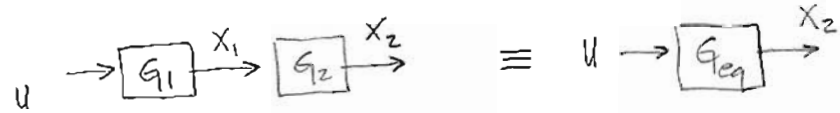
Block Diagram Algebra And Block Diagram Simplification

(March 03, 2015 as Handout)

How does it work? - Well we operate on the block diagrams
- We apply equivalencies (or algebraic equalities) coming directly from manipulating equations:

Example: Cascade connection of two blocks.

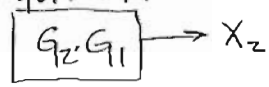


Well, it can be easily derived: $X_1 = G_1 \cdot U$

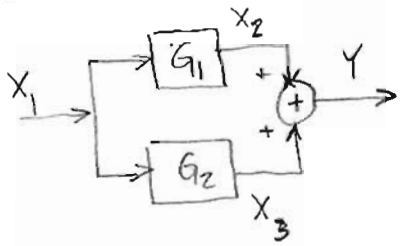
$X_2 = G_2 \cdot X_1 = G_2 \cdot G_1 \cdot U \rightarrow \boxed{G_{eq} = G_2 G_1}$

Because this is simple polynomial multiplication (for a single-input single output system) we may say: $G_{eq} = G_1 G_2 = G_2 G_1$

Note: For a multiple-input multiple output system, in general this is not the case and $G_{eq} = G_2 \cdot G_1$ and order important.



Example: Parallel connection of two blocks

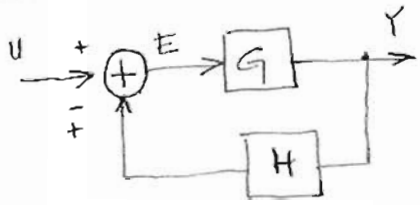


$Y = X_2 + X_3$

$= G_1 X_1 + G_2 X_1$

$Y = (G_1 + G_2) X_1 \rightarrow \boxed{G_{eq} = G_1 + G_2}$

Example: Eliminating a feedback loop (we have already solved this)

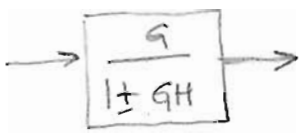


$Y = GE$

$E = U - HY$

$\rightarrow Y = G(U - HY) = GU - GHY$

$(1 + GH)Y = GU \rightarrow \boxed{Y = \frac{G}{1 \pm GH} \cdot U}$

$\equiv$ 

- Now we can consider the tank temperature control system and derive its transfer function.

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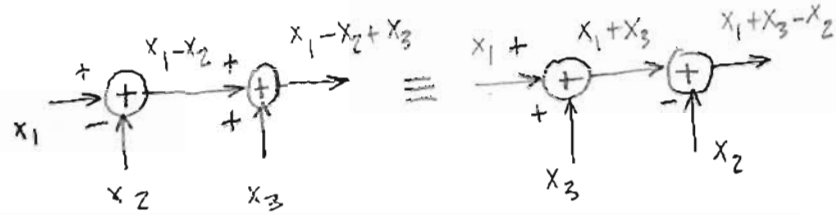
(as Handout)

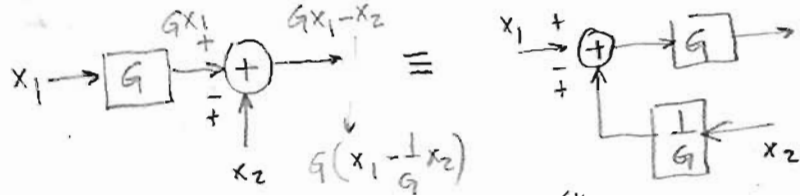
DO IT.

Other block diagram equivalencies:

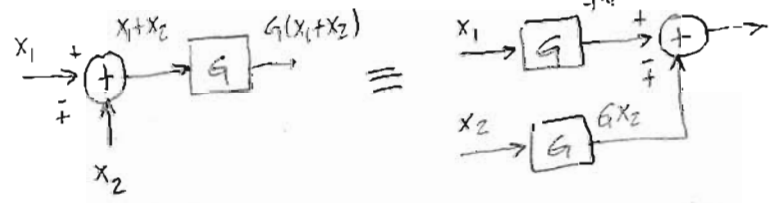
* Interchange of summing points



* Moving a summing point ahead of a block.

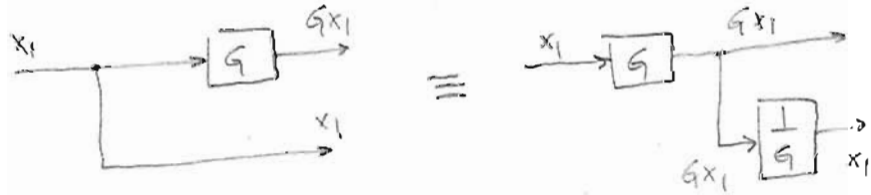


* Moving a summing point after a block



* Moving a branch point ahead of a block

* Moving a branch point after a block



Clearly:
- The basic tools for simplifying block diagram is to move branch points, summing points and reduce the feedback loops.
- As we simplify the block diagram:
  - → Reduces the subsequent labor for the mathematical analysis
  - → But the individual blocks become more complex
  - → Internal behavior is lost in the simplified form.
  - → However if the aim is to find the input output behavior then the simplified form is enough.

NOTE: When you are asked to provide block diagram simplification, do not provide an algebraic derivation of TF!!