MEM 255 Introduction to Control Systems: *Working with Block Diagrams*

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Outline

- **Block diagrams as an aid in model building**
- **Working with linear SISO blocks – building system transfer functions**
- **MATLAB tools**
- **General nonlinear MIMO blocks – building simulation models**
- **SIMULINK**

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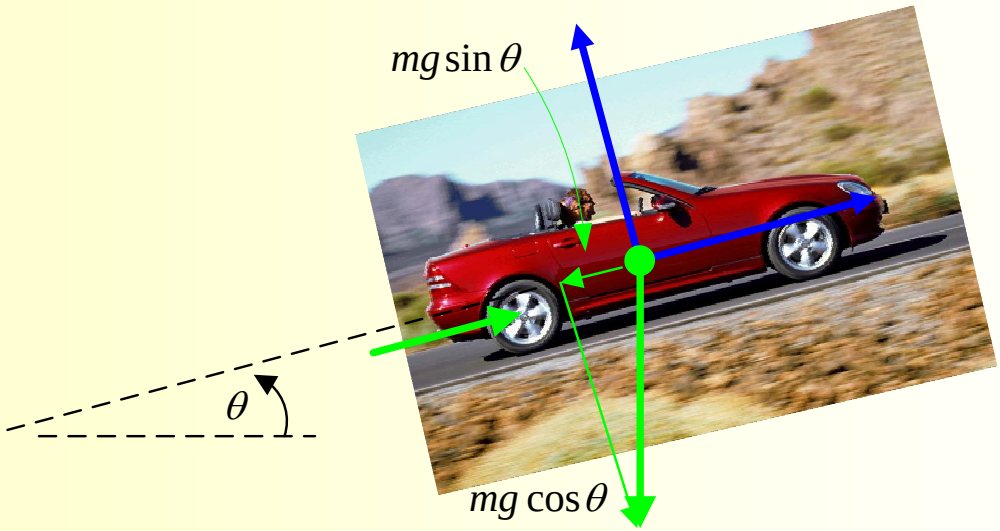
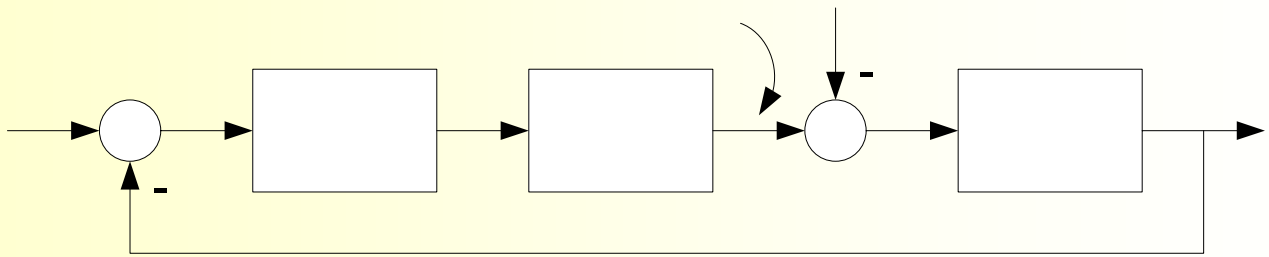
Example: Cruise Control





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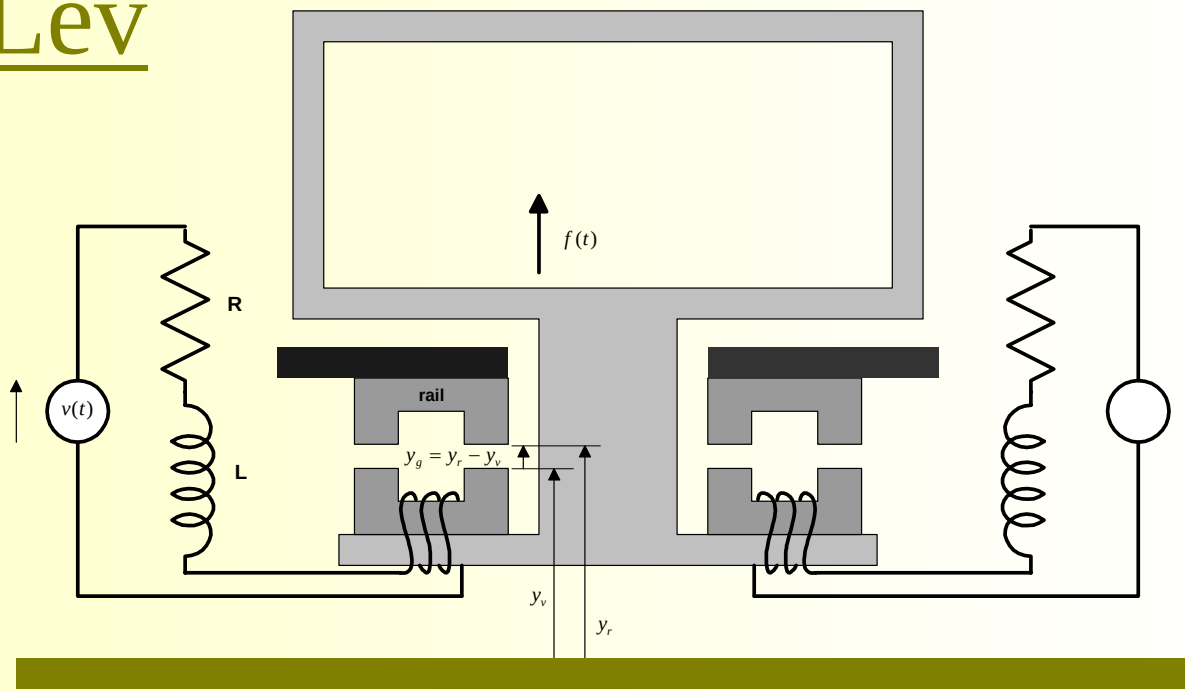
Preliminary Example: MagLev



The vertical support via attracting magnets is inherently unstable since attractive forces decrease with air gap, so a small disturbance from equilibrium causes the vehicle to either clamp to the rail or fall. Thus, a feedback control is employed using the magnet excitation voltage to stabilize the motion and control the air gap and vehicle position.

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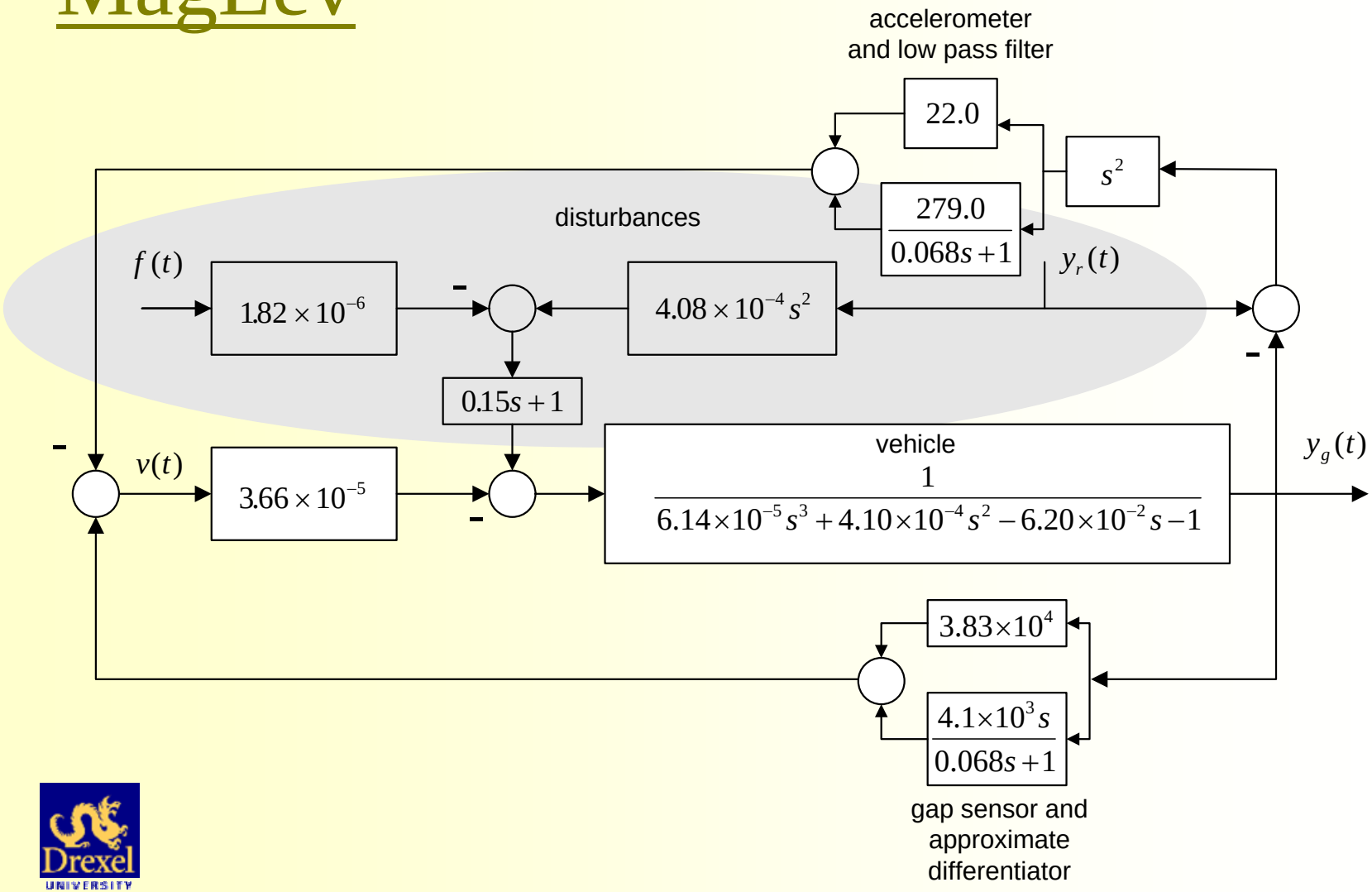
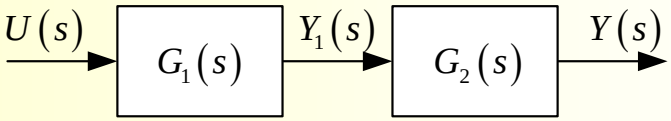
Preliminary Example: MagLev



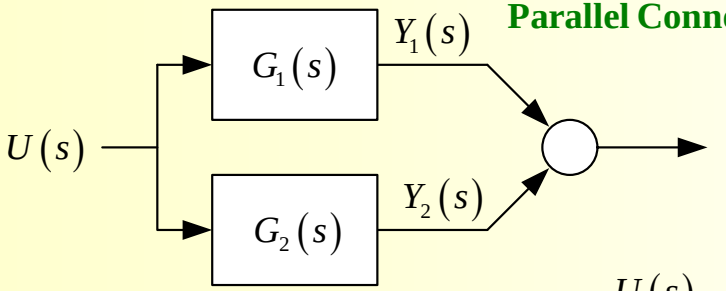
Three Basic Interconnections

Series Connection



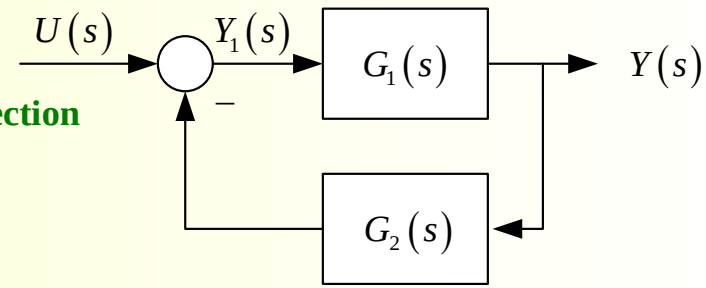
$$Y(s) = G_2(s)Y_1(s) \;\&\; Y_1(s) = G_1(s)U(s) \Rightarrow \boxed{Y(s) = G_2(s)G_1(s)U(s)}$$

Parallel Connection



$$\boxed{Y(s) = \{G_1(s) + G_2(s)\}U(s)}$$

Negative Feedback Connection



$$Y_1(s) = U(s) - G_2(s)Y(s) \;\&\; Y(s) = G_1(s)Y_1(s) \Rightarrow \boxed{Y(s) = \frac{G_1(s)}{1 + G_2(s)G_1(s)}}$$

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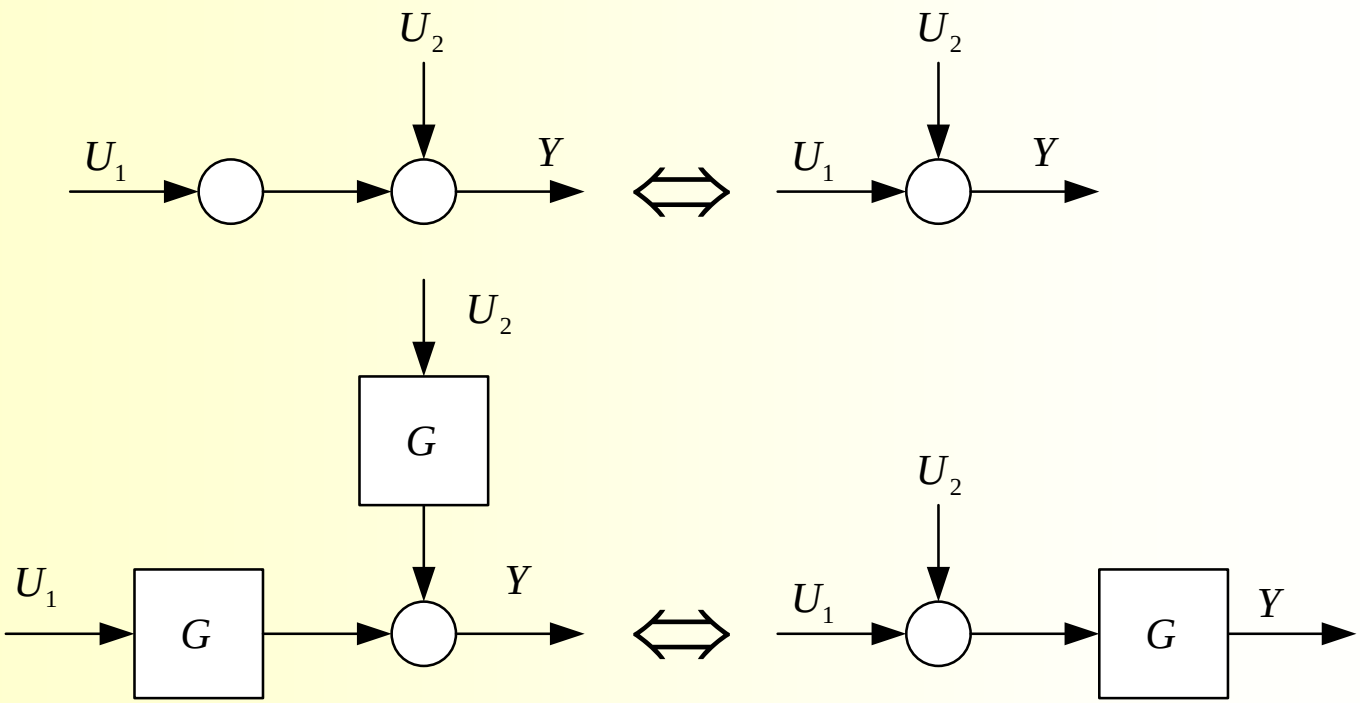
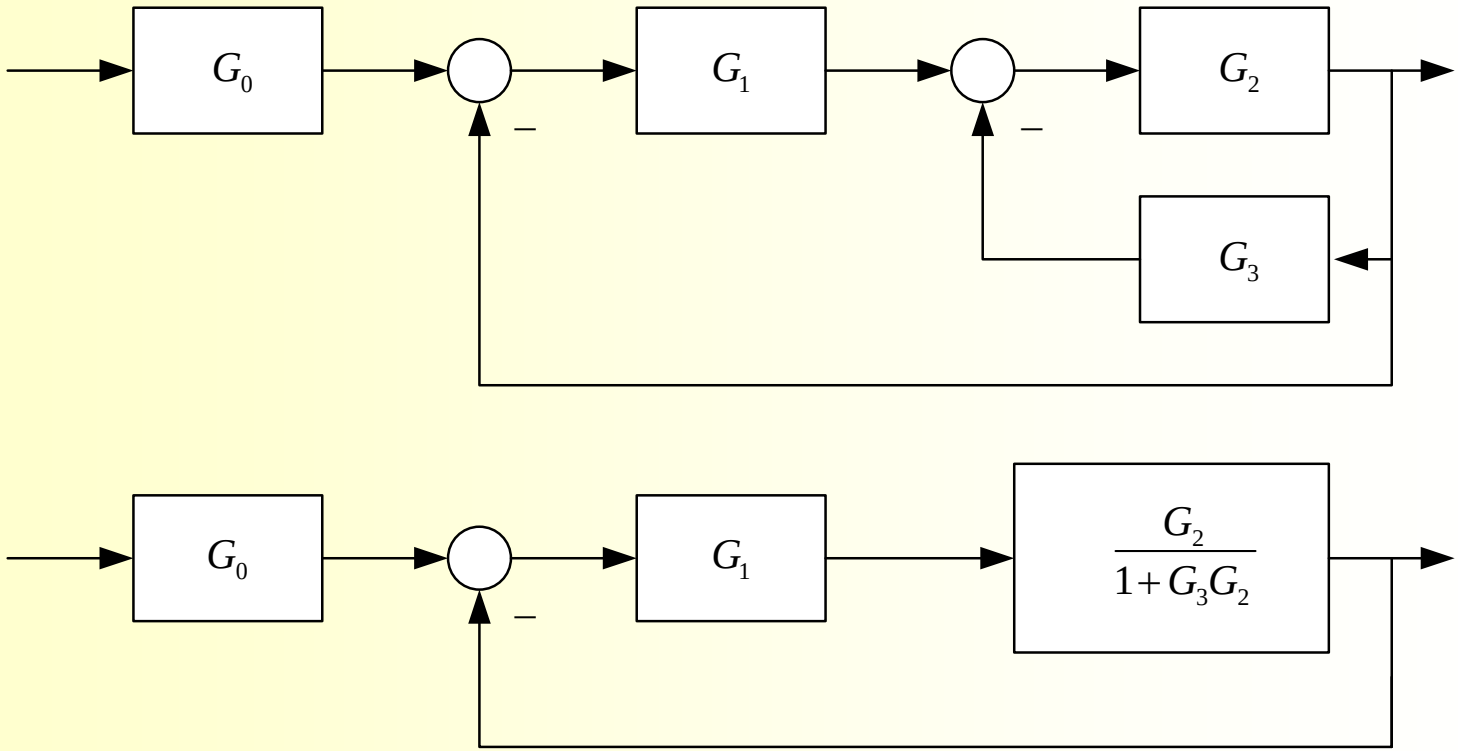
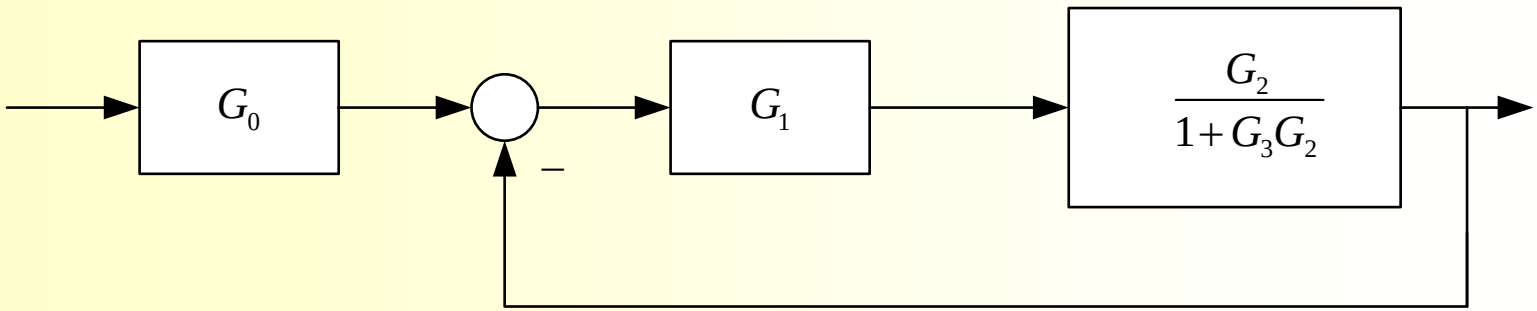
Summing Junction Linearity



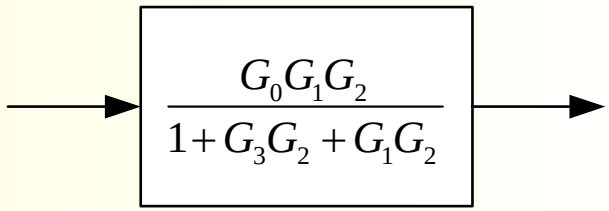
Example



Example, Cont'd



$$\frac{\frac{G_1G_2}{1+G_3G_2}}{1+\frac{G_1G_2}{1+G_3G_2}} = \frac{G_1G_2}{1+G_3G_2+G_1G_2} \Rightarrow$$



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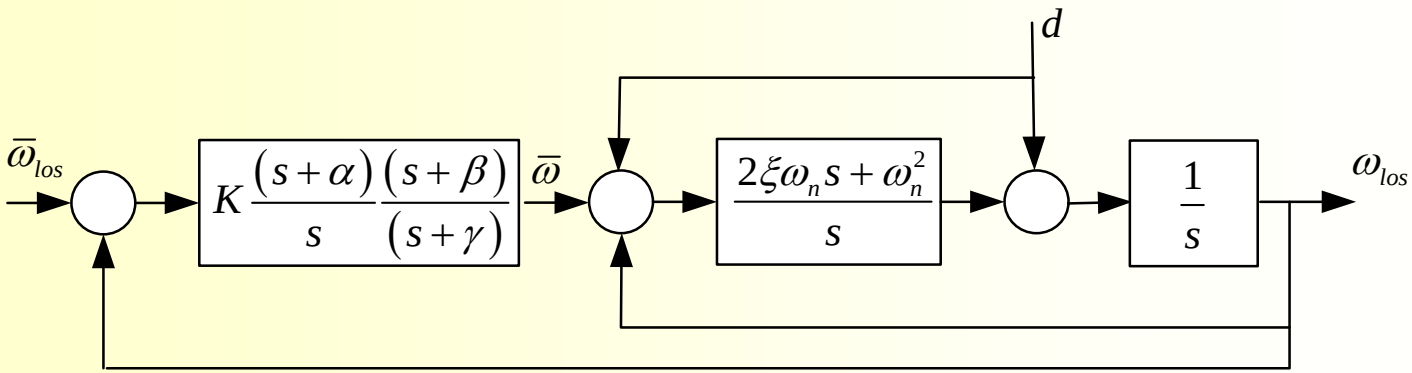
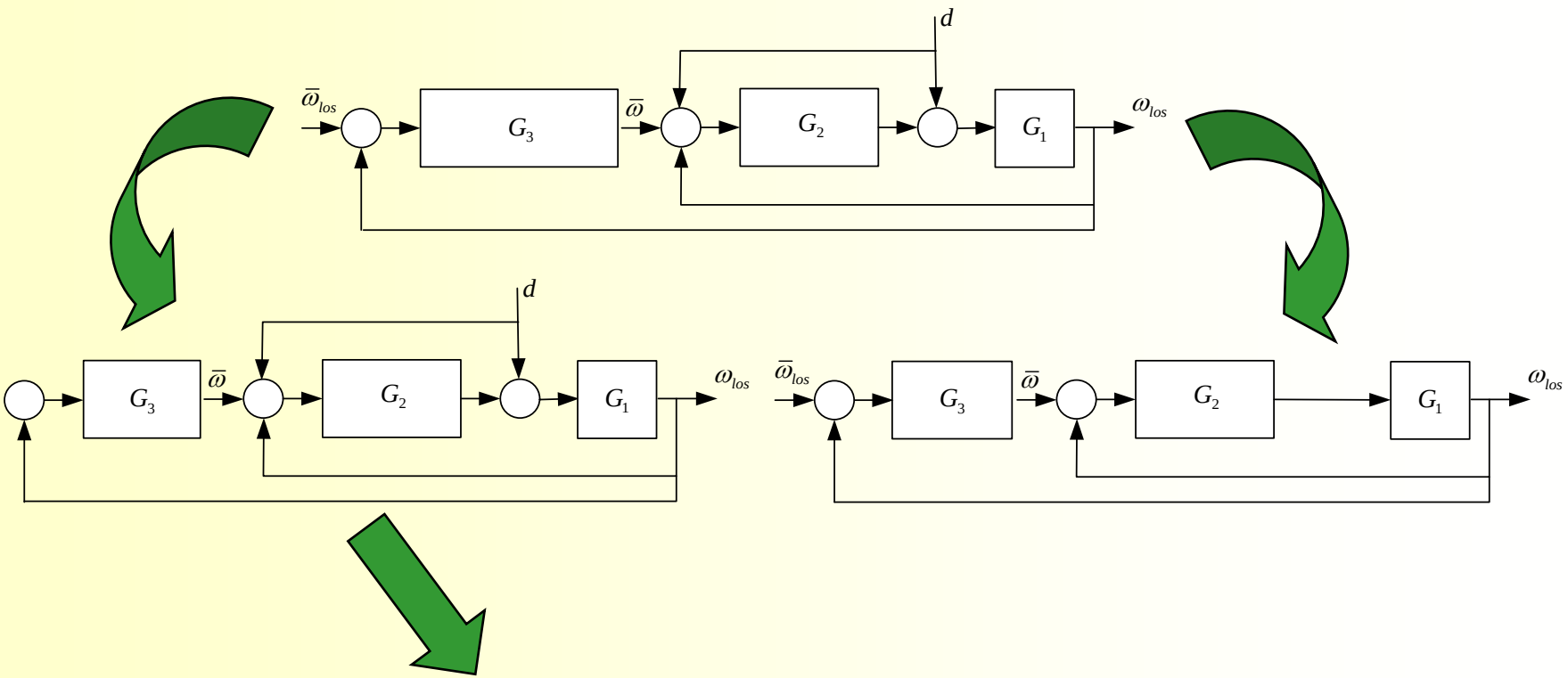
Example: Platform Rate Controller

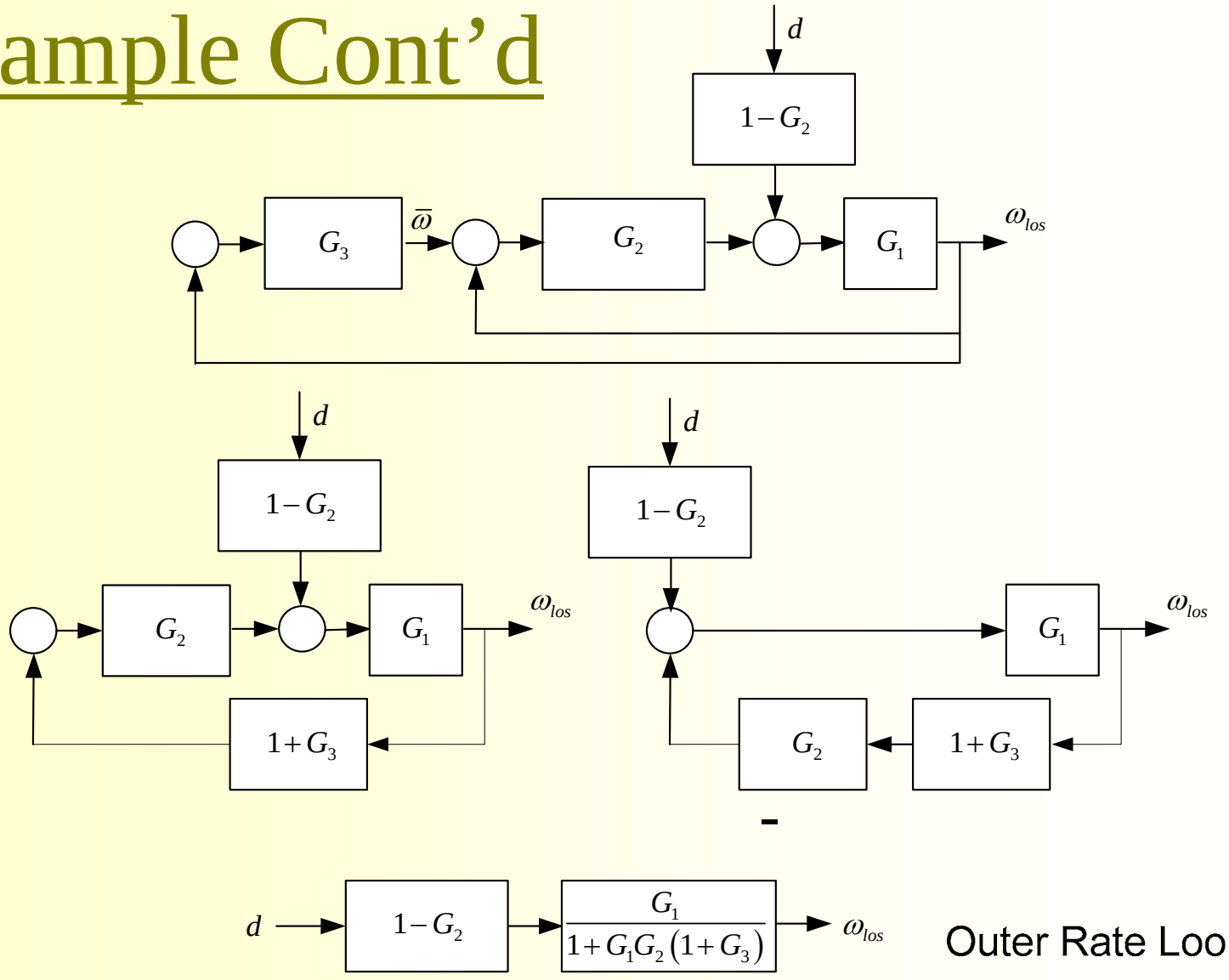


1) Find transfer function from command to los
2) Find transfer function from disturbance to los

Example Cont'd



Example Cont'd



Outer Rate Loop

Using MATLAB

The MATLAB functions:

series sys = series(sys1,sys2)

parallel sys = parallel(sys1,sys2)

feedback sys = feedback(sys1,sys2)

or sys = feedback(sys1,sys2,sign)

do the algebra for you. General syntax works for MIMO systems.

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More General Block Diagrams as a Modeling Tool

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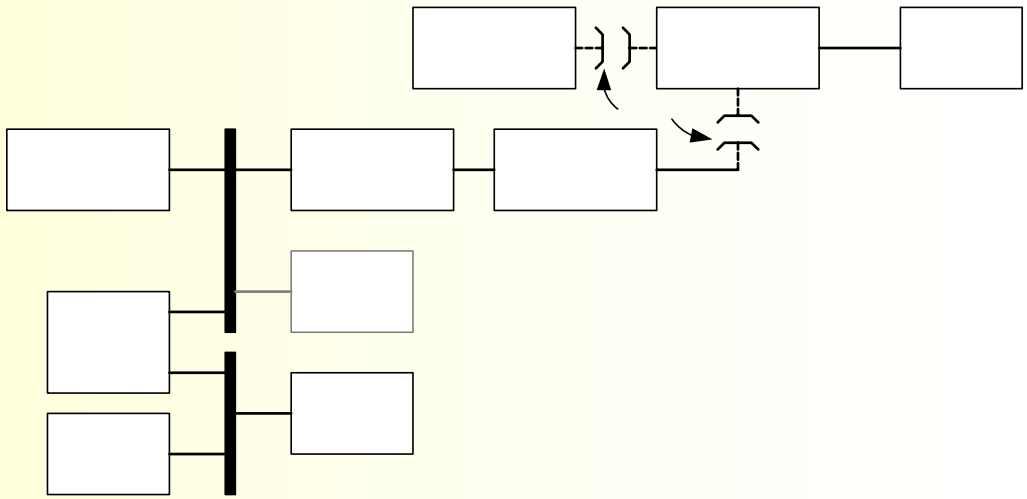
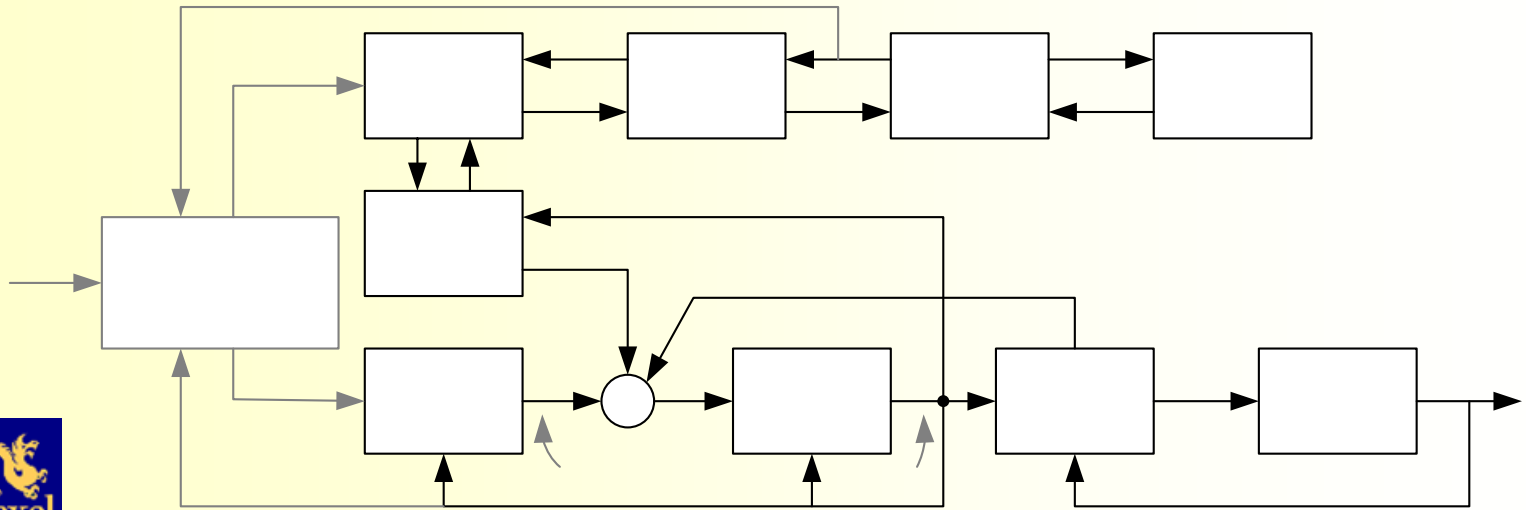
Preliminary Example: Hybrid Drive



Preliminary Example: Hybrid Drive



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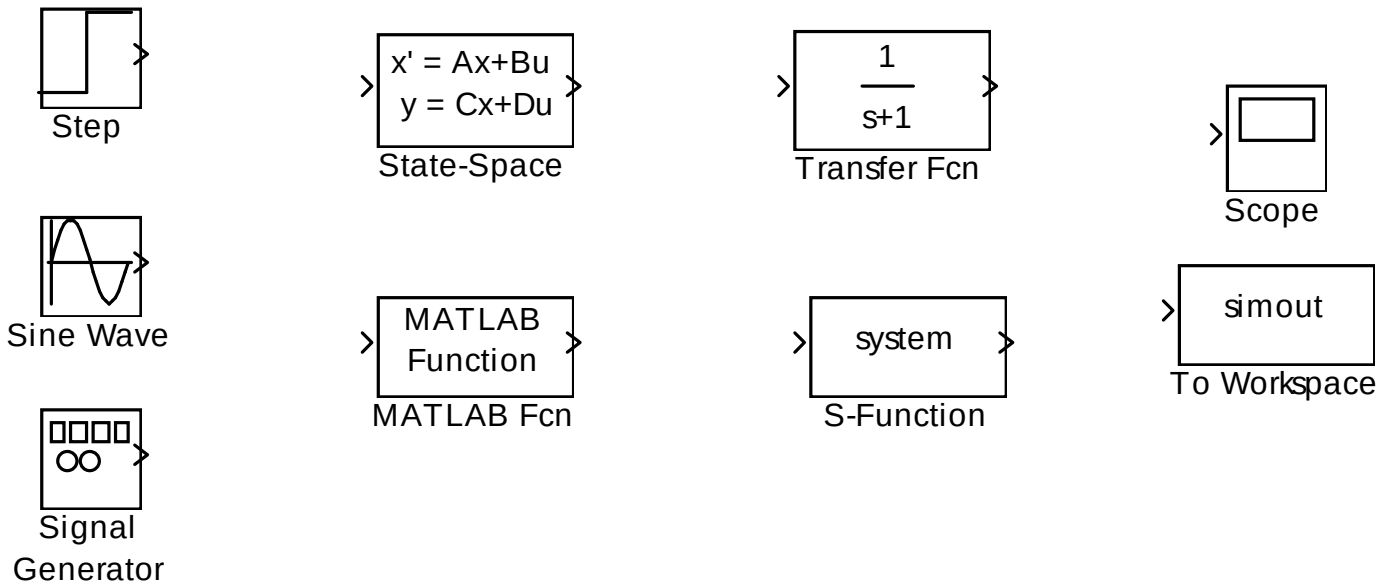
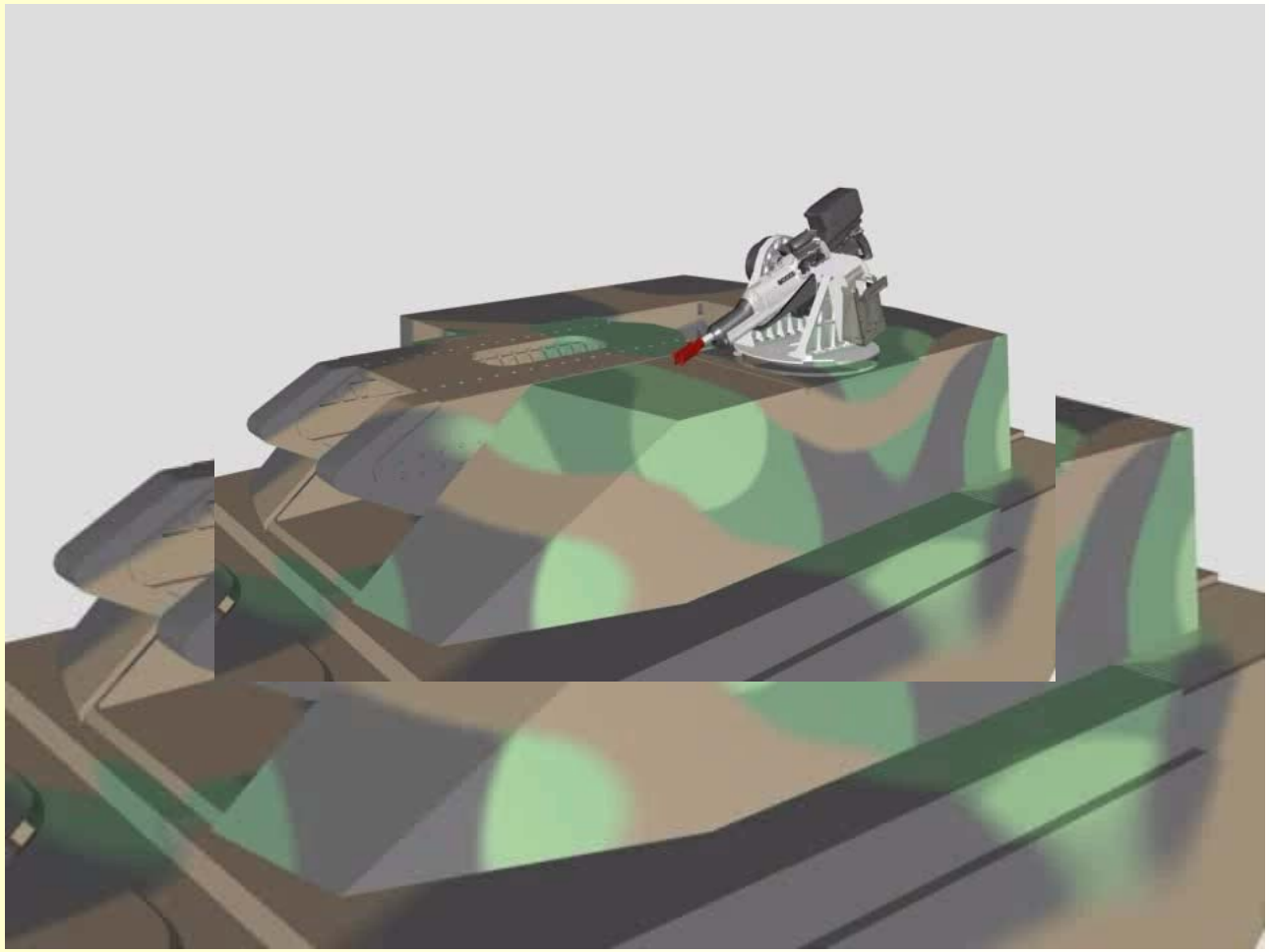
Simulink


Step
x' = Ax+Bu
y = Cx+Du
State-Space
1
s+1
Transfer Fcn
Scope
Sine Wave
MATLAB
Function
MATLAB Fcn
system
S-Function
simout
To Workspace
Signal
Generator

SAS Animation



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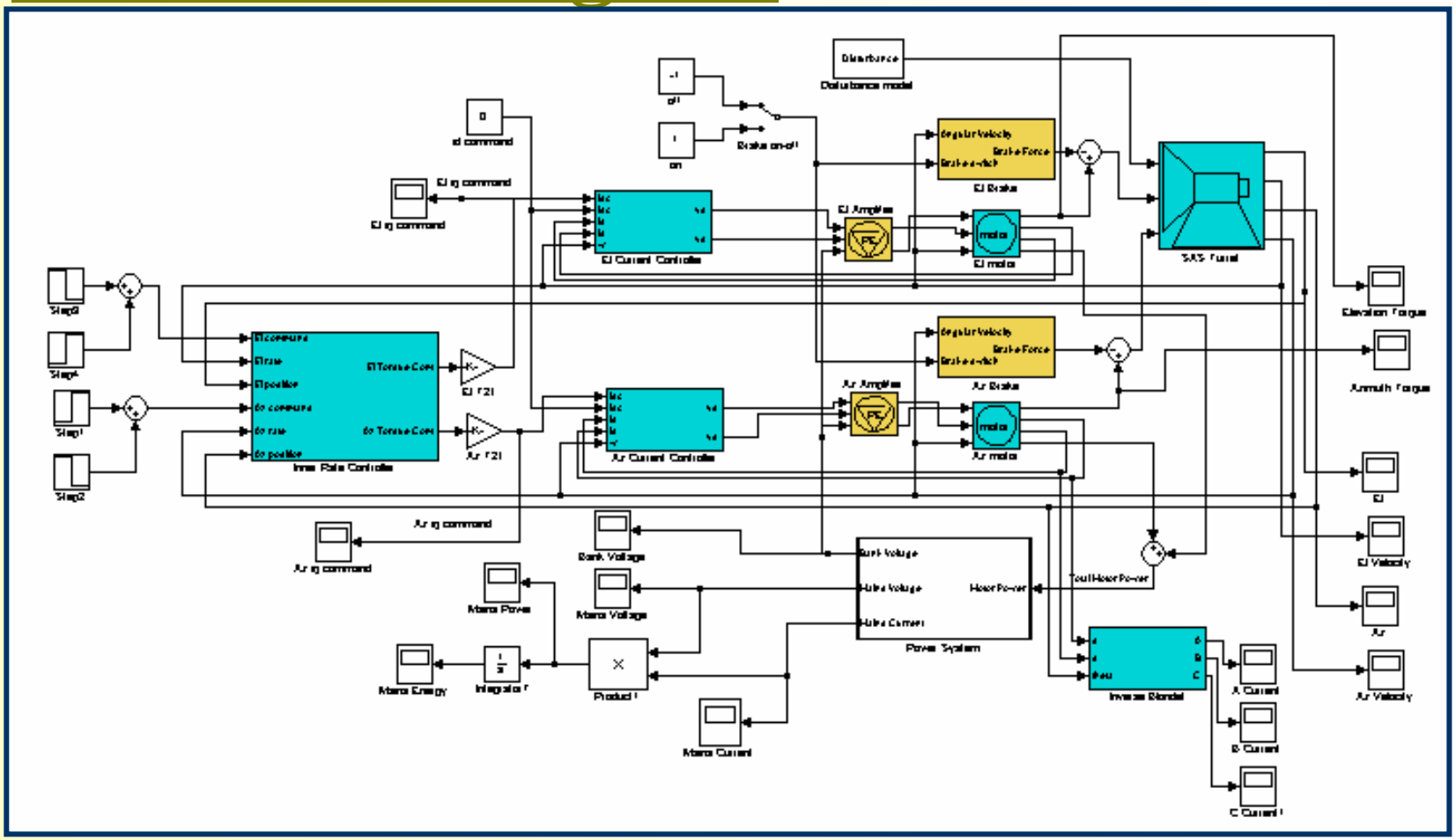
Simulink Diagram



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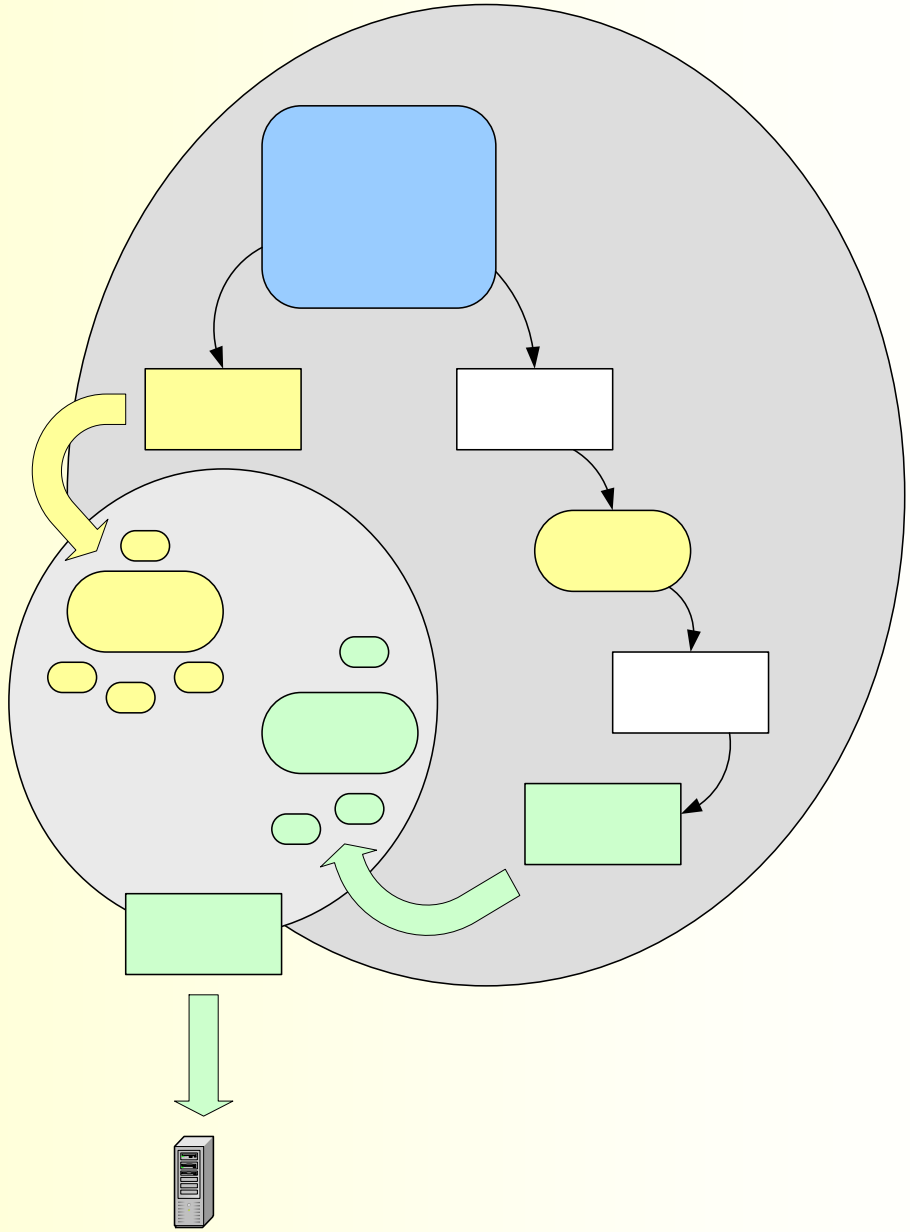
ProPac



Code
generati

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Summary

- Linear SISO system block diagrams
- Basics of block diagram algebra
- Using MATLAB
- General block diagrams
- Modeling with Simulink

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