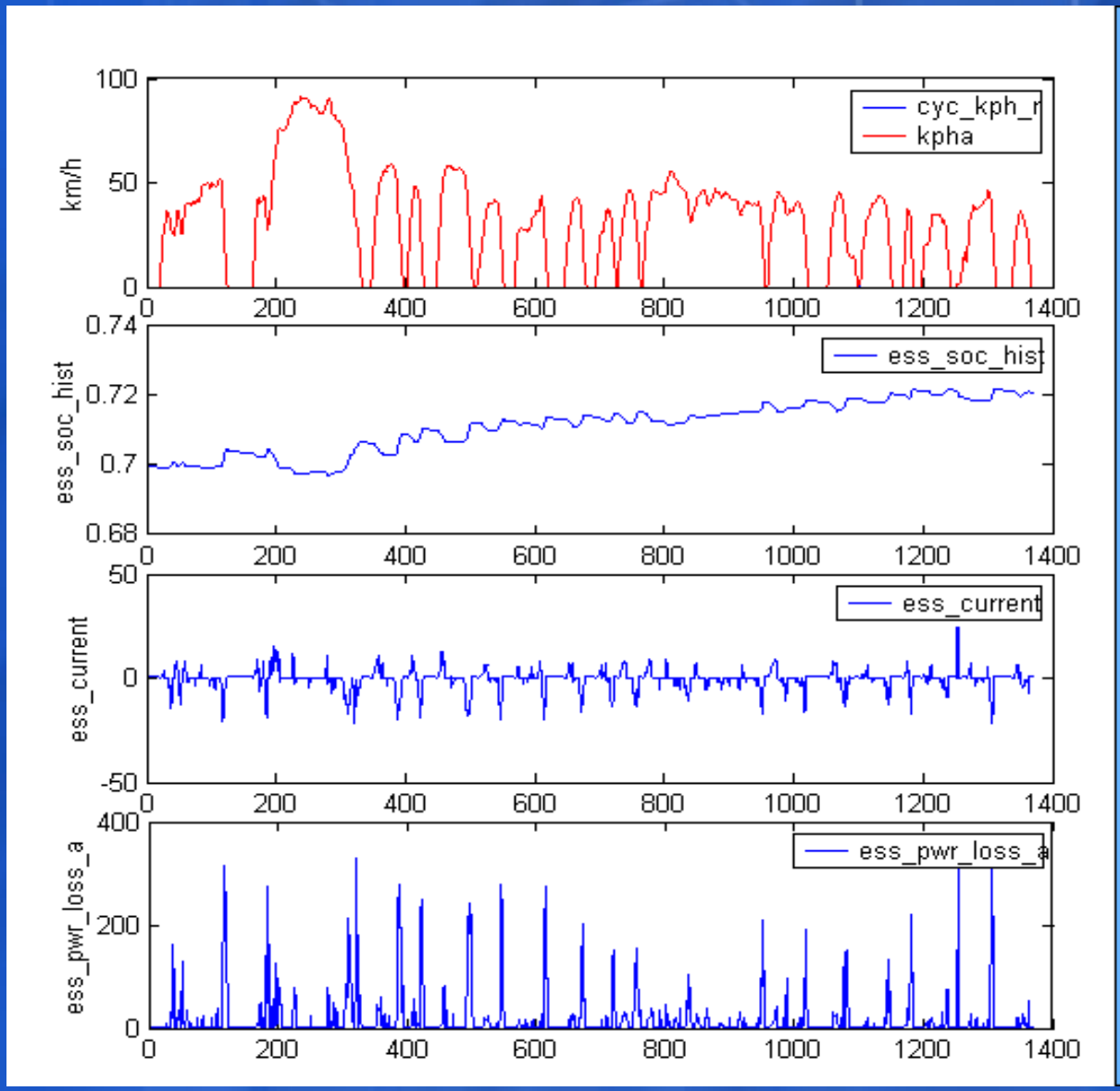
IPRO 314:
Hybrid Electric Augmentation Using Ultra-capacitors

Ultra-Capacitor Augmentation into HEVs (An ADVISOR Based Simulation Model)

- Objective
  - To augment a low-cost capacitor into the energy storage module of a HEV in order to extend the lifetime of the vehicle's battery.
- Methodology
  - An HEV was simulated in ADVISOR by using a parallel battery-capacitor combination headed by a control system.
  - This approach was aimed at eliminating the battery's transient charge/discharge cycle, allowing the capacitor to accommodate for the transient supply/demand of power.

Battery Only Model



Results figure

Componer
energy_storage
plot control
Plot Variable (Select Axis
ess_pwr_loss_a
?
# of plots

Fuel Consumption (L/100 km)	3.9
Gasoline Equivalent	3.9
Distance (km)	12

Emissions (grams/km) Standards

HC	CO	NOx	PM
0	0	0	0

Acceleration Test

0-96.6 km/h n/a	Max. Accel. n/a
64.4-96.6 n/a	Distance in 5s n/a
0-136.8 n/a	Time in 0.4km (s): n/a
	Max. Speed n/a

Gradeability: n/a %

Energy Use Figure | Output Check Plots

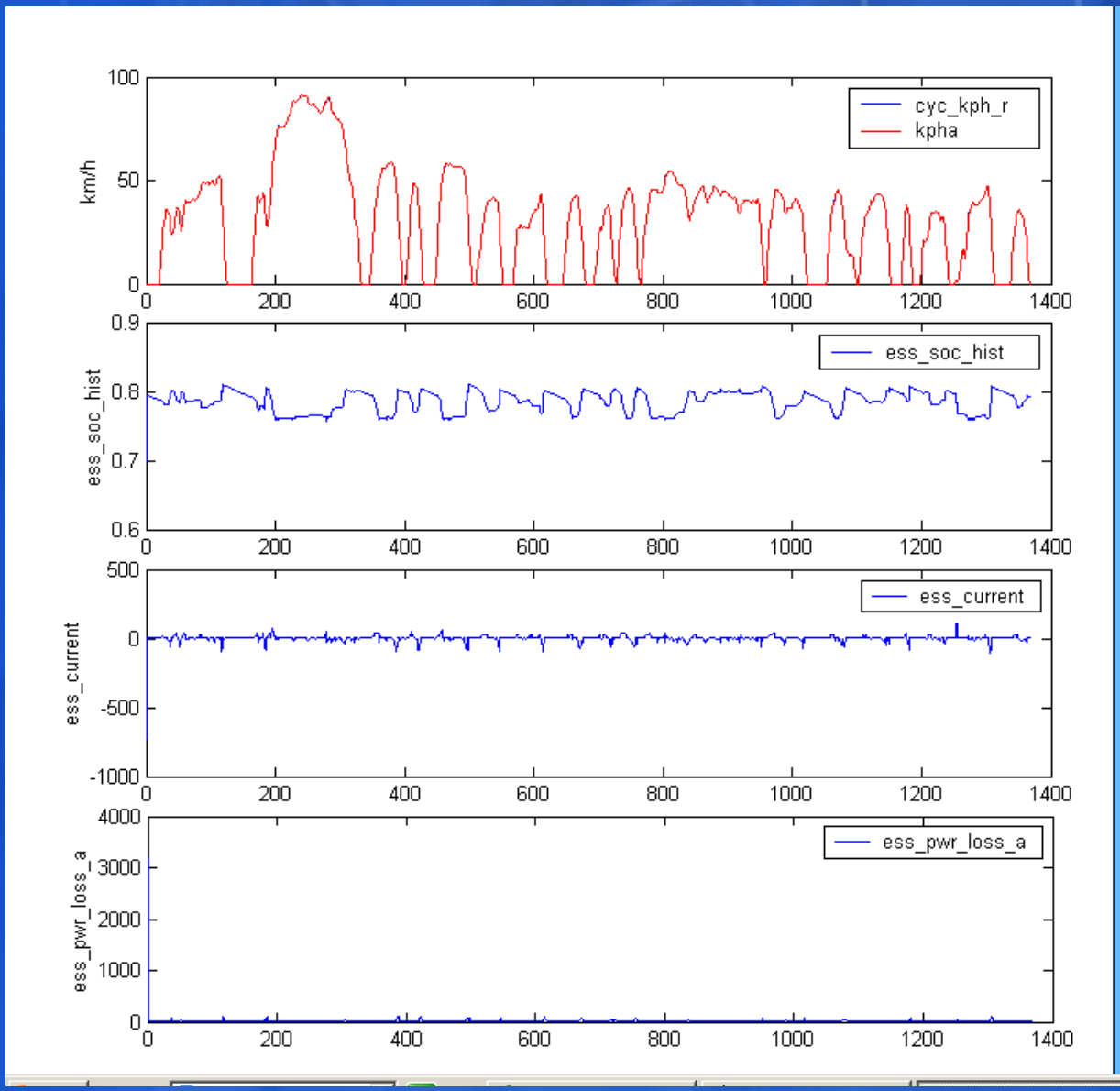
Compare Results With: Sim Data | Test Data

Warnings/Messages

none

Replay | Back Two | Help | Back | Exit

Capacitor Only Model



Results figure

Component
energy_storage
plot control
Plot Variable (Select Axis First)
ess_pwr_loss_a
?
# of plots
4

Fuel Consumption (L/100 km)	3.9
Gasoline Equivalent	3.9
Distance (km)	12

Emissions (grams/km) — Standards

HC	CO	NOx	PM
0	0	0	0

Acceleration Test

0-96.6 km/h (s): n/a	Max. Accel. (m/s^2): n/a
64.4-96.6 km/h (s): n/a	Distance in 5s (m): n/a
0-136.8 km/h (s): n/a	Time in 0.4km (s): n/a
	Max. Speed (kmph): n/a

Gradeability: n/a %

Energy Use Figure | Output Check Plots

Compare Results With: Sim Data | Test Data

Warnings/Messages

none

Replay | Back Two | Help | Back | Exit

Analysis

Battery vs. Ultra-Capacitor/Battery Combination

Battery

- Power loss is relatively high
- Rapid charge / discharge shortens the life-span of the battery
- State of Charge increases gradually

Combination

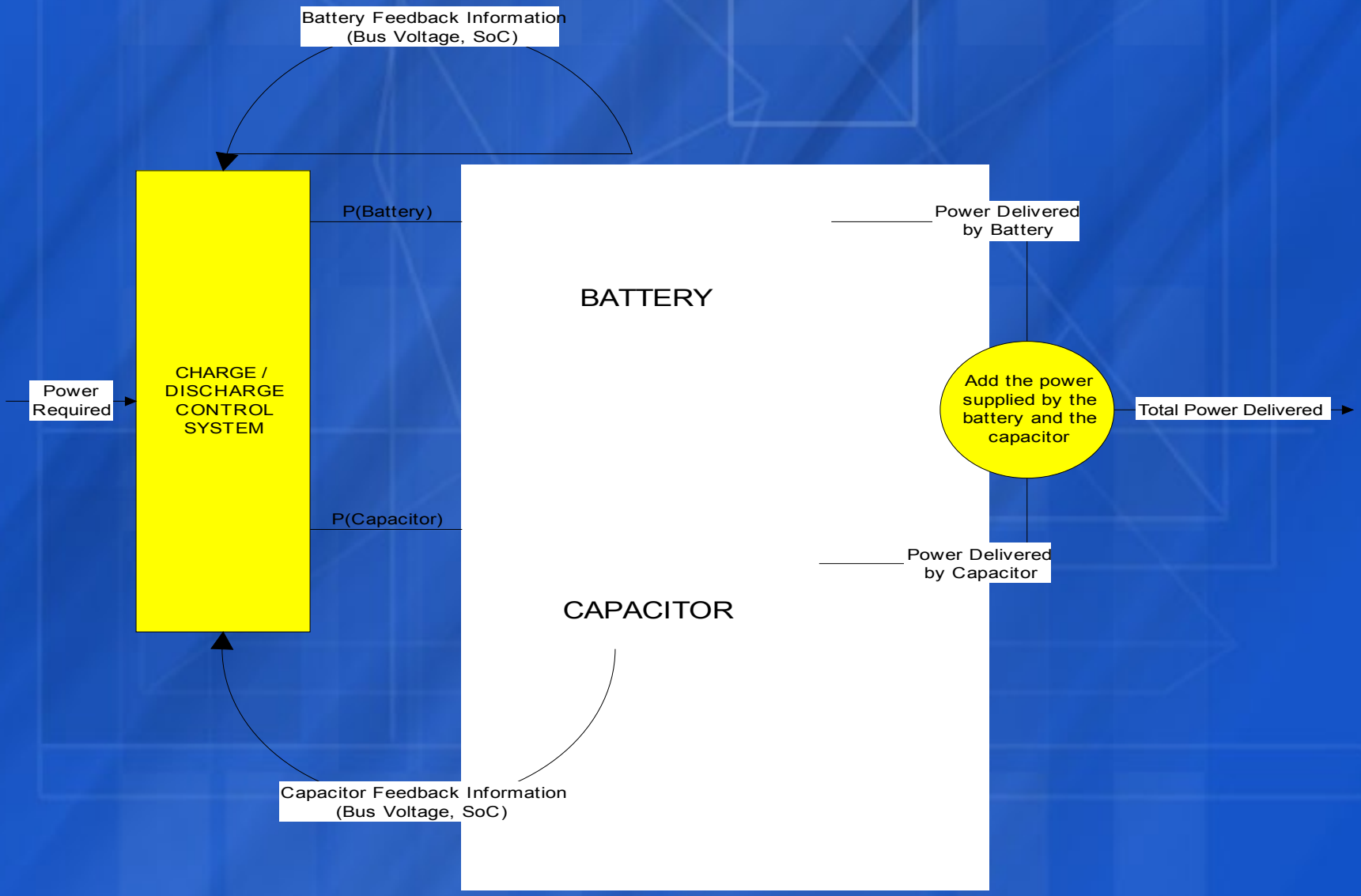
- ✓ Power loss is relatively low
- ✓ Capacitor can accommodate for rapid charge / discharge quite efficiently
- ✓ State of Charge stays relatively constant and changes only during transient cycles

How Can We Extend the Lifetime of an HEV's Battery?

Solution: Create a hybrid energy model that uses a battery and ultra-capacitors in combination with a control system, which will determine the amount of energy required from the battery and ultra-capacitors

- The battery will deliver the steady power requirements of the vehicle.
- The Ultra-Capacitors will provide the transient power requirements for the system.

HEV Power System



Control System - Requirements

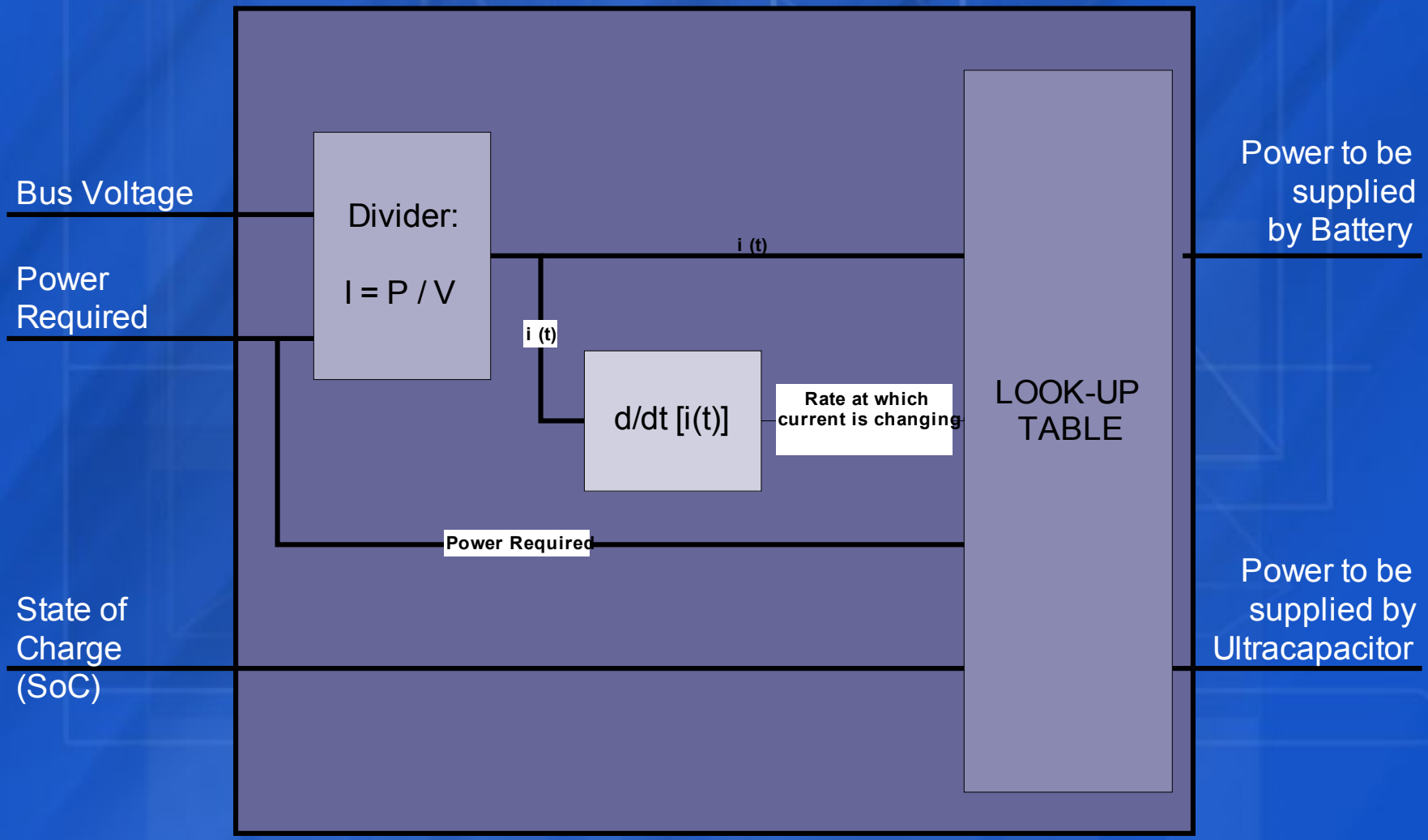
The control system determines the amount of power that should be supplied by the battery and ultra-capacitors based on:

- Battery bus voltage
- Power required by the hybrid electric vehicle
- State of charge Information

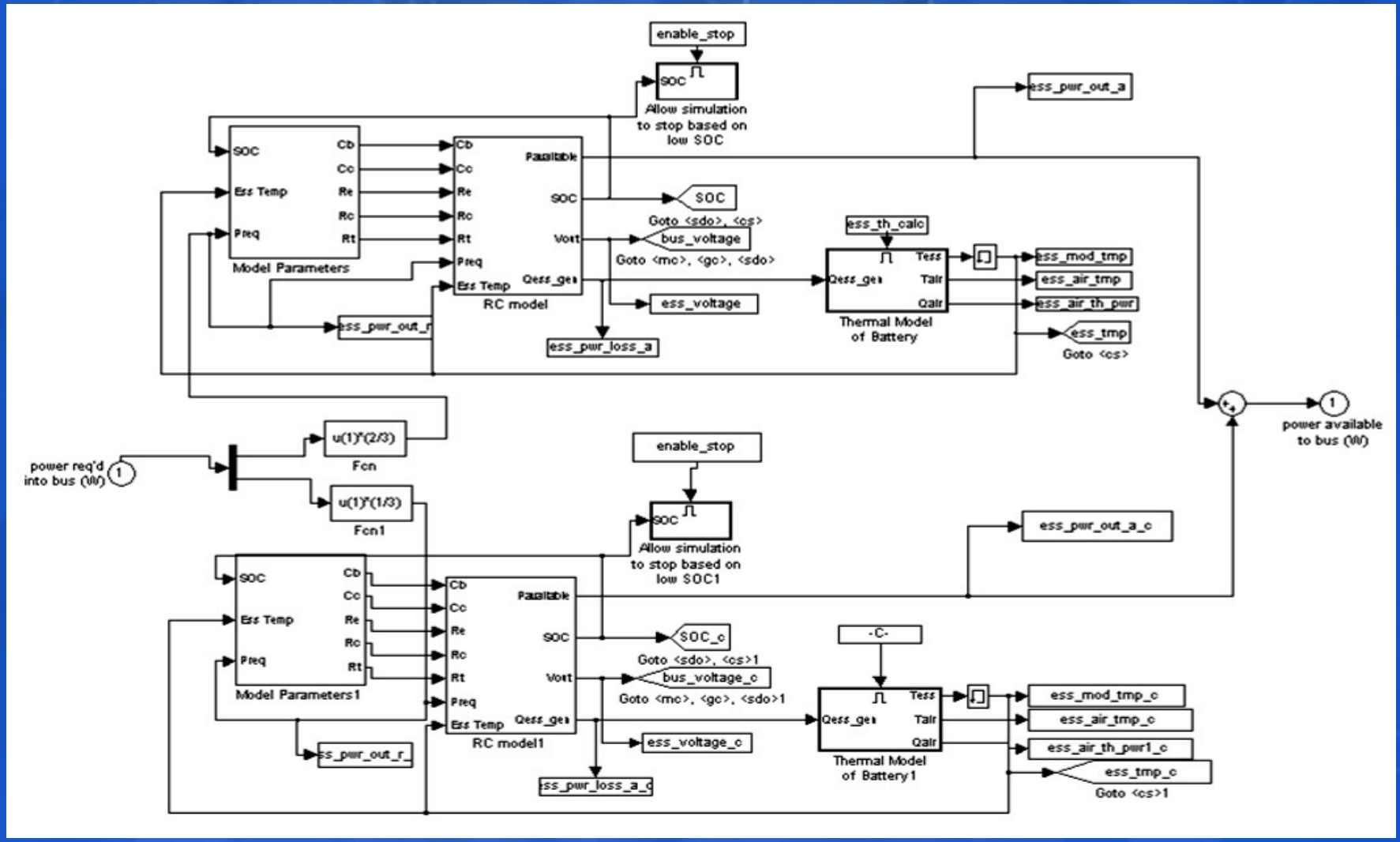
The control system must ensure that:

- Battery state of charge is always approximately 0.6
- Ultra-Capacitor overall state of charge is between 0.3 and 0.8

Control System – Diagram



ADVISOR Energy Module Model



Progress Report

- ✓ Control system design has been verified and approved
- ✓ Hybrid electric vehicle model has been implemented in ADVISOR
- ✓ A battery-capacitor integration is being created. Currently 80% of it has been completed, thus setting the foundation for future simulations

Questions?