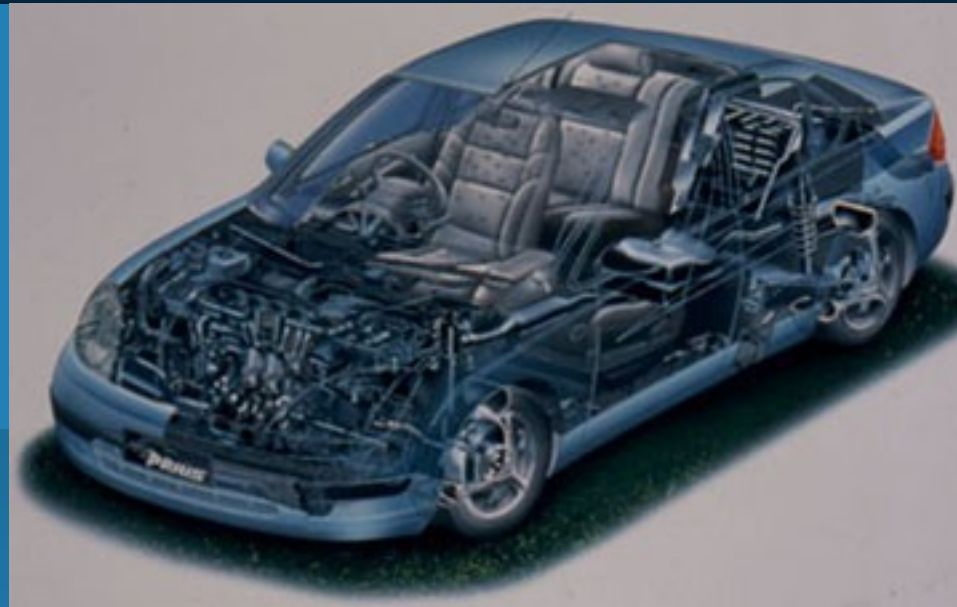


# Hybrid Cars with UltraCapacitor Augmentation



•Toyota Prius



# Introduction

- ✧ **More efficient hybrid vehicles**
- ✧ **Researched:**
  - **Ultra-Capacitors**
  - **Batteries**





# Overview

---

- ✧ **Problems with regular battery life**
- ✧ **Benefits of Lithium Ion Batteries**
- ✧ **Benefits of Ultra-Capacitors**
- ✧ **Combination of batteries and Ultra-Capacitors**

# Circuit Design

## ✦ Various circuits developed for model

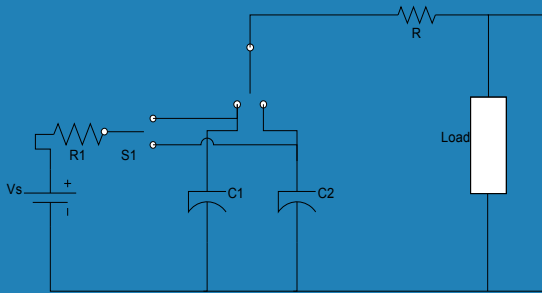


Figure 1

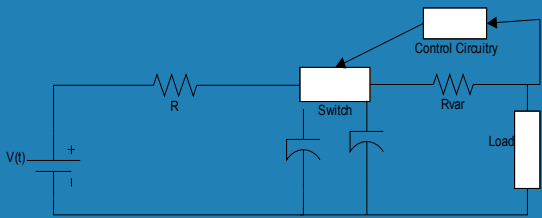


Figure 2

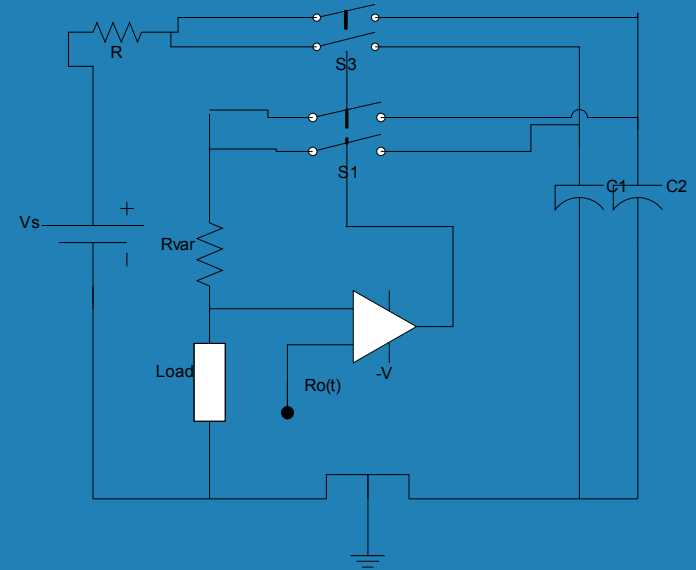


Figure 3

# DC Converters



# Specifications of DC to DC Converter

| DC-100-2 converter specifications |  |
|-----------------------------------|--|
| Input voltage range               | 0.5 – 1.6 V                              |
| Working input voltage             | 1.2 V                                    |
| Output voltage range              | 9 – 24 V                                 |
| Average working output voltage    | 12 V                                     |
| Maximum Input Power               | 12 W                                     |
| Average efficiency                | 90%                                      |
| Acceptable ambient temperature    | -30 to +50 ° C                           |
| Dimensions                        | 12 x 7 x 3.5 cm or<br>4.7 x 2.8 x 1.4 in |

| DC-100 basic unit specifications |  |
|----------------------------------|--|
| Input voltage range              | 0.3 – 0.9 V                              |
| Working input voltage            | 0.5 V                                    |
| Output voltage range             | 3 – 18 V                                 |
| Average working output voltage   | 6 V                                      |
| Maximum Input Power              | 5 W                                      |
| Average efficiency               | 85%                                      |
| Acceptable ambient temperature   | -30 to +50 ° C                           |
| Dimensions                       | 12 x 7 x 3.5 cm or<br>4.7 x 2.8 x 1.4 in |

# Specifications of Relays

## Physical specifications

**Size: 1.75" x 2.50" x 1.25"**

**Weight: 4 oz.**

**Supply voltage: 4.1 – 5.5 Vdc.**

**Supply current: 20ma stand-by, 220ma when relay energized.**

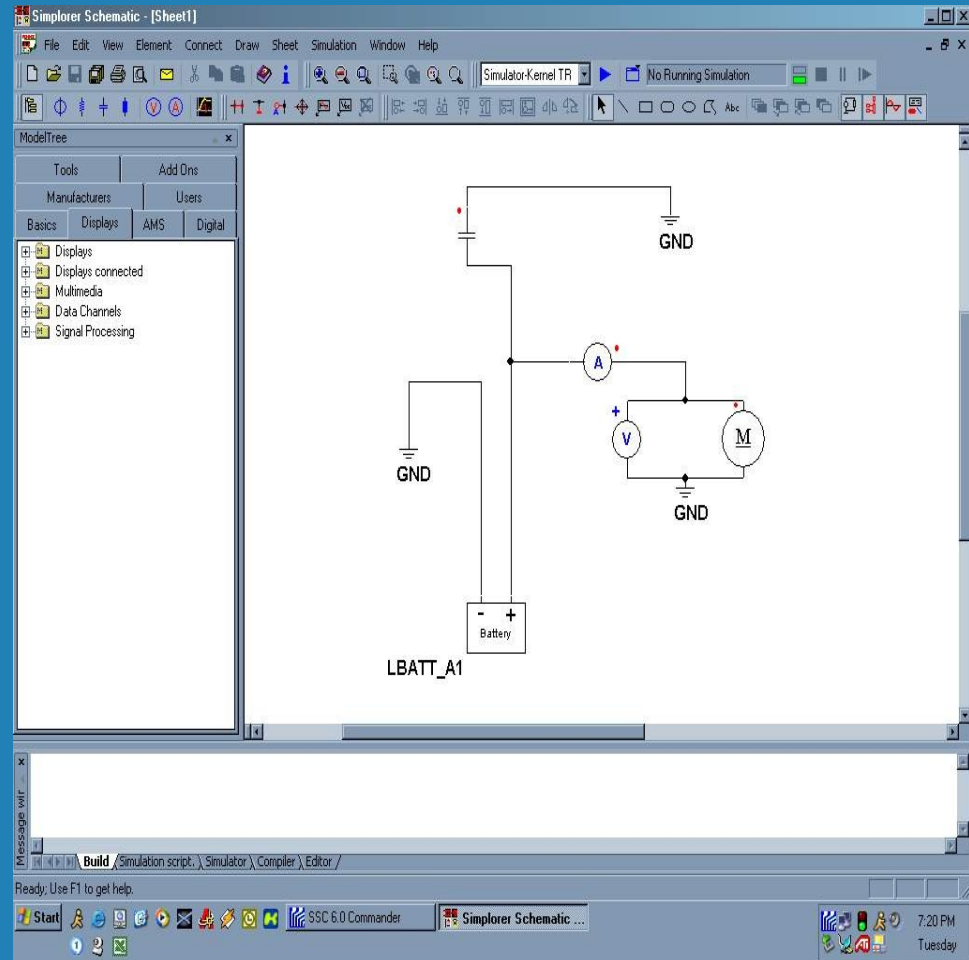
**Load rating: relay is rated for non-welding contact up to 24 amps at 30 volts DC.**

**Switching time: 8.0 milliseconds typical.**

# Simplorer

## ✧ Simplorer Goals

## ✧ Brief overview of the circuit simulations





# Simplorer

## ✦ Simplorer Problems

The screenshot displays the Simplorer software interface for a "DC Motor Model" simulation. The main workspace shows a circuit diagram titled "Battery with starting fan load" connected to a motor model. The motor parameters are listed as  $ra = 10m$ ,  $la = 1m$ , and  $ke = 100m$ . A control signal is defined as  $CTRL = t >= 1$ . To the right, a graph plots "Motor Speed" and "Motor Current" over time. A modal dialog box with a red 'X' icon displays the error: "FLEXlm License error: -18 License server does not support this feature". Below the dialog, simulation statistics are shown: Simulation Start, Minimum Start, Maximum Start, Simulation End Time (3), and Local Discretization error (0.1). The ModelTree on the left lists various components like Voltage Source, Current Source, and Semiconductors. The bottom status bar shows the file path: "C:\Documents and Settings\Josh\Desktop\IPRO2\Sheet1.sml" and the error message: "Error - Cannot load compiled model from file <C:\Ansoft\Simplorer60\Examples\AddOns\Automotive\example dc motor.sml>> Initialize". The Windows taskbar at the bottom shows the Start button, several application icons, and the system clock indicating 4:13 PM on Thursday.

# Simplorer

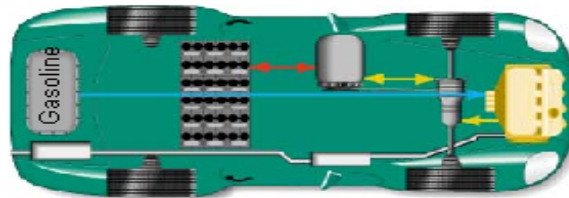
☀ **Simplorer Benefits**

☀ **The future Simplorer**

The screenshot displays the Simplorer software interface for an automotive lighting system simulation. The main window, titled "Simplorer Schematic - [Automotive Lighting System]", shows a detailed circuit diagram of an "AUTOMOTIVE EXTERIOR LIGHTING" system. The diagram includes components like a "Lamp Switch", "Fuse", "Relay", "LH HeadLamp", "RH HeadLamp", "Tail Lamp", and "Park Lamp". A license error dialog box is open in the foreground, displaying the message: "FLEXlm License error: -18 License server does not support this feature." The command window at the bottom shows the following text: "Create model script (C:\Ansoft\Simplorer60\Examples\Applications\Automotive\Automotive Lighting System\Automotive Lighting Sorting blocks automatically. ... Creation of model script (C:\Ansoft\Simplorer60\Examples\Applications\Automotive\Automotive Lighting System\Automotive ...". The taskbar at the bottom shows the Start button, several application icons, and the system tray with the date and time: "7:25 PM Tuesday".

# Advisor

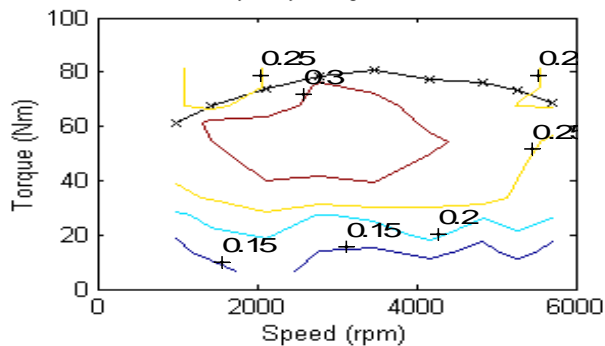
## Vehicle Input



Motor pre transmission

Component Plot Selection  
 fuel\_convert fc\_efficiency

Fuel Converter Operation  
 Geo 1.0L (41kW) SI Engine - transient data



Load File: PARALLEL\_defaults\_in

Drivetrain Config: parallel

|  | version | type |                      | max pwr | peak eff | mass (kg) |
|--|---------|------|----------------------|---------|----------|-----------|
| <input checked="" type="checkbox"/> Vehicle            | ?       | ?    | VEH_SMCAR            |         |          | 592       |
| <input checked="" type="checkbox"/> Fuel Converter     | ic      | si   | FC_SI41_emis         | 41      | 0.3      | 131       |
| <input checked="" type="checkbox"/> Exhaust Aftertreat | ?       | ?    | EX_SI                |         |          | 11        |
| <input checked="" type="checkbox"/> Energy Storage     | rc      | cap  | ESS_UC2_Maxwell      | 33      | 41       | 23        |
| <input type="checkbox"/> Energy Storage 2              | ?       |      | ess 2 options        |         |          |           |
| <input checked="" type="checkbox"/> Motor              | ?       |      | MC_AC75              | 75      | 0.9      | 91        |
| Motor 2  | ?       |      | motor 2 options      |         |          |           |
| Starter  | ?       |      | starter options      |         |          |           |
| <input type="checkbox"/> Generator                     | ?       |      | gc options           |         |          |           |
| <input checked="" type="checkbox"/> Transmission       | mar     | man  | TX_5SPD              |         |          | 114       |
| Transmission 2   | ?       |      | trans 2 options      |         |          |           |
| Clutch/Torq. Conv                                      | ?       |      | clutch/torque conver |         |          |           |
| <input checked="" type="checkbox"/> Torque Coupling    | ?       |      | TC_DUMMY             |         |          | 1         |
| <input checked="" type="checkbox"/> Wheel/Axle         | Crr     | Crr  | WH_SMCAR             |         |          | 0         |
| <input checked="" type="checkbox"/> Accessory          | Con     | Con  | ACC_HYBRID           |         |          |           |
| Acc Electrical   | ?       |      | acc elec options     |         |          |           |
| <input checked="" type="checkbox"/> Powertrain Control | par     | man  | PTC_PAR              |         |          |           |

Auto-Size Scale

Cargo: 136

Calculated: 1098

override mass: 1

View Block Diagram: BD\_PAR

### Variable

Component: fuel\_converter [Edit Var.]  
 Variables: fc\_acc\_mass 32.8056

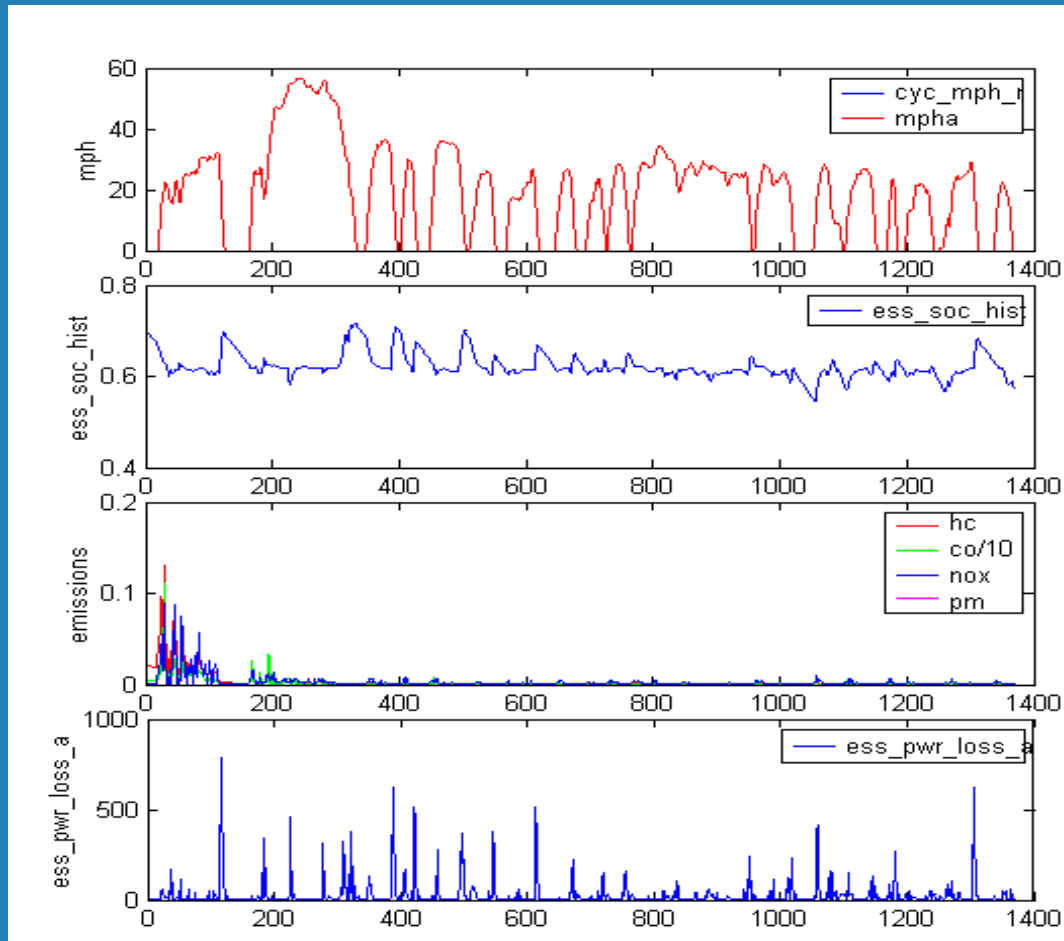
Save Help  
 Back Continue

# Advisor Overview

✦ **Powered by Matlab and Simulink,  
Designed for simulation of:**

- **Fuel economy-**
  - **Conventional cars**
  - **Electrical cars**
  - **Hybrid cars**
- **Drivetrain components**
- **Vehicle data and algorithms**

# Ultracapacitor Simulation



## Results figure

Componer

energy\_storage

plot control

Plot Variable (Select Axis

ess\_pwr\_loss\_a

? # of plots 4

|                     |      |
|---------------------|------|
| Fuel Economy (mpg)  | 32.7 |
| Gasoline Equivalent | 32.7 |
| Distance (miles)    | 7.5  |

|                        |       |      |    |           |
|------------------------|-------|------|----|-----------|
| Emissions (grams/mile) |       |      |    | Standards |
| HC                     | CO    | NOx  | PM |           |
| 0.618                  | 2.612 | 0.52 | 0  |           |

|                   |      |                      |      |
|-------------------|------|----------------------|------|
| Acceleration Test |      |                      |      |
| 0-60 mph          | 15.7 | Max. Accel.          | 16.2 |
| 40-60 mph         | 9.3  | Distance in 5s (ft): | n/a  |
| 0-85 mph          | 42.2 | Time in 0.25mi (s):  | n/a  |
|                   |      | Max. Speed (mph):    | 96.7 |

Gradeability: n/a %

Energy Use Figure Output Check Plots

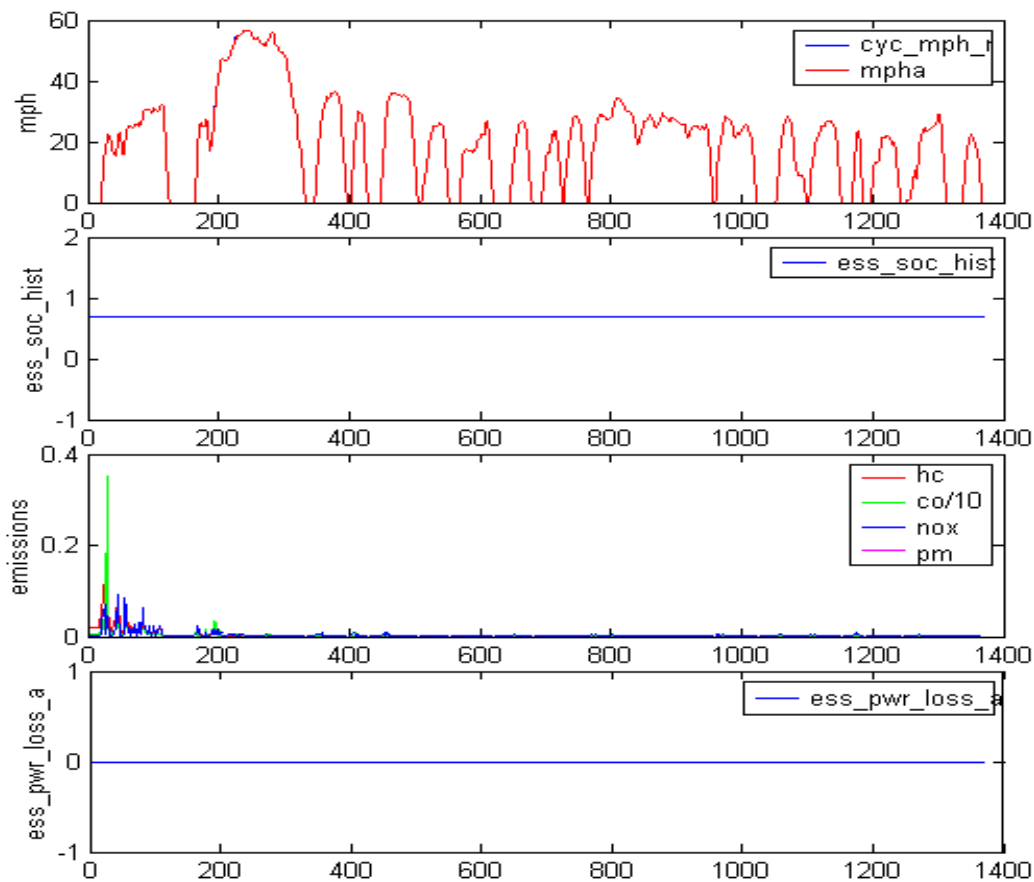
Compare Results With: Sim Data Test Data

Warnings/Messages

none

Replay Back Two Help Back Exit

# Lead Acid Battery Simulation



## Results figure

Componer  
   
 Plot Variable (Select Axis)  
 # of plots

|                     |             |
|---------------------|-------------|
| Fuel Economy (mpg)  | <b>34.4</b> |
| Gasoline Equivalent | <b>34.4</b> |
| Distance (miles)    | <b>7.4</b>  |

|   |              |              |          |
|---|--------------|--------------|----------|
| Emissions (grams/mile) <input type="button" value="Standards"/> |              |              |          |
| HC  | CO           | NOx          | PM       |
| <b>0.602</b>  | <b>3.044</b> | <b>0.495</b> | <b>0</b> |

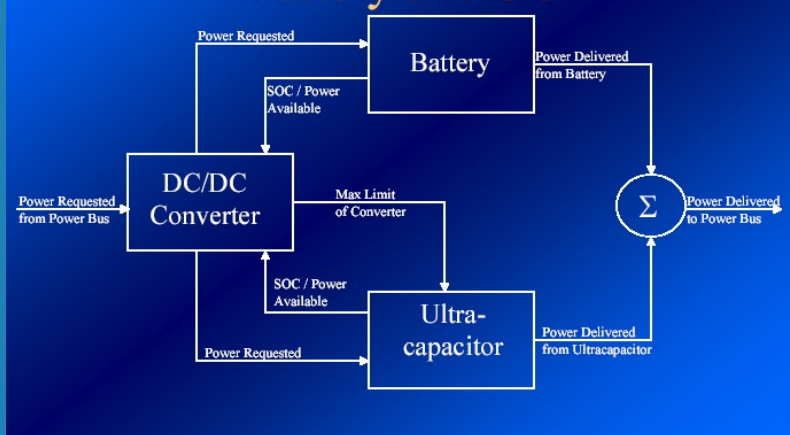
|                       |                                 |
|-----------------------|---------------------------------|
| Acceleration Test     |                                 |
| 0-60 mph <b>23.5</b>  | Max. Accel. <b>7</b>            |
| 40-60 mph <b>11.8</b> | Distance in 5s (ft): <b>n/a</b> |
| 0-85 mph <b>58.9</b>  | Time in 0.25mi (s): <b>n/a</b>  |
|                       | Max. Speed (mph): <b>93.8</b>   |
| Gradeability:         | <b>n/a</b> %                    |

Compare Results With:

Warnings/Messages

# Advisor Model

## ADVISOR's model to couple the Battery and UC



## Problems

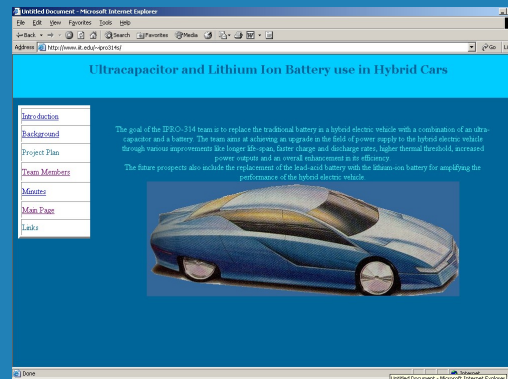
Unable to implement correct model



**Correct model which connects the lead acid battery to the ultra-capacitor**

# Webpage

- ★ Updated weekly with current progress and information



- ★ Visit us at <http://www.iit.edu/~ipro314s/>



# Acknowledgements

- ✧ **Ellen Allston - Manager, University Program  
Ansoft Corporation**
- ✧ **Professor Emadi**
- ✧ **Professor Tomal**
- ✧ **Professor Williamson**
- ✧ **[http://www.ctts.nrel.gov/analysis/advisor\\_doc/advisor\\_ch1.htm](http://www.ctts.nrel.gov/analysis/advisor_doc/advisor_ch1.htm)**
- ✧ **<http://www.ansoft.com/products/em/simplorer/>**
- ✧ **<http://www.maxwell.com>**
- ✧ **<http://www.teamdelta.com/pdf/rce210r2.pdf>**

# Team

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- \* **Hakan Akdeniz**
- \* **Saurav Batra**
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- \* **Israel Gonzalez**
- \* **Ben Hunter**
- \* **Toh Chu Lee**
- \* **Benito Lugo**
- \* **Luke Radwanski**
- \* **Jeffery Stano**
- \* **Karen Stone**
- \* **Rafael Tudor**
- \* **Ima Ufot**



# Summary and Q/A

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✦ **Any questions?**