

Highlights:

Handles ANY hybrid configuration and control strategy

Contains Full vehicle, driveline model, plus HEV components

Energy Management:

Dedicated controllers are provided for control of IC engine, battery, electric machines and brakes. Their use greatly simplifies hybrid model building

The “brain” of the HEV mode is a central “supervisory” controller which contains the overall energy management strategy (which can be completely modified by the user)

Evaluation of HEV, PHEV and EV fuel economy by EPA and SAE standards

Optimization of control strategy for fuel economy and emissions

Hybrid and Electric Vehicle Modeling

Hybrids, Electrics and their Control Systems

GT-SUITE offers a versatile set of tools for the simulation of vehicles with **Hybrid-Electric** (HEV) or **Electric-only** (EV) drivelines, as well as the control systems and strategies that are key to the operation of these vehicles. A set of HEV components (electromechanical and energy storage devices) are provided and can be combined with Vehicle, Engine, Electrical and Control libraries to create comprehensive and integrated models of HEV or EV vehicles and drivelines. Such models are indispensable for studies aimed at component sizing and selection; evaluation and optimization of various powertrain architectures and related control strategies implemented to achieve better fuel economy, reduced emissions, acceptable driveability, etc.

HEV COMPONENTS AND POWER ELECTRONICS



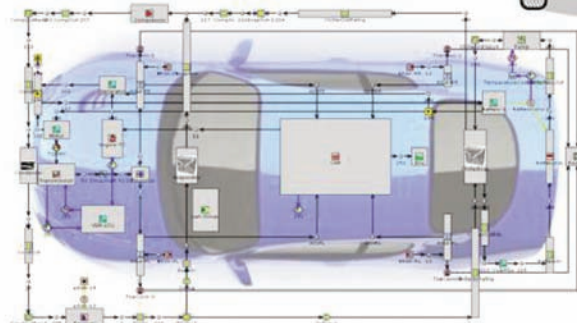
DRIVELINE COMPONENTS



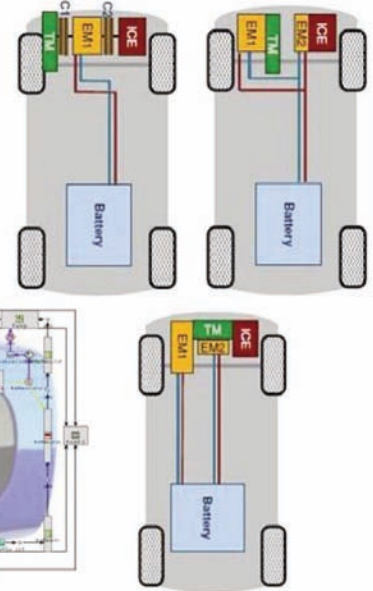
ENGINE / POWERTRAIN CONTROLS



VEHICLE ENERGY MANAGEMENT



VEHICLE ARCHITECTURES



The following are the key elements of GT-SUITE which enable modeling of HEV drivelines

- Electromechanical component models (motor, generator)
- Energy storage (battery)
- Electrical (circuit) modeling elements
- Control/signal processing library
- Torque-splitting devices (e.g. planetary gear)

Advanced Features and Applications:

System-level or detailed-level (circuit) modeling of Electric Machines and Batteries

Evaluation, design and optimization of hybrid vehicle as a system, through integrated simulation of components and energy management

Complete vehicle energy management studies incorporating multiple subsystems

Study various degrees of hybridization and their impact on overall efficiency and performance

Vehicle electrical system and additional battery loads

Thermal management for battery and electronic components

Incorporation of separate control strategies during engine warm-up

Smart "Event manager" for event-based setup of dynamic duty cycles with complex interdependent segments

These capabilities are included in every GT-SUITE license

Together, these allow modeling of **virtually any HEV driveline configuration** (series, parallel, power-split or combinations) as well as electric vehicles. HEV driveline models can encapsulate, in full detail, the master supervisory ("strategy") controller, as well as individual device controllers, to simultaneously apply strategies for all common HEV functions:

- Electric launch and transition to IC engine drive
- Regenerative braking, braking load distribution (mechanical vs. electrical)
- IC engine assist and efficient operation for best fuel economy and driveability
- Battery state of charge control
- Charge-depleting (PHEV) and charge-sustaining strategies can be applied together or independently according to vehicle architecture

GT-SUITE provides both **map-based** and **simplified "electro-mechanical"** models of a **motor** or **generator**. In the map-based model, a torque (or mechanical or electrical power) map is user-specified as a function of speed and an "actuator". In the electro-mechanical model the device is "driven" with an applied voltage and a simple circuit is solved for. The back-voltage is a function of rotor speed through a multiplier, which by energy conservation principles is also the ratio of torque to current. The multiplier can be made variable, for example specified as a map/function of speed and current. A third alternative is the construction of detailed electro-mechanical models using basic mechanical and electrical primitives. This enables integration of any external circuit models (e.g. for controller, inverter circuits) which control applied voltages to be included in the simulation.

There are several **battery models**. One is based on a simple circuit and is controlled by power request. The battery open circuit voltage, internal resistance, as well as a Columbic efficiency can be specified as a function of battery state of charge (SOC) and temperature, all separately for charging and discharging. The model solves for the current and integrates SOC. A **thermal model based on stacked cylindrical cells** can be activated by the user to simulate mean battery temperature, and an interface to a user thermal model is also provided. Electrical and thermal libraries may also be used together to construct a battery model which can be integrated with models of external circuits

