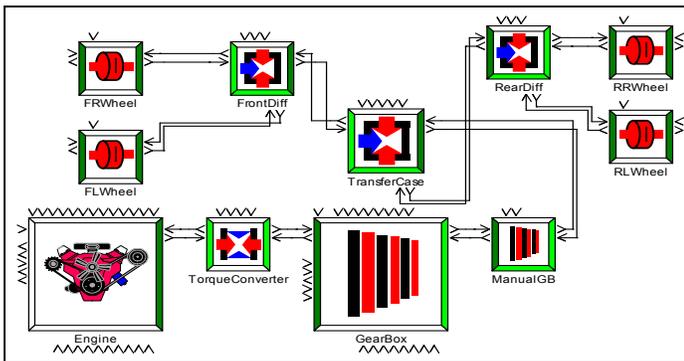




The **Powertrain Library** is a collection of drive train components made to augment the standard collection of over 90 control system and graphical components that ship with Realtime's SimCreator\* software package.

Powertrain uses a power flow modeling approach with torque and angular velocity representing the power variables. Typically, data flows back and forth between upstream components, such as engines, to downstream components, such as inertias that represent wheels. Additional components, such as differentials, control how torques and angular velocities are propagated through the model.



A basic 4x4 drive train model created using SimCreator\*

### Differential

models an open or limited slip differential



The differential model includes a final drive gear ratio which is applied to the upstream drive torque and split equally between the two downstream drive shafts. If the limited slip differential is active, additional torque is transferred from the slipping wheel to the non-slipping wheel, based on user definable variables.

The average of the two downstream drive shaft angular velocities is passed back upstream.

## \*SimCreator®

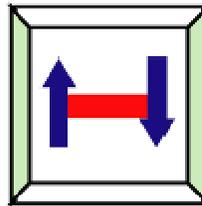
RTI's SimCreator is a graphical, hierarchical, real time simulation and modeling system. Its GUI interface allows you to develop distributed simulation models with surprising speed and ease. You just add and connect the components — at times with just a single mouse click. SimCreator comes with a standard set of over 90 control system and graphical components.

## components

- Differential
- Engine
- FlexShaft
- GearBox
- Inertia
- Manual GearBox
- TorqueConverter
- TorqueSum
- TransferCase

### FlexShaft

calculates the torque generated by a flexible shaft, given the angular velocity of the shaft at each end

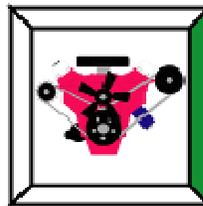


The speed difference between the two ends of the shaft is integrated to calculate the difference in the angular position between the two ends of the shaft.

The output torques are calculated based on a spring/damper model of the shaft and the current angular twist and speed of the shaft.

### Engine

models a gasoline or diesel engine using a torque map



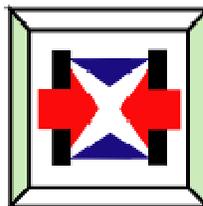
The torque map is a user defined, three dimensional lookup that calculates engine torque based on the engine speed and accelerator pedal position. The engine torque is summed with additional drag torque from any accessories and the torque applied by downstream components. This total torque is divided by the engine inertia and integrated to calculate the engine angular velocity. This is passed to downstream components.

The torque map is a user defined, three dimensional lookup that calculates engine torque based on the engine speed and accelerator pedal position. The engine torque is summed with additional drag torque from any accessories and the torque applied by downstream components. This total torque is divided by the engine inertia and integrated to calculate the engine angular velocity. This is passed to downstream components.

### TorqueConverter

calculates upstream and downstream torques based on the input speed ratio

$$\frac{\text{Downstream Angular Velocity}}{\text{Upstream Angular Velocity}}$$



Torque Converter's torque ratio and capacity factor are calculated using user defined, two dimensional lookup functions. The resulting torque ratio and capacity factor are then used to calculate the upstream and downstream torques. A first order lag model is used to smooth the calculated torque and predict any transient behavior.

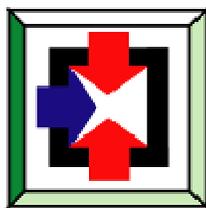
SimCreator is a registered trademark of Realtime Technologies, Inc.

## TransferCase

*models a four wheel vehicle transfer case in one of four modes*

RWD - Rear Wheel Drive  
FWD - Front Wheel Drive

AWD - All Wheel Drive  
4WD - Four Wheel Drive



In RWD all the upstream torque is applied to the rear wheels and the rear wheel velocity is communicated to the upstream components.

In FWD all upstream torque is applied to the front wheels and front wheel velocity is communicated to upstream components.

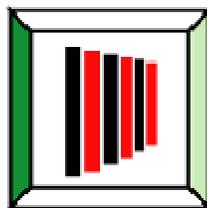
In AWD the input torque is split equally between the front and rear wheels. If a limited slip AWD system is modeled, additional torque is transferred from the high speed axle to the lower speed axle.

In 4WD a spring and damper are placed between the front and rear shafts to keep their velocities close to equal.

The input torque is applied to the front wheels and the front axle speed is communicated to upstream components.

## GearBox

*models an automatic transmission gearbox*



The selected gear is determined using a shift map. The upshift map is defined by a set of upshift angles and upshift speeds. The downshift map is defined by a set of downshift angles and downshift speeds.

The current vehicle speed is estimated by dividing the downstream velocity by the final drive ratio and multiplying by the wheel radius.

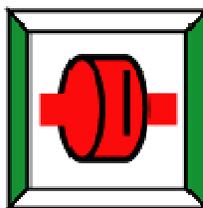
The accelerator pedal angle is fed to the component and used in the upshift map to calculate the speed required for an upshift. If the estimated speed is greater than the required speed, the transmission is shifted up to the next gear.

The accelerator pedal angle is also used in the downshift map to calculate the speed required for a downshift. If the estimated speed is less than the required speed, the transmission is shifted down to the next lower gear.

Once the current gear is calculated using the procedure above, the appropriate gear ratio, downstream torques and upstream speeds are calculated. The gear ratio is filtered using a first order lag.

## Inertia

*calculates the angular velocity of an inertia based on the torques input on either end of the inertia component*

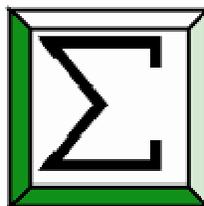


The angular acceleration of the component is calculated by summing the applied torques and dividing by the inertia.

Angular velocity is calculated by integrating the acceleration.

## TorqueSum

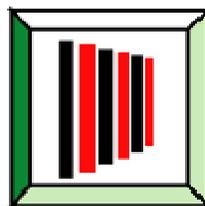
*sums the two input torques to calculate the output torque*



Torque sum is an ideal merge of two torques. The two torques are summed and the result is propagated upstream. The upstream velocity is propagated down to each of the torque generating components.

## Manual GearBox

*models a manual gearbox*



Based on a gear number provided by the user, the appropriate gear ratio is selected and used to calculate the downstream torques and upstream speeds of the component. The gear shift is modeled using a first order lag.

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You can augment SimCreator's component collection with our Multibody Dynamics Component Library. Ask Clayne for more information about RTI's components or any of our other products.