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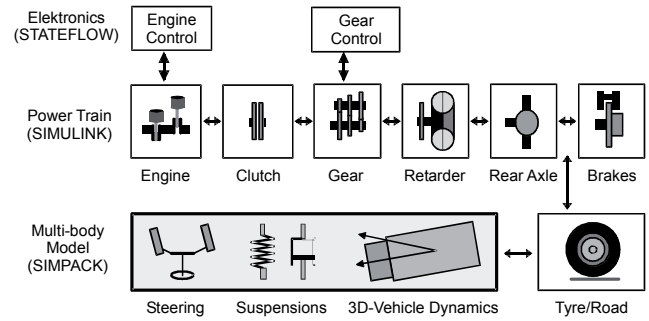
Realtime Simulations With SIMPACK

A procedure to incorporate SIMPACK multi-body models into the software tool SIMULINK for real time calculations has been developed at FKFS, the Research Institute of Automotive Engineering and Vehicle Engines Stuttgart, in cooperation with INTEC. Such type of calculations is very common in the automotive industry, where it is part of the design process of suspension systems, vehicle dynamics and complete power trains. This newly developed procedure, however, is not restricted to these types of systems but enables the real time simulation of general mechanical systems as well as mechatronic systems.



Application Domain

Real time simulation is generally regarded as a vital part in the development of mechatronic systems. Especially in the automotive industry hardware-in-the-loop-simulators as test and development facilities are essential. Also driving simulators require real time motor vehicle models for demonstration and training purposes. SIMPACK is often used by FKFS for creating simulation models of motor vehicles in case the multi-body approach is suitable for a certain problem. This applies in general for the simulation of the handling performance of a vehicle, since the modelling of the interaction between the suspension and the chassis has proved to be successful using rigid and elastic bodies interconnected by joints. Force elements act between those bodies to represent components like springs, dampers, stabilisers and rubber elements. SIMPACK contains a large library of force-elements and additionally offers a user-routine interface which has been applied to write user force elements in FORTRAN code for active suspension elements. Summarising SIMPACK offers a universal tool for simulation of general mechanical systems and motor vehicles. Detailed models of complete motor vehicles, however, often require additional elements than traditionally used in multi-body simulation. Hydraulic and pneumatic components for instance are required for the accurate modelling of braking and steering systems. Furthermore it is desirable to model electronic control devices that can be simulated efficiently with so-called CACE software tools. The software tool SIMULINK with its module STATEFLOW is especially suitable for the modelling of these reactive systems and control loops. The creation of these detailed and advanced motor vehicle models is now attainable by using the specially designed interface between SIMPACK and SIMULINK. By combining these two powerful simulation tools an advanced modelling technique has been made available which even allows real time modelling. The figure aside shows a complete real time model that contains elements from a SIMULINK library created by FKFS consisting of a large number of power train components. The electronic control units of the engine and the gearbox are implemented within STATEFLOW. The dynamic model of the vehicle including the suspension and the steering system is contained within the MBS model created in SIMPACK and linked to SIMULINK. The tyre is modelled within SIMULINK using a special algorithm suitable for

real time simulations. Extensive tests on the FKFS driving simulator demonstrate the efficiency of the interface for real time applications (see figure aside). The described vehicle model proves to be stable under all load case scenarios. This also holds true for situations where skid or wheel lift occurs.

Coupling of SIMPACK and SIMULINK for Real Time Applications

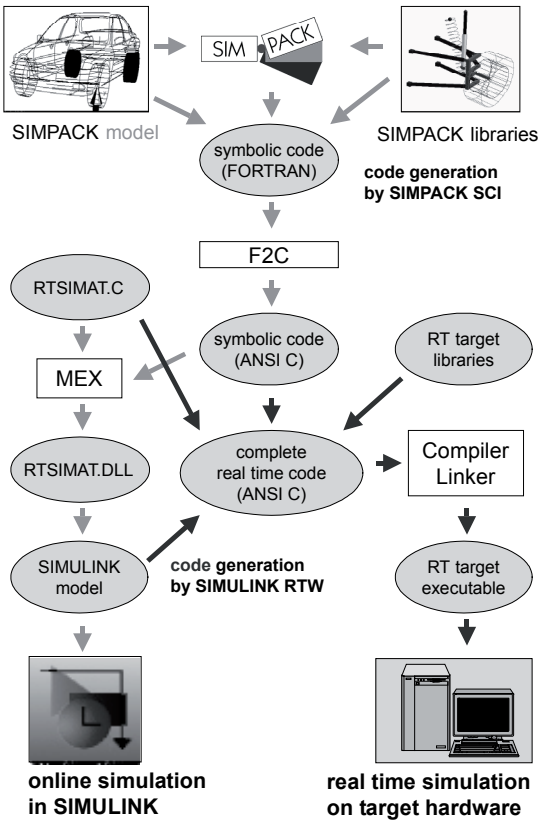
SIMPACK and SIMULINK are both simulation tools that contain efficient code generators and enable an almost fully automated implementation of combined models on real time computers. The figure aside gives a schematic representation of the real time coupling of SIMPACK and SIMULINK. The SIMPACK-code generator (Symbolic Code Interface) creates FORTRAN code that represents the MBS model. A conversion program F2C converts the FORTRAN code to ANSI-C code. This code is linked to the SIMULINK model through a function called RTSIMAT – a component of the general interface SIMAT, which was originally not suitable for real time applications, but has been modified by FKFS. The SIMPACK model emerges within SIMULINK as an S-Function-Block with in- and outputs that correspond with in- and output vectors defined in the SIMPACK model. The online simulation can now be performed from within SIMULINK using any integration procedure for ordinary differential equations available within SIMULINK. In an additional step the SIMULINK code generator (Real Time Workshop) creates C code that can be implemented for real time simulations on all the platforms that are supported by SIMULINK Real Time Workshop. At FKFS combined SIMPACK/SIMULINK models were tested on an Industry-PC (Software: MathWorks xPC-Target), a Standard-PC (MathWorks RT Windows Target), a DSPACE DSP/alpha-System (DSPACE RTI) and a Power-PC (Lynx OS). To extend this option to further platforms will require little effort.

Force Elements in SIMULINK

As mentioned earlier force elements can be chosen from the standard SIMPACK library or imported via the user routine interface. But there is also a third option: force elements that interact with the MBS model can be modelled in SIMULINK. Sensors defined in SIMPACK provide measurements (displacement, velocity, and acceleration) that can be used as inputs to the force element model in SIMULINK. The calculated forces and moments can be fed back into the SIMPACK model, where they act at certain markers. The already mentioned tyre model is an example of such a force element.

Development

The interface is currently being developed and further improved by INTEC, DLR and FKFS. A new objective is to 'dissolve' the constraints in SIMPACK models. This will enable models that contain kinematically closed loops to be used with real time calculations. Furthermore a link between SIMPACK and ASCET-SD is planned, as this tool has become more and more popular in software development for ECUs in motor vehicles. The combination of ASCET-SD Prototyping Systems, SIMULINK/STATEFLOW and SIMPACK will provide a new opportunity to test control functions in a closed control loop in real time.



The FKFS Driving Simulator