Real-Time Interface

Automatic Implementation of Simulink Models

- Easy graphical I/O configuration and automatic code generation
- Aperiodic event handling: Support of triggered and enabled subsystems, hardware and software interrupts
- Smooth implementation on multiprocessor systems with multiprocessor option
- Reduces implementation time to a minimum

Real-Time Interface (RTI) is the link between dSPACE’s real-time systems and the development software MATLAB/Simulink from The MathWorks. It extends Real-Time Workshop (C code generator) for the seamless and automatic implementation of your Simulink models on the dSPACE real-time hardware. This allows you to concentrate fully on the actual design process and to carry out fast design iterations. Labo-
rious manual editing becomes a thing of the past.

To specify a dSPACE I/O board, you can simply pick up the correspond-
ing I/O module graphically from the RTI block library and then attach and parameterize it within Simulink. After this, RTI compiles, downloads, and starts your entire real-time model with a single mouse click and without you having to write a single line of code.

RTI handles any kind of continuous-time, discrete-time, hybrid, and multirate system. Different channels of the same I/O board can be used with different sample rates, and even in different subsystems. RTI sup-
ports aperiodic events, for example, software interrupts and external hardware interrupts, and lets you set task priorities for the execution of the interrupt-triggered subsystems.

Supported Hardware
- DS1102 DSP Controller Board (p. 70)
- DS1103 PPC Controller Board (p. 72)
- DS1003 DSP Board (p. 82)
- I/O Boards for modular systems (p. 88)

Software Requirements
- Texas Instruments C Compiler version 4.70 (p. 42) for DS1102 and DS1003
- Microtec C Compiler version 1.4 (p. 42) for the DS1103
- MATLAB 5.x from The MathWorks (p. 28)
- Simulink 2.x from The MathWorks (p. 28)
- Real-Time Workshop 2.x from The MathWorks (p. 28)

System Requirements
- Windows 95 or NT 4.0
- ≥ 32 MB RAM

Order Number
RTI for:
- DS1102 DSP Controller Board
  - RTI1102
- DS1103 PPC Controller Board
  - RTI1103
- DS1003 DSP Board
  - RTI1003

AD DA

Real-Time Interface
Configuring I/O
- Specification of the hardware setup for your real-time applications
- Implementation of any dSPACE I/O board simply by connecting the corresponding blocks to the Simulink model
- I/O parameter specification, such as voltage ranges or resolutions
- Separate blocks for different functions of complex I/O boards
- Includes S-functions and user-written C code

Generating C code
- Generation of C code by Real-Time Workshop including Real-Time Interface
- C code optimization for real-time implementation
- Generation of initialization functions and I/O function calls
- Support of multirate systems and pre-emptive multitasking

Invoking the Make Utility
- Automatic compiler call that compiles and links the model

Loading and Starting the Application
- Program download to the processor
- Model execution
- Variable reference file for easy access from ControlDesk
Implementing an Application with Real-Time Interface

1. Design your model within Simulink and simulate off-line.

As an example, this block diagram shows the closed control loop of the positioning system for a disk drive. In this case, the target real-time hardware is the DS1102 DSP Controller Board. Both the controller and the plant model are designed within the MATLAB/Simulink development environment. For off-line simulation, a signal generator block produces the reference signal \( u_{x_{\text{ref\_scaled}}} \), while a scope displays the control signal \( u_x \).

When your model is tested off-line, it has to be prepared for implementation on the real-time system. That is, the plant model has to be exchanged for I/O components that form the interfaces to the real plant. To add an I/O module, simply drag it to your block diagram from the dSPACE I/O library and connect it with the inputs/outputs of the controller. I/O parameters are specified by double-clicking on an I/O block and entering the data. Here, the input signals are the reference signal \( u_{x_{\text{ref}}} \), now coming from an external signal generator, and the feedback value \( u_x \). The output signal from the controller is the control signal \( u_M \).

2. Drag I/O components to your block diagram from the dSPACE I/O library and parameterize them.
3. Choose the “RTW Options” command to implement your application on the real-time hardware.

4. Interact with your experiment with the dSPACE experiment software.

Automatic implementation of the Simulink model on the prototyping hardware is the key to rapid design iterations. With RTI, you will never see a single line of code during this process. The proverbial single mouse click starts the implementation, including code generation and customization, compiling, and downloading. For continuous systems, you can select an integration algorithm and a step size in the RTW Options dialog.

When your application is running on the real-time hardware, the whole dSPACE experiment software is at your disposal. RTI ensures that you have control over each single variable immediately after the implementation process - online and without regenerating the code. ControlDesk provides a virtual instrument panel that enables you to change parameters and monitor signals. In addition, ControlDesk displays time histories of any variable being used by your application.
Real-Time Interface for Multiprocessor Systems (RTI-MP)

- Graphical setup of multiprocessor structure within Simulink
- Automatic implementation of multiprocessor systems on dSPACE real-time hardware
- Optimum performance through individual parameter tuning for each processor

The increasing complexity of today’s real-time simulation models sometimes requires parallelization of processors to achieve the required computing power. In this case, engineers face two challenges:

- They have to partition the system for optimum processor load and avoid as much inter-processor communication as possible.
- The communication code for a network of several processors has to be produced and maintained.

The multiprocessor option for Real-Time Interface (RTI-MP) offers a maximum of convenience to accomplish these tasks. Within Simulink, RTI-MP not only lets you design system dynamics, but also allows you to set up the structure of the multiprocessor network, including the communication channels between the processors. RTI-MP enables you to partition your system model and allocate the parts to the processors by using simple drag & drop operations. Each subsystem can be adjusted individually for optimum performance, including step sizes, integration algorithms, and trigger conditions. After specification, you can implement your model on the processor boards with a single mouse click.
RTI-MP Functionality Overview

Partitioning Your Simulink Model
- Partition of Simulink block diagrams via drag & drop
- Generates highly optimized real-time simulation frame and communication code
- Event-based simulation with Stateflow
- Supports triggered and enabled subsystems distributed over multiple processors
- Full support for interprocessor interrupts
- Priority-based low-latency scheduler
- External simulation mode

Optimizing Speed and Accuracy
- Integration algorithm and step size (individual for processor)
- Single/Multitasking mode (global)
- Swinging Buffer or Shared Memory communication mechanism (individual per connection)
- I/O at different sample rates
- Non real-time execution mode (global)
- Double precision arithmetic on DS1004 Alpha board

Testing and Documenting
- Automatic detection of multiprocessor configuration errors and deadlocks
- Documentation of complete multiprocessor setup

Implementing the Model on Multiprocessor Hardware
- Automatic code generation for one processor or complete system
- Code generation parameters selectable in dialog box
- Download and start with a single mouse click
- Execution time traced for one processor or complete system

Communication Mechanisms
- Communication via dual-port memory interface or C40 communication ports
- Asynchronous data transfer in Shared Memory mode
- Synchronized block data transfer in Swinging Buffer mode

Software Requirements
- Same as RTI, plus
  - RTI1003

System Requirements
- Windows 95 or NT 4.0
- ≥ 32 MB RAM

Order Number
- ISA bus and Ethernet version available for the Alpha Combo (DS1003/DS1004)
  - RTI-MP