MATRIXx™

SystemBuild™ HyperBuild User Guide

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[ ] Square brackets enclose optional items—for example, [`response`].

» The » symbol leads you through nested menu items and dialog box options to a final action. The sequence **File»Page Setup»Options** directs you to pull down the **File** menu, select the **Page Setup** item, and select **Options** from the last dialog box.

✎ This icon denotes a note, which alerts you to important information.

bold Bold text denotes items that you must select or click in the software, such as menu items and dialog box options. Bold text also denotes parameter names.

italic Italic text denotes variables, emphasis, a cross reference, or an introduction to a key concept. This font also denotes text that is a placeholder for a word or value that you must supply.

`monospace` Text in this font denotes text or characters that you should enter from the keyboard, sections of code, programming examples, and syntax examples. This font is also used for the proper names of disk drives, paths, directories, programs, subprograms, subroutines, device names, functions, operations, variables, filenames, and extensions.

`monospace bold` Bold text in this font denotes the messages and responses that the computer automatically prints to the screen. This font also emphasizes lines of code that are different from the other examples.

`monospace italic` Italic text in this font denotes text that is a placeholder for a word or value that you must supply.

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1

Introduction

This guide provides a summary of how to use HyperBuild to accelerate the simulation of any SystemBuild model. This includes the following major topics:

- Chapter 1, *Introduction*
- Chapter 2, *Running HyperBuild from SystemBuild*
- Chapter 3, *Running HyperBuild from Xmath*
- Chapter 4, *Using HyperBuild*

Overview

HyperBuild provides a way to decrease the computer simulation time of SystemBuild models, especially medium and large models. The more complex the SystemBuild model, the more significant the decrease in simulation speed when using HyperBuild.

HyperBuild achieves this improvement by converting a SystemBuild block diagram into highly optimized C code (called HyperCode). The HyperCode version of a model executes much faster than the original model itself, because the simulator is interpretive. The simulator normally evaluates a model block-by-block, whereas HyperBuild typically takes an existing SystemBuild model and replaces it with a new model built from HyperBuild blocks, which are derivatives of UserCode Blocks (UCBs). Since the new model has only a single HyperBuild block per subsystem, the simulator can evaluate it quickly. DataStores from the original model are transferred to the new model outside of the HyperCode.

You can use HyperBuild to generate code for most models, including multirate models and those containing procedures or blocks with state events.

HyperBuild provides support for most SystemBuild features, including the following:

- Software constructs
- Models with algebraic loops
- Zero-crossing blocks
- Implicit blocks (including implicit UCBs)
- Read From and Write To Variable blocks
- Resettable integrators
- Procedure SuperBlocks (includes Standard, Startup, Macro, Background, Interrupt, and Inline Procedure SuperBlocks)
- Multirate models
- Condition SuperBlocks

For specific information on any of these features, refer to the *SystemBuild User Guide* or the *MATRIXx Help*. For additional information about HyperBuild performance and limitations, refer to Chapter 4, *Using HyperBuild*.

Simulation Process

Figure 1-1 shows an overview of the HyperBuild simulation process. This figure traces the progress of the imaginary UFO model through the steps of loading, analyzing, simulating, compiling, and relinking. Each of the HyperBuild steps is described in Chapter 2, *Running HyperBuild from SystemBuild*. The SystemBuild process is described in the *SystemBuild User Guide*.

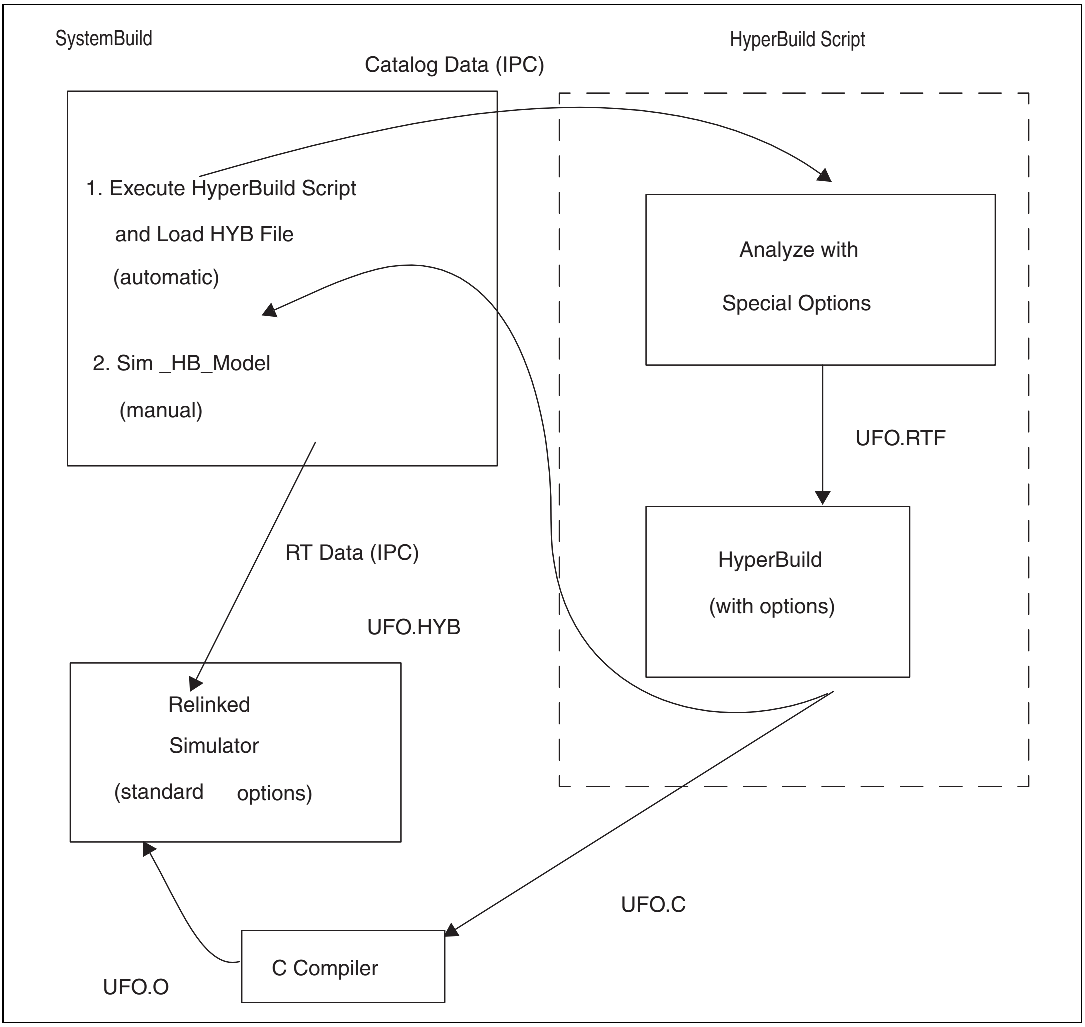


Figure 1-1. HyperBuild Simulation Process

2

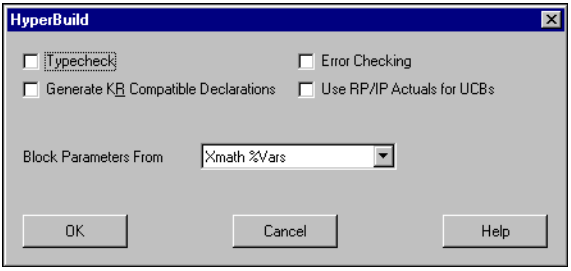
Running HyperBuild from SystemBuild

Running HyperBuild and Generating HyperCode

To run HyperBuild and generate HyperCode, complete the following steps:

1. Select a top-level SuperBlock of your model from the SystemBuild Catalog Browser and then select **Tools»HyperBuild**.

   The HyperBuild dialog box appears.



□ Typecheck

□ Generate KR Compatible Declarations

□ Error Checking

□ Use RP/IP Actuals for UCBs

Block Parameters From: Xmath %Vars

2. From this dialog box, select the options you want and click **OK**.

   HyperBuild generates HyperCode and creates a catalog in your working directory named *blockname*.hyb.

   The available options include:

   Typecheck — Enables data type checking in the generated code. Default is unchecked.

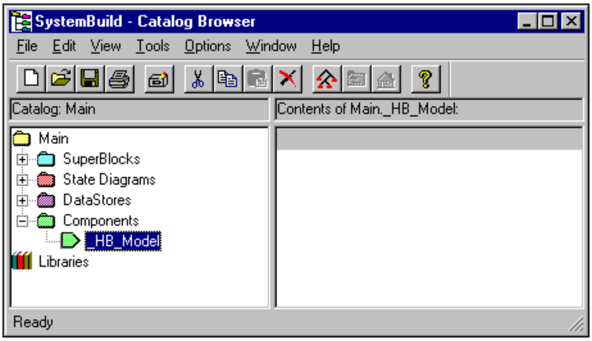
   Generate KR Compatible Declarations — Enables the generation of Kernigan and Ritchie style C code declarations. Default is unchecked.

   Error Checking — Enables error checking in the generated code. Default is unchecked.

   User RP/IP Actuals for UCBs — Provides for a selection between RP/IP (real parameter/integer parameter) hardcoded numbers and %var encoding for UCBs. Default is unchecked.

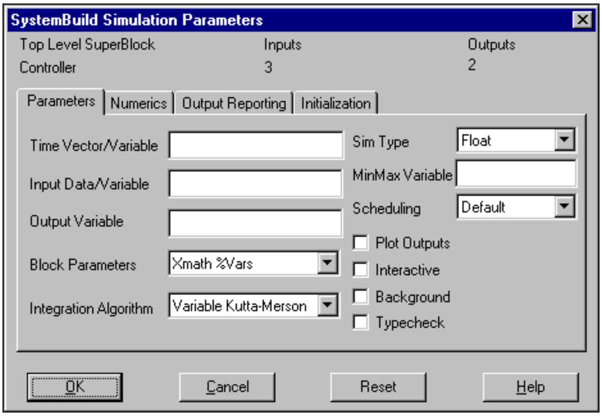
Block Defaults or Xmath %Vars	Provides a choice between putting default variable block parameters or %vars into the HyperBuild code. Default is Xmath %Vars.

SystemBuild automatically loads the `*modelname*.hyb` model after it is generated as the component _HB_Model.



Loading and Using HyperCode

After you have run HyperBuild on your model, you select the **_HB_Model** component. Then select **Tools»Simulate** from the Catalog Browser. The SystemBuild Simulation Parameters dialog box appears.



Top Level SuperBlock	Inputs	Outputs
Controller	3	2

Time Vector/Variable

Input Data/Variable

Output Variable

Block Parameters: Xmath %Vars

Integration Algorithm: Variable Kutta-Merson

Sim Type: Float

MinMax Variable

Scheduling: Default

□ Plot Outputs

□ Interactive

□ Background

□ Typecheck

To simulate your HyperCode, enter the following required parameters:

Parameters tab: Time Vector/Variable	Requires a time column vector (for example, `[0:0.1:300]'`).
Parameters tab: Input Data/Variable	Required variable for models with 1 or more inputs (for example, `u`).

To make the best use of your HyperCode, select from the following options:

Parameters tab: Output Variable	Keep at a minimum for best performance.
Parameters tab: Sim type	Select **Float** for best performance. **Note**: If the original model uses fixed-point types, these will be simulated last in the HyperBuild object, not by the simulator. Therefore, select Float even if there are fixed-point types within the HyperCode.
Parameters tab: Scheduling	Select **actiming** if you plan to use AutoCode to generate C or Ada code.
Numerics tab: Time Delay Buffer	Set to a low number to minimize delays (20 is the default).
Initialization tab: Remake sim executable	Leave unchecked to minimize simulation time.

Note The `LINKHYPER` Xmath command is no longer supported. HyperCode is linked to the simulator immediately after generation.

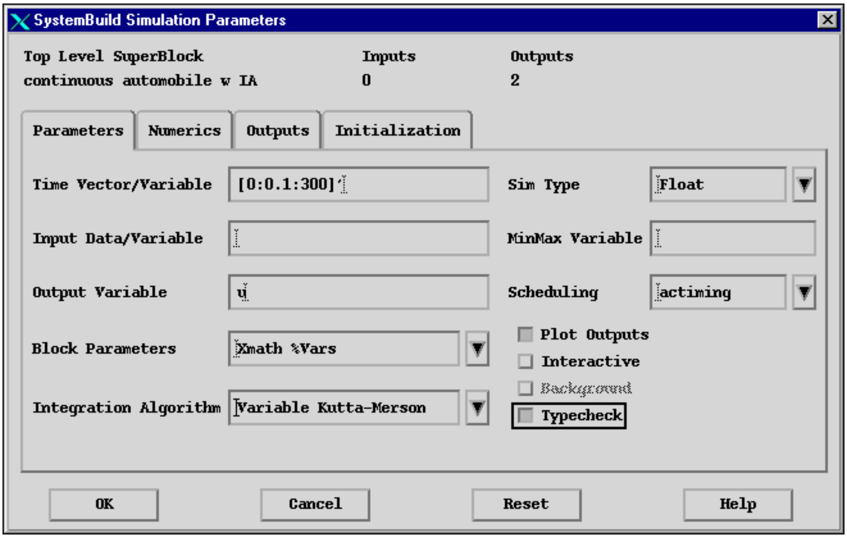
Simulation Example

As an example, load the super_cruise model from the *`MTXHOME`*`/sysbld/demo` directory, select a top level block such as the **continuous automobile with IA** block, and then simulate the model with and without HyperBuild.

Simulation Without HyperBuild

To simulate a model without HyperCode, complete the following steps:

1. Select **Tools»Simulate**, which opens the SystemBuild Simulation Parameters dialog box.
2. In the **Parameters** tab, set the **Time Vector/Variable** to `[0:0.1:300]'`, enter an **Output Variable** of `u`, and select any of the optional checkboxes such as **Typecheck** and **Plot Output**.



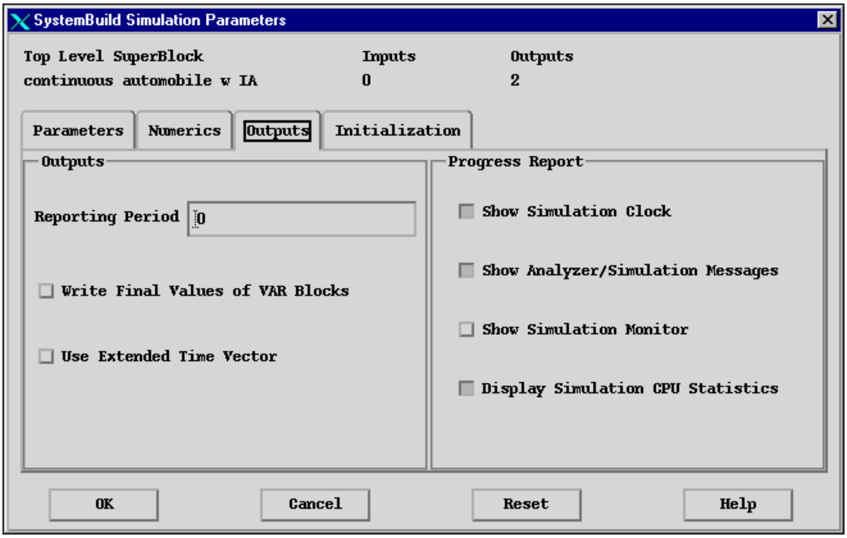
SystemBuild Simulation Parameters

Top Level SuperBlock: continuous automobile w IA
Inputs: 0
Outputs: 2

Time Vector/Variable: [0:0.1:300]'
Input Data/Variable:
Output Variable: u
Block Parameters: Xmath %Vars
Integration Algorithm: Variable Kutta-Merson
Sim Type: Float
MinMax Variable:
Scheduling: actiming

□ Plot Outputs
□ Interactive
□ Background
□ Typecheck

3. Select **Show Simulation Clock** (optional), **Show Analyzer/ Simulation Messages** (optional), and **Display Simulation CPU Statistics** (to display comparative results) from the **Outputs** tab.



SystemBuild Simulation Parameters

Top Level SuperBlock: continuous automobile w IA
Inputs: 0
Outputs: 2

Outputs

Reporting Period: 0

□ Write Final Values of VAR Blocks

□ Use Extended Time Vector

Progress Report

□ Show Simulation Clock

□ Show Analyzer/Simulation Messages

□ Show Simulation Monitor

□ Display Simulation CPU Statistics

After the simulation, you see output similar to the following:

```
Using variable step Variable Kutta-Merson integration.
Continuous states are solved explicitly.
Continuous outputs are solved explicitly.

Initialization Complete.
The solution is   1% complete.
The solution is   2% complete.
The solution is   5% complete.
The solution is  10% complete.
The solution is  20% complete.
The solution is  40% complete.
The solution is  60% complete.
The solution is  80% complete.
elapsed:  0 00:00:01.07   cpu:  0 00:00:01.06
The solution is 100% complete.
```

Simulation With HyperBuild

Using the same model and simulation parameters as in the *Simulation Without HyperBuild* section, you can compare your simulation time using HyperBuild.

In this example, you again use the super_cruise model and complete the following steps from the SystemBuild - Catalog Browser.

1. Load (or open) the super_cruise model from the `*MTXHOME*/sysbld/demo` directory.
2. Select the **continuous automobile with IA** block.
3. Select **Tools»HyperBuild** to create the _HB_Model component.
4. Simulate the model with HyperBuild by clicking **_HB_Model** and then selecting **Tools»Simulate**.

The output from the simulation with HyperBuild is identical to the “without HyperBuild” example except for the elapsed and cpu times.

```
elapsed:  0 00:00:00.54   cpu:  0 00:00:00.52
```

Because the super_cruise model is a small demonstration model, you do not see the full power of the tool. However, you see about a 50% improvement in the simulation speed even with this small model.

Note If you simulate a model and then load another model, you may need to delete some of the generated files (for example, `ucbhook.*`) before simulating the _HB_Model component again.

3

Running HyperBuild from Xmath

Running HyperBuild from the Xmath Commands Window

To run HyperBuild from the Xmath Commands window, you can use the following HyperBuild command:

```
hyperbuild "topSB", {keywords}
```

where *topSB* (a text string) is the name of the top SuperBlock of the model and keywords are described in Table 3-1.

Table 3-1. HyperBuild Keyword Options

Keyword	Type	Description
`errorcheck`	Integer	Enables error checking in the generated code. Default = 0.
`file`	File	Output file to receive generated code. **Note**: The keyword has no suffix.
`typecheck`	Boolean	Enables data type checking in the generated code. Default = 0.
`ucbparams`	Boolean	Lets the user configure UCBs to use either RP/IP (real parameter/integer parameter) hardcoded numbers or %var encoding.
`vars`	Boolean	If 1 (default), put `%Variables` into the HyperBuild code.

The `hyperbuild` command generates three files: the C file (*topSB*`.c`), the model file containing the _HB_Model component (*topSB*`.hyb`), and the real-time file (*topSB*`.rtf`).

For example, to generate HyperCode for the super_cruise model, enter the following command sequence from the Xmath Commands window:

```
load file = "cruise_d.cat";
main.t = [0:0.1:300]';
hyperbuild "continuous automobile w IA", {typecheck};
```

where `continuous automobile with IA` is a top-level SuperBlock. HyperBuild code is generated for the SuperBlocks contained in this *`topSB`*. The _HB_Model component that is generated contains UCBs that reference the HyperCode.

Linking a Simulation (Optional)

With HyperBuild, you can generate HyperCode and simulate the _HB_Model component directly, or you can use the `linksim` command to link your code with other UserCode Block files.

The `linksim` command has the following syntax:

```
linksim model, {csource, fsource}
```

where `model` is a string specifying the SystemBuild model to search for UserCode Block source files, `csource` is a string specifying the C source files to be compiled and linked into the simulator, and `fsource` is a string specifying the FORTRAN source files to be compiled and linked into the simulator.

Note File names must be separated by spaces, and files specified in the UCB dialog boxes need not be included.

The `linksim` command compiles and links UserCode Block source files and creates a UCB shared library (`simucb.*`, where the extension is platform dependent), in your local directory. For Windows, the extension is `.dll`. For Solaris, SGI, and IBM platforms, the extension is `.so.1.0`. For Compaq Tru64 platforms, the extension is `.so`. For HP platforms, the extension is `.sl`.

Source files can be specified in the parameter dialog of each UserCode Block reference in a model (no more than one file reference per UserCode Block reference). The specified SystemBuild model is searched for source files listed in any UCB, or referenced by the values of the `csource` and `fsource` values set using `setsbdefault`.

Simulating Linked HyperCode or linksim Output

To simulate linked HyperBuild code (the _HB_Model component) or the output from `linksim`, use the following `sim` command (for example):

```
outputPDM = sim ("_HB_Model", InputPDM, {keywords})
```

where `inputPDM` is a PDM with domain as a time vector, the range is the input, and keywords are as described in the *MATRIXx Help*.

Note Simulation of a HyperBuild model is exactly the same as simulation of any other SystemBuild model and is described fully in the *MATRIXx Help*.

Running HyperBuild from a Script

The `hyperbuild` command is especially useful if you want to run a script to perform your HyperCode creation and simulation. For example, the following script loads the super_cruise model, runs HyperBuild, and then simulates the `continuous automobile with IA`. This script also simulates the _HB_Model component:

```
load file = "cruise_d.cat";
pause 6;
main.t = [0:0.1:300]’;
hyperbuild "continuous automobile w IA", {typecheck};
[,main.ycsim] = sim("continuous automobile w IA",main.t,
{simtimer, typecheck});
[,main.ychyp] = sim("_HB_Model",main.t, {simtimer,
typecheck});
```

For additional information about writing Xmath scripts, refer to the *Xmath User Guide*.

4

Using HyperBuild

Usage Notes

When you are using HyperBuild, give special consideration to the following:

- If your regular SystemBuild simulation takes more than a few minutes, or if you want to run it repeatedly, NI recommends the use of HyperCode.
- Only one HyperCode model at a time can be linked with the simulation engine.
- Because the HyperCode SuperBlock _HB_Model is automatically generated, the best way to change initial states, connections, or parameters is to edit the original SuperBlock in the SystemBuild model and then regenerate the HyperCode.
- The generated code has comments that indicate the original SuperBlock name, block name, and block type for each section of code.
- UserCode Blocks (UCBs) are allowed in HyperBuild models, just as in conventional SystemBuild models. If you use the `UPDUSR` interface to UCBs, you must specify all required source code files as `csource` in Xmath, by using the `SETSBDEFAULT` command, and specify a positive integer for the function name in the block dialog box. UCBs created prior to version 4.0 are in this format.

Performance Results

Performance results will vary, but simulation speeds using HyperBuild have been tested at seven to 10 times the speed of simulations without HyperBuild. You can improve performance results by simplifying your model in the following ways:

- Avoid implicit outputs and algebraic loops if possible.
- Minimize the number of inputs and outputs.

- Use procedure states instead of task states where possible in discrete subsystems.
- Use floating-point signals instead of other types of signals for subsystem inputs and outputs.

For additional information on improving performance, refer to the *Code Optimizations* chapter of the *AutoCode Reference*.

Limitations

HyperBuild has the following limitations:

- Algebraic loops within procedures are supported but discouraged for efficiency reasons.
- MathScript blocks are not supported.
- %var data from the Xmath stack are re-initialized. HyperCode takes the %var values that are set within Xmath at the time of code generation. To change these values, you must change them in Xmath and regenerate the code.

For specific information on SystemBuild topics, refer to the *SystemBuild User Guide* or the *MATRIXx Help*.

A

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