

Simulink[®] Verification and Validation

For Use with Simulink[®]

- Modeling
- Simulation
- Implementation

User's Guide

Version 1



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Simulink Verification and Validation User's Guide

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Getting Started

Simulink® Verification and Validation uses component tools that contribute to the work of certifying the correct design, implementation, and testing of Simulink models. Use the following topics to introduce yourself to Simulink Verification and Validation.

“What Is Simulink Verification and Validation?” (p. 1-2)	Tells you why you want to use Simulink Verification and Validation in your models
“System Requirements” (p. 1-3)	Lists system requirements necessary to qualify for installation
“Organization of This User’s Guide” (p. 1-4)	Describes the expected background for using Simulink Verification and Validation and the organization of this guide

What Is Simulink Verification and Validation?

Simulink Verification and Validation is a Simulink® based product that helps you do the following:

- Establish requirements for a Simulink model by linking them with model elements that satisfy them
- Verify proper function of the model by monitoring model signals during extensive testing
- Validate the model, making sure that all possible model decisions are taken through testing.

In short, the elements of Simulink Verification and Validation give you complete confidence in the behavior of your Simulink models.

System Requirements

Operating System Requirements

Simulink Verification and Validation works with the following operating systems:

- Microsoft Windows NT, Windows 2000, and Windows XP systems
- UNIX systems where MATLAB supports Java (for HTML-based requirements documents only)

MATLAB Requirements

To use Simulink Verification and Validation in MATLAB®, you need the following software products installed:

- MATLAB Version 5.3.1 or later
- Simulink Version 3.0.1 or later
- Stateflow® Version 2.0.1 or later, if you want to use the Requirements Management Interface for Stateflow diagrams
- For the Simulink Verification and Validation version of the Requirements Management Interface, you need the applications that you use to view your requirements documents. The following applications are supported:
 - Microsoft Word 2000 or later
 - Microsoft Excel 98 or later
- For the Simulink Verification and Validation version of the Requirements Management Interface with DOORS, install DOORS version 6.0 or 7.0. For older DOORS versions, use the old Requirements Management Interface as follows:
 - To use Version 4.0.3 of DOORS, you need Version 1.0 of the Requirements Management Interface
 - To use Version 5 of DOORS, you need Version 1.02 of the Requirements Management Interface.
 - To use Version 5.2 of DOORS, you need Version 1.04 of the Requirements Management Interface.

Organization of This User's Guide

The components of the Simulink Verification and Validation tools are organized on the basis of work flow that you follow in certifying the correct and complete behavior of your models. This work flow is described in the following steps, which encapsulate the organization of this User's Guide:

- 1** Establish performance requirements for the model and link them with model elements using the Requirements Management Interface, which is described in the following chapters:
 - Chapter 2, “Managing Model Requirements” — Instructions for using the standard version of the Requirements Management Interface. Use this to associate Simulink models, Stateflow diagrams, and MATLAB M-files with requirements in HTML, Microsoft Word, and Microsoft Excel documents.
 - Chapter 3, “Managing Model Requirements with DOORS” — Instructions for using the DOORS version of the Requirements Management Interface. Use this if you use the DOORS requirements management system and want to associate Simulink models, Stateflow diagrams, and MATLAB M-files with requirements in DOORS.
- 2** Verify proper performance of the model by monitoring model signals during extensive testing with model verification blocks using the Verification Manager, which is described in the following chapter:
 - Chapter 4, “Managing Model Verification Blocks” — Shows you how to use verification blocks individually in Simulink models and how to manage them as a group for testing.
- 3** Validate the model, making sure that all possible model decisions are taken through testing, by using the Model Coverage tool, which is described in the following chapter:
 - Chapter 5, “Using Model Coverage” — Shows you how to generate and interpret model coverage reports and displays for validating model decisions.

The last portion of the User's Guide is comprised of function and block reference chapters:

- Chapter 6, “Functions — Categorical List” — Provides a categorical list of functions used in executing and managing model coverage tests and reports from MATLAB. Automate your model coverage tests with scripts of MATLAB commands calling these functions.
- Chapter 7, “Functions — Alphabetical List” — Provides an alphabetical reference of functions used in executing and managing model coverage tests and reports from MATLAB.
- Chapter 8, “Blocks – Alphabetical List” — Provides reference information for the Simulink Verification and Validation library, which currently contains only one block, System Requirements. This block lets you list all the requirements for a model or subsystem on its Simulink diagram.

Managing Model Requirements

The Requirements Management Interface (RMI) associates requirements documents with objects in Simulink models. To learn how to use the RMI, see the following sections:

“What Is the Requirements Management Interface?” (p. 2-3)

Introduces you to the Requirements Management Interface for linking requirements documents to model elements

“Configuring the Requirements Management Interface” (p. 2-4)

Describes what you need to do before using the Requirements Management Interface

“Adding and Viewing Requirement Links” (p. 2-5)

Shows you how to link model elements with requirements documents, and modify both links and documents

“Linking to Custom Types of Requirements Documents” (p. 2-28)

Shows you how to register additional types of requirements documents and create links to them

“Viewing Objects with Requirement Links” (p. 2-44)

Shows you how to provide meaningful displays of model elements that are linked to requirements documents

“Generating a Requirements Report” (p. 2-47)

Shows you how to generate a report on all the requirements associated with a model and its blocks

“Displaying the System Requirements in a Diagram” (p. 2-49)

Shows you how to display the system requirements directly in your Simulink diagram

“Including Requirements with Generated Code” (p. 2-55)

Shows you how to specify that requirements descriptions are included in generated code for your model

What Is the Requirements Management Interface?

The Requirements Management Interface (RMI) allows you to associate requirements with Simulink models and Stateflow diagrams. Simulink and Stateflow requirements have the following parts:

- A requirement description of up to 255 characters
- The pathname of a requirements document, such as a Microsoft Word file. (Simulink supports several built-in document formats and also allows you to register your own custom types of requirements documents.)
- A link to a location inside the requirements document

Use the Requirements Management Interface to

- Associate requirements with
 - Simulink models
 - Simulink subsystems and blocks
 - Stateflow charts, states, transitions, boxes, and functions
- Navigate from a Simulink block or Stateflow object in a diagram or in the Model Explorer to a requirement
- Navigate from an embedded link in a requirements document to the corresponding Simulink or Stateflow object (when you create two-way links using the selection-based linking mechanism)
- View objects in Simulink or Stateflow diagrams that have requirements associated with them

Configuring the Requirements Management Interface

Before you start using the Requirements Management Interface, in the MATLAB Command Window type

```
rmi setup
```

This command runs a setup script that installs the ActiveX controls, needed for establishing two-way selection-based links. If DOORS is installed on the machine, this command also invokes the DOORS setup. For more information, see “Configuring the Requirements Management Interface for DOORS” on page 3-3.

Adding and Viewing Requirement Links

You use the Requirements dialog box to associate a requirements document with a requirements object.

Use the following topics to learn how to add, view, and modify requirements you associate with a requirements object:

- “Object and Document Types” on page 2-5 — Learn about the supported types of objects, requirements documents, and locations within the documents.
- “Adding Requirement Links to an Object” on page 2-8 — Make a link between a model element and a requirements document.
- “Viewing Requirements Documents” on page 2-13 — Edit a requirements document through the model element it is linked to.
- “Resolving the Document Path” on page 2-15 — Learn where the Requirements Management Interface looks to resolve the absolute or relative path you specify for a requirement.
- “Adding Requirement Links to Multiple Objects Simultaneously” on page 2-17 — Make a link between each of a group of selected model elements and a requirements document.
- “Selection-Based Linking” on page 2-20 — Use a simplified procedure to make a two-way link between a model element and a requirements document.

Object and Document Types

You can add requirements to the following types of objects:

- Simulink model
- Simulink block
- Stateflow chart, state, transition, box, or function

Note You can add requirements to top-level reference blocks but not to their contents. For example, if you copy a subsystem consisting of multiple blocks from a library, you will be able to add requirements to the subsystem block in your model, but not to its component blocks.

The Requirements Management Interface supports the following built-in types of requirements documents:

- Text
- HTML
- Microsoft Word
- Microsoft Excel
- PDF

You can also link to a DOORS item (see “Linking Objects to DOORS Requirements” on page 3-7), or register your own custom type of documents to link to (see “Linking to Custom Types of Requirements Documents” on page 2-28).

Location Types

Depending on the document type, you can link to specific locations within a document.

Document Type	Location Options
Text	<ul style="list-style-type: none">• Search text — Type a string in the Location text field. The Requirements Management Interface searches for the first occurrence of the text string within the document.• Line number — Type a line number in the Location text field. The Requirements Management Interface makes a link to the specified line.

Document Type	Location Options
HTML	<p>You can only link to a named anchor.</p> <p>For example, if you define the anchor</p> <pre data-bbox="599 440 1188 470"> ...contents... </pre> <p>in your HTML requirements document, you can enter <code>valve_timing</code> in the Location text field or click the Document Index tab to select <code>valve_timing</code> from an automatically generated list of anchors in the document.</p>
Microsoft Word	<ul style="list-style-type: none"> • Search text — Type a string in the Location text field. The Requirements Management Interface searches for the first occurrence of the text string within the document. • Named item — Link to a bookmark within the document. The Requirements Management Interface automatically generates a document index based on its headings and bookmarks, or you can type the name in the Location text field. • Page/item number — Type a page number in the Location text field. The Requirements Management Interface makes a link to the top of the page.
Microsoft Excel	<ul style="list-style-type: none"> • Search text — Type a string in the Location text field. The Requirements Management Interface searches for the first occurrence of the text string within the document. • Named item — Link to a named item within the document (defined in Excel using Insert → Name). Type the name in the Location text field. • Sheet range — Type a cell number or a range of cells (such as <code>C5:D7</code>) in the Location text field. The Requirements Management Interface makes a link to the specified cell or cells.

Document Type	Location Options
PDF	<ul style="list-style-type: none">• Named item — Link to a bookmark within the document. The Requirements Management Interface automatically generates a document index based on its headings and bookmarks, or you can type the bookmark name in the Location text field.• Page/item number — Type a page number in the Location text field. The Requirements Management Interface makes a link to the top of the page.
Web Browser URL	You can only link to a URL location. Type the URL location string in the Document text field. When you follow the link, the document opens in the system Web browser.

Adding Requirement Links to an Object

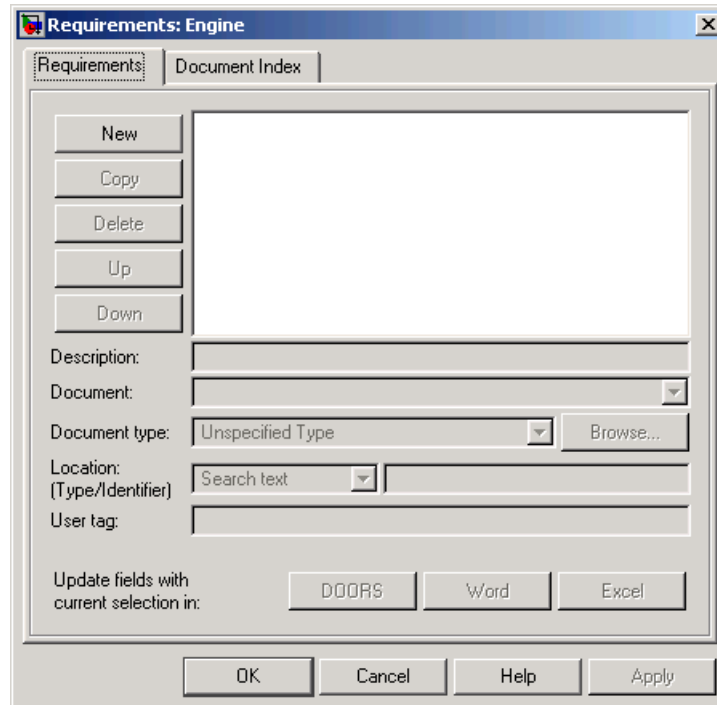
You can link a particular location in an existing Microsoft Word or HTML document to a block in a Simulink diagram or a Stateflow object in a Stateflow diagram. In the following procedure, you add three requirement links to a Simulink block in the demo model `sf_car`. In later topics you modify both the links and the documents they point to.

- 1 Create and save the Microsoft Word document `requirements.doc` with the following format:

```
Primary Requirements
<filler text - 10 lines>
Secondary Requirements
<filler text - 10 lines>
Tertiary Requirements
<filler text - 10 lines>
```

- 2 Open the demo model `sf_car` by typing `sf_car` at the MATLAB prompt.
- 3 Right-click the Engine block and, from the resulting pop-up menu, select **Requirements > Edit/Add Links**.

The Requirements dialog box for the Engine block appears, as shown.

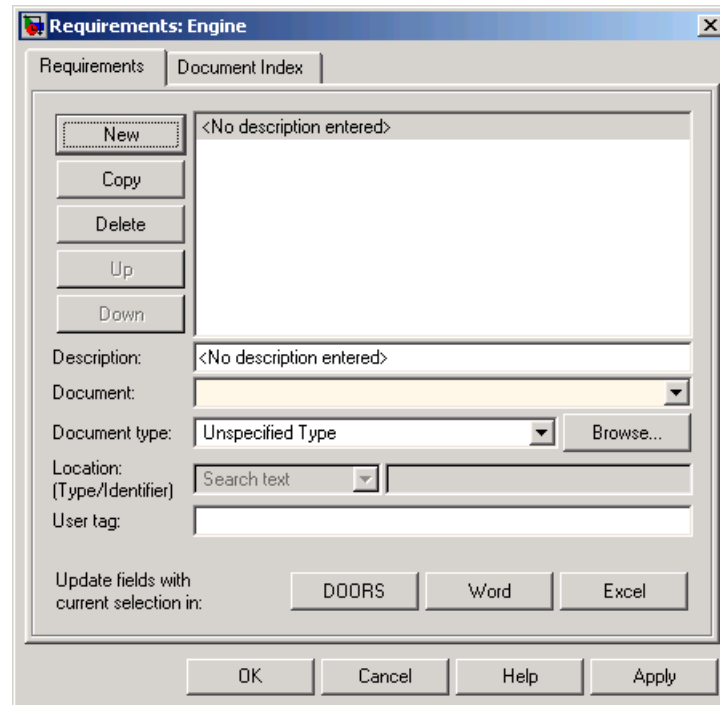


You can access the Requirements dialog box to add requirements in the following right-click contexts.

Model Element	Context
Simulink model	Simulink diagram — Empty diagram space
Simulink block	Simulink diagram Model Explorer Contents pane
Stateflow chart	Simulink diagram — Stateflow block Stateflow Diagram — Empty diagram space
Stateflow object	Stateflow diagram Model Explorer Contents pane

- 4 In the Requirements dialog box, click **New** to add a new default requirement.

Fields and tools of the Requirements dialog box are now enabled for a default unspecified requirement, as shown.

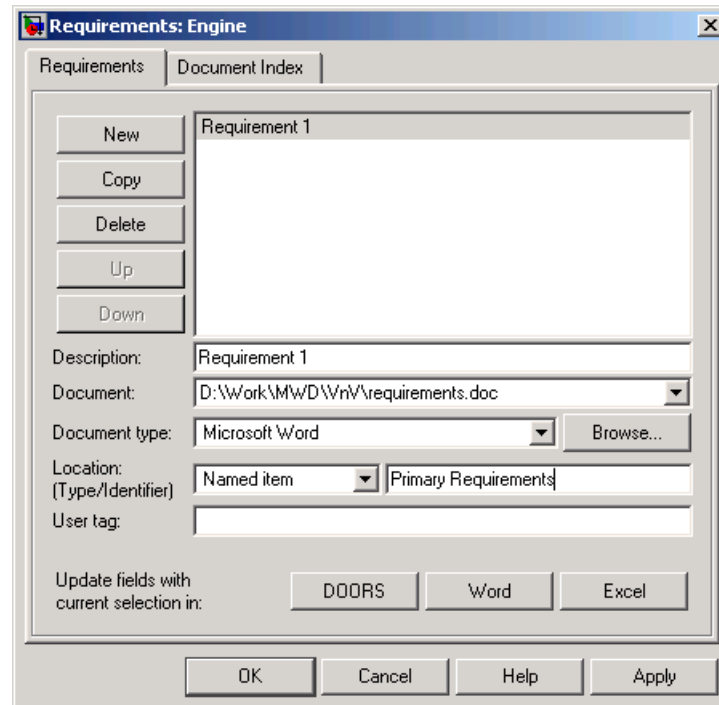


- 5 Click in the **Description** field and enter Requirement 1.
- 6 Click **Browse** next to the **Document Type** field, browse to the requirement file requirements.doc, and select **Open**.

Note that the **Document Type** field is now set to Microsoft Word. If you specify the document type in the **Document Type** field prior to browsing for the requirements document, only the files of the appropriate type are shown in the browser. If you set **Document Type** to Unspecified Type, the browser shows all files.

- 7 To define a particular location in the document, click the **Document Index** tab and select Primary Requirements from an automatically generated list

of headings and bookmarks in the document. Alternately, you can just type Primary Requirements in the **Location** text field.



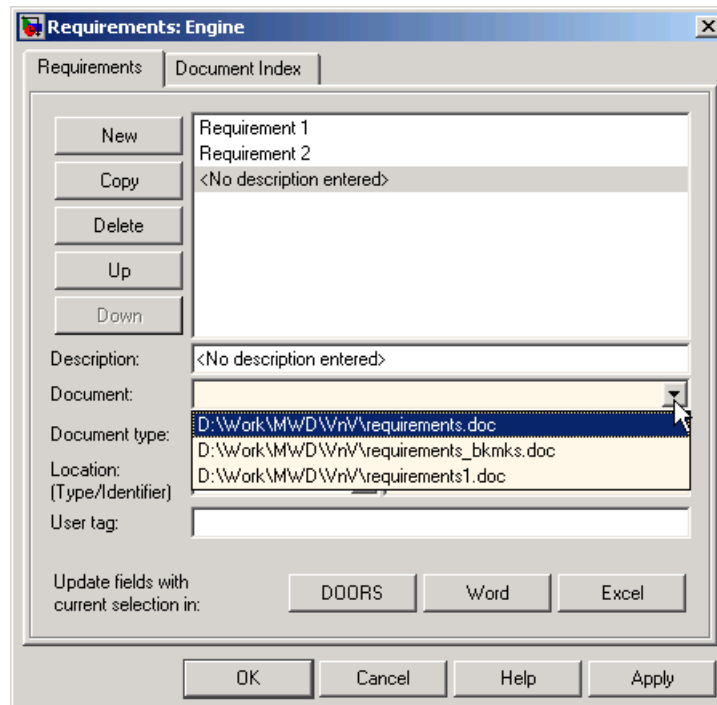
- 8 With Requirement 1 selected, click **Copy** to add a copy of Requirement 1 as a new requirement.
- 9 Modify the copy of Requirement 1 to be Requirement 2, pointing to the text “Secondary Requirements” in the document requirements.doc.

In addition to the **Copy** tool, you can edit existing requirements using the following tools.

Tool Button	Description
Delete	Deletes the requirement

Tool Button	Description
Up	Moves the selected requirement up one line in the list of requirements
Down	Moves the selected requirement down one line in the list of requirements

As you add requirements, the Requirements dialog box makes it easier for you to enter a previous document name by remembering up to five of the most recent documents entered. The list of five is taken for all entries made across all models. For example, if you were to add a new requirement after entering two requirements for the Engine block, and click the drop-down arrow in the **Document** field for the new requirement, a selectable list of previous documents like the following example would appear.



- 10 Click **OK** to apply the requirement links you have added and close the Requirements dialog box.

Note When you add a requirement link to a block such as a subsystem, the requirement is not added to children of the block.

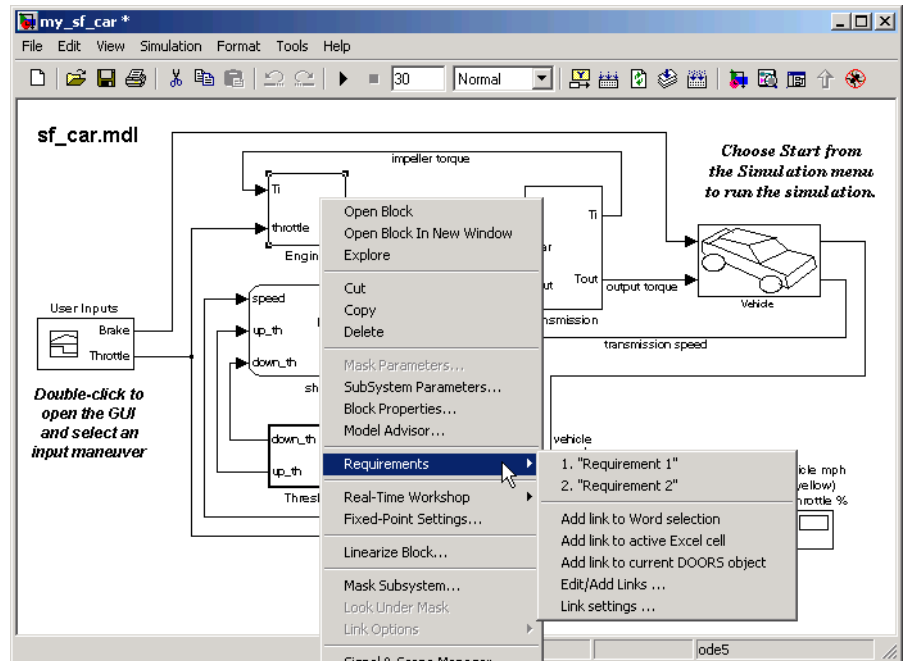
- 11 Save the model as `my_sf_car.mdl`.

Viewing Requirements Documents

You can access a requirements document through its associated model element. You added requirement links to the Engine block of the model `my_sf_car` in “Adding Requirement Links to an Object” on page 2-8. To access the document for the second requirement link, do the following:

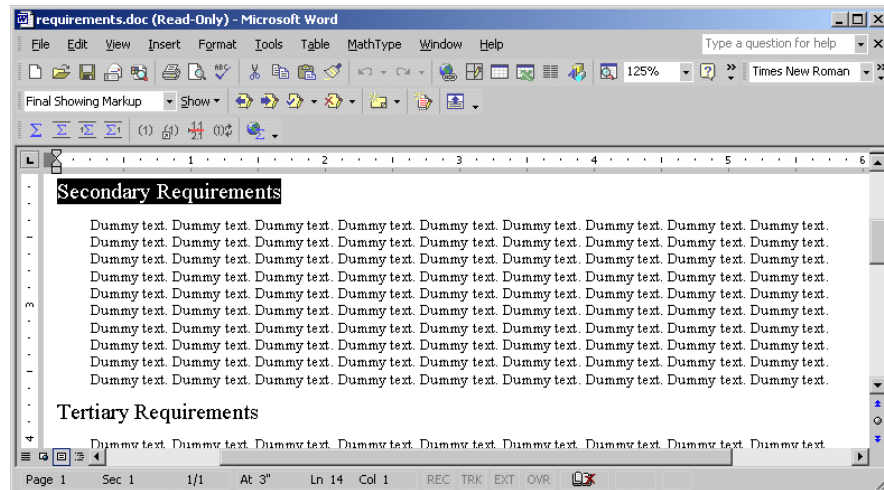
- 1 Open the model `my_sf_car` that you saved in the previous topic, “Adding Requirement Links to an Object” on page 2-8.
- 2 Right-click the Engine block and select **Requirements** from the context menu.

The requirements you added now appear as submenu selections, as shown.



3 Select **Requirement 2** from the submenu.

The document requirements.doc opens in its editor, Microsoft Word, scrolled to the highlighted first occurrence of the text “Secondary Requirements,” as shown.



If a string location in the file is not specified, the document appears scrolled to the top of the file.

- 4 Try to access the other requirements and make sure that they open scrolled to the specified text location.

Resolving the Document Path

Browsing for a document to enter it in a requirements link enters the location of the document with a fully specified absolute path. You can also enter a relative path for the document location. A relative path can be a partial path or no path at all. In many cases it is preferable to use a relative path so that the document is not constrained to a single location in the file system. With a relative path the Requirements Management Interface resolves the exact location of the requirements document with the following procedure:

- 1 An attempt is made to resolve the path relative to the current MATLAB directory.
- 2 If there is no path specification and the document is not in the current directory, the MATLAB search path is used to locate the file.
- 3 If the document is not located relative to the current directory or the MATLAB search path, it is resolved relative to the model file directory.

The following examples illustrate the procedure for locating the specified requirements document.

Relative Path Specified Example

Current MATLAB directory:	C:\work\scratch
Model file:	C:\work\models\controllers\pid.mdl
Document link:	..\reqs\pid.html
Documents searched for: (in order)	C:\work\reqs\pid.html C:\work\models\reqs\pid.html

No Path Specified Example

Current MATLAB directory:	C:\work\scratch
Model file:	C:\work\models\controllers\pid.mdl
Requirements document:	pid.html
Documents searched for: (in order)	C:\work\reqs\scratch\pid.html <MATLAB path dir>\pid.html C:\work\models\controllers\pid.html

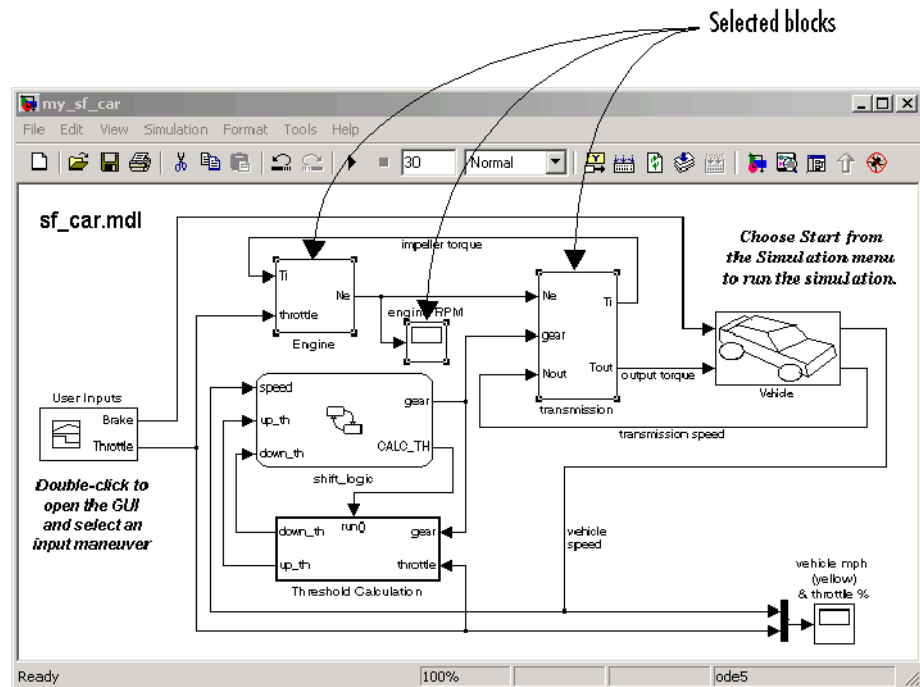
Absolute Path Specified Example

Current MATLAB directory:	C:\work\scratch
Model file:	C:\work\models\controllers\pid.mdl
Requirements document:	C:\work\reqs\pid.html
Documents searched for:	C:\work\reqs\pid.html

Adding Requirement Links to Multiple Objects Simultaneously

In “Adding Requirement Links to an Object” on page 2-8, you added requirement links to an individual block. You can also add or delete requirement links for a selection of multiple Simulink blocks or Stateflow objects as follows:

- 1 Open the demo model `my_sf_car` you saved in “Adding Requirement Links to an Object” on page 2-8 and select the Engine, engine RPM, and transmission blocks.

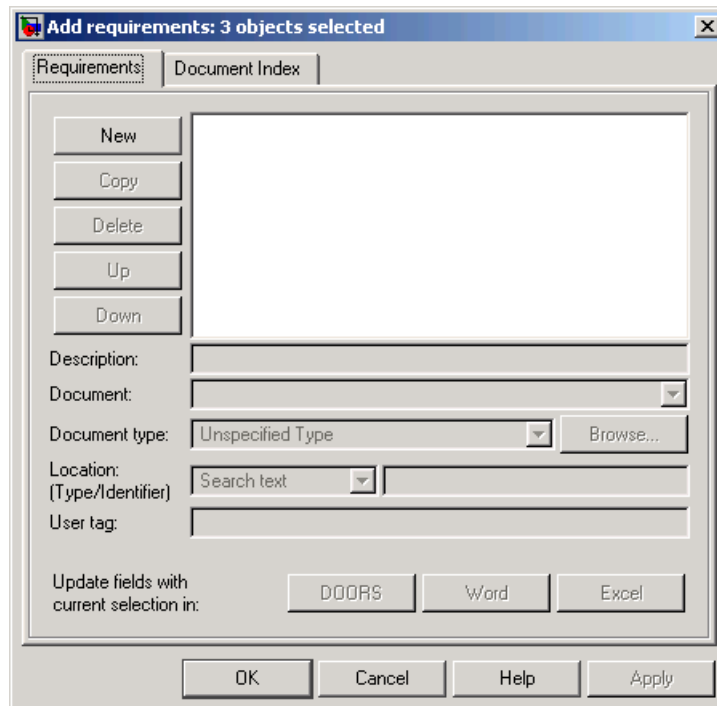


You can select multiple Simulink blocks or Stateflow objects in one of the following ways:

- Hold down the **Shift** key while clicking each block.
- Click and drag a selection rectangle around them.

- 2 Right-click any of the selected blocks and, from the resulting context menu, select **Requirements > Add Links to All**.

The Add Requirements dialog box appears, as shown, for the three selected blocks.



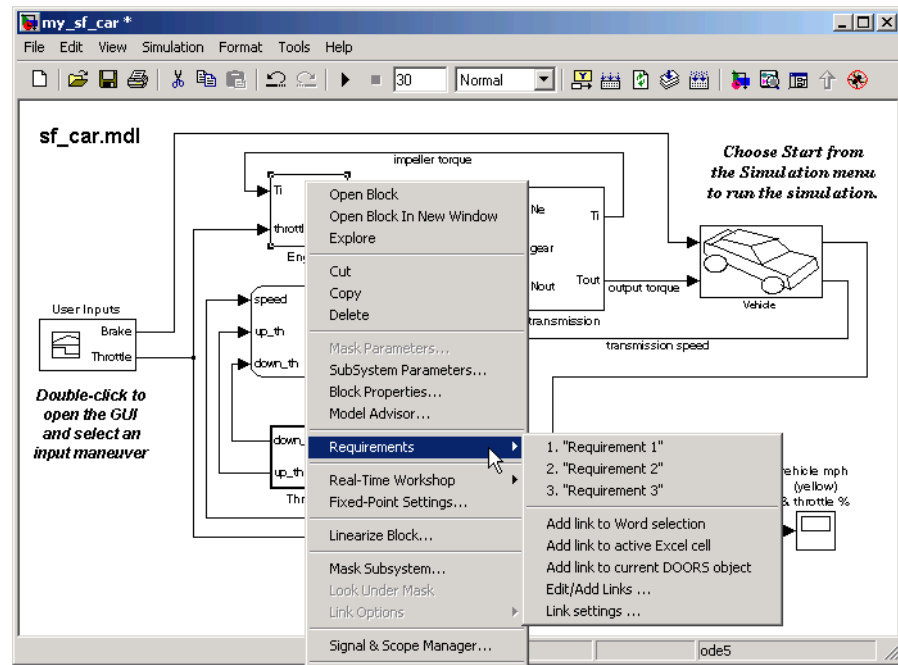
- 3 Add a new Requirement 3 for the set of blocks that points to the text “Tertiary Requirements” in the file requirement.doc.

Add the requirement as you would for a single block as described in “Adding Requirement Links to an Object” on page 2-8.

Note When you add a requirement link to a block such as a subsystem, the requirement is not added to children of the block.

- 4 Click outside the three objects to deselect them.
- 5 Right-click the Engine block and select **Requirements**.

The Engine block now has three requirements, as shown.



- 6 Right-click the engine RPM and transmission blocks to verify that they have only one requirement.
- 7 Save the model (my_sf_car).

Deleting All Requirement Links for Multiple Objects Simultaneously

In “Adding Requirement Links to Multiple Objects Simultaneously” on page 2-17, you added requirement links to each block in a multiple selection of blocks. To delete the existing requirements for a group of selected blocks, right-click any of a group of selected blocks and, from the resulting context menu, select **Requirements > Delete All**. Notice that this deletes all of the

requirement links for all of the selected blocks, whether they were added individually or as a group.

Selection-Based Linking

Selection-based linking is a quick way to make links between model elements and selected portions of a requirements document, which can be a Microsoft Word or Microsoft Excel file only. This method provides an ability to create two-way links by embedding an ActiveX control into the requirements document next to the selected string or cell.

The following tasks show you how to work with selection-based linking:

- “Opening the External Application” on page 2-20
- “Specifying Your Linking Preferences” on page 2-21
- “Making Selection-Based Links” on page 2-22
- “Navigating from the Requirements Document to the Simulink Model” on page 2-25

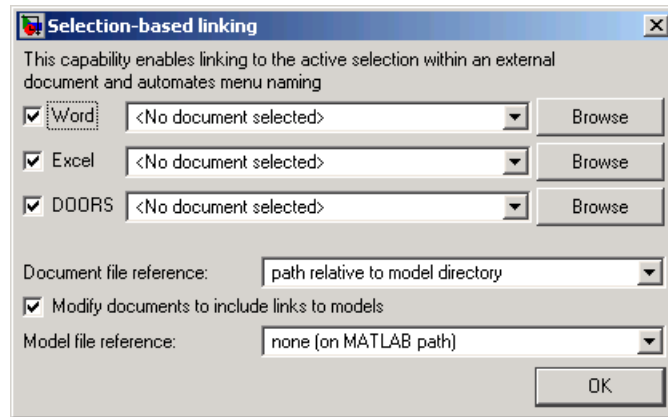
Opening the External Application

Before creating selection-based links, you need to establish communication between Simulink and the external application (Microsoft Word or Microsoft Excel) by opening the application from within the Simulink. The document you open cannot be read-only, or be already open in another application.

Note If you open a document some other way and try to create selection-based links to it, Simulink displays an error message.

Use the following procedure to open a document for selection-based linking:

- 1 Open the model `my_sf_car`.
- 2 In Simulink, from the **Tools** menu, select **Requirements > Link settings**. The Selection-based linking dialog box opens.



Another way to open the Selection-based linking dialog box is to right-click on a Simulink block and, from the resulting pop-up menu, select **Requirements > Link settings**.

- From the drop-down list next to **Word**, select `requirements.doc`. Note that the **Browse** button to the right of it changes to **Open**. Click the **Open** button. The document `requirements.doc` opens in its editor, Microsoft Word.

Note If you click **Browse** with no document selected, the Requirement Management Interface lets you browse to the document of the appropriate type to open it.

You can now make links between the blocks in the `my_sf_car` model and portions of the `requirements.doc` document, as described in “Making Selection-Based Links” on page 2-22.

Specifying Your Linking Preferences

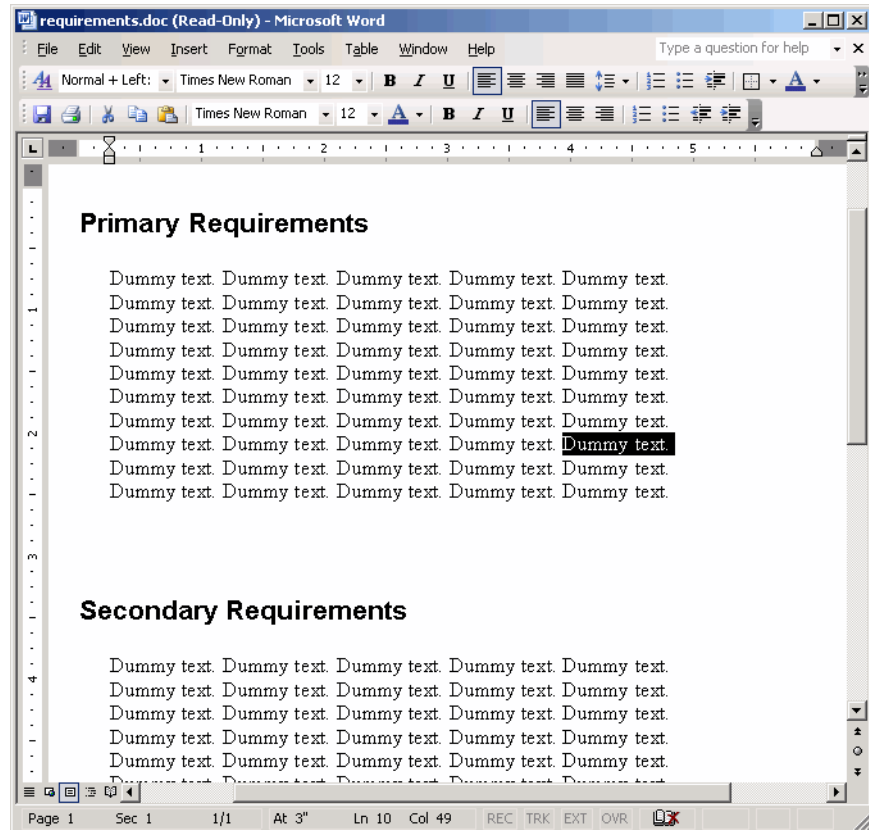
In selection-based linking, the process of making links is streamlined to minimize the number of menu clicks necessary to create a link. The Selection-based linking dialog box lets you specify your preferences:

- Two-way linking embeds an ActiveX control in your requirements document, which lets you navigate from the requirements document to the Simulink model. If you don't want to create two-way links, clear the **Modify documents to include links to models** check box.
- Use the **Document file reference** drop-down list to specify how to store the document location. For more information on the choices available, see “Resolving the Document Path” on page 2-15.
- If you create two-way links, use the **Model file reference** drop-down list to similarly specify how to resolve the model location when you navigate from a requirements document to the Simulink model.

Making Selection-Based Links

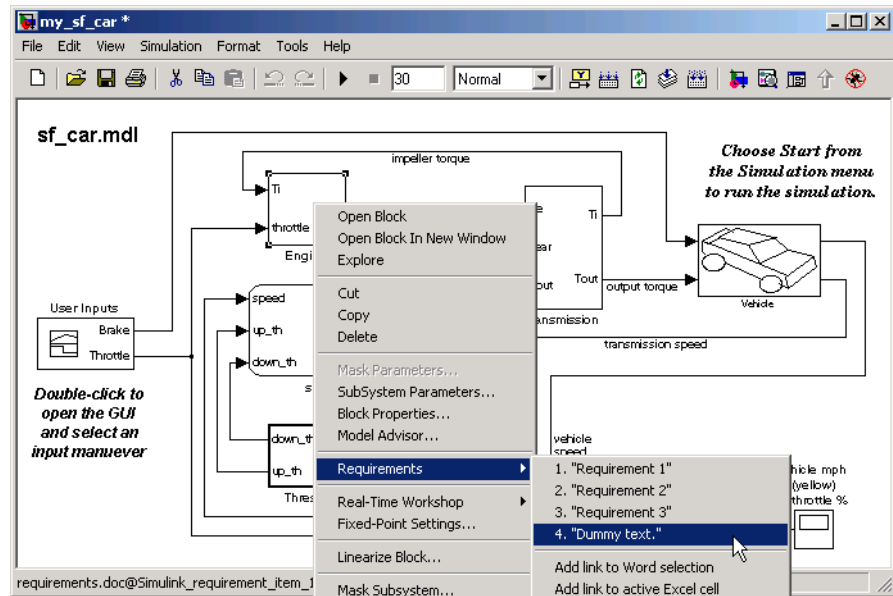
Use the following procedure to create selection-based requirement links:


- 1** Open the requirements.doc document, as described in “Opening the External Application” on page 2-20.
- 2** Select a portion of the text that documents the desired requirement. For example, select a “Dummy text.” string, as shown in the following illustration.

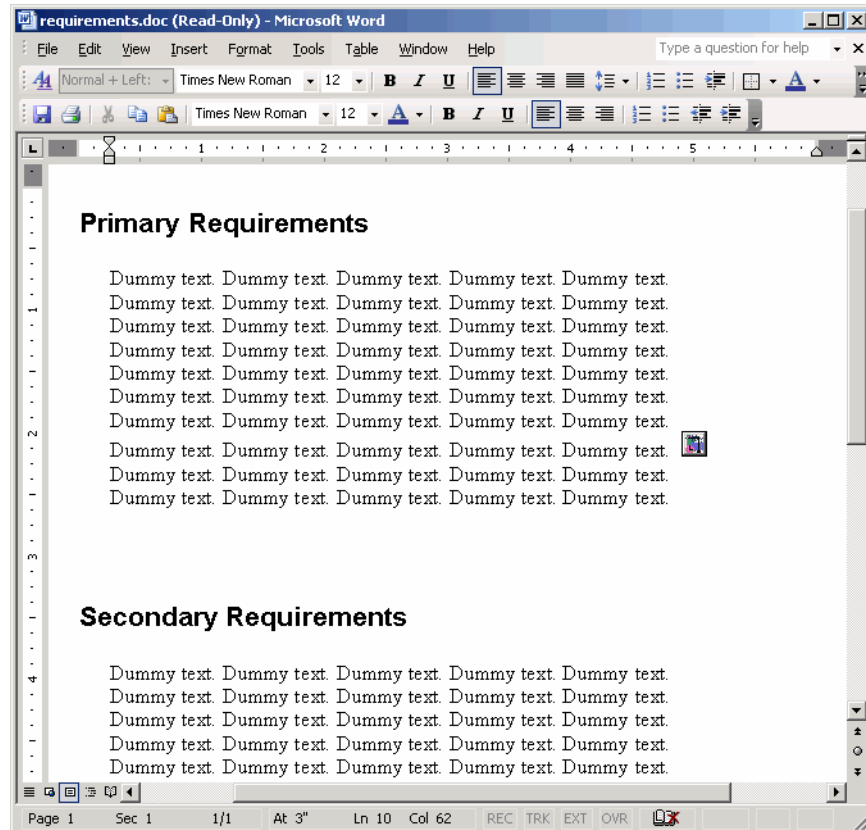


- 3 In the Simulink diagram, right-click the Engine block and, from the resulting pop-up menu, select **Requirements > Add link to Word selection**.

The Requirement Management Interface creates the link. If you right-click on the Engine block and select **Requirements**, the Engine block will now have four requirement links, as shown. You can use this link to navigate from the model to the requirements document, as described in “Viewing Requirements Documents” on page 2-13.



Because your linking preferences are set to two-way linking, an ActiveX control  is embedded in the requirements document next to the selected string, as shown in the next illustration. You can use it to navigate from the requirements document to the model, as described in “Navigating from the Requirements Document to the Simulink Model” on page 2-25.



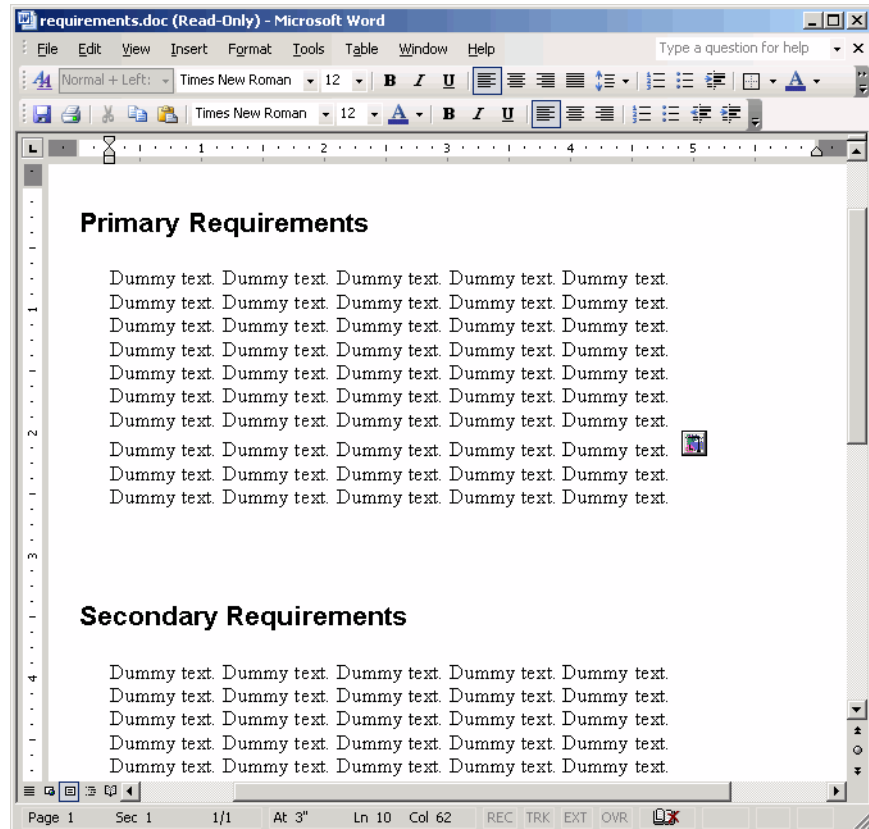
Note If you have the Requirements dialog box open, you can use the **Word** and **Excel** buttons next to the **Update fields with current selection in** label to create selection-based links to Microsoft Word or Microsoft Excel requirements documents, respectively.


Navigating from the Requirements Document to the Simulink Model

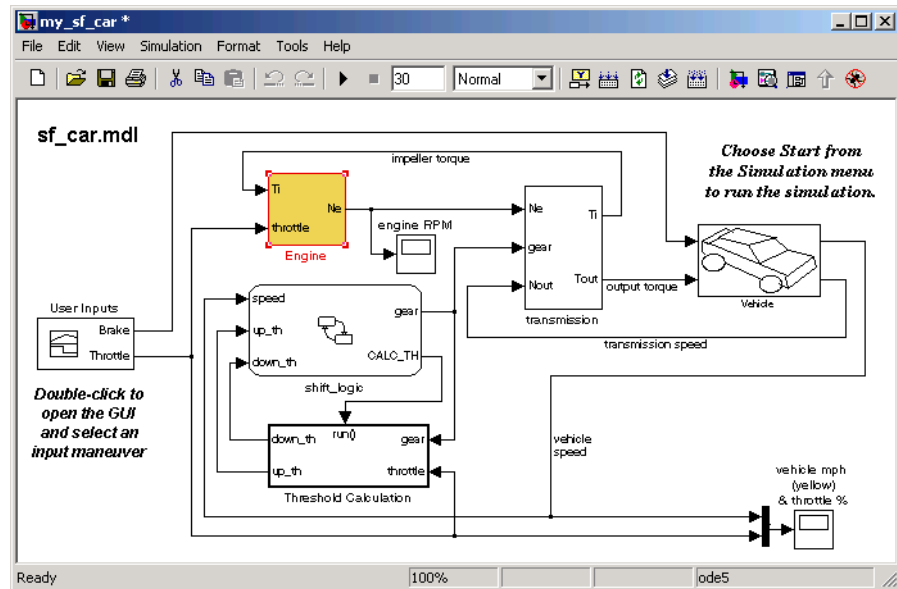
When you create two-way links, the Requirements Management Interface embeds an ActiveX control in your requirements document next to the

selected string or cell. This allows you to navigate from the requirements document to the Simulink model.

- 1 Open the requirements.doc document in Microsoft Word.



- 2 Click the ActiveX control  embedded in the requirements document.
- 3 The Requirements Management Interface opens the model my_sf_car and highlights the Engine block, as shown in the following illustration.



The requirement item that is linked with the ActivX control is identified internally with a special unique string that is saved in the model. If you rename the item or change the path, the links in the external document will continue to work.

Linking to Custom Types of Requirements Documents

In addition to linking to built-in types of requirements documents described above, you can register your own custom types of requirements documents with the Requirements Management Interface, and then create requirement links to these types of documents.

Why Create a Custom Link Type?

Custom link types let you define how a document will be opened and navigated, and how you or another user can browse for a document and view an index of its contents. When you define a custom link type, you create MATLAB M-code functions that perform these operations. The Requirements Management Interface invokes the registered code when navigating to a document with the new link type, and when browsing for a document or displaying the index of a document within the Requirements dialog box.

Using the external interfaces supported by MATLAB, you can communicate with external applications and run programs from the command shell. You can also use the built-in Web browser and text editor to display custom variants of HTML and text files without loading external applications.

Custom link types enable you to

- Link to requirement items in commercial requirement tracking software
- Link to in-house database systems
- Link to document types that are not internally supported in the tool

Custom Link Type Registration

You register custom link types with a unique MATLAB function name. The function must exist on the MATLAB path and must not require any input arguments. It must return a single output argument that is an instance of the requirements link type class. You can register your link type with the following MATLAB command:

```
rmi register mytargetfilename
```

where `mytargetfilename` is the name of the MATLAB function contained in the M-file named `mytargetfilename.m`.

Once you register a link type, it appears as an entry in the **Document type** drop-down list in the Requirements dialog box. The list of registered link types is stored in a file in your preference directory, so it can be restored in new MATLAB sessions. You can remove a link type with the following MATLAB command:

```
rmi unregister mytargetfilename
```

When you create links using custom link types, the registration name is saved in the model. When you attempt to navigate a link, the Requirements Management Interface resolves the link type against the registered list and displays an error message if the link type is not found.

Built-In Link Types

Built-in link types use the same format and naming convention as custom types, although they use a different system for identification in the model file that supports backwards and forwards compatibility. You can use the built-in types as examples when developing your custom link types. The files for built-in link types are contained in the private directory of the requirements management tool (`matlabroot\toolbox\simulink\reqmgt\private`):

```
linktype_rmi_doors.m  
linktype_rmi_excel.m  
linktype_rmi_html.m  
linktype_rmi_pdf.m  
linktype_rmi_text.m  
linktype_rmi_word.m
```

Link Properties

Requirement links are the data structures, saved in the Simulink model, that identify a specific location within a document. You can get and set the links on a block using the `rmi` command. Link information is encapsulated within a MATLAB structure array. Each element of the array is a single requirement link.

Links and link types work together to perform navigation and manage requirement interfaces. The document and ID fields of links uniquely identify the linked item in an external document. The Requirements Management Interface passes both of these string parameters to the navigation command of

the associated link type when it follows a link from the model or a generated report.

Link Type Properties

Link type properties define how links are created, identified, navigated and stored within the requirement management tool. The following table explains each of these properties.

Property	Description
Registration	The name of the M-file that creates the link type. This is stored in the Simulink model.
Label	A string to identify this link type. It is displayed on the Document Type drop-down list in the Requirements dialog box for a Simulink or Stateflow object.
IsFile	A Boolean property that indicates if the linked documents are files within the computer file system. If a document is a file, then the standard method for resolving the path is used and the standard file selection dialog is invoked when the user presses the Browse button in the Requirements dialog box.
Extensions	An array of file extensions. These are used as filter options for the Browse button in the Requirements dialog box. The extensions are also used to infer the link type based on the document name. If more than one link type is registered for the same file extension, the link type that was registered first will take priority.
LocDelimiters	A string containing the list of supported navigation delimiters. The first character in the ID of a requirement specifies the type of identifier. For example, an identifier might refer a specific page number (#4), a named bookmark (@my_tag), or some text to search (?search_text). The valid location delimiters determine the possible entries on the Location drop-down list in the Requirements dialog box.

Property	Description
NavigateFcn	The MATLAB callback that is invoked when a user follows a link. The function is evaluated with two input arguments, the document field and the ID field of the link: <code>feval(LinkType.NavigateFcn, Link.document, Link.id)</code>
ContentsFcn	The MATLAB callback that is invoked when a user presses Document Index tab in the Requirements dialog box. This function is evaluated with a single input argument containing the full path of the resolved function, or the entry from the Document field if the link type is not a file. The function should return three outputs: <ul style="list-style-type: none"> • Labels • Depths • Locations
BrowseFcn	The MATLAB callback that is invoked when a user presses the Browse button in the Requirements dialog box. This function is unnecessary when the link type is a file. The function should not take any input arguments and should return a single output argument identifying the document that the user selected.

Creating a Custom Link Requirement Type

In this example, you implement a custom link type to a hypothetical document format, which is a text file with the extension `.abc`. Within a document, the requirement items are identified with a special text string `Requirement::`, followed by a single space and then the requirement item inside double quotes (`"`).

You provide the ability to see a document index, containing a listing of all the requirement items. When navigating from the Simulink model to the requirements document, the document opens in the MATLAB editor and pans the display to the line containing the desired requirement item.

Use the following procedure to create a custom link requirement type:

- 1 Write a function that implements the custom link type and save it as an M-file on MATLAB path. In this example, the file `rmicustabcinterface.m`, containing the function `rmicustabcinterface` that implements the ABC files, is included in the installation. You can view it below, or by typing `edit rmicustabcinterface` at the MATLAB prompt.

```
function linkType = rmicustabcinterface
%RMICUSTABCINTERFACE - Example custom requirement link type
%
% This file implements a requirements link type that maps
% to "ABC" files.
% You can use this link type to map a line or item within an ABC
% file to a Simulink or Stateflow object.
%
% You must register a custom requirement link type before using it.
% Once registered, the link type will be reloaded in subsequent
% sessions until you unregister it. The following commands
% perform registration and registration removal.
%
% Register command:  >> rmi register rmicustabcinterface
% Unregister command: >> rmi unregister rmicustabcinterface
%
% There is an example document of this link type contained in the
% requirement demo directory to determine the path to the document
% invoke:
%
% >> which demo_req_1.abc

% Copyright 1984-2005 The MathWorks, Inc.
% $Revision: 1.1.4.2 $ $Date: 2005/04/07 20:00:10 $

% Create a default (blank) requirement link type
linkType = ReqMgr.LinkType;
linkType.Registration = mfilename;

% Label describing this link type
linkType.Label = 'ABC file (for demonstration)';

% File information
linkType.IsFile = 1;
```

```

linkType.Extensions = {'.abc'};

% Location delimiters
linkType.LocDelimiters = '>@';
linkType.Version = '';           % not needed

% Uncomment the functions that are implemented below
linkType.NavigateFcn = @NavigateFcn;
linkType.ContentsFcn = @ContentsFcn;

function NavigateFcn(filename,locationStr)
    if ~isempty(locationStr)
        findId=0;
        switch(locationStr(1))
            case '>'
                lineNum = str2num(locationStr(2:end));
                openFileToLine(filename, lineNum);
            case '@'
                openFileToItem(filename,locationStr(2:end));
            otherwise
                openFileToLine(filename, 1);
        end
    end

function openFileToLine(fileName, lineNum)
    if lineNum > 0
        err = javachk('mwt', 'The MATLAB Editor');
        if isempty(err)
            editor = com.mathworks.mlservices.MLEditorServices;
            editor.openDocumentToLine(fileName, lineNum);
        end
    else
        edit(fileName);
    end

function openFileToItem(fileName, itemName)
    reqStr = ['Requirement:: "' itemName '"'];

```

```
lineNum = 0;
fid = fopen(fileName);
i = 1;
while lineNum == 0
    lineStr = fgetl(fid);
    if ~isempty(strfind(lineStr, reqStr))
        lineNum = i;
    end;
    if ~ischar(lineStr), break, end;
    i = i + 1;
end;
fclose(fid);
openFileToLine(fileName, lineNum);
```

```
function [labels, depths, locations] = ContentsFcn(filePath)
% Read the entire M-file into a variable
fid = fopen(filePath,'r');
contents = char(fread(fid)');
fclose(fid);

% Find all the requirement items
fList1 = regexpi(contents,'\nRequirement:: "(.*?)"', 'tokens');

% Combine and sort the list
items = [fList1{:}]';
items = sort(items);
items = strcat('@',items);

if (~iscell(items) && length(items)>0)
    locations = {items};
    labels = {items};
else
    locations = [items];
    labels = [items];
end

depths = [];
```


- 2 To register the custom link type ABC, type the following MATLAB command:

```
rmi register rmicustabcinterface
```

This will cause the ABC file type to be added to the drop-down list of document types in the Requirements dialog box.

- 3 Create a text file with the .abc extension, containing several requirement items marked by the Requirement:: string, as described above. For your convenience, an example of such a file is included in the installation. It is named demo_req_1.abc, and is located in matlabroot\toolbox\simulink\reqmgt\rmidemos. The contents of this file is displayed below.

```
Requirement:: "Altitude Climb Control"
```

```
Altitude climb control is entered whenever:  
|Actual Altitude- Desired Altitude | > 1500
```

```
Units:  
Actual Altitude - feet  
Desired Altitude - feet
```

```
Description:
```

```
When the autopilot is in altitude climb  
control mode, the controller maintains a  
constant user-selectable target climb rate.
```

```
The user-selectable climb rate is always a  
positive number if the current altitude is  
above the target altitude. The actual target  
climb rate is the negative of the user  
setting.
```

```
<END "Altitude Climb Control">
```

Requirement:: "Altitude Hold"

Altitude hold mode is entered whenever:

$| \text{Actual Altitude} - \text{Desired Altitude} | <$
 $30 * \text{Sample Period} * (\text{Pilot Climb Rate} / 60)$

Units:

Actual Altitude - feet

Desired Altitude - feet

Sample Period - seconds

Pilot Climb Rate - feet/minute

Description:

The transition from climb mode to altitude hold is based on a threshold that is proportional to the Pilot Climb Rate.

At higher climb rates the transition occurs sooner to prevent excessive overshoot.

<END "Altitude Hold">

Requirement:: "Autopilot Disable"

Altitude hold control and altitude climb control are disabled when autopilot enable is false.

Description:

Both control modes of the autopilot can be disabled with a pilot setting.

<END "Autopilot Disable">

Requirement:: "Glide Slope Armed"

Glide Slope Control is armed when Glide Slope Enable and Glide Slope Signal are both true.

Units:

Glide Slope Enable - Logical

Glide Slope Signal - Logical

Description:

ILS Glide Slope Control of altitude is only enabled when the pilot has enabled this mode and the Glide Slope Signal is true. This indicates the Glide Slope broadcast signal has been validated by the on board receiver.

<END "Glide Slope Armed">

Requirement:: "Glide Slope Coupled"

Glide Slope control becomes coupled when the control is armed and (Glide Slope Angle Error > 0) and Distance < 10000

Units:

Glide Slope Angle Error - Logical

Distance - feet

Description:

When the autopilot is in altitude climb control mode the controller maintains a constant user selectable target climb rate.

The user-selectable climb rate is always a positive number if the current altitude is above the target

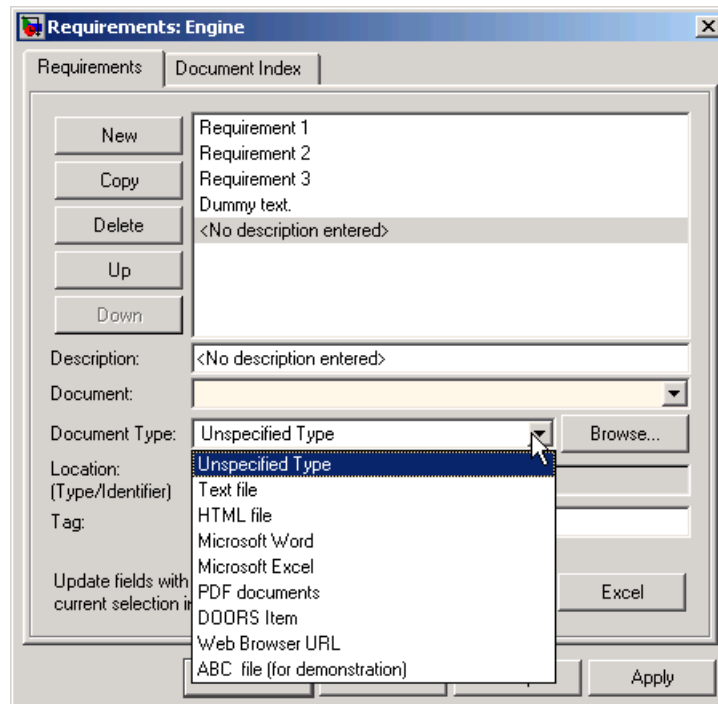
```
altitude the actual target climb rate is the  
negative of the user setting.
```

```
<END "Glide Slope Coupled">
```

- 4 Open the model `my_sf_car`.
- 5 Right-click the Engine block and, from the resulting pop-up menu, select **Requirements > Edit/Add Links**.

The Requirements dialog box appears.

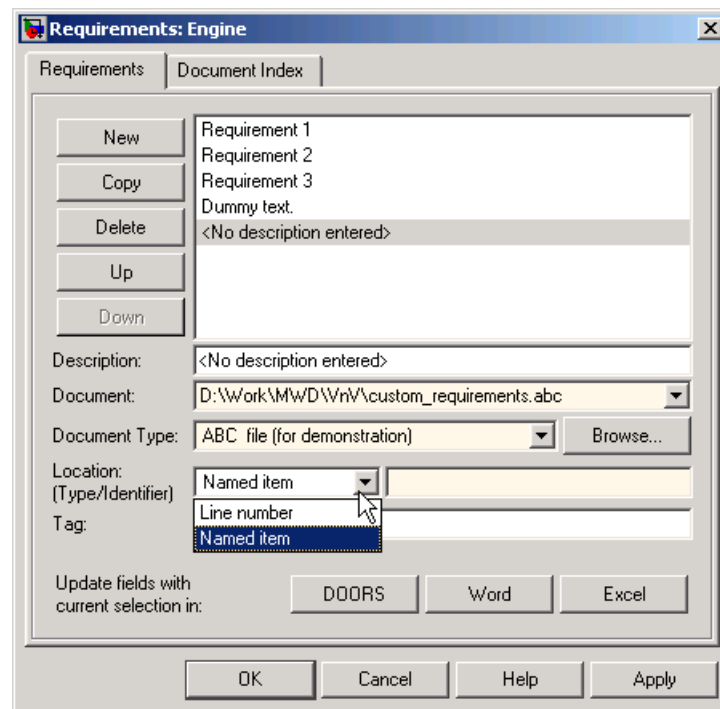
- 6 Click **New** to add a new default requirement. Note that ABC file type is now available in the **Document Type** drop-down list, as shown.



- 7 Set **Document Type** to ABC file (for demonstration) and browse to the `demo_req_1.abc` file, or to your own `.abc` requirements file that you

created in Step 3. Note that the browser shows only the files with the .abc extension.

- 8 Define a particular location in the document. In this example, you can either use a line number or a requirement name as the item identifier, so the location delimiters in the `rmicustabcinterface` function are specified as `'>@'`. As a result of this parameter, the **Location** drop-down menu contains these two items whenever the document type is set to ABC file, as shown.



Creating a Document Index

The example file format clearly defines requirement items that are easily listed. To generate a document index, set the `ContentsFcn` to a valid function. The MATLAB code uses file I/O to read the contents into the MATLAB variable. The Requirements Management Interface uses the regular

expression utility in MATLAB to extract a list of requirement items that it returns.

The following code generates an index for the ABC files.

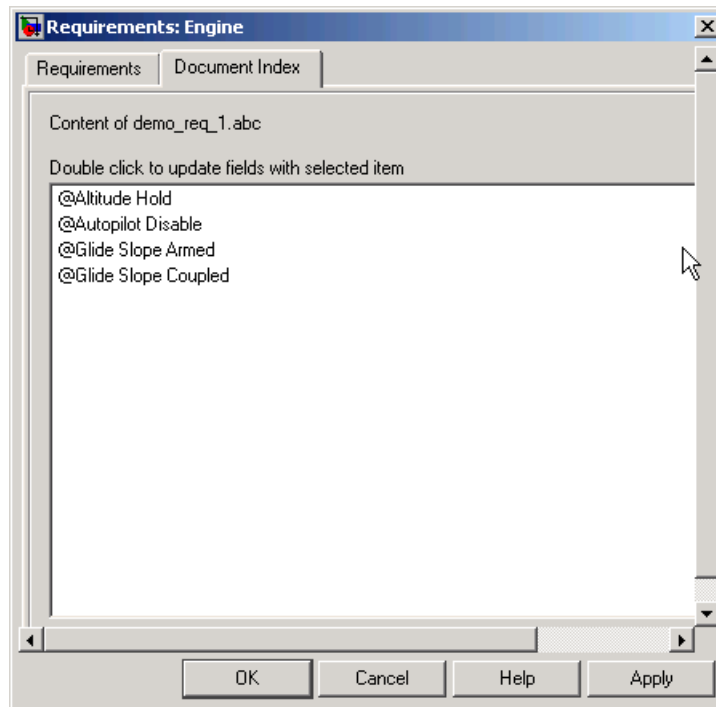
```
function [labels, depths, locations] = ContentsFcn(filePath)
    % Read the entire M-file into a variable
    fid = fopen(filePath,'r');
    contents = char(fread(fid)');
    fclose(fid);

    % Find all the functions
    fList1 = regexpi(contents,'\nRequirement:: "(.*?)"', 'tokens');

    % Combine and sort the list
    items = [fList1{:}]';
    items = sort(items);
    items = strcat('@',items);

    locations = [items];
    labels = [items];
    depths = [];
```

For example, for the `demo_req_1.abc` file discussed earlier in “Creating a Custom Link Requirement Type” on page 2-31, this function generates the document index as shown in the following illustration.



Navigating to Simulink from External Documents

The Requirements Management Interface includes several functions that simplify creating navigation interfaces in external documents. The external application that displays your document must support an application program interface (API) for communicating with MATLAB.

Providing Unique Object Identifiers

Whenever you create a requirement link for an object in Simulink or Stateflow, a globally unique identifier is created for that object. This identifier is used to identify the object and will not change if the object is renamed or moved or when requirement links are added or deleted. Although the unique identifier is only used to resolve an object within a model, the identifier is globally unique and should not collide with identifiers in other models unless the two models derive from the same original model. Unique object identifiers have formats like GIDa_cd14afcd_7640_4ff8_9ca6_14904bdf2f0f.

Using the `rmiobjnavigate` Utility

The `rmiobjnavigate` function performs the required actions to identify the appropriate Simulink or Stateflow object, highlight that object, and bring the appropriate editor window to the front of the screen. When you navigate to Simulink from an external application, invoke this command. Internally this function creates a table of all the unique object identifiers within a model, which is used for efficient object lookup.

The first time you navigate to an item in a particular model, there may be a slight delay while the internal navigation table is constructed. Subsequent navigation should have minimal delay.

Determining the Navigation Command

Once you have created a requirement link for a Simulink or Stateflow object, you can find the appropriate navigation command string using the `rmi` function in MATLAB. The return value of the `navCmd` method is a string that navigates to the correct object when evaluated in MATLAB:

```
cmdString = rmi('navCmd', block);
```

You need to send this exact string to MATLAB for evaluation as part of navigating from the external application to Simulink.

Using the ActiveX Navigation Control

A special ActiveX control is included with Simulink Verification and Validation and is used to enable linking to Simulink models from Microsoft Word and Microsoft Excel documents. You can use this same control from any other application that supports ActiveX within its documents.

The control is derived from a pushbutton and has the Simulink icon. There are two instance properties that define how the control works. The `tooltipstring` property is the string that is displayed in the ToolTip of the control. The `MLEvalCmd` property is the string that is passed to MATLAB for evaluation when the control is pushed.

Typical Code Sequence for Establishing Two-Way Links

When you create an interface to an external tool, the procedure for establishing links can often be automated so that no dialog fields need to be manually updated. This type of automation is part of the selection-based linking that is implemented for certain built-in types, such as Microsoft Word and Microsoft Excel.

In generic terms, use the following process:

- 1** Select an object in Simulink or Stateflow and an item in the external document.
- 2** Invoke the link creation action either from a menu or command in Simulink, or a similar mechanism in the external application.
- 3** Identify the document and current item using the scripting capability of the external tool. Pass this information to MATLAB and create a requirement link on the selected object using `rmi('createempty')` and `rmi('cat')`.
- 4** Determine the MATLAB navigation command string that must be embedded in the external tool using the `navCmd` method:

```
cmdString = rmi('navCmd',obj)
```
- 5** Create a navigation item in the external document using the scripting capability of the external tool and set the MATLAB navigation command string in the appropriate property.

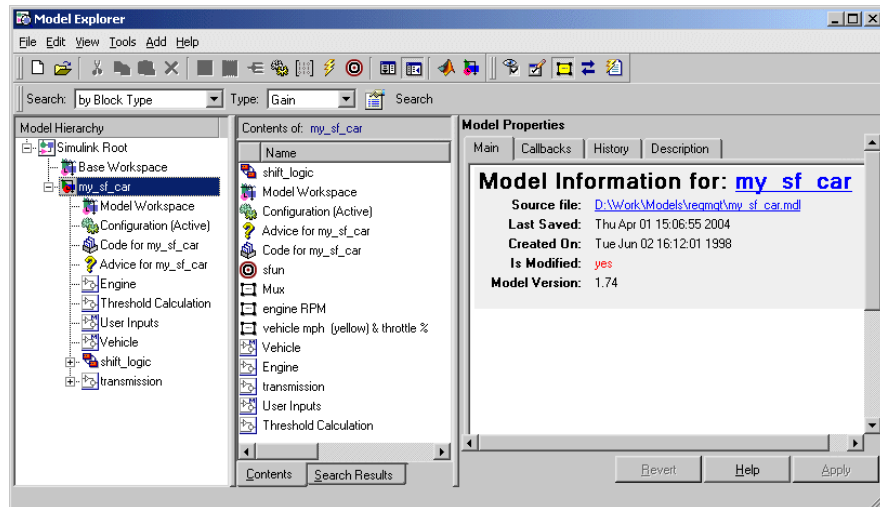
You can use the code for selection-based linking to Word, Excel, and DOORS as an example of this type of automation. The files are contained in `matlabroot\toolbox\simulink\reqmgt\private`:


```
selection_link_doors.m
selection_link_excel.m
selection_link_word.m
```

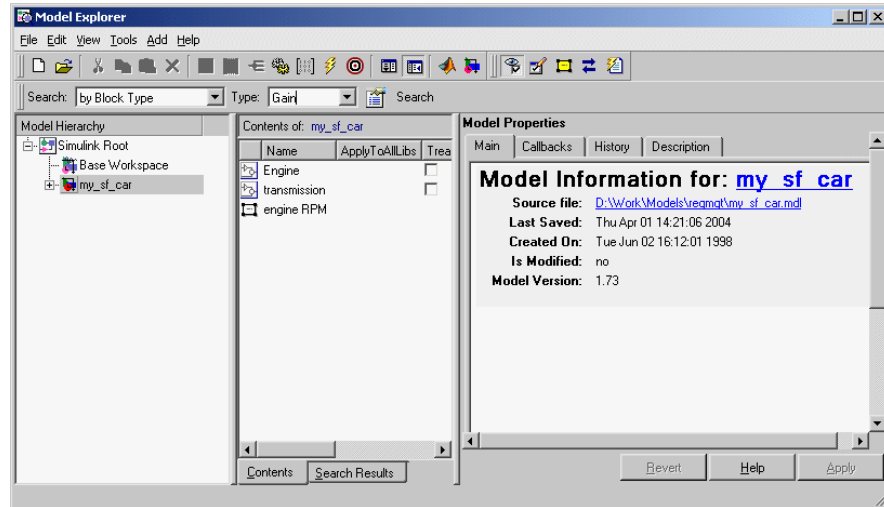
Viewing Objects with Requirement Links

After you have added requirements to blocks in a model, you can change the view in the Model Explorer window to show only objects that have requirements associated with them. In “Adding Requirement Links to an Object” on page 2-8 and “Adding Requirement Links to Multiple Objects Simultaneously” on page 2-17, you add requirements to the Engine, Engine RPM, and transmission blocks in the model you save as `my_sf_car`. Use the following procedure to highlight these objects in the Model Explorer and Simulink:

- 1 Open the model `my_sf_car`.
- 2 In Simulink, from the **View** menu, select **Model Explorer**.
- 3 The model and its elements appear in the Model Explorer window as shown.




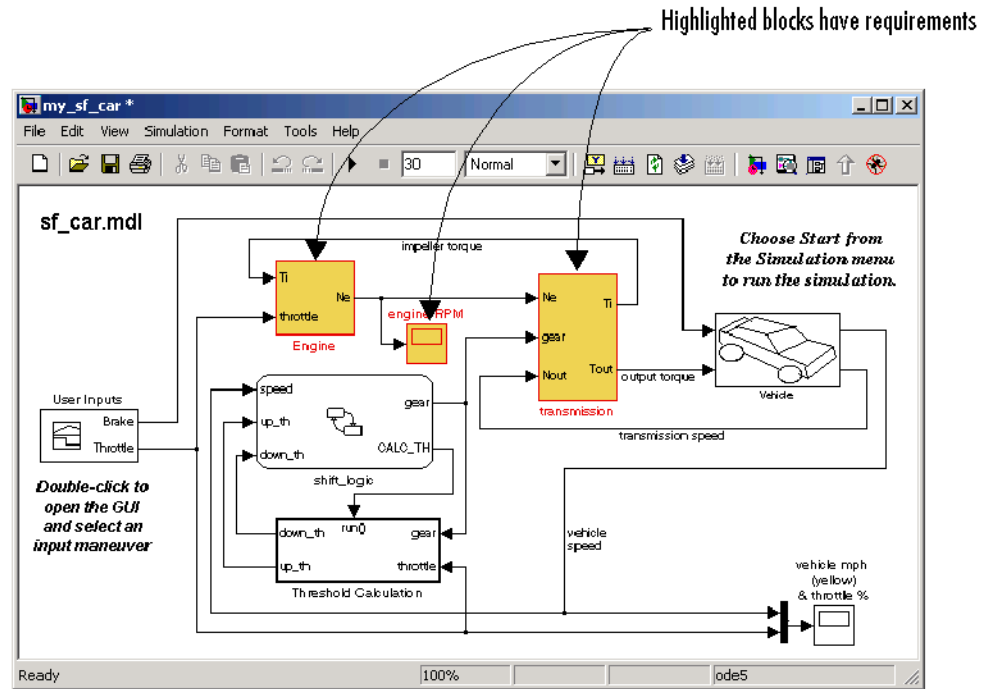
- 4 In the **Model Explorer** toolbar, select the Display Objects with Linked Requirements tool .



- 5 To see all objects, click the Display Objects with Linked Requirements tool again to deselect it.

You can also highlight blocks of a Simulink model with associated requirements in a Simulink model window as follows:

- 1 In the **Model Explorer** toolbar, select the Highlight Items with Requirements in Model tool .



- 2 To drop the highlighting, click the Highlight Items with Requirements in Model tool again to deselect it.

Generating a Requirements Report

After you have added requirements to a model, you can generate a report on all the requirements associated with the model and its blocks. In “Adding Requirement Links to an Object” on page 2-8 and “Adding Requirement Links to Multiple Objects Simultaneously” on page 2-17, you add requirements to the Engine, Engine RPM, and transmission blocks in the model you save as `my_sf_car`. Use the following procedure to generate a requirements report:

- 1 Open the model `my_sf_car`.
- 2 In Simulink, from the **Tools** menu, select **Requirements > Generate Report**.

The Requirements Management Interface searches through all the blocks and subsystems in the model for associated requirements, generates a complete report in HTML format with the default name `rmi.html`, and displays it in your system Web browser, as shown.

Model Requirements - Microsoft Internet Explorer

File Edit View Favorites Tools Help

Address <D:\Work\MWD\Wm\ymi.html>

Links Customize Links FAQ Page Free Hotmail Help Page

Model Requirements

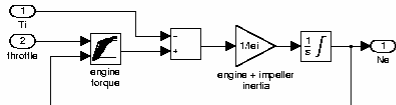
jsmith

17-Feb-2005 15:14:53

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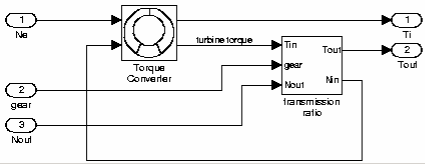
[1. System - Engine](#)
[2. System - transmission](#)
[3. Block - engine RPM](#)

Chapter 1. System - Engine



Description	Document	ID
Requirement 1	requirements.doc	Primary Requirements
Requirement 2	requirements.doc	Secondary Requirements
Requirement 3	requirements.doc	Tertiary Requirements

Chapter 2. System - transmission



- To save the report with a meaningful name, in the Web browser main menu click **File > Save As**, type the desired filename, and click **Save**.

Displaying the System Requirements in a Diagram

You can list all the requirements for a model or a subsystem directly on the Simulink diagram. You do this by adding the System Requirements block from the Simulink Verification and Validation library to the diagram. You can place this block anywhere in a diagram. It is not connected to other Simulink blocks.

Once you place the System Requirements block in a Simulink diagram, it automatically lists the requirements associated with the model or subsystem depicted in the current diagram. It does not list requirements associated with individual blocks in the diagram.

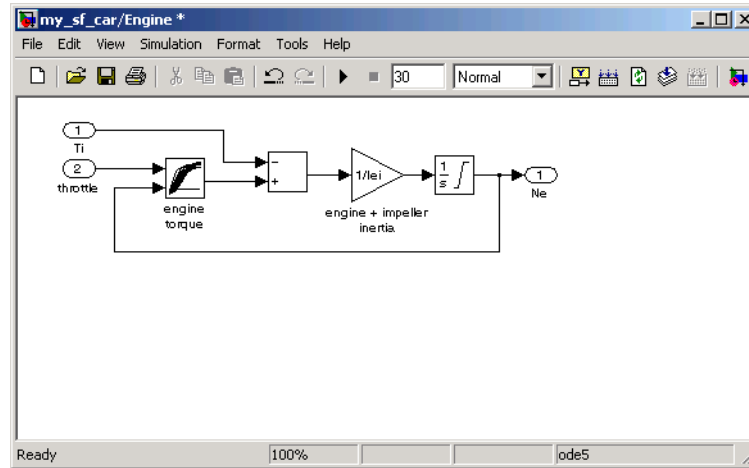
The following topics show you how use the System Requirements block:


- “Adding the System Requirements Block” on page 2-49 — Describes how to display a listing of system requirements in a diagram by adding the System Requirements block
- “Renaming the System Requirements Block” on page 2-52 — Describes how to change the heading of the listing of system requirements in a diagram
- “Changing Fonts for the System Requirements Block” on page 2-53 — Describes how to change the font size or style for the listing of system requirements in a diagram

Adding the System Requirements Block

In “Adding Requirement Links to an Object” on page 2-8, you added requirement links to the Engine block of the model `my_sf_car`. You can list these requirements in the block diagram of the Engine subsystem as follows:

- 1 Open the model `my_sf_car`.
- 2 Double-click on the Engine block. The Engine subsystem diagram opens, as shown.



- 3 Click the Library Browser tool .

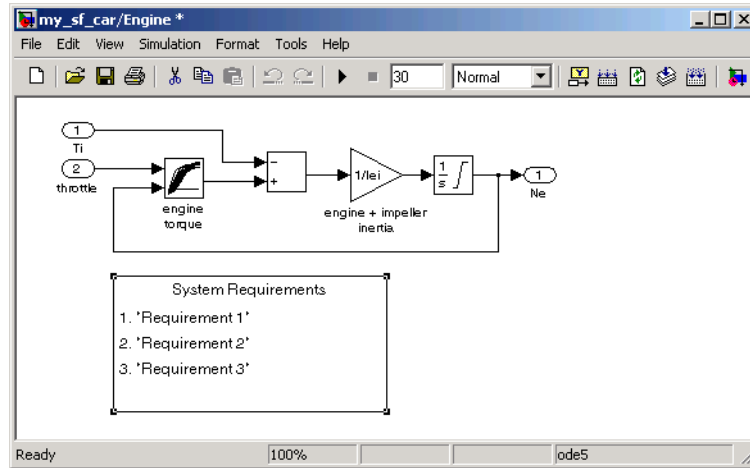
The Simulink Library browser opens.

- 4 In the left pane of the Simulink Library browser, select **Simulink Verification and Validation**.

The Simulink Verification and Validation library opens in the right pane of the Simulink Library browser. It contains one block, System Requirements.

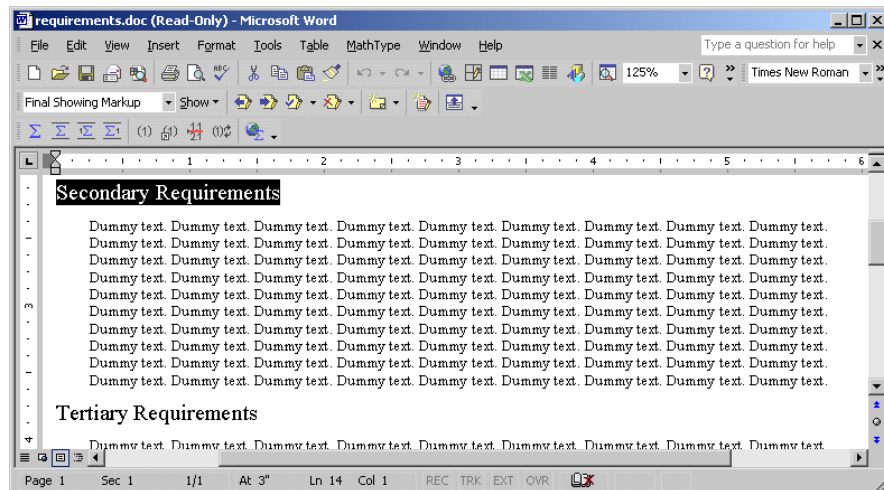
- 5 Select the System Requirements block in the right pane of the Simulink Library browser and drag it to an empty space in the Engine diagram.

The block is automatically populated with the system requirements for the Engine diagram, as shown.



- 6 Each of the listed requirements is an active link to the actual requirements document. For example, to access the document for the second requirement link, double-click on 2. Requirement 2.

The document requirements.doc opens in its editor, Microsoft Word, scrolled to the highlighted first occurrence of the text “Secondary Requirements,” as shown.



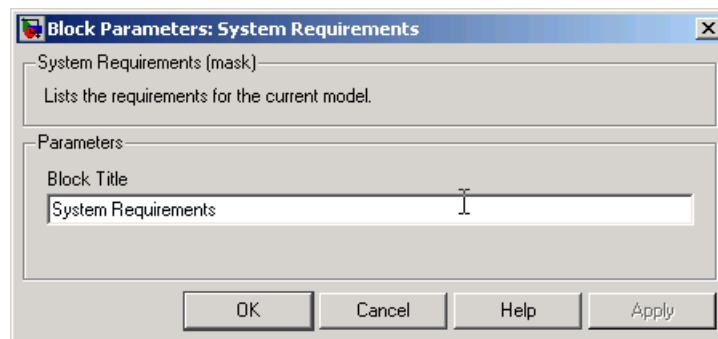
Once the System Requirements block is placed in a diagram, it automatically updates the listing as you add, modify, or delete requirements for the model or subsystem.

Note The System Requirements block automatically lists all the system requirements for the current model or subsystem. You cannot have more than one System Requirements block in a diagram.

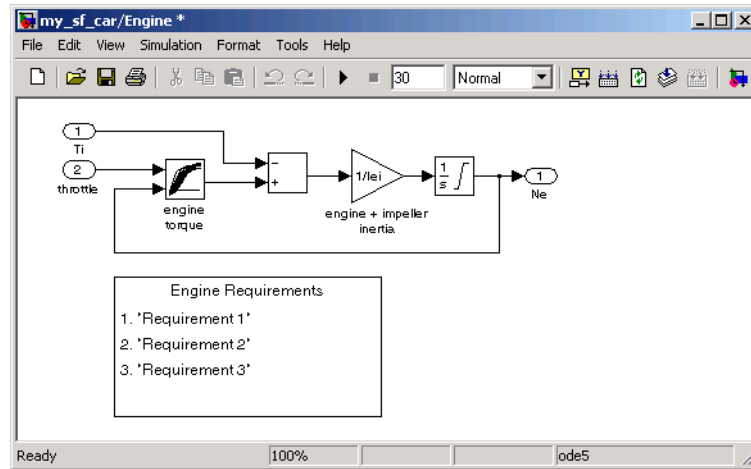
Renaming the System Requirements Block

By default, the list of the system requirements in a diagram appears under a heading System Requirements. You can change the heading by renaming the System Requirements block in the diagram, as follows:

- 1 Right-click on the System Requirements block in the my_sf_car/Engine diagram.
- 2 From the resulting pop-up menu, select **Mask Parameters**. The Block Parameters dialog box opens, as shown.



- 3 Type Engine Requirements in the **Block Title** field and click **OK**.
The requirements heading in the diagram is updated as shown.

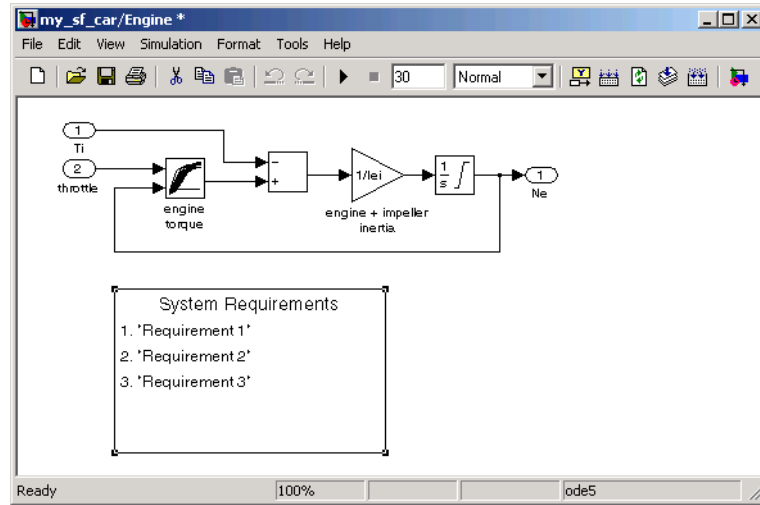


Changing Fonts for the System Requirements Block

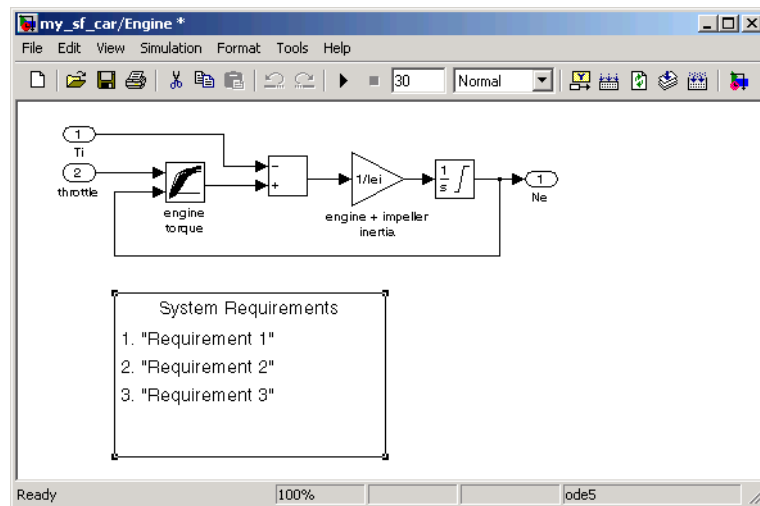
The System Requirements block is implemented using a set of empty subsystems. Because of this, occasionally the appearance is not refreshed correctly, for example, when you make a change to the font style or size. You can easily fix this problem by double-clicking the top label for the block, which causes the entire block display to refresh.

Use the following procedure to change the font used in the block.

- 1** Right-click on the System Requirements block in the my_sf_car/Engine diagram.
- 2** From the resulting pop-up menu, select **Format > Font**. The Set Font dialog box opens.
- 3** Under **Size**, select 14, then click **OK**. The block display partially refreshes, as shown.



- 4 To refresh the entire block display, double-click the top label, System Requirements. The block diagram now looks as shown below.



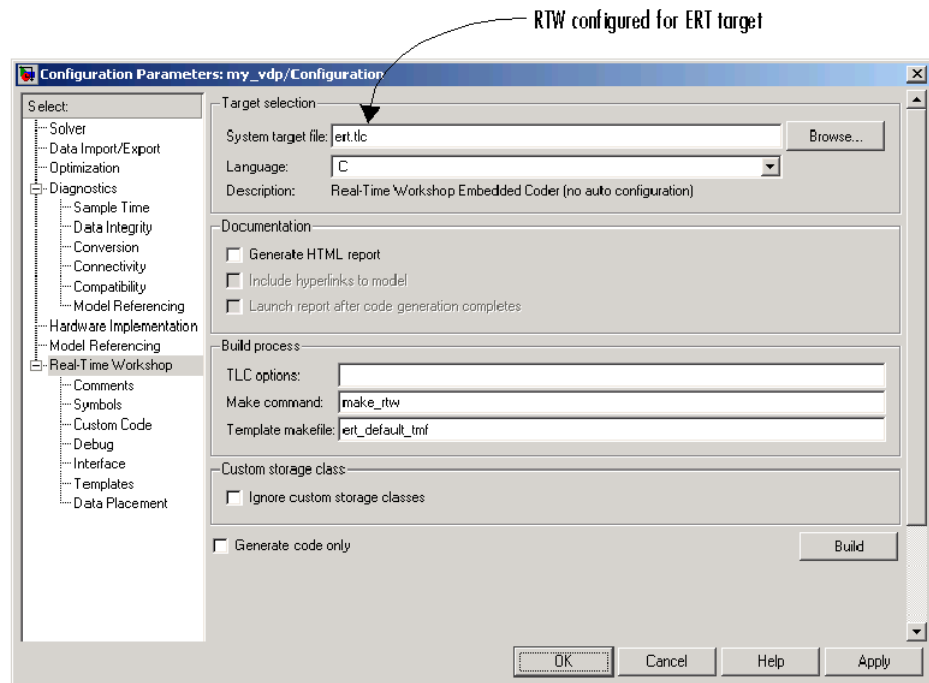
Including Requirements with Generated Code

Once you finish simulating your model and verifying its performance against the requirements, you might want to use it to generate code for an embedded real-time application. Simulink includes the requirements that you assign to Simulink blocks in generated code for Embedded Real-Time (ERT) targets of Real-Time Workshop® Embedded Coder.

To specify that requirements be included in the generated code of an ERT target, do the following:

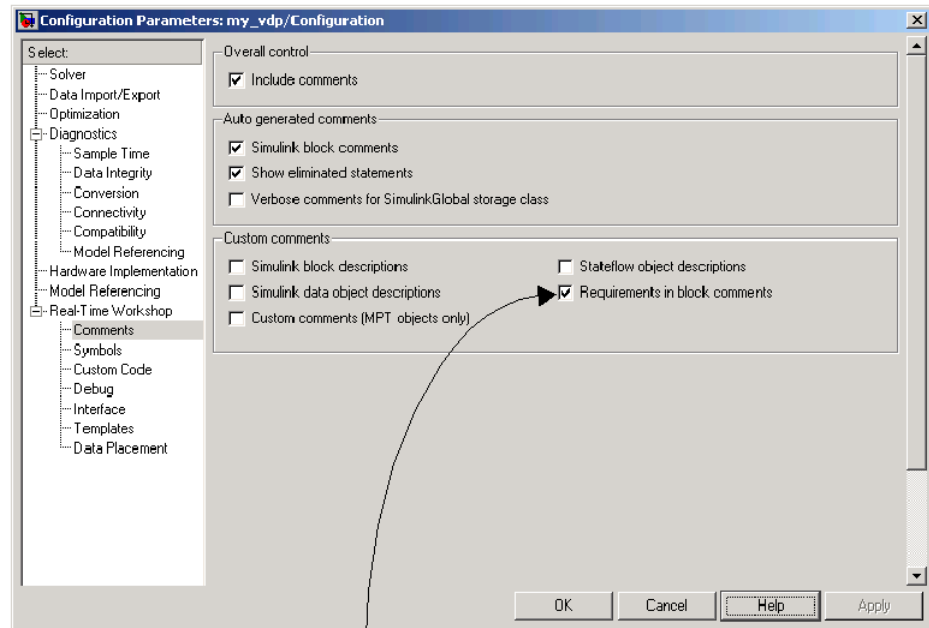
- 1** Load the model.
- 2** In the Simulink window, from the **Simulation** menu item, select **Configuration Parameters**.
- 3** In the **Select** pane of the Configuration Parameters dialog box, select the Real-Time Workshop node.

The currently configured system target must be an ERT target, as shown.



4 In the **Select** pane, under **Real-Time Workshop**, select **Comments**.

5 In the **Custom comments** section on the right, select **Requirements in block comments**, as shown.



Include requirements descriptions
in generated code comments

Requirement descriptions are included with generated code in the following locations.

Model Element	Requirement Description Location
Model	In the main header file <model>.h
Nonvirtual subsystems	At the call site for the subsystem
Virtual subsystems	At the call site of the closest nonvirtual parent subsystem. If a virtual subsystem has no nonvirtual parent, requirement descriptions are located in the main header file for the model, <model>.h.
Nonsubsystem blocks	In the generated code for the block

Managing Model Requirements with DOORS

The Requirements Management Interface for DOORS associates DOORS requirements with model objects. To learn how to use these applications together, see the following sections:

“What Is the Requirements Management Interface for DOORS?” (p. 3-2)

Shows how the Requirements Management Interface associates objects with DOORS requirements

“Configuring the Requirements Management Interface for DOORS” (p. 3-3)

Specifies additional files from MATLAB that you need to copy into your installation for DOORS

“Starting the Requirements Management Interface for DOORS” (p. 3-5)

Describes how to start the Requirements Management Interface for DOORS and create projects

“Linking Objects to DOORS Requirements” (p. 3-7)

Describes how to add two-way links between Simulink or Stateflow objects and DOORS requirements

“Synchronizing DOORS with the Simulink Model” (p. 3-12)

Describes how to synchronize the model and link synchronized objects with DOORS requirements

“Navigating Between Model Objects and DOORS” (p. 3-24)

Describes how to move between the model and the DOORS synchronized module, and how to view the nodes in an object that have associated requirements

What Is the Requirements Management Interface for DOORS?

DOORS is a requirements management application that captures, tracks, and manages user requirements. The Requirements Management Interface for DOORS is a special interface between your Simulink model and DOORS.

Configuring the Requirements Management Interface for DOORS

DOORS is a requirements management application for capturing, tracking, and managing requirements. If you plan to use DOORS with the Requirements Management Interface for DOORS, you must install some additional files to establish communication between DOORS and the Requirements Management Interface for DOORS:

- If DOORS is installed at the time you install the Requirements Management Interface and run the setup script, as described in “Configuring the Requirements Management Interface” on page 2-4, no additional installation for DOORS is necessary. The setup script automatically copies all the necessary files to the correct location.
- If you install DOORS after you install the Requirements Management Interface, or if you upgrade the DOORS installation at a later date, run the setup script again. To do this, in the MATLAB Command Window type

```
rmi setup
```

Manual Installation for DOORS

Normally, the setup script automatically copies all the files to the correct location. However, in some cases the script might fail because of file permissions in your DOORS installation. If this happens, you have to manually install additional files, as described in the following procedure:

- 1 If DOORS is running, close DOORS.
- 2 Copy the following files from `matlabroot\toolbox\simulink\reqmgt` to the `<doors>\lib\dx1\addins` directory:

```
addins.idx  
addins.hlp
```

`<doors>` represents the top-level directory where DOORS is installed. Replace any existing versions of the files if they have not been modified; otherwise, merge their contents.

- 3 Copy the following files from `matlabroot\toolbox\simulink\reqmgt` to the `<doors>\lib\dxl\addins\dmi` directory.

```
dmi.hlp  
dmi.idx  
dmi.inc  
runsim.dxl  
selblk.dxl
```

Replace any existing versions of these files.

- 4 Open the file `<doors>\lib\dxl\startup.dxl`, and add the following `include` statement in the user-defined files section:

```
#include <addins/dmi/dmi.inc>
```

Starting the Requirements Management Interface for DOORS

Use this procedure to start the Requirements Management Interface for DOORS. Do this prior to synchronizing the model with DOORS and linking objects to DOORS requirements.

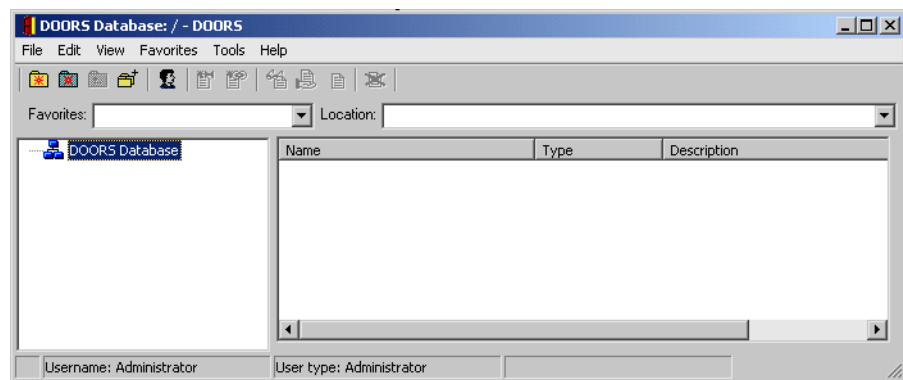
- 1 Start MATLAB in DOS or UNIX with the following command:

```
\\...\\matlab.exe /automation
```

MATLAB starts up minimized with a default `matlabroot\bin` path. This mode of operation is necessary to navigate between an object mapping in DOORS and its source object in the Simulink model. If this type of navigation is not needed, open MATLAB in default mode.

- 2 Start DOORS.

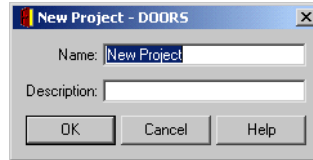
The DOORS Database window appears, as shown.



You must have a project open in DOORS in order to use the MATLAB Requirements Management Interface. If you do not have a project to open, create and open one as follows:

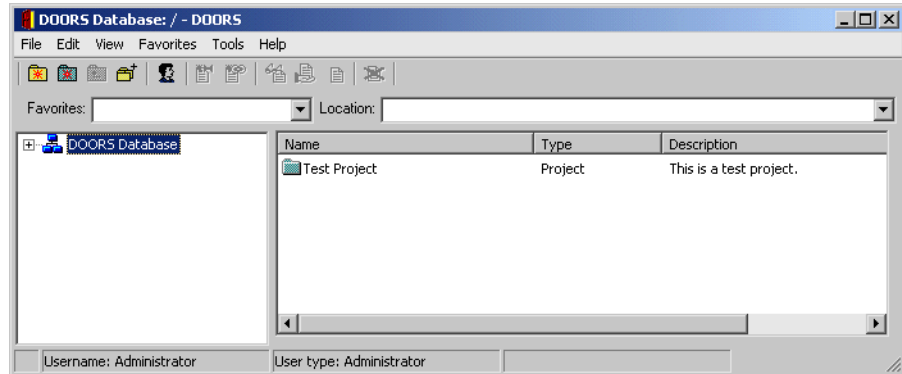
- 1 Right-click the DOORS Database node in the left pane and, from the resulting menu, select **New > Project**.

The New Project dialog box appears, as shown.

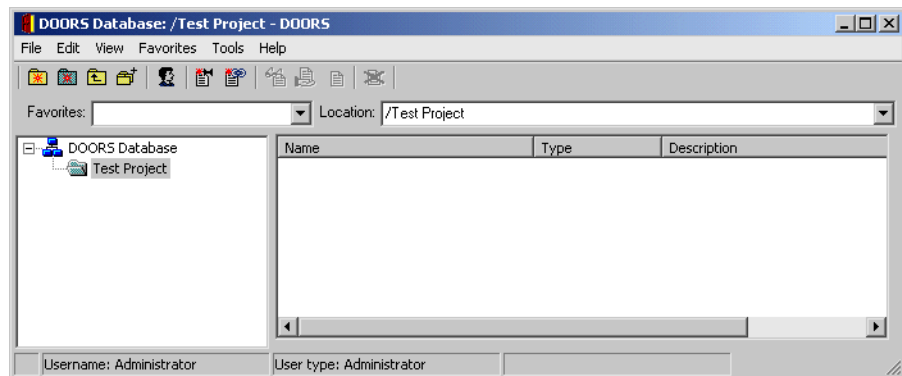


- 2 Enter the name Test Project and the description This is a test project. and click **OK**.

The new project appears in the right pane of the dialog box, as shown.



- 3 In the right pane, double-click the project to open it. The projects opens, as shown.



Linking Objects to DOORS Requirements

The Requirements Management Interface for DOORS lets you add links to DOORS requirements directly to the Simulink or Stateflow objects, without having to synchronize the model and navigate to the surrogate DOORS module. This linking mechanism is similar to selection-based linking to Microsoft Word and Microsoft Excel documents, described in “Selection-Based Linking” on page 2-20. It also creates two-way links by creating a special navigation object in DOORS, which allows you to navigate from the DOORS requirement to the associated object in the Simulink or Stateflow diagram.

The following topics describe how to link a Simulink or Stateflow object to a DOORS requirement:

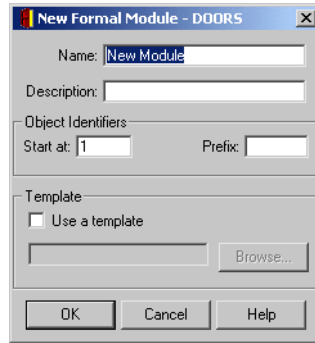
- “Creating a DOORS Requirement Object” on page 3-7 — If you are not familiar with DOORS, use this procedure to create requirement items in a formal module.
- “Linking a Simulink or Stateflow Object to a DOORS Requirement” on page 3-9 — Use this procedure to link an object to a DOORS requirement.

Creating a DOORS Requirement Object

Use the following procedure to create a DOORS requirement object in a formal module.

- 1 In the main DOORS window, from the **File** menu, select **New > Formal Module** to create a new formal module.

The New Formal Module dialog box appears, as shown.

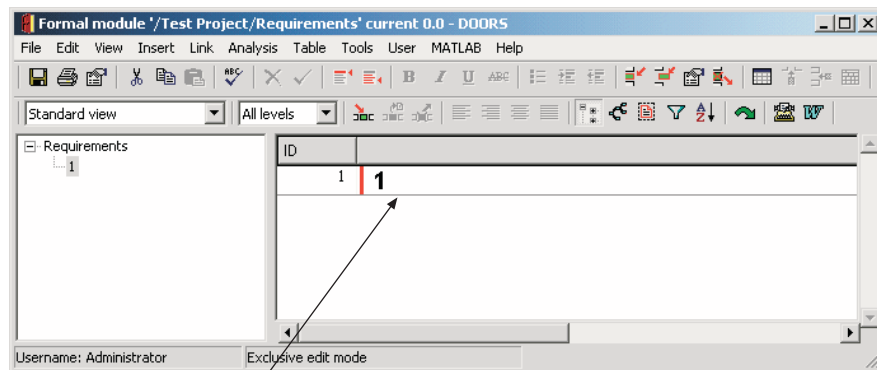


- 2 In the **Name** text field, enter the name Requirements and click **OK**.

The new formal module Requirements appears listed in the DOORS main window. A window for Requirements is already open, but not in focus.

- 3 In the main DOORS window, double-click the Requirements module to bring it in focus.
- 4 In the formal module window Requirements, from the **Insert** menu select **Object**.

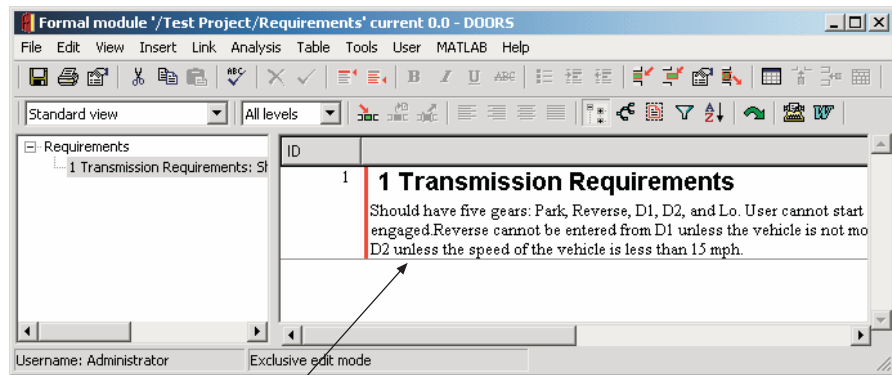
A new object appears in the formal module, as shown.



New object in Requirements module

- 5 Right-click the object in the right pane and, from the resulting context menu, select **Properties**.
- 6 In the resulting Object properties dialog box, enter the **Heading** Transmission Requirements, some text for **Object Text**, and select **OK**.

You should now see an object similar to the following in the Requirements formal module.

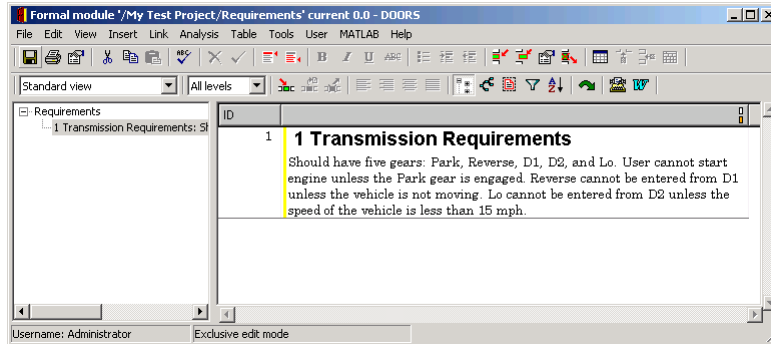


Specified object in Requirements module

Linking a Simulink or Stateflow Object to a DOORS Requirement

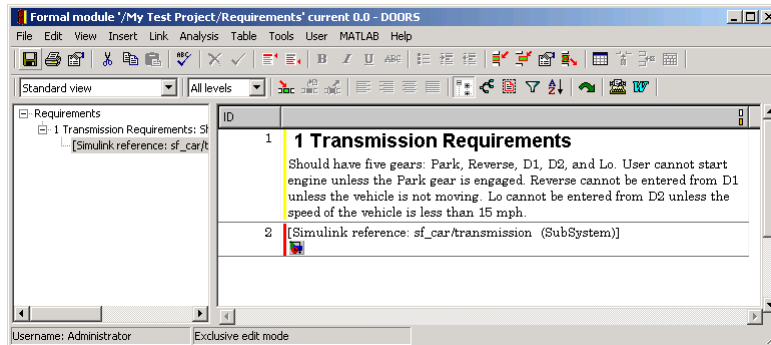
In “Creating a DOORS Requirement Object” on page 3-7, you created a Transmission Requirements object in the Requirements formal module in DOORS. Now use the following procedure to link the transmission block in the sf_car model to this DOORS requirement.

- 1 In the MATLAB Command Window, type sf_car at the MATLAB prompt to open the demo model sf_car.mdl.
- 2 In the formal module window Requirements, select the Transmission Requirement node in the left pane, as shown.



- 3 In the Simulink diagram, right-click on the transmission block and, from the resulting pop-up menu, select **Requirements > Add link to current DOORS object**.

The Requirements Management Interface for DOORS adds the link to the DOORS requirement object, as shown.



- 4 Save the DOORS module.
- 5 Save the Simulink model as sf_car_doors.mdl.

The Requirements Management Interface uses the DOORS absolute number and the unique module number to identify items in DOORS. This ensures that the correct item is identified even if the module is renamed or the items in the module are rearranged.

You can also use the Requirements dialog box to create links to DOORS objects. Set the **Document type** field to DOORS Item and click **Browse**. The Requirements Management Interface opens the DOORS database. Browse to the desired module and specify the DOORS item number.

Synchronizing DOORS with the Simulink Model

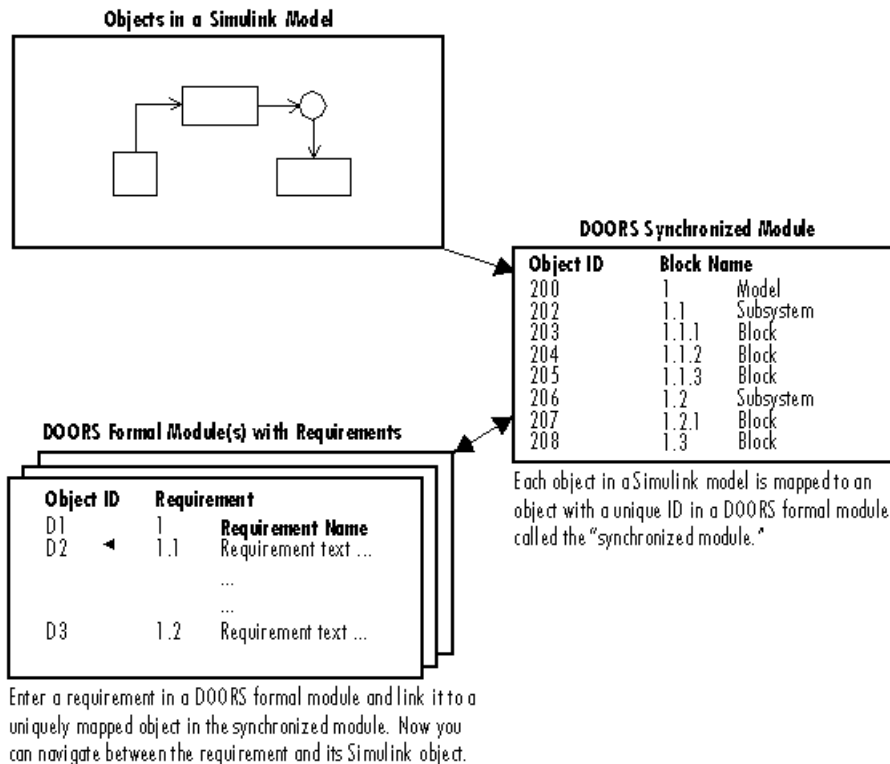
This section shows you how to create the synchronized module and link objects with DOORS requirements in the following topics:

- “Synchronizing a Model with DOORS” on page 3-13 — Describes why synchronization is needed, when to synchronize, and how to synchronize
- “Linking Requirements to the DOORS Synchronized Module” on page 3-22 — Describes how to link synchronized objects with DOORS requirements

Keep in mind the following synchronization rules:

- Synchronization is optional
- You can create requirement links before or after you synchronize, in any order
- The synchronized module captures requirement information from the model into the DOORS database, enabling further analysis and reporting

The following diagram illustrates the synchronization process.



Note The Requirements Management Interface and DOORS both use the term *object*, but each uses the term differently. In the Requirements Management Interface for DOORS, and in this document, the term *object* refers to a Simulink model, a Simulink block, a Stateflow block, and elements of a Stateflow diagram. In DOORS, *object* refers to each numbered element in the synchronized formal module for the objects in a Simulink model. DOORS assigns each of these objects a unique object identifier. In this document, these objects are referred to as DOORS objects.

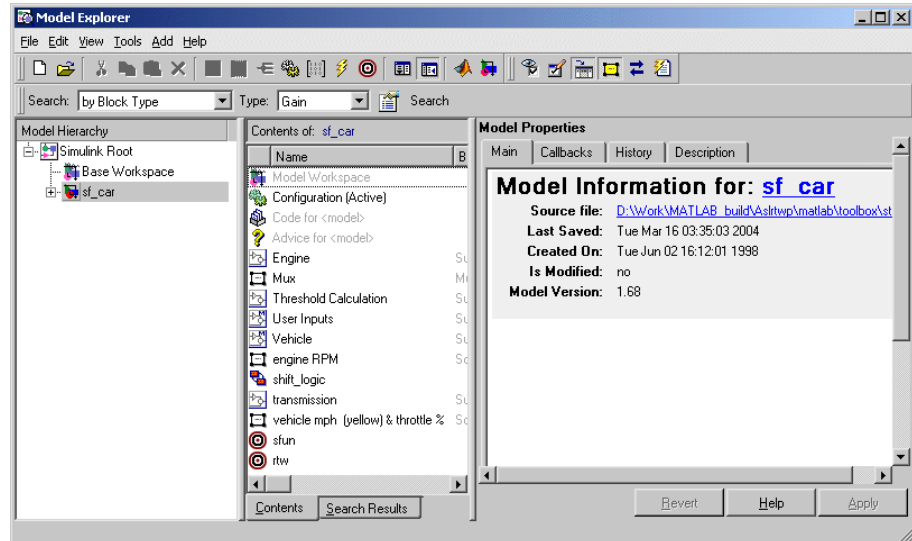
Synchronizing a Model with DOORS


In "Starting the Requirements Management Interface for DOORS" on page 3-5, you open MATLAB, open DOORS, and open a project in DOORS. Begin

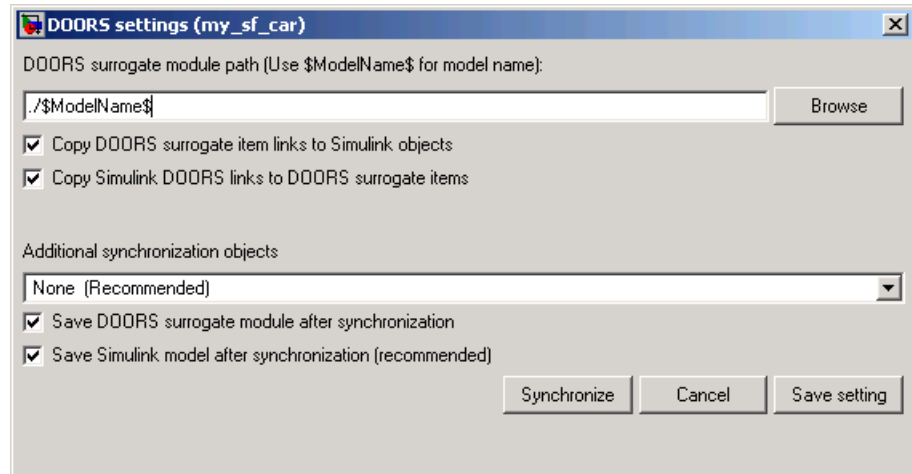
the process of mapping requirements in DOORS to a Simulink model by first synchronizing the model with the open project in DOORS. Synchronization maps a hierarchical representation of a Simulink model's blocks and Stateflow objects to a formal module in a DOORS project. Later, you use this formal module to add requirements.

Use the following procedure to synchronize a Simulink model with DOORS:

- 1 In the MATLAB Command Window, type `sf_car` at the MATLAB prompt to open the demo model `sf_car.mdl`.
- 2 In the Simulink model, from the **View** menu, select **Model Explorer**.

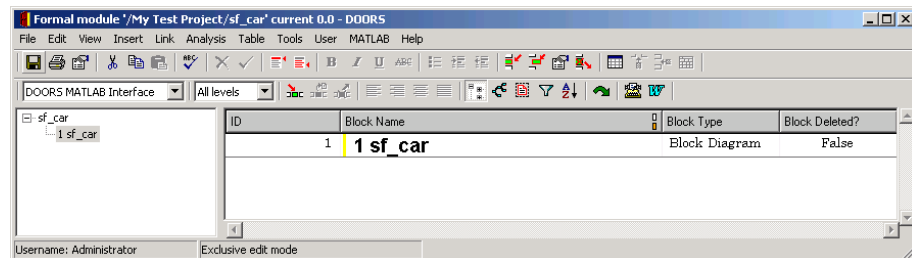


- 3 Select the Synchronize Requirements with DOORS tool  in the Model Explorer window. The DOORS settings dialog box opens, as shown.



4 Click **Synchronize**.

Synchronizing creates and opens a DOORS formal module for the model, which appears as shown.




Notice that by default the DOORS formal module contains only one synchronized object, which corresponds to the top-level diagram. To include all the model blocks in the DOORS formal module, use the following procedure, “Customizing the Level of Synchronization Detail” on page 3-15.

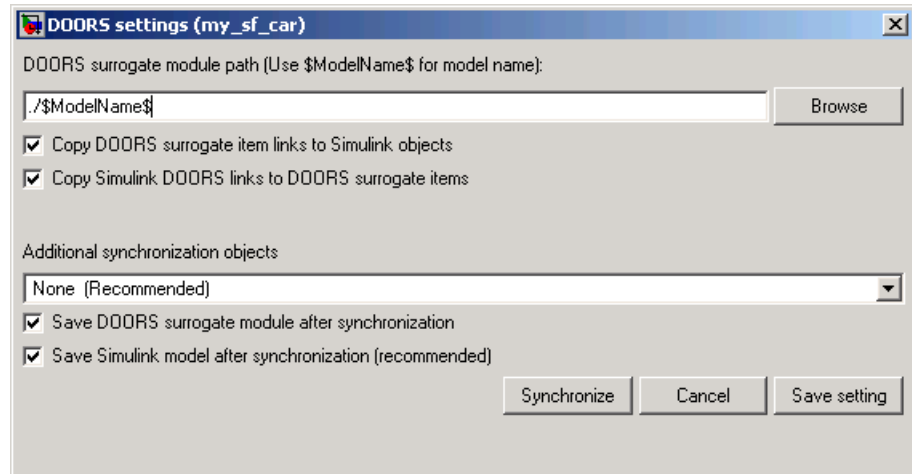
Customizing the Level of Synchronization Detail

The DOORS surrogate module always contains the model objects that have DOORS requirement links and objects that were previously synchronized. You can choose a desired detail level to make the surrogate better reflect the

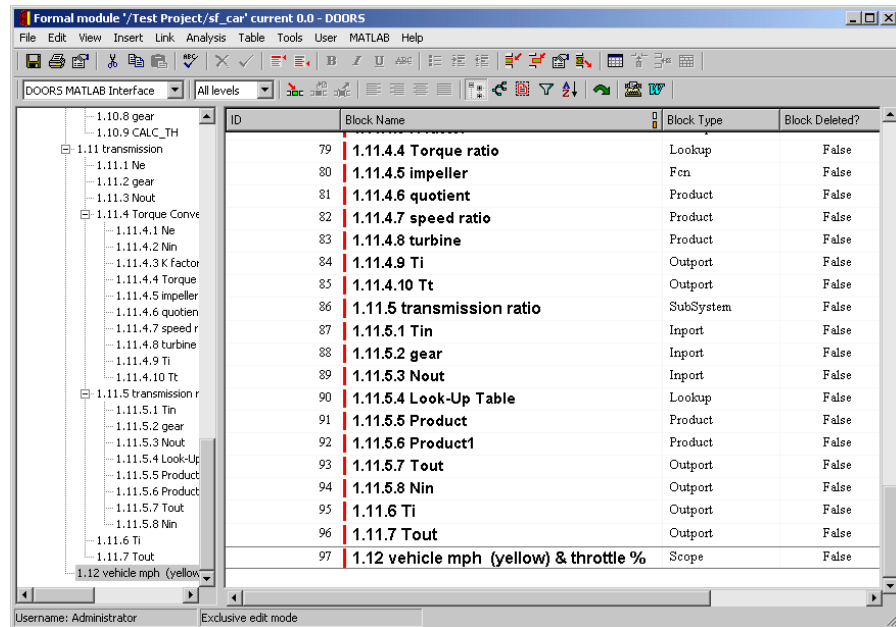
model. Additional synchronization objects improve the surrogate detail at the expense of slower synchronization.

To include all the model blocks in the DOORS formal module, use the following procedure.

- 1 Open the `sf_car` model.
- 2 From the **Tools** menu in the Simulink window select **Requirements > Synchronize with DOORS**. The DOORS settings dialog box opens, as shown. Another way to access this dialog box is to select the Synchronize Requirements with DOORS tool  in the Model Explorer window.




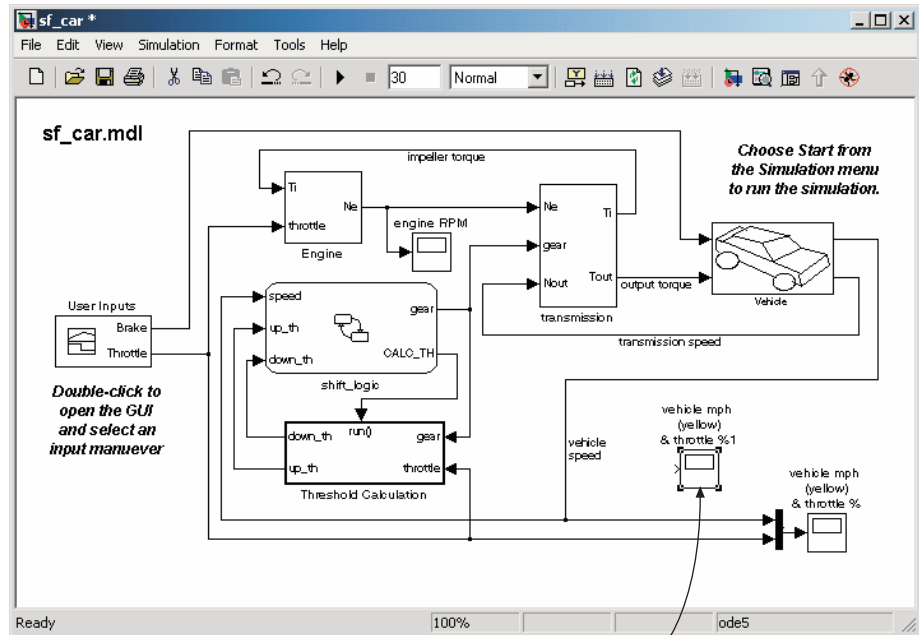
- 3 From the drop-down list in the **Additional synchronization objects** pane, select **Complete All blocks, subsystems, states, and transitions**.
- 4 Click **Synchronize**. The DOORS formal module for the model appears as shown.




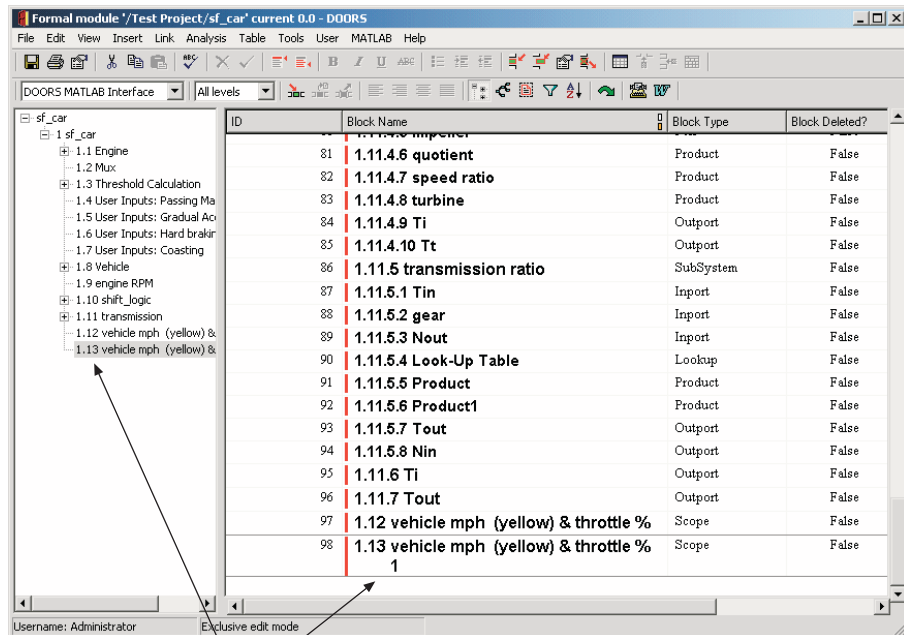
Notice the following:

- The formal module is named `sf_car` in the title bar, after the model.
- The left pane displays a node for each synchronized object. All nodes are expanded and the pane is scrolled to the bottom.
- The right pane displays a DOORS object for each model object, which consists of the model object title only. It is also scrolled to the bottom.
- Each DOORS object has a unique identifier displayed in the **ID** column. For example, the identifier for the DOORS object for the Product block turbine in the preceding figure is 83.
- Each DOORS object has a hierarchical identifier displayed in the **Block Name** column, which represents its relationship to other objects in the engine model. The hierarchical identifier of each block begins with 1, the hierarchical identifier for the model `sf_car` that contains them.
- For each DOORS object, there is a **Block Type** description that identifies each object as a particular block or a subsystem.

- You can add additional information columns to the right pane with the Insert Column tool  in the DOORS toolbar.
- 5 In the Simulink model, right-click and drag a copy of the Scope block, as shown.



- 6 Select the Synchronize Requirements with DOORS tool  again.
- The synchronized module is updated with the new block, as shown.



New block and link

Note The Requirements Management Interface for DOORS does not detect model changes made after a synchronization. It is up to you to synchronize a changed model with the DOORS formal module.


- 7 In the Simulink model, delete the added Scope block and resynchronize.

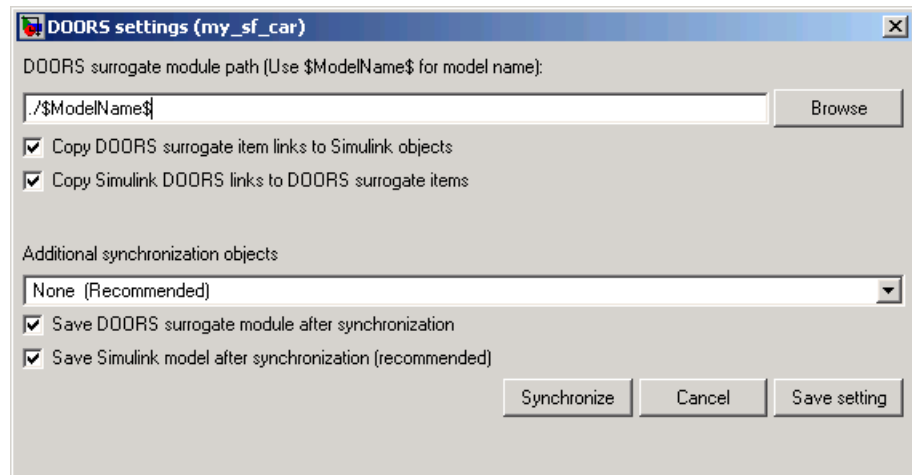
The deleted block appears at the bottom of the list of objects in the formal module and its entry in the **Block Deleted** column is True. If you want, you can delete this entry by right-clicking the line and selecting **Delete**. Otherwise, the module records the former presence of the deleted block.

- 8 Before you close the DOORS project, save the synchronized module in DOORS.

Customizing the DOORS Synchronization Settings

The DOORS settings dialog box lets you control not only the level of synchronization detail, but also the actions that the Requirements Management Interface for DOORS performs upon synchronization.

- 1 From the **Tools** menu in the Simulink window select **Requirements > Synchronize with DOORS**. The DOORS settings dialog box opens, as shown. Another way to access this dialog box is to select the Synchronize Requirements with DOORS tool  in the Model Explorer window.

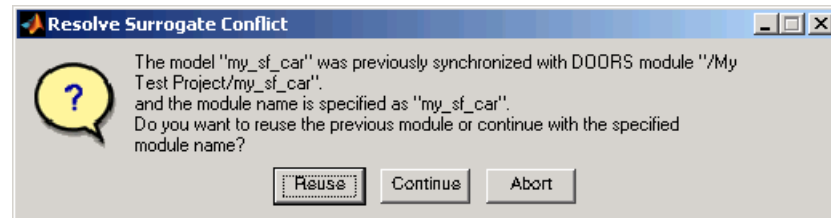


The **DOORS surrogate module path** field identifies the module within the DOORS database. You can specify a module with either a relative path (starting with `./`) or a full path (starting with `/`). Relative paths are appended to the current DOORS project. Absolute paths must specify a project and a module name.

After you synchronize a model, the Requirements Management Interface for DOORS automatically updates the **DOORS surrogate module path** field with the actual full path. It also saves the unique module identifier with the module, to identify when the surrogate is renamed.

If you select a new module path, or if the surrogate module is renamed, the Resolve Surrogate Conflict dialog box appears when you click **Synchronize**,

as shown below. It gives you the options to reuse the previous module, to continue with the specified path, or to abort synchronization.



2 Use the following options in the DOORS settings dialog box to customize your synchronization settings:

- **Copy DOORS surrogate item links to Simulink objects** — If this check box is selected, at the time of synchronization the Requirements Management Interface for DOORS copies all the requirement links created from the surrogate module items into the appropriate Simulink model objects.
- **Copy Simulink DOORS links to DOORS surrogate items** — If this check box is selected, at the time of synchronization the Requirements Management Interface for DOORS copies all the requirement links created directly from the Simulink model into the appropriate surrogate module items.

Keeping both these check boxes selected ensures that your requirement link information is completely synchronized.

- **Additional synchronization objects** — Lets you select the level of synchronization detail, as described in “Customizing the Level of Synchronization Detail” on page 3-15.
- **Save DOORS surrogate module after synchronization** — If this check box is selected, the DOORS formal modules are automatically saved upon synchronization. If you clear the check box, you will have to manually save them.
- **Save Simulink model after synchronization (recommended)** — If this check box is selected, the Simulink model is automatically saved upon synchronization. It is recommended that you use this option.

3 After you select the desired configuration, click **Save Settings**.

Linking Requirements to the DOORS Synchronized Module

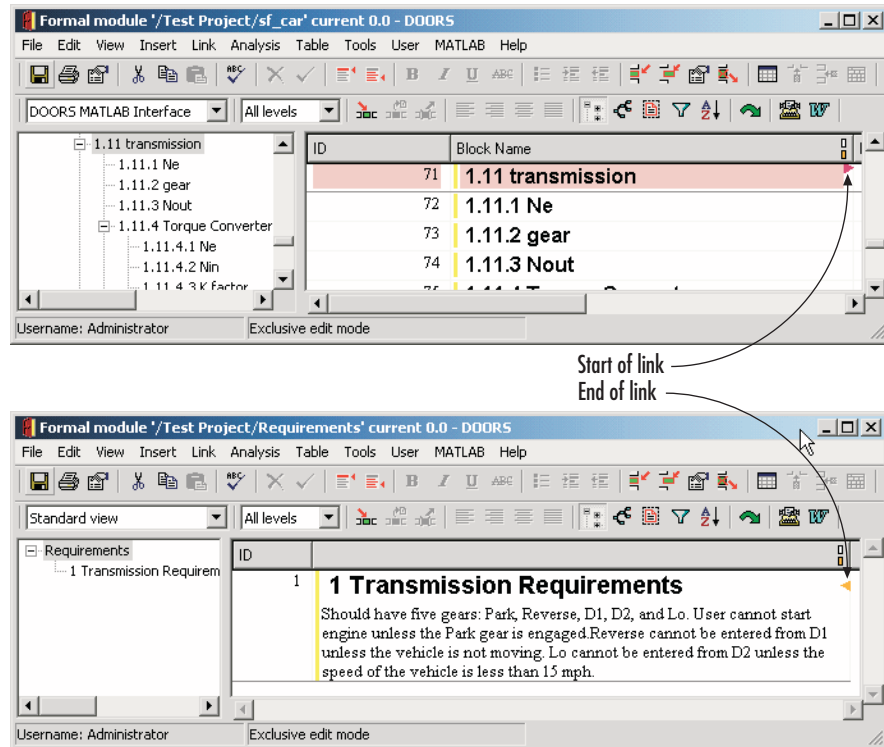
After you create or resynchronize a synchronized module, you can add requirements for its objects in another DOORS formal module. Each requirement is then linked to its DOORS object in the synchronized module. This establishes recognizable requirements in the Requirements Management Interface for DOORS.

In “Creating a DOORS Requirement Object” on page 3-7, you created a Transmission Requirements object in the Requirements formal module in DOORS.

Now use the following procedure to add this requirement to the synchronized module you created for the sf_car model in “Synchronizing DOORS with the Simulink Model” on page 3-12:

- 1 Open the Requirements formal module in DOORS.
- 2 In the DOORS main window, open the synchronized module sf_car and scroll down to the transmission object.
- 3 Right-click the transmission object and select **Link > Start Link** from the resulting context menus.
- 4 In the Requirements formal module window, right-click the Transmission Requirements object and select **Link > Make Link from Start** from the resulting context menus.

A link now exists between the transmission object in the synchronized module and the Transmission Requirements object in the Requirements module. The presence of the link is indicated by a right-facing arrow for the transmission object in the synchronized module and a left-facing arrow in the Transmission Requirements object in the Requirements module, as shown.



The requirement you install in this section is an example of an official DOORS requirement for the Requirements Management Interface for DOORS. You can navigate between the object in the synchronized module and its requirement in DOORS by right-clicking one of the arrows and selecting from the resulting pop-up menu. You can also establish more links from the object to other requirements. Later on, when you display Simulink objects with DOORS requirements in “Navigating Between Model Objects and DOORS” on page 3-24, these are the requirements that the Requirements Management Interface for DOORS detects.

Navigating Between Model Objects and DOORS

The following sections explain how to create views that show which model objects have requirements. They also describe how to navigate between Simulink or Stateflow objects and the associated requirements in DOORS, or between model elements and the synchronized DOORS formal module.

- “Viewing Model Elements with Requirements” on page 3-24 — Modify the view of a Simulink model and identify the subsystems and blocks that have associated requirements
- “Navigating from Simulink to DOORS” on page 3-26 — Navigate to a requirement in DOORS from its object in Simulink or the Model Explorer
- “Navigating from DOORS to Simulink” on page 3-28 — Navigate from a requirement in DOORS to its object in Simulink

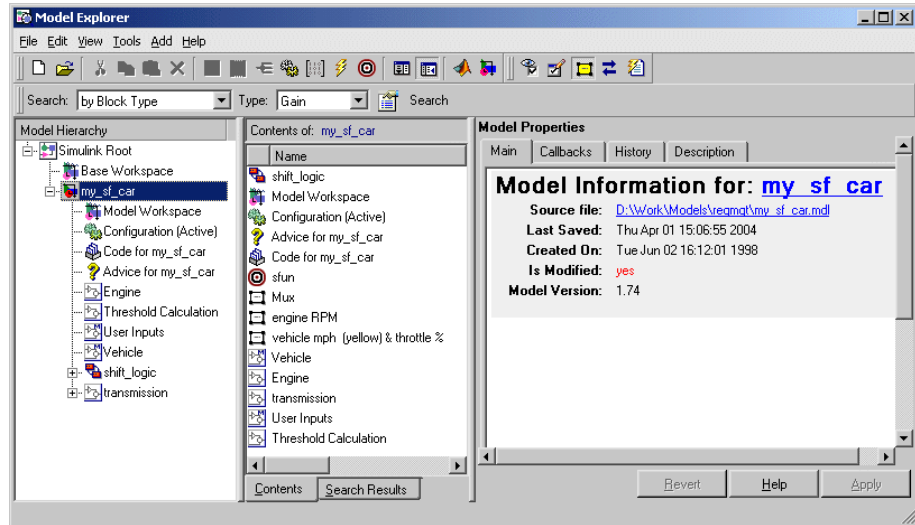
Viewing Model Elements with Requirements


It is sometimes helpful to distinguish model objects with requirements from those without requirements in a single glance. The Requirements Management Interface for DOORS lets you see model elements with requirements linked to the synchronized module both in Simulink and in the Model Explorer.

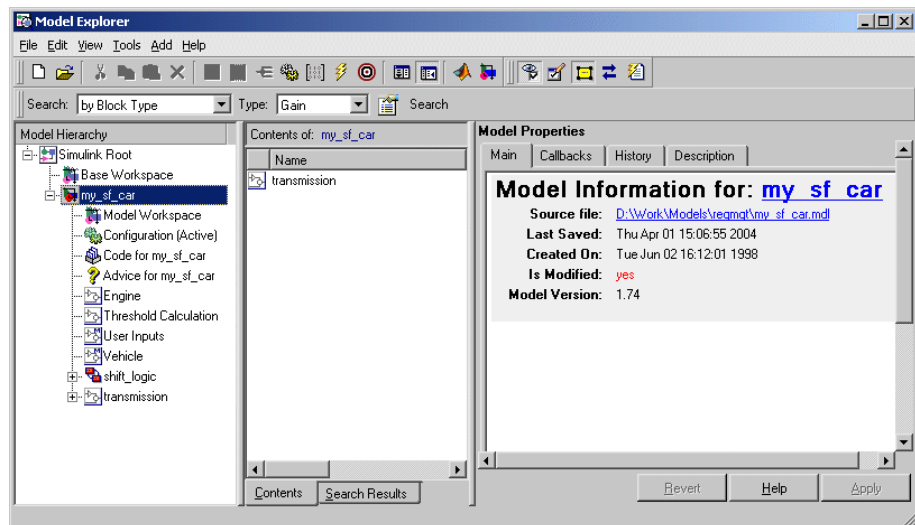
Use the following procedure to display only those model elements with requirements:

- 1 In the Simulink model, from the **View** menu, select **Model Explorer**.

The Model Explorer window appears with the model highlighted in the **Model Hierarchy** pane, as shown.



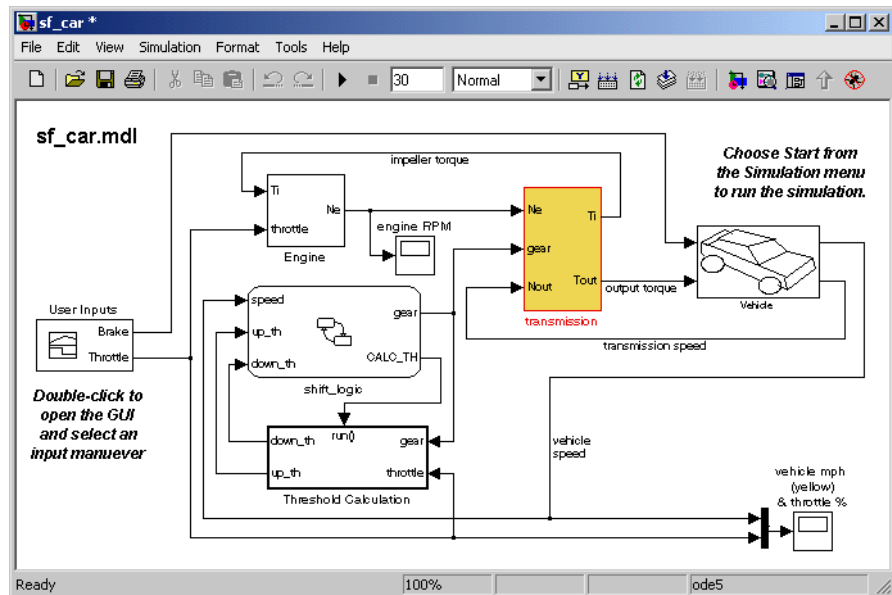
2 Select the Display Objects with Linked Requirements tool  in the Model Explorer toolbar.



The Model Explorer displays only the transmission object, which you added requirements to in “Linking Objects to DOORS Requirements” on page 3-7.

- 3 Select the Highlight Items with Requirements on Model tool  in the Model Explorer toolbar.

The transmission block in the Simulink model becomes highlighted, as shown.

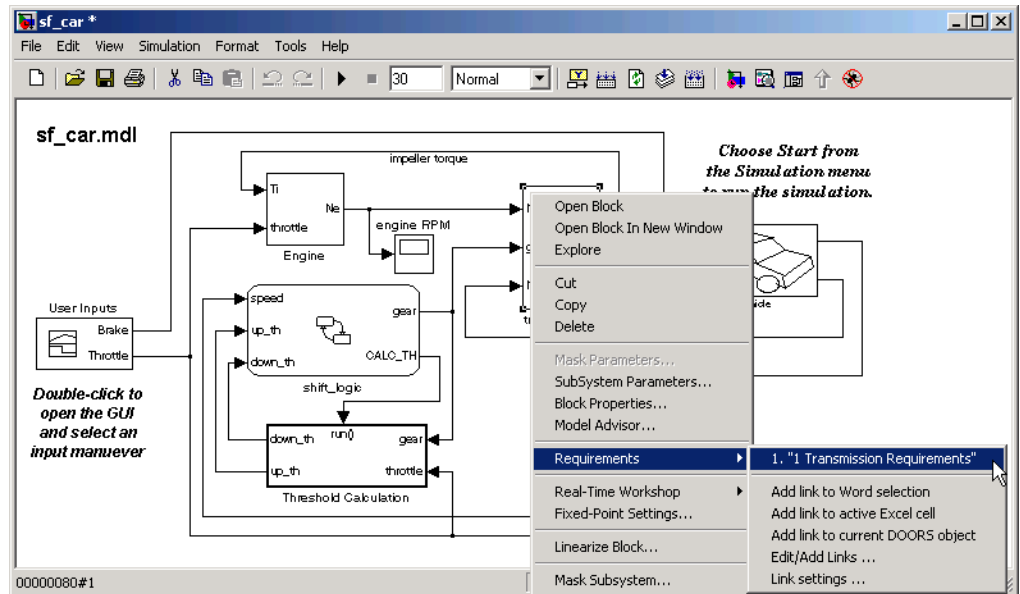


Navigating from Simulink to DOORS

If you create requirement links directly from the Simulink or Stateflow object, you can navigate directly from the object to the DOORS requirement. In “Linking Objects to DOORS Requirements” on page 3-7, you create a link from the transmission block in Simulink to the Transmission Requirements DOORS object.

Use the following procedure to navigate from the transmission block in Simulink to its associated requirement in DOORS:

- 1 In Simulink, open the model sf_car_doors.
- 2 Right-click on the transmission block and, from the resulting pop-up menu, select **Requirements > 1. "Transmission Requirements"** as shown.



The Requirements formal module window opens scrolled to the Transmission Requirements link.

Navigating Through the Synchronized Module

If you use the synchronized module to create requirement links to DOORS, as described in “Linking Requirements to the DOORS Synchronized Module” on page 3-22, then you can navigate between Simulink objects and DOORS requirements by using the synchronized module as an intermediary. You first navigate to the unique object in the synchronized module from its object in Simulink or the Model Explorer. From the synchronized module, you then access requirements for each object through the linking process in DOORS.

Use the following procedure to navigate from a Simulink object to the object mapped in the synchronized module:

- 1 In Simulink, right-click a block with requirements.

A pop-up menu appears.

- 2 In the pop-up menu, select **Requirements > DOORS Surrogate Item**.

If the synchronized module is closed, it opens and the mapped object is highlighted. If the synchronized module is already open, only the mapped object is highlighted.

- 3 Access individual requirements in the synchronized module.

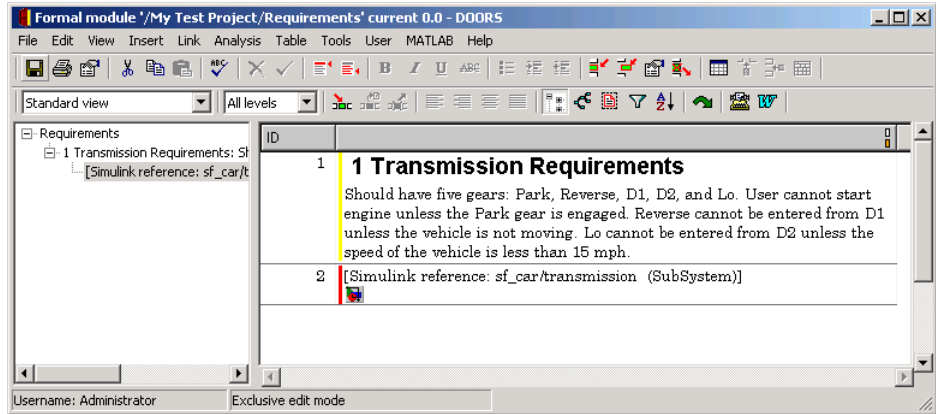
You can access individual requirements by right-clicking the arrows that appear in the **Block Name** column for each mapped object with requirements and making a requirement selection.

Navigating from DOORS to Simulink

If you create two-way requirement links directly from the Simulink or Stateflow object, you can navigate from the DOORS requirement directly to the associated object in Simulink or Stateflow. In “Linking Objects to DOORS Requirements” on page 3-7, you create a link from the transmission block in Simulink to the Transmission Requirements DOORS object.

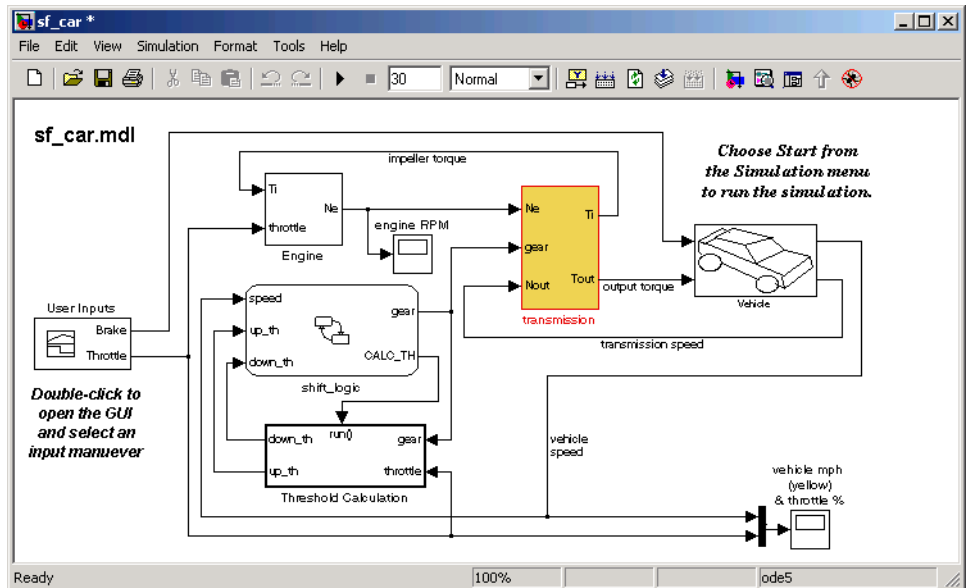
Use the following procedure to navigate from the Transmission Requirements DOORS object to the transmission block in Simulink:

- 1 In DOORS, open the formal module window Requirements.
- 2 Select the Simulink Reference sub-node of the Transmission Requirements node in the left pane, as shown.



- From the **MATLAB** menu in the formal module window Requirements, select **Select item**.

The transmission block in the Simulink diagram is highlighted, as shown.



Navigating Through the Synchronized Module

In DOORS, you can navigate from a requirement in a formal module to its mapped object in the synchronized module through the left-facing arrows in the **Block Name** column for each requirement. This brings focus to the synchronized module with the owning object selected.

You can navigate from an object in the synchronized module to its Simulink object as follows:

- 1 In the DOORS synchronized module, click an object in either the left or right pane to select it.
- 2 From the **MATLAB** menu, choose **Select item**.

The object opens in its native diagram as follows:

- For a Simulink object, the subsystem containing the selected object opens in Simulink with that block or subsystem selected in the model. All parent Simulink blocks are selected as well, so that you can reach the object from any higher-level object.
- For a Stateflow object, the diagram containing the selected object opens in Stateflow with the object highlighted.

Note Although the **MATLAB** menu and **Select item** feature appear in all DOORS formal modules, you can only use them in a synchronized formal module.

If the DOORS **Block Deleted** status for the object is True, you cannot navigate to the object.

Managing Model Verification Blocks

You use Model Verification blocks throughout your model to monitor individual signals relative to limits that you impose on them. Use Model Verification blocks in conjunction with the Verification Manager tool in the Signal Builder block to carefully construct simulation tests for your model from a single location.

“Using Model Verification Blocks”
(p. 4-2)

Using Model Verification blocks in Simulink to monitor model signals against a specified limit

“Using the Verification Manager”
(p. 4-5)

Managing the Model Verification blocks in your models with the Verification Manager

“Managing Verification Requirements” (p. 4-17)

Linking requirements documents to test groups and their Model Verification block schedule in the Verification Manager

Using Model Verification Blocks

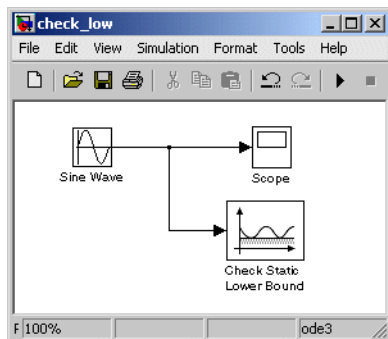
You use Model Verification blocks throughout your model to monitor model signals. You can set a verification block to assert when its signal leaves the specified limit or range. During simulation, when the signal crosses the limit, the verification block can

- Stop simulation and bring immediate focus to its part of the model
- Report the limit encounter with a logical signal output of its own, which can be true if the limit is not encountered and false if the limit is encountered

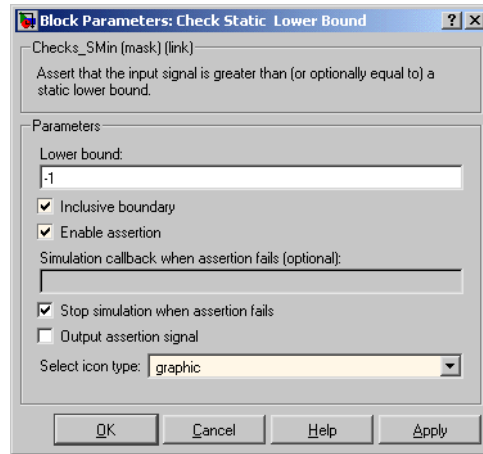
To see a complete list of all Model Verification blocks and references for each, see the Model Verification category in the Simulink Block Reference documentation.

In the following example, a Check Static Lower Bound verification block is used to stop simulation when a signal from a Sine Wave block crosses its lower bound limit.

- 1 Attach a Check Static Lower Bound verification block to the signal from a Sine Wave block, as shown in the following schematic.



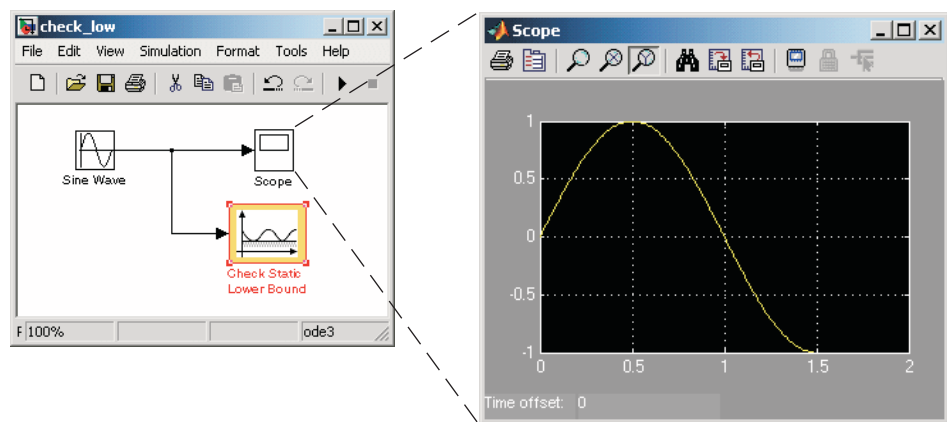
- 2 Set the model to run for 2 seconds while the Sine Wave block outputs a signal with an amplitude of 1 and a frequency of π radians per second.
- 3 Open the Check Static Lower Bound block and set the parameters as follows:



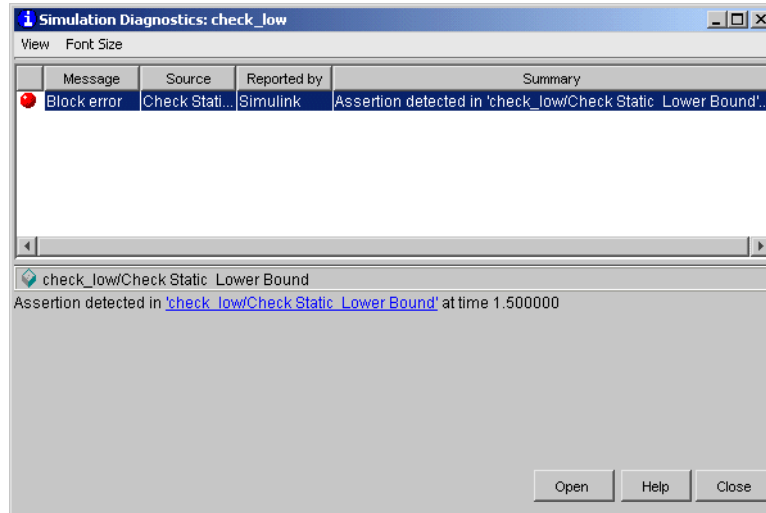
A verification block is enabled for an assertion when the **Enable assertion** checkbox is selected (this is the default setting). According to the preceding property settings, the Check Static Lower Bound block is set to detect a signal value of -1 or lower. If this signal is detected, simulation is stopped.

4 Run the simulation.

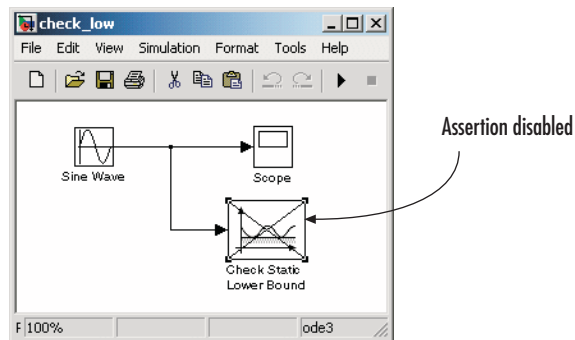
The model stops simulating after 1.5 seconds, when the output is -1, as shown. This brings focus to the asserting verification block, which is highlighted.



The stop in simulation is also accompanied by the following status diagnostic message.



- 5 You can disable the block from asserting its limit by clearing the **Enable assertion** checkbox, which has the following effect on the block's appearance in the model.



Using the Verification Manager

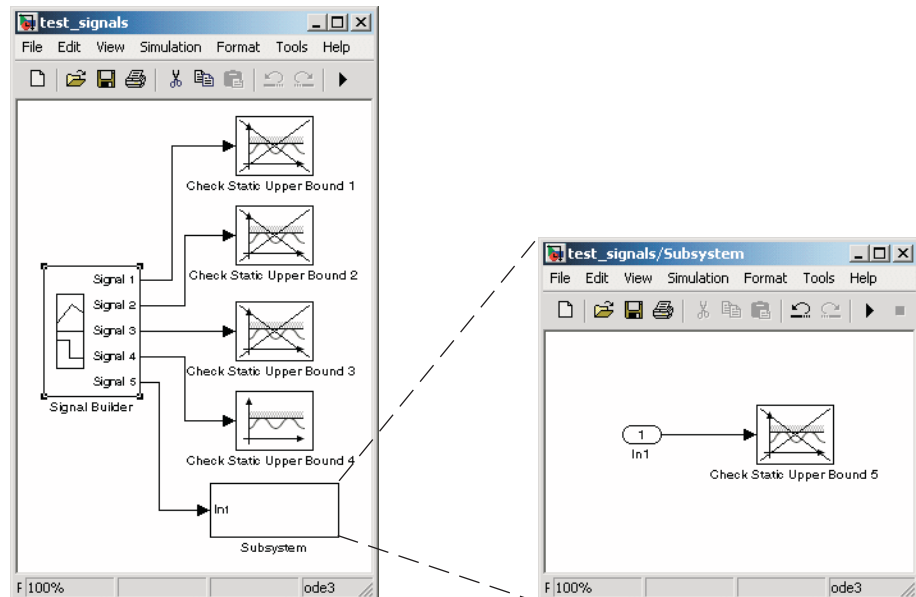
You can manage the Model Verification blocks in your models from a central location with the Verification Manager tool of the Signal Builder block. Use the following topics to learn how to manage Model Verification blocks in your Simulink models:

- “Opening the Verification Manager” on page 4-5
- “Enabling and Disabling Model Verification Blocks with the Verification Manager” on page 4-9

Opening the Verification Manager

In this topic you create a model that you use to examine the Verification Manager in Simulink in the following steps:

- 1 Create the following example model in Simulink.

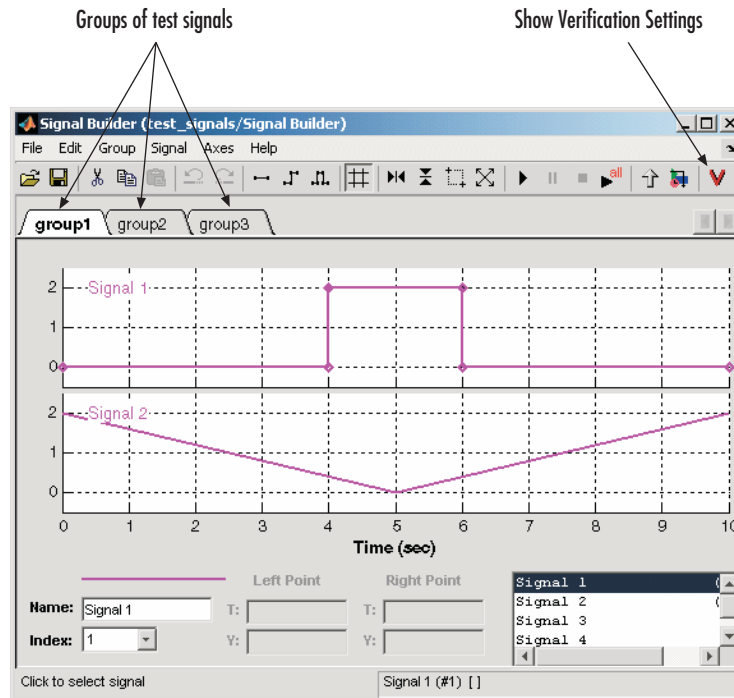


Typically, a Signal Builder block provides test signals for an entire model from one location. The example model contains a Signal Builder block

feeding five test signals to Model Verification blocks. Signals 1 through 4 are sent directly to Check Static Upper Bound Model Verification blocks. The fifth signal is sent to a subsystem that contains a Check Static Upper Bound verification block.


Each Check Static Upper Bound verification block is set to assert for an upper bound of 1 (property **Upper bound** = 1). Blocks 1, 2, 3, and 5 appear crossed out because they are disabled (property **Enable assert** is cleared). Block 4 is enabled (property **Enable assert** is checked).

- 2 Double-click the Signal Builder block in the preceding model to open its Signal Builder dialog box.

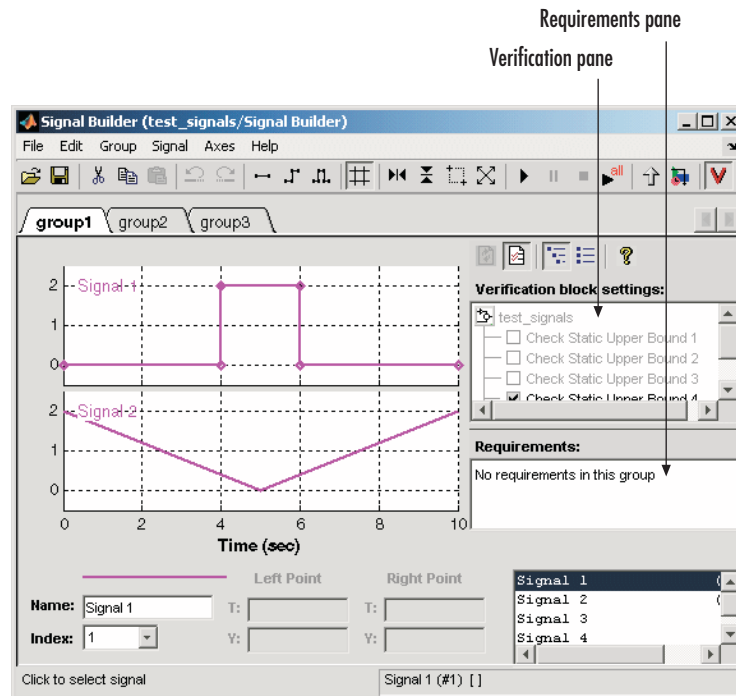


The Signal Builder dialog box displays tabbed pages for three groups of signal values. Each group contains independent values for all five signals. However, only a subset of the signals is displayed for each group. For example, **group1** displays signals 1 and 2. For more information on the


Signal Builder block, see "Working with Signal Groups" in the Simulink documentation.

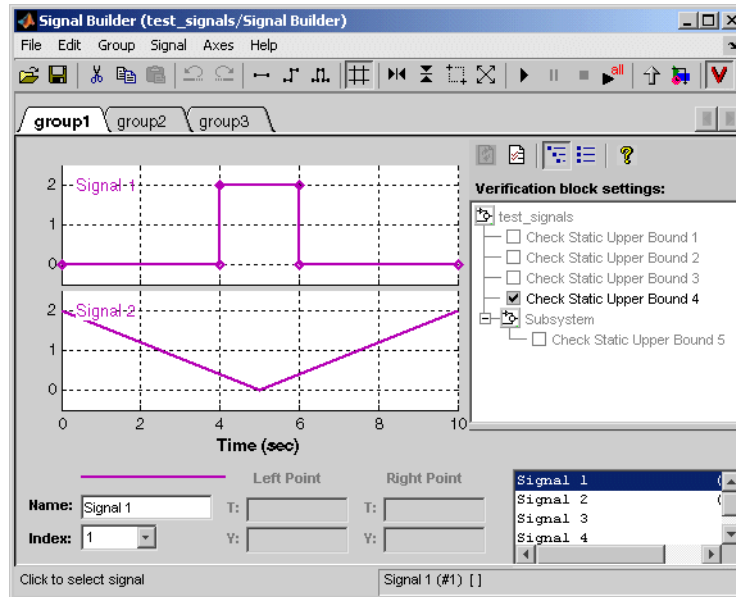
- 3 In the Signal Builder dialog toolbar, select the Show Verification Settings tool .

The **Verification block settings** pane and the **Requirements** pane appear as shown.




By default, the **Verification block settings** pane lists all Model Verification blocks for the model, grouped by subsystem. The **Requirements** pane lists the requirements document links for the current signal group. See "Managing Verification Requirements" on page 4-17 for details on adding requirement document links in the Signal Builder dialog box. For now, delete the **Requirements** pane in the next step.

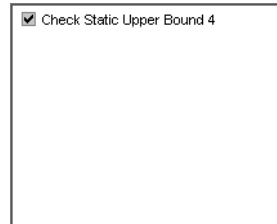
- 4 Just above the **Verification block settings** pane, select  to close the **Requirements** pane.




The example **Verification block settings** pane displays five Model Verification blocks. Four are in the top level of the model, and one is in a subsystem.

- 5 Select the List Enabled Verifications tool  in the **Verification block settings** toolbar.

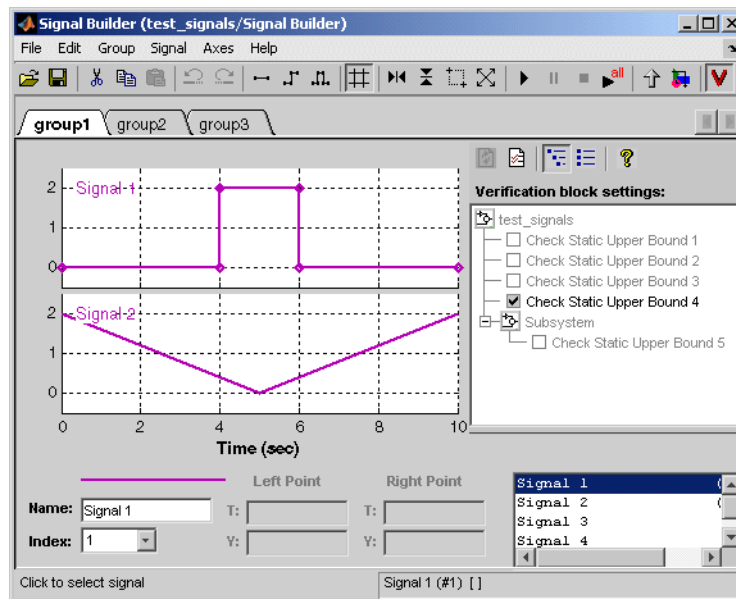
The **Verification block settings** pane now shows only the enabled Model Verification blocks for the current group, as shown.



- 6 Select the Show Verification Block Hierarchy tool  to list all Model Verification blocks for the current group again.

Enabling and Disabling Model Verification Blocks with the Verification Manager

In this section you use the Verification Manager to selectively enable and disable Model Verification blocks in group tests. In “Opening the Verification Manager” on page 4-5, you open the Verification Manager in the Signal Builder, as shown.



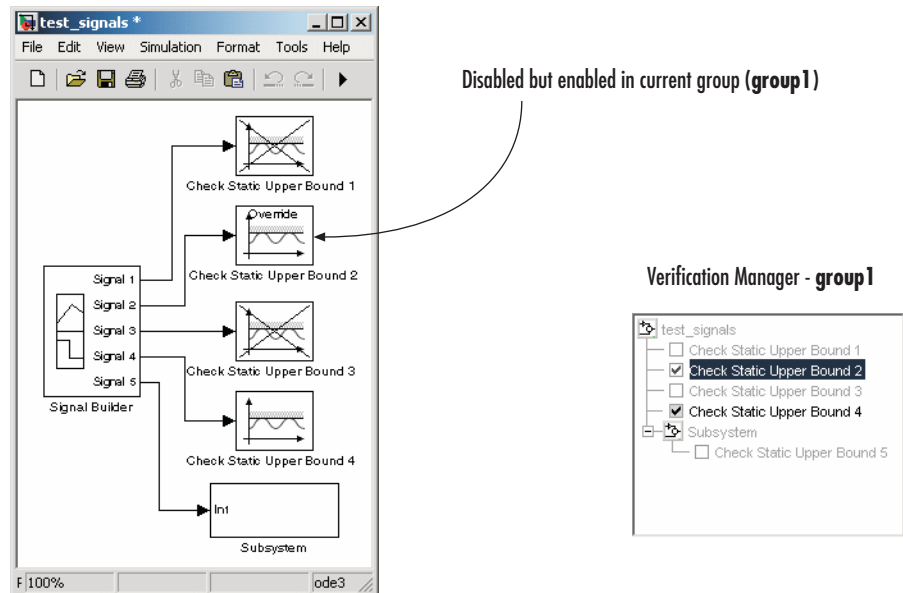
The **Verification block settings** pane in the preceding example lists the Model Verification blocks in the model. Each verification block has a preceding status node that indicates whether its assertion is enabled or disabled and whether that setting applies universally or to the active group. The preceding status node can be one of the following.

Node	Status
<input type="checkbox"/>	Verification block is disabled for this group. Click to enable for current group.
<input checked="" type="checkbox"/>	Verification block is enabled for the current group. Click to disable for current group.
<input checked="" type="checkbox"/>	Verification block is enabled for all test groups.

Use the Verification Manager to enable or disable model verification blocks in the `test_signals` model you created in “Opening the Verification Manager” on page 4-5, as follows:

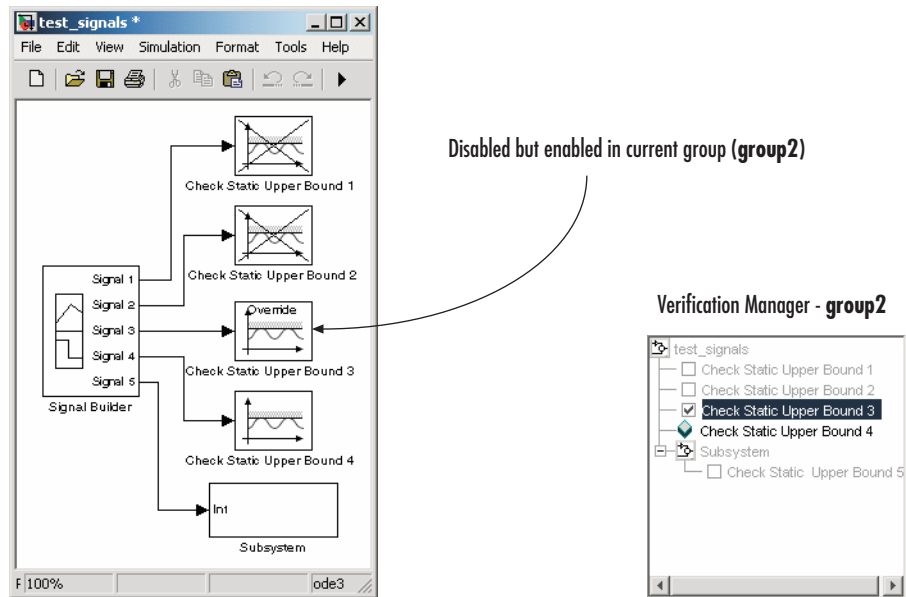
- 1 In the Verification Manager, click the empty check box next to the Check Static Upper Bound 2 node to enable it for the current group (**group1**).

Enabling a disabled block in the **Verification block settings** pane leads to the following change in block appearance in the model.






Because it is enabled in the current group, the **Check Static Upper Bound 2** block gains an **Override** label and loses its cross-out. The meaning behind the change in appearance becomes clearer when another group is selected.

- 2 In the Signal Builder dialog box, select the **group2** tab and click the empty check box next to the **Check Static Upper Bound 3** block to enable it for the current group (**group2**).




The Check Static Upper Bound 3 block loses its cross to indicate that it is enabled for the current group. However, Check Static Upper Bound 2 gains a cross because it is enabled in another group, but not this one.

The change in appearance of the Check Static Upper Bound blocks in the preceding steps is exemplary of the change in appearance of every other Model Verification block except the Assert block. The change in appearance of the Assert block is summarized in the following table:

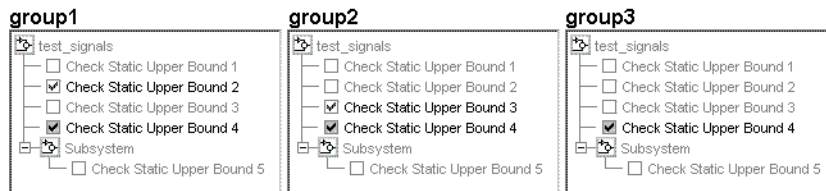
Assert Block	Description
	Enabled for all groups
	Disabled in current group
	Enabled in current group

Using Enabling and Disabling Tools in the Verification Manager

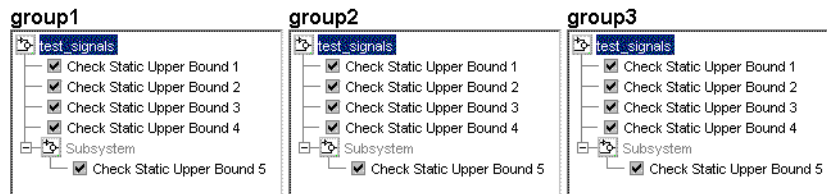
If you have many verification blocks, it is tedious to enable and disable blocks individually. For this reason, the Verification Manager lets you enable and disable blocks from ancestors through selections from a context menu. These selections vary with the node as follows:

Node	Context Menu Selections
	<ul style="list-style-type: none"> • Enable contents of all groups • Enable contents by group • Group enable contents • Group disable contents
<input checked="" type="checkbox"/>	<ul style="list-style-type: none"> • Enable by group
<input type="checkbox"/>	<ul style="list-style-type: none"> • Enable for all groups • Group enable
<input checked="" type="checkbox"/>	<ul style="list-style-type: none"> • Enable for all groups • Group disable

As an example, assume that the following groups are defined in the Verification Manager for a model with five Model Verification blocks.

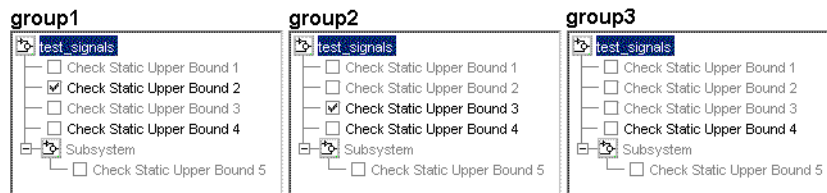


1 Right-click the `test_signals` node and select **Enable contents of all groups**.



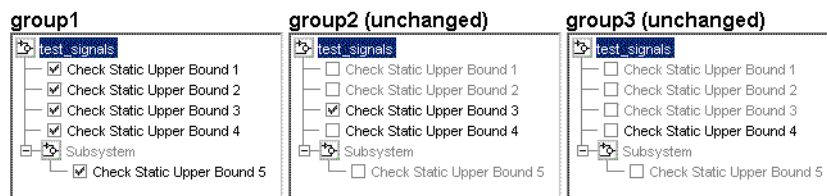
Applying the **Enable contents of all groups** selection to the model node enables all contained Model Verification blocks, for all test groups, in all contained subsystems.

2 Right-click test_signals and select **Contents enable by group**.



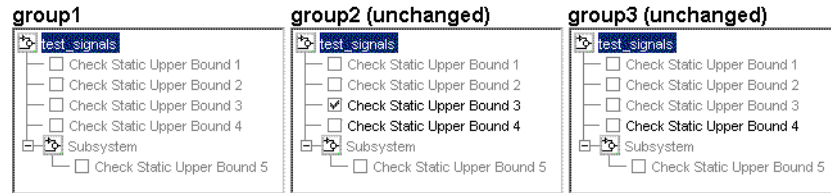
Applying the **Contents enable by group** selection to the model node restores the previous individually enabled/disabled settings for each block in each group.

3 Right-click test_signals and select **Contents group enable**.



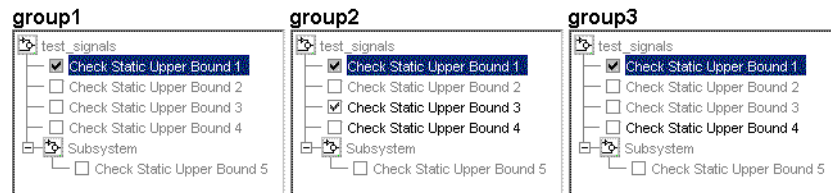
Applying **Contents Group enable** to the test_signals model node in **group1** individually enables all contained blocks for **group1**, but leaves the other groups untouched.

4 Right-click test_signals and select **Contents group disable**.



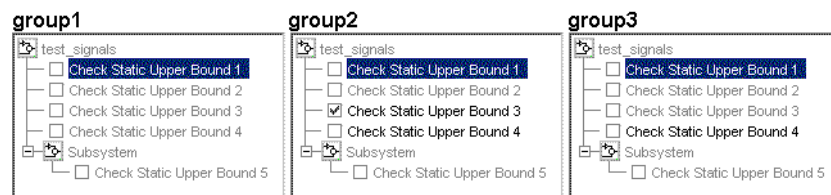
Applying **Contents group disable** to the `test_signals` model node in **group1** individually disables all contained blocks for **group1**, but leaves the other groups untouched.

- 5 Right-click `Check Static Upper Bound 1` and select **Block enable for all groups**.



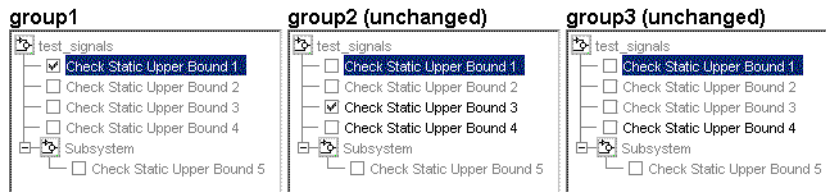
Applying **Block enable for all groups** to the individual **group1** block node for `Check Static Upper Bound 1` in **group1** enables this block for all groups.

- 6 Right-click `Check Static Upper Bound 1` and select **Block enable by group**.



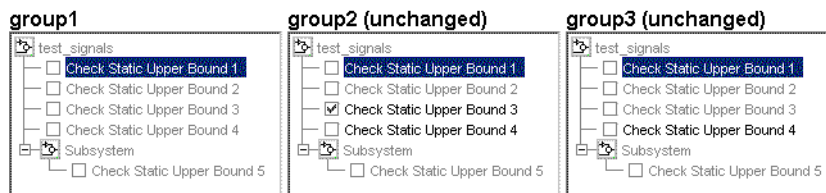
Applying **Block enable by group** to the individual **group1** block node for `Check Static Upper Bound 1` in **group1** restores the previous individually enabled/disabled state to this block for all groups. This lets you enable or disable this node individually for each group.

7 Right-click Check Static Upper Bound 1 and select **Block group enable**.



Applying **Block group enable** to the individual **group1** block node for Check Static Upper Bound 1 in **group1** enables this block for this group only. This is equivalent to selecting the empty check box in **group1** for this node.

8 Right-click Check Static Upper Bound 1 and select **Block group disable**.



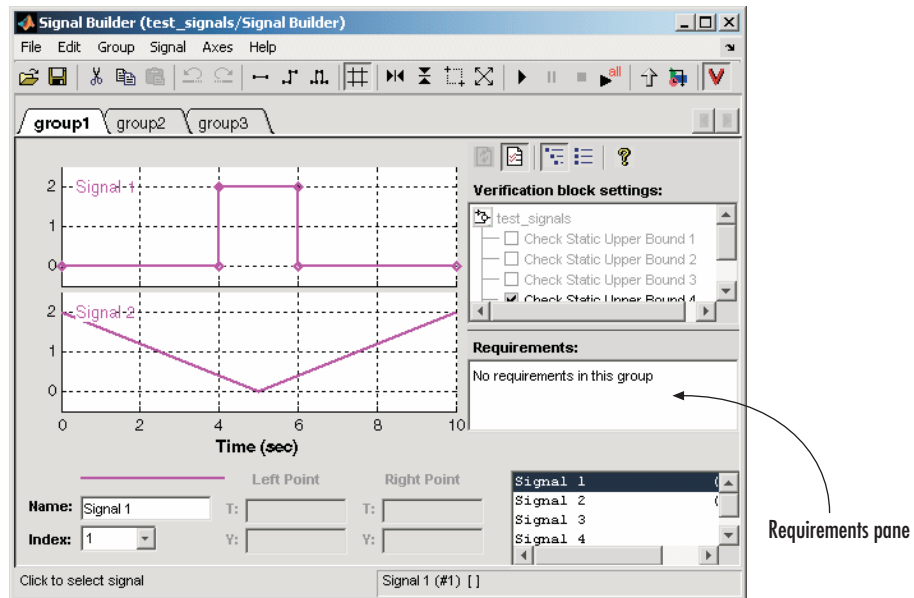
Applying **Block group disable** to the individual block node for Check Static Upper Bound 1 in **group1** disables this block for this group only. This is equivalent to clearing the check box for this node.

Managing Verification Requirements

In “Using the Verification Manager” on page 4-5, you learn how to use the Verification Manager to manage Model Verification blocks along with signal group tests in a Simulink model. The combination of test groups and their schedules of enabled and disabled Model Verification blocks is used to verify the correct behavior for your Simulink model. In this section you learn how to link the requirements to this combination that specify correct behavior.

You can link requirements documents to individual verification blocks just as you can for any Simulink block. See “Adding Requirement Links to an Object” on page 2-8 for details on linking requirements documents to individual Simulink blocks.

You can link requirements documents to test groups and their scheduled Model Verification blocks through the **Requirements** pane of the Verification Manager in the Signal Builder. By default, when you display the Verification Manager in the Signal Builder window, the **Requirements** pane appears, as shown.

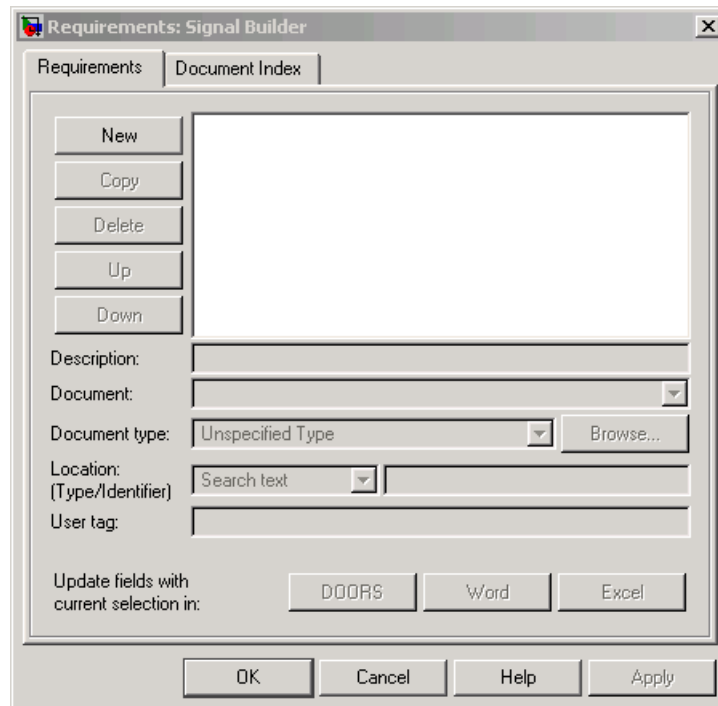


- 1 Right-click anywhere in the **Requirements** pane.

A pop-up menu appears.

- 2 From the pop-up menu, select **Edit/Add Links**.

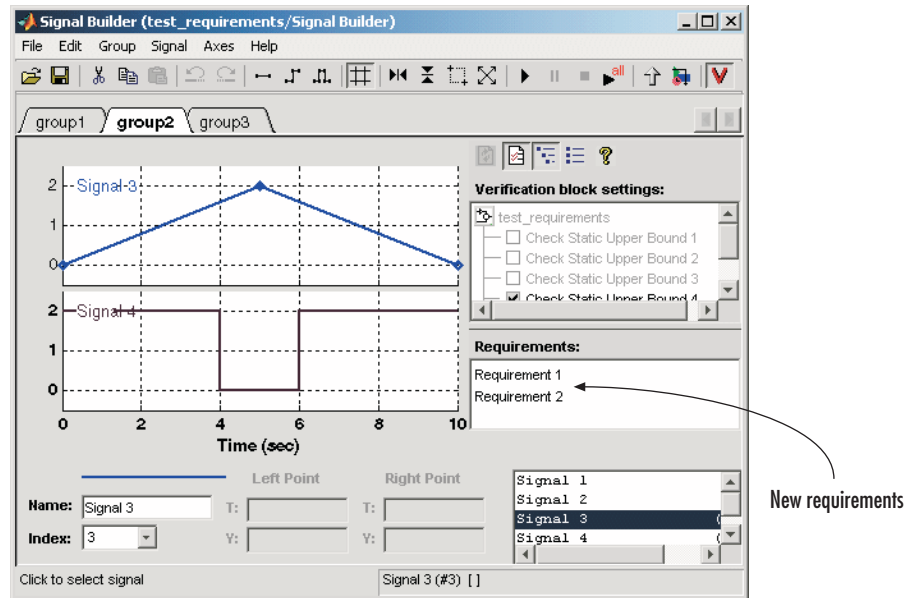
The Requirements dialog box appears, as shown.



You can also access the Requirements dialog box for a Signal Builder block by right-clicking it in the Simulink model and selecting **Edit/Add Requirements**.

- 3 Add links to requirements documents as described in steps 4 through 9 of “Adding Requirement Links to an Object” on page 2-8.

The descriptions for the links that you add appear in the **Requirements** pane, as shown.



- 4 Right-click a requirement link and select **View** to view the requirements document in its native editor.
- 5 Right-click a requirement link and select **Delete** to delete it.

Using Model Coverage

Model coverage helps you to validate your model tests by measuring how thoroughly the model objects are tested. The following sections describe tools in the Simulink Performance Tools that measure and display model coverage for the model.

“Introduction to Model Coverage” (p. 5-3)	Introduces you to the concept of model coverage and how it measures the effectiveness of your model during testing
“Using Model Coverage” (p. 5-7)	Shows you how to use model coverage and the tests to determine the effectiveness of your model during testing
“Specifying Model Coverage Reporting Options” (p. 5-10)	Shows you how to select the model coverage measurements and reports that are performed during simulation
“Understanding Model Coverage Reports” (p. 5-19)	Shows and describes the different parts of a basic model coverage report
“N-Dimensional Lookup Table Report” (p. 5-25)	Describes the interactive chart that summarizes the extent to which elements of a Lookup Table are accessed
“Signal Range Analysis Report” (p. 5-31)	Lists the maximum and minimum signal values at each block in the model measured during simulation

“Colored Simulink Diagram Coverage Display” (p. 5-34)	Shows you how to use the option to display coverage of a model by coloring its elements
“Using Model Coverage Commands” (p. 5-39)	Shows you how to perform and report model coverage tests during simulation with MATLAB commands
“Model Coverage for Embedded MATLAB Function Blocks” (p. 5-45)	How to use model coverage for Embedded MATLAB Function blocks and interpret the results

Introduction to Model Coverage

Model coverage determines the extent to which a model test case exercises simulation pathways through a model. The percentage of pathways that a test case exercises is called its *model coverage*. Model coverage is a measure of how thoroughly a test tests a model. Model coverage therefore helps you to validate your model tests.

How Model Coverage Works

Model coverage works by analyzing the execution of blocks that directly or indirectly determine simulation pathways through your model. If a model includes Stateflow charts, the tool also analyzes the states and transitions of those charts. During a simulation run, the tool records the behavior of the covered blocks, states, and transitions. At the end of the simulation, the tool reports the extent to which the run exercised potential simulation pathways through each covered block.

See “Understanding Model Coverage Reports” on page 5-19 for an example of a model coverage report along with descriptions of the coverages it contains. Before you do, you might need to review the types of coverages that model coverage performs in “Types of Model Coverage” on page 5-3.

Types of Model Coverage

The tool performs any or all of the following types of coverage analysis, depending on the coverage options you select:

- Cyclomatic complexity

Cyclomatic complexity is a measure of the structural complexity of a model. It approximates the McCabe complexity measure for code generated from the model. In general, the McCabe complexity measure is slightly higher because of error checks that the model coverage analysis does not consider.

Model coverage uses the following formula to compute the cyclomatic complexity of an object (block, chart, state, etc.)

$$c = \sum_{1}^N (o_n - 1)$$

where N is the number of decision points that the object represents and o_n is the number of outcomes for the n th decision point. The tool adds 1 to the complexity number computed by this formula for atomic subsystems and Stateflow charts.

- Decision coverage

Examines items that represent decision points in a model, such as a Switch block or Stateflow states. For each item, decision coverage determines the percentage of the total number of simulation paths through the item that the simulation actually traversed.

- Condition coverage

Examines blocks that output the logical combination of their inputs (for example, the Logic block), and Stateflow transitions). A test case achieves full coverage if it causes each input to each instance of a logic block in the model and each condition on a transition to be true at least once during the simulation and false at least once during the simulation. Condition coverage analysis reports for each block in the model whether the test case fully covered the block.

- Modified condition/decision coverage (MC/DC)

Examines blocks that output the logical combination of their inputs (for example, the Logic block), and Stateflow transitions to determine the extent to which the test case tests the independence of logical block inputs and transition conditions. A test case achieves full coverage for a block if, for every input, there is a pair of simulation times when changing that input alone causes a change in the block's output. A test case achieves full coverage for a transition if, for each condition on the transition, there is at least one time when a change in the condition triggers the transition.

- Lookup table (LUT) coverage

Examines blocks, such as the 1D Lookup block, that output the result of looking up one or more inputs in a table of inputs and outputs, interpolating between or extrapolating from table entries as necessary. Lookup table coverage records the frequency that table lookups use each interpolation

interval. A test case achieves full coverage if it executes each interpolation and extrapolation interval at least once. For each LUT block in the model, the coverage report displays a colored map of the lookup table indicating where each interpolation was performed.

Blocks That Receive Model Coverage

The following table lists the Simulink blocks analyzed by the tool and the kind of coverage analysis performed for each block.

Block	Decision	Condition	MC/DC	LUT
1D Lookup				•
2D Lookup				•
ND Lookup				•
ND Interpolation using Prelookup				•
ND Direct Lookup				•
Abs	•			
Combin. Logic	•	•		
Discrete-Time Integrator (when saturation limits are enabled)	•			
Embedded MATLAB Function	•	•	•	
Fcn (Boolean operators only)		•		

Block	Decision	Condition	MC/DC	LUT
For	•			
If	•			
Logic		•	•	
MinMax	•			
Multiport Switch	•			
Rate Limiter	• (Relative to slew rates)			
Relay	•			
Saturation	•			
Stateflow (see note below)	•	•	•	
Subsystem	•	•	•	
Switch	•			
SwitchCase	•			
While	•			

Note Model coverage provides decision coverage for Stateflow states, events, and state temporal logic decisions. It also provides decision, condition, and MCDC coverage for Stateflow transitions. See the section "Understanding Model Coverage for Stateflow Charts" in your Stateflow documentation for details on the model coverage of Stateflow charts.

Using Model Coverage

To develop effective tests with model coverage,

- 1 Develop one or more test cases for your model (see “Creating and Running Test Cases” on page 5-7).
- 2 Run the test cases to verify that the model behavior is correct.
- 3 Analyze the coverage reports produced by Simulink.
- 4 Using the information in the coverage reports, modify the test cases to increase their coverage or add new test cases that cover areas not covered by the current set of test cases.
- 5 Repeat the preceding steps until you are satisfied with the coverage of your test set.

Note Simulink comes with an online demonstration of the use of model coverage to validate model tests. To run the demo, enter `simcovdemo` at the MATLAB command prompt.

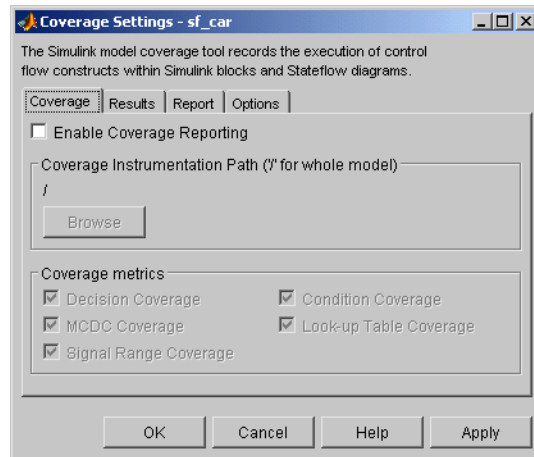
Creating and Running Test Cases

Model coverage provides two MATLAB commands, `cvtest` and `cvsim`, for creating and running test cases. The `cvtest` command creates test cases to be run by the `cvsim` command (see “Creating Tests with `cvtest`” on page 5-39 and “Running Tests with `cvsim`” on page 5-41).

You can also run the coverage tool interactively as follows:

- 1 From the Simulink **Tools** menu, select **Coverage Settings**.

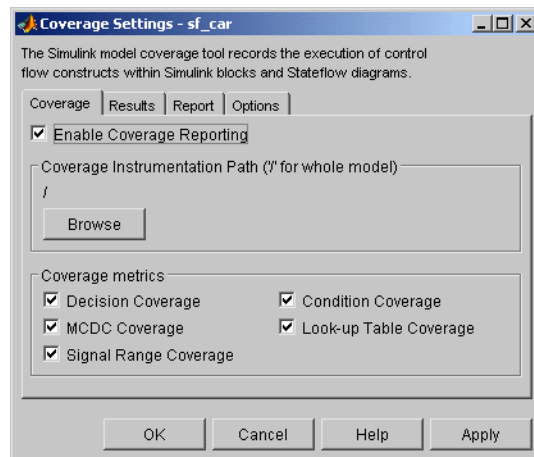
Simulink displays the Coverage Settings dialog box, as shown.



The Coverage Settings dialog box has four tabs. The **Coverage** tab is displayed by default.

2 Select **Enable Coverage Reporting**.

By default, this setting is disabled. When you select it, the **Browse** button for the **Coverage Instrumentation Path** is enabled along with the check boxes of the **Coverage metrics** section, as shown.



Selecting **Enable Coverage Reporting** also enables fields on the other tabs of the Coverage Settings dialog box.

- 3** Select the coverages you want to appear in the coverage report.

For a complete inventory of coverage selections in all four tabs of the Coverage Settings dialog box, see “Specifying Model Coverage Reporting Options” on page 5-10.

- 4** Select **OK** to close the dialog box.

- 5** Select **Start** from the **Simulation** menu or the **Start** button on the Simulink toolbar to start simulation of the model.

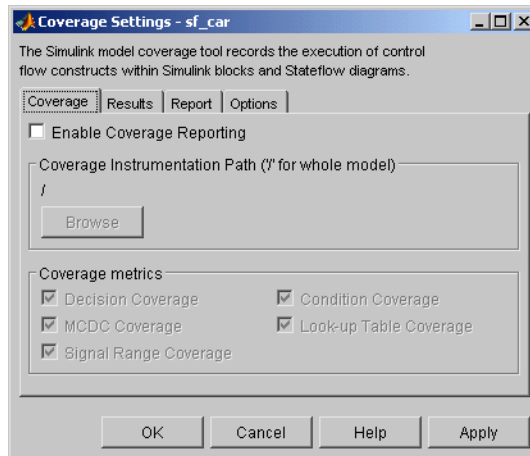
By default, Simulink saves coverage data for the current run in the workspace object `covdata` and cumulative coverage data in `covCumulativeData`. This data appears in an HTML report that is displayed automatically at the end of simulation.

Note You cannot run simulations with both model coverage reporting and acceleration options enabled. Simulink disables model coverage reporting if the accelerator is enabled.

Block reduction optimization and conditional branch input optimization are disabled when you perform coverage analysis because they interfere with coverage recording.

Specifying Model Coverage Reporting Options

A large part of using model coverage is specifying model coverage reporting options in the Coverage Settings dialog box. You open this dialog from the **Tools** menu of a Simulink window by selecting **Coverage Settings**. The Coverage Settings dialog box appears with its **Coverage** tab in focus, as shown.



The following topics describe the settings for each tab of the Coverage Settings dialog box:

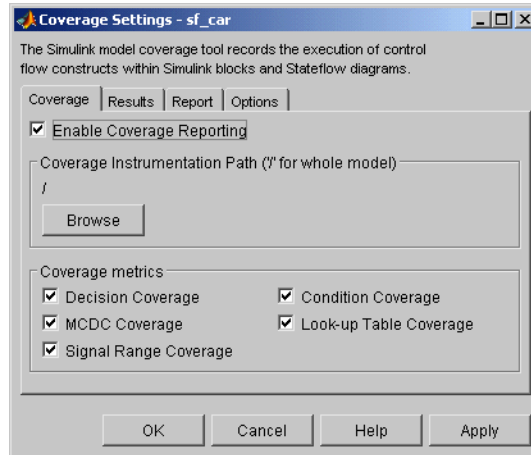
- “Coverage Tab” on page 5-10
- “Results Tab” on page 5-12
- “Report Tab” on page 5-13
- “Options Tab” on page 5-17

Coverage Tab

You select the model coverages calculated during simulation in the fields of the **Coverage** tab of the Coverage Settings dialog box.

Enable Coverage Reporting

Causes Simulink to gather and report the specified model coverages during simulation. When you select the **Enable Coverage Reporting** field, all other fields in the **Coverage** page of the Coverage Settings dialog box are enabled, as shown.



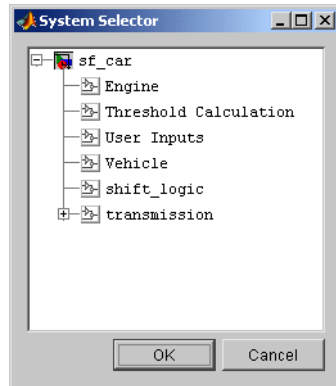
Coverage Instrumentation Path

Path of the subsystem for which Simulink gathers and reports coverage data. By default, Simulink generates coverage data for the entire model.

To restrict coverage reporting to a particular subsystem,

- 1 In the **Coverage** page of the Coverage Settings dialog box, click **Browse**.

Simulink displays a System Selector dialog box.



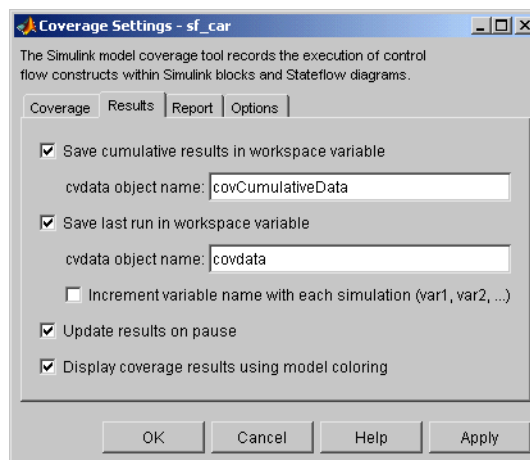
- 2 Select the subsystem for which you want coverage reporting to be enabled and click **OK** to close the dialog box.

Coverage Metrics

Select the types of test case coverage analysis that you want the tool to perform. See “Types of Model Coverage” on page 5-3 for more information.

Results Tab

You select the destination of model coverage results from model coverage in the **Results** page of the Coverage Settings dialog box.



Save Cumulative Results in Workspace Variable

Causes model coverage to accumulate and save the results of successive simulations in the workspace variable specified in the **cvdata object name** field below. The coverage running total in the workspace variable is updated with new results at the end of each simulation.

Save Last Run in Workspace Variable

Causes model coverage to save the results of the last simulation run in the workspace variable specified in the **cvdata object name** field below.

Increment Variable Name with Each Simulation

Causes Simulink to increment the name of the coverage data object variable used to save the last run with each simulation. This prevents the current simulation run from overwriting the results of the previous run.

Update Results on Pause

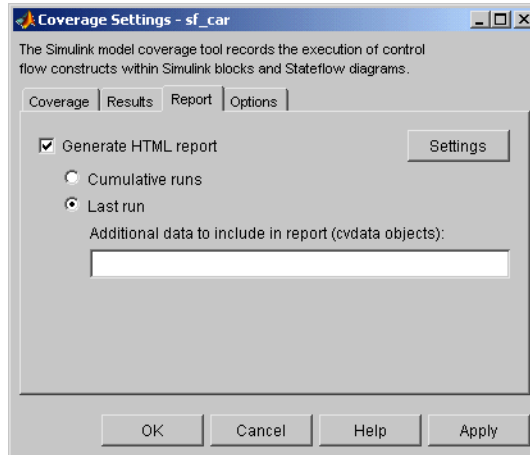
When you pause during simulation the first time, causes the HTML model coverage report to appear with model coverage results recorded up to the pause point. When you resume simulation and later pause or stop simulation, the model coverage report reappears in updated form with coverage results up to the current pause or stop time.

Display Coverage Results Using Model Coloring

After simulation, causes coloring of Simulink blocks according to their level of model coverage. Blocks highlighted in light green received full coverage during testing. Blocks highlighted in light red received incomplete coverage. In addition, model coverage results for each block receiving it is available in context-sensitive form. See “Colored Simulink Diagram Coverage Display” on page 5-34 for a complete description.

Report Tab

You select the model coverage test sessions (runs) reported by model coverage in the **Report** page of the Coverage Settings dialog box.

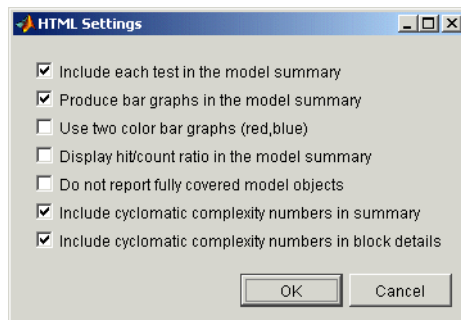


Generate HTML Report

Causes Simulink to create an HTML report containing the coverage data. Simulink displays the report in the MATLAB Help browser at the end of the simulation. Click the **Settings** button to select various reporting options (see “Settings” on page 5-14).

Settings

The HTML Settings dialog box allows you to choose various model coverage report options. To display the dialog box, click **Settings** on the **Report** page of the Coverage Settings dialog box. The HTML Settings dialog box appears.



Include each test in the model summary. When this option is selected, the model hierarchy table at the top of the HTML report includes columns listing the coverage metrics for each test. When this option is not selected, the model summary reports only the total coverage.

Produce bar graphs in the model summary. Causes the model summary to include a bar graph for each coverage result. The bar graphs provide a visual representation of the coverage.

Use two color bar graphs (red, blue). Causes the report to use red and blue bar graphs instead of black and white. The color graphs might not print well in black and white.

Display hit/count ratio in the model summary. Reports coverage numbers as both a percentage and a ratio, e.g., 67% (8/12).

Do not report fully covered model objects. Causes the coverage report to include only model objects that the simulation does not cover fully. This option is useful when you are developing tests, because it reduces the size of the generated reports.

Include cyclomatic complexity numbers in summary. Includes the cyclomatic complexity (see “Types of Model Coverage” on page 5-3) of the model and its top-level subsystems and charts in the report summary. A cyclomatic complexity number shown in boldface indicates that the analysis considered the subsystem itself to be an object when computing its complexity. This occurs for atomic and conditionally executed subsystems as well as Stateflow blocks.

Include cyclomatic complexity numbers in block details. Includes the cyclomatic complexity metric in the block details section of the report.

Cumulative Runs

Display the coverage results from successive simulations in the report.

Whenever the check box **Save cumulative results in workspace variable** in the **Results** page is selected, a coverage running total is updated with new results at the end of each simulation. In a cumulative coverage report the results in the rightmost column reflect that running total value. The report is

organized so that you can easily compare the additional coverage from the most recent run with the coverage from all prior runs in the session.

You can make cumulative coverage results persist between MATLAB sessions by using `cvsave` to save results to a file at the end of the session and `cvload` to load the results at the beginning of the session. Note that the `cvload` parameter `RESTORETOTAL` must be 1 in order to restore cumulative results.

When you save the coverage results to a file using `cvsave` and a model name argument, the file also contains the cumulative running total. When you load that file back into the coverage tool using `cvload`, you can select whether you want to restore the running total from the file.

When you restore a running total from saved data, the saved results are reflected in the next cumulative report that is generated. If a running total already exists when you restore a saved value, the existing value is overwritten.

Whenever you report on more than a single simulation, the coverage displayed for truth tables and lookup-table maps is based on the total coverage of all the reported runs. In the case of a cumulative report, this includes all the simulations where cumulative results were stored.

Calculating cumulative coverage results is also possible at the command line via the `+` operator. The following script demonstrates this usage:

```
covdata1 = cvsim(test1);  
covdata2 = cvsim(test2);  
cvhtml('cumulative_report', covdata + covdata2);
```

Last Run

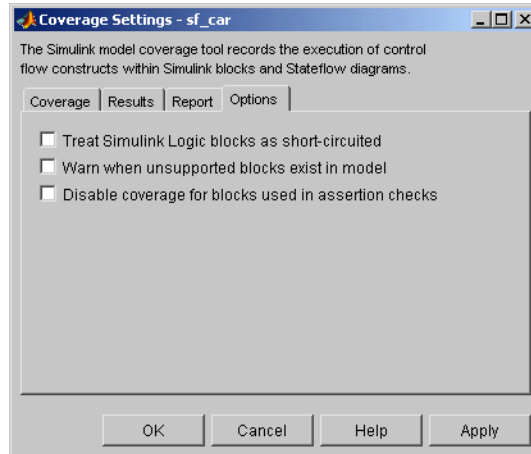
Display only the results of the most recent simulation run in the report.

Additional Data to Include in Report

Names of coverage data from previous runs to include in the current report along with the current coverage data. Each entry causes a new set of columns to appear in the report.

Options Tab

You select important options for model coverage reports in the **Options** page of the Coverage Settings dialog box.



Treat Simulink Logic Blocks as Short-Circuited

Applies only to condition and MC/DC coverage. If enabled, coverage analysis treats Simulink logic blocks as though they short-circuit their input. In other words, Simulink treats such a block as if the block ignores remaining inputs if the previous inputs alone determine the block's output. For example, if the first input to an And block is false, MC/DC coverage analysis ignores the values of the other inputs in determining MC/DC coverage for a test case.

You should select this option if you plan to generate code from a model and want the MC/DC coverage analysis to approximate the degree of coverage that your test cases would achieve for the generated code (most high-level languages short-circuit logic expressions).

Note A test case that does not achieve full MC/DC coverage for non-short-circuited logic expressions might achieve full coverage for short-circuited expressions.

Warn When Unsupported Blocks Exist in a Model

Select this option if you want the tool to warn you at the end of the simulation if the model contains blocks that require coverage analysis but are not currently covered by the tool.

Disable Coverage for Blocks Used in Assertion Checks

Disable coverage of blocks from Simulink's Model Verification library (see the Model Verification category in the Simulink Block Reference documentation).

Understanding Model Coverage Reports

The coverage report generated by model coverage contains the basic reports described in the following topics:

- “Summary Report Section” on page 5-19
- “Details Report Section” on page 5-20
- “Decisions Analyzed Table” on page 5-22
- “Conditions Analyzed Table” on page 5-22
- “MC/DC Analysis Table” on page 5-23

For an understanding of model coverage reports for Stateflow diagrams and their objects, see "Understanding Model Coverage for Stateflow Charts" in Stateflow documentation.

Summary Report Section

The coverage summary section has two subsections: Tests and Summary.

Coverage Report for fuelsys










Tests

Test 1

Started Execution: 05-Apr-2001 15:51:41

Ended Execution: 05-Apr-2001 15:52:08

Summary

Model Hierarchy:	Test 1			
	D1	C1	MCDC	TBL
1. fuelsys	39% 	34% 	13% 	1%
2. . . . EGO_sensor	50% 	NA	NA	NA
3. . . . MAP_sensor	50% 	NA	NA	NA
4. . . . engine_speed	50% 	NA	NA	NA
5. . . . engine_gas_dynamics	60% 	NA	NA	NA
6. Mixing & Combustion	50% 	NA	NA	NA
7. Throttle & Manifold	63% 	NA	NA	NA

The Tests section lists the simulation start and stop time of each test case and any setup commands that preceded the simulation. The heading for each test case includes the test case label, for example "Test throttle," specified using the cvtest command.

The Summary section summarizes the results for each subsystem. Clicking the name of the subsystem takes you to a detailed report for that subsystem.

Details Report Section

The Details section reports the model coverage results in detail.

Details:

1. Model "fuelsys"

Child Systems: [EGO sensor](#), [MAP sensor](#), [engine speed](#), [engine gas dynamics](#), [fuel rate controller](#), [speed sensor](#), [throttle command](#), [throttle sensor](#)

Metric	Coverage (this object)	Coverage (inc. descendants)
Cyclomatic Complexity	1	86
Decision (D1)	NA	38% (53/140) decision outcomes
Condition (C1)	NA	34% (11/32) condition outcomes
MCDC (C1)	NA	13% (2/16) conditions reversed the outcome
Look-up Table	NA	1% (15/1508) interpolation intervals

2. Subsystem "[EGO sensor](#)"

Parent: [/fuelsys](#)

Metric	Coverage (this object)	Coverage (inc. descendants)
Cyclomatic Complexity	0	1
Decision (D1)	NA	50% (1/2) decision outcomes

Switch block "[Switch](#)"

Parent: [fuelsys/EGO sensor](#)

Uncovered Links: 

Metric	Coverage
Cyclomatic Complexity	1
Decision (D1)	50% (1/2) decision outcomes

Decisions analyzed:

logical trigger input	50%
false (output is from 3rd input port)	0/17940
true (output is from 1st input port)	17940/17940

The Details section starts with a summary of results for the model as a whole followed by a list of subsystems and charts that the model contains. Subsections on each subsystem and chart follow. Clicking the name of a subsystem or chart in the model summary takes you to a detailed report on that subsystem or chart. The section for each subsystem starts with a summary of the test coverage results for the subsystem and a list of the subsystems that it contains. The overview is followed by block reports, one for each block that contains a decision point in the subsystem.

Each section of the detailed report summarizes the results for the metrics used to test the object (model, subsystem, chart, block) to which the section

applies. The sections for models and subsystems give results for the model and subsystem considered as a covered object and for the contents of the model or subsystem.

You can also access an individual object's subsection of the Details section from the Simulink model as follows:

- 1 Right-click a Simulink block

A pop-up menu appears.

- 2 In the pop-up menu, select **Coverage**, and from the resulting pop-up submenu, select **Report**.

The model coverage report appears, scrolled to the applicable Details subsection.

Each section can include coverage results for more than one simulation run. The report displays the results for each simulation run in a separate column. A numeric prefix in the column heading indicates the run that produced the data.

Decisions Analyzed Table

This table lists possible outcomes for a decision and the number of times that an outcome occurred in each test simulation.

Decisions analyzed:

logical trigger input	50%
false (output is from 3rd input port)	0/17940
true (output is from 1st input port)	17940/17940

The report highlights outcomes that did not occur in red. Clicking the block name causes Simulink to display the block diagram containing the block. Simulink also highlights the block to help you find it in the diagram.

Conditions Analyzed Table

This table lists the number of occurrences of true and false conditions on each input port of a block.

Conditions analyzed:

Description:	#1 T	#1 F
input port 1	481	17060
input port 2	0	17541

MC/DC Analysis Table

This table lists the MC/DC input condition cases represented by the corresponding block and the extent to which the reported test cases cover the condition cases.

MC/DC analysis (combinations in parentheses did not occur)

Decision/Condition:	#1 True Out	#1 False Out
expression for output		
input port 1	FF	TF
input port 2	FF	(FT)

Each row of the table represents a condition case for a particular input to the block. A condition case for input *n* of a block is a combination of input values such that changing the value of input *n* alone is sufficient to change the value of the block's output. Input *n* is called the *deciding input* of the condition case.

The table uses a condition case expression to represent a condition case. A condition case expression is a character string where

- The position of a character in the string corresponds to the input port number.
- The character at the position represents the value of the input (T means true, F means false).
- Boldfacing a character indicates that it corresponds to the value of the deciding input.

For example, FTF represents a condition case for a three-input block where the second input is the deciding input.

The table's **Decision/Condition** column specifies the deciding input for an input condition case. The **#1 True Out** column specifies the deciding input value that causes the block to output a true value for a condition case. The

#1 True Out entry uses a condition case expression, for example, FF, to express the values of all the inputs to the block, with the value of the deciding variable indicated by boldfacing.

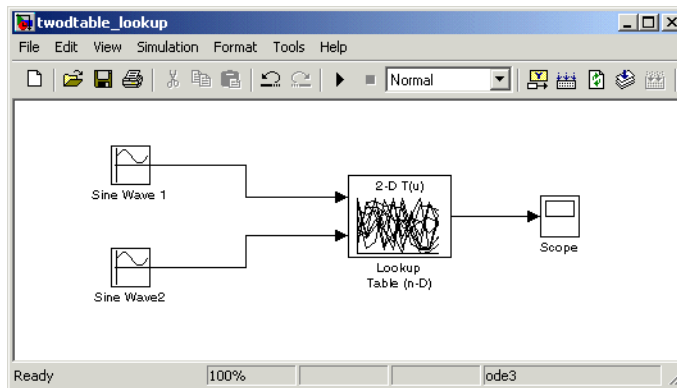
Parentheses around the expression indicate that the specified combination of inputs did not occur during the first (or only) test case included in this report. In other words, the test case did not cover the corresponding condition case. The **#1 False Out** column specifies the deciding input value that causes the block to output a false value and whether the value actually occurred during the first (or only) test case included in the report. The report adds additional **#n True Out** and **#n False out** columns for additional test cases, where n is the number of the test case.

If you select **Treat Simulink Logic blocks as short-circuited** in the Coverage Settings dialog box (see “Specifying Model Coverage Reporting Options” on page 5-10), MC/DC coverage analysis does not check whether short-circuited inputs actually occur. The MC/DC details table uses an x in a condition expression (e.g., TFxxx) to indicate short-circuited inputs that were not analyzed by the tool.

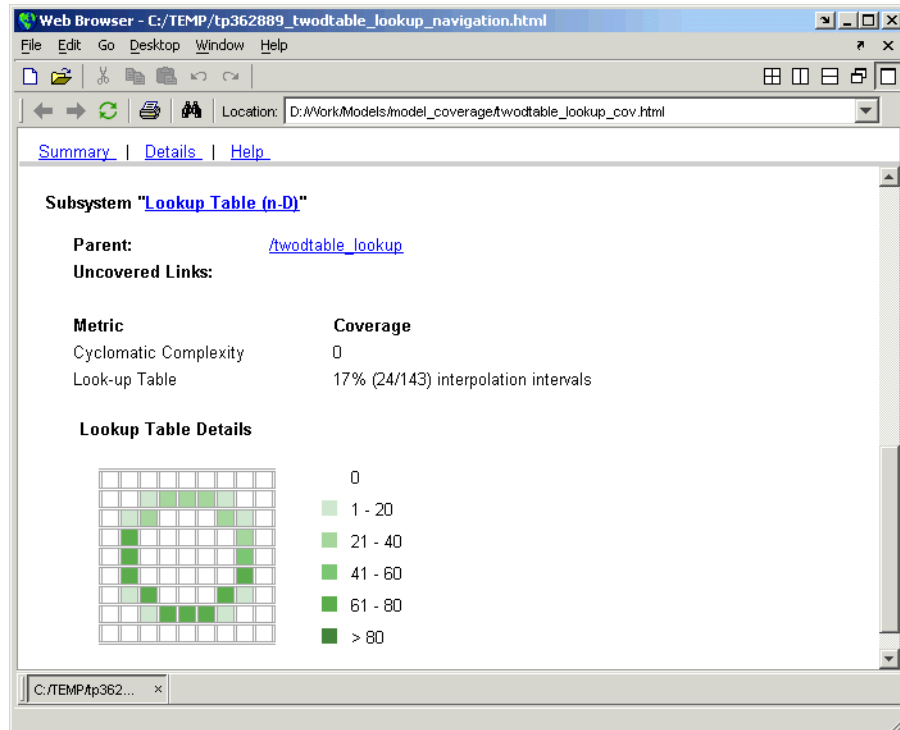
Navigation Arrows. The section for each block contains a backward and a forward arrow. Clicking the forward arrow takes you to the next section in the report that lists an uncovered outcome. Clicking the back arrow takes you back to the previous uncovered outcome in the report.

N-Dimensional Lookup Table Report

This report section displays an interactive chart that summarizes the extent to which elements of a Lookup Table are accessed. In the following example, a Lookup Table of 10-by-10 elements filled with random values is accessed with x and y indices generated from two Sine Wave blocks.



In this example, table indices are 1, 2,..., 10 in each direction. The Sine Wave2 block is out of phase with the Sine Wave1 block by $\pi/2$ radians. This generates x and y numbers for the edge of a circle, which becomes apparent when you examine the resulting Lookup Table coverage.

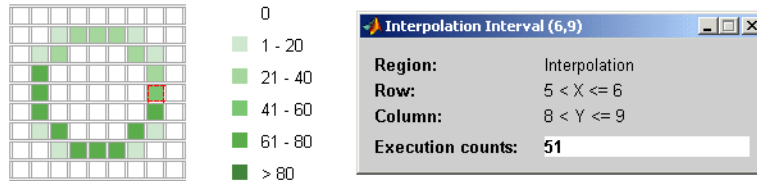


The report contains a two-dimensional table representing the elements of the Lookup Table. The element indices are represented by the cell border grid lines, which number 10 in each dimension. Areas where the Lookup Table interpolates between table values are represented by the cell areas. Areas of extrapolation left of element 1 and right of element 10 are represented by cells at the edge of the table, which have no outside border.

The number of values interpolated (or extrapolated) for each cell (*execution counts*) during testing is represented by a shade of green assigned to the cell. Each of six levels of shading and the range of execution counts represented are displayed on the side of the table.

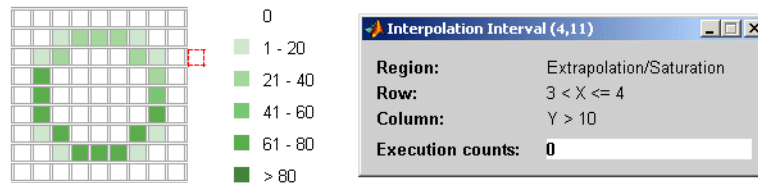
If you click an individual table cell, you receive a dialog that displays the index location of the cell and the exact number of execution counts generated for it during testing. The following example shows the contents of a color shaded cell on the right edge of the circle:

Lookup Table Details



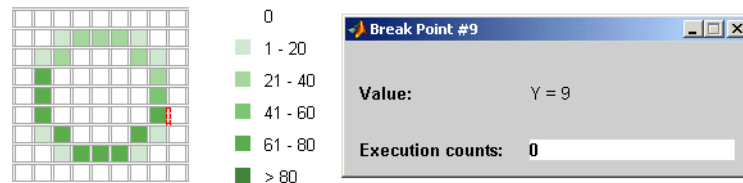
Notice that the selected cell is outlined in red. You can also click on extrapolation cells on the edge of the table, as shown.

Lookup Table Details

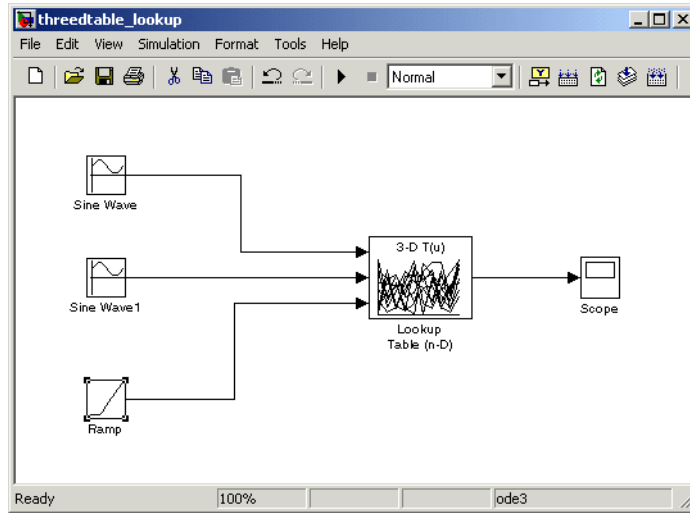


A bold grid line indicates that at least one block input equal to its exact index value occurred during the simulation. Click the border to display the exact number of hits for that index value, as shown in the following example:

Lookup Table Details

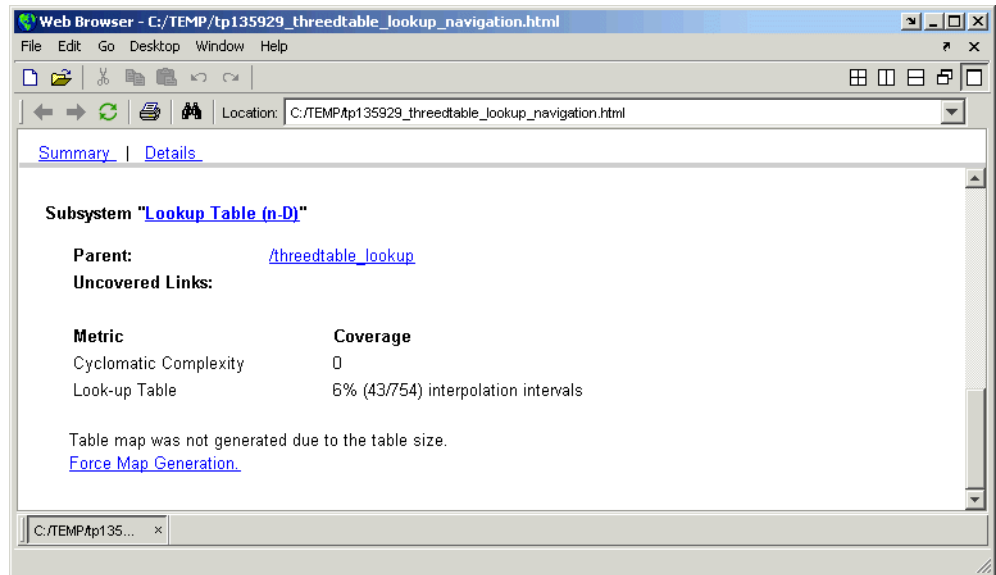


The following example model uses a Lookup Table of 10-by-10-by-5 elements filled with random values.

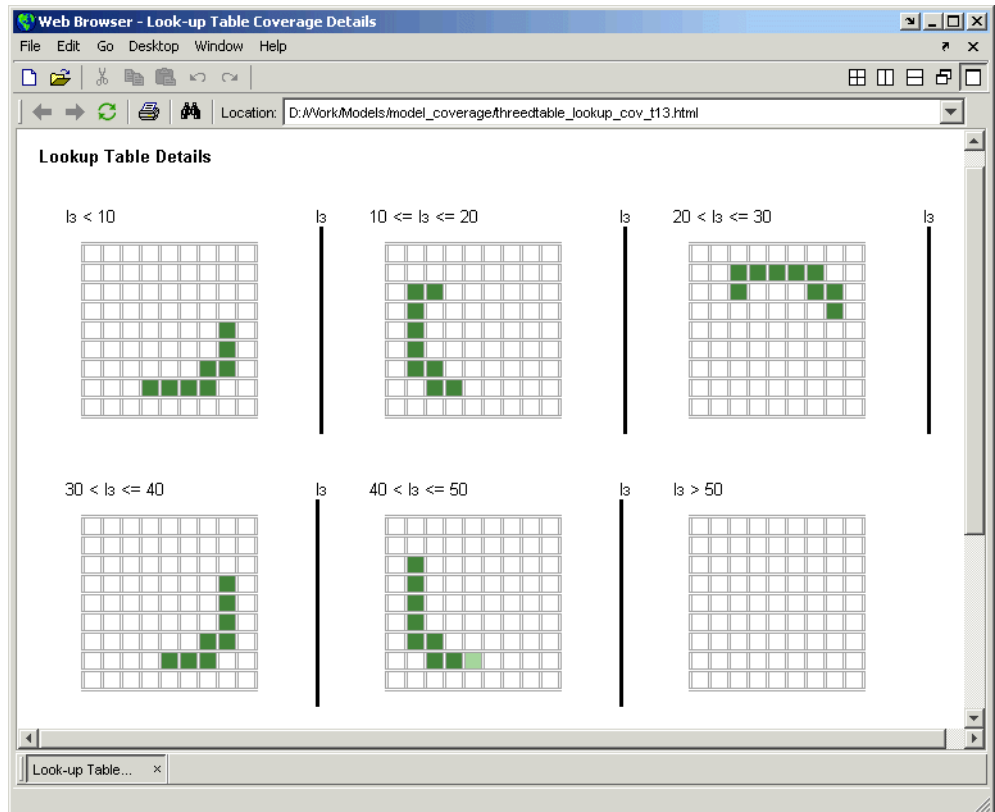


Both the x and y table axes have the indices 1, 2,..., 10, while the z axis has the indices 10, 20,...,50. Lookup Table values are accessed with x and y indices generated from the two Sine Wave blocks in the preceding example, and a z index generated from a Ramp block.

After simulation, the following Lookup Table report appears:



Instead of a two-dimensional table, the link Force Map Generation appears, which displays the following tables:



Notice that Lookup Table coverage for a three-dimensional Lookup Table block is reported as a set of two-dimensional tables. If you overlay these tables last on top of first, you notice that the coverage values corkscrew up to the reader.

The vertical bars represent the exact z index values: 10, 20, 30, 40, 50. If a vertical bar is bold, this indicates that at least one block input was equal to the exact index value it represents during the simulation. Click a bar to get a report of coverage for the exact index value it represents.

You can report Lookup Table coverage for Lookup Tables of any dimension. Coverage for four-dimensional tables is reported as sets of three-dimensional sets like those in the preceding example. Five-dimensional tables are reported as sets of sets of three-dimensional sets, and so on.

Signal Range Analysis Report

If you select **Signal Range Coverage** in the Coverage Settings dialog box, you receive a Signal Range Analysis report at the bottom of the model coverage report. This report gives you the maximum and minimum signal values at each block in the model measured during simulation.

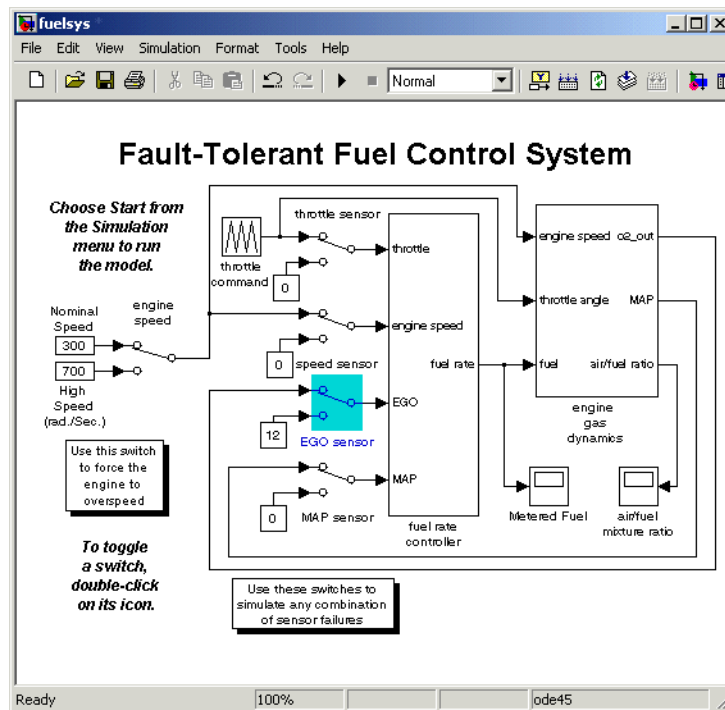
Note When **Inline parameters** is enabled, some signal range information may be missing (for example, if there is a gain with a value of 1). To get a complete signal range report, clear the **Inline parameters** option on the **Optimization** pane of the model's active configuration set.

You can access the Signal Range Analysis report quickly with the **Signal Ranges** link in the nonscrolling region at the top of the model coverage report, as shown for the fuelsys model.

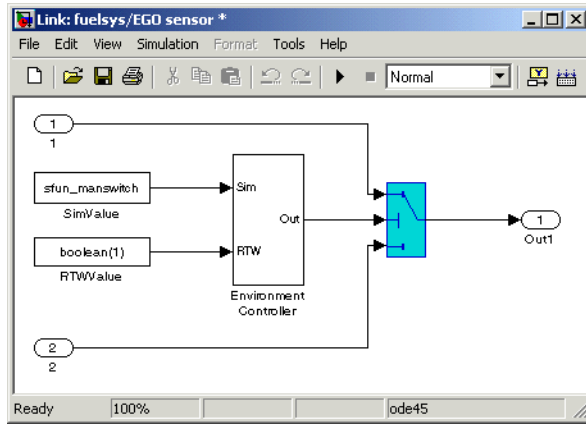
Hierarchy	Min value	Max value
fuelsys		
... Constant2	0	0
... Constant3	12	12
... Constant4	0	0
... Constant5	0	0
... High Speed (rad/Sec.)	700	700
... Nominal Speed	300	300
... EGO sensor		
..... Switch	0.180421	12
..... RTWValue	0	1

Link to Signal Range Coverage report

Each block is reported in hierarchical fashion: child blocks are displayed directly under parent blocks. Each block name in the signal report is a link that brings the block into immediate focus. For example, selecting the link EGO sensor displays this block highlighted in its native diagram, as shown.



Selecting the link Switch displays this block in its own subsystem by looking under the mask for EGO sensor, as shown.



Colored Simulink Diagram Coverage Display

Model coverage displays model coverage results for individual blocks directly in Simulink diagrams. If you enable this feature, model coverage does the following:

- Highlights (colors) blocks that have received model coverage during simulation
- Provides a context-sensitive display of summary model coverage information for each block

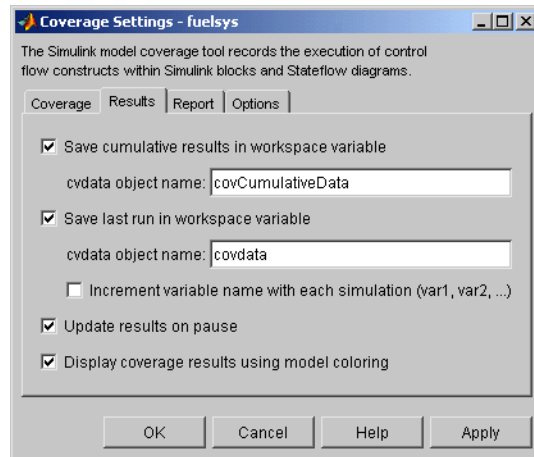
Use the following topics to learn how to enable and interpret colored diagram coverage display:

- “Enabling the Colored Diagram Display” on page 5-34
- “Displaying Model Coverage with Model Coloring” on page 5-35
- “Accessing Coverage Information for Colored Blocks” on page 5-37

Enabling the Colored Diagram Display

You enable the model coverage colored diagram display as follows:

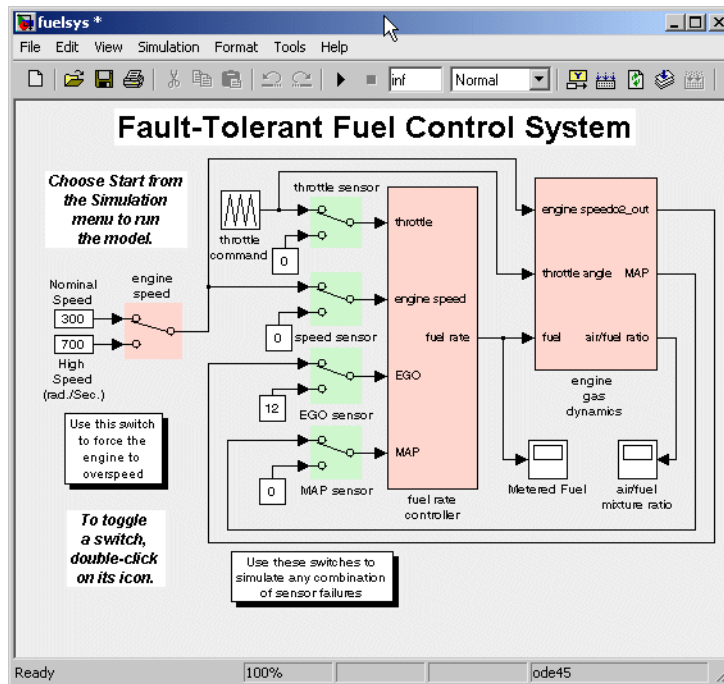
- 1** In the Simulink window, from the **Tools** menu, select **Coverage Settings**.
The Coverage Settings dialog box appears.
- 2** In the **Coverage** tab of the Coverage Settings dialog box, select **Enable Coverage Reporting**.
- 3** Select the **Results** tab, as shown.



The **Display coverage results using model coloring** option is selected by default for all models. This check box becomes visible only after **Enable Coverage Reporting** is enabled in the **Coverage** tab. You can disable this option for the current session by clearing this check box.

Displaying Model Coverage with Model Coloring

You enable display coverage as described in “Enabling the Colored Diagram Display” on page 5-34. After you enable this display, any time that the model generates a model coverage report, individual blocks receiving coverage are highlighted with light green or light red, as shown.



For users seeing the above figure in black and white, the colored blocks are marked with a **G** (light green) or a **R** (light red) in their lower right-hand corner. The light green Manual Switch blocks received full coverage during testing. The light red blocks (the engine speed Manual Switch block, and the fuel rate controller and engine gas dynamics subsystems) received incomplete coverage during testing. Blocks with no color highlighting (the Constant blocks, Scope blocks, and the throttle command Repeating Sequence block) received no coverage at all.

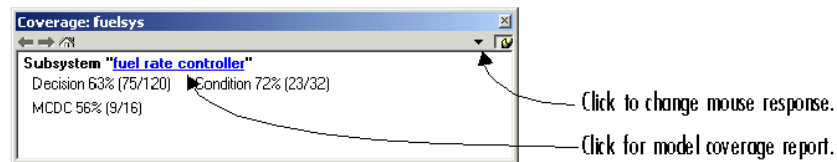
Note To restore the Simulink model diagram to its original colors, right-click a colored block and select **Coverage** from the resulting context menu followed by **Remove information** from the resulting submenu.

Accessing Coverage Information for Colored Blocks

“Displaying Model Coverage with Model Coloring” on page 5-35 describes the highlighted Simulink display that appears after simulation when you enable display coverage with model coloring in the coverage settings for the model. Along with the highlighted Simulink display, a Coverage Display window appears, as shown.



If you click a colored block in the Simulink model, its summarized coverage appears in the Coverage Display window. In the preceding example, the following summary report appears when you click the `fuel` rate controller subsystem block:



Summary coverage information appears in the Coverage Display window for the block, whose hyperlinked name appears at the top of the window. Click the hyperlink to access the appropriate section of the coverage report for this block. You can also see this section of the report by right-clicking the block and selecting **Coverage > Report**.

You can set the Coverage Display window to display coverage for a block in response to a hovering mouse cursor instead of a mouse click in one of two ways:

- Select the down arrow on the right side of the Coverage Display window, and, from the resulting menu, select **Focus**.

- Right-click a colored block and select **Coverage** from the resulting context menu followed by **Display details on mouse-over** from the resulting submenu.

Using Model Coverage Commands

Using model coverage commands lets you automate the entire model coverage process with MATLAB scripts. You can use model coverage commands in MATLAB to completely set up model coverage tests, execute them in simulation, store the results, and report them.

Use the following topics, in the order of the work flow of creating, running, storing, and reporting model coverage tests to understand model coverage commands:

- “Creating Tests with `cvtest`” on page 5-39 — Start the process by creating a test object that specifies the model or part of the model tested.
- “Running Tests with `cvsim`” on page 5-41 — Execute (simulate) the test object. This creates a results object for the test object.
- “Producing HTML Reports with `cvhtml`” on page 5-42 — Create a report for the results object.
- “Saving Test Runs to a File with `cvsave`” on page 5-42 — Save the test object and its results object in a file.
- “Loading Stored Coverage Test Results with `cvload`” on page 5-43 — Load the file containing test and results objects to create new reports of model coverage data.

Creating Tests with `cvtest`

The `cvtest` command creates a test specification object. Once you create the object, you simulate it with the `cvsim` command.

The call to `cvtest` has the following default syntax:

```
cvto = cvtest(root)
```

`root` is the name of, or a handle to, a Simulink model or a subsystem of a model. `cvto` is a handle to the resulting test specification object. Only the specified model or subsystem and its descendants are subject to model coverage testing.

The following command creates a test object with a specified label used for reporting results:

```
cvto = cvtest(root, label)
```

The following command creates a test with a setup command:

```
cvto = cvtest(root, label, setupcmd)
```

The setup command is executed in the base MATLAB workspace just prior to running the instrumented simulation. This command is useful for loading data prior to a test.

The returned `cvtest` object, `cvto`, has the following structure.

Field	Description
<code>id</code>	Read-only internal data-dictionary ID
<code>modelcov</code>	Read-only internal data-dictionary ID
<code>rootPath</code>	Name of the system or subsystem instrumented for analysis
<code>label</code>	String used when reporting results
<code>setupCmd</code>	Command executed in the base workspace just prior to simulation.
<code>settings.condition</code>	Set to 1 if condition coverage is desired
<code>settings.decision</code>	Set to 1 if decision coverage is desired
<code>settings.mcdc</code>	Set to 1 if MC/DC coverage is desired
<code>settings.sigRange</code>	Set to 1 if signal range coverage is desired
<code>settings.tableExec</code>	Set to 1 if lookup table coverage is desired

Running Tests with `cvsim`

Once you create a test specification object, you simulate it with the `cvsim` command.

Note You do not have to enable model coverage reporting for the model (see “Creating and Running Test Cases” on page 5-7) to use the `cvsim` command.

The call to `cvsim` has the following default syntax:

```
cvdo = cvsim(cvto)
```

This command executes the `cvtest` object `cvto` by starting a simulation run for the corresponding model. The results are returned in the `cvdata` object `cvdo`.

You can also control the simulation in a `cvsim` command by using parameters for the MATLAB `sim` command, as shown in the following examples:

- The following command returns the simulation time vector `t`, matrix of state values `x`, and matrix of output values `y`.

```
[cvdo,t,x,y] = cvsim(cvto)
```

- The following command overrides default simulation values with new values.

```
[cvdo,t,x,y] = cvsim(cvto, timespan, options)
```

See online help for the MATLAB `sim` command for descriptions of the parameters `t`, `x`, `y`, `timespan`, and `options` in the previous examples.

You can execute multiple test objects with the `cvsim` command. The following command executes a set of coverage test objects, `cvto1`, `cvto2`, ... and returns the results in a set of `cvdata` objects, `cvdo1`, `cvdo2`,

```
[cvdo1, cvdo2, ...] = cvsim(cvto1, cvto2, ...)
```

You can also use the `cvsim` command to create and execute a `cvtest` object in one command as shown in the following example:

```
[cvdo,t,x,y] = cvsim(cvto, label, setupcmd)
```

Producing HTML Reports with `cvhtml`

Once you run a test in simulation with `cvsim`, you produce results that are saved to `cvdata` objects in MATLAB. Use the `cvhtml` command to produce an HTML report of these objects.

The following command creates an HTML report of the coverage results in the `cvdata` object `cvdo`, which is written to the file `file` in the current MATLAB directory:

```
cvhtml(file, cvdo)
```

The following example creates a combined report of several `cvdata` objects:

```
cvhtml(file, cvdo1, cvdo2, ...)
```

The results from each object are displayed in a separate column of the HTML report. Each `cvdata` data object must correspond to the same root model or subsystem, or the function produces errors.

You can specify the detail level of the report with the value of `detail`, an integer between 0 and 3, as shown in the following example:

```
cvhtml(file, cvdo1, cvdo2, ..., detail)
```

Greater numbers for `detail` indicate greater detail. The default value is 2.

Saving Test Runs to a File with `cvsave`

Once you run a test with `cvsim`, save its coverage tests and results to a file with the function `cvsave`:

```
cvsave(filename, model)
```

Save all the tests and results related to `model` in the text file `filename.cvt`:

```
cvsave(filename, cvto1, cvto2, ...)
```

Save the specified tests in the text file `filename.cvt`. Information about the referenced models is also saved.

You can also save specified `cvdata` objects to file. The following example saves the tests, test results, and referenced models' structure in `cvdata` objects to the text file `filename.cvt`:

```
cvsave(filename, cvdo1, cvdo2, ...)
```

Loading Stored Coverage Test Results with `cvload`

The `cvload` command loads into memory the coverage tests and results stored in a file by the `cvsave` command. The following example loads the tests and data stored in the text file `filename.cvt`:

```
[cvtos, cvdos] = cvload(filename)
```

The `cvtest` objects that are successfully loaded are returned in `cvtos`, a cell array of `cvtest` objects. The `cvdata` objects that are successfully loaded are returned in `cvdos`, a cell array of `cvdata` objects. `cvdos` has the same size as `cvtos`, but can contain empty elements if a particular test has no results.

In the following example, if `restorettotal` is 1, the cumulative results from prior runs are restored:

```
[cvtos, cvdos] = cvload(filename, restorettotal)
```

If `restorettotal` is unspecified or 0, the model's cumulative results are cleared.

cvload Special Considerations

The following are some special considerations for using the `cvload` command:

- If a model with the same name exists in the coverage database, only the compatible results are loaded from the file and they reference the existing model to prevent duplication.
- If the Simulink models referenced in the file are open but do not exist in the coverage database, the coverage tool resolves the links to the models that are already open.

- When you are loading several files that reference the same model, only the results that are consistent with the earlier files are loaded.

Coverage Script Example

The following example demonstrates some of the common model coverage commands:

```
testObj1 = cvtest('ratelim_harness/Adjustable Rate Limiter');
testObj1.label = 'Gain within slew limits';
testObj1.setupCmd = 'load(''within_lim.mat'');';
testObj1.settings.mcdc = 1;

testObj2 = cvtest('ratelim_harness/Adjustable Rate Limiter');
testObj2.label = 'Rising gain that temporarily exceeds slew
limit';
testObj2.setupCmd = 'load(''rising_gain.mat'');';
testObj2.settings.mcdc = 1;

[dataObj1,T,X,Y] = cvsim(testObj1,[0 2]);
[dataObj2,T,X,Y] = cvsim(testObj2,[0 2]);

cvhtml('ratelim_report',dataObj1,dataObj2);
cumulative = dataObj1+dataObj2;
cvsave('ratelim_testdata',cumulative);
```

In this example, you create two `cvtest` objects, `testObj1` and `testObj2`, and simulate them according to their specifications. Each `cvtest` object uses the `setupCmd` property to load a data file prior to simulation. Decision coverage is enabled by default, and MC/DC coverage is enabled as well. After simulation you use `cvhtml` to display the coverage results for two tests and the cumulative coverage. Lastly, you compute cumulative coverage with the `+` operator and save the results. For more detailed examples of how to use the model coverage commands, see `simcovdemo.m` and `simcovdemo2.m` in the coverage root folder.

Model Coverage for Embedded MATLAB Function Blocks

This section describes the model coverage for an Embedded MATLAB Function block function. Model coverage reports tell you what decision outcomes occur during simulation and the values of the conditions that they depend on. See the following topics for a description of Embedded MATLAB Function block model coverage elements and model coverage for an example Embedded MATLAB Function block function:

- “Types of Model Coverage in Embedded MATLAB Function Blocks” on page 5-45 — Lists the types of elements in an Embedded MATLAB Function block function that receive model coverage during simulation
- “Creating a Model with Embedded MATLAB Function Block Decisions” on page 5-46 — Creates an Embedded MATLAB Function block with decisions and conditions that you execute later during simulation
- “Understanding Embedded MATLAB Function Block Model Coverage” on page 5-49 — Describes the individual coverages reported in the model coverage report for the example Embedded MATLAB Function block

Note Model coverage is available to you if you have the Simulink Performance Tools license.

Types of Model Coverage in Embedded MATLAB Function Blocks

During simulation, the following Embedded MATLAB Function block function statements are tested for decision coverage:

- Function header — Decision coverage is 100% if the function or subfunction is executed.
- `if` — Decision coverage is 100% if the `if` expression evaluates to true at least once, and false at least once.
- `switch` — Decision coverage is 100% if every switch case is taken, including the fall-through case.

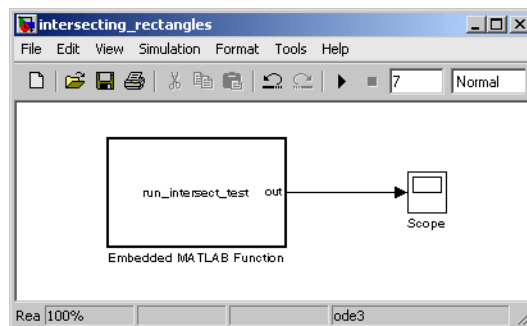
- **for** — Decision coverage is 100% if the equivalent loop condition evaluates to true at least once, and false at least once.
- **while** — Decision coverage is 100% if the equivalent loop condition evaluates to true at least once, and false at least once.

During simulation, the following logical conditions are tested for condition coverage and MCDC coverage in the Embedded MATLAB Function block function:

- **if** statement conditions
- **while** statement conditions, if present

Creating a Model with Embedded MATLAB Function Block Decisions

In this topic you use an example model to examine model coverage of an Embedded MATLAB Function block in Simulink. The following model contains a single Embedded MATLAB Function block with output data sent to a Scope block.



Double-click the Embedded MATLAB Function block to specify its program content as shown.

The screenshot shows the Embedded MATLAB Editor interface. The main window title is "Embedded MATLAB Editor - Block: intersecting_rectangles/Embedded MATLAB Function". The code is as follows:

```

1  function out = run_intersect_test
2  % Call rect_intersect to see if a moving test rectangle
3  % and a stationary rectangle intersect
4
5  x1 = x1+1;
6  y1 = y1+1;
7  out = rect_intersect([x1 y1 2 2],[2 4 2 2]);
8
9  function out = rect_intersect(rect1,rect2)
10 % Return 1 if two rectangle arguments intersect; 0 if not.
11
12 left1 = rect1(1);
13 bottom1 = rect1(2);
14 right1 = left1 + rect1(3);
15 top1 = bottom1 + rect1(4);
16
17 left2 = rect2(1);
18 bottom2 = rect2(2);
19 right2 = left2 + rect2(3);
20 top2 = bottom2 + rect2(4);
21
22 if (top1 < bottom2 || top2 < bottom1)
23     out = 0;
24 else
25     if (right1 < left2 || right2 < left1)
26         out = 0;
27     else
28         out = 1;
29     end
30 end

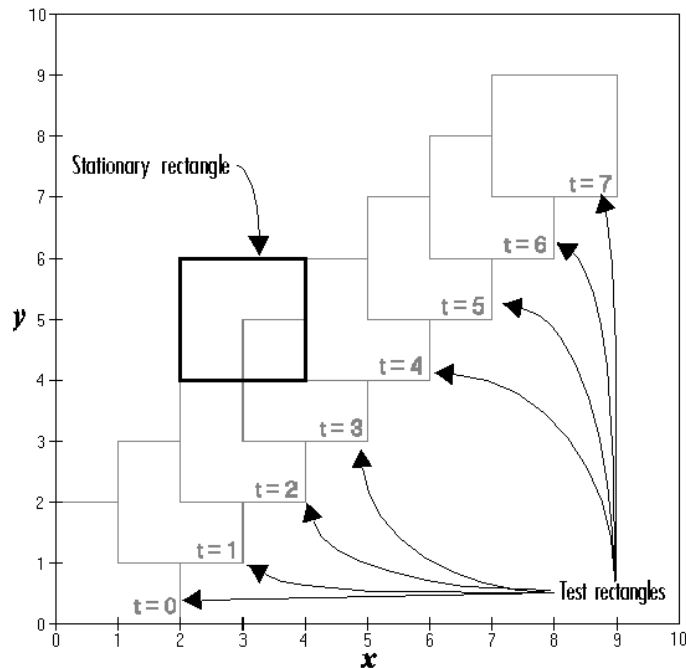
```

Annotations in the image point to specific parts of the code:

- Function:** Points to the first function definition line (line 1).
- Subfunction:** Points to the second function definition line (line 9).
- Decisions:** Points to the two conditional statements (lines 22 and 25).

The `run_intersect_test` Embedded MATLAB Function block contains two functions. The top-level function, `run_intersect_test`, sends the coordinates for two rectangles, one fixed and the other moving, as arguments to the subfunction `rect_intersect`, which tests for intersection between the two. The origin of the moving rectangle increases by 1 in the x and y directions with each time step.

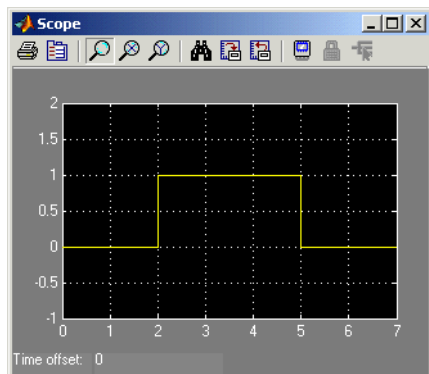
The coordinates for the origin of the moving test rectangle are represented by local data `x1` and `y1`, which are both initialized to -1. For the first sample, `x1` and `y1` are both incremented to 0. From then on, the progression of rectangle arguments during simulation is as follows:



The fixed rectangle is shown in bold with a lower left origin of $(2, 4)$ and a width and height of 2. At time $t = 0$, the first test rectangle has an origin of $(0, 0)$ and a width and height of 2. For each succeeding sample, the origin of the test rectangle is incremented by $(1, 1)$. The rectangles at sample times $t = 2, 3,$ and 4 intersect with the test rectangle.

The subfunction `rect_intersect` checks to see if its two rectangle arguments intersect. Each argument consists of coordinates for the lower left corner of the rectangle (origin), and its width and height. x values for the left and right sides and y values for the top and bottom are calculated for each rectangle and compared in nested `if-else` decisions. The function returns a logical value of 1 if the rectangles intersect and 0 if they do not.

Scope output during simulation, which plots the return value against the sample time, confirms the intersecting rectangles for sample 2, 3, and 4 as shown.



Understanding Embedded MATLAB Function Block Model Coverage

Model coverage reports are generated automatically after a simulation if you specify them. See “Creating and Running Test Cases” on page 5-7 for instructions on how to specify a model coverage report.

When simulation is finished, the model coverage report appears in a browser window. After the summary for the model, the Details section of the model coverage report reports on each of the parts of the model. Model coverage for the parts of the example model in “Creating a Model with Embedded MATLAB Function Block Decisions” on page 5-46 appears in the following model-block-function order.

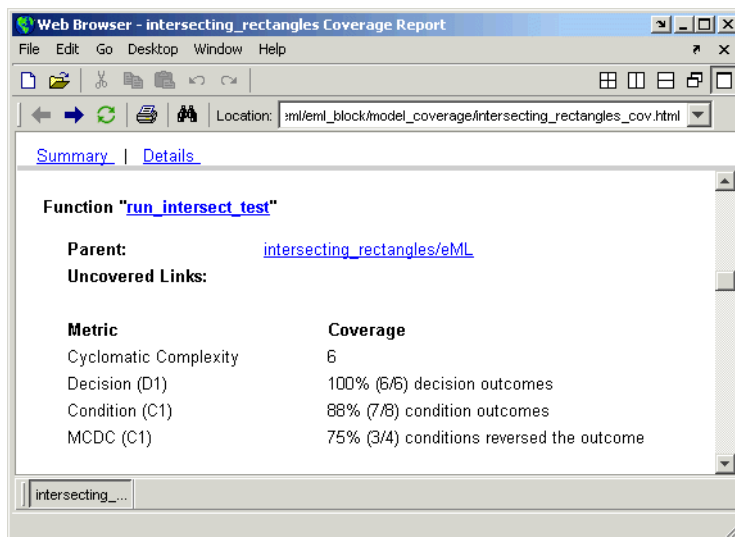
Model:	intersecting_rectangles
Block:	Embedded MATLAB Function
Function:	run_intersect_test
Decision Lines:	1: function out = rect_intersect_test
	9: function out = rect_intersect(rect1, rect2)

	22: if (top1 < bottom2 top2 < bottom1)
	25: if (right1 < left2 right2 < left1)

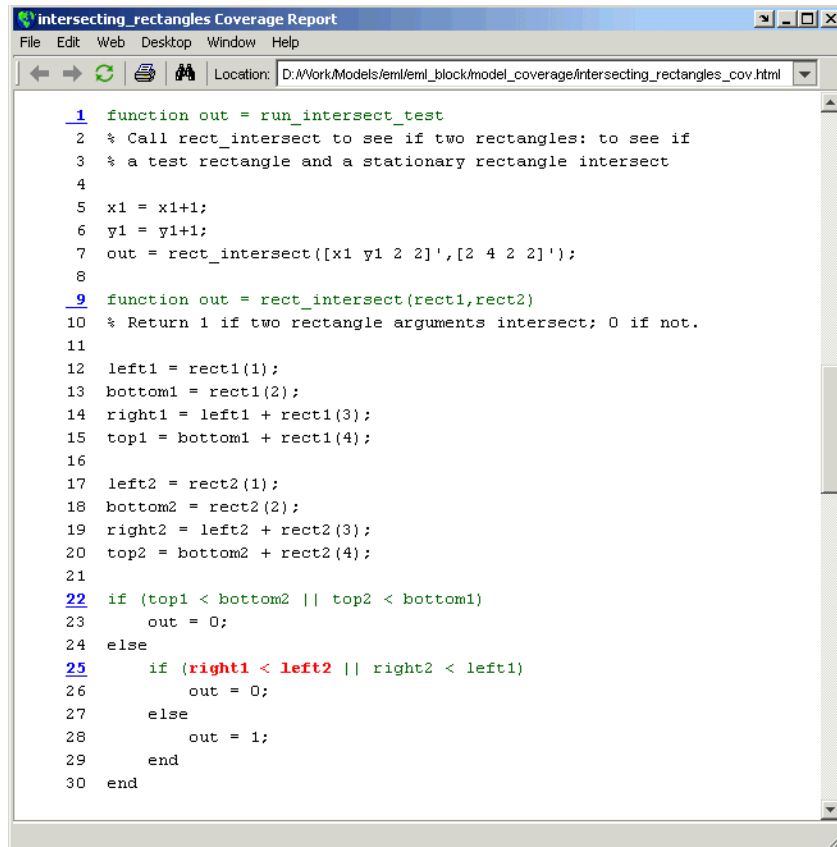
The following subtopics examine the model coverage report for the example model in reverse function-block-model order. Reversing the order helps you make sense of the summary information that appears at the top of each section.

Model Coverage for the Embedded MATLAB Function Block Function `run_intersect_test`

Model coverage for the Embedded MATLAB Function function `run_intersect_test` is reported under the linked name of the function. Clicking this link opens the function in the Embedded MATLAB Editor. Following the linked function name is a link to the model coverage report for the parent Embedded MATLAB Function block of `run_intersect_test`.



The top half of the report for the function summarizes its model coverage results as shown. The coverage metrics for `run_intersect_test` include decision, condition, and MCDC coverage. These metrics are best understood by examining the code listing for `run_intersect_test` that follows.



```

1 function out = run_intersect_test
2 % Call rect_intersect to see if two rectangles: to see if
3 % a test rectangle and a stationary rectangle intersect
4
5 x1 = x1+1;
6 y1 = y1+1;
7 out = rect_intersect([x1 y1 2 2]',[2 4 2 2]');
8
9 function out = rect_intersect(rect1,rect2)
10 % Return 1 if two rectangle arguments intersect; 0 if not.
11
12 left1 = rect1(1);
13 bottom1 = rect1(2);
14 right1 = left1 + rect1(3);
15 top1 = bottom1 + rect1(4);
16
17 left2 = rect2(1);
18 bottom2 = rect2(2);
19 right2 = left2 + rect2(3);
20 top2 = bottom2 + rect2(4);
21
22 if (top1 < bottom2 || top2 < bottom1)
23     out = 0;
24 else
25     if (right1 < left2 || right2 < left1)
26         out = 0;
27     else
28         out = 1;
29     end
30 end

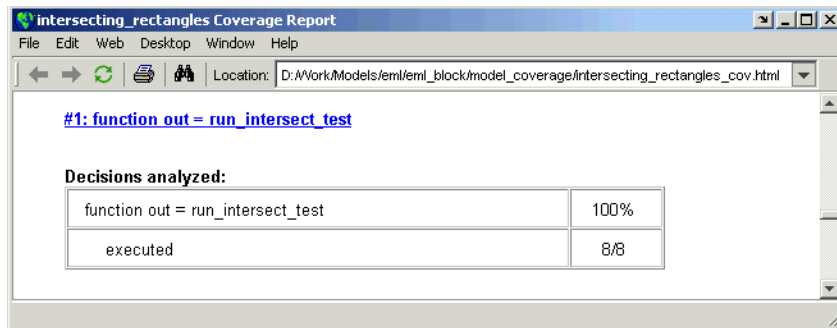
```

Lines with coverage elements are marked by a highlighted line number in the listing. Line 1 receives decision coverage on whether the top-level function `run_intersect_test` is executed. Line 9 receives decision coverage on whether the subfunction `rect_intersect` is executed. Lines 22 and 25 receive decision, condition, and MCDC coverage for their `if` statements and conditions. Each of these lines is the subject of a report that follows the listing.

Notice that the condition `right1 < left2` in line 25 is highlighted in red. This means that this condition was not tested for all of its possible outcomes during simulation. Exactly which of the outcomes was not tested is answered by the report for the decision in line 25.

The following subtopics display the coverage for each decision line of `run_intersect_test`. The coverage for each line is titled with the line itself, which is linked to display the function with the line highlighted.

Coverage for Line 1. The coverage metrics for line 1 appear below the listing for the function `run_intersect_test`.



Decisions analyzed:	
function out = run_intersect_test	100%
executed	8/8

The first line of every function receives coverage analysis indicative of the decision to run the function in response to a call. Coverage for `run_intersect_test` indicates that it executed during testing.

Coverage for Line 9. The coverage metrics for line 9 appear below the coverage metrics for line 1.

#9: [function out = rect_intersect\(rect1,rect2\)](#)

Decisions analyzed:

function out = rect_intersect(rect1,rect2)	100%
executed	8/8

This table indicates that the subfunction `rect_intersect` executed during testing.

Coverage for Line 22. Coverage metrics for line 22 appear below the coverage metrics for line 9.

#22: [if \(top1 < bottom2 || top2 < bottom1\)](#)

Decisions analyzed:

if (top1 < bottom2 top2 < bottom1)	100%
false	5/8
true	3/8

Conditions analyzed:

Description:	True	False
top1 < bottom2	2	6
top2 < bottom1	1	5

MC/DC analysis (combinations in parentheses did not occur)

Decision/Condition:	True Out	False Out
top1 < bottom2 top2 < bottom1		
top1 < bottom2	Tx	FF
top2 < bottom1	FT	FF

The **Decisions analyzed** table indicates that there are two possible outcomes for the decision in line 22: true and false. Five of the eight times it was executed, the decision evaluated to false, and the remaining three times, it evaluated to true. Because both possible outcomes occurred, decision coverage is 100%.

The **Conditions analyzed** table sheds some additional light on the decision in line 22. Because this decision consists of two conditions linked by a logical OR (|) operation, only one condition must evaluate true for the decision to be true. If the first condition evaluates to true, there is no need to evaluate the second condition. The first condition, `top1 < bottom2`, was evaluated eight times, and was true twice. This means that it was necessary to evaluate the second condition only six times. In only one case was it true, which brings the total true occurrences for the decision to three, as reported in the **Decisions analyzed** table.

MCDC coverage looks for decision reversals that occur because one condition outcome changes from T to F or from F to T. The **MCDC analysis** table identifies all possible combinations of outcomes for the conditions that lead to a reversal in the decision. The character x is used to indicate a condition outcome that is irrelevant to the decision reversal. Decision-reversing condition outcomes that are not achieved during simulation are marked with a set of parentheses. There are no parentheses, therefore all decision-reversing outcomes occurred and MCDC coverage is complete for the decision in line 22.

Coverage for Line 25. Coverage metrics for line 25 appear below the coverage metrics for line 22.

#25: if (right1 < left2 || right2 < left1)

Decisions analyzed:

if (right1 < left2 right2 < left1)	100%
false	3/5
true	2/5

Conditions analyzed:

Description:	True	False
right1 < left2	0	5
right2 < left1	2	3

MC/DC analysis (combinations in parentheses did not occur)

Decision/Condition:	True Out	False Out
right1 < left2 right2 < left1		
right1 < left2	(Tx)	FF
right2 < left1	FT	FF

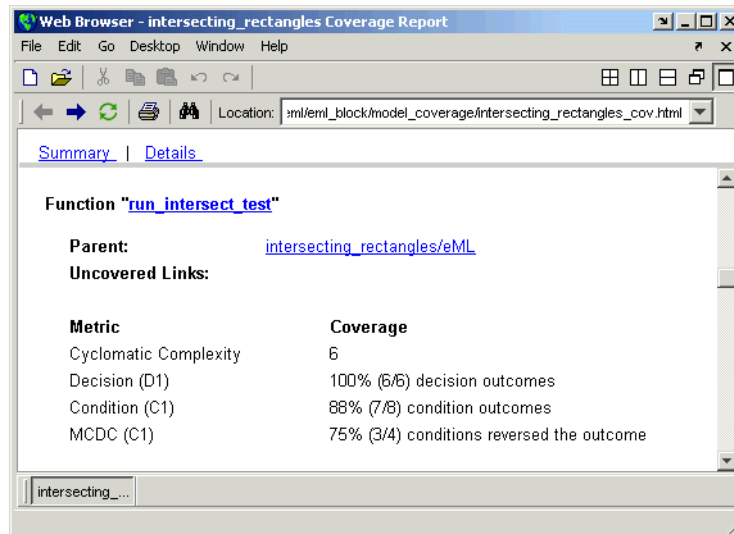
The line 25 decision, `if (right1 < left2 || right2 < left1)`, is nested in the `if` statement of the line 22 decision and is evaluated only if the line 22 decision is false. Because the line 22 decision evaluated false five times, line 25 is evaluated five times, three of which were false. Because both the true and false outcomes were achieved, decision coverage for line 25 is 100%.

Because line 25, like line 22, has two conditions related by a logical OR operator (`||`), condition 2 is tested only if condition 1 is false. Because condition 1 tests false five times, condition 2 is tested five times. Of these, condition 2 tests true two times and false three times, which accounts for the two occurrences of the true outcome for this decision.

Because the first condition of the line 25 decision does not test true, both outcomes did not occur for that condition and the condition coverage for the first condition is highlighted with a rose color. MCDC coverage is also

highlighted in the same way for a decision reversal based on the true outcome for that condition.

Coverage for run_intersect_test. The metrics that summarize coverage for the entire run_intersect_test function are reported prior to its listing and are repeated here as shown.



The results summarized in the coverage metrics summary can be expressed in the following conclusions:

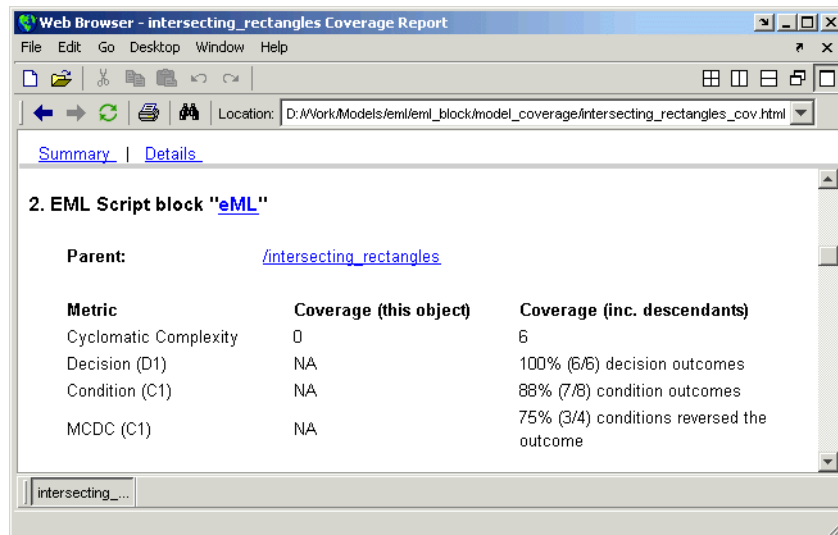
- There are six decision outcomes reported for run_intersect_test in the line reports: one for line 1 (executed), one for line 9 (executed), two for line 22 (true and false), and two for line 25 (true and false). The decision coverage for each line shows 100% decision coverage. This means that decision coverage for run_intersect_test is six of six possible outcomes, or 100%.
- There are four conditions reported for run_intersect_test in the line reports. Lines 22 and 25 each have two conditions, and each condition has two condition outcomes (true and false), for a total of eight condition outcomes in run_intersect_test. All conditions tested positive for both the true and false outcome except for the first condition of line 25 (right 1

$< \text{left2}$). This means that condition coverage for `run_intersect_test` is seven of eight, or 88%.

- The MCDC coverage tables for decision lines 22 and 25 each list two cases of decision reversal for each condition, for a total of four possible reversals. Only the decision reversal for a change in the evaluation of the condition `right1 < left2` of line 25 from true to false did not occur during simulation. This means that three of four, or 75% of the possible reversal cases were tested for during simulation, for a coverage of 75%.

Model Coverage for the Embedded MATLAB Function Block and the Model

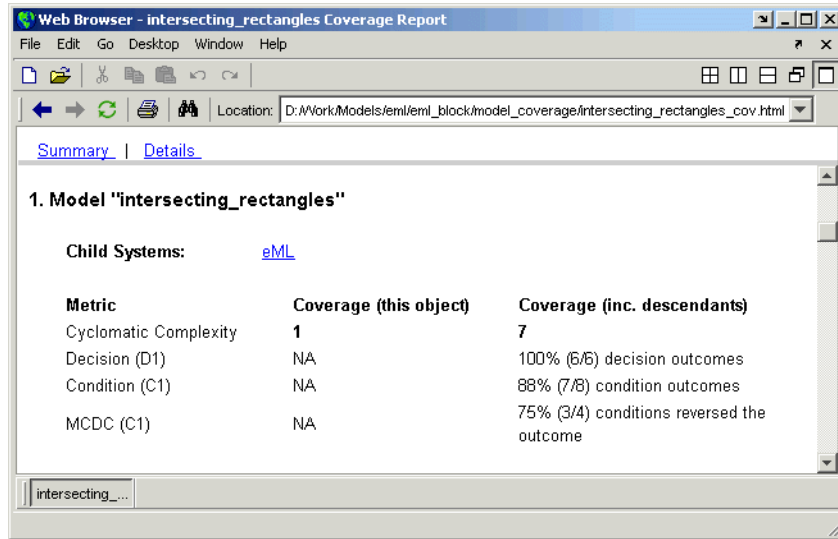
The model coverage report for the block Embedded MATLAB shows that it has no decisions of its own apart from its function. However, it does repeat the summary information for its function `run_intersect_test` as coverage for its descendent objects, as shown.



The screenshot shows a web browser window titled "Web Browser - intersecting_rectangles Coverage Report". The address bar shows the location: `D:\Work\Models\eml\eml_block\model_coverage\intersecting_rectangles_cov.html`. The page content includes a "Summary" tab and a "Details" tab. The main heading is "2. EML Script block 'eML'". Below this, the parent is listed as `/intersecting_rectangles`. A table provides coverage metrics for this object and its descendants.

Metric	Coverage (this object)	Coverage (inc. descendants)
Cyclomatic Complexity	0	6
Decision (D1)	NA	100% (6/6) decision outcomes
Condition (C1)	NA	88% (7/8) condition outcomes
MCDC (C1)	NA	75% (3/4) conditions reversed the outcome

Because there are no additional coverage objects in the model apart from the Embedded MATLAB Function block, the remaining report for the model `intersecting_rectangles` also repeats the preceding coverage for descendent objects, as shown.



Functions — Categorical List

Simulink Verification and Validation organizes its functions with the following category topics:

“Requirements Management
Interface Functions” (p. 6-2)

“Model Coverage Functions” (p. 6-2)

Requirements Management Interface Functions

The following table lists and describes the requirements methods of Simulink Verification and Validation.

Method	Purpose
rminav	Start Requirements Management Interface

Model Coverage Functions

The following table lists and describes the model coverage methods of Simulink Verification and Validation.

Method	Purpose
cvhtml	Produce HTML report from model coverage objects in memory
cvload	Load into memory the coverage tests and results stored in a file
cvsave	Save coverage tests and results to a file
cvsim	Simulate and return model coverage results for test objects
cvtest	Create a model coverage test specification object

Functions — Alphabetical List

cvhtml

Purpose Produce HTML report from model coverage objects in memory

Syntax

```
cvhtml(file, cvdo)
cvhtml(file, cvdo1, cvdo2,...)
cvhtml(file, cvdo1, cvdo2,..., detail)
```

Description Use the `cvhtml` command to produce an HTML report from `cvdata` objects you produce when you run a model coverage test in simulation.

`cvhtml(file, cvdo)` creates an HTML report of the coverage results in the `cvdata` object `cvdo`, which is written to the file `file` in the current MATLAB directory.

`cvhtml(file, cvdo1, cvdo2,...)` creates a combined report of several `cvdata` objects. The results from each object are displayed in a separate column of the HTML report. Each `cvdata` data object must correspond to the same root model or subsystem, or the function produces errors.

`cvhtml(file, cvdo1, cvdo2,..., detail)` creates a combined report of several `cvdata` objects and specifies the detail level of the report with the value of `detail`, an integer between 0 and 3. Greater numbers for `detail` indicate greater detail. The default value is 2.

Purpose	Load into memory the coverage tests and results stored in a file
Syntax	<pre>[cvtos, cvdos] = cvload(filename) [cvtos, cvdos] = cvload(filename, restoretotal)</pre>
Description	<p>The <code>cvload</code> command loads into memory the coverage tests and results stored in a file by the <code>cvsave</code> command.</p> <p><code>[cvtos, cvdos] = cvload(filename)</code> loads the tests and data stored in the text file <code>filename.cvt</code>. The <code>cvtest</code> objects that are successfully loaded are returned in <code>cvtos</code>, a cell array of <code>cvtest</code> objects. The <code>cvdata</code> objects that are successfully loaded are returned in <code>cvdos</code>, a cell array of <code>cvdata</code> objects. <code>cvdos</code> has the same size as <code>cvtos</code>, but can contain empty elements if a particular test has no results.</p> <p><code>[cvtos, cvdos] = cvload(filename, restoretotal)</code> restores the cumulative results from prior runs if <code>restoretotal</code> is 1. If <code>restoretotal</code> is unspecified or 0, the model's cumulative results are cleared.</p>

cvload Special Considerations

The following are some special considerations for using the `cvload` command:

- If a model with the same name exists in the coverage database, only the compatible results that reference the existing model are loaded to prevent duplication.
- If the Simulink models referenced from the file are open but do not exist in the coverage database, the coverage tool resolves the links to the existing models.
- When you are loading several files that reference the same model, only the results that are consistent with the earlier files are loaded.

cvsave

Purpose Save coverage tests and results to a file

Syntax

```
cvsave(filename, model)
cvsave(filename, cvto1, cvto2, ...)
cvsave(filename, cvdo1, cvdo2, ...)
```

Description Save the coverage tests and results from simulations to a file with the function `cvsave`.

`cvsave(filename, model)` saves all the tests (`cvtest` objects) and results (`cvdata` objects) in memory related to the model `model` in the text file `filename.cvt`.

`cvsave(filename, cvto1, cvto2, ...)` saves the tests in the `cvtest` objects `cvto1`, `cvto2`, ... in the text file `filename.cvt`. Information about the referenced models is also saved.

`cvsave(filename, cvdo1, cvdo2, ...)` saves the tests, test results, and referenced models' structure for `cvdata` objects `cvdo1`, `cvdo2`, ... to the text file `filename.cvt`.

Purpose	Simulate and return model coverage results for test objects
Syntax	<pre>cvdo = cvsim(cvto) [cvdo,t,x,y] = cvsim(cvto) [cvdo,t,x,y] = cvsim(cvto, timespan, options) [cvdo,t,x,y] = cvsim(cvto, label, setupcmd) [cvdo1, cvdo2, ...] = cvsim(cvto1, cvto2, ...)</pre>
Description	You simulate a test specification object (a cvtest object) with the cvsim command.

Note You do not have to enable model coverage reporting for the model to use the cvsim command.

`cvdo = cvsim(cvto)` executes the cvtest object cvto by starting a simulation run for the corresponding model. The results are returned in the cvdata object cvdo.

`[cvdo,t,x,y] = cvsim(cvto)` returns the time vector t, matrix of state values x, and matrix of output values y from the simulation. See online help for the MATLAB sim command for descriptions of the parameters t, x, and y.

`[cvdo,t,x,y] = cvsim(cvto, timespan, options)` returns the time vector t, matrix of state values x, and matrix of output values y from the simulation, and overrides default simulation values with the values for timespan and options. See online help for the MATLAB sim command for descriptions of the parameters t, x, y, timespan, and options.

`[cvdo,t,x,y] = cvsim(cvto, label, setupcmd)` creates the cvtest object cvto and simulates it in one command. The arguments label and setupcmd are passed directly to the cvtest command, which creates the cvtest object cvto.

`[cvdo1, cvdo2, ...] = cvsim(cvto1, cvto2, ...)` executes the cvtest objects cvto1, cvto2, ... and returns the results in the set of cvdata objects cdvo1, cvdo2,

cvtest

Purpose Create a model coverage test specification object

Syntax

```
cvto = cvtest(root)
cvto = cvtest(root, label)
cvto = cvtest(root, label, setupcmd)
```

Description The `cvtest` command creates a test specification object, that you simulate with the `cvsim` command.

`cvto = cvtest(root)` creates a test object with the handle `cvto`. `root` is the name of, or a handle to, a Simulink model or a subsystem of a model. Only the specified model or subsystem and its descendants are subject to model coverage testing.

`cvto = cvtest(root, label)` creates a test object with the label `label`, which is used for reporting results.

`cvto = cvtest(root, label, setupcmd)` creates a test object with the setup command `setupcmd` and labels it with `label`. The setup command is executed in the base MATLAB workspace just prior to running the instrumented simulation. This command is useful for loading data prior to a test.

A test object has the following structure.

Field	Description
<code>id</code>	Read-only internal data-dictionary ID
<code>modelcov</code>	Read-only internal data-dictionary ID
<code>rootPath</code>	Name of the system or subsystem instrumented for analysis
<code>label</code>	String used when reporting results
<code>setupCmd</code>	Command executed in the base workspace just prior to simulation
<code>settings.decision</code>	Set to 1 if Decision Coverage is desired
<code>settings.condition</code>	Set to 1 if Condition Coverage is desired

Field	Description
settings.mcdc	Set to 1 if MC/DC coverage is desired
settings.tableExec	Set to 1 if lookup table coverage is desired

rminav

Purpose Start Requirements Management Interface

Syntax `rminav`

Description `rminav` starts the deprecated Requirements Management Interface Navigator window.

If you specified `reqsys = 'OTHERS'` in the MATLAB file `reqmgropts.m`, the standard version of the Requirements Management Interface Navigator window opens. You can associate requirements documents written in HTML, Microsoft Word, or Microsoft Excel with Simulink models, Stateflow diagrams, and MATLAB M-files.

If you specified `reqsys = 'DOORS'` in `reqmgropts.m`, the DOORS version of the Requirements Management Interface Navigator window opens. You can associate DOORS requirements with Simulink models, Stateflow diagrams, and MATLAB M-files.

To associate DOORS requirements with MATLAB objects, you must start MATLAB with the `/automation` option.

Blocks – Alphabetical List

System Requirements

Purpose List system requirements in Simulink diagrams

Library Simulink Verification and Validation

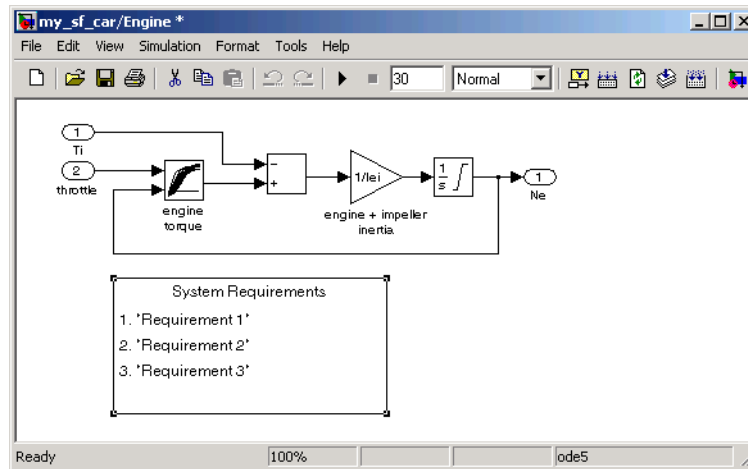
Description



The System Requirements block lists all the system requirements associated with the model or subsystem depicted in the current diagram. It does not list requirements associated with individual blocks in the diagram.

You can place this block anywhere in a diagram. It is not connected to other Simulink blocks. You cannot have more than one System Requirements block in a diagram.

When you drag the System Requirements block from the library browser into your Simulink diagram, it is automatically populated with the system requirements, as shown.



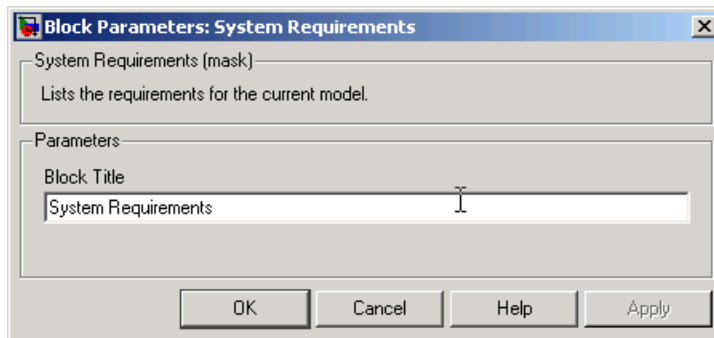
Each of the listed requirements is an active link to the actual requirements document. When you double-click on a requirement name, the associated requirements document opens in its editor window, scrolled to the target location.

If the System Requirements block exists in a diagram, it automatically updates the requirements listing as you add, modify, or delete requirements for the model or subsystem.

For more information on using the System Requirements block, see “Displaying the System Requirements in a Diagram” on page 2-49.

Dialog Box and Parameters

To access the Block Parameters dialog box for the System Requirements block, right-click on the System Requirements block and, from the resulting pop-up menu, select **Mask Parameters**. The Block Parameters dialog box opens, as shown.



The Block Parameters dialog box for the System Requirements block contains one parameter.

Block Title

The title of the system requirements list in the diagram. The default title is System Requirements. You can type a customized title, for example, Engine Requirements.

Examples

Use this list to find examples in the documentation.

Requirements Management Interface

- “Adding Requirement Links to an Object” on page 2-8
- “Viewing Requirements Documents” on page 2-13
- “Making Selection-Based Links” on page 2-22
- “Creating a Custom Link Requirement Type” on page 2-31
- “Viewing Objects with Requirement Links” on page 2-44
- “Generating a Requirements Report” on page 2-47
- “Displaying the System Requirements in a Diagram” on page 2-49
- “Including Requirements with Generated Code” on page 2-55

Requirements Management Interface - DOORS Version

“Linking Objects to DOORS Requirements” on page 3-7

“Synchronizing a Model with DOORS” on page 3-13

“Navigating from Simulink to DOORS” on page 3-26

“Navigating from DOORS to Simulink” on page 3-28

Verification Manager

“Opening the Verification Manager” on page 4-5

“Enabling and Disabling Model Verification Blocks with the Verification Manager” on page 4-9

“Using Enabling and Disabling Tools in the Verification Manager” on page 4-13

“Managing Verification Requirements” on page 4-17

Model Coverage

- “Details Report Section” on page 5-20
- “Decisions Analyzed Table” on page 5-22
- “Conditions Analyzed Table” on page 5-22
- “MC/DC Analysis Table” on page 5-23
- “N-Dimensional Lookup Table Report” on page 5-25
- “Signal Range Analysis Report” on page 5-31
- “Displaying Model Coverage with Model Coloring” on page 5-35
- “Creating a Model with Embedded MATLAB Function Block Decisions” on page 5-46
- “Understanding Embedded MATLAB Function Block Model Coverage” on page 5-49

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