

Link for Code Composer Studio[®] Development Tools

For Use with MATLAB[®] and Simulink[®]

- Computation
- Visualization
- Programming
- Simulation

How to Contact The MathWorks:



www.mathworks.com	Web
comp.soft-sys.matlab	Newsgroup



support@mathworks.com	Technical support
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bugs@mathworks.com	Bug reports
doc@mathworks.com	Documentation error reports
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info@mathworks.com	Sales, pricing, and general information



508-647-7000	Phone
--------------	-------



508-647-7001	Fax
--------------	-----



The MathWorks, Inc. 3 Apple Hill Drive Natick, MA 01760-2098	Mail
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For contact information about worldwide offices, see the MathWorks Web site.

Link for Code Composer Studio Development Tools User's Guide

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Shows you what a link object is and how to construct one

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Explains what makes a function overloaded and where to get more information about the overloaded functions in this product

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Guides you through the process of creating and using links and embedded objects

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Demonstrates one process for using RTDX to communicate with CCS IDE and transferring data between MATLAB and CCS IDE

What Is Link for Code Composer Studio

Link for Code Composer Studio Development Tools lets you use MATLAB functions to communicate with Code Composer Studio® and with information stored in memory and registers on a target. With the links you can transfer information to and from Code Composer Studio and with the embedded objects you get information about data and functions stored in your signal processor memory and registers, as well as information about functions in your project.

Note Both the links and the embedded objects are objects, and you work with them in the same way you use all MATLAB objects. You can set and get their properties, and use their methods to change them or manipulate them.

With Link for Code Composer Studio, you create two kinds of objects:

- Links that connect MATLAB to Code Composer Studio. For information about using links, refer to “Requirements for Link for Code Composer Studio” on page 1-7.
- Embedded objects you create that provide access to data and functions in your project in Code Composer Studio and on your target. The link objects let you use the embedded objects to access your target. Refer to “Introduction to Objects” on page 2-3 for more information about using the embedded objects, their properties, and their methods.

Specific Link Features Supported For Each Board Family

Within the collection of hardware that Link for Code Composer Studio supports, some features of the link do not apply. In the next table, each board family appears with headings that specify the support provided. The information here is general according to the processor family. For details about the support for processors within a family, such as the C24xx, refer to Appendix A, “Reference — Supported Hardware”.

Some Board Families Do Not Support Full Link for Code Composer Studio Functions

Board Family	Hardware/ Simulators?	Debug Mode?	Embedded Objects?	Hardware-in-the-Loop?	RTDX
C2xx	Yes/No	Yes	No	No	No
C54x	Yes/Yes	Yes	Yes	Yes	Yes
C55x	Yes/Yes	Yes	Yes	No	Yes
C6x	Yes/Yes	Yes	Yes	Yes	Yes
TMS470Rxx	Yes/Yes	Yes	Yes	No	No

Debug mode includes those operations that CCS handles and that Link for Code Composer Studio enables you to use from MATLAB—a yes tells you that the listed hardware supports MATLAB interaction with CCS. Embedded objects support indicates that the board family supports using objects in MATLAB to work with symbol table entries in CCS. A yes in the Hardware-in-the-Loop column means the board family supports using function objects to run functions on your target from MATLAB.

Link for Code Composer Studio provides four components that work with and use CCS IDE and TI Real-Time Data Exchange (RTDX™):

- **Link for Code Composer Studio IDE** — lets you use objects to create links between CCS IDE and MATLAB®. From the command window, you can run applications in CCS IDE, send to and receive data from target memory, and check the processor status, as well as other functions such as starting and stopping applications running on your digital signal processors.
- **Link for Real-Time Data Exchange Interface** — provides a communications pathway between MATLAB and digital signal processors installed on your PC. Using objects in the Link for Code Composer Studio, you open channels to processors on boards in your computer and send and retrieve data about the processors and executing applications, as well as send data to the processes for use and get data from the applications.
- **Embedded Objects**—provides object methods and properties that let you access and manipulate information stored in memory and registers on digital signal processors, or in your Code Composer Studio project. From MATLAB

you gather information from your project, work with the information in MATLAB, doing things like converting data types, creating function declarations, or changing values, and return the information to your project—all from the MATLAB command line.

- **Hardware-in-the-Loop**—enables you to write scripts in MATLAB that exercise functions from your project on your target processor. From MATLAB, you can generate data, send the data to your target and use a C function in your program to manipulate the data on your hardware or simulator. Afterwards, you return the output to MATLAB so you can analyze the results.

Configuration Information

To determine whether the Link for Code Composer Studio is installed on your system, type this command at the MATLAB prompt.

```
help ccslink
```

When you enter this command, MATLAB displays the contents of the product, the first few lines of which are shown here. What you see should look similar, although the product version numbers change.

```
Link for Code Composer Studio(tm)
Version 1.1 (R13) 19-Apr-2002
```

```
Methods for Link for Code Composer Studio
ccshelp/ccsdsp - Construct CCS object.
```

If you do not see the listing, or MATLAB does not recognize the command, you need to install the Link for Code Composer Studio. Without the software, you cannot use MATLAB with the links to communicate with Code Composer Studio.

Note For up-to-date information about system requirements, refer to the system requirements page, available in the products area at the MathWorks Web site (<http://www.mathworks.com>).

To verify that CCS is installed on your machine, enter

```
ccsboardinfo
```

at the MATLAB command line. With CCS installed and configured, MATLAB returns information about the boards that CCS recognizes on your machine, in a form similar to the following listing.

Board Num	Board Name	Proc Num	Processor Name	Processor Type
1	C6xxx Simulator (Texas Instrum ...	0	6701	TMS320C6701
0	C6x11 DSK (Texas Instruments)	0	CPU	TMS320C6x1x

If MATLAB does not return information about any boards, revisit your CCS installation and setup in your CCS documentation.

As a final test, start CCS to ensure that it starts up successfully. For the Link for Code Composer Studio to operate with CCS, the CCS IDE must be able to run on its own.

Objects and Link for Code Composer Studio

The Link for Code Composer Studio Development Tools uses objects to create:

- Links to Code Composer Studio Integrated Development Environment (CCS IDE)
- Links to Real-Time Data Exchange (RTDX) Interface. This link is a subset of the link to CCS IDE.

Concepts you need to know about the objects for linking in this toolbox are covered in these sections:

- “Constructing Link Objects”
- “Properties and Property Values”
- “Setting and Retrieving Property Values”
- “Setting Property Values Directly at Construction”
- “Setting Property Values with set”
- “Retrieving Properties with get”
- “Direct Property Referencing to Set and Get Values”
- “Overloaded Functions for Links”

Refer to MATLAB Classes and Objects in your MATLAB documentation for more details on object-oriented programming in MATLAB.

Many of the links use COM server features to create handles for working with the links. Refer to your MATLAB documentation for more information about COM as used by MATLAB.

Requirements for Link for Code Composer Studio

This section describes the hardware and software you need to run the Link for Code Composer Studio Development Tools on your Microsoft Windows PC.

Link for Code Composer Studio runs on Microsoft Windows NT 4.0 Workstation and Server, Windows XP, and Windows 2000 platforms.

Platform Requirements—Hardware and Operating System

To run the Link for Code Composer Studio, your host PC must meet the following hardware configuration:

- Intel Pentium or Intel Pentium processor compatible PC
- 64 MB RAM (128 MB recommended)
- 20 MB hard disk space available after installing MATLAB
- Color monitor
- One full-length peripheral component interface (PCI) slot available to use the C6701 EVM internally in your PC
- Slots or connectors, such as USB or parallel ports, for connecting your hardware
- CD-ROM drive
- Microsoft Windows NT 4.0 Server or Workstation, Windows XP, or Windows 2000

Refer to your documentation from The MathWorks for more information on installing the software required to support Link for Code Composer Studio, list in this table.

Prerequisites for Using Link for Code Composer Studio Software for Targeting

Installed Product	Additional Information
MATLAB 7	Core software from The MathWorks
Signal Processing Toolbox 6.2 or later	Software package for analyzing signals, processing signals, and developing algorithms

For information about the software required to use the Link for Code Composer Studio Development Tools, refer to the Products area of the MathWorks Web site—<http://www.mathworks.com>.

Texas Instruments Software

In addition to the required software from The MathWorks, Link for Code Composer Studio requires that you install the Texas Instruments development tools and software listed in the following table. Installing Code Composer Studio IDE for the C2000, C5000, C6000, or OMAP series installs the software shown in the table.

Required TI Software for Link for Code Composer Studio

Installed Product	Additional Information
Assembler	Creates object code (.obj) for supported boards from assembly code.
Compiler	Compiles C code from the blocks in Simulink models into object code (.obj). As a by-product of the compile process, you get assembly code (.asm) as well.
Linker	Combines various input files, such as object files and libraries.
Code Composer Studio 2.12, 2.2 or 2.21	Texas Instruments integrated development environment (IDE) that provides code debugging and development tools (recommended). <ul style="list-style-type: none">• For C2000• For C5000• For C6000• For OMAP

Required TI Software for Link for Code Composer Studio (Continued)

Installed Product	Additional Information
TI miscellaneous utilities	Various tools for developing applications for the supported digital signal processor families.
Code Composer Setup Utility	Program you use to configure your CCS installation by selecting your target boards or simulator.

In addition to the TI software, you need one or more of the following in any combination:

- One or more boards that CCS supports in the Setup utility, either C2800™, C5000™, or C6000™ digital signal processor platforms, such as the C6416 DSK or C6713 DSK
- One or more OMAP boards
- One or more simulators from CCS

To use C5000 platforms from TI, install the Code Composer Studio IDE version that supports C5000 products.

To use C2000 platforms from TI, install the Code Composer Studio IDE version that supports C2000 platforms.

To use OMAP platforms from TI, install the Code Composer Studio IDE version that supports OMAP platforms.

For up-to-date information about the software from The MathWorks you need to use the Link for Code Composer Studio, refer to the MathWorks Web site—www.mathworks.com. Check the Product area for the Link for Code Composer Studio.

Constructing Link Objects

When you create a link to CCS IDE using the `ccsdsp` command, you are creating a “link to CCS IDE and RTDX Interface” object (called a link object for brevity from here on). The link object implementation relies on MATLAB object-oriented programming capabilities similar to the objects you find in the Filter Design and Control Systems Toolboxes.

The discussions in this section apply to the link objects in the Link for Code Composer Studio. For a discussion of the embedded objects that are also part of this product, refer to “Introduction to Objects” on page 2-3. Since both object types use the MATLAB programming techniques, the information about working with the links, such as how you get or set properties, or use methods, apply equally to the link objects and the embedded objects. Only their constructors, properties, and methods are different.

Like other MATLAB structures, objects (also called links; we use the terms interchangeably here) in the Link for Code Composer Studio Development Tools have predefined fields called *object properties*.

If you are new to objects, you might find the glossary section, “Some Object-Oriented Programming Terms” on page 2-5, helpful to explain the terms used in this User’s Guide.

You specify object property values by either:

- Specifying the property values when you create the object
- Creating an object with default property values, and changing some or all of these property values later

For examples of setting link properties, refer to “Setting Property Values with `set`” on page 1-13.

Example— Constructor for Links

The easiest way to create a link object is to use the function `ccsdsp` to create a link with the default properties. Create a link named `cc` to CCS IDE by typing

```
cc = ccsdsp
```

MATLAB responds with a list of the properties of the link `cc` you created along with the associated default property values.

```
CCSDSP Object:
```

```
API version      : 1.0
Processor type   : C67
Processor name   : CPU
Running?        : No
Board number     : 0
Processor number : 0
Default timeout  : 10.00 secs
```

```
RTDX channels    : 0
```

Inspecting the output reveals two objects listed—a CCS IDE object and an CCS IDE and RTDX objects cannot be created separately. By design they maintain a member class relationship; the RTDX object is a class, a member of the CCS object class. In this example, `cc` is an instance of the class CCS. If you type

```
rx = cc.rtdx
```

`rx` is a handle to the RTDX portion of the CCS object. As an alias, `rx` replaces `cc.rtdx` in functions such as `readmat` or `writemsg` that use the RTDX communications features of the CCS link. Typing `rx` at the command line now produces

```
rx
```

```
RTDX channels    : 0
```

The link properties are described in “Functions — Categorical List” on page 4-3, and in more detail in “Link Properties” on page 1-18. These properties are set to default values when you construct links.

Properties and Property Values

Links (or objects) in this Link for Code Composer Studio have properties associated with them. Each property is assigned a value. You can set the values of most properties, either when you create the link or by changing the property value later. However, some properties have read-only values. And a few property values, such as the board number and the target processor to which the link attaches, become read-only after you create the object. You cannot change those after you create your link.

Setting and Retrieving Property Values

You can set Link for Code Composer Studio for Texas Instruments DSP link property values either:

- Directly when you create the link
- By using the set function with an existing link

Retrieve CCS IDE link property values with the get function.

In addition, direct property referencing lets you either set or retrieve property values for links.

Setting Property Values Directly at Construction

To set property values directly when you construct a link, include the following pair of entries in the input argument list for the link construction function `ccsdsp`:

- A string for the property name to set followed by a comma. Enclose the string in single quotation marks as you do any string in MATLAB.
- The associated property value. Sometimes this value is also a string.

Include as many property names in the argument list for the object construction command as there are properties to set directly.

Example—Setting Link Property Values at Construction

Suppose you want to set the following link characteristics when you create a link to a DSP on a board in your computer:

- Link to the second DSP board installed on your computer.
- Connect to the first processor on the target board.
- Set the global timeout to 5 s. The default is 10 s.

Do this by typing

```
cc = cc dsp('boardname',1,'procnum',0,'timeout',5);
```

boardname, procnum, and timeout properties are described in “Link Properties” on page 1-18, as are the other properties for links.

Note When you set link property values, the strings for property names and their values are not sensitive to the case of the string. In addition, you only need to type the shortest uniquely identifying string in each case. For example, you could have typed the above code as

```
cc = cc dsp('board',1,'proc',0,'tim',5);
```

Setting Property Values with set

Once you construct a link, the set function lets you modify its property values.

You can use the set function to both:

- Set specific property values
- Display a list of the link properties showing all allowed values for each property and the default setting for each property

Example—Setting Link Property Values Using set

For example, set the timeout specification for the link cc from the previous section.

To do this, type

```
set(cc,'time',8);
```

Now use `get` to check that the desired changes have been made to `cc`.

```
get(cc)

ans =

    rtdx: [1x1 rtdx]
  apiversion: [1 0]
   ccsappexe: []
   boardnum: 0
   procnum: 0
   timeout: 8
    page: 0
```

Notice that the display reflects the changes in the property values.

To display a listing of all of the properties associated with a link `cc` that you can set, type

```
get(cc)

ans =

    rtdx: [1x1 rtdx]
  apiversion: [1 0]
   ccsappexe: []
   boardnum: 0
   procnum: 0
   timeout: 10
    page: 0
```

Retrieving Properties with `get`

You can use the `get` command to:

- Retrieve property values for an object
- Display a listing of the properties associated with an object and their associated property values

Example—Retrieving Link Property Values Using `get`

For example, to retrieve the value of the `apiversion` property for `cc`, and assign it to a variable, type

```
v = get(cc,'apiversion')
```

```
ans =
```

```
1     0
```

Note When you retrieve properties, the strings for property names and their values are not case-sensitive. In addition, you only need to type the shortest uniquely identifying string in each case. For example, you could have typed the above code as

```
v = get(cc,'api');
```

To list the properties of a link `cc`, and their values, type

```
get(cc)
```

```
ansrtdx: [1x1 rtdx]
```

```
    rtdx: [1x1 rtdx]
apiversion: [1 0]
ccsappexe: []
boardnum: 0
procnum: 0
timeout: 10
page: 0
```

Direct Property Referencing to Set and Get Values

You can reference directly into a property for setting or retrieving property values using MATLAB structure-like referencing. Do this by using a period to index into an object property by name.

Example—Direct Property Referencing in Links

- 1 Create a link with default values.
- 2 Change its timeout and number of open channels.

```
cc = ccsdsp;  
cc.time = 6;  
cc.rtdx.numchannels = 4;
```

Notice that you do not have to type the full name of the timeout property name, and you can use lower case to refer to the property name.

To retrieve property values, you can use direct property referencing.

```
num = cc.rtdx.numchannels  
  
num =  
4
```


Overloaded Functions for Links

Several functions in this Link for Code Composer Studio have the same name as functions in other MathWorks toolboxes or in MATLAB. These behave similarly to their original counterparts, but you apply these functions directly to an object. This concept of having functions with the same name operate on different types of objects (or on data) is called *overloading* of functions.

For example, the `set` command is overloaded for link objects (links). Once you specify your link by assigning values to its properties, you can apply the functions in this toolbox (such as `readmat` for using RTDX to read an array of data from the target processor) directly to the variable name you assign to your link, without having to specify your link parameters again.

For a complete list of the functions that act on links, refer to the tables of functions in the function reference pages.

Link Properties

The Link for Code Composer Studio provides links to your target hardware so you can communicate with processors for which you are developing systems and algorithms. Each link comprises two objects—a CCS IDE object and an RTDX Interface object. The link objects are not separable; the RTDX object is a subclass of the CCS IDE object. Each of the link objects has multiple properties. To configure the links for CCS IDE and RTDX, you set parameters that define details such as the desired target board, the target processor, the timeout period applied for communications operations, and a number of other values. Since the Link for Code Composer Studio uses objects to create the links, the parameters you set are called properties and you treat them as properties when you set them, retrieve them, or modify them.

This section details the properties for the links for CCS IDE and RTDX. First the section provides tables of the properties, for quick reference. Following the tables, the section offers in-depth descriptions of each property, its name and use, and whether you can set and get the property value associated with the property. Descriptions include a few examples of the property in use.

MATLAB users may find much of this handling of objects familiar. Objects, or links as we call them in the Link for Code Composer Studio, behave like objects in MATLAB and the other object-oriented toolboxes. For C++ programmers, this discussion of object-oriented programming is likely to be a review.

Quick Reference to Link Properties

The following table lists the properties for the links in the Link for Code Composer Studio. The second column tells you which object the property belongs to. Knowing which property belongs to each object in a link tells you how to access the property.

Table 1-1: Properties for the Links in Link for Code Composer Studio

Property Name	Applies to Which Link?	User Settable?	Description
apiversion	CCS IDE	No	Reports the version number of your CCS API.
boardnum	CCS IDE	Yes/initially	Specifies the index number of a board that CCS IDE recognizes.
ccsappexe	CCS IDE	No	Specifies the path to the CCS IDE executable. Read-only property.
numchannels	RTDX	No	Contains the number of open RTDX channels for a specific link.
page	CCS IDE	Yes/default	Stores the default memory page for reads and writes.
procnum	CCS IDE	Yes/at start only	Stores the number CCS Setup Utility assigns to the processor.
rtdx	RTDX	No	Specifies RTDX in a syntax.
rtdxchannel	RTDX	No	A string. Identifies the RTDX channel for a link.
timeout	CCS IDE	Yes/default	Contains the global timeout setting for the link.
version	RTDX	No	Reports the version of your RTDX software.

Some properties are read only—you cannot set the property value. Other properties you can change at all times. If the entry in the User Settable column is “Yes/initially”, you can set the property value only when you create the link. Thereafter it is read only.

Details About the Link Properties

To use the links for CCS IDE and RTDX Interface you set values for:

- boardnum—The board with which the link communicates
- procnum—The processor on the board, if the board has multiple processors
- timeout—Global timeout value. (Optional. Default is 10 s.)

Details of the properties associated with links to CCS IDE and RTDX Interface appear in the following sections, listed in alphabetical order by property name.

Many of these properties are object linking and embedding (OLE) handles. The MATLAB COM server creates the handles when you create links for CCS IDE and RTDX. You can manipulate the OLE handles using get, set, and invoke to work directly with the COM interface with which the handles interact.

apiversion

Property appversion contains a string that reports the version of the application program interface (API) for CCS IDE that you are using when you create a link. You cannot change this string. When you upgrade the API, or CCS IDE, the string changes to match. Use display to see the apiversion property value for a link. This example shows the appversion value for link cc.

```
display(cc)
```

```
CCSDSP Object:
```

```
API version      : 1.0  
Processor type   : C67  
Processor name   : CPU  
Running?        : No  
Board number     : 0  
Processor number : 0  
Default timeout  : 10.00 secs
```

```
RTDX channels    : 0
```

Note that the API version is not the same as the CCS IDE version.

boardnum

Property `boardnum` identifies the target board referenced by a link for CCS IDE. When you create a link, you use `boardnum` to specify the board you are targeting. To get the value for `boardnum`, use `ccsboardinfo` or the CCS Setup utility from Texas Instruments. The CCS Setup utility assigns the number for each board installed on your system.

ccsappexe

Property `ccsappexe` contains the path to the CCS IDE executable file `cc_app.exe`. When you use `ccsdsp` to create a link, MATLAB determines the path to the CCS IDE executable and stores the path in this property. This is a read-only property. You cannot set it.

numchannels

Property `numchannels` reports the number of open RTDX communications channels for an RTDX link. Each time you open a channel for a link, `numchannels` increments by one. For new links `numchannels` is zero until you open a channel for the link.

To see the value for `numchannels` create a link to CCS IDE. Then open a channel to RTDX. Use `get` or `display` to see the RTDX link properties.

```
cc=ccsdsp
```

```
CCSDSP Object:
```

```
API version      : 1.0
Processor type   : C67
Processor name   : CPU
Running?        : No
Board number     : 0
Processor number : 0
Default timeout  : 10.00 secs
```

```
RTDX channels    : 0
```

```
rx=cc.rtdx
```

```
RTDX channels    : 0
```

```
open(rx, 'ichan', 'r', 'ochan', 'w');

get(cc.rtdx)

ans =

    numChannels: 2
           Rtdx: [1x1 COM ]
    RtdxChannel: {' ' ' '}
           procType: 103
           timeout: 10
```

page

Property page contains the default value CCS IDE uses when the user does not specify the page input argument in the syntax for a function that access memory.

procnum

Property procnum identifies the processor referenced by a link for CCS IDE. When you create a link, you use procnum to specify the processor you are targeting. The CCS Setup Utility assigns a number to each processor installed on each board. To determine the value of procnum for a processor, use ccsboardinfo or the CCS Setup utility from Texas Instruments.

To identify a processor, you need both the boardnum and procnum values. For boards with one processor, procnum equals zero. CCS IDE numbers the processors on multiprocessor boards sequentially from 0 to the number of processors. For example, on a board with four processors, the processors are numbered 0, 1, 2, and 3.

rtdx

Property rtdx is a subclass of the cc dsp link and represents the RTDX portion of a link for CCS IDE. As shown in the example, rtdx has properties of its own that you can set, such as timeout, and that report various states of the link.

```
get(cc.rtdx)

ans =

    version: 1
```

```

numChannels: 0
    Rtdx: [1x1 COM ]
RtdxChannel: {'' [] ''}
    procType: 103
    timeout: 10

```

In addition, you can create an alias to the `rtdx` portion of a link, as shown in this code example.

```

rx=cc.rtdx

RTDX channels    : 0

```

Now you can use `rx` with the functions in the Link for Code Composer Studio, such as `get` or `set`. If you have two open channels, the display looks like the following

```

get(rx)

ans =

numChannels: 2
    Rtdx: [1x1 COM ]
RtdxChannel: {2x3 cell}
    procType: 98
    timeout: 10

```

when the processor is from the C62 family.

rtdxchannel

Property `rtdxchannel`, along with `numchannels` and `proctype`, is a read-only property for the RTDX portion of a link for CCS IDE. To see the value of this property, use `get` with the link. Neither `set` nor `invoke` work with `rtdxchannel`.

`rtdxchannel` is a cell array that contains the channel name, handle, and mode for each open channel for the link. For each open channel, `rtdxchannel` contains three fields, as follows:

<code>.rtdxchannel{i,1}</code>	Channel name of the <i>i</i> th-channel, <i>i</i> from 1 to the number of open channels
<code>.rtdxchannel{i,2}</code>	Handle for the <i>i</i> th-channel
<code>.rtdxchannel{i,3}</code>	Mode of the <i>i</i> th-channel, either 'r' for read or 'w' for write

With four open channels, `rtdxchannel` contains four channel elements and three fields for each channel element.

timeout

Property `timeout` specifies how long CCS IDE waits for any process to finish. Two timeout periods can exist—one global, one local. You set the global timeout when you create a link for CCS IDE. The default global `timeout` value is 10 s. However, when you use functions to read or write data to CCS IDE or your target, you can set a local timeout that overrides the global value. If you do not set a specific timeout value in a read or write process syntax, the global timeout value applies to the operation. Refer to the help for the read and write functions for the syntax to set the local `timeout` value for an operation.

version

Property `version` reports the version number of your RTDX software. When you create a link, `version` contains a string that reports the version of the RTDX application that you are using. You cannot change this string. When you upgrade the API, or CCS IDE, the string changes to match. Use `display` to see the `version` property value for a link. This example shows the `appversion` value for link `rx`.

```
get(rx) % rx is an alias for cc.rtdx.
```

```
ans =  
    version: 1  
  numChannels: 0  
        Rtdx: [1x1 COM ]  
  RtdxChannel: {'' [] ''}  
    procType: 103  
      timeout: 10
```


Tutorial 1-1 – Using Links and Embedded Objects

The Link for Code Composer Studio® IDE (CCS IDE), a part of the Link for Code Composer Studio, provides a connection between MATLAB and a digital signal processor in Code Composer Studio. Using links provides a mechanism for you to control and manipulate a signal processing application using the computational power of MATLAB. This can help you while you debug and develop your application. Another possible use is for creating MATLAB scripts that you use to verify and test algorithms that run in their final implementation on your production processor target.

Before using the functions available with the link for CCS IDE, you must select a digital signal processor to be your target because any link you create is specific to a designated digital signal processor. Selecting a processor is only necessary for multiprocessor boards or multiple board configurations of Code Composer Studio. When you have only one board with a single processor, the link defaults to the existing processor. For the links, the simulator counts a board; if you have both a board and a simulator that CCS recognizes, you must specify the target explicitly.

Introducing the Tutorial

To get you started using links for CCS IDE software, the Link for Code Composer Studio includes an example script `ccstutorial.m`. As you follow along with this tutorial, you perform five tasks that step you through creating and using links for CCS IDE:

- 1 Select your target.
- 2 Create and query links to CCS IDE.
- 3 Use MATLAB to load files into CCS IDE.
- 4 Work with your CCS IDE project from MATLAB.
- 5 Close the links you opened to CCS IDE.

For this tutorial, you load and run a simple digital signal processing application on target processor you select. To help you understand how they work, the tutorial demonstrates both writing to memory and reading from

memory in the “Working with Links and Data” on page 1-34 portion of the tutorial.

Using the read and write functions gets a bit complicated. MATLAB supports only double-precision values for calculations, but you can read and write a range of data types to and from your target. Seeing how the read and write functions work can help you when you need to do your work.

The tutorial covers the link functions listed below. The functions listed first apply to CCS IDE independent of the links—you do not need a link to use these functions. The functions listed next require a CCS IDE link in place before you can use the function syntax:

- Global functions for CCS IDE
 - `ccsboardinfo`—return information about the boards that CCS IDE recognizes as installed on your PC.
 - `boardprocse1`—select the board to target. Although you can use this generally, the Link for Code Composer Studio provides it as an example of a user interface you can build and as a tool in the tutorial. We do not recommend that you use this to select your target. Use `ccsboardinfo` and `ccsdsp` to specify the target for your processing application
 - `ccsdsp`—construct a link to CCS IDE. When you construct the link you specify the target board and processor.
 - `clear`—remove a specific link to CCS IDE or remove all existing links.
- CCS IDE link functions
 - `address`—return the address and page for an entry in the symbol table in CCS IDE
 - `disp`—display the properties of a link to CCS IDE and RTDX
 - `halt`—terminate execution of a process running on the processor
 - `info`—return information about the target processor or information about open RTDX channels
 - `isrunning`—test whether the target processor is executing a process
 - `isrtdxcapable`—test whether your target supports RTDX communications
 - `read`—retrieve data from memory on the target processor
 - `restart`—restore the program counter (PC) to the entry point for the current program

- `run`—execute the program loaded on the target processor
- `visible`—set whether CCS IDE window is visible on the desktop while CCS IDE is running
- `write`—write data to memory on the target processor
- Link for Code Composer Studio functions for working with embedded objects
 - `cast`—create a new object with a different datatype (the `represent` property) from an object in Link for Code Composer Studio. Demonstrated with a numeric object.
 - `convert`—change the `represent` property for an object from one datatype to another. Demonstrated with a numeric object.
 - `createobj`—return an object in MATLAB that accesses embedded data. Demonstrated with structure, string, and numeric objects.
 - `getmember`—return an object that accesses a single field from a structure. Demonstrated with a structure object.
 - `goto`—position the program counter to the specified location in the project code.
 - `list`—return various information listings from Code Composer Studio.
 - `read`—read the information at the location accessed by an object into MATLAB as numeric values. Demonstrated with a numeric, string, structure, and enumerated objects.
 - `readnumeric`—return the numeric equivalent of data at the location accessed by an object. Demonstrated with an enumerated object.
 - `write`—write to the location referenced by an object. Demonstrated with numeric, string, structure, and enumerated objects.

Running the Interactive Tutorial

You have the option of running this tutorial from the MATLAB command line or entering the functions as described in the following tutorial sections.

To run the tutorial in MATLAB, click `run ccstutorial`. Running the interactive tutorial in MATLAB puts you in an interactive mode where the tutorial program provides prompts and text descriptions to which you respond to move to the next portion of the lesson. The interactive tutorial covers the same information provided by the following tutorial sections. You can view the tutorial M-file used here by clicking `ccstutorial.m`.

Selecting Your Target

Links for CCS IDE provides two tools for selecting a DSP board and processor in multiprocessor configurations. One is a command line tool called `ccsboardinfo` which prints a list of the available boards and processors. So that you can use this function in a script, `ccsboardinfo` can return a MATLAB structure that you use when you want your script to select a target board without your help.

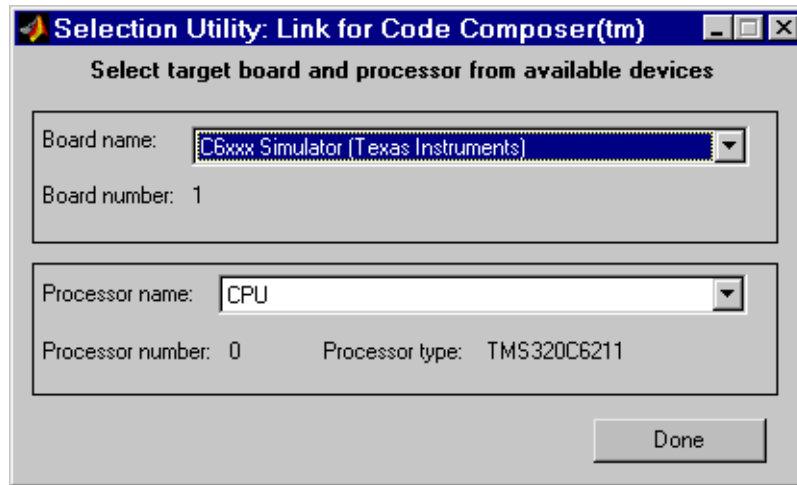
Note The board and processor you select in the tutorial remains the target throughout the tutorial.

- 1 To see a list of the boards and processors installed on your PC, type
`ccsboardinfo`

MATLAB returns a list that shows you all the boards and processors that CCS IDE recognizes as installed on your system.

- 2 To use the Selection Utility, `boardprocel`, to select a target board, type
`[boardnum,procnum] = boardprocel`

When you use `boardprocel`, you see a dialog similar to the following. Note that some entries vary depending on your board set.



- 3 Select a board name and processor name from the lists.

You are selecting a board and processor number that identifies your particular target. When you create the link for CCS IDE in the next section of this tutorial, the selected board and processor become the target of the link.

- 4 Click **Done** to accept your board and processor selection and close the dialog.

boardnum and procnum now represent the **Board name** and **Processor name** you selected—boardnum = 1 and procnum = 0

Creating and Querying Links for CCS IDE

In this tutorial section you create the connection between MATLAB and Code Composer Studio IDE. This connection, or link, is represented by a MATLAB object, which for this session you save as variable `cc`. You use function `ccsdsp` to create link objects. When you create links, `ccsdsp` input arguments let you define other link properties, such as the global timeout. Refer to the `ccsdsp` documentation for more information on these input arguments.

Use the generated link `cc` to direct actions to your target processor. In the following tasks, `cc` appears in all function syntax that interact with CCS IDE and the target:

- 1 Create a link to your selected board and processor by typing

```
cc=ccsdsp('boardnum',boardnum,'procnum',procnum)
```

If you were to watch closely, and your machine is not too fast, you see Code Composer Studio appear briefly when you call `ccsdsp`. If CCS IDE was not running before you established the new link, CCS starts and gets placed in the background.

Note When CCS IDE is running in the background it does not appear on your desktop, in your task bar, or on the **Applications** page in the Task Manager. It does show up as a process, `cc_app.exe`, on the **Processes** tab in Task Manager.

- 2 Type `visible(cc,1)` to force CCS IDE to be visible on your desktop

In most cases, you need to interact with Code Composer Studio while you develop your application, so the first link function we introduce, `visible`, controls the state of Code Composer Studio on your desktop. `visible` accepts Boolean inputs that make Code Composer Studio either visible on your desktop (input to `visible` ≥ 1) or invisible on your desktop (input to `visible` = 0). For the rest of this tutorial you need to interact with CCS IDE so we use `visible` to set the CCS IDE visibility to 1.

- 3 Now type `disp(cc)` at the prompt to see the status information.

```
CCSDSP Object:
  API version      : 1.0
  Processor type   : C67
  Processor name   : CPU
  Running?        : No
  Board number     : 0
  Processor number : 0
  Default timeout  : 10.00 secs

  RTDX channels    : 0
```

The Link for Code Composer Studio provides three functions to read the status of a target board and processor:

- `info`—return a structure of testable target conditions
- `disp`—print information about the target CPU
- `isrunning`—return the state (running or halted) of the CPU
- `isrtdxcapable`—return whether the target handle RTDX

4 Type `linkinfo = info(cc)`.

The `cc` link status information tells you about the target

```
linkinfo =

    procname: 'CPU'
  isbigendian: 0
         family: 320
    subfamily: 103
    revfamily: 1
         timeout: 10
```

5 Check to see if the target is running by entering

```
runstatus = isrunning(cc)
```

MATLAB responds by telling you that the processor is stopped

```
runstatus =

    0
```

6 At last, check to see whether the target supports RTDX communications by entering

```
usesrtdx = isrtdxcapable(cc)
usesrtdx =
```

```
1
```

Loading Files into CCS

You have established the link to CCS IDE and to target. Using three functions you learned about the target, whether it was running, its type, and whether CCS IDE was visible. Now the target needs something to do.

In this tutorial section you load the executable code for the target CPU in CCS IDE. For this tutorial, the Link for Code Composer Studio includes a Code Composer Studio project file. With the following commands in the tutorial you locate the tutorial project file and load it into CCS IDE. The open function directs Code Composer Studio to load a project file or workspace file

Note Code Composer Studio has its own workspace and workspace files which are quite different from MATLAB workspace files and the MATLAB workspace. Remember to pay attention to both workspaces.

After you have executable code running on your target you can exchange data blocks with the target. This is the purpose of the links for CCS IDE:

- 1 To load the appropriate project file to your target, do one of the following depending on the class of your target processor.

C54xx processor family—Type the following commands to load the project file. Notice that these functions also change your CCS IDE working directory.

```
projfile =  
fullfile(matlabroot, 'toolbox', 'ccslink', 'ccsdemos', ...  
'ccstutorial', 'ccstut_54xx.pjt')  
projpath = fileparts(projfile)  
open(cc,projfile) % Open project file  
cd(cc,projpath) % Change working directory of Code Composer(only)
```

C6x11 processor family—Type the following commands to load the project file. Notice that these functions also change your CCS IDE working directory.

```
projfile =  
fullfile(matlabroot, 'toolbox', 'ccslink', 'ccsdemos', ...  
'ccstutorial', 'ccstut_6x11.pjt')  
projpath = fileparts(projfile)  
open(cc,projfile) % Open project file
```



```
cd(cc,projpath) % Change Code Composer working directory
```

C6x0x processor family—Type the following commands to load the project file. Notice that these functions also change your CCS IDE working directory.

```
projfile =
fullfile(matlabroot,'toolbox','ccslink','ccsdemos',...
'ccstutorial','ccstut_6x0x.pjt')
projpath = fileparts(projfile)
open(cc,projfile) % Open project file
cd(cc,projpath) % Change Code Composer working directory
```

- 2 Next, build the target executable file in CCS IDE. Select **Project->Build** from the menu bar in CCS IDE.

You may get an error here related to one or more missing .lib files. If you installed CCS IDE in a directory other than the default installation directory, browse in your installation directory to find the missing file or files. Use the path in the error message as an indicator of where to find the missing files.

- 3 Type `load(cc, 'a.out')` to load the target execution file.
- 4 You now have a loaded program file and associated symbol table. To determine the memory address of the global symbol `ddat`, type

```
ddata = address(cc, 'ddat')
```

```
ddata =
```

```
1.0e+009 *
```

```
2.1475      0
```

Your values for `ddata` may be different depending on your target.

Note The symbol table is available after you load the program file into the target, not after you build a program file.

- 5** To convert `ddata` to a hexadecimal string that contains the memory address and memory page, type

```
dec2hex(ddata)
```

MATLAB displays

```
ans =
```

```
80000010
```

```
00000000
```

where the memory page is `0x00000000` and the address is `0x80000010`.

Working with Links and Data

With the target code loaded, you can use the Link for Code Composer Studio functions to examine and modify data values in the processor.

When you look at the source file listing in the CCS IDE Project view window, there should be a file named `ccstut.c`. The Link for Code Composer Studio ships this file with the tutorial and includes it in the project. `ccstut.c` has two global data arrays—`ddat` and `idat`. They are declared and initialized in lines 10 and 11 of the source code. You access these processor memory arrays from MATLAB using the functions `read` and `write`.

The Link for Code Composer Studio provides three functions to control target execution—`run`, `halt`, and `restart`. To demonstrate these commands, use CCS IDE to add a breakpoint to line 64 of `cctut.c`. Line 64 is

```
printf("Link for Code Composer: Tutorial - Memory Modified by Matlab!\n");
```

For information about adding breakpoints to a file, refer to your *Code Composer Studio User's Guide* from Texas Instruments. Then proceed with the tutorial.

- 1** To demonstrate the new functions, try the following functions.

```
halt(cc)                % Halt the processor  
restart(cc)             % Reset the PC to start of program
```

```
run(cc,'runtohalt',30); % Wait for program execution to stop at
                       % breakpoint! (timeout = 30 seconds)
```

When you switch to viewing CCS IDE, you see that your program stopped at the breakpoint you inserted on line 64, and the program printed

```
Link for Code Composer: Tutorial - Initialized Memory
Double Data array = 16.3 -2.13 5.1 11.8
Integer Data array = 1-508-647-7000
```

in the CCS IDE Stdout tab. Nothing prints in MATLAB.

- 2 Before you restart your program (currently stopped at line 64) you can change some of the values in memory. Perform one of the procedures listed below based on your target processor.

C5xxx processor family—Type the following functions to demonstrate the read and write functions.

- a Type `ddatv = read(cc,address(cc,'ddat'),'double',4)`.

MATLAB responds with

```
ddatv =
    16.3000   -2.1300    5.1000   11.8000
```

- b Type `idatv = read(cc,address(cc,'idat'),'int16',4)`.

Now MATLAB returns

```
idatv =
     1     0   508     0
```

Because you requested 16-bit integers, whose maximum value is 512, the values 647 and 7000 come back as zeros since they cannot be represented as 16-bit integers. Using `int32` would have returned the full values for all the data in `idatv`.

- c You can change the values stored in `ddat` by typing `write(cc,address(cc,'ddat'),double([pi 12.3 exp(-1)... sin(pi/4)]))`

The `double` argument directs MATLAB to write the values to the target as double-precision data.

- d** To change `idat`, type

```
write(cc,address(cc,'idat'),int32([1:4]))
```

Here you write the data to the target as 32-bit integers (convenient for representing phone numbers, for example).

- e** Start the program running again by typing

```
run(cc,'runtohalt',30);
```

Checking the Stdout tab in CCS IDE reveals that `ddat` and `idat` contain new values. Now we read those new values back into MATLAB.

- f** Type `ddatv = read(cc,address(cc,'ddat'),'double',4)`.

```
ddatv =
```

```
    3.1416    12.3000    0.3679    0.7071
```

`ddatv` does contain the values you wrote in step c.

- g** Check that the change to `idatv` occurred by typing

```
idatv = read(cc,address(cc,'idat'),'int16',4)
```

MATLAB returns the new values for `idatv`.

```
idatv =
```

```
    1    2    3    4
```

- h** Finally, use `restart` to reset the program counter for your program to the beginning. Type

```
restart(cc);
```

C6xxx processor family—Type the following commands to demonstrate the read and write functions.

- a** Type `ddatv = read(cc,address(cc,'ddat'),'double',4)`.

MATLAB responds with

```
ddatv =
```

```
    16.3000   -2.1300    5.1000   11.8000
```

- b** Type `idatv = read(cc,address(cc,'idat'),'int16',4)`.

Now MATLAB responds

```
idatv =
```

```
    1     0   508     0
```

Because you requested 16-bit integers, whose maximum value is 512, the values 647 and 7000 come back as zeros since they cannot be represented as 16-bit integers. Using `int32` would have returned the full values for all the data in `idatv`.

- c** You can change the values stored in `ddat` by typing
`write(cc,address(cc,'ddat'),double([pi 12.3 exp(-1)...
sin(pi/4)]))`

The `double` argument directs MATLAB to write the values to the target as double-precision data.

- d** To change `idat`, type

```
write(cc,address(cc,'idat'),int32([1:4]))
```

Here you write the data to the target as 32-bit integers (convenient for representing phone numbers, for example).

- e** Now start the program running again by typing

```
run(cc,'runtohalt',30);
```

Checking the Stdout tab in CCS IDE reveals that `ddat` and `idat` contain new values. Now read those new values back into MATLAB.

- f** Type `ddatv = read(cc,address(cc,'ddat'),'double',4)`.

```
ddatv =
```

```
    3.1416   12.3000    0.3679    0.7071
```

`ddatv` does contain the values you wrote in step c.

g Check that the change to `idatv` occurred by typing

```
idatv = read(cc,address(cc,'idat'),'int32',4)
```

MATLAB returns the new values for `idatv`.

```
idatv =
```

```
1      2      3      4
```

h Finally, use `restart` to reset the program counter for your program to the beginning. Type

```
restart(cc);
```

3 The Link for Code Composer Studio offers two more functions for reading and writing data to your target. These functions let you read and write data to the processor registers: `regread` and `regwrite`. They let you change variable values on the processor in real time. As before, the functions behave slightly differently depending on your target. Select the appropriate procedure for your target to demonstrate `regread` and `regwrite`.

C5xxx processor family—Most registers are memory-mapped and consequently are available using `read` and `write`. However, the PC register is not memory mapped. To access this register, you use the special pair of functions—`regread` and `regwrite`. The following commands demonstrate how to use these functions to read and write to the PC register.

a To read the value stored in register PC, type

```
cc.regread('PC','binary')
```

To tell MATLAB what datatype you are reading, the string `binary` indicates that the PC register contains a value stored as an unsigned binary integer.

In response, MATLAB displays

```
ans =
```

```
33824
```

- b** To write a new value to the PC register, type

```
cc.regwrite('PC',hex2dec('100'),'binary')
```

This time, `binary` as an input argument tells MATLAB to write the value to the target as an unsigned binary integer. Notice that you used `hex2dec` to convert the hexadecimal string to decimal.

- c** Check the PC contains the value you wrote.

```
cc.regread('PC','binary')
```

C6xxx processor family—`regread` and `regwrite` let you access the processor registers directly. Type the following functions to get data into and out of the A0 and B2 registers on your target.

- a** Retrieve the value in register A0 and store it in a variable in your MATLAB workspace. Type

```
treg = cc.regread('A0','2scomp');
```

`treg` now contains the two's complement representation of the value in A0.

- b** Retrieve the value in register B2 as an unsigned binary integer, by typing
- ```
cc.regread('B2','binary');
```
- c** Now, use `regwrite` to put the value in `treg` into register A2.

```
cc.regwrite('A2',treg,'2scomp');
```

CCS IDE reports that A0, B2, and A2 have the values you expect. Select **View→CPU Registers→Core Registers** from the CCS IDE menu bar to see a listing of the processor registers.

## Working with Embedded Objects

Having direct access to the memory on your target DSP, as provided by the links in Link for Code Composer Studio, can be a powerful tool for helping you develop and troubleshoot your digital signal processing applications. But for programming in C, it is perhaps more valuable to be able to work with memory and data in ways that are consistent with the C variables embedded in your programs.

Link for Code Composer Studio implements just this sort of access and manipulation capability by using MATLAB objects (called embedded objects in this guide) that access and represent variables and data embedded in your

project. Various functions that compose the Link for Code Composer Studio, such as `createobj`, `convert`, and `write`, help you create the embedded objects you use to work with your data in DSP memory and registers, and let you manipulate the data in MATLAB and in your code.

This portion of the tutorial introduces some of the functions and how to use them to access and manipulate them.

Function `list` generates a lot of information for you about an embedded variable in the symbol table. An even more useful function is `createobj` that creates a MATLAB object that represents a C variable in the symbol table in CCS. Working with the object that `createobj` returns, you can read the entire contents of a variable, or one or more elements of the variable when the variable is an array or structure.

From the beginning of this tutorial you have used the link object `cc` with all of the functions. `cc` represents the path to communicate with a particular processor in CCS. For the remainder of this tutorial you work with a variety of functions that use, not the link object `cc`, but other objects such as numeric or structure objects, that represent embedded objects in CCS. All of these new functions use the object names (handles) as the first input argument to the function (in just the way you used `cc`). When you create the object `cvar` in step 4 that follows, `cvar` represents the embedded variable `idat`.

To begin, restart the program and use `list` to get some information about a variable (an embedded object) in Code Composer Studio.

## Using `list`

- 1 To restart the program in CCS, enter

```
restart(cc)
```

This resets the program counter to the beginning of your program.

- 2 To move the program counter (PC) to the beginning of `main`, which you should do before rerunning your program, enter

```
goto(cc, 'main')
run(cc, 'main')
```

Moving the PC to `main` ensures that the program initializes the embedded C variables.



- 3** Now, to get information about a variable in your program, use `list` with two input options—**'variable'** which defines the type of information to return, and **'idat'** which identifies the symbol itself.

```
idatlist = list(cc, 'variable', 'idat')
```

`idat` is a global variable; the input keyword **variable** identifies it as one. Other keywords for `list` include **project**, **globalvar**, **function**, and **type**. Refer to `list` for more information about these options.

In your MATLAB workspace and window, you see a new structure named `idatlist`. If you use the MATLAB Workspace browser, double-click `idatlist` in the browser to see `idatlist`.

- 4** Rather than using `list` to get information about `idat`, create an object that represents `idat` in your MATLAB workspace by entering

```
cvar = createobj(cc, 'idat')
```

which creates the new numeric object `cvar`.

```
NUMERIC Object
Symbol Name : idat
Address : [40060 0]
Wordsize : 16 bits
Address Units per value : 2 AU
Representation : signed
Binary point position : 0
Size : [4]
Total address units : 8 AU
Array ordering : row-major
Endianness : little
```

You use `cvar`, through the numeric object properties and functions, to access and manipulate the embedded variable `idat`, both in your MATLAB workspace and in CCS if you write your changes back to CCS from your workspace.

## Using read and write

- 5** Try the following functions to read and write `cvar`. Notice the way the return values change as you change the function syntax. Notice also that `write`

actually changes the data in memory on the target, as you see from what comes back to MATLAB after the third read.

**a** `read(cvar)`

This form returns all of the entries in the embedded array `cvar` to your MATLAB workspace.

`ans =`

```
 1 508 647 7000
```

**b** `read(cvar,2)`

In contrast to the previous syntax, this one returns only the second element of `cvar`—508.

**c** `write(cvar,4,7001)`

Using `write` to change the value stored in the fourth element of `cvar` to 7001.

**d** `write(cvar,1,'FFFF')`

Change the first element of `cvar` to -1, which is the decimal equivalent of 0xFFFF. When you entered FFFF as a string (enclosed in single quotation marks), `write` converts the string to its decimal equivalent and stores that at the target location in memory.

**e** `read(cvar)`

At last, read the embedded array `cvar` to see if your changes to the first and fourth elements really occurred (they did).

**f** `read(cvar,[1 size(cvar)])`

Finally, read the first and last elements of the embedded variable `cvar`.

## Using cast, convert, and size

Each time you used `read`, the function took the raw values of `idat` stored in memory on your target and converted them to equivalent MATLAB numeric values. The way that `read` converts `idat` elements to numeric values is controlled by the properties of the object `cvar` which resulted from using `createobj` to create it. When you created `cvar`, the object that accesses the embedded variable `idat`, `createobj` assigned default property values to the

properties of `cvar` that were appropriate for your target DSP architecture and for the C representation of variable `idat`.

In many cases, it may help you develop your program if you change the default conversion properties. Several of the object properties, such as `endianness`, `arrayorder`, and `size` respond to changes made using function `set`. To make more complex changes, use functions like `cast` and `convert` that adjust multiple object property values simultaneously.

In step 6 of this tutorial, you have the opportunity to use `cast`, `convert`, and `size` to modify `cvar` by changing property values. Unlike `read` and `write`, `cast`, `convert`, and `size` (and `set` mentioned earlier) do not affect the information stored on the target; they only change the properties of the object in MATLAB. Unless you write your changes back to your target, the changes you make in MATLAB stay in MATLAB.

- 6 To introduce changing the properties of `cvar` using `cast`, `convert`, and `size`, enter the following commands at the prompt. In this series of examples, you use `read` to view the changes each command makes to `cvar`.

a `set(cvar, 'size', [2])`

As a result of this function, `idat` gets resized to only the first two elements in the array.

b `read(cvar)`

`ans =`

```
1 508
```

Returns only two values, not the full data set you saw in step 5a.

c `uintcvar = cast(cvar, 'unsigned short')`

`uintcvar` is a new object, a copy of `cvar` (and thus `idat`), but with the `datatype` property value of `unsigned short` instead of `double`. Notice that the actual values are not different—just the interpretation. Where `cvar` interprets the values in `idat` as doubles, `uintcvar` interprets the values in `idat` as unsigned integers with 16 bits each. Now when you use the object to read `idat`, the returned values from `idat` are interpreted differently.

d `read(uintcvar)`

**e** `convert(cvar, 'unsigned short')`

In contrast to `cast`, `convert` does not make a copy of `cvar`; it changes the datatype property of `cvar` to be unsigned short.

NUMERIC Object

|                         |              |
|-------------------------|--------------|
| Symbol Name             | : idat       |
| Address                 | : [ 40060 0] |
| Wordsize                | : 16 bits    |
| Address Units per value | : 2 AU       |
| Representation          | : unsigned   |
| Binary point position   | : 0          |
| Size                    | : [ 2 ]      |
| Total address units     | : 4 AU       |
| Array ordering          | : row-major  |
| Endianness              | : little     |

**f** `read(cvar)`

`ans =`

1 508

Remember that one of the first things you did in these examples was change the size of `cvar` to 2. You should see that reflected in the returned values. The values returned by `cvar` after you change the datatype property should match the values returned by `uintcvar` since the objects have the same properties.

One more thing to notice—the first value of `idat` is no longer -1, although you changed the value in step 5d. Recall that you changed the datatype to unsigned short for `cvar`, so the first element of `idat` that you set to -1 is now shown as the unsigned equivalent 1.

## Using `getmember`

To this point you have worked with fairly simple data in memory on your target. However, with functions in Link for Code Composer Studio, you can manipulate more complex data like strings, structures, bitfields, enumerated data types, and pointers in a very similar way.

In the next, somewhat extended examples, the tutorial demonstrates some common functions for manipulating structures, strings, and enumerated data types on your target. Pay particular attention to function `getmember` which extracts a single specified field from a structure on your target as an object in MATLAB.

**7** `cvar = createobj(cc, 'myStruct')`

Here you create a new object `cvar`, replacing the old `cvar`, that represents an embedded structure named `myStruct` on your target. When you loaded this tutorial program, one of the defined structures in the program was `myStruct`.

```
STRUCTURE Object
 Symbol Name : myStruct
 Address : [40032 0]
 Size : [1]
 Total Address Units : 28 AU
 Members : 'iy', 'iz'
```

**8** `read(cvar)`

```
ans =

 iy: [2x3 double]
 iz: 'MatlabLink'
```

Now you see the contents of `myStruct`, its fields and values.

Here's the definition of `myStruct` from `ccstut.c` in CCS.

```
struct TAG_myStruct {
 int iy[2][3];
 myEnum iz;
} myStruct = { {{1,2,3}},{4,-5,6}}, MatlabLink}
```

**9** `write(cvar, 'iz', 'Simulink')`

After this command, you have updated the field `iz` in `myStruct` with the actual enumerated name `Simulink`. If you look into `ccstut.c`, you see that `iz` is an enumerated datatype. That feature comes into play in the next steps.

```
10 cfield = getmember(cvar,'iz')
```

cfield, the object returned by getmember, represents the embedded variable iz in the project. Here's what cfield looks like in property form.

```
ENUM Object
Symbol Name : iz
Address : [40056 0]
Wordsize : 32 bits
Address Units per value : 4 AU
Representation : signed
Binary point position : 0
Size : [1]
Total address units : 4 AU
Array ordering : row-major
Endianness : little
Labels & values : MATLAB=0, Simulink=1, SignalToolbox=2,
MatlabLink=3, EmbeddedTargetC6x=4
```

```
11 write(cfield,4)
```

```
12 read(cvar)
```

```
ans =

 iy: [2x3 double]
 iz: 'EmbeddedTargetC6x'
```

Your command write(cfield,4) replaced the string MatlabLink with the fourth value EmbeddedTargetC6x. That is an example of writing to an embedded variable by value.

```
13 cstring = createobj(cc,'myString')
```

createobj returns the object cstring that represents a C structure embedded in the project. When you leave off the closing semicolon (;) on the command, you see

```
STRING Object :
Symbol Name : myString
Address : [40104 0]
Total wordsize : 8 bits
Address Units per value : 1 AU
Representation : signed
Binary point position : 0
```

```

Size : [29]
Total address units : 29 AU
Array ordering : col-major
Endianness : little
Char Conversion Type : ASCII

```

which provides details about `cstring`. Using `get` with `cstring` returns the same information, plus more, in a form listing the property names and property values of `cstring`.

**14** `read(cstring)`

In response you see the contents of `cstring`

```
ans =
```

```
Treat me like an ASCII String
```

**15** `write(cstring,7,'ME')`

This changes the seventh element of `MyString` to `ME`. When you reread `cstring`, `me` should be replaced by `ME`, so the string becomes

```
Treat ME like an ASCII String
```

as you see in the next example.

**16** `read(cstring)`

```
ans =
```

```
Treat ME like an ASCII String
```

**17** `write(cstring,1,127)`

`write` changes the contents of the first element of `MyString` to the ASCII character 127—a nonprinting character.

**18** `readnumeric(cstring)`

Using `readnumeric` with a string object returns the numeric equivalent of the characters in `MyString`, as shown here.

```
ans =
```

Columns 1 through 12

```
127 114 101 97 116 32 77 69 32 108 105 107
```

Columns 13 through 24

```
101 32 97 110 32 65 78 83 73 32 83 116
```

Columns 25 through 29

```
114 105 110 103 0
```

## Closing the Links or Cleaning Up CCS IDE

Objects that you create in Link for Code Composer Studio have COM handles to CCS. Until you delete these handles, the CCS process (`cc_app.exe` in the Task Manager) remains in memory. Closing MATLAB removes these COM handles automatically, but there may be times when it helps to delete the handles manually, without quitting MATLAB. Use `clear` to remove objects from your MATLAB workspace and to delete any handles they contain. `clear all` deletes everything in your workspace. When you need to retain your MATLAB data while deleting objects and handles, use `clear objname`. Note that this applies both to objects you create with `ccdsp` and `createobj`. To clean up the objects created during the tutorial, the tutorial program enters

```
clear cc cvar cfield uintcvar
```

at the prompt.

One more bit of clean up that this tutorial does is to close the project in CCS with the command

```
close(cc,projfile,'project')
```

Finally, to delete your link to Code Composer, use `clear cc`.



---

**Note** If a link to CCS IDE exists when you close Code Composer Studio, the application does not close. Windows moves it to the background (it becomes invisible). Only after you clear all links to CCS IDE, or close MATLAB, does closing CCS IDE unload the application. You can see if CCS IDE is running in the background by checking in the Windows Task Manager. When CCS IDE is running, the entry `cc_app.exe` appears in the **Image Name** list on the **Processes** page.

---

Your development tutorial using CCS IDE is done.

During the tutorial you:

- 1 Selected your target.
- 2 Created and queried links to CCS IDE to get information about the link and the target.
- 3 Used MATLAB to load files into CCS IDE, and used MATLAB to run that file.
- 4 Worked with your CCS IDE project from MATLAB by reading and writing data to your target, and changing the data from MATLAB.
- 5 Created and used the embedded objects to manipulate data in a C-like way.
- 6 Closed the links you opened to CCS IDE.

In future development work with your signal processing applications you follow the same set of tasks. Thus the tutorial provided here gives you a working process for using the Link for Code Composer Studio and your signal processing programs to develop programs for a range of Texas Instruments digital signal processors. While the target may change, and the program will change, the essentials of the process remain the same, as do the functions you use to interact with the processor and CCS IDE.

## **Tutorial 1-2—Using Links for RTDX**

The Link for Code Composer Studio and the links for CCS IDE and RTDX speed and enhance your ability to develop and deploy digital signal processing systems on Texas Instruments digital signal processors. By using MATLAB and the Link for Code Composer Studio, your MathWorks tools, CCS IDE and RTDX work together to help you test and analyze your processing algorithms in your MATLAB workspace.

In contrast to CCS IDE, using links for RTDX lets you interact with your process in real time while it's running on the target. Across the link, you can:

- Send and retrieve data from memory on the processor
- Change the operating characteristics of the program
- Make changes to algorithms as needed without stopping the program or setting breakpoints in the code

Enabling real-time interaction lets you more easily see your process or algorithm in action, the results as they develop, and the way the process runs.

This tutorial assumes you have Texas Instruments Code Composer Studio and at least one DSP development board. You can use the CCS IDE simulator to run this tutorial. Within the tutorial we use the TMS320C6701 EVM as the target board, with the C6701 DSP on the C6701 EVM as the target processor.

After you complete the tutorial, either in the demonstration form or by entering the functions along with this text, you are ready to begin using RTDX to work with your applications and hardware.

### **Introducing the Tutorial for Using RTDX**

Digital signal processing development efforts begin with an idea for processing data; an application area, such as audio or wireless communications or multimedia computing; and a platform or hardware to host the signal processing. Usually these processing efforts involve applying strategies like signal filtering, compression, and transformation to change data content; or isolate features in data; or transfer data from one form to another or one place to another.

In all cases, developers create algorithms that they need to accomplish the desired result. Once they have the algorithms, developers use models and DSP processor development tools to test their algorithms, to determine whether the

processing achieves the goal, and whether the processing works on the proposed platform. The Link for Code Composer Studio and the links for RTDX and CCS IDE ease the job of taking algorithms from the model realm to the real world of the target digital signal processor on which the algorithm will run.

RTDX and links for CCS IDE provide a communications pathway to manipulate data and processing programs on your target digital signal processor. RTDX offers real-time data exchange in two directions between MATLAB and your target process. Data you send to the target has little effect on the running process and plotting the data you retrieve from the target lets you see how your algorithms are performing in real time.

To introduce the techniques and tools available in the Link for Code Composer Studio for using RTDX, the following procedures use many of the methods in the link software to configure the target processor, open and enable channels, send data to the target, and clean up after you finish your testing. Among the functions covered are:

- From links for CCS IDE
  - `ccsdsp`—create links to CCS IDE and RTDX.
  - `cd`—change your CCS IDE working directory from MATLAB.
  - `open`—load program files in CCS IDE.
  - `run`—run processes on the target processor.
- From the RTDX class
  - `close`—close the RTDX links between MATLAB and your target.
  - `configure`—determine how many channel buffers to use and set the size of each buffer.
  - `disable`—disable the RTDX links before you close them.
  - `display` and `disp`—return the results of functions `get` and `set`. When you omit the closing semicolon (;) on a function, `disp` provides the default display for the results of the operation.
  - `enable`—enable open channels so you can use them to send and retrieve data from your target.
  - `isenabled`—determine whether channels are enabled for RTDX communications.
  - `isreadable`—determine whether MATLAB can read the specified memory location.

- `iswritable`—determine whether MATLAB can write to the target.
- `msgcount`—find out how many messages are waiting in a channel queue.
- `open`—open channels in RTDX.
- `readmat`—read data matrices from the target into MATLAB as an array.
- `readmsg`—read one or more messages from a channel.
- `writemsg`—write messages to the target over a channel.

This tutorial provides the following procedure to show you how to use many of the functions in the links. By doing the steps listed, you can work through many of the operations yourself. As a bonus, the tutorial follows the general task flow for developing digital signal processing programs through testing with the links for RTDX.

Four tasks comprise this tutorial:

- 1** Create an RTDX link to your desired target and load the program to the processor.

All projects begin this way. Without the links you cannot load your executable to the target.

- 2** Configure channels to communicate with the target.

Notice that creating the links in Task 1 did not open communications to the processor. With the links in place, you open as many channels as you need to support the data transfer for your development work. This task includes configuring channel buffers to hold data when the data rate from the target exceeds the rate at which MATLAB can capture the data.

- 3** Run your application on the target. At this stage you use MATLAB to investigate the results of your running process.

The previous tasks are common to all projects where you use RTDX to communicate with a target. While this step is also common to all development projects, the program used and the methods and details are up to you.

- 4** Close the links to the target and clean up the links and associated debris left over from your work.

Once again, all projects end with these tasks. Closing channels and cleaning up the memory and links you created ensures that CCS IDE, RTDX, and the Link for Code Composer Studio are ready for the next time you start development on a project.

Within this set of tasks, numbers 1, 2, and 4 are considered fundamental to all development projects. Whenever you work with MATLAB and links for RTDX, you perform the functions and tasks outlined and presented in this tutorial. Where the differences lie is in Task 3. Task 3 is the most important for using the Link for Code Composer Studio to develop your processing system.

In this tutorial you use an executable program named `rtdxtutorial_6xevm.out` as your application. When you use the RTDX and CCS IDE links to develop applications, replace `rtdxtutorial_6xevm.out` in Task 3 with the filename and path to your digital signal processing application.

You can view the tutorial M-file used here by clicking `rtdxtutorial`. To run this tutorial in MATLAB, click `run rtdxtutorial`.

---

**Note** To be able to open and enable channels over a link to RTDX, the program loaded on your target must include functions or code that define the channels.

Your C source code might look something like this to create two channels, one to write and one to read.

```
rtdx_CreateInputChannel(ichan); % Target reads from this.
rtdx_CreateOutputChannel(ochan); % Target writes to this.
```

These are the entries we use in `int16.c` (the source code that generates `rtdxtutorial_6xevm.out`) to create the read and write channels.

If you are working with a model in Simulink and using code generation, use the `To Rtdx` and `From Rtdx` blocks in your model to add the RTDX communications channels to your model and to the executable code on your target.

---

One more note about this tutorial. Throughout the code we use the dot notation (direct property referencing) to access functions and link properties. For example, we use

```
cc.rtdx.open('ichan','w');
```

to open and configure `ichan` for write mode. You could use an equivalent syntax instead that does not use direct property referencing.

```
open(cc.rtdx,'ichan','w');
```

Or, use

```
open(rx,'ichan','w');
```

if you created an alias `rx` to the RTDX portion of `cc`, as follows

```
rx = cc.rtdx;
```

## Creating the Links

With your processing model converted to an executable suitable for your desired target, you are ready to use the links to test and run your model on your processor. The Link for Code Composer Studio and the links do not distinguish the source of the executable—whether you used the Link for Code Composer Studio and Real-Time Workshop, CCS IDE, or some other development tool to program and compile your model to an executable does not affect the links. So long as your `.out` file is acceptable to the target you select, the Link for Code Composer Studio provides the links to the processor.

---

**Note** Program `rtdxtutorial_6xevm.out` targets the C6701 EVM. We compiled, built, and linked the program as an executable to run on the C6701 digital signal processor. To use the tutorial without changes, target your C6701 EVM when you define properties `boardnum` and `procnum`.

---

Before continuing with this tutorial, you must load a valid GEL file to configure the EMIF registers of your target and perform any required processor initialization steps. Default GEL files provided by Code Composer Studio are stored in `..\cc\gel` in the folder where you installed Code Composer Studio. Select **File->Load\_GEL** in CCS IDE to load the default GEL file that matches

your processor family, such as `init6x0x.gel` for the C6x0x processor family, and your configuration.

Begin the process of getting your model onto the target by creating a link to CCS IDE. Start by clearing all existing handles and setting `echo` on so you see functions in the M-file execute as the program runs:

```
1 clear all; echo on;
```

`clear all` has the side effect of removing debugging breakpoints and resetting persistent variables since function breakpoints and persistent variables are cleared whenever the M-file changes or is cleared. Breakpoints within your executable remain after `clear`. Clearing the MATLAB workspace does not affect your executable.

**2** Now construct the link to your target board and processor by typing

```
cc=ccsdsp('boardnum',0);
```

`boardnum` defines which board the new link accesses. In this example, `boardnum` is 0. The Link for Code Composer Studio connects the link to the first, and in this case only, processor on the board. To find the `boardnum` and `procnum` values for the boards and simulators on your system, use `ccsboardinfo`. When you type

```
ccsboardinfo
```

at the prompt, the Link for Code Composer Studio returns a list like the following one that identifies the boards and processors in your computer.

| Board Num | Board Name                     | Proc Num | Processor Name | Processor Type |
|-----------|--------------------------------|----------|----------------|----------------|
| 1         | C6xxx Simulator (Texas Inst... | 0        | CPU            | TMS320C6211    |
| 0         | C6701 EVM (Texas Instruments)  | 0        | CPU_1          | TMS320C6701    |

**3** To open and load the target file, change the path for MATLAB to be able to find the file.

```
tgt_dir = fullfile(matlabroot,'toolbox','tidsp','tidemos','tutorial');
cd(cc,tgt_dir); % Or cc.cd(tgt_dir)
dir(cc); % Or cc.dir
```

- 4 You have reset the directory path to find the tutorial file. Now open the file.  
`cc.open('rtdxtutorial_6xevm.out')`

Because `open` is overloaded for the CCS IDE and RTDX links, this may seem a bit strange. In this syntax, `open` loads your executable file onto the target processor identified by `cc`. Later in this tutorial, you use `open` with a different syntax to open channels in RTDX.

In the next section, you use the new link to open and enable communications between MATLAB and your target.

## Configuring Communications Channels

Communications channels to the target do not exist until you open and enable them through the Link for Code Composer Studio and CCS IDE. Opening channels consists of opening and configuring each channel for reading or writing, and enabling the channels.

In the `open` function, you provide the channel names as strings for the channel name property. The channel name you use is not random. The channel name string must match a channel defined in the executable file. If you specify a string that does not identify an existing channel in the executable, the `open` operation fails. In this tutorial, two channels exist on the target—`ichan` and `ochan`. Although the channels are named `ichan` for input channel and `ochan` for output channel, neither channel is configured for input or output until you configure them from MATLAB or CCS IDE. You could configure `ichan` as the output channel and `ochan` as the input channel. The links would work just the same. For simplicity, the tutorial configures `ichan` for input and `ochan` for output. One more note—read and write are defined as seen by the target. When you write data from MATLAB, you write to the channel that the target reads, `ichan` in this case. Conversely, when you read from the target, you read from `ochan`, the channel that the target writes to:

- 1 Configure buffers in RTDX to store the data until MATLAB can read it into your workspace. Often, MATLAB cannot read data as quickly as the target can write it to the channel.

```
cc.rtdx.configure(1024,4); % define 4 channels of 1024 bytes each
```

Channel buffers are optional. Adding them provides a measure of insurance that data gets from your target to MATLAB without getting lost.



- 2** Define one of the channels as a write channel. Use 'ichan' for the channel name and 'w' for the mode. Either 'w' or 'r' fits here, for write or read.

```
cc.rtdx.open('ichan','w');
```

- 3** Now enable the channel you opened.

```
cc.rtdx.enable('ichan');
```

- 4** Repeat steps 2 and 3 to prepare a read channel.

```
cc.rtdx.open('ochan','r');
cc.rtdx.enable('ochan');
```

- 5** To use the new channels, enable RTDX by typing

```
cc.rtdx.enable;
```

You could do this step before you configure the channels—the order does not matter.

- 6** Reset the global timeout to 20 s to provide a little room for error. ccstdsp applies a default timeout value of 10 s. In some cases this may not be enough.

```
cc.rtdx.get('timeout')
ans =
 10
cc.rtdx.set('timeout', 20); % Reset timeout = 20 seconds
```

- 7** Check that the timeout property value is now 20 s and that your link has the correct configuration for the rest of the tutorial.

```
cc.rtdx
```

```
RTDX Object:
```

```
API version: 1.0
Default timeout: 20.00 secs
Open channels: 2
```

## Running the Application

To this point you have been doing housekeeping functions that are common to any application you run on the target. You load the target, configure the communications, and set up other properties you need.

In this tutorial task, you use a specific application to demonstrate a few of the functions available in the Link for Code Composer Studio that let you experiment with your application while you develop your prototype. To demonstrate the link for RTDX `readmat`, `readmsg`, and `writemsg` functions, you write data to your target for processing, then read data from the target after processing:

- 1** Restart the program you loaded on the target. `restart` ensures the program counter (PC) is at the beginning of the executable code on the processor.

```
cc.restart
```

Restarting the target does not start the program executing. You use `run` to start program execution.

- 2** Type `cc.run('run');`

Using 'run' for the run mode tells the processor to continue to execute the loaded program continuously until it receives a halt directive. In this mode, control returns to MATLAB so you can work in MATLAB while the program runs. Other options for the mode are

- 'runthalt'—start to execute the program and wait to return control to MATLAB until the process reaches a breakpoint or execution terminates.
  - 'thalt'—change the state of a running processor to 'runthalt' and wait to return until the program halts. Use `thalt` mode to stop the running processor cleanly.
- 3** Type the following functions to enable the write channel and verify that the enable takes effect.

```
cc.rtdx.enable('ichan');
cc.rtdx.isenabled('ichan')
```

If MATLAB responds `ans = 0` your channel is not enabled and you cannot proceed with the tutorial. Try to enable the channel again and reverify the status.

- 4 Write some data to the target. Check that you can write to the target, then use `writemsg` to send the data. You do not need to type the if-test code shown.

```
if cc.rtdx.iswritable('ichan'), % Used in a script application.
 disp('writing to target...') % Optional to display progress.
 indata=1:10
 cc.rtdx.writemsg('ichan', int16(indata))
end % Used in scripts for channel testing.
```

We included the if-statement to simulate writing the data from within a MATLAB script. The script uses `iswritable` to check that the input channel is functioning. If `iswritable` returns 0 the script would skip the write and exit the program, or respond in some way. When you are writing or reading data to your target in a script or M-file, checking the status of the channels can help you avoid errors during execution.

As your application runs you may find it helpful to display progress messages. In this case, the program directed MATLAB to print a message as it reads the data from the target by adding the function

```
disp('writing to target...')
```

---

**Note** Function `cc.rtdx.writemsg('ichan', int16(indata))` results in 20 messages stored on the processor. Here's how.

When you write `indata` to the target, the following code running on the target takes your input data from `ichan`, adds one to the values and copies the data to memory:

```
while (!RTDX_isInputEnabled(&ichan))

/* wait for channel enable from MATLAB */
RTDX_read(&ichan, recvd, sizeof(recvd));
puts("\n\n Read Completed ");

for (j=1; j<=20; j++) {
 for (i=0; i<MAX; i++) {
 recvd[i] +=1;
 }
}
```

```
while (!RTDX_isOutputEnabled(&ochan))
 { /* wait for channel enable from MATLAB */ }
RTDX_write(&ochan, recvd, sizeof(recvd));
while (RTDX_writing != NULL)
 { /* wait for data xfer INTERRUPT DRIVEN for C6000 */ }
}
```

Program `int16_rtdx.c` contains this source code. You can find the file in a folder in the `..\tldemos\rtdxtutorial` directory.

---

- 5** Type the following to check the number of available messages to read from the target.

```
num_of_msgs = cc.rtdx.msgcount('ochan');
```

`num_of_msgs` should be zero. Using this process to check the amount of data can make your reads more reliable by letting you or your program know how much data to expect.

- 6** Type the following to verify that your read channel `ochan` is enabled for communications.

```
cc.rtdx.isenabled('ochan')
```

You should get back `ans = 0`—you have not enabled the channel yet.

- 7** Now enable and verify `'ochan'`.

```
cc.rtdx.enable('ochan');
cc.rtdx.isenabled('ochan')
```

To show that `ochan` is ready, MATLAB responds `ans = 1`. If not, try enabling `ochan` again.

- 8** Type

```
pause(5);
```

The `pause` function gives the processor extra time to process the data in `indata` and transfer the data to the buffer you configured for `ochan`.

- 9** Repeat the check for the number of messages in the queue. There should be 20 messages available in the buffer.

```
num_of_msgs = cc.rtdx.msgcount('ochan')
```

With `num_of_msgs = 20`, you could use a looping structure to read the messages from the queue in to MATLAB. In the next few steps of this tutorial you read data from the ochan queue to different data formats within MATLAB.

- 10** Read one message from the queue into variable `outdata`.

```
outdata = cc.rtdx.readmsg('ochan', 'int16')
```

```
outdata =
 2 3 4 5 6 7 8 9 10 11
```

Notice the `'int16'` represent option. When you read data from your target you need to tell MATLAB the data type you are reading. You wrote the data in step 4 as 16-bit integers so you use the same data type here.

While performing reads and writes, your process continues to run. You did not need to stop the processor to get the data or send the data, unlike using most debuggers and breakpoints in your code. You placed your data in memory across an RTDX channel, the processor used the data, and you read the data from memory across an RTDX channel, without stopping the processor.

- 11** You can read data into cell arrays, rather than into simple double-precision variables. Use the following function to read three messages to cell array `outdata`, an array of three, 1-by-10 vectors. Each message is a 1-by-10 vector stored on the processor.

```
outdata = rtdx.readmsg('ochan', 'int16', 3)
```

```
outdata =
 [1x10 int16] [1x10 int16] [1x10 int16]
```

- 12** Cell array `outdata` contains three messages. Look at the second message, or matrix, in `outdata` by using dereferencing with the array.

```
outdata{1,2}
```

```
outdata =
 4 5 6 7 8 9 10 11 12 13
```

- 13** Read two messages from the target into two 2-by-5 matrices in your MATLAB workspace.

```
outdata = cc.rtdx,readmsg('ochan','int16',[2 5],2)
```

```
outdata =
 [2x5 int16] [2x5 int16]
```

To specify the number of messages to read and the data format in your workspace, you used the `siz` and `nummsgs` options set to `[2 5]` and `2`.

- 14** You can look at both matrices in `outdata` by dereferencing the cell array again.

```
outdata{1,:}
```

```
ans =
 6 8 10 12 14
 7 9 11 13 15
```

```
ans =
 7 9 11 13 15
 8 10 12 14 16
```

- 15** For a change, read a message from the queue into a column vector.

```
outdata = cc.rtdx.readmsg('ochan','int16',[10 1])
```

```
outdata =
 8
 9
 10
 11
 12
 13
 14
 15
 16
 17
```

- 16** The Link for Code Composer Studio provides a function for reading messages into matrices — `readmat`. Use `readmat` to read a message into a 5-by-2 matrix in MATLAB.

```
outdata = readmat('ochan','int16',[5 2])
```

```
outdata =
 9 14
 10 15
 11 16
 12 17
 13 18
```

Since a 5-by-2 matrix requires ten elements, MATLAB reads one message into `outdata` to fill the matrix.

- 17** To check your progress, see how many messages remain in the queue. You have read eight messages from the queue so 12 should remain.

```
num_of_msgs = cc.rtdx.msgcount('ochan')
```

```
num_of_msgs =
 12
```

- 18** To demonstrate the connection between messages and a matrix in MATLAB, read data from 'ochan' to fill a 4-by-5 matrix in your workspace.

```
outdata = cc.rtdx.readmat('ochan','int16',[4 5])
```

```
outdata =
 10 14 18 13 17
 11 15 19 14 18
 12 16 11 15 19
 13 17 12 16 20
```

Filling the matrix required two messages worth of data.

- 19** To verify that the last step used two messages recheck the message count. You should find 10 messages waiting in the queue.

```
num_of_msgs = cc.rtdx.msgcount('ochan')
```

- 20** Continuing with matrix reads, fill a 10-by-5 matrix (50 matrix elements or five messages).

```
outdata = cc.rtdx.readmat('ochan','int16',[4 5])
```

```
outdata =
 12 13 14 15 16
 13 14 15 16 17
 14 15 16 17 18
 15 16 14 18 19
 16 17 18 19 20
 17 18 19 20 21
 18 19 20 21 22
 19 20 21 22 23
 20 21 22 23 24
 21 22 23 24 25
```

- 21** Recheck the number of messages in the queue to see that five remain.

- 22** `flush` lets you remove messages from the queue without reading them. Data in the message you remove is lost. Use `flush` to remove the next message in the read queue. Then check the waiting message count.

```
cc.rtdx.flush('ochan',1)
num_of_msgs = cc.rtdx.msgcount('ochan')
```

```
num_of_msgs =

 4
```

- 23** Empty the remaining messages from the queue and verify that the queue is empty.

```
cc.rtdx.flush('ochan','all')
```

With the 'all' option, `flush` discards all messages in the `ochan` queue.

## Closing the Links or Cleaning Up

One of the most important programmatic processes you should do in every RTDX session is to clean up at the end. Cleaning up includes stopping your target processor, disabling the RTDX channels you enabled, disabling RTDX



and closing your open channels. Performing this series of tasks ensures that future processes avoid trouble caused by unexpected interactions with left-over handles, channels, and links from your earlier development work. Best practices suggest that you include the following tasks (or an appropriate subset that meets your development needs) in your development scripts and programs.

We use four functions in this section; each has a purpose—the operational details in the following list explain how and why we use each one. They are

- `clear`—remove all RTDX objects and handles associated with a CCS and RTDX link. When you finish a session with RTDX, `clear` removes all traces of the specified link, or all links when you use the 'all' option in the syntax. When you clear one or more links, they no longer exist and cannot be reopened or used. If you are ending your programming session and do not want to retain any of the channels or links you created, use `clear` to end the RTDX communications and links and release all channels and resources associated with existing CCS IDE and RTDX links. You do not need to use the `close` or `disable` functions first.

To load a new program to a processor on which you have a program running, and to which you have links, you must clear the existing links before you load the new program to the target.

- `close`—close the specified RTDX channel. To use the channel again, you must open and enable the channel. Compare `close` to `disable`. `close('rtdx')` closes the communications provided by RTDX. After you close RTDX, you cannot communicate with your target.
- `disable`—remove RTDX communications from the specified channel, but does not remove the channel, or link. Disabling channels may be useful when you do not want to see the data that is being fed to the channel, but you may want to read the channel later. By enabling the channel later, you have access to the data entering the channel buffer. Note that data that entered the channel while it was disabled is lost.
- `halt`—stop a running processor. You may still have one or more messages in the host buffer.

Use the following procedure to shut down communications between MATLAB and the target, and end your session:

- 1 Begin the process of shutting down the target and RTDX by stopping the target processor. Type the following functions at the prompt.

```
if (isrunning) % Use this test in scripts.
 cc.halt; % Halt the processor.
end % Done.
```

Your processor may already be stopped at this point. In a script, you might put the function in an `if`-statement as we have done here. Consider this test to be a safety check. No harm comes to the processor if it is already stopped when you tell it to stop. When you direct a stopped processor to halt, the function returns immediately.

- 2 You have stopped the processor. Now disable the RTDX channels you opened to communicate with the target.

```
cc.rtdx.disable('all');
```

If necessary, using `disable` with channel name and target identifier input arguments lets you disable only the channel you choose. When you have more than one board or processor, you may find disabling selected channels meets your needs.

When you finish your RTDX communications session, disable RTDX to ensure that the Link for Code Composer Studio releases your open channels before you close them.

```
cc.rtdx.disable;
```

- 3 Use one or all of the following function syntaxes to close your open channels. Either close selected channels by using the channel name in the function, or use the `'all'` option to close all open channels.

- `cc.rtdx.close('ichan')` to close your input channel in this tutorial.
- `cc.rtdx.close('ochan')` to close your output channel in the tutorial.
- `cc.rtdx.close('all')` to close all of your open RTDX channels, regardless of whether they are part of this tutorial.

Consider using the `'all'` option with the `close` function when you finish your RTDX work. Closing channels reduces unforeseen problems caused by channel objects that may exist but do not get closed correctly when you end your session.

- 4** When you created your RTDX link (`cc = ccdsp('boardnum',1)`) at the beginning of this tutorial, the `ccdsp` function opened CCS IDE and set the visibility to 0. To avoid problems that occur when you close the link to RTDX with CCS visibility set to 0, be sure to make CCS IDE visible on your desktop. The following if-statement checks the visibility and changes it if needed.

```
if cc.isvisible,
 cc.visible(1);
end
```

---

**Note** Visibility can cause problems. When CCS IDE is running invisibly on your desktop, meaning you set visibility to 0, do not use `clear all` to get rid of your links for CCS IDE and RTDX. Without a link to CCS IDE you cannot access CCS IDE to change the visibility setting, or unload the application. To close CCS IDE when you do not have an existing link, either create a new link to CCS IDE, or use Windows Task Manager to end the process `cc_app.exe`, or close MATLAB.

---

- 5** You have finished the work in this tutorial, type the following to close all your remaining links to CCS IDE and release all the associated resources.

```
clear ('all'); % Calls the link destructors to remove all links
echo off
```

Note that `clear all` (without the parentheses) removes all variables from your MATLAB workspace.

You have completed the tutorial using RTDX. During the tutorial you:

- 1** Opened links to CCS IDE and RTDX and used those links to load an executable program to your target processor.
- 2** Configured a pair of channels so you could transfer data to and from your target.
- 3** Ran the executable on the target, sending data to the target for processing and retrieving the results.
- 4** Stopped the executing program and closed the links to CCS IDE and RTDX.

In future development work with your signal processing applications you follow the same set of tasks. Thus the tutorial provided here gives you a working process for using the Link for Code Composer Studio and your signal processing programs to develop programs for a range of Texas Instruments digital signal processors. While the target may change, the essentials of the process remain the same.

## Listing the Functions for Links

To review a complete list of functions that operate on links, either CCS IDE or RTDX, type either

```
help ccsdsp
help rtdx
```

at the command line. If you already have a link `cc`, you can use dot notation to return the methods for CCS IDE or RTDX by entering

```
cc.methods or cc.rtdx.methods
```

at the prompt. In either instance MATLAB returns a list of the available functions for the specified link type, including both public and private functions. For example, to see the functions (methods) for links to CCS IDE, type:

```
help ccsdsp

CCDSP - Base constructor for the 'Link to Code Composer Studio(tm)'
Description of methods available for CCSDSP

ACTIVATE Set the active project, text file or build configuration
ADD Add source file to a project
ANIMATE Initiate a target execution with breakpoint animation
ADDRESS Search the target's symbol table for an address
BUILD Compile/Link to build a program file
CCSDSP Constructor which establishes the link to CCS
CD Change or query working directory of Code Composer Studio
CLOSE Close Code Composer Studio project or text file
CREATEOBJ Creates objects for manipulating target values
DELETE Delete a debug point from DSP memory
DIR List files in Code Composer Studio working directory
DISP Display information about the CCSDSP object
GOTO Executes the target to the entry of a function
HALT Immediately terminate execution of the DSP processor
INFO Produce a list of information about the target processor
```

INSERT        Insert a debug point into DSP memory  
ISREADABLE   Query if a block of DSP memory is available for reading  
ISRUNNING    Query status of DSP execution  
ISRTDXCAPABLE Query if DSP supports RTDX communications  
ISVISIBLE    Query visibility of Code Composer Studio application  
ISWRITABLE   Query if a block of DSP memory is available for writing  
LIST         Produces various lists of information from Code Composer  
LOAD         Loads a program file into the DSP processor  
NEW         Create a default project, text file or build configuration  
OPEN         Loads a workspace, project or program file  
PROFILE      Return measurements from any DSP/BIOS(tm) STS objects  
READ         Return a block of data from the memory of the DSP  
REGREAD      Return data storied in a DSP register  
REGWRITE     Modify the contents of a DSP register  
RELOAD      Reload most recently loaded program file  
REMOVE      Remove a file from a project  
RESTART      Return PC to the beginning of a target program  
RUN         Initiates execution of the DSP processor  
SAVE         Save Code Composer Studio project or text file  
SYMBOL      Returns the target's entire symbol table  
VISIBLE      Hide or reveal Code Composer Studio application window  
WRITE        Places a block of Matlab data into the memory of the DSP



# Objects for Link for Code Composer Studio Software

---

These sections of the User's Guide introduce both the objects you use to work with the software and tutorial and reference pages for using the objects.

|                                                         |                                                                                                             |
|---------------------------------------------------------|-------------------------------------------------------------------------------------------------------------|
| Introduction to Objects (p. 2-3)                        | Object classes that compose Link for Code Composer Studio                                                   |
| Numeric Objects—Their Methods and Properties (p. 2-16)  | Reference numeric data in memory                                                                            |
| Bitfield Objects—Their Methods and Properties (p. 2-19) | Objects that reference bitfield data in memory                                                              |
| Enum Objects—Their Methods and Properties (p. 2-22)     | Objects that reference enumerated data in memory                                                            |
| Pointer Objects—Their Methods and Properties (p. 2-25)  | Reference pointers in memory                                                                                |
| String Objects—Their Methods and Properties (p. 2-28)   | Introduces objects that reference strings in memory                                                         |
| Rnumeric Objects—Their Methods and Properties (p. 2-31) | Introduces objects that reference numeric data in registers                                                 |
| Renum Objects—Their Methods and Properties (p. 2-34)    | Objects that reference enumerated data in registers                                                         |
| Rpointer Objects—Their Methods and Properties (p. 2-39) | Introduces objects that reference pointers in registers                                                     |
| Rstring Objects—Their Methods and Properties (p. 2-42)  | Introduces objects that reference strings in registers                                                      |
| Function Objects—Their Methods and Properties (p. 2-45) | About objects that reference functions, either ANSI C or assembly (that have C prototypes), in your project |

|                                                                        |                                                                                                                |
|------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------|
| Structure Objects—Their Methods and Properties (p. 2-49)               | Introduces objects that reference data structures                                                              |
| Type Objects—Their Methods and Properties (p. 2-51)                    | Objects that reference typedefs in your project source code                                                    |
| Constructing Objects That Access Bitfields (p. 2-53)                   | Introduces the concepts behind using bitfield objects                                                          |
| Creating Function Objects (p. 2-55)                                    | Provides an extensive introduction to function objects                                                         |
| Creating Type Objects (p. 2-71)                                        | Shows some of the ways you use type objects in projects                                                        |
| Tutorial 2-1—Using Function Objects and Hardware-in-the-Loop (p. 2-74) | Run a tutorial that shows you how to work with function objects and use them in a hardware-in-the-loop fashion |
| Managing Custom Data Types with the Data Type Manager (p. 2-105)       | Describes and demonstrates how you use custom data types that are part of your projects                        |
| Reference for the Properties of Embedded Objects (p. 2-116)            | Provides a comprehensive property reference                                                                    |



## Introduction to Objects

Within your Link for Code Composer Studio Development Tools software, the links and the objects use object-oriented programming techniques. Along with the link object you use to connect MATLAB to your target hardware, Link for Code Composer Studio provides many objects for creating, accessing (reading from and writing to), and manipulating (changing the contents of in MATLAB) all the symbols in the symbol table for a program loaded on your signal processor. Within the table, each object in the class name column provides access to objects as described.

| <b>Class Name</b> | <b>Inherits From</b> | <b>Description</b>                                                                                                                                               |
|-------------------|----------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| bitfield          | memoryobj class      | Access the contents of a bitfield defined in your code                                                                                                           |
| enum              | numeric class        | Contents of an enumerated data type stored in memory defined in your code                                                                                        |
| function          | None                 | Contents of a function in your source code, or used in your project as a library function. Can also represent new functions you develop and add to your project. |
| numeric           | memoryobj class      | Access the contents of a numeric data type stored in memory defined in your code                                                                                 |
| pointer           | numeric class        | Contents of a pointer stored in a memory location on your target                                                                                                 |
| renum             | rnumeric class       | Contents of an enumerated data type stored in a register on your target                                                                                          |

| <b>Class Name</b> | <b>Inherits From</b> | <b>Description</b>                                                             |
|-------------------|----------------------|--------------------------------------------------------------------------------|
| rnumeric          | registerobj class    | Contents of register that contains a numeric data type                         |
| rpointer          | rnumeric class       | Contents of a pointer stored in a register on your target                      |
| rstring           | rnumeric class       | Contents of a string stored in a register on your target                       |
| string            | numeric class        | Contents of a string stored in a memory location on your target                |
| structure         | None                 | Contents of a structure stored in memory on your target                        |
| type              | None                 | Typedefs stored in memory on your target after you add them to the type object |

In the Inherits From column you see the name of another class. Classes that inherit from another class contain all the properties and methods of the Inherited From class as well as their own unique properties. Note that although object and class seem to be interchangeable, objects are instances of classes—the properties of a class are the properties of an instance of the class, an object. This guide treats the distinction fairly loosely, using object in most instances.

For example, the String object has the properties and methods of the Numeric class, and its own properties and methods.

By using the objects provided, you can modify and view any and all symbols from MATLAB.

Each of the objects has properties and methods specific to its use, although many of the objects use the same methods and properties, as you see in the next sections.

While you can use the Link for Code Composer Studio software without knowing about its object-oriented design and implementation, you might find

the next sections about objects useful to gain a better understanding of the objects.

## Some Object-Oriented Programming Terms

As an object-oriented software package, describing how to use the Link for Code Composer Studio requires discussing the objects, classes, properties, and methods you use to manipulate and access data. To ensure we use the same terms and understand them in the same way, this section provides definitions of some terms commonly used throughout the this guide.

### Definitions of Object-Oriented Terms

|                |                                                                                                                                                                                                                                                                     |
|----------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Abstract class | A class without instances. Abstract classes expect that their concrete subclasses will add to their structure and behavior.                                                                                                                                         |
| Aggregation    | The part-of relationship between two objects. For example, a bicycle has wheels, so wheels are part of a bicycle. Note that the wheels can exist separately from the bicycle. Compare to composition.                                                               |
| Base class     | The most general class in a class structure. Also called root classes, most applications or systems have more than one base class.                                                                                                                                  |
| Behavior       | How an object reacts to its methods. How the object state changes in response to one of its methods acting on it.                                                                                                                                                   |
| Class          | A set of abstract objects that share a common structure and behavior. A class forms the prototype that defines the properties and methods common to all objects of the class. Types and classes are not quite the same, but are used interchangeably in this guide. |

|                 |                                                                                                                                                                                                                                                                       |
|-----------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Class diagram   | Used to show the existence of classes and their relationships. Class diagrams can represent part or all of the class structure of a system.                                                                                                                           |
| Composition     | A relationship between objects where one part object exists only as part of the whole object. The parts live and die together. You create and destroy them as one.                                                                                                    |
| Constructor     | A function that creates an object and initializes its state. Constructors can also initialize the state without creating the object.                                                                                                                                  |
| Container Class | A class whose instances are collections of other objects in the system. Also called a package.                                                                                                                                                                        |
| Function        | Same as method. Used in MATLAB for consistency with other functions. Functions and methods are not quite the same, but are used interchangeably.                                                                                                                      |
| Handle          | A means to access any object that Link for Code Composer Studio creates. Used in this guide to refer to the object. Often the handle is the name you assign when you create the object. For example, cc is the object and handle when you create a link object.       |
| Inheritance     | A relationship between classes. One class shares the structure (properties) and behavior (methods) defined in one or more other classes. Subclasses inherit from one or more superclasses, typically augmenting the superclass with their own properties and methods. |

---

|                          |                                                                                                                                                                                                                                                                                                        |
|--------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Instance                 | Something you can operate on. Instance and object are synonyms and this guide uses them interchangeably. Instantiate is the verb form—to create an instance of a class or object.                                                                                                                      |
| Instantiation            | To create an object—an instance of a class.                                                                                                                                                                                                                                                            |
| Method                   | An operation on an object, defined as part of the class of the object. We call this a function.                                                                                                                                                                                                        |
| Object                   | Something you can operate on. Objects that are the same class share similar structure and behavior. An object is a collection of properties and methods. Some sources call properties “variables.” In all cases, an object is an instance of a class. Classes are abstract; objects are not.           |
| Object Diagram           | Shows the existence of objects and their relationships in the logical design of a system. Object diagrams can represent part or all of the class structure of a system.                                                                                                                                |
| Object-based Programming | <p>Programming style that organizes programs as cooperative collections of objects.</p> <p>Each object represents an instance of a type; where the types are members of an hierarchy, united through relationships that are not inheritance relationships. Compare to object-oriented programming.</p> |

|                             |                                                                                                                                                                                                                                                                                          |
|-----------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Object-oriented Programming | Programming implementation that organizes programs as cooperative collections of objects.<br><br>Each object represents an instance of some class, and the classes are members of an hierarchy of classes united through inheritance relationships. Compare to object-based programming. |
| Property                    | Part of an object—treated as a variable at times. Also called attribute, it is part of the structure that defines the state of an object.                                                                                                                                                |
| Subclass                    | A class that inherits from one or more classes, called its superclasses.                                                                                                                                                                                                                 |
| Superclass                  | A class that other classes inherit from. The inheriting classes are called subclasses.                                                                                                                                                                                                   |
| State                       | The accumulated results of the behavior of an object. At any time, the state of an object encompasses the properties of the object and the values for each of the properties.                                                                                                            |
| Structure                   | The concrete representation of the state of an object.                                                                                                                                                                                                                                   |

For more information about objects and working with their properties and methods (or functions), refer to “Constructing Link Objects” on page 1-10.

---

**Note** Except for read and write, all functions that work with objects operate solely in your MATLAB workspace. They do not affect the data stored in memory, registers, functions, or structures on your signal processor and in CCS. Only read and write allow you to access and change information on your target or in your project in CCS.

---

## Determining an Object Class

After you create an object, use `whos` to determine the class for your new object (although you should know the class from the input argument you provided to `createobj`). Being able to query the class for an object is particularly important in this case because the constructor `createobj` determines the class of the object created—you cannot specify the object class. Depending on the input symbol name you provide to `createobj`, the returned class changes. So you need to be able to determine the class. `whos` lets you do this.

If you use the MATLAB Workspace browser, your object appears in the list of the contents of your workspace, indicating the object type and class—just like `whos`.

Alternatively, using `createobj` or `ccsdsp` without the closing semicolon (;) at the end of the command directs MATLAB to display the properties of your new object in the MATLAB window when you create the object.

## About the Relationships Between Objects

Link for Code Composer Studio uses objects exclusively to access and manipulate complex data structures and functions, among other programming constructs, in your project and code. Many of the objects inherit properties and functions, also called methods, from other objects. The class diagrams and tables presented in the next sections discuss and show the relationships between the objects that you create when you use `createobj`.

### The Base Classes

| <b>Class Name</b> | <b>Description</b>                                                                                                                                                                                                                                                             |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Memoryobj         | An abstract class. The numeric and bitfield classes inherit properties and methods from this class, making this a superclass. You cannot create an instance of this class. Subclasses of the memoryobj class always describe objects that reside in DSP memory on your target. |
| Registerobj       | An abstract class. The rnumeric class inherits properties and methods from this class, making this a superclass. You cannot create an instance of this class. Subclasses of the registerobj class always describe objects that reside in DSP registers on your target.         |

### The Subclasses

| <b>Class Name</b> | <b>Description</b>                                                                                                                                                                                           |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Numeric           | A superclass from which the enum, pointer, and string subclasses inherit properties and methods. You can create an object of this class using createobj. Numeric inherits from the abstract class memoryobj. |
| Enum              | A subclass of the numeric class. You can create an object of this class using createobj.                                                                                                                     |
| Pointer           | A subclass of the numeric class. You can create an object of this class using createobj.                                                                                                                     |
| String            | A subclass of the numeric class. You can create an object of this class using createobj.                                                                                                                     |



| <b>Class Name</b> | <b>Description</b>                                                                                                                                                                                                 |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Bitfield          | A subclass of the memoryobj class. You can use createobj to make a bitfield object.                                                                                                                                |
| Rnumeric          | A superclass from which the renum, rpointer, and rstring subclasses inherit properties and methods. You can create an object of this class using createobj. Rnumeric inherits from the abstract class registerobj. |
| Renum             | A subclass of the registerobj class. You can create an object of this class using createobj.                                                                                                                       |
| Rpointer          | A subclass of the registerobj class. You can create an object of this class using createobj.                                                                                                                       |
| Rstring           | A subclass of the registerobj class. You can create an object of this class using createobj.                                                                                                                       |

### Other Classes

| <b>Class Name</b> | <b>Description</b>                                                                                                                                                                                                 |
|-------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Function          | A class containing information about a function in your project. createobj constructs this class directly.                                                                                                         |
| Structure         | A class containing information about a structure in memory on your target. createobj constructs this class directly.                                                                                               |
| Type              | A class containing information about C type definitions in the source code for your project. Type objects are composition objects to ccstdsp objects. When you create a ccstdsp object, it includes a type object. |

### **Class Diagrams for the Link for Code Composer Studio**

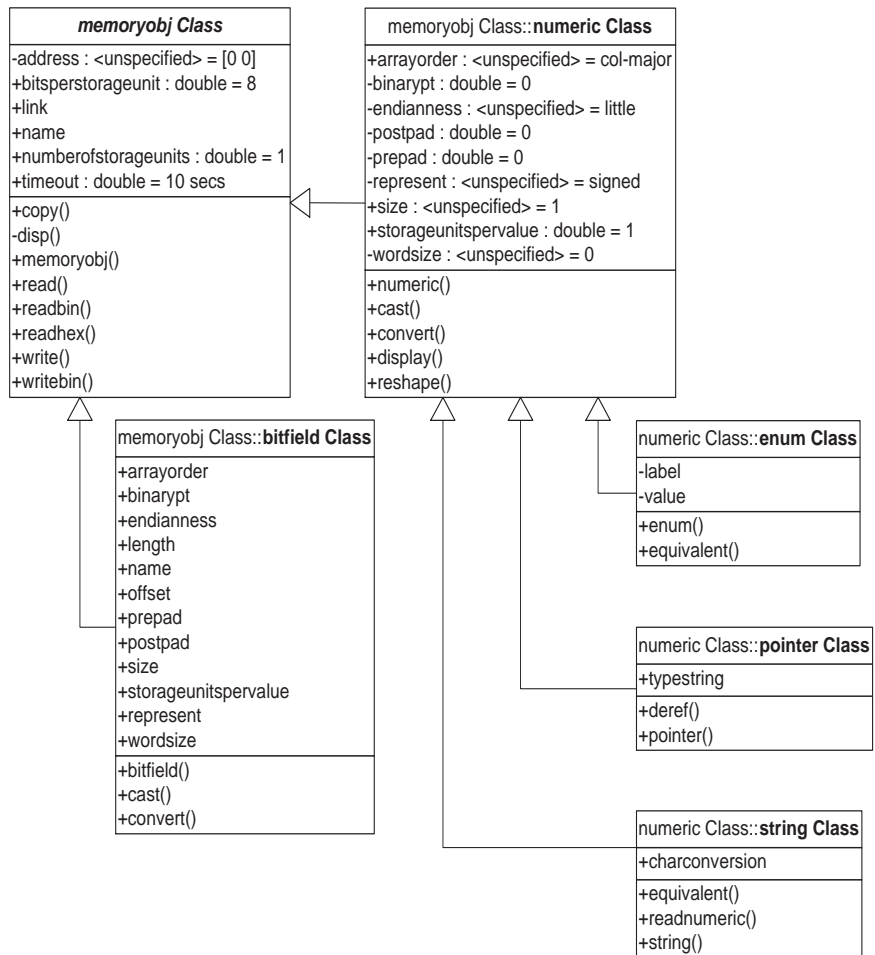
One of the most important features of object-oriented programming is the relationship between the classes that compose the system. Class relationships lend themselves to a graphical layout like a tree structure, where the structure of the tree shows clearly the super classes and subclasses, the base classes, and the other classes. In addition, the diagrams can show the properties and methods for each class, and where a subclass adds properties and methods to those it inherits from its superclass.

The following figures show the methods and properties of each class or object. For short descriptions about the properties for each class, refer to the tables in the following sections:

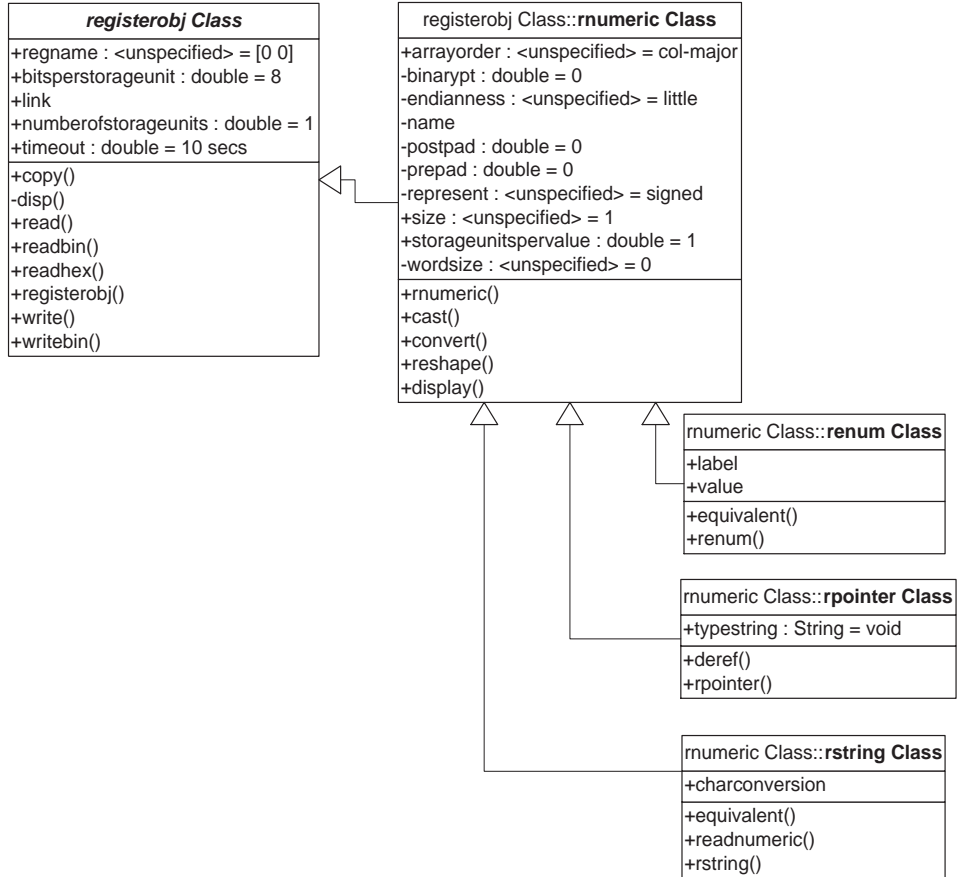
- “Numeric Objects—Their Methods and Properties” on page 2-16
- “Bitfield Objects—Their Methods and Properties” on page 2-19
- “Enum Objects—Their Methods and Properties” on page 2-22
- “Pointer Objects—Their Methods and Properties” on page 2-25
- “String Objects—Their Methods and Properties” on page 2-28
- “Rnumeric Objects—Their Methods and Properties” on page 2-31
- “Renum Objects—Their Methods and Properties” on page 2-34
- “Rpointer Objects—Their Methods and Properties” on page 2-39
- “Rstring Objects—Their Methods and Properties” on page 2-42
- “Function Objects—Their Methods and Properties” on page 2-45
- “Structure Objects—Their Methods and Properties” on page 2-49
- “Type Objects—Their Methods and Properties” on page 2-51

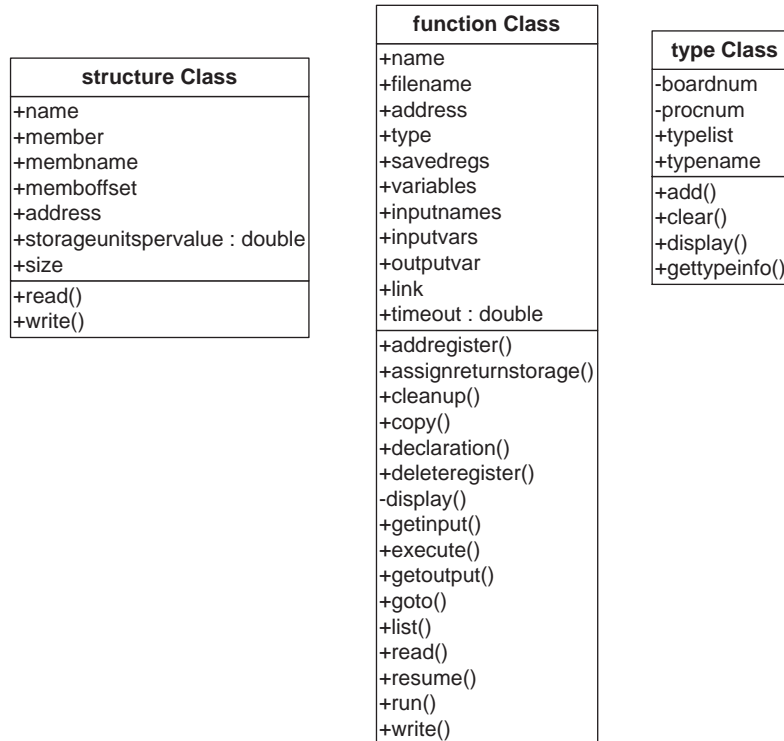
Detailed descriptions of the properties appear in the section “Reference for the Properties of Embedded Objects” on page 2-116.

## Class Diagram of the Memory Class



### Class Diagram of the Register Class



**Class Diagram of the Structure, Function, and Type Classes**

## Numeric Objects—Their Methods and Properties

When you create an object that accesses a numeric symbol in your source code, the object constructor `createobj` returns a `numeric` object. `createobj` uses the information in your source code to set the properties of the object appropriately to match the code. Within the properties and their values you find all the information about the symbol, so that MATLAB understands how to handle the symbol in your MATLAB workspace.

To add to the properties of the numeric class, numeric objects inherit properties and methods from the `memory` class.

### Properties of Numeric Objects

Object properties can include both properties that the object inherits from its superclass, if any, and some properties that are unique to the class itself. For this reason, many objects in Link for Code Composer Studio share common properties; as you use the objects you will become familiar with the common and special properties for each.

| Property Name                     | Property Type                      | Default Value          | Description                                                                            |
|-----------------------------------|------------------------------------|------------------------|----------------------------------------------------------------------------------------|
| <code>name</code>                 | <code>string</code>                | None                   | Name of the embedded symbol in the symbol table                                        |
| <code>arrayorder</code>           | <code>{col-major,row-major}</code> | <code>col-major</code> | Ordering of values when moving data from linear memory storage to N-D arrays in MATLAB |
| <code>address</code>              | <code>mxArray</code>               | <code>[0 0]</code>     | Memory address of the symbol, in <code>[Offset Page]</code> format                     |
| <code>bitsperstorageunit</code>   | <code>double</code>                | 8                      | Bits per smallest addressable unit in the signal processor                             |
| <code>numberofstorageunits</code> | <code>double</code>                | 1                      | Number of storage units needed to represent the object                                 |
| <code>link</code>                 | MATLAB handle                      | None                   | Object handle that identifies the object                                               |

| <b>Property Name</b> | <b>Property Type</b>                     | <b>Default Value</b> | <b>Description</b>                                                                                                    |
|----------------------|------------------------------------------|----------------------|-----------------------------------------------------------------------------------------------------------------------|
| timeout              | double                                   | 10 seconds           | Time-out period for link methods                                                                                      |
| endianness           | {little, big}                            | 'little'             | Specifies whether the data is stored as little endian or big endian data                                              |
| postpad              | int                                      | 0                    | Number of bits of padding added at the end of the memory buffer. Added bits are ignored in final numeric values       |
| prepad               | int                                      | 0                    | Number of bits of padding added at the beginning of the memory buffer. Added bits are ignored in final numeric values |
| represent            | {signed, unsigned, float, fract, ufract} | signed               | Reports the data type of the values                                                                                   |
| size                 | mxArray                                  | 1                    | Specifies the size of the array created in MATLAB from the data received from memory                                  |
| storageunitspervalue | int                                      | 32                   | Addressable units (au) per value in memory. May be less than one when you use bit packing                             |

## Methods of Numeric Objects

Like properties, methods for objects may come from the superclass or derive only from the class itself. For example, the `cast` and `convert` methods do not appear in all objects; listing them here indicates that the object does not inherit these methods but provides them itself.

| <b>Name</b> | <b>Overloaded?</b> | <b>Description</b>                                                     |
|-------------|--------------------|------------------------------------------------------------------------|
| cast        | Yes                | Copies an object and change the data type for a value at the same time |
| convert     | No                 | Changes the data type for a value                                      |
| reshape     | Yes                | Changes the dimensions of the array that contains the data in MATLAB   |
| display     | Yes                | Display the properties of the numeric object                           |



## Bitfield Objects—Their Methods and Properties

When you create an object that accesses a bitfield symbol in your source code, the object constructor `createobj` returns a struct object that includes the bitfield as members of the struct object. Bitfields are always parts of structures, so you create struct objects to access bitfields. `createobj` uses the information in your source code to set the properties of the object appropriately to match the code. Within the properties and their values, you find all the information about the symbol, so that MATLAB understands how to handle the symbol in your MATLAB workspace.

To add to the properties of the class, bitfield objects inherit properties and methods from the `numeric` and `memoryobj` classes.

### Properties of Bitfield Objects

Object properties can include both properties that the object inherits from its superclass, if any, and some properties that are unique to the class itself. For this reason, many objects in Link for Code Composer Studio share common properties; as you use the objects you will become familiar with the common and special properties for each.

| Property Name                     | Property Type                      | Default Value          | Description                                                                            |
|-----------------------------------|------------------------------------|------------------------|----------------------------------------------------------------------------------------|
| <code>name</code>                 | <code>string</code>                | None                   | Name of the embedded symbol in the symbol table                                        |
| <code>arrayorder</code>           | <code>{col-major,row-major}</code> | <code>row-major</code> | Ordering of values when moving data from linear memory storage to N-D arrays in MATLAB |
| <code>address</code>              | <code>mxAarray</code>              | <code>[0 0]</code>     | Memory address of the symbol, in [Offset Page] format                                  |
| <code>bitsperstorageunit</code>   | <code>double</code>                | 8                      | Bits per addressable unit in the signal processor                                      |
| <code>numberofstorageunits</code> | <code>double</code>                | 1                      | Number of memory units needed to represent the object                                  |

| <b>Property Name</b> | <b>Property Type</b>                     | <b>Default Value</b> | <b>Description</b>                                                                                                    |
|----------------------|------------------------------------------|----------------------|-----------------------------------------------------------------------------------------------------------------------|
| link                 | MATLAB handle                            | None                 | Object handle that identifies the object                                                                              |
| timeout              | double                                   | 10 seconds           | Time-out period for link methods                                                                                      |
| endianness           | {little, big}                            | little               | Specifies whether the data is stored as little endian or big endian data                                              |
| postpad              | int                                      | 0                    | Number of bits of padding added at the end of the memory buffer. Added bits are ignored in final numeric values       |
| prepad               | int                                      | 0                    | Number of bits of padding added at the beginning of the memory buffer. Added bits are ignored in final numeric values |
| represent            | {signed, unsigned, float, fract, ufract} | signed               | Reports the data type of the values                                                                                   |
| size                 | mxArray                                  | 1                    | Size of the array created in MATLAB from the data received from memory                                                |
| storageunitspervalue | int                                      | 32                   | Addressable units (au) per value in memory. May be less than one when you use bit packing                             |
| wordsize             | int                                      | 32                   | Number of bits in a word for the processor                                                                            |
| binarypt             | int                                      | 0                    | Location of the binary point for fractional data types                                                                |

| Property Name | Property Type | Default Value | Description                                         |
|---------------|---------------|---------------|-----------------------------------------------------|
| offset        | int           | 0             | Starting point of the bitfield in relation to bit 0 |
| length        | int           | 0             | Number of bits in the bitfield                      |

## Methods of Bitfield Objects

Like properties, methods for objects may come from the superclass or derive only from the class itself.

| Name    | Overloaded? | Description                                                            |
|---------|-------------|------------------------------------------------------------------------|
| cast    | Yes         | Copies an object and change the data type for a value at the same time |
| convert | No          | Changes the data type for a value                                      |
| copy    | Yes         | Copies an existing object by creating a new pointer to the object      |
| display | Yes         | Displays the properties of the object                                  |
| read    | Yes         | Returns the contents of the memory location specified by the symbol    |
| write   | Yes         | Writes one or more values to the memory location                       |

## Enum Objects—Their Methods and Properties

When you create an object that accesses an enumerated symbol in your source code, the object constructor `createobj` returns an enum object. `createobj` uses the information in your source code to set the properties of the object appropriately to match the code. Within the properties and their values you find all the information about the symbol, so that MATLAB understands how to handle the symbol in your MATLAB workspace.

To add to the properties of the enum class, enum objects inherit properties and methods from the `numeric` and `memoryobj` classes.

### Properties of Enum Objects

Object properties can include both properties that the object inherits from its superclass, if any, and some properties that are unique to the class itself. For this reason, many objects in Link for Code Composer Studio share common properties; as you use the objects you will become familiar with the common and special properties for each.

| Property Name                     | Property Type                      | Default Value          | Description                                                                            |
|-----------------------------------|------------------------------------|------------------------|----------------------------------------------------------------------------------------|
| <code>name</code>                 | <code>string</code>                | None                   | Name of the embedded symbol in the symbol table                                        |
| <code>arrayorder</code>           | <code>{col-major,row-major}</code> | <code>row-major</code> | Ordering of values when moving data from linear memory storage to N-D arrays in MATLAB |
| <code>address</code>              | <code>mxArray</code>               | <code>[0 0]</code>     | Memory address of the symbol, in [Offset Page] format                                  |
| <code>bitsperstorageunit</code>   | <code>double</code>                | 8                      | Bits per smallest addressable unit in the signal processor                             |
| <code>numberofstorageunits</code> | <code>double</code>                | 1                      | Number of memory units needed to represent the object                                  |
| <code>link</code>                 | MATLAB handle                      | None                   | Object handle that identifies the object                                               |

| <b>Property Name</b> | <b>Property Type</b>                     | <b>Default Value</b> | <b>Description</b>                                                                                                    |
|----------------------|------------------------------------------|----------------------|-----------------------------------------------------------------------------------------------------------------------|
| timeout              | double                                   | 10 seconds           | Time-out period for link methods                                                                                      |
| endianness           | {little, big}                            | little               | Specifies whether the data is stored as little endian or big endian data                                              |
| postpad              | int                                      | 0                    | Number of bits of padding added at the end of the memory buffer. Added bits are ignored in final numeric values.      |
| prepad               | int                                      | 0                    | Number of bits of padding added at the beginning of the memory buffer. Added bits are ignored in final numeric values |
| represent            | {signed, unsigned, float, fract, ufract} | signed               | Reports the data type of the values                                                                                   |
| size                 | mxAarray                                 | 1                    | Specifies the size of the array created in MATLAB from the data received from memory                                  |
| storageunitspervalue | int                                      | 32                   | Addressable units (au) per value in memory. May be less than one when you use bit packing                             |
| label                | mxAarray                                 | N/A                  | Lists the enumerated labels for the object                                                                            |
| value                | mxAarray                                 | 0                    | Contains a vector of the enumerated type                                                                              |

## Methods of Enum Objects

Like properties, methods for objects may come from the superclass or derive only from the class itself. For example, the cast and convert methods do not

appear in all objects; listing them here indicates that the object does not inherit these methods but provides them itself.

| <b>Name</b> | <b>Overloaded?</b> | <b>Description</b>                                                         |
|-------------|--------------------|----------------------------------------------------------------------------|
| display     | Yes                | Displays the properties of the object                                      |
| equivalent  | No                 | Returns the equivalent string or numeric value based on the input argument |

## Pointer Objects—Their Methods and Properties

When you create an object that accesses a pointer symbol in your source code, the object constructor `createobj` returns a pointer object. `createobj` uses the information in your source code to set the properties of the object appropriately to match the code. Within the properties and their values you find all the information about the symbol, so that MATLAB understands how to handle the symbol in your MATLAB workspace.

To add to the properties of the pointer class, pointer objects inherit properties and methods from the numeric and memory classes.

### Properties of Pointer Objects

Object properties can include both properties that the object inherits from its superclass, if any, and some properties that are unique to the class itself. For this reason, many objects in Link for Code Composer Studio share common properties; as you use the objects you will become familiar with the common and special properties for each.

| Property Name           | Property Type                  | Default Value | Description                                                                                                     |
|-------------------------|--------------------------------|---------------|-----------------------------------------------------------------------------------------------------------------|
| <code>arrayorder</code> | { 'col-major'<br>'row-major' } | row-major     | Describes the ordering of the data moved from linear memory storage to n-dimensional arrays                     |
| <code>binarypt</code>   | int                            | 0             | Locates binary point needed to interpret the value                                                              |
| <code>endianness</code> | character                      | little        | Specifies whether the data is stored as little endian or big endian data                                        |
| <code>postpad</code>    | int                            | 0             | Number of bits of padding added at the end of the memory buffer. Added bits are ignored in final numeric values |

| <b>Property Name<br/>(Continued)</b> | <b>Property<br/>Type</b>                             | <b>Default Value</b> | <b>Description</b>                                                                                                    |
|--------------------------------------|------------------------------------------------------|----------------------|-----------------------------------------------------------------------------------------------------------------------|
| prepad                               | int                                                  | 0                    | Number of bits of padding added at the beginning of the memory buffer. Added bits are ignored in final numeric values |
| represent                            | {signed,<br>unsigned,<br>float,<br>fract,<br>ufract} | signed               | Reports the representation of the values in the object                                                                |
| size                                 | mxArray                                              | 1                    | Specifies the size of the array created in MATLAB from the data received from memory                                  |
| storageunitspervalue                 | double                                               | 1                    | Addressable units per memory value in memory on the DSP                                                               |
| name                                 | mxArray                                              | None                 | Name of the embedded symbol in the symbol table                                                                       |
| address                              | mxArray                                              | [0 0]                | Memory address of the symbol, in [Offset Page] format                                                                 |
| bitsperstorageunit                   | double                                               | 8                    | Bits per smallest addressable unit in the signal processor                                                            |
| numberofstorageunits                 | double                                               | 1                    | Number of memory units needed to represent the object                                                                 |
| wordsize                             | int                                                  | 0                    | Valid bits per value (read-only)                                                                                      |
| typestring                           | string                                               | void                 | Specifies the type of data the pointer points to                                                                      |

### Methods of Pointer Objects

Like properties, methods for objects may come from the superclass or derive only from the class itself. For example, the cast and convert methods do not



appear in all objects; listing them here indicates that the object does not inherit these methods but provides them itself.

| <b>Name</b> | <b>Overloaded?</b> | <b>Description</b>                                     |
|-------------|--------------------|--------------------------------------------------------|
| deref       | No                 | Returns the data to which the specified pointer points |

## String Objects—Their Methods and Properties

When you create an object that accesses a string symbol in your source code, the object constructor `createobj` returns a string object. `createobj` uses the information in your source code to set the properties of the object appropriately to match the code. Within the properties and their values you find all the information about the symbol, so that MATLAB understands how to handle the symbol in your MATLAB workspace.

To add to the properties of the string class, string objects inherit properties and methods from the numeric and memory classes.

### Properties of String Objects

Object properties can include both properties that the object inherits from its superclass, if any, and some properties that are unique to the class itself. For this reason, many objects in Link for Code Composer Studio share common properties; as you use the objects you will become familiar with the common and special properties for each.

| Property Name                     | Property Type                       | Default Value          | Description                                                                            |
|-----------------------------------|-------------------------------------|------------------------|----------------------------------------------------------------------------------------|
| <code>name</code>                 | <code>string</code>                 | None                   | Name of the embedded symbol in the symbol table                                        |
| <code>arrayorder</code>           | <code>{col-major, row-major}</code> | <code>row-major</code> | Ordering of values when moving data from linear memory storage to N-D arrays in MATLAB |
| <code>address</code>              | <code>mxArray</code>                | <code>[0 0]</code>     | Memory address of the symbol, in [Offset Page] format                                  |
| <code>bitsperstorageunit</code>   | <code>double</code>                 | 8                      | Bits per smallest addressable unit in the signal processor                             |
| <code>numberofstorageunits</code> | <code>double</code>                 | 1                      | Number of units needed to represent the object                                         |
| <code>link</code>                 | MATLAB handle                       | None                   | Object handle that identifies the object                                               |

| Property Name        | Property Type                            | Default Value | Description                                                                                                           |
|----------------------|------------------------------------------|---------------|-----------------------------------------------------------------------------------------------------------------------|
| timeout              | double                                   | 10 seconds    | Time-out period for link methods                                                                                      |
| endianness           | {little, big}                            | little        | Specifies whether the data is stored as little endian or big endian data                                              |
| postpad              | int                                      | 0             | Number of bits of padding added at the end of the memory buffer. Added bits are ignored in final numeric values       |
| prepad               | int                                      | 0             | Number of bits of padding added at the beginning of the memory buffer. Added bits are ignored in final numeric values |
| represent            | {signed, unsigned, float, fract, ufract} | signed        | Reports the representation of the values in the object                                                                |
| size                 | mxAarray                                 | 1             | Specifies the size of the array created in MATLAB from the data received from memory                                  |
| storageunitspervalue | int                                      | 32            | Addressable units (au) per value in memory. May be less than one when you use bit packing                             |
| wordsize             | int                                      | 0             | Valid bits per value (read-only)                                                                                      |
| charconversion       | mxAarray                                 | ASCII         | Conversion type of the characters in the object                                                                       |

## Methods of String Objects

Like properties, methods for objects may come from the superclass or derive only from the class itself. For example, the cast and convert methods do not

appear in all objects; listing them here indicates that the object does not inherit these methods but provides them itself.

| <b>Name</b> | <b>Overloaded?</b> | <b>Description</b>                                                                     |
|-------------|--------------------|----------------------------------------------------------------------------------------|
| equivalent  | Yes                | Returns the equivalent numeric value for the input string                              |
| readnumeric | Yes                | Returns the data in memory to MATLAB as numeric equivalent of the values on the target |

## Rnumeric Objects—Their Methods and Properties

When you create an object that accesses a numeric symbol stored in a register in your source code, the object constructor `createobj` returns an `rnumeric` object. `createobj` uses the information in your project to set the properties of the object appropriately to match the code. Within the properties and their values you find all the information about the symbol, so that MATLAB understands how to handle the symbol in your MATLAB workspace.

To add to the properties of the `rnumeric` class, `rnumeric` objects inherit properties and methods from the `register` class.

Classes that inherit from the `registerobj` base class always access data that resides in registers on the target, not in memory locations.

### Properties of Rnumeric Objects

Object properties can include both properties that the object inherits from its superclass, if any, and some properties that are unique to the class itself. For this reason, many objects in Link for Code Composer Studio share common properties; as you use the objects you will become familiar with the common and special properties for each.

| Property Name                     | Property Type                | Default Value | Description                                                                                 |
|-----------------------------------|------------------------------|---------------|---------------------------------------------------------------------------------------------|
| <code>name</code>                 | <code>string</code>          | None          | Name of the register symbol in the symbol table                                             |
| <code>regname</code>              | <code>mxArray</code>         | None          | Name of the register on the signal processor                                                |
| <code>numberofstorageunits</code> | <code>double</code>          | 1             | Number of register units needed to represent the register object                            |
| <code>link</code>                 | MATLAB handle                | None          | Object handle that identifies the object                                                    |
| <code>timeout</code>              | <code>double</code>          | 10 seconds    | Time-out period for link methods                                                            |
| <code>arrayorder</code>           | {'col-major'<br>'row-major'} | row-major     | Describes the ordering of the data moved from linear memory storage to n-dimensional arrays |

| <b>Property Name</b> | <b>Property Type</b>                     | <b>Default Value</b> | <b>Description</b>                                                                                                    |
|----------------------|------------------------------------------|----------------------|-----------------------------------------------------------------------------------------------------------------------|
| binarypt             | int                                      | 0                    | Locates binary point needed to interpret fractional data types                                                        |
| postpad              | int                                      | 0                    | Number of bits of padding added at the end of the memory buffer. Added bits are ignored in final numeric values       |
| prepad               | int                                      | 0                    | Number of bits of padding added at the beginning of the memory buffer. Added bits are ignored in final numeric values |
| represent            | {signed, unsigned, float, fract, ufract} | signed               | Reports the representation of the values in the object, such as numeric or string                                     |
| size                 | mxAarray                                 | 1                    | Specifies the size of the array created in MATLAB from the data received from memory                                  |
| storageunitspervalue | double                                   | 1                    | Register units per register value in memory on the DSP                                                                |
| bitsperstorageunit   | double                                   | 8                    | Bits per smallest register unit in the signal processor                                                               |
| wordsize             | int                                      | 0                    | Valid bits per value (read-only)                                                                                      |

### Methods of Rnumeric Objects

Like properties, methods for objects may come from the superclass or derive only from the class itself. For example, the cast and convert methods do not appear in all objects; listing them here indicates that the object does not inherit these methods but provides them itself.

| <b>Name</b> | <b>Overloaded?</b> | <b>Description</b>                                                    |
|-------------|--------------------|-----------------------------------------------------------------------|
| cast        | No                 | Changes the data type of the input argument to another data type      |
| convert     | No                 | Converts the current data type to the specified data type             |
| display     |                    | Displays the properties of the object                                 |
| reshape     | No                 | Reshapes the object in MATLAB                                         |
| read        | Yes                | Returns the contents of the register location specified by the symbol |
| write       | Yes                | Writes one or more values to the register location                    |

## Renum Objects—Their Methods and Properties

When you create an object that accesses an enumerated symbol stored in a register in your source code, the object constructor `createobj` returns an `renum` object. `createobj` uses the information in your source code to set the properties of the object appropriately to match the code. Within the properties and their values you find all the information about the symbol, so that MATLAB understands how to handle the symbol in your MATLAB workspace.

To add to the properties of the `renum` class, `renum` objects inherit properties and methods from the `rnumeric` and `register` classes.

Classes that inherit from the `registerobj` base class always access data that resides in registers on the target, not in memory locations.

### Properties of Renum Objects

Object properties can include both properties that the object inherits from its superclass, if any, and some properties that are unique to the class itself. For this reason, many objects in Link for Code Composer Studio share common properties; as you use the objects you will become familiar with the common and special properties for each.

| Property Name                     | Property Type                  | Default Value | Description                                                                                 |
|-----------------------------------|--------------------------------|---------------|---------------------------------------------------------------------------------------------|
| <code>name</code>                 | <code>string</code>            | None          | Name of the register symbol in the symbol table                                             |
| <code>regname</code>              | <code>mxArray</code>           | None          | Name of the register on the signal processor                                                |
| <code>numberofstorageunits</code> | <code>double</code>            | 1             | Number of register units needed to represent the register object                            |
| <code>link</code>                 | MATLAB handle                  | None          | Object handle that identifies the object                                                    |
| <code>timeout</code>              | <code>double</code>            | 10 seconds    | Time-out period for link methods                                                            |
| <code>arrayorder</code>           | { 'col-major'<br>'row-major' } | row-major     | Describes the ordering of the data moved from linear memory storage to n-dimensional arrays |



| <b>Property Name</b> | <b>Property Type</b>                     | <b>Default Value</b> | <b>Description</b>                                                                                                    |
|----------------------|------------------------------------------|----------------------|-----------------------------------------------------------------------------------------------------------------------|
| binarypt             | int                                      | 0                    | Locates binary point needed to interpret fractional data types                                                        |
| postpad              | int                                      | 0                    | Number of bits of padding added at the end of the memory buffer. Added bits are ignored in final numeric values       |
| prepad               | int                                      | 0                    | Number of bits of padding added at the beginning of the memory buffer. Added bits are ignored in final numeric values |
| represent            | {signed, unsigned, float, fract, ufract} | signed               | Reports the representation of the values in the object, such as numeric or string                                     |
| size                 | mxAarray                                 | 1                    | Specifies the size of the array created in MATLAB from the data received from memory                                  |
| storageunitspervalue | double                                   | 1                    | Register units per register value in memory on the DSP                                                                |
| bitsperstorageunit   | double                                   | 8                    | Bits per smallest register unit in the signal processor                                                               |
| wordsize             | int                                      | 0                    | Valid bits per value (read-only)                                                                                      |
| label                | mxAarray                                 | N/A                  | Lists the enumerated labels for the object                                                                            |
| value                | mxAarray                                 | 0                    | Contains a vector of the enumerated type                                                                              |

| <b>Property Name</b> | <b>Property Type</b>                     | <b>Default Value</b> | <b>Description</b>                                                                                                    |
|----------------------|------------------------------------------|----------------------|-----------------------------------------------------------------------------------------------------------------------|
| binarypt             | int                                      | 0                    | Locates binary point needed to interpret fractional data types                                                        |
| postpad              | int                                      | 0                    | Number of bits of padding added at the end of the memory buffer. Added bits are ignored in final numeric values       |
| prepad               | int                                      | 0                    | Number of bits of padding added at the beginning of the memory buffer. Added bits are ignored in final numeric values |
| represent            | {signed, unsigned, float, fract, ufract} | signed               | Reports the representation of the values in the object, such as numeric or string                                     |
| size                 | mxAarray                                 | 1                    | Specifies the size of the array created in MATLAB from the data received from memory                                  |
| storageunitspervalue | double                                   | 1                    | Register units per register value in memory on the DSP                                                                |
| bitsperstorageunit   | double                                   | 8                    | Bits per smallest register unit in the signal processor                                                               |
| wordsize             | int                                      | 0                    | Valid bits per value (read-only)                                                                                      |
| label                | mxAarray                                 | N/A                  | Lists the enumerated labels for the object                                                                            |
| value                | mxAarray                                 | 0                    | Contains a vector of the enumerated type                                                                              |

| <b>Property Name</b> | <b>Property Type</b>                     | <b>Default Value</b> | <b>Description</b>                                                                                                    |
|----------------------|------------------------------------------|----------------------|-----------------------------------------------------------------------------------------------------------------------|
| binarypt             | int                                      | 0                    | Locates binary point needed to interpret fractional data types                                                        |
| postpad              | int                                      | 0                    | Number of bits of padding added at the end of the memory buffer. Added bits are ignored in final numeric values       |
| prepad               | int                                      | 0                    | Number of bits of padding added at the beginning of the memory buffer. Added bits are ignored in final numeric values |
| represent            | {signed, unsigned, float, fract, ufract} | signed               | Reports the representation of the values in the object, such as numeric or string                                     |
| size                 | mxAarray                                 | 1                    | Specifies the size of the array created in MATLAB from the data received from memory                                  |
| storageunitspervalue | double                                   | 1                    | Register units per register value in memory on the DSP                                                                |
| bitsperstorageunit   | double                                   | 8                    | Bits per smallest register unit in the signal processor                                                               |
| wordsize             | int                                      | 0                    | Valid bits per value (read-only)                                                                                      |
| label                | mxAarray                                 | N/A                  | Lists the enumerated labels for the object                                                                            |
| value                | mxAarray                                 | 0                    | Contains a vector of the enumerated type                                                                              |

### Methods of Renum Objects

Like properties, methods for objects may come from the superclass or derive only from the class itself. For example, the cast and convert methods do not appear in all objects; listing them here indicates that the object does not inherit these methods but provides them itself.

| <b>Name</b> | <b>Overloaded?</b> | <b>Description</b>                                 |
|-------------|--------------------|----------------------------------------------------|
| equivalent  | No                 | Returns the equivalent string or numeric           |
| read        | Yes                | Returns the data from the register on the target   |
| write       | Yes                | Writes one or more values to the register location |

## Rpointer Objects—Their Methods and Properties

When you create an object that accesses a pointer symbol stored in a register in your source code, the object constructor `createobj` returns an `rpointer` object. `createobj` uses the information in your source code to set the properties of the object appropriately to match the code. Within the properties and their values you find all the information about the symbol, so that MATLAB understands how to handle the symbol in your MATLAB workspace.

To add to the properties of the `rpointer` class, `rpointer` objects inherit properties and methods from the `rnumeric` and `register` classes.

Classes that inherit from the `registerobj` base class always access data that resides in registers on the target, not in memory locations.

### Properties of Rpointer Objects

Object properties can include both properties that the object inherits from its superclass, if any, and some properties that are unique to the class itself. For this reason, many objects in Link for Code Composer Studio share common properties; as you use the objects you will become familiar with the common and special properties for each.

| Property Name                     | Property Type                | Default Value | Description                                                                                 |
|-----------------------------------|------------------------------|---------------|---------------------------------------------------------------------------------------------|
| <code>name</code>                 | <code>string</code>          | None          | Name of the register symbol in the symbol table                                             |
| <code>regname</code>              | <code>mxArray</code>         | None          | Name of the register on the signal processor                                                |
| <code>numberofstorageunits</code> | <code>double</code>          | 1             | Number of register units needed to represent the register object                            |
| <code>link</code>                 | MATLAB handle                | None          | Object handle that identifies the object                                                    |
| <code>timeout</code>              | <code>double</code>          | 10 seconds    | Time-out period for link methods                                                            |
| <code>arrayorder</code>           | {'col-major'<br>'row-major'} | row-major     | Describes the ordering of the data moved from linear memory storage to n-dimensional arrays |

| <b>Property Name</b> | <b>Property Type</b>                     | <b>Default Value</b> | <b>Description</b>                                                                                                    |
|----------------------|------------------------------------------|----------------------|-----------------------------------------------------------------------------------------------------------------------|
| binarypt             | int                                      | 0                    | Locates binary point needed to interpret fractional data types                                                        |
| postpad              | int                                      | 0                    | Number of bits of padding added at the end of the memory buffer. Added bits are ignored in final numeric values       |
| prepad               | int                                      | 0                    | Number of bits of padding added at the beginning of the memory buffer. Added bits are ignored in final numeric values |
| represent            | {signed, unsigned, float, fract, ufract} | signed               | Reports the representation of the values in the object, such as numeric or string                                     |
| size                 | mxAarray                                 | 1                    | Specifies the size of the array created in MATLAB from the data received from memory                                  |
| storageunitspervalue | double                                   | 1                    | Register units per register value in memory on the DSP                                                                |
| bitsperstorageunit   | double                                   | 8                    | Bits per smallest register unit in the signal processor                                                               |
| wordsize             | int                                      | 0                    | Valid bits per value (read-only)                                                                                      |
| typestring           | string                                   | void                 | Specifies the type of data the pointer points to                                                                      |

## Methods of Rpointer Objects

Like properties, methods for objects may come from the superclass or derive only from the class itself. For example, the cast and convert methods do not appear in all objects; listing them here indicates that the object does not inherit these methods but provides them itself.

| <b>Name</b> | <b>Overloaded?</b> | <b>Description</b>                                                    |
|-------------|--------------------|-----------------------------------------------------------------------|
| deref       | No                 | Returns the data to which the specified pointer points                |
| read        | Yes                | Returns the contents of the register location specified by the symbol |
| write       | Yes                | Writes one or more values to the register location                    |

## Rstring Objects—Their Methods and Properties

When you create an object that accesses a string symbol stored in a register in your source code, the object constructor `createobj` returns an `rstring` object. `createobj` uses the information in your source code to set the properties of the object appropriately to match the code. Within the properties and their values you find all the information about the symbol, so that MATLAB understands how to handle the symbol in your MATLAB workspace.

To add to the properties of the `rstring` class, `rstring` objects inherit properties and methods from the `rnumeric` and `register` classes.

Classes that inherit from the `registerobj` base class always access data that resides in registers on the target, not in memory locations.

### Properties of Rstring Objects

Object properties can include both properties that the object inherits from its superclass, if any, and some properties that are unique to the class itself. For this reason, many objects in Link for Code Composer Studio share common properties; as you use the objects you will become familiar with the common and special properties for each.

| Property Name                     | Property Type                  | Default Value | Description                                                                                 |
|-----------------------------------|--------------------------------|---------------|---------------------------------------------------------------------------------------------|
| <code>name</code>                 | <code>string</code>            | None          | Name of the register symbol in the symbol table                                             |
| <code>regname</code>              | <code>mxArray</code>           | None          | Name of the register on the signal processor                                                |
| <code>numberofstorageunits</code> | <code>double</code>            | 1             | Number of register units needed to represent the register object                            |
| <code>link</code>                 | MATLAB handle                  | None          | Object handle that identifies the object                                                    |
| <code>timeout</code>              | <code>double</code>            | 10 seconds    | Time-out period for link methods                                                            |
| <code>arrayorder</code>           | { 'col-major'<br>'row-major' } | row-major     | Describes the ordering of the data moved from linear memory storage to n-dimensional arrays |



| Property Name      | Property Type                            | Default Value | Description                                                                                                           |
|--------------------|------------------------------------------|---------------|-----------------------------------------------------------------------------------------------------------------------|
| binarypt           | int                                      | 0             | Locates binary point needed to interpret fractional data types                                                        |
| postpad            | int                                      | 0             | Number of bits of padding added at the end of the memory buffer. Added bits are ignored in final numeric values       |
| prepad             | int                                      | 0             | Number of bits of padding added at the beginning of the memory buffer. Added bits are ignored in final numeric values |
| represent          | {signed, unsigned, float, fract, ufract} | signed        | Reports the representation of the values in the object, such as numeric or string                                     |
| size               | mxAarray                                 | 1             | Specifies the size of the array created in MATLAB from the data received from memory                                  |
| storageunitspvalue | double                                   | 1             | Register units per register value in memory on the DSP                                                                |
| bitsperstorageunit | double                                   | 8             | Bits per smallest register unit in the signal processor                                                               |
| wordsize           | int                                      | 0             | Valid bits per value (read-only)                                                                                      |
| charconversion     | mxAarray                                 | ASCII         | Conversion character set applied for the characters in the referent string                                            |

## Methods of Rstring Objects

Like properties, methods for objects may come from the superclass or derive only from the class itself. For example, the cast and convert methods do not

appear in all objects; listing them here indicates that the object does not inherit these methods but provides them itself.

| <b>Name</b> | <b>Overloaded?</b> | <b>Description</b>                                           |
|-------------|--------------------|--------------------------------------------------------------|
| equivalent  | Yes                | Returns the equivalent numeric value for the input string    |
| readnumeric | Yes                | Returns the data in memory as a numeric array in MATLAB      |
| write       | Yes                | Writes data to memory on the target                          |
| writebin    | Yes                | Write datas to memory on the target as binary data—0s and 1s |

## Function Objects—Their Methods and Properties

When you create an object that accesses a function declared in your source code, or a library function in your project, the object constructor `createobj` returns a function object. `createobj` uses the information in your source code to set the properties of the object appropriately to match the code. Within the properties and their values, you find all the information about the function, so that MATLAB understands how to handle the function in your MATLAB workspace and how to run the function on your target.

Unlike memory and register objects, function objects do not inherit properties from a parent class.

### Properties of Function Objects

Object properties can include both properties that the object inherits from its superclass, if any, and some properties that are unique to the class itself. For this reason, many objects in Link for Code Composer Studio share common properties; as you use the objects you will become familiar with the common and special properties for each.

| Property Name | Property Type | Default Value | Description                                                                                                                                                |
|---------------|---------------|---------------|------------------------------------------------------------------------------------------------------------------------------------------------------------|
| name          | string        | None          | Name of the register symbol in the symbol table                                                                                                            |
| filename      | string        | None          | Reports the name of the file that contains the function                                                                                                    |
| address       | mxArray       | 0             | Returns the starting memory address for the function                                                                                                       |
| type          | string        | ASCII         | Specifies the function return type                                                                                                                         |
| savedregs     | mxArray       | ASCII         | Lists the names of the processor registers that are saved during processing. Contents of saved registers are preserved after you run a function or program |

| Property Name | Property Type | Default Value | Description                                                                                                            |
|---------------|---------------|---------------|------------------------------------------------------------------------------------------------------------------------|
| variables     | mxArray       | ASCII         | Lists the names of variables in the function                                                                           |
| inputnames    | mxArray       | ASCII         | Lists the name of the input arguments for the function                                                                 |
| inputvars     | MATLAB handle | None          | Handles to the objects that access each input argument to the function. Created when you create the function object    |
| outputvar     | MATLAB handle | None          | Handles to the object that accesses the output argument from the function. Created when you create the function object |
| link          | MATLAB handle | None          | Identifies the name of the link object you used to create the associated embedded object                               |
| timeout       | double        | 10 s          | Specifies how long MATLAB waits for calls to the function to complete their work                                       |

### Methods of Function Objects

Like properties, methods for objects may come from the superclass or derive only from the class itself. For example, the cast and convert methods do not appear in all objects; listing them here indicates that the object does not inherit these methods but provides them itself

| Name                | Overloaded? | Description                                                     |
|---------------------|-------------|-----------------------------------------------------------------|
| addregister         | No          | Adds registers to the saved register list                       |
| assignreturnstorage | No          | Assigns a storage location for the return value from a function |

| <b>Name</b>    | <b>Overloaded?</b> | <b>Description</b>                                                                                                   |
|----------------|--------------------|----------------------------------------------------------------------------------------------------------------------|
| copy           | Yes                | Makes a copy of the function object                                                                                  |
| getinput       | No                 | Gets information about one or more input arguments for a function                                                    |
| getoutput      | No                 | Gets information about the output argument for a function                                                            |
| declare        | No                 | Provides a function declaration to MATLAB                                                                            |
| deleteregister | No                 | Removes a register you added to the saved register list                                                              |
| display        | Yes                | Returns the properties of the function                                                                               |
| execute        | No                 | Runs a function or program                                                                                           |
| goto           | No                 | Positions the cursor in CCS IDE to the start of the specified function. This method does not initialize the function |
| list           | Yes                | Returns information about one or more variables in your function                                                     |
| read           | Yes                | Reads a value from memory on the processor                                                                           |
| resume         | Yes                | Restarts execution of a paused or stopped process                                                                    |
| run            | Yes                | Runs a program or function. Similar to execute                                                                       |

| <b>Name</b> | <b>Overloaded?</b> | <b>Description</b>                                                                                                              |
|-------------|--------------------|---------------------------------------------------------------------------------------------------------------------------------|
| write       | Yes                | Write to the processor memory                                                                                                   |
| cleanup     | No                 | Restore CCS to the state it was in before you ran a function.<br>Restores the register contents to their previous state as well |

## Structure Objects—Their Methods and Properties

When you create an object that accesses a structure symbol declared in your source code, the object constructor `createobj` returns a structure object. `createobj` uses the information in your source code to set the properties of the object appropriately to match the code. Within the properties and their values you find all the information about the symbol, so that MATLAB understands how to handle the symbol in your MATLAB workspace.

Like memory and register class objects, structure objects do not inherit properties from a parent class.

### Properties of Structure Objects

Object properties can include both properties that the object inherits from its superclass, if any, and some properties that are unique to the class itself. For this reason, many objects in Link for Code Composer Studio share common properties; as you use the objects you will become familiar with the common and special properties for each.

| Property Name                     | Property Type          | Default Value | Description                                                                            |
|-----------------------------------|------------------------|---------------|----------------------------------------------------------------------------------------|
| <code>name</code>                 | string                 | None          | Name of the C or assembly function                                                     |
| <code>filename</code>             | mxArray                | None          | Name of the file that contains the function                                            |
| <code>address</code>              | mxArray                | None          | Address of the function                                                                |
| <code>arrayorder</code>           | {col-major, row-major} | row-major     | Ordering of values when moving data from linear memory storage to N-D arrays in MATLAB |
| <code>member</code>               | cell array             | None          | Object that contains a list of the structure members                                   |
| <code>membname</code>             | cell array             | None          | Object that contains the names of the members of the structure                         |
| <code>storageunitspervalue</code> | double                 | 1             | Memory units per value in memory on the DSP                                            |

| <b>Property Name<br/>(Continued)</b> | <b>Property<br/>Type</b> | <b>Default Value</b> | <b>Description</b>                                                                   |
|--------------------------------------|--------------------------|----------------------|--------------------------------------------------------------------------------------|
| numberofstorageunits                 | double                   | 1                    | Number of memory units needed to represent the object                                |
| memboffset                           | int                      | 0                    | Offset of the member from the starting address of the structure                      |
| size                                 | mxArray                  | 1                    | Specifies the size of the array created in MATLAB from the data received from memory |

### Methods of Structure Objects

Like properties, methods for objects may come from the superclass or derive only from the class itself. For example, the cast and convert methods do not appear in all objects; listing them here indicates that the object does not inherit these methods but provides them itself.

| <b>Name</b> | <b>Overloaded?</b> | <b>Description</b>                                        |
|-------------|--------------------|-----------------------------------------------------------|
| getmember   | No                 | Returns an object that accesses one member of a structure |
| copy        | Yes                | Returns a copy of the object                              |
| display     | Yes                | Returns information about the object                      |
| read        | Yes                | Reads a structure from the symbol table                   |
| write       | Yes                | Writes changes or values to the structure in memory       |



## Type Objects—Their Methods and Properties

When you create an object that accesses a typedef declared in your source code, the object constructor `createobj` returns a type object. `createobj` uses the information in your source code to set the properties of the object appropriately to match the code. Within the properties and their values, you find all the information about the declaration, so that MATLAB understands how to handle the typedef in your MATLAB workspace and how to read and write the typedef on your target.

Like `memoryobj` and `registerobj` class objects, type class objects do not inherit properties from a parent class. Unlike the other objects in Link for Code Composer Studio, type objects only exist as members of `ccsdsp` objects. You cannot directly create a type object using `createobj`. When you delete the `ccsdsp` object, you delete the type object as well. This relationship is called composition in the standard object modeling language (UML). Instead, when you call `createobj`, the resulting object includes by composition a type object, with the object properties set to their default values.

### Properties of Type Objects

Object properties can include both properties that the object inherits from its superclass, if any, and some properties that are unique to the class itself. For this reason, many objects in Link for Code Composer Studio share common properties; as you use the objects you will become familiar with the common and special properties for each.

| Property Name         | Property Type | Default Value | Description                                                                                                                                                                                                                                   |
|-----------------------|---------------|---------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>typelist</code> | cell array    | None          | List of the typedef equivalents in the object. This list relates the typedef name to its equivalent data type, either a native data type or a custom type definition. Equivalent types follow the order of the names in <code>typename</code> |

| <b>Property Name<br/>(Continued)</b> | <b>Property<br/>Type</b> | <b>Default Value</b> | <b>Description</b>                                    |
|--------------------------------------|--------------------------|----------------------|-------------------------------------------------------|
| typename                             | string                   | None                 | Names of the typedef entries in the object            |
| timeout                              | integer                  | 30 s                 | Local time-out value applied to type class operations |

### Methods of Type Objects

Like properties, methods for objects may come from the superclass or derive only from the class itself. For example, the cast and convert methods do not appear in all objects; listing them here indicates that the object does not inherit these methods but provides them itself.

| <b>Name</b> | <b>Overloaded?</b> | <b>Description</b>                                               |
|-------------|--------------------|------------------------------------------------------------------|
| add         | No                 | Adds a new type definition to the type object in MATLAB          |
| clear       | Yes                | Removes an existing type declaration from your type object       |
| display     | Yes                | Displays the properties of a type object                         |
| gettypeinfo | No                 | Returns information about a type declaration in your type object |

## Constructing Objects That Access Bitfields

Since bitfield objects do not stand by themselves, but only as parts of struct objects, you work with bitfields by starting with struct object. You create an object that accesses the structure the uses the bitfield. With the struct object now in your workspace, use `getmember` to create objects that access the elements of the structure. For example, in the next code offerings, we create a structure that contains a bitfield, then access the bitfield elements to be able to read and write to them.

Here is the target structure definition

```
struct {
 int b_2 : 1;
 unsigned int b_22 : 22;
 unsigned int b_10 : 3;
} bit_field = { 0, 689, 4};
```

create the struct object

```
bit_field=createobj(cc,'bit_field')
```

Use `bit_field` and `getmember` to construct objects for the components in the bit field.

```
b_2=getmember(bit_field,'b_2')
```

BITFIELD Object stored in memory:

```
Symbol name : b_2
Address : [2147501596 0]
Wordsize : 32 bits
Address units per value : 4 au
Representation : signed
Size : [1]
Total address units : 4 au
Array ordering : row-major
Endianness : little
Length (bits) : 1
Offset (bits) : 0
```

```
b_22=bfield.member.b_22 % Alternate syntax for accessing members
```

```
BITFIELD Object stored in memory:
Symbol name : b_22
Address : [2147501596 0]
Wordsize : 32 bits
Address units per value : 4 au
Representation : unsigned
Size : [1]
Total address units : 4 au
Array ordering : row-major
Endianness : little
Length (bits) : 22
Offset (bits) : 1
```

## Creating Function Objects

Like the other objects in Link for Code Composer Studio, you use `createobj` to construct objects that access the functions in your program and project in CCS. However, unlike many of the other objects, constructing function objects has some peculiarities with which you must be familiar.

The Link for Code Composer Studio function objects support two kinds of program functions:

- Functions that you write in ANSI C
- Functions that you write in Assembly but that have C function prototypes, such as library functions

A number of classes of functions that are allowed in your program are not supported by function objects:

- Assembly language functions that do not have C prototypes
- Functions where the number of input arguments changes
- Functions written in non-ANSI C language

For the unsupported function types, you cannot create function objects that access them and you cannot work with them with Link for Code Composer Studio.

In general, Link for Code Composer Studio provides three related ways to create function objects, all of which use `createobj` as a starting point.

- 1 Use `createobj` with the function name in the syntax. For example, to create an object that accesses `func_name`, use

```
ff = createobj(cc,func_name)
```

which creates the handle `ff` that accesses `func_name`. This syntax tells MATLAB to try to locate the function declaration string in your project. When it finds the required declaration, `createobj` generates the objects and information, such as function object property values, that enable MATLAB to run `func_name`. Note that searching your project for the function declaration may take some time, depending on projects you have open in CCS and the communications speed between your PC and the target.

If MATLAB cannot find the function declaration for `func_name`, one of the next two approaches works to create the necessary function object.

---

**Note** An important note about creating function objects and `createobj`. Even when MATLAB cannot find your specified function by name, it creates the function object `ff`, although populated with default values for the properties. Method 3 below takes advantage of this fact of object creation.

---

**2** Pass the function declaration string in the calling syntax for `createobj`. When you use this method, MATLAB skips the search for the function prototype and creates the function object from your input string. Here is one way to do it, using the `createobj` optional keywords `function` and `funcdecl`.

```
ff = createobj(cc,func_name,'function','funcdecl',declaration_string)
```

**3** When the function object exists already, but it does not have full property values associated with it, pass the function declaration string to the function object with `declare`, and the keyword `decl`.

```
declare(ff,'decl','declaration_string')
```

### When to Use `declare` to Provide the Function Declaration

Some types of functions in your project require that you explicitly provide the function declaration to MATLAB. In the following types of functions, MATLAB cannot determine the function declaration from CCS:

- Functions that you write in assembly, but you provide C declaration string for them
- Functions in a CCS project that you compile without enabling symbolic debugging
- Projects where you load the COFF file but not the project
- Instances where something in your function declaration, such as a non-ANSI C keyword, causes `createobj` to fail to read the declaration fully

Using `declare` to send the declaration string corrects each of the above situations so you can use MATLAB to run the function on your target.

To help you see what this means, here is one example of using `declare`. Note that you cannot run this example code.

In your project:

```
#define NumDefinedQualifier extern
NumDefinedQualifier void foo(void)
```

In MATLAB:

```
ff = createobj(ff,'foo')
```

generates a warning that MATLAB could not read the function declaration for `foo`. So try either of the following to overcome the error:

```
declare(ff,'decl','void foo(void)')
```

or:

```
declare(ff,'decl','extern void foo(void)')
```

## Differences Between Objects for Library Functions and C Functions

To run functions on your target, MATLAB needs a range of information about the function you are running. Function objects in Link for Code Composer Studio provide the information MATLAB needs. When you create an object that accesses a function, the properties of the new function object contain all the information MATLAB requires to be able to run the function.

Unfortunately, this is not true for all functions—function objects that access library functions do not contain the same function prototype that C function objects contain when you create them. When you try to create a function object to access a library function, MATLAB returns a warning message that it created the object you requested but could not set all the properties of the object.

### Library Functions

Library functions are functions that are not compiled when you build your project. They represent precompiled functions that you call from your C source code and the compiler does not know about the functions beyond their locations. Examples of library functions include those functions in the C standard library, or functions in other standard libraries. Another example of library functions are functions written in assembly but accompanied by C

prototypes (the TI run-time libraries fall into this category). In CCS IDE, you find library functions listed in the `Libraries` directory in your project directory tree.

Functions written in non-ANSI C or functions written in another language like assembly that do not have C prototypes; or functions that have variable numbers of input arguments, do not work with the function objects in Link for Code Composer Studio.

Because library functions are not part of the compile and build process for projects in CCS, the information about library function declarations, or prototypes, is not available to MATLAB from the symbol table in CCS. To overcome this problem, Link for Code Composer Studio includes a method named `declare` that lets you provide the declaration for a library function from the MATLAB command line. For more about using `declare` to enter function prototype strings in to MATLAB, refer to the reference page for `declare`, and to the tutorial about using functions in “Tutorial 2-1—Using Function Objects and Hardware-in-the-Loop” on page 2-74.

### Examples of Creating Function Objects

The following sections cover many situations you may encounter when you create function objects:

- Run a C function.
- Run a library function.
- Run a function that includes a custom data type.
- Run code generated by Real-Time Workshop.
- Run a function that has input vectors.

Unless you have project code that supports the functions used here you cannot run these examples. They are for instruction only.

These examples refer to four functions—`sin_taylor`, `dotprod`, `adotprod`, and `cdotprod`. Here is the code for each one.

- Function `sin_taylor`

```
/*-----*
 * Taylor Series expansion of sin function - Fixed Point
 * Limitations: input range: -pi <x <pi;
 *
```



```

* Input Datatype is:
* Q2.13 (or MATLAB sfix16_En13), scale factor = 2^13
* Output Datatype is:
* Q1.14 (or MATLAB sfix16_En14), scale factor = 2^14
*
* Taylor Expansion of sin function (first 4 terms)
* sin(x) =(approx) x[1 - (x^2/6)*[1 + (x^2/20)*[1 - (x^2/42)]]]

-----/
#define SFIX32_EN26_VAL_1 67108864 // Integer equivalent of
1.0 in Q5.26
#define SFIX32_EN28_VAL_1 268435456 // Integer equivalent of
1.0 in Q3.28
#define SFIX32_EN30_VAL_1 1073741824 // Integer equivalent of
1.0 in Q1.30

/* Global buffers */
short ibuf[63];
short obuf[63];

short sin_taylor(short x)
{

// Define 16/32 bit local variables depending on processor
#if INT_MAX == 0x7FFFFFFF
int acc,a1,a2,a3,xpow;
#elif LONG_MAX == 0x7FFFFFFF
long acc,a1,a2,a3,xpow;
#endif

 xpow = x*x; // x^2 sfix32_En26

 a1 = xpow/42; // x^2/42 sfix32_En26
 a2 = xpow/20; // x^2/20 sfix32_En26
 a3 = xpow/6; // x^2/6 sfix32_En26

 acc = SFIX32_EN26_VAL_1 - a1;
 acc >>= 11;

```

```
 acc *= (a2>>11);

 acc = SFIX32_EN30_VAL_1 - acc;
 acc >>= 14;
 acc *= (a3>>14);

 acc = SFIX32_EN28_VAL_1 - acc;
 acc >>= 11;
 acc *= x;

 return (acc>>16);
 }
}
```

- Function `dotprod` is a library function and has only a prototype; no source code.

```
int dotprod (short *x, short *y, int nx);
```

- Function `adotprod`

```
/* Global buffers */
short a[] = {1, 2, 3,4,5};
short b[] = {1, 2, 3, 4,5};

int adotprod(short x[4], short y[4])
{
 int sum;
 int i;
 sum = 0;
 for(i=0;i<4;i++) {
 sum += (x[i]*y[i]);
 }
 return sum;
}
}
```

- Function `cdotprod`

```
/* Global buffers */
short a[] = {1, 2, 3,4,5};
short b[] = {1, 2, 3, 4,5};

/* Typedef info */
```

```

typedef int INT;
typedef short SHORT;

/*
 Function cdotprod returns the dot product of
 two integer arrays (datatype=short).
 Inputs:
 x, y - pointer to an array of shorts
 n - size of array pointed to by x and y
*/
INT cdotprod(SHORT x[], SHORT y[], INT n)
{
 int sum;
 int i;
 sum = 0;
 for(i=0;i<n;i++) {
 sum += (x[i]*y[i]);
 }
 return sum;
}

```

### Run a Standard C Function

In this example, we run function `sin_taylor` that computes the value for the sine of an input value. This function accepts one input, `x` (using data type `short`), and returns a short data type result.

To get the correct values, the input data must be converted to Q16.13 format before passing to the function. After execution, the output value must be converted from Q16.14 to decimal representation.

Create a `ccsdsp` link:

```

cc = ccsdsp;
reset(cc);
pause(1); % Wait for hardware reset to complete before proceeding

```

Run to start of `main`—ensures that global variables are initialized:

```

run(cc, 'main', 1000);

```

Create a function object for `sin_taylor`:

```
ff = createobj(cc, 'sin_taylor')
inputdata = 0.5; % input value to be used
```

Set value of input `x`:

```
x_obj = getinput(ff, 'x');
write(x_obj, inputdata * 2^13);
```

Run the function:

```
outputdata = run(ff);
```

### Run a Library Function

For a library function, you pass the declaration string explicitly through `declare`.

This example runs the function `dotprod` that computes the dot product of two arrays. This function requires three inputs:

- `x`—a pointer to a vector of short data type values
- `y`—a pointer to a vector of short data type values
- `n`—the size of `x` and `y` vectors

We use the global variable `a` for input `x`, `b` for input `y`, and 4 for input `nx` (since `a` and `b` are four element vectors). The function returns a short.

Create a `ccsdsp` link:

```
cc = ccsdsp;
reset(cc);
pause(1); % Wait for hardware reset to complete before proceeding
```

Run to start of `main` to ensure that you initialize the global variables:

```
run(cc, 'main', 1000);
a_addr = address(cc, 'a'); % Global buffer for 'x'
b_addr = address(cc, 'b'); % Global buffer for 'y'
```

Create the function object for the library function `dotprod`:

```
ff = createobj(cc, 'dotprod')
```

The previous step yields an incomplete function object `ff` because library functions always require that you provide the function declaration explicitly, as follows:

```
declare(ff,'decl','int dotprod (short *x, short *y, int nx)')
```

Set the value for the input parameter `x`:

```
x_obj = getinput(ff,'x');
write(x_obj,a_addr(1));
xRef_obj = deref(x_obj);
reshape(xRef_obj,4);
x_inputval = read(xRef_obj) % Verify 'y' referent value
```

Set the value for `y`, the second input parameter:

```
y_obj = getinput(ff,'y');
write(y_obj,b_addr(1));
yRef_obj = deref(y_obj);
reshape(yRef_obj,4);
y_inputval = read(yRef_obj) % Verify 'y' referent value
```

Pass the value for `nx` to the function:

```
nx_obj = getinput(ff,'nx');
write(nx_obj,4);
nx_inputval = read(nx_obj) % Verify 'nx' value
```

Now run the function:

```
run(ff);
```

### Run a Function That Has a Custom Type Definition in the Prototype

Having custom data types in your function declaration can cause problems when you run the functions from MATLAB.

#### Case 1—Running a Function That Has a Typedef in the Function Prototype

This example runs the function `cdotprod` that computes the dot product of two matrices. This function requires three inputs:

- `x`—a pointer to a vector of short data type values
- `y`—a pointer to a vector of short data type values

- $n$ —the size of  $x$  and  $y$  vectors

Both  $n$  and the return argument are defined as data type `INT`, a custom data type defined in the source code.

We use the global variable `a` for input  $x$ , `b` for input  $y$ , and `4` for input  $n$  (since `a` and `b` are four-element vectors). The function returns a short.

Create a `ccsdsp` link:

```
cc = ccsdsp;
reset(cc);
pause(1); % Wait for hardware reset to complete before proceeding
```

Run to start of `main` to ensure that CCS initializes all of the global variables before you create your function object for `cdotprod`:

```
run(cc, 'main', 1000);
a_addr = address(cc, 'a'); % Global buffer for x
b_addr = address(cc, 'b'); % Global buffer for y
```

Create a function object for the library function `cdotprod`:

```
ff = createobj(cc, 'cdotprod')
```

The previous call to `createobj` yields an incomplete function object because the function declaration includes an unresolved typedef—the type `INT`. To resolve this error, add the custom data type `INT` to the type object and use `declare` to pass the function declaration to MATLAB:

```
add(cc.type, 'INT', 'int'); % Earlier warning that data type
 % INT cannot be resolved
declare(ff, 'decl', 'INT cdotprod (short x[], short y[], INT n)')
```

Set values for the inputs  $x$ ,  $y$ , and  $n$ , and run the function, passing the input values in the run syntax. Input  $x$  is a pointer so pass an address. Input  $y$  is a pointer as well, so pass another address. Input  $n$  is an integer that specifies the size of  $x$  and  $y$ :

```
run(ff, 'x', a_addr(1), 'y', b_addr(1), 'n', 4);
```

### Case 2—A Second Approach to Solving the Typedef Problem

We now run the function `cdotprod`, which computes the dot product of two matrices. This function accepts three inputs:

- `x`—a pointer to a vector of short data type values
- `y`—a pointer to a vector of short data type values
- `n`—the size of `x` and `y` vectors

We are going to use the global variable `a` for input `x`, `b` for input `y`, and 4 for input `n` (since `a` and `b` are four element vectors). The function returns a short.

Create `ccsdsp` link:

```
cc = ccsdsp;
reset(cc);
pause(1); % Wait for hardware reset to complete before proceeding
```

Run to start of `main` to ensure that CCS initializes all of the global variables before you create your function object for `cdotprod`:

```
run(cc, 'main', 1000);
a_addr = address(cc, 'a'); % Global buffer for 'x'
b_addr = address(cc, 'b'); % Global buffer for 'y'
```

Create function object for library function `cdotprod`:

```
ff = createobj(cc, 'cdotprod')
```

Again `createobj` generates an incomplete function object because of the unresolved data type `INT` in the function declaration. In this case, fix the problem by adding the custom data type `INT` to the type object and create the object `ff` again, instead of using `declare` to pass the function declaration to MATLAB:

```
add(cc.type, 'INT', 'int'); % Warning only mentioned that type INT
 % cannot be resolved
ff = createobj(cc, 'cdotprod')
```

Set values for the inputs `x`, `y`, and `n`, and run the function, passing the input values in the `run` syntax. Input `x` is a pointer so pass an address. Input `y` is a pointer as well, so pass another address. Input `n` is an integer that specifies the size of `x` and `y`:

```
run(ff, 'x', a_addr(1), 'y', b_addr(1), 'n', 4);
```

### Case 3—A Third Approach to Solving the Typedef Problem

Once more we are going to run the function `cdotprod` which computes the dot product of two matrices. This function accepts three inputs:

- `x`—a pointer to a vector of shorts
- `y`—a pointer to a vector of shorts
- `n`—the size of `x` and `y` vectors

We are going to use the global variable `a` for input `x`, `b` for input `y`, and 4 for input `n` (since `a` and `b` are four element vectors). `cdotprod` returns a short.

Create `ccsdsp` link:

```
cc = ccsdsp;
reset(cc);
pause(1); % wait for hardware reset to complete before proceeding
```

Run to start of main, ensuring that CCS initializes all of the global variables before you create the function object that accesses `cdotprod`:

```
run(cc, 'main', 1000);
a_addr = address(cc, 'a'); % Global buffer for x
b_addr = address(cc, 'b'); % Global buffer for y
```

Create a function object for the library function `cdotprod`:

```
ff = createobj(cc, 'cdotprod')
```

This attempt to create a new function object `ff` results in an incomplete function object because MATLAB could not resolve the data type `INT` in the function declaration. In this approach to overcoming the unresolved type error, use `declare` to pass to MATLAB a version of the `cdotprod` function declaration that does not include the offending type `INT`—you do not need to add the `typedef` to the type object:

```
declare(ff, 'decl', 'int cdotprod (short x[], short y[], short n)')
```

Notice that the data types for the return argument and for `n` now specify `int`, Set values for the inputs `x`, `y`, and `n`, and run the function, passing the input values in the `run` syntax. Input `x` is a pointer so pass an address. Input `y` is



a pointer as well, so pass another address. Input `n` is an integer that specifies the size of `x` and `y`:

```
run(ff, 'x', a_addr(1), 'y', b_addr(1), 'n', 4);
```

### Run a Function Generated by Real-Time Workshop

We run the function `'mwdsp_fir_df_dd'` which applies a filter to a noisy input signal. This function accepts nine input parameters and returns the filtered signal in the input argument `y`.

Create a `ccsdsp` link:

```
cc = ccsdsp;
reset(cc);
pause(1); % Wait for hardware reset to finish before proceeding
```

Now run the Real-Time Workshop generated code from the beginning to `Md1Outputs`. You run from program start until `Md1Outputs` to ensure that all of the code configuration processes get done—the CCS initializes all of the variables in program. In the case of generated code, running to main is not sufficient to ensure that all the variable get initialized:

```
run(cc, 'runtofunc', Md1Outputs);
```

After running to `Md1Outputs`, you create the function object—pass the function declaration to avoid MATLAB returning an error when you create the function object. Due to the complexity of this function declaration, we have assigned the string to a variable `decl`. We use the variable in the `createobj` syntax:

```
decl = ['MWDSP_IDECL void MWDSP_FIR_DF_DD(const real_T *u,...
real_T *y, real_T * const mem_base,int_T *mem_offset,...
const int_T numDelays, const int_T sampsPerChan,...
const int_T numChans, const real_T * const b,...
const boolean_T one_fpf)'];
ff = createobj(cc, 'MWDSP_FIR_DF_DD', 'function', 'funcdecl', decl);
```

Examine the function declaration above. This declaration causes MATLAB to fail to create the fully populated function object `ff` because of the `MWDSP_IDECL` macro at the beginning of the string. MATLAB cannot recognize this string. Since the information in `MWDSP_IDECL` is not relevant to creating the function object, you can remove this from the declaration string:

```
decl = ['void MWDSP_FIR_DF_DD(const real_T *u,...
real_T *y, real_T * const mem_base,int_T *mem_offset,...
const int_T numDelays, const int_T sampsPerChan,...
const int_T numChans, const real_T * const b,...
const boolean_T one_fpf)'];
ff = createobj(cc,'MWDSP_FIR_DF_DD','function','funcdecl',decl);
```

Now function object `ff` has all the information MATLAB needs.

---

**Note** You may not always be able to remove offending entries in a declaration string, as we did with the macro `MWDSP_IDECL`. Often you can try your declaration and see if it works. If not, use add to include typedefs in the type object when MATLAB complains about a data type, or try removing the problem portion of the declaration string if the function does not require the troublesome text.

---

With the function object in your MATLAB workspace, create objects for the inputs to `MWDSP_FIR_DF_DD`:

Create an object for `rtB`:

```
rtBobj = createobj(cc,'rtB');
```

Get the relevant `rtB` member objects:

```
SumObj = getmember(rtBobj,'Sum');
% Store Output of MWDSP_FIR_DF_DD in FilObj
FilObj = getmember(rtBobj,'Digital_Lowpass_Fil');
```

Next, create an object for `rtDWork`

```
rtDWorkObj = createobj(cc,'rtDWork');
```

and again get the relevant member objects:

```
Fil_FILT_STATES = getmember(rtDWorkObj,...
'Digital_Lowpass_Fil_FILT_STATES');
DF_INDX = getmember(rtDWorkObj,...
'Digital_Lowpass_Fil_FILT_STATES');
```

Create one last object for filterCoeffs:

```
filterCoeffsObj = createobj(cc, 'filterCoeffs');
```

To run the function, you need to provide the input values:

```
u = SumObj.address(1); % Input 1
y = FilObj.address(1); % Input 2
mem_base = Fil_FILT_STATES.address(1); % Input 3
mem_offset = DF_INDX.address(1); % Input 4
numDelays = 65; % Input 5
sampsPerChan = 256; % Input 6
numChans = 1; % Input 7
b = filterCoeffsObj.address(1); % Input 8
one_fpf = 1; % Input 9
```

Run the function, providing the input argument values in input value/input name pairs, such as 3, membase and 6, sampPerChan:

```
run(ff, 1, u, 2, y, 3, mem_base, 4, mem_offset, 5, numDelays, 6, ...
 sampsPerChan, 7, numChans, 8, b, 9, one_fpf)
```

### Run a Function That Has Vector Inputs

This example shows how to run a function that accepts vector inputs.

We are going to run the function `adotprod` that computes the dot product of two matrices. `adotprod` accepts two inputs:

- `x`—a four-element vector of short data type values
- `y`—a four-element vector of short data type values

The compiler converts the vector inputs into pointers to the vectors. We use the global variable `a` for input `x` and `b` for input `y`. The function returns a short.

Create a `ccsdsp` link:

```
cc = ccsdsp;
reset(cc);
pause(1); % Wait for hardware reset to complete before proceeding
```

Run to the start of `main` to ensure that the global variables are initialized:

```
run(cc, 'main', 1000);
a_addr = address(cc, 'a'); % Global buffer for 'x'
```

```
b_addr = address(cc, 'b'); % Global buffer for 'y'
```

Create a function object ff to access adotprod:

```
ff = createobj(cc, 'adotprod')
```

The function prototype for adotprod is

```
int adotprod(short x[4], short y[4])
```

adotprod requires as input two vector arrays x and y. The compiler requires that you pass the addresses of x[4] and y[4], not the actual vectors x and y. So instead of writing a data vector to input object x\_obj and y\_obj, you provide the addresses of existing four element vectors:

```
display('INPUT VALUE 'x':')
x_obj = getinput(ff, 'x') % Note that this is a pointer to a vector
 % of shorts
display('INPUT VALUE 'y':')
y_obj = getinput(ff, 'y') % note that this is a pointer to a vector
 %of shorts
```

Set values of inputs x and y and run the function. Pass addresses to x and y since both are pointers to other data:

```
write(x_obj, a_addr(1))
write(y_obj, b_addr(1))
x_inputval = read(reshape(deref(x_obj), 4));
y_inputval = read(reshape(deref(y_obj), 4));
```

In contrast to using pointers, using the following commands to write data to x and y does not give you the expected result—the compiler cannot determine where to put array [1:4]:

```
write(x_obj, [1:4]);
write(y_obj, [1:4]);
```

Now run your function:

```
run(ff);
```

The preceding examples present a few of the wide variety of functions and conditions you may encounter when you construct function objects.

## Creating Type Objects

Type objects are unique among the objects in Link for Code Composer Studio because you cannot use `createobj` to create a type object directly. Each time you create a `ccsdsp` object `objectname`, the new object contains an empty type object, called `objectname.type`. You may note that this looks very much like a property of the object `objectname`. It is, however, an object: it has properties and methods that let you manipulate it from MATLAB.

When you create a type object, the object constructor add the following DSP BIOS data types to the `namelist` property:

| <b>BIOS Data Type</b> | <b>Equivalent C Data Type</b> |
|-----------------------|-------------------------------|
| Void                  | <code>void</code>             |
| Float                 | <code>float</code>            |
| Double                | <code>double</code>           |
| Long                  | <code>long</code>             |
| Int                   | <code>int</code>              |
| Short                 | <code>short</code>            |
| Char                  | <code>char</code>             |

Link for Code Composer Studio ignores certain CCS keywords when you create type objects: `interrupt`, `near`, `far`, `cregister`, and `volatile`. These have no meaning in the MATLAB workspace.

## Working with Type Definitions in Projects

Type definitions (`typedef`) in your C source code present a special problem in Link for Code Composer Studio. While you can use any valid `typedef` in the C programs you use in your project, MATLAB cannot read your custom data types from the project in CCS without your help. You must supply each `typedef` to MATLAB explicitly. There is no way for MATLAB to interpret existing `typedefs` in your CCS project.

In particular, until you tell MATLAB about the typedefs you use in your project, you cannot use your typedefs when you create objects that access functions whose prototypes include the typedefs as either input or output arguments. Unless MATLAB recognizes your custom data types, you get an error when you try to create the object or use `declare` to specify the function prototype in MATLAB.

To tell MATLAB about your custom data types, you use `add` to add the type definitions to a `ccsdsp` object that accesses your project in CCS.

### To Add a Type Definition to an Existing `ccsdsp` Object

Adding a new type definition to a `ccsdsp` object entails using `add` to include the new data type in the type object associated with your `ccsdsp` object. Follow this example to see how you add a typedef to your type object. At the end of the example, you use your new typedef in a function declaration.

- 1 Create a `ccsdsp` object:

```
mylink = ccsdsp;
```

- 2 Look at the properties of `mylink`, and the associated type object  
`mylink.type`:

```
get(mylink)
```

```
rtdx: [1x1 rtdx]
apiversion: [1 2]
ccsappexe: 'D:\Applications\ti\cc\bin\'
boardnum: 0
procnum: 0
type: [1x1 type]
timeout: 10
page: 0
```

```
get(mylink.type)
```

```
typename: {'Void' 'Float' 'Double' 'Long' 'Int' 'Short' 'Char'}
typelist: {1x7 cell}
timeout: 10
```

`typename` contains the default set of defined types. `typelist` contains seven cell arrays of the form `[1x1 struct]`. You can verify this by issuing the command

```
mylist.type.typelist
```

- 3** Now add a new type definition to the type object. For now add a `typedef mytype` which uses the `uint32` data type:

```
add(mylink.type,'mytype','uint32')
```

```
ans =
```

```
 type: 'uint32'
 size: 1
 uclass: 'numeric'
```

```
mylink.type.typename
```

```
ans =
```

```
Columns 1 through 7
```

```
'Void' 'Float' 'Double' 'Long' 'Int' 'Short' 'Char'
```

```
Column 8
```

```
'mytype'
```

`typelist` now contains eight 1-by-7 cell arrays, one additional one for the new type `mytype`.

With MATLAB now informed about your custom data type `mytype`, you could use the `typedef` in a function declaration, such as the following command where `ff` is an object that accesses the function `myfunction`:

```
declare(ff,'decl','void myfunction(short x* int32 y* float z mytype m)')
```

# Tutorial 2-1 – Using Function Objects and Hardware-in-the-Loop

The Link for Code Composer Studio Development Tools provides a connection between MATLAB and a digital signal processor in CCS. Using objects with the links provides a mechanism for you to control and manipulate a signal processing application using the computational power of MATLAB. This can help you debug and develop your application. Another use for links and objects is creating MATLAB scripts that you use to verify and test algorithms by running the algorithms on your potential target during development.

The Link for Code Composer Studio provides hardware-in-the-loop (HIL) functionality that enables you to verify your signal processing (DSP) application implementation, within the context of a system design, by simulating in MATLAB components that you did not implement on the digital signal processor. You may want to verify your implementation of an FIR filter, for example, on your processor while simulating your input data and processing your output data in MATLAB. The performance of your closed-loop system design may be assessed with the real-world constraints of your hardware (the processor) and software (DSP implementation).

In this tutorial, you

- call digital signal processing functions
- get the function signature information, such as
  - input argument names and types
  - the function return type
  - the starting address
- specify the values for each input argument
- run the function
- read the returned value(s)

all from MATLAB.

This tutorial assumes that you are relatively familiar with the Link for Code Composer Studio. If not, we suggest that you run `csstutorial` first to give you a better understanding of what the Link for Code Composer Studio does. Run `csstutorial` by typing `csstutorial` at the command prompt in MATLAB.



Before using the function object available with the Link for Code Composer Studio, you must select a digital signal processor to be your target because your objects require a link to refer to. Selecting a processor is only necessary for multiprocessor boards or multiple board configurations of CCS. When you have only one board with a single processor, the link defaults to the existing processor. For the links, the simulator counts as a board; if you have both a board and a simulator that CCS recognizes, you must specify the target explicitly.

## Introducing the Tutorial

To get you started using function objects in your CCS IDE software, the Link for Code Composer Studio includes an example script `hiltutorial.m`. As you follow along with this tutorial, you perform tasks that step you through creating and using function objects in MATLAB and in your projects:

- 1 Selecting your target.
- 2 Creating and querying links to CCS IDE.
- 3 Constructing and using various objects, such as numeric and string objects.
- 4 Creating and using function objects to access functions in your project.
- 5 Closing the links you opened to CCS IDE.

For this tutorial, you load and run a sample DSP application on a target processor you select. To help you understand how objects work, the tutorial also demonstrates writing to memory and reading from memory and registers.

Using the data manipulation functions gets a bit complicated. MATLAB supports only double-precision values for calculations, but you can convert and cast a range of data types to and from other data types. Seeing how the functions work with many of the different objects can help you when you are doing your work.

The tutorial covers the objects and methods listed below. The functions listed first apply to CCS IDE independent of the links—you do not need a link to use these functions. The functions and methods listed next require a CCS IDE link in place before you can use the function syntax. Finally, the last set of entries

use the `function` object, using the methods that apply to working with function objects in MATLAB and your project:

### Global functions for CCS IDE—no link required

- `ccsboardinfo`—return information about the boards that CCS IDE recognizes as installed on your PC.
- `boardprocse1`—select the board to target. Although you can use this generally, the Link for Code Composer Studio provides it as an example of a user interface you can build and as a tool in the tutorial. We do not recommend that you use this to select your target. Use `ccsboardinfo` and `ccsdsp` to specify the target for your processing application
- `ccsdsp`—construct a link to CCS IDE. When you construct the link you specify the target board and processor.
- `clear`—remove a specific link to CCS IDE or remove all existing links.

### Link for Code Composer Studio functions for working with embedded objects—uses links

- `cast`—create a new object with a different data type (the `represent` property) from an object in the Link for Code Composer Studio. Demonstrated with a numeric object.
- `convert`—change the `represent` property for an object from one data type to another. Demonstrated with a numeric object.
- `createobj`—return an object in MATLAB that accesses embedded data. Demonstrated with structure, string, and numeric objects.
- `getmember`—return an object that accesses a single field from a structure. Demonstrated with a structure object.
- `goto`—position your cursor in CCS to the specified function in the project code.
- `list`—return various information listings from CCS.
- `read`—read the information at the location accessed by an object into MATLAB as numeric values. Demonstrated with numeric, string, structure, and enum objects.

- `readnumeric`—return the numeric equivalent of data at the location accessed by an object. Demonstrated with an enum object.
- `write`—write to the location referenced by an object. Demonstrated with numeric, string, structure, and enum objects.

### **Link for Code Composer Studio functions for working with embedded functions—uses function objects**

- `createobj`—construct a function object that accesses a function in your project in CCS.
- `run`—run a function on your target.
- `copy`—copy an existing function.
- `declare`—create a new function for your project from MATLAB. With this method you create the function prototype, configuring the input and output arguments, among other things.
- `getinput`—create the input arguments for your new function.
- `getoutput`—create the output arguments for your new function.
- `assignreturnstorage`—assign the location for storing the output from your function.

### **Running the Interactive Tutorial**

You have the option of running this tutorial from the MATLAB command line or entering the functions as described in the following tutorial sections.

To run the tutorial in MATLAB, click `run ccstutorial`. Running the interactive tutorial in MATLAB puts you in an interactive mode where the tutorial program provides prompts and text descriptions to which you respond to move to the next portion of the lesson. The interactive tutorial covers the same information provided by the following tutorial sections. If you wish to view the tutorial M-file itself, click `hiltutorial.m`.

### **To Run the Hardware-in-the-Loop Tutorial**

Running the tutorial consists of completing the following tasks that cover setting up and running a project in CCS and interacting with the project from MATLAB, as well as running functions from MATLAB on your target hardware. In order, the tasks are

- 1 Select your target and establish the link between MATLAB and the target. These operations, or some variant of them, are the first things you do to work between MATLAB and CCS.
- 2 Load the tutorial project.
- 3 Initialize the embedded C variables, then construct and work with an embedded object.
- 4 Use `read`, `write`, `cast`, and `convert` to manipulate a few variables. Within this section you learn that `read`, `write`, `cast`, and `convert` behave differently depending on the object you are using.
- 5 Construct a function object and run the function from MATLAB.
- 6 Exercise various methods that work with function objects, such as `copy`.
- 7 Construct other embedded objects and work with them, such as pointer objects, enum objects, and type objects.
- 8 Close the tutorial and clean up the lingering objects, handles, and assorted variables left over. Close CCS as well.

---

**Note** To run this tutorial, you must have either a C54xx or C6xxx processor and board, or be using one of the C54 or C6x simulators in CCS. Link for Code Composer Studio does not support HIL or this tutorial on other TI processors.

---

This is a rather long and complicated tutorial, because the embedded object concepts are somewhat less straightforward and more numerous than the `ccsdsp` or `rtdx` objects and concepts.

### Stopping and Saving the Tutorial Program

If you stop in the middle of the tutorial, save your workspace so you can reload the tutorial program (`hiltut.board.out`, where `board` is the numeric designation of your target, such as `6x11` or `54xx`) directly into CCS and continue later. To save your workspace before you close MATLAB, select **File->Save Workspace As...** from the MATLAB menu bar. To start the tutorial again,

reload the MATLAB workspace you stored and build and load the .out file to start the tutorial.

## Select Your Target and Load the Tutorial Project

You start by selecting your target DSP using a tool called `boardprocse1`. Then you create a link between MATLAB and CCS. The link is represented by a MATLAB object which you save in variable `cc`.

---

**Note** You use the digital signal processor that you select in the GUI for the rest of this tutorial. For single processor installations of CCS, click **OK** to continue. When you click **OK**, `boardprocse1` assigns the board and processor identification information to the output arguments `boardnum` and `procnum`.

---

- 1 Start the board selection tool by entering

```
[board,processor] = boardprocse1
```

Follow the instructions on the dialog to select your target processor.

- 2 Use the board and processor variables to construct a `ccsdsp` object named `cc`:

```
cc=ccsdsp(boardnum,board,procnum,processor)
```

Now that you have established the connection between MATLAB and your target (the link), the target processor needs something to do. Your next step is to create or load executable code for the target DSP with CCS.

For this tutorial, we created a CCS project file and board-specific executables and included them with MATLAB. In this tutorial section, you load the included executable directly; if the load fails (perhaps because you selected a different board or processor target), you build the included project to compile and generate the executable for your target.

The following functions locate the HIL tutorial project and load it into CCS. Loading the project uses `open`, and directs CCS to load the project files or a program file.

- 3** Start by gathering some information about the `cc` object you constructed. Enter the following function calls to learn more about `cc` and to assign MATLAB variables to the values of some properties of `cc`:

```
linkinfo = info(cc);
familycpu = linkinfo.subfamily;
revisioncpu = linkinfo.revfamily;
board = GetDemoProp(familycpu,revisioncpu,hiltutorial);
```

- 4** Now locate the project file for the tutorial and assign the path to a variable:

```
projfile = fullfile(matlabroot,toolbox,ccslink,ccsdemos,...
hiltutorial,board.hiltut.projname);
```

- 5** For convenience, assign the path to the project file to a variable (you use it in a later step):

```
projpath = fileparts(projfile);
```

- 6** Now open the project file, using the link `cc`:

```
open(cc,projfile); % Open project file
```

- 7** To make your CCS working directory the same as your project directory, use `cd`:

```
cd(cc,projpath); % Change working directory of CCS
```

Changing the working directory ensures that CCS finds all the project files and stores changes in the same area as well.

- 8** When you created `cc`, the process opened CCS with the visibility set to 0—not visible. You are going to need to see the source files and variables for the tutorial, so set the visibility for CCS to 1:

```
visible(cc,1)
```

- 9** Finally, open the tutorial source file, activate it, and bring it to the foreground in CCS:

```
open(cc,'hiltut.c','text');
activate(cc,'hiltut.c','text');
```

Notice that the tutorial project is loaded in CCS. Examine the files in CCS that compose this project. The main source file the project uses is `hiltut.c`

(the same for all targets), accompanied by a linker command file (\*.cmd) and a vector table source file (\*.asm) that will be different depending on the DSP family you are using. Also review the variables and functions in the file `hiltut.c`—you manipulate them from MATLAB later in the tutorial. Throughout the remaining tutorial, we call these variables and functions *embedded* objects or variables. Before you build this project, try to load the included executable program file `hiltut.loadfile`.

- 10** Use `load` to load the target executable file to the target by entering the following command:

```
load(cc,board.hiltut.loadfile,30)
```

Possibly the load failed. This might happen when the load file was created for a different target than the one you are using. When this happens, try rebuilding the executable and then loading it before proceeding.

- 11** To create the executable file for the project from the source files, use `build`. Before proceeding to build the file, you should set up the build options for the build process, just as you would in CCS. From MATLAB, use `setbuilddopt` with `cc` to provide the build options and needed configuration:

```
cc.setbuilddopt(compiler,board.hiltut.Cbuilddopt);
```

- 12** To avoid overwriting the existing executable file, redirect the output program file to a temporary directory on your system:

```
eval([cc.setbuilddopt(Linker , -c -o 'tempdir...
board.hiltut.loadfile' -x)]);
```

In the `eval` syntax, notice that you use the dot notation to access the members of the structure or object `cc`. Using this notation to access properties of an object is common in MATLAB operations.

- 13** Everything is ready for you to build your project. Use the following command to start the build:

```
build(cc,all,60);
```

Depending on your configuration, building a project can be slow and the default time-out value may not be long enough. Therefore, an explicit 60 second time-out is supplied as an input argument with the `build` syntax. Wait for the build operation to complete and press `Enter` before proceeding.

- 14** You've built the executable. Now load the program to your target with this code. Note that you are loading the program from your temporary directory and you provide an explicit time-out value of 40 s:

```
load(cc,['tempdir','board.hiltut.loadfile'],40)
```

Again, this load might fail for a number of reasons. One might be that your target DSP needs different linker command (\*.cmd) and vector table source (\*.asm) files. If so, attempt to rebuild the executable with the appropriate files and then load it from the CCS IDE. After you load the executable successfully, continue the tutorial.

- 15** To make sure the working directory is correct for the rest of the tutorial, reset it to the project path from step 5:

```
cd(cc,projpath); % Restore CCS working directory
```

### Initialize the Embedded C Variables and Use read and write

Direct access to DSP memory is powerful, but for C programmers it can be more convenient to manipulate memory in ways more like working with the defined C variables. Link for Code Composer Studio implements this approach by using MATLAB objects as representations of embedded entities (entries in the symbol table for your project).

This section of the tutorial starts by investigating data values in the program and manipulating them using embedded objects. For that you apply the method `list` with variable `idat`, which queries CCS for information about the variable. `idat` is a global C variable in the tutorial program `hiltut.c`.

- 1** Enter the following code to ensure that the embedded C variables in your project are initialized. In this tutorial, `main` contains all the variables required for the project. Otherwise the methods for accessing variables outside of `main` do not work because they are not initialized by running to `main`:

```
run(cc,'main')
```

When you look at the project in CCS, you see that the program is running—CCS shows the CPU as running.



- 2** Function `list` provides one way to gather information about the embedded variables and functions in your project. Use the following `list` examples to explore the tutorial program. In each example, you could assign the return structure to an output argument by including an argument on the left side of the `list` syntax:

```
list(cc, 'function')
```

```
Warning: NAME 'ASM$' is an invalid ML structure fieldname. The
dollar ($) character is replaced by 'DOLLAR'.
```

```
ans =
```

```
 ASMDOLLAR: [1x1 struct]
 fir_filter: [1x1 struct]
 main: [1x1 struct]
 sin_taylor: [1x1 struct]
sin_taylor_vect: [1x1 struct]
```

This syntax, with the **function** keyword, returns a structure that contains the names of all the functions in your project:

```
list(cc, 'variable')
```

```
ans =
```

```
 coeff: [1x1 struct]
 ddat: [1x1 struct]
 din: [1x1 struct]
 dout: [1x1 struct]
 ibuf: [1x1 struct]
 idat: [1x1 struct]
myString: [1x1 struct]
myStruct: [1x1 struct]
 nbuf: [1x1 struct]
 ncoeff: [1x1 struct]
 obuf: [1x1 struct]
 data: [1x1 struct]
 min: [1x1 struct]
 result: [1x1 struct]
```

Switching to the **variable** keyword returns a structure that contains the names of all the variable defined in the tutorial.

```
list(cc, 'type')
ans =

 TAG_myStruct: [1x1 struct]
 TAG_myEnum: [1x1 struct]
```

The last keyword, **type**, returns all the data types defined in the program, in a structure in your workspace.

- 3** To focus on just one variable, the next code example returns the information about one variable, named `idat`. Again, the results come back in structure form. In this case, you use an output argument to store the structure:

```
listI = list(cc, 'variable', 'idat')
listI =

 idat: [1x1 struct]
```

`idat` is a global variable, as you see from the structure contents.

- 4** Now take a look at the `idat` element in structure `listI`:

```
listI.idat
ans =

 name: 'idat'
 isglobal: 0
 address: [17468 0]
 size: [2 3]
 bitsize: 16
 type: 'short'
```

`list` generates quite a lot of information about the embedded `idat` variable. However, an even more useful method is `createobj`, which constructs a MATLAB object to represent the C variable—in this case `idat`. The object you construct using `createobj` acquires the properties of the C variable. Applying the object returned by `createobj`, you can directly read the entire variable or access individual elements of the variable, such as the elements of an array for array variables.

To this point in the tutorial, you have applied all the methods to the original `cc` object that you created with `ccdsp`. The `cc` object represents communication with a particular digital signal processor in CCS.

For the remainder of this tutorial, you apply methods to many different objects. In typical object-oriented programming fashion, the action performed by a method depends on its object. The relevant or target object is always the first input argument passed to the method. For example, in the following section `cvar` is an object representing the embedded `idat` variable.

- 5 Use `createobj` to construct a MATLAB object that accesses the embedded variable `idat`. By assigning the return value to the variable `cvar`, you have a handle in MATLAB that represents access to `idat` on your DSP target:

```
cvar = createobj(cc,idat)
NUMERIC Object stored in memory:
Symbol name : idat
Address : [17468 0]
Datatype : unsigned short
Wordsize : 16 bits
Address units per value : 2 au
Representation : unsigned
Size : [2]
Total address units : 4 au
Array ordering : row-major
Endianness : little
```

- 6 Now you use `cvar` to get information about `idat`, or to manipulate the way MATLAB interprets `idat` in your workspace. Try the code examples below to see how some of the data manipulation methods work:

```
get(cvar,'size') % Size of cvar should be 2-by-3 as defined in
 % our DSP application
```

```
ans =
```

```
 2 3
```

```
read(cvar) % Reads the entire embedded matrix into the MATLAB
 % workspace
```

```
ans =
```

```
 -1 508 647
 7000 8 619

readhex(cvar) % Reads cvar in hex

ans =

 'FFFF' '1FC' '287'
 '1B58' '8' '26B'

readbin(cvar) % Reads cvar in binary

ans =

 '1111111111111111' '0000000111111100' '0000001010000111'
 '0001101101011000' '0000000000001000' '0000001001101011'
```

The previous read examples return the entire `idat` matrix to your MATLAB workspace. You can read and write selected elements of `idat` by indexing into it. Being able to read or write with objects is easier and more powerful than reading and writing to raw DSP memory, or manually figuring out the right address offsets for your data arrays.

- 7** In the next code examples, you use indexing to return specific elements of embedded variable `idat`, as accessed by `cvar`. Note the write method for changing the contents of `cvar` from MATLAB:

```
read(cvar,[2 1]) % Read element specified by column 2, row 1

ans =

 7000

write(cvar,[2 1], -7000) % Modifies 7000 to -7000
read(cvar)

ans =

 -1 508 647
 -7000 8 619
```

## Use read, write, cast, and convert with Objects

The previous read operations with `cvar` took raw memory values and converted them into equivalent MATLAB numeric values. The conversion that gets applied is controlled by the properties of `idat`, which were initially configured in `createobj` to settings appropriate for your DSP architecture and C representation. In some cases, changing these default conversion properties can help your development process. Several properties of the object, such as `endianness`, `arrayorder`, and `size`, can be directly modified using `set`. Methods such as `convert` and `cast`, which adjust multiple object properties simultaneously, enable you to make more complex changes from MATLAB.

- 8** To introduce the idea of changing the representation in MATLAB of an object, try the following `set` function on `cvar`, which changes the way MATLAB interprets `idat`. After the change, check that `cvar` is indeed smaller:

```
set(cvar,'size',[2]) % Reduce size of 'idat' to first 2 elements
read(cvar)
```

```
ans =
```

```
 -1 508
```

- 9** Now change the data type of `cvar` using `cast`:

```
uicvar = cast(cvar,'unsigned short')
```

```
NUMERIC Object stored in memory:
```

```
Symbol name : idat
Address : [17468 0]
Datatype : unsigned short
Wordsize : 16 bits
Address units per value : 2 au
Representation : unsigned
Size : [2]
Total address units : 4 au
Array ordering : row-major
Endianness : little
```

Using `cast` in this way changes the representation of `cvar` from double precision to unsigned short. As a result, MATLAB interprets the first value in `cvar` as the unsigned equivalent of -1, as shown when you read the new `uicvar` object. And do note that `uicvar` is a new object, not an alias or handle to `cvar`, but fully independent of `cvar`.

```
read(uicvar)
ans =

 65535 508
```

In the next step you meet the method `convert`, which changes the data type of the specified object, rather than creating a new object with the new data type.

- 10** For the second data type conversion method, use `convert` with `cvar` to change the data type for `idat` in MATLAB:

```
convert(cvar,'unsigned short')

NUMERIC Object stored in memory:
Symbol name : idat
Address : [17468 0]
Datatype : unsigned short
Wordsize : 16 bits
Address units per value : 2 au
Representation : unsigned
Size : [2]
Total address units : 4 au
Array ordering : row-major
Endianness : little
```

```
read(cvar)
ans =

 65535 508
```

Note that the embedded object `cvar` has the new data type and size; it is not a new embedded object. Writing this version of `cvar` back to the DSP memory would cause `idat` to take on the new data type definition.

Embedded DSP variables such as strings, structures, bitfields, enumerated types, and pointers can be manipulated in exactly the same way. The following operations demonstrate manipulations on structures, strings and enumerated types. In particular, note the method `getmember`, which extracts one field from a structure as a new MATLAB object in your workspace.

- 11** To demonstrate `getmember`, you need an embedded object that accesses a structure in memory. In the following code, you replace your current `cvar` object with one that represents a structure named `myStruct`, an embedded C structure in the symbol table for the tutorial program:

```
cvar = createobj(cc,'myStruct')
STRUCTURE Object stored in memory:
 Symbol name : myStruct
 Address : [17440 0]
 Address units per value : 28 au
 Size : [1]
 Total Address Units : 28 au
 Array ordering : row-major
 Members : 'iy', 'iz'

read(cvar)

ans =

 iy: [2x3 double]
 iz: 'MatlabLink'
```

`myStruct` is a fairly complex structure containing a variety of data types, including enumerated data and strings. Since you use the elements of `myStruct` in the next steps, carefully review it so you see what it contains and how.

- 12** In this step you read, write, and manipulate the elements of `myStruct`. As you enter each command, try to determine what you expect to get back from MATLAB. Notice that we ask you to perform read operations between other operations. `read` lets you see the changes you make in DSP memory when you write variables to CCS, not just in MATLAB:

```
write(cvar,'iz', 'Simulink')
cfield = getmember(cvar,'iz') % Extract iz field from cvar
```

```
ENUM Object stored in memory:
 Symbol name : iz
 Address : [17464 0]
 Wordsize : 32 bits
 Address units per value : 4 au
 Representation : signed
 Size : [1]
 Total address units : 4 au
 Array ordering : row-major
 Endianness : little
 Labels & values : MATLAB=0, Simulink=1, SignalToolbox=2,
 MatlabLink=3, EmbeddedTargetC6x=4

write(cfield,4) % Write to same cvar enumerated variable by value
read(cvar)
ans =

 iy: [2x3 double]
 iz: 'EmbeddedTargetC6x'

cstring = createobj(cc,'myString') % cstring represents an
 % embedded C structure

STRING Object stored in memory:
 Symbol name : myString
 Address : [17512 0]
 Wordsize : 8 bits
 Address units per value : 1 au
 Representation : signed
 Size : [29]
 Total address units : 29 au
 Array ordering : row-major
 Endianness : little
 Char Conversion Type : ASCII
read(cstring)

ans =

Treat me like an ANSI String

write(cstring,7,'ME')
```



```

read(cstring)
ans =

Treat ME like an ANSI String

write(cstring,1,127) % Set first location to numeric value 127
 % (nonprinting ASCII character)
readnumeric(cstring) % Read cstring as equivalent numeric values
ans =

Columns 1 through 13

 127 114 101 97 116 32 77 69 32 108 105 107 101

Columns 14 through 26

 32 97 110 32 65 78 83 73 32 83 116 114 105

Columns 27 through 29

 110 103 0

```

## Construct a function Object

In step 12 you performed a number of operations on `myStruct` in your workspace, and between MATLAB and CCS.

Manipulating embedded data is useful, but eventually you must contend with embedded functions, not just variables. To facilitate your debugging and verification work, the [Link for Code Composer Studio](#) provides objects for accessing embedded functions directly from MATLAB. This permits you to execute any C-callable function on your target from MATLAB for hardware-in-the-loop functionality.

The first step in running embedded functions from MATLAB is to make function objects by applying the (now familiar) `createobj` on `cc`. Just like variables, use `list` to retrieve information about functions that you access.

The following steps create an object `listI` that you use to access the embedded function `sin_taylor`.

- 1 Get information about an embedded function, then create an object to access the function. Your target function is `sin_taylor`:

```
listI =

 sin_taylor: [1x1 struct]

listI.sin_taylor

ans =

 name: 'sin_taylor'
 filename: 'hiltut.c'
 uclass: 'function'
islibfunc: 0
 address: [1x1 struct]
 linepos: [86 116]
 funcvar: {'a1' 'a2' 'a3' 'acc' 'x' 'xpow'}

cfunc = cc.createobj('sin_taylor') % Create function object

FUNCTION Object
Function name : sin_taylor
File found : hiltut.c
Start address : [12328 0]
All variables : a1, a2, a3, acc, x, xpow
Input variables : x
Return type : short
```

At this point, you are ready to run function object listI.

Embedded function `sin_taylor` computes a fixed-point sine function using four terms of the Taylor series representation. Let's use your new object `cfunc` to verify the embedded function. From the information returned by `list`, you know that the input fixed-point data format is Q2.13 and the output is Q1.14.

**2** To run `sin_taylor`, you provide a number between  $-\pi$  and  $\pi$  to use for the sine calculation. Enter a value as shown in this code:

```
userval = pi/2; % Use any value between -pi and pi
```

- 3** Now run `sin_taylor` using `userval` and the `cfunc` object:

```
sintf = run(cfunc, 'x', userval*2^13)/2^14
```

The numeric values in the command provide scaling for the binary point in `userval` to prevent the output (`sintf`) from saturating in Q1.14 format.

The returned values from the MATLAB `sin` function and `sin_taylor` should match quite closely.

## Use Methods That Work with Function Objects

In some cases you may find it useful to alter function object properties that were initialized to reflect your DSP source code. Several function object properties, like `returntype`, `savedregs`, and `timeout`, can be set using `set`. For applying other complex properties, Link for Code Composer Studio offers the `cast` and `convert` methods.

At times you might like to change the properties of an object while keeping the original object unchanged, and, if the object is a function, apply the new properties to a copy of the function. The method `copy` does just that. In the following steps of the tutorial, you create a copy of `cfunc` and use the copy for program debugging purposes.

- 1** Create the copy of your `cfunc` object, and get the properties for it:

```
cfunc_copy = copy(cfunc)
```

```
FUNCTION Object
```

```
Function name : sin_taylor
File found : hiltut.c
Start address : [12328 0]
All variables : a1, a2, a3, acc, x, xpow
Input variables : x
Return type : short
```

```
getprop(cfunc_copy, 'outputvar') % Get the function return type
```

```
NUMERIC Object stored in register(s):
```

```
Symbol name :
Register : A4
Datatype : Unknown
Wordsize : 16 bits
```

```
Register units per value : 1 ru
Representation : signed
Bit padding (post) : 16
Size : [1]
Total register units : 1 ru
Array ordering : row-major
```

As you review the information returned by `getprop`, notice the difference in the `wordsize` property between `cfunc` and `cfunc_copy`.

- 2 With the copy of `cfunc` in your workspace, convert the output data type to `int8` from `Q1.14`. Recall that `int8` is both a MATLAB data type and a C native data type:

```
convert(cfunc_copy.outputvar, 'int8')
```

Property `outputvar` holds the data type specification for the returned value from `sin_taylor`.

- 3 Entering the following command at the prompt

```
int8_OUT = run(cfunc_copy, 'x', userval*2^13)/2^14
```

executes the copy of the `sin_taylor` function that you modified to have the output data type `int8` instead of the original output data type.

Function calls support different types of DSP variables, such as strings, structures, bitfields, enumerated types, and pointers. In the next examples, you create an object that accesses `sin_taylor_vect`, a vectorized version of `sin_taylor`.

To prepare to run `sin_taylor_vect`, you create input and output buffer objects, each containing 10 memory locations; you supply the start addresses of both buffers to the function object; and you run the function from MATLAB with the `run` method. With vectors needed for its input and output, `sin_taylor_vect` uses buffers to store the data in both directions. As a function that used one input value and returned one output value, `sin_taylor` did not require buffers.

- 4 Enter the following commands to construct objects that access `sin_taylor_vect` and input and output buffers:

```
cfunc_vec = cc.createobj('sin_taylor_vect') % Yet another object
```

```

ibufobj = createobj(cc,'ibuf'); % Create input buffer object
obufobj = createobj(cc,'obuf'); % Create output buffer object

```

- 5** With the buffer objects in place, make the input data vector and write the data to your input buffer:

```

inputdata = [-pi:0.1:pi]; % Input data to write to the DSP target
write(ibufobj,int16(inputdata*2^13)); % Write data to buffer with
 % scaling
write(obufobj,int16(zeros(1,63))); % Set output buffer to zeros
read(ibufobj) % (optional) % Verify data initialization
ans =

```

Columns 1 through 6

```

-25735 -24916 -24097 -23278 -22459 -21639

```

Columns 7 through 12

```

-20820 -20001 -19182 -18363 -17543 -16724

```

Columns 13 through 18

```

-15905 -15086 -14267 -13447 -12628 -11809

```

Columns 19 through 24

```

-10990 -10171 -9351 -8532 -7713 -6894

```

Columns 25 through 30

```

-6075 -5255 -4436 -3617 -2798 -1979

```

Columns 31 through 36

```

-1159 -340 478 1297 2116 2936

```

Columns 37 through 42

```

3755 4574 5393 6212 7032 7851

```

Columns 43 through 48

|      |      |       |       |       |       |
|------|------|-------|-------|-------|-------|
| 8670 | 9489 | 10308 | 11128 | 11947 | 12766 |
|------|------|-------|-------|-------|-------|

Columns 49 through 54

|       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|
| 13585 | 14404 | 15224 | 16043 | 16862 | 17681 |
|-------|-------|-------|-------|-------|-------|

Columns 55 through 60

|       |       |       |       |       |       |
|-------|-------|-------|-------|-------|-------|
| 18500 | 19320 | 20139 | 20958 | 21777 | 22596 |
|-------|-------|-------|-------|-------|-------|

Columns 61 through 63

|       |       |       |
|-------|-------|-------|
| 23416 | 24235 | 25054 |
|-------|-------|-------|

read(obufobj) % (optional) Should be zeros

ans =

Columns 1 through 13

|   |   |   |   |   |   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|

Columns 14 through 26

|   |   |   |   |   |   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|

Columns 27 through 39

|   |   |   |   |   |   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|

Columns 40 through 52

|   |   |   |   |   |   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|

Columns 53 through 63

|   |   |   |   |   |   |   |   |   |   |   |   |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
|---|---|---|---|---|---|---|---|---|---|---|---|

- 6** You've done all the preparation—now run `sin_taylor_vect`. Remember that the object you named `cfunc_vec` accesses `sin_taylor_vect`:

```
outputAddress = run(cfunc_vec, 'x', ibufobj.address(1), 'y', ...
obufobj.address(1), 'npts', 63);
```

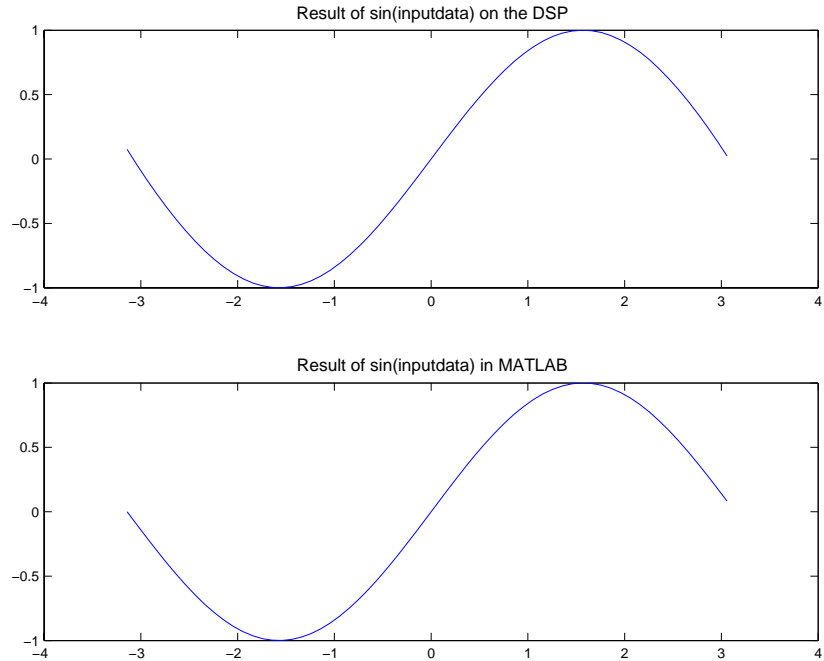
Notice how the input and output parameters correspond to the prototype of the function. Also notice how input parameters are supplied in pairs—parameter name/parameter value.

- 7** You need to use a new method, `deref`, to read the output data buffer. The value in object property `outputvar` is a pointer. To get to the actual data, you dereference the pointer (just as you do in C, since you are working in C). The next code does the dereferencing for you:

```
outputdataAddress = deref(cfunc_vec.outputvar);
outputdataAddress.size = 63; % Need to read the next 63
 % addresses (obufobj)
outputdata = read(outputdataAddress)/2^14; % Get output scaling
 %for binary point
```

- 8** If you are interested in seeing what you have done, the following code plots the results from running `sin_taylor_vect` on your input data set. Comparing the output from the MATLAB `sin` function and `sin_taylor_vect` gives you an idea of how your algorithm performs on your DSP target:

```
subplot(2,1,1)
plot(inputdata,outputdata)
title('Result of sin(inputdata) on the DSP')
a = gca;
set(get(a, 'title'), 'fontsize', 10);
set(a, 'fontsize', 8);
set(a, 'fontweight', 'light') ;
subplot(2,1,2)
plot(inputdata,sin(inputdata))
title('Result of sin(inputdata) in MATLAB')
b = gca;
set(get(b, 'title'), 'fontsize', 10);
set(b, 'fontsize', 8);
set(b, 'fontweight', 'light')
```



Among other things, this example plotting technique might be handy for other plotting tasks.

### **Construct Different Objects and Work with Them**

In the previous tutorial section, you created an object that accessed a C function and ran the function in your project from MATLAB. The Link for Code Composer Studio also supports calling library functions—those functions in your project that are precompiled and callable directly from your C program—in your project from MATLAB. Library functions do not build when you build your project in CCS or from MATLAB and therefore do not have the function prototype available that compiled functions provide and that MATLAB needs to get the information about the function.



The difference between using function objects with library functions and regular C functions is you must use the method `declare` with library functions to provide the function declaration for the object to MATLAB. Because CCS cannot provide full information about library functions, MATLAB gets its library function information from your `declare` operation. The `declare` method accepts C declaration strings for any functions.

In this part of the tutorial, you create an object to access the `fir_filter` filter library function, using `declare` to supply the function declaration to MATLAB. Then you use the object to run the function in CCS and on your target. To introduce the concepts needed to work with typedefs you might have defined in your projects, you use `add` in this process to define some typedefs in MATLAB to include in your `cc` object. Your additional typedefs remain available as long as the `cc` object exists for this project.

- 1 Start this section by creating and plotting the frequency response for a lowpass FIR filter in MATLAB. Use `fir1` from the Signal Processing Toolbox to create the FIR filter. Later in this section you compare the results of filtering with this filter to the results of filtering with an FIR filter function (`fir_filter`) on your target—they should match closely, within the differences caused by the filter coefficients being stored on the target with lower precision:

```
n = 10;
wb1 = 0.3;
bcoeff = fir1(n,wb1);
[sco sw]=freqz(bcoeff,1);
scodb = 20*log10(abs(sco));
swdb = sw./pi;
h = figure;
plot(swdb,scodb);
hold on; grid on; % Save the figure to add another later.
nfrm = 128;
```

```
cscaling = 2^15;
ncoeff = length(bcoeff);
```

To plot the filter magnitude response, you could have used the Filter Visualization Tool (FVTool), as shown here:

```
fvtool(bcoeff,1);
```

Using FVTool gives you access to a full range of analyses for your lowpass filter. Plotting the magnitude response in the more conventional way allows you to compare the results of running the same FIR filter on your target that you do later in this tutorial.

- 2 Now create handles to three filter parameters in CCS—`coeff` (filter coefficients), `nbuf` (input buffer), and `ncoeff` (number of filter coefficients; equal to [filter order + 1]):

```
coeff = createobj(cc, 'coeff');
nbuf = createobj(cc, 'nbuf');
ncoeff = createobj(cc, 'ncoeff');
```

- 3 You need input and output objects so create them:

```
din = createobj(cc, 'din');
dout = createobj(cc, 'dout');
```

- 4 To run the filter function, you create and scale input data for the function to process. The following code creates an input data set with scaling:

```
datain = randn(nfrm,1);
glim = max([abs(max(datain)) abs(min(datain))]);
dscale = 2^15/(glim*0.99);
idin =int16(dscale*datain);
```

- 5 Provide data to your target to initialize the filtering function (`fir_filter`) by writing the required input data and filter specifications to the target:

```
write(coeff,int16(cscaling.*bcoeff));
write(din,idin);
write(ncoeff,n);
write(nbuf,nfrm);
```

After you've initialized your input data and written the data to the target, you are ready to run the library function `fir_filter` in the tutorial project.

- 6** First create an object to access `fir_filter`:

```
ff = createobj(cc, 'fir_filter'); % Expect a warning message
```

Recall from earlier comments in this tutorial that library functions behave slightly differently from compiled C code functions. When you try to create a function object to access a library function, you get a warning message telling you to use `declare` to supply the function declaration. For library functions you supply the function declaration to MATLAB using the `declare` method. In spite of the warning message, MATLAB creates `ff` with default property values.

- 7** Use `declare` to provide the function declaration for `fir_filter` to MATLAB:

```
declare(ff, 'decl', 'short fir_filter (short *x, short *h, ...
short *r, short **dbuffer, unsigned short nh, unsigned short nx)');
```

Rather than using `declare` to define the input and output arguments, you could use the `createinput` and `createoutput` methods with `ff` to define the arguments in the function prototype.

- 8** Add a custom type definition (C typedef) `INT16` to the type definitions in `cc`. Use `list` to see the available type definitions:

```
add(cc.type, 'INT16', 'int16');
list(cc.type) % Display existing defined types. Includes INT16.
Defined types : Void, Float, Double, Long, Int, Short, Char, INT16
```

- 9** Running the function requires one more object—a pointer to a buffer. Use `createobj` to create the object that accesses `dbptr` in the symbol table for your project:

```
dbptr = createobj(cc, 'dbptr');
```

- 10** Now run `fir_filter` from MATLAB. Position the program counter to the beginning of the function, set the input argument values `x`, `r`, `h`, `nh`, `n`, `nr`, and `nfrm`, and run `ff`:

```
goto(ff, 'x', din.address(1), 'h', coeff.address(1), ...
'r', dout.address(1), 'nh', n, 'nr', nfrm);
execute(ff); %
```

You took advantage of the ability to use `goto` to both position the PC and set values for the `fir_filter` function input arguments. This feature can be convenient for developing and testing algorithms with HIL work.

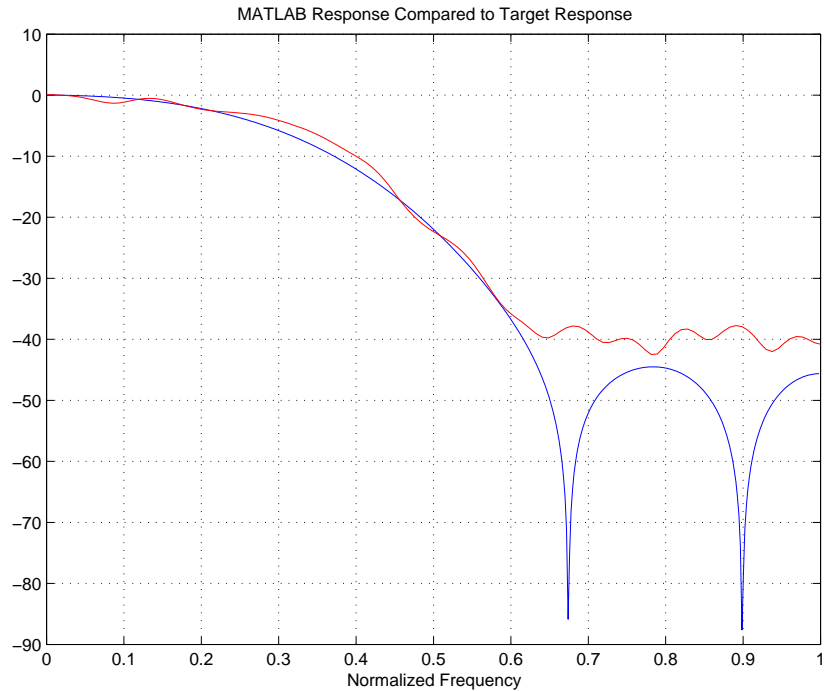
- 11** After the filtering process finishes, use `read` to get the results back from CCS to MATLAB:

```
idout = read(dout);
```

- 12** Plot `idout` to see the magnitude response of the FIR filter on your target:

```
[sout wsd]= pwelch(double(idout));
sin = pwelch(double(idin));
runningsum = (sout./sin);
wplotdb = 10*log10(runningsum/1);
wsdn = wsd/pi;
plot(wsdn,wplotdb, 'r');
title('Target Generated Filter Response');
```

Compare this response to the magnitude response from FVTool you created earlier. Your target stores the filter coefficients slightly differently from MATLAB, so the results are not identical—the filters are not quite the same.



## Close The Tutorial and Clean Up

Finally, the objects created during this tutorial have COM handles to CCS. Until you delete these handles, the CCS process remains in memory. Closing MATLAB removes these handles, but in some cases you may find it useful to delete them without closing MATLAB. Use `clear` to remove objects from your MATLAB workspace and delete the handles that objects contain. `clear all` deletes everything in your workspace. To retain your MATLAB workspace contents while removing specific objects, use `clear` on the objects to remove, such as those derived from your `ccsdsp` object, including all embedded objects returned by `createobj`.

In addition the tutorial performs a close operation to remove the tutorial project from CCS.

- 1 First close your project file from MATLAB by entering

```
close(cc, 'projfile', 'project') % Clean-up CCS by closing the...
 %project file
```

- 2 To remove the objects you created during the tutorial, enter

```
clear cc cvar cfield uicvar cstring ibufobj obufobj cfunc
cfunc_vec cfunc_copy
```

at the command line.

If you do not care about keeping other variables and objects that were in your MATLAB workspace when you started this tutorial, use `clear all` to remove everything from your workspace—objects, variables, and more—in one operation.

## Managing Custom Data Types with the Data Type Manager

Using custom data types, called typedefs (using the C keyword typedef), is one of the complications you encounter when you use hardware-in-the-loop (HIL) to run a function in your project from MATLAB. Since MATLAB does not recognize custom type definitions you use in your projects, it cannot interpret data that you define in your project code with the typedef keyword, or use as arguments in your function prototype (declaration).

To allow you to use functions that include custom type definitions in HIL, Link for Code Composer Studio offers the Data Type Manager (DTM), a tool for defining custom type definitions to MATLAB. Using options in the DTM, you define one or more custom data types for a project and use them in the project. Or you define your custom data types and save them to use in many projects. This second feature is particularly useful when you use the same custom data types in many projects. Rather than redefining your custom types for each new project or function, you reload the types from an earlier project to use them again.

As programmers, usually you use typedefs for one or more of a few reasons:

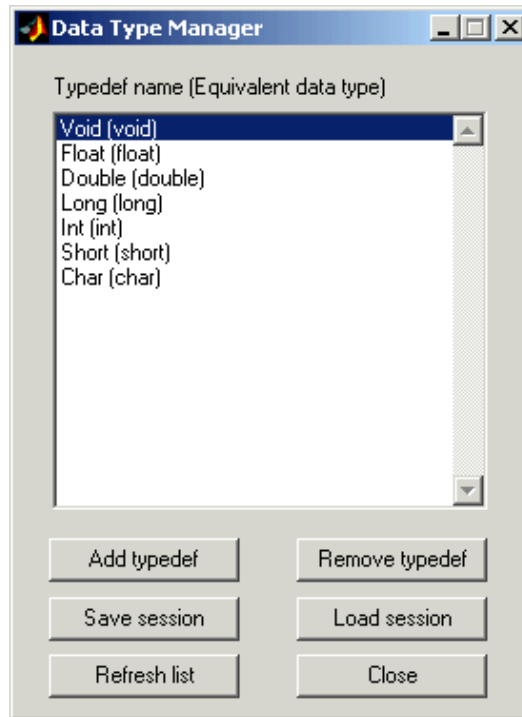
- Make your code more accessible by providing more information about the variable(s)
- Create a Boolean data type that C does not provide
- Define structures in your programs
- Define nonstandard data types

The DTM lets you define all of these things in the MATLAB context so your C function that uses typedefs works with your MATLAB command line functions. For reference information about the DTM, go to `datatypemanager`.

Entering

```
datatypemanager(cc)
```

at the MATLAB command line opens the DTM, with the **Data Type Manager** dialog shown here:



When the DTM opens, a variety of information and options displays in the **Data Type Manager** dialog:

- **Typedef name (Equivalent data type)**—provides a list of default data types. When you create a typedef, you see it added to this list.  
The lowercase versions of the data types appear because MATLAB does not recognize the initial capital versions automatically. In the data type list the project data type with the initial capital letter is mapped to the lowercase MATLAB data type.
- **Add typedef**—opens the **Add Typedef** dialog so you can add one or more typedefs to your object. Your added typedef appears on the **Typedef name (Equivalent data type)** list and is added to your ccdsp object. Also, when you pass the cc object to the DTM, then add a typedef, the command  
`cc.type`



returns the list of data types in the type property of your cc object, including the typedefs you added.

- **Remove typedef**—removes a selected typedef from the **Typedef name (Equivalent data type)** list.
- **Load session**—loads a previously saved session so you can use the typedefs you defined earlier without reentering them.
- **Refresh list**—updates the list in **Typedefs name (Equivalent data type)**. Refreshing the list ensures the contents are current. If you changed your project data type content or loaded a new project, this updates the type definitions in the DTM.
- **Close**—closes the DTM and prompts you to save the session information. This is the only way to save your work in this dialog. Saving the session creates an M-file you can reload into the DTM later.

## Adding Custom Type Definitions to MATLAB

Every custom type definition in your project must appear on the **Typedef name (Equivalent data type)** list for MATLAB to understand the data types involved. To add entries the list, use the **Add typedef** option to identify your type definition with a data type that MATLAB recognizes. When you click **Add typedef**, the **List of Known Data Types** dialog opens, displaying the data types currently recognized by MATLAB. To make finding a specific type easier, the known data types are grouped into categories:

- MATLAB types
- TI C types
- TI fixed point types
- Struct, union, enum types
- Other (e.g. pointers, typedefs)

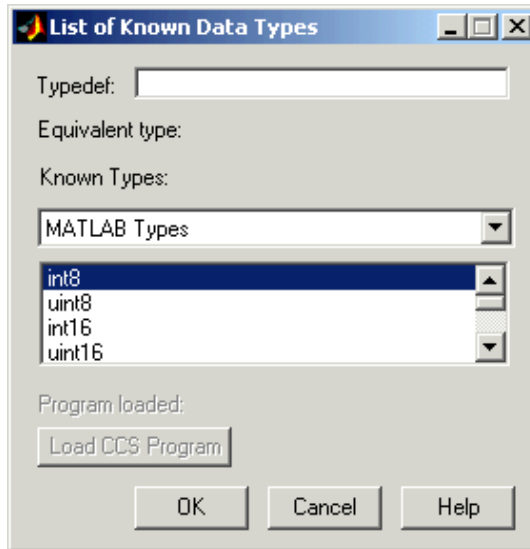
Each custom type definition added in the DTM becomes part of the `ccdsp` object passed to the DTM in `datatypemanager(objectname)`. The list of data types in the object, both default and custom, is available by entering

```
objectname.type
```

at the command prompt.

The same list appears in the DTM on the **Typedef name (Equivalent data type)**

MATLAB uses the type definitions when you run a function residing on your target from MATLAB.



### To Add a Typedef to MATLAB

You use the DTM to add typedefs for MATLAB to recognize, such as:

- Typedefs that use a MATLAB data type in the type definition
- Typedefs that use an enumerated or union data type in the type definition
- Typedefs that use a structure in the type definition
- Typedefs that use pointers or typedefs in the type definition

To define custom data types that use structs, enums, or unions from a project, the project must be loaded on the target before you add the custom type definitions. Either load the project and .out file before you start the DTM, or use the **Load Program** option in the DTM to load the .out file.

---

**Note** When the load process works, you see the name of the file you loaded in **Loaded program**. Otherwise you get an error message that the load failed.

Only programs that you load from this dialog appear in **Program loaded**. Programs that are already loaded on your target do not appear in the **Loaded program** option. MATLAB cannot determine what program you have loaded.

---

You need to know the custom definitions you used so you can add them in the DTM. Use the options for `list` to verify whether you loaded a `.out` file on the target.

Follow the example procedure to add type definitions to your project. To go directly to a specific typedef example, click one of these links:

- “Add a MATLAB type definition” on page 2-111
- “Add an enumerated type definition” on page 2-112
- “Add a structure typedef” on page 2-113

#### **Create an object and load a program.**

**1** Create a `ccsdsp` object.

```
cc=ccsdsp;
```

**2** Load a program on your target. For example, the MATLAB command

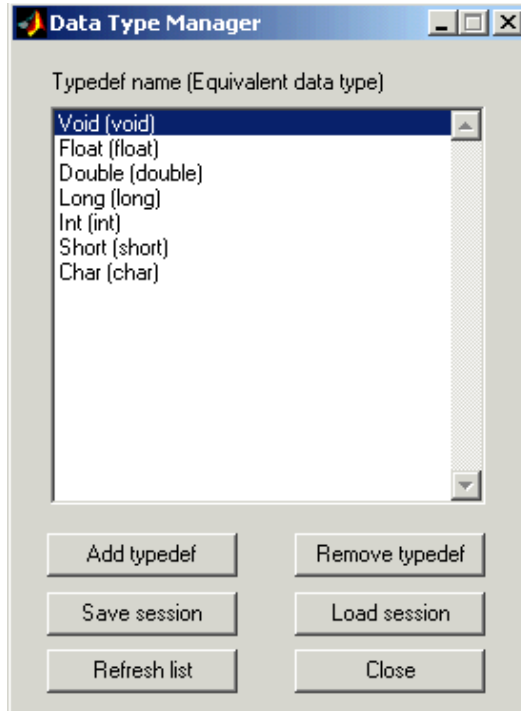
```
load(cc, 'c6701evmwdnoisf_c6000_rtwD\c6701evmwdnoisf.out');
```

loads the executable file from the model `C6701evmwdnois.mdl` on the target.

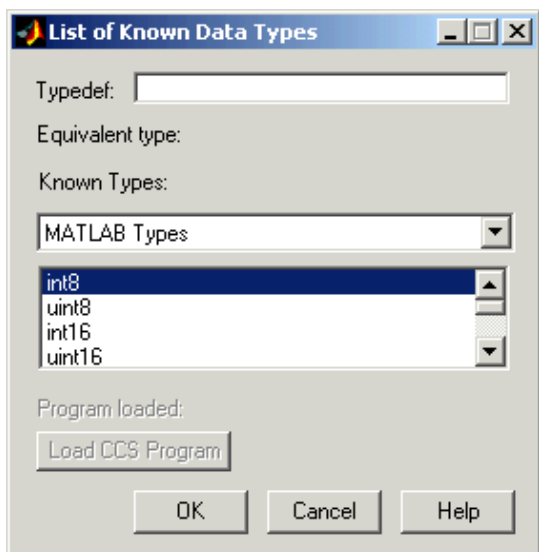
**3** Start the DTM with the object you created.

```
datatypemanager(cc);
```

The DTM starts, showing the default data types.

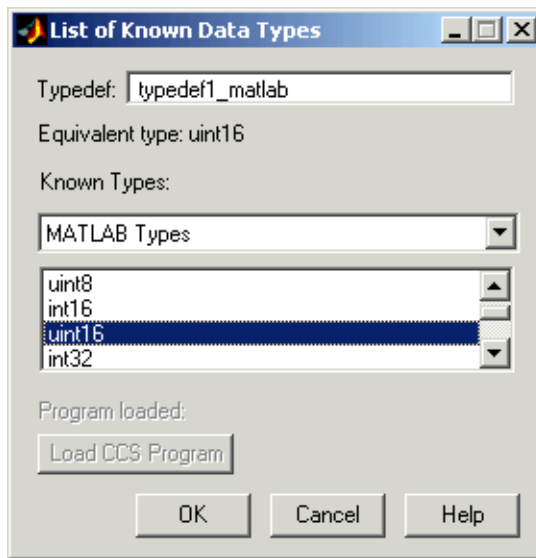


- 4 Click **Add typedef** to add your first custom data type. The **List of Known Data Types** dialog appears as shown.



**Add a MATLAB type definition.**

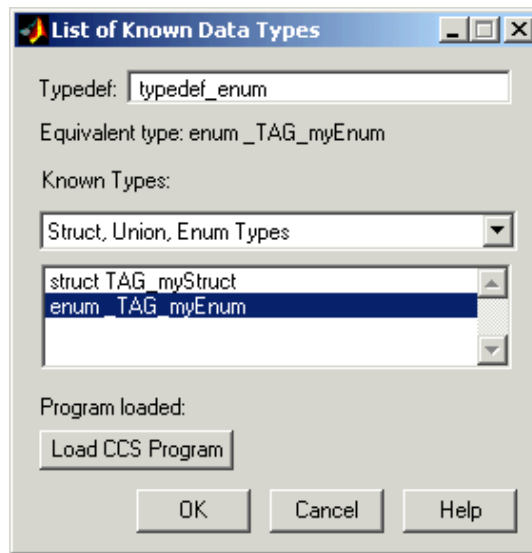
- 5** In **Typedef**, enter the name of the typedef as you defined it in your code. For this example, use typedef1\_matlab.
- 6** Select an appropriate MATLAB data type from the MATLAB Types in **Known Types**. uint16 is the choice. Choose the data type that best represents the data type in your code.



- 7 Click **OK** to close the dialog and add the new type definition to the **Typedef name** list.

**Add an enumerated type definition.**

- 8 Click **Add Typedef**.
- 9 From the **Known Types** list, select Struct, Enum, Union Types.
- 10 To define your type definition, give it a name in **Typedef**, such as typedef\_enum
- 11 From the Struct, Enum, Union Types list, select the appropriate enumerated data type to use with typedef\_enum. The enum\_TAG\_myEnum choice fills the enumerated type chosen.



**12** Click **OK** to close the dialog and add `typedef_enum` to your defined types that MATLAB recognizes.

**Add a structure typedef.**

**13** Click **Add Typedef**.

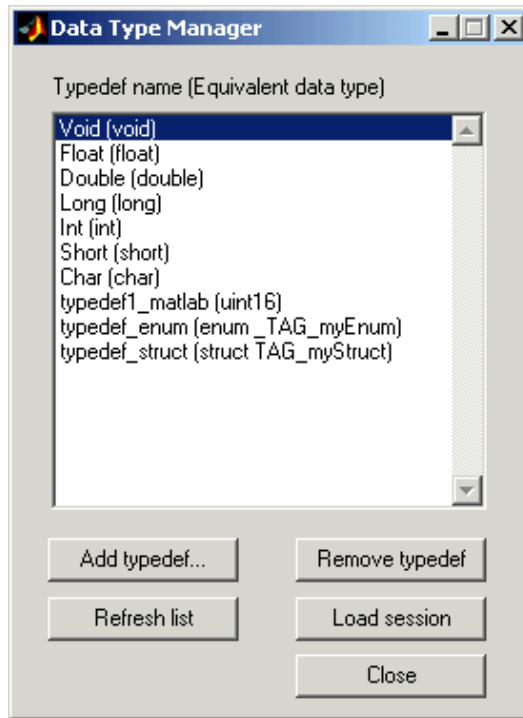
**14** From the **Known Types** list, select Struct, Enum, Union Types.

**15** To define your type definition, give it a name in **Typedef**, such as `typedef_struct`.

**16** From the Struct, Enum, Union Types list, select the appropriate enumerated data type to use with `typedef_struct`. This example uses `struct_TAG_myStruct`.

**17** Click **OK** to close the dialog and add the new data type to the list.

After you close the dialog, the **Typedef name** list in the **Data Type Manager** looks like this.



To check the data types in the cc object, enter

```
cc.type
```

which returns

```
Defined types : Void, Float, Double, Long, Int, Short, Char,
typedef1_matlab, typedef_enum, typedef_struct
```

If your function declaration uses any of the types listed by `cc.type`, MATLAB can interpret the data correctly. For example, MATLAB interprets the `typedef1_matlab` data type as `uint16`.

Clicking **Close** in the DTM prompts you to save your session. Saving the session creates an M-file that contains operations that create your final list of data types, identical to the data types in the **Typedef name** list.



The first line of the M-file is a function definition, where the name of the function is the filename of the session you saved. In the stored M-file, you find a function that includes add and remove operations that replicate the add and remove typedef operations you used to create the list of known data types in the DTM. For each time you added a typedef in the DTM, the M-file contains an add command that adds the new type definition to the type property of the cc object. When you removed a data type, you created an equivalent clear command that removes the specified data type from the type property of the cc object.

An interesting note—all of the operations you performed adding and removing data types in the DTM during the session are stored in the generated M-file that you save. This has the effect of storing any mistakes you made while creating or removing type definitions. One consequence of storing mistakes is when you load your saved session into the DTM, you see the same error messages you saw, if any, when you created the data types in the session. You might find this disconcerting.

# Reference for the Properties of Embedded Objects

This section presents details of the properties that apply to the embedded objects in Link for Code Composer Studio. The reference information contained can help you learn about using the links and objects.

## Property Reference Format and Contents

Ordered alphabetically by property name, references include

- Property name heading
- Description
- Property characteristics, including
  - Data type
  - Default value
  - Read/Write status
- Range of valid property values
- One or more examples using the property
- Referrals to related properties where appropriate

Some reference pages do not include all the features listed; in particular some pages may not provide examples or the range of valid property values or referrals.

## address

### Description

Reports the starting address of the symbol the object references—either a memory address or a register name. In some cases the address is in [Offset Page] format when the processor supports memory pages and the address is a location in memory.

### Characteristics

Either a numeric value (for memory locations) or alphanumeric value (for register locations), this is a writable value.

If you change the offset and page values for the property, the object points to a different location in memory. Changing the address property does not affect the location of the symbol.

### Range

Covers the entire range of addresses available on the target.

## apiversion

### Description

Contains a string that defines the version of the CCS application program interface (API) being used by the link object.

### Characteristics

A string value. The first entry in the square brackets is the major version number and the second entry is the minor revision number. You cannot set this value—it is read only.

### Range

Any ASCII characters that make up the name and version number of the API.

### Examples

Create a link object and use `get` to review the object properties. For this object, the `API version` returns 1.2 and `apiversion` is [1 2]. The API version may not be the same as the version of CCS:

```
cc=ccsdsp
```

```
CCSDSP Object:
```

```
API version : 1.2
Processor type : TMS320C6711
Processor name : CPU_1
Running? : No
Board number : 0
Processor number : 0
Default timeout : 10.00 secs
```

```
RTDX channels : 0
```

```
get(cc)
 rtdx: [1x1 rtdx]
 apiversion: [1 2]
 ccsappexe: 'D:\Applications\ti\cc\bin\'
 boardnum: 0
 procnum: 0
 timeout: 10
 page: 0
```

## arrayorder

### Description

Specifies the manner in which the object interprets data stored linearly in memory, whether as rows or columns of an array.

### Characteristics

A string with one of two possible values—`row-major` (C style interpretation) or `col-major` (normal MATLAB ordering).

### Range

Allowed strings are `row-major` and `column-major`.

### Examples

When you have nine values in memory, such as 1, 2,..., 9, the `arrayorder` property value determines how to build an array from the values:

- In `row-major` order, the values form the 3-by-3 array by filling the array row by row and left to right:  

```
1 2 3
4 5 6
7 8 9
```
- In `column-major` order, the values form the 3-by-3 array by filling the array column by column and top to bottom:

```
1 4 7
2 5 8
3 6 9
```

You can increase the number of array dimensions without limit.

## **binarypt**

### **Description**

Specifies the location of the binary point in a value. To interpret the actual value of a value in memory, you need both the data type and binary point to convert correctly from the binary or hexadecimal representation to decimal. A fixed-point data type is characterized by the word size in bits, the binary point, and whether it is signed or unsigned. The position of the binary point is the means by which fixed-point values are scaled and interpreted. Since the object uses double-precision representation, the word size and binary point form the basis for simulating fixed-point values.

### **Characteristics**

A positive or negative integer.

### **Range**

`binarypt` ranges from 0 to the word size. You can use negative binary point locations and binary point locations larger than the word size, to the limit of double-precision representation.

### **Referrals**

See also `wordsize`.

## **bitsperstorageunit**

### **Description**

Reports the smallest number of bits per address location (addressable unit) on the target. Memory locations and registers may have different values on a target. Different processors can use different values as well.

### **Characteristics**

An integer.

### **Range**

Depends on the target processor. Usually 8, 16, or 32 bits.

### **Referrals**

See also `numberofstorageunits` and `storageunitspvalue`.

## **boardnum**

### **Description**

Specifies the target board or simulator with which the link object communicates.

### **Characteristics**

An integer. This is a read-only value determined when you create link objects and select your target.

### **Range**

Integer values ranging from 0 for the first board up to the number of boards that CCS recognizes configured on your machine. Note that both simulators and hardware count as boards.

## **ccsappexe**

### **Description**

Reports the full directory path to the CCS executable.

### **Characteristics**

A string that shows the path to your CCS installation. You cannot change this string except by moving your CCS storage location.

## Examples

If your CCS installation is in a folder called Applications on your D: drive, you might see a string such as

```
'D:\Applications\ti\cc\bin\'
```

for the `ccsappexe` property value when you use the command

```
cc.ccsappexe
```

at the MATLAB prompt.

## charconversion

### Description

Specify the character set that `read` and `write` use to interpret data in memory or when transferring data to target memory. When you set the `charconversion` property, you are telling `read` or `write` to interpret the data, either in MATLAB or on the target, as though they represent values in the specified character set.

For `read`, `charconversion` tells MATLAB to return the values from memory as characters from the specified data set. For `write`, `charconversion` tells MATLAB to write the data to target memory as the numeric equivalents of the specified character set. Recall that all data in memory is numeric. `charconversion` defines how the numeric values in memory become characters in MATLAB. And how characters in MATLAB become numeric values on the target.

### Characteristics

This is a string and should be entered as a string in single quotation marks.

### Range

The only valid entry for `charconversion` is `ascii`.

## endianness

### Description

Specifies whether to interpret the bit pattern in memory as little-endian or big-endian format. Big-endian format assumes the least significant bit (LSB) is

last in a word that spans more than one addressable unit in memory; little-endian assumes the LSB is first in a word that spans multiple addressable units.

### Characteristics

Property values are strings, either `little` or `big`. You can change the state within the object, which changes the way MATLAB interprets the bits stored in memory on your target.

### Range

You have two options for endianness—`little` or `big`.

### Examples

When you have a variable in memory, such as `ddat` from the link object tutorial, creating a numeric object to access `ddat` shows you whether `ddat` is big endian or little endian:

```
ddat = createobj(cc, 'ddat')
```

```
NUMERIC Object
Symbol Name : ddat
Address : [40072 0]
Wordsize : 64 bits
Address Units per value : 8 AU
Representation : float
Binary point position : 0
Size : [4]
Total address units : 32 AU
Array ordering : row-major
Endianness : little
```

```
get(ddat)
 address: [40072 0]
 bitsperstorageunit: 8
 numberofstorageunits: 32
 link: [1x1 ccdsp]
 timeout: 10
 name: 'ddat'
 wordsize: 64
```



```
storageunitspervalue: 8
 size: 4
 endianness: 'little'
 arrayorder: 'row-major'
 prepad: 0
 postpad: 0
 represent: 'float'
 binarypt: 0
```

## filename

### Description

Specifies the name of the file in the project that contains the function declaration. When you create an object that accesses a function, MATLAB returns the name of the file in `filename`. When the target function is a library function, `filename` is empty.

### Characteristics

A string that contains the full path name to a file.

### Range

Any valid filename and directory path.

## inputnames

### Description

Defines and contains the names of input arguments to a function in your project. For library functions, `inputnames` is empty until you use `declare` or `getinputs` to define the input arguments for the function.

### Characteristics

A character string in the form of an `mxArray`.

### Range

Any valid C variable name string.

### inputvars

#### Description

The objects that represent each input argument to a function when you create a function object to access a specific function. When you create a new function object, MATLAB creates appropriate objects to access each input argument to the function.

#### Characteristics

An object that represents the input argument type, such as numeric or pointer. These are handles to objects.

#### Range

Any valid object in Link for Code Composer Studio.

### label

#### Description

Contains the names of the fields in an enumerated object or memory location.

#### Characteristics

ASCII characters of any type. Contains as many strings as there are enumerated entries, entered as a cell array of strings.

#### Examples

Using the `cfield` object created in the link tutorial (run `ccstutorial` at the MATLAB prompt), you see the following when you display the object:

```
cfield

ENUM Object
 Symbol Name : iz
 Address : [40056 0]
 Wordsize : 32 bits
 Address Units per value : 4 AU
 Representation : signed
 Binary point position : 0
 Size : [1]
```

```

Total address units : 4 AU
Array ordering : row-major
Endianness : little
Labels & values : MATLAB=0, Simulink=1, SignalToolbox=2,
 MATLABLink=3, EmbeddedTargetC6x=4

```

The labels are MATLAB, Simulink, SignalToolbox, MATLABLink, and EmbeddedTargetC6x. In this case, label is {1x5 cell}.

## Referrals

See also property value.

## link

### Description

Specifies the link object you used when you created the embedded object.

### Characteristics

A 1-by-1 array containing the name of the link object associated with the symbol table that holds the symbol.

### Examples

In the tutorial, you created a numeric object named `uicvar`, using `cast` with the numeric object `cvar`. To create `cvar`, you used link object `cc` to determine the symbol table and project or target. When you view the properties of `uicvar`, you see the property `link` listing the link object as `ccsdsp`:

```

get(uicvar)
 address: [40060 0]
 bitsperstorageunit: 8
 numberofstorageunits: 4
 link: [1x1 ccsdsp]
 timeout: 10
 name: 'idat'
 wordsize: 16
 storageunitspervalue: 2
 size: 2
 endianness: 'little'
 arrayorder: 'row-major'

```

```
 prepad: 0
 postpad: 0
 represent: 'unsigned'
 binarypt: 0
```

Delving more deeply into the property link reveals the properties of the link object:

```
 uicvar.link

 CCSDSP Object:
 API version : 1.2
 Processor type : TMS320C6711
 Processor name : CPU_1
 Running? : No
 Board number : 0
 Processor number : 0
 Default timeout : 10.00 secs

 RTDX channels : 0
```

### Referrals

See also `createobj`

## Member

### Description

This identifies a MATLAB structure that holds the entry for each C member in the structure accessed by the object.

### Characteristics

A MATLAB array containing

- Array type
- Array dimensions
- Data associated with this array
- If numeric, whether the variable is real or complex
- If a structure or object, the number of fields and field names

## Examples

If you have a structure in DSP memory declared like the following structure

```

struct TAG_myStruct {
 int iy[2][3];
 myEnum iz;
} myStruct = { {{1,2,3}},{4,-5,6}}, MatlabLink};

```

the member property of an object the access myStruct, might look like

```

get(cvar)
 name: 'myStruct'
 member: [1x1 ccs.containerobj]
 membname: {'iy' 'iz'}
 memboffset: [0 24]
 address: [40032 0]
 storageunitspervalue: 28
 size: 1
 numberofstorageunits: 28
 arrayorder: 'row-major'

```

where member is a 1-by-1 MATLAB array with a handle to the object that contains it named ccs.containerobj.

## Membrane

### Description

Contains the names of the fields in a structure or union accessed by a structure object.

### Characteristics

membname is one or more strings providing the names of the structure fields, formatted as a cell array.

### Range

Strings in membname contain any valid ASCII characters that might be found in a C structure field.

### Examples

In CCS, if you had the following structure in your project code

```
struct tag {
 int _a;
 int B;
 int b;
} var;
```

you could create a structure object, `var`, that accesses the structure. Using `get` with `var` lets you review the names of the fields in the structure by looking at the `memname` property for `var`:

```
var = createobj(cc, 'var')
get(var, 'memname')
'a' 'B' 'b'
```

### memboffset

#### Description

While this is not directly useful to you, the values in the vector specify how far, in memory in addressable units, each field in a structure is from the starting address for the structure.

#### Characteristics

Any numeric or alphanumeric value that represents a valid address or register location on the target. The vector contains one element for each field in the structure, representing the offset to that field in memory.

#### Range

A vector containing `M` element, where `M` is the number of fields in the structure. The second element in the vector is the offset to the second field in the structure, the third element in the vector is the offset to the third field, and so on until the final element is the offset to the final field. The first element in the `memoffset` vector is always 0, since this represents the offset to the first element in the structure, which is where the structure begins.

## Examples

When you are working with structure objects, the property `memoffset` tells you how far one structure field is from another in memory:

```
cvar = createobj(cc,'myStruct')

STRUCTURE Object:
Symbol Name : myStruct
Address : [40032 0]
Address Units per value : 28 AU
Size : [1]
Total Address Units : 28 AU
Array ordering : row-major
Members : 'iy', 'iz'

read(cvar)

ans =

 iy: [2x3 double]
 iz: 'MatlabLink'
get(cvar)
 name: 'myStruct'
 member: [1x1 ccs.containerobj]
 memname: {'iy' 'iz'}
 memoffset: [0 24]
 address: [40032 0]
 storageunitspervalue: 28
 size: 1
 numberofstorageunits: 28
 arrayorder: 'row-major'
```

From the property `memoffset`, you see that member `iz` of `myStruct` is 24 addresses from member `iy`, and from the start of the structure.

### **name**

#### **Description**

Provides the name of the symbol or embedded object (mostly they are the same thing) to which the object refers. Contains the name of the function when the embedded object is a function.

#### **Characteristics**

ASCII character string that composes a valid C variable name.

#### **Range**

Any valid C variable name that occurs in your project.

### **numberofstorageunits**

#### **Description**

Reports the number of smallest addressable units necessary to represent the symbol to which the object refers.

#### **Characteristics**

Reported in addressable units. Property `bitsperstorageunit` tells you how many bits are in each addressable unit—the smallest value supported by the processor. Combined with property `numberofstorageunits`, you can determine the storage used by the symbol.

#### **Range**

Any number of addressable units up to the limit of memory on the target.

### **numchannels**

#### **Description**

Reports the number of RTDX communications channels configured for the RTDX link. Includes both read and write channels and does not depend on whether the channels are enabled.



## Examples

As you did if you followed the RTDX tutorial in “Tutorial 1-2—Using Links for RTDX” on page 1-50, create a link object, then open two RTDX channels for the link:

```
cc=ccsdsp('boardnum',boardNum,'procnum',procNum)
```

CCSDSP Object:

```
API version : 1.2
Processor type : TMS320C6711
Processor name : CPU_1
Running? : No
Board number : 0
Processor number : 0
Default timeout : 10.00 secs
```

```
RTDX channels : 0
```

```
cc.rtdx.configure(1024,4);
```

```
cc.rtdx.open('ichan','w');
```

```
cc.rtdx.open('ochan','r');
```

```
cc.rtdx.enable;
```

```
get(cc,'rtdx')
```

RTDX Object:

```
Default timeout : 15.00 secs
Open channels : 2
```

| Ch Name | Mode  |
|---------|-------|
| -- ---- | ----  |
| 1 ichan | write |
| 2 ochan | read  |

Where the listing for the RTDX object shows two open channels, this is the numChannels property value.

### **offset**

#### **Description**

Specifies the starting position of the bitfield relative to bit 0 of the address. For A value of zero indicates that the bitfield begins at bit 0.

#### **Characteristics**

offset is an integer specifying a number of bits. The default value is zero.

### **outputvar**

#### **Description**

An object created by Link for Code Composer Studio that represents the output argument from a function.

#### **Characteristics**

A handle to an object

#### **Range**

A handle to any valid object in Link for Code Composer Studio.

### **page**

#### **Description**

When you get the properties of an object, the address comes back in the format [address page]. In the address field for your object, page specifies which memory page contains the symbol address. For processors that do not use pages in memory, such as the C6701, the page value is always 0.

#### **Characteristics**

An integer that specifies the memory page for an address in memory.

#### **Range**

From 0 to the maximum number of memory pages supported by the processor.

## Examples

Given a symbol in memory named `ddat`, after you create an object to access `ddat`, you can get the properties for the object and see the address format:

```
ddat=createobj(cc,'ddat')

NUMERIC Object
Symbol Name : ddat
Address : [40072 0]
Wordsize : 64 bits
Address Units per value : 8 AU
Representation : float
Binary point position : 0
Size : [4]
Total address units : 32 AU
Array ordering : row-major
Endianness : little
```

Notice that the memory page value is 0—the second value in the address field [40072 0] in the example. Since this example targets a C6701 digital signal processor, the page property value is always zero—the C6701 processor does not support memory pages.

## postpad

### Description

Reports the number of bits of padding required at the end of the memory buffer to fill the buffer. Determining the final numeric value stored in memory ignores the added bits.

### Characteristics

Double-precision value that specifies the number of added bits.

### **prepad**

#### **Description**

Reports the number of bits of padding required at the beginning of the memory buffer to fill the buffer. Determining the final numeric value stored in memory ignores the added bits.

#### **Characteristics**

Double-precision value that specifies the number of added bits.

### **procnum**

#### **Description**

The number assigned by CCS to the processor on the board or simulator. When the board contains more than one processor, CCS assigns a number to each processor, numbering from 0 for the first processor on the first board. For example, when you have two recognized boards, and the second has two processors, the first processor on the first board is `procnum=0`, and the first and second processors on the second board are `procnum=1` and `procnum=2`. This is also a property used when you create a new link to CCS IDE.

#### **Range**

From 0 for one processor to  $N-1$ , where  $N$  is the number of processors that CCS recognizes as installed and configured on your machine.

#### **Description**

Contains the name of the register as used by the target. Note that this is not the same as a CPU register on the target.

#### **Characteristics**

`regname` is a MATLAB array with no initial value nor a default value.

#### **Range**

Any valid register used by your target.

## represent

### Description

Contains a string that specifies the data type for the accessed symbol. Memory locations consist of bits and bytes. The property value for `represent` specifies to MATLAB how to interpret the data stored in memory on the target.

### Characteristics

A string that defines the data type for the variable—one of the following strings applies:

- `float`—IEEE floating point representation, either 32- or 64 bits
- `fract`—fractional fixed-point data
- `signed`—two’s complement signed integers
- `ufract`—unsigned fractional fixed-point data
- `unsigned`—unsigned two’s complement integer data

### Range

While MATLAB recognizes many different data types, C and the TI processors are somewhat different. The tables provided here show the valid data types (from property `datatype`) and the strings that appear for them as the `represent` property value.

| <b>datatype Property String</b> | <b>represent Property Value</b> |
|---------------------------------|---------------------------------|
| 'double'                        | 'float'                         |
| 'single'                        | 'float'                         |
| 'int32'                         | 'signed'                        |
| 'int16'                         | 'signed'                        |
| 'int8'                          | 'signed'                        |
| 'uint32'                        | 'unsigned'                      |
| 'uint16'                        | 'binary'                        |

| <b>datatype Property String</b> | <b>represent Property Value</b> |
|---------------------------------|---------------------------------|
| 'uint8'                         | 'binary'                        |
| 'long double'                   | 'float'                         |
| 'float'                         | 'float'                         |
| 'long'                          | 'signed'                        |
| 'int'                           | 'signed'                        |
| 'char'                          | 'signed'                        |
| 'unsigned long'                 | 'signed'                        |
| 'unsigned int'                  | 'unsigned'                      |
| 'unsigned char'                 | 'binary'                        |
| 'Q0.15'                         | 'fract'                         |
| 'Q0.31'                         | 'fract'                         |

Various TI processors restrict the sizes of the data types used by objects in Link for Code Composer Studio. Shown in the next table, the processor families restrict the valid word sizes for the listed data types.

| <b>represent Property Value</b> | <b>C54 Processor Word Size Limits</b> | <b>C6x Processor Word Size Limits</b> |
|---------------------------------|---------------------------------------|---------------------------------------|
| 'float'                         | 32, 64 bits                           | 32,64 bits                            |
| 'signed'                        | 16, 32 bits                           | 8, 16, 32, 40, 64 bits                |
| 'unsigned'                      | 16, 32 bits                           | 8, 16, 32, 40, 64 bits                |
| 'binary'                        | 16, 32 bits                           | 8, 16, 32, 40,64 bits                 |
| 'fract'                         | 16, 32 bits                           | 8, 16, 32, 40, 64 bits                |

Using the properties of the objects, you change the word size by changing the value of the `storageunitspvalue` property of the object. Note that you

cannot change the `bitsperstorageunit` property value which depends on the processor and whether the object represents a memory location or a register.

## Referrals

See also `cast`, `convert`

## rtdx

### Description

Specifies whether the link object has RTDX channels included in the link. When the link has open RTDX channels, this property contains a structure of cell arrays that detail the information about the channels—the number of channels and the names of the channels.

### Characteristics

Empty or an array of cell arrays containing strings and values.

### Examples

When you create a link, the default state is not to have RTDX channels and the property `rtdx` is empty, as you see here:

```
cc=ccsdsp('boardnum',boardNum,'procnum',procNum)
```

```
CCSDSP Object:
```

```
API version : 1.2
Processor type : TMS320C6711
Processor name : CPU_1
Running? : No
Board number : 0
Processor number : 0
Default timeout : 10.00 secs
```

```
RTDX channels : 0
```

Now, configure and open two RTDX channels to the target:

```
cc.rtdx.configure(1024,4);
```

```
cc.rtdx.open('ichan','w');
```

```
cc.rtdx.open('ochan','r');
```

After creating the channels, displaying the link shows that the rtdx property is no longer empty. It contains the names and number of channels available, and the channel mode, either read or write:

```
get(cc)
 rtdx: [1x1 rtdx]
 apiversion: [1 2]
 ccsappexe: 'D:\Applications\ti\cc\bin\'
 boardnum: 0
 procnum: 0
 timeout: 10
 page: 0
```

```
get(cc,'rtdx')
```

RTDX Object:

```
Default timeout : 15.00 secs
Open channels : 2
```

| Ch Name | Mode  |
|---------|-------|
| -- ---- | ----  |
| 1 ichan | write |
| 2 ochan | read  |

### Referrals

See also `ccdsp`, `enable`, `open`

## rtdxchannel

### Description

Provides the names of open RTDX channels for the link.

### Characteristics

Alphanumeric strings using ASCII characters that define the channel names.



**Range**

From 0 to the number of defined and open channels in your project.

**size****Description**

Defines the number of dimensions for the numeric array that is accessed by the numeric object. The size property provides the same information that function size provides in MATLAB.

**Characteristics**

size is a vector having as many elements as the number of dimensions in the symbol represented by the object. Each element in the vector reports the number of entries in that dimension.

**Range**

size can be a scalar greater than or equal to one, or a vector of integers, each greater than or equal to one.

**Examples**

When you have a variable declaration in your code like

```
int x[3] [2] = {(1,2), (3,4), (5,6)};
```

the size property tells you about x if you create an object that accesses x.

```
x = createobj(cc, 'x');
```

```
get(x, 'size')
```

```
ans =
```

```
[3 2]
```

so x represents a 3-by-2 array having six elements.

### **savedregisters**

#### **Description**

Contains the list of registers whose contents are saved during function processing. The list of registers is different for each processor, and you can change the registers on the `savedregisters` list using `addregister` and `deleteregister`. Note that you cannot delete the default registers for a processor. You can delete only registers that you add.

#### **Characteristics**

An `mxAarray` that contains the names of all registers on the target that are preserved during processing.

#### **Examples**

For the C54x family of signal processors, the default saved registers are AR1, AR6, AR7, and SP. Register SP is not required to be saved by the processor but Link for Code Composer Studio requires that the contents of SP be saved.

### **storageunitspvalue**

#### **Description**

Describes how many storage units (addressable (AU) or register (RU) units) make up the accessed symbol.

#### **Characteristics**

Given in addressable units (AU or RU), `storageunitspvalue` is an integer.

#### **Range**

`storageunitspvalue` is an integer equal to or greater than one, up to the limit of your target processor. This can have a value less than one in the case of packing of the bits in the symbol.

#### **Examples**

From the HIL tutorial (“Tutorial 2-1—Using Function Objects and Hardware-in-the-Loop” on page 2-74, object `cfield` returns the following

properties when you create an object to provide access to the myStruct member iz:

```
cfield = getmember(cvar,'iz') % Extract object from structure
```

```
ENUM Object
```

```
Symbol Name : iz
Address : [40056 0]
Wordsize : 32 bits
Address Units per value : 4 AU
Representation : signed
Binary point position : 0
Size : [1]
Total address units : 4 AU
Array ordering : row-major
Endianness : little
Labels & values : MATLAB=0, Simulink=1, SignalToolbox=2,
 MatlabLink=3, EmbeddedTargetC6x=4
```

```
get(cfield)
```

```
address: [40056 0]
bitsperstorageunit: 8
numberofstorageunits: 4
link: [1x1 ccscdsp]
timeout: 10
name: 'iz'
wordsize: 32
storageunitspervalue: 4
size: 1
endianness: 'little'
arrayorder: 'row-major'
prepad: 0
postpad: 0
represent: 'signed'
binarypt: 0
label: {1x5 cell}
value: [0 1 2 3 4]
```

Requiring 4 addressable units (storage units) with 8 bits per storage unit (property `bitsperstorageunit = 8`) and a size of 1, `cfield` requires 32 bits of storage space in memory.

### **timeout**

#### **Description**

Specifies how long Link for Code Composer Studio waits for an operation to complete, or at least to return a status of complete. In some cases, operations continue after the time-out expires, since the time period depends on the status of the operation, not the actual completion.

#### **Characteristics**

A value in seconds.

#### **Range**

A value greater than zero. 10 s is the default value. The time-out period for build is 1000 s.

#### **Examples**

In this example, the time-out period is 10 seconds for the new object:

```
cc=ccsdsp('boardnum',boardNum,'procnum',procNum)
```

```
CCSDSP Object:
```

```
API version : 1.2
Processor type : TMS320C6711
Processor name : CPU_1
Running? : No
Board number : 0
Processor number : 0
Default timeout : 10.00 secs

RTDX channels : 0
```

## **type**

### **Description**

Specifies the return type for a function in your project.

### **Characteristics**

A string that contains a valid return type, such as a data type or void.

## **typelist**

### **Description**

Lists the type entries in a type object. When you construct a `ccsdsp` object `cc`, it contains a type object `cc.type` with default entries `void`, `float`, `double`, `long`, `int`, `short`, and `char`. After you add your typedefs to the type object, `typelist` contains a listing of the types in the object.

### **Characteristics**

An cell array of alphanumeric strings. The default entries in `typelist` are `void`, `float`, `double`, `long`, `int`, `short`, and `char`.

## **typename**

### **Description**

Lists the type names in a type object. When you construct a `ccsdsp` object `cc`, it contains a default type object `cc.type`. After you add your typedefs to the type object, `typename` contains a list of the names of the types in the object.

### **Characteristics**

An `mxArray` of alphanumeric strings.

### **Examples**

Add a type definition to a `cc` object. You add your typedef to the type object that is part of the `ccsdsp` object:

```
cc=ccsdsp;
add(cc.type, 'mytypedef', 'uint32')
```

```
ans =

 type: 'uint32'
 size: 1
 uclass: 'numeric'

cc.type
```

```
Defined types : Void, Float, Double, Long, Int, Short, Char,
mytypedef
```

## typestring

### Description

Describes the data type of the referent for the pointer object accesses. `typestring` returns the data type for the referent as well as an asterisk to indicate that the symbol is a pointer.

### Examples

For a pointer object that points to a floating-point symbol, the property value for `typestring` is `float *`. For a pointer to an integer, the value is `int *`.

## value

### Description

Reports the values associated with labels in an enumerated object.

### Characteristics

Numbers, one or more, configured as a vector depending on the number of entries.

### Examples

Using the enumerated data type variable `myEnum` from the link tutorial, create an object that accesses the labels and values for the enumerated data variable `iz`:

```
cvar = createobj(cc, 'myStruct')
```

```

STRUCTURE Object:
 Symbol Name : myStruct
 Address : [40032 0]
 Address Units per value : 28 AU
 Size : [1]
 Total Address Units : 28 AU
 Array ordering : row-major
 Members : 'iy', 'iz'

```

```
cfield = getmember(cvar,'iz')
```

```

ENUM Object
 Symbol Name : iz
 Address : [40056 0]
 Wordsize : 32 bits
 Address Units per value : 4 AU
 Representation : signed
 Binary point position : 0
 Size : [1]
 Total address units : 4 AU
 Array ordering : row-major
 Endianness : little
 Labels & values : MATLAB=0, Simulink=1, SignalToolbox=2,
 MatlabLink=3, EmbeddedTargetC6x=4

```

The values for `iz` are 0, 1, 2, 3, and 4. In the value property, the values show up as `[0 1 2 3 4]`, a vector whose elements are the values.

## wordsize

### Description

Specifies the word size for the target processor, and the referenced symbol.

### Characteristics

Depends on the processor architecture. Because this is fixed on the processor, it is read only, set when you create an embedded object.

### **Range**

For most processors, the word size can be from 8 to 64 bits, usually 8, 16, or 32.



# Using FDA Tool with the Link for Code Composer Studio

---

Guidelines on Exporting Filters from FDA Tool to CCS IDE (p. 3-3)

Tutorial—Exporting Filters from FDA Tool to CCS IDE (p. 3-9)

Things to think about when you export filters to Code Composer Studio®

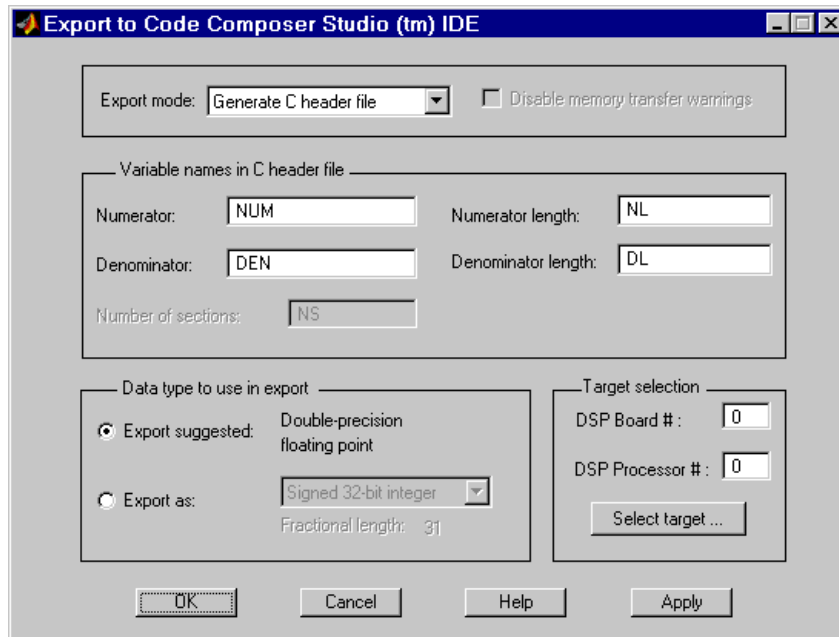
Takes you through the process of exporting a filter from FDA Tool to Code Composer Studio

The Filter Design and Analysis Tool (FDATool) in the Signal Processing Toolbox is a powerful user interface used for designing and analyzing filters. FDATool enables you to quickly design digital FIR or IIR filters by setting filter performance specifications, by importing filters from your MATLAB workspace, or by directly specifying filter coefficients. FDATool also provides tools for analyzing filters, such as magnitude and phase response plots and pole-zero plots.

Once you have designed a filter in FDATool, you can export it to Code Composer Studio® Integrated Development Environment (CCS IDE) to test the filter on an actual target digital signal processor (DSP). Using FDATool with CCS IDE takes filter design to the next level by enabling you to quickly test your filter on a target DSP, tune and optimize the filter in FDATool, and test your redesigned filter on the target.

## Guidelines on Exporting Filters from FDATool to CCS IDE

You can export filters from FDATool to CCS IDE by generating a C header file, or by writing the filter coefficients directly to target memory. To export a filter from FDATool to CCS IDE, use the **Export to Code Composer Studio(r) IDE** dialog (shortened to **Export to CCS IDE** dialog in this section). Open the dialog from the FDATool **Targets** menu.



For guidelines on exporting filters using the **Export to CCS IDE** dialog, see the following sections:

- “Selecting the Export Mode” on page 3-4
- “Cautions Regarding Writing Directly to Memory” on page 3-4
- “Variables and Memory Necessary for Filter Export” on page 3-5
- “Selecting the Export Data Type” on page 3-7

For instructions on using the **Export to CCS IDE** dialog, see “Tutorial—Exporting Filters from FDATool to CCS IDE” on page 3-9.

## Selecting the Export Mode

You can export a filter by generating a C header file, or by writing the filter coefficients directly to target memory. The following table summarizes when and how to use the two export modes.

| Export Mode              | When to Use                                                                                                                                                                                                    | Suggested Use                                                                                                                                                                                                                                                                                                                                                                                                                                               |
|--------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Generate C header file   | You have not yet allocated memory in your target DSP for the filter coefficients to export.<br><br>(For a sample generated header file, see “Contents of the C Header File Generated in Task 1” on page 3-14.) | Create a program file from the generated C header file. Loading this program file into your target allocates static memory locations in the target, and exports your filter coefficients to these memory locations. You may want to edit the header file so that the program file allocates extra target memory, providing you more freedom to change your filter. See “Allocating Sufficient or Extra Memory for Filter Coefficients” in the next section. |
| Write directly to memory | You have already allocated memory in your target DSP for the filter coefficients to export.                                                                                                                    | Tune your filter coefficients in FDATool, and write the updated filter coefficients directly to the allocated target memory. See the next section, “Cautions Regarding Writing Directly to Memory”.                                                                                                                                                                                                                                                         |

## Cautions Regarding Writing Directly to Memory

When you write filter coefficients directly to target memory, you need to allocate sufficient memory for the coefficients, and proceed with caution when you update your filter coefficients in target memory.

### Allocating Sufficient or Extra Memory for Filter Coefficients

When you export filter coefficients directly to target memory, the filter coefficients overwrite as many memory locations as they need. The export process does not check whether you allocated sufficient memory for your filter coefficients. You must allocate enough memory for your filter coefficients or you

may get unexpected results. To ensure you allocate enough target memory for your filter, export the filter by generating a C header file, as described in “Tutorial—Exporting Filters from FDATool to CCS IDE” on page 3-9.

You can allocate extra memory by editing the generated C header file, and then loading the associated program file into your target as described in the tutorial in “Step 8—Export the Filter by Generating a Program File” on page 3-13. Allocating extra memory provides more freedom for changing a filter and overwriting its previous version stored in target memory. Even after you allocate extra memory, you should still proceed with caution when overwriting old filter coefficients with updated coefficients as discussed in the next section.

### **Overwriting Old Filter Coefficients with Updated Coefficients**

When you tune a filter to overwrite its previous version in target memory, carefully consider changes that increase the memory required to store the filter coefficients, or that alter the export data type.

**Do Not Tune a Filter’s Export Data Type.** Never tune a filter by changing its data type, because the allocated memory expects the data type of the first version of the filter that you exported. Overwriting a filter with a filter that has a different data type usually yields unexpected results.

**Be Wary of Filter Changes that Increase Memory Required to Store Filter Coefficients.** If you do not allocate extra memory when exporting the first version of your filter, do not tune the filter in ways that increase the memory required to store its coefficients. For instance, you should not increase the order of the filter. When you overwrite your original filter with one of a higher order, the updated filter may overwrite data in memory locations that you did not intend for storing filter coefficients. Even if you do allocate extra memory for your filter coefficients, be cautious about making changes that increase the memory required to store the coefficients. Examples of such changes include

- Changing an FIR filter to an IIR filter
- Increasing the filter order
- Increasing the number of filter sections

### **Variables and Memory Necessary for Filter Export**

When you export a filter by generating a C header file, the header file stores the filter coefficients in filter coefficient variables. You must name these

variables in the **Export to CCS IDE** dialog. Variable names cannot be reserved words of the C programming language, such as `if`. By generating a program file from the C header file and loading the program file into your target, the filter coefficient variables in the header file appear in the target application symbol table.

When you export a filter by writing directly to target memory, the target stores the filter coefficients in memory locations. These memory locations correspond to filter coefficient variables in the target application symbol table. To export directly to target memory, you specify these variables in the **Export to CCS IDE** dialog.

The necessary filter coefficient variables depend on the structure of your filter. The **Export to CCS IDE** dialog provides you with the following parameters to specify or name the necessary filter coefficient variables. The dialog activates only the parameters you need to set; the others become invisible or inactive.

| <b>Parameters for Specifying Filter Coefficient Variables</b> | <b>Description</b>                                                                    |
|---------------------------------------------------------------|---------------------------------------------------------------------------------------|
| <b>Numerator</b>                                              | Numerator filter coefficients                                                         |
| <b>Numerator length</b>                                       | Number of numerator filter coefficients                                               |
| <b>Denominator</b>                                            | Denominator filter coefficients                                                       |
| <b>Denominator length</b>                                     | Number of denominator filter coefficients                                             |
| <b>Lattice coeffs</b>                                         | Lattice coefficients                                                                  |
| <b>Lattice coeffs length</b>                                  | Number of lattice coefficients                                                        |
| <b>Ladder coeffs</b>                                          | Ladder coefficients                                                                   |
| <b>Ladder coeffs length</b>                                   | Number of ladder coefficients                                                         |
| <b>Number of sections</b>                                     | Number of filter sections (parameter is inactive if your filter has only one section) |

In the following table, x marks indicate the parameters you need to set for each filter structure.

## Filter Coefficient Variables Necessary for Exporting Filters with Various Structures

### Parameters for Naming Filter Coefficient Variables

| Filter Structures | Numerator | Numerator length | Denominator | Denominator length | Lattice coeffs | Lattice coeffs length | Ladder coeffs | Ladder coeffs length | Number of sections<br>(Inactive for filters<br>with one section.) |
|-------------------|-----------|------------------|-------------|--------------------|----------------|-----------------------|---------------|----------------------|-------------------------------------------------------------------|
| df1               | X         | X                | X           | X                  |                |                       |               |                      | X                                                                 |
| df1t              | X         | X                | X           | X                  |                |                       |               |                      | X                                                                 |
| df2               | X         | X                | X           | X                  |                |                       |               |                      | X                                                                 |
| df2t              | X         | X                | X           | X                  |                |                       |               |                      | X                                                                 |
| fir               | X         | X                |             |                    |                |                       |               |                      | X                                                                 |
| firt              | X         | X                |             |                    |                |                       |               |                      | X                                                                 |
| latticearma       |           |                  |             |                    | X              | X                     | X             | X                    | X                                                                 |
| latticeima        |           |                  |             |                    | X              | X                     |               |                      | X                                                                 |

## Selecting the Export Data Type

When you export a filter, the export process suggests the export data type that best preserves the performance of your filter. Use the suggested export data type by selecting **Export suggested** in the **Export to CCS IDE** dialog. The supported export data types are

- Signed integer (8-, 16-, or 32-bit)
- Unsigned integer (8-, 16-, or 32-bit)

- Double-precision floating point
- Single-precision floating point

### Recommended Procedure for Selecting Export Data Type

By adhering to the following procedure when you set the export data type of your filter, the exported filter coefficients closely match the coefficients of the filter you designed in FDATool.

**Step 1 — Set the Numerical Precision of Your Filter in FDATool.** Set the numerical precision of your filter in FDATool by using the **Quantized Filter** pane, available when you install the Filter Design Toolbox. If you do not have the Filter Design Toolbox, your filters in FDATool have the default precision—double-precision floating point.

**Step 2 — Select an Export Data Type in the Export to CCS IDE Dialog.** Use the export data type indicated by the **Export suggested** parameter in the **Export to CCS IDE** dialog. See the following note.

Though Step 2 insists you use the **Export suggested** parameter, you may find it useful to select the **Export as** option and select an export data type other than the one suggested. However, if you deviate from the suggested data type, the exported filter coefficients can be very different from the coefficients of the filter you designed in FDATool.

---

**Note** When you design your filter using an unsupported data type, the **Export to CCS IDE** dialog rounds the word length up to the next supported data type, and maintains the specified difference between the word length and fraction length. For example, for a filter with 14-bit word length and an 11-bit fraction length, the **Export suggested** parameter sets the export data type to a signed 16-bit integer with a 13-bit fraction length.

---



## Tutorial—Exporting Filters from FDATool to CCS IDE

This tutorial shows you how to export filters from FDATool to CCS IDE with the **Export to CCS IDE** dialog. The tutorial covers exporting filters by generating C header files, and by writing filter coefficients directly to the target memory. Also see the previous section, “Guidelines on Exporting Filters from FDATool to CCS IDE” on page 3-3.

### Descriptions of the Two Tutorial Tasks

“Task 1—Export Filter by Generating a C Header File” — You should complete this task before starting Task 2. Exporting a filter by generating a C header file not only exports your filter; it also ensures that you allocate enough target memory for the exported filter coefficients.

“Task 2—Export Filter by Writing Directly to Target Memory” — You should complete Task 1 before starting this task to ensure you allocate enough target memory for the filter coefficients to export. Exporting directly to target memory is useful when you want to repeatedly tune your filter in FDATool, and then export the updated filter coefficients directly to the allocated target memory.

### Setting Up for the Tutorial

To complete this tutorial, you must install both the Signal Processing Toolbox and the Embedded Target for the TI TMS320C6000 DSP Platform (shortened to Embedded Target for TI C6000 DSP in this section). You do not need to open CCS IDE before starting the tutorial.

### Task 1—Export Filter by Generating a C Header File

In Task 1, you export a filter by generating a C header file. The generated C header file defines global arrays of filter coefficients that correspond to static memory locations in the final target program. By generating a program file from the C header file and loading the program file into your target, not only do you export your filter, but you ensure that you allocated enough memory for the exported filter coefficients. In Task 2, you write filter coefficients directly to the memory allocated in Task 1. You should complete Task 1 before starting Task 2.

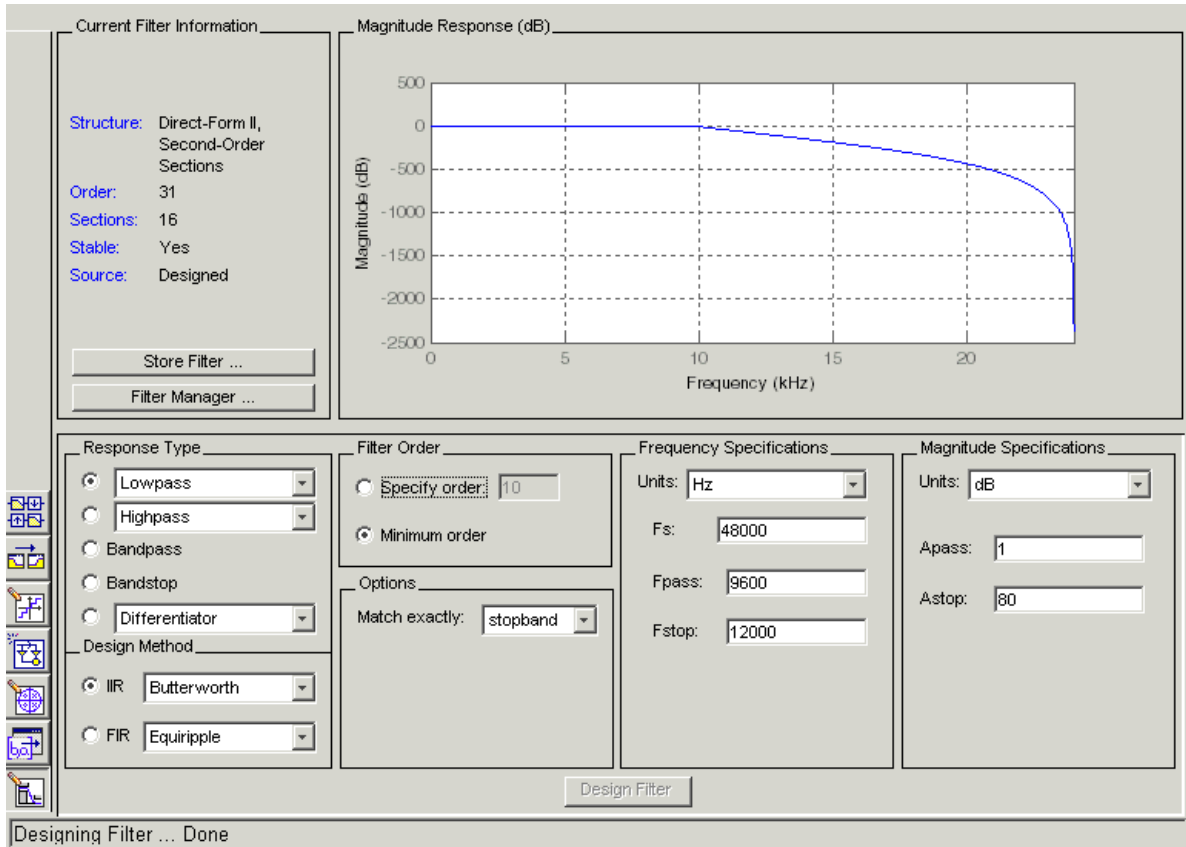
#### Step 1—Open FDATool

Open FDATool by typing `fdatool` in the MATLAB command window.

### 3 Using FDATool with the Link for Code Composer Studio

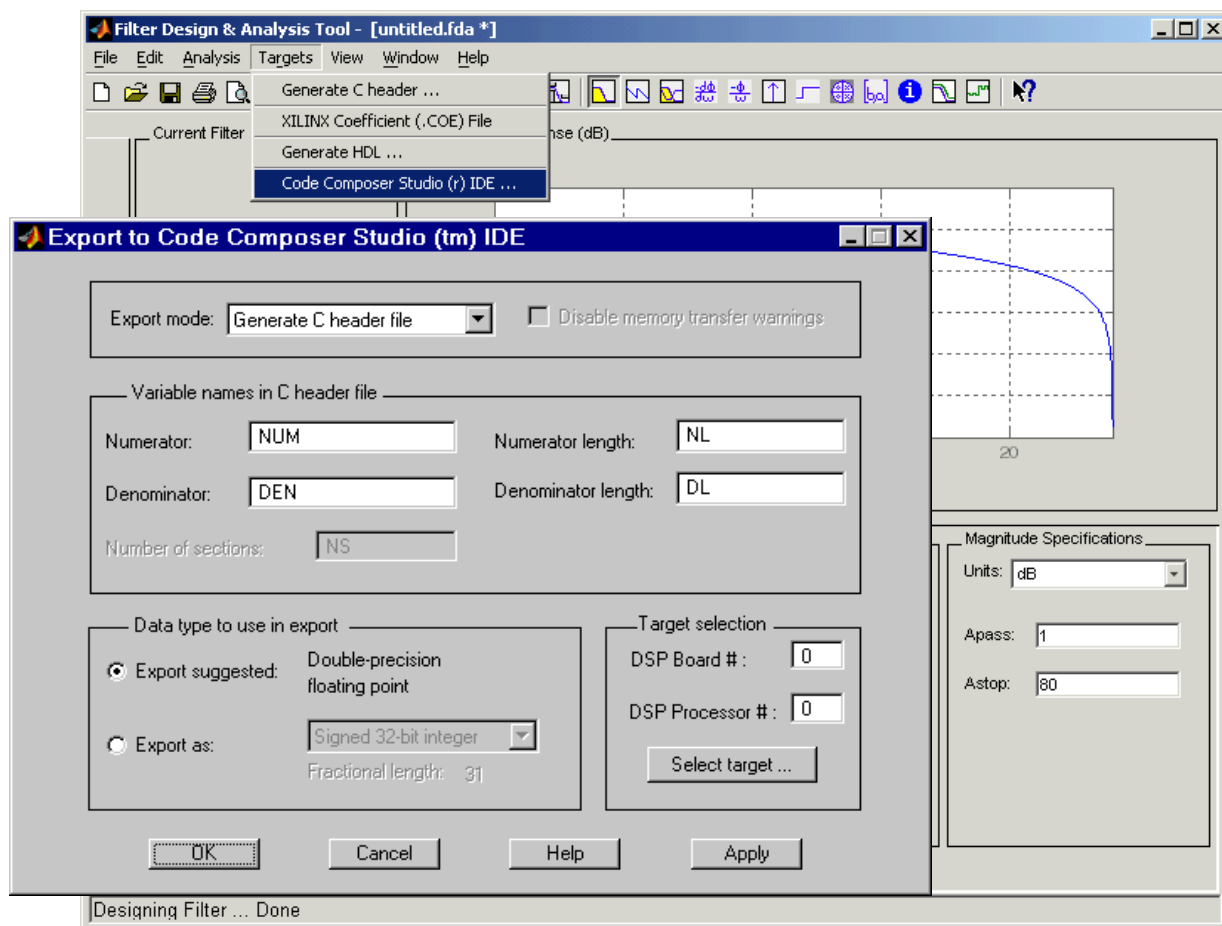
```
fdatool % Open FDATool
```

FDATool opens with a default lowpass equiripple FIR filter that you export in this tutorial (you do not need to design a filter for this tutorial).



#### Step 2—Open the Export to Code Composer Studio(r) IDE Dialog

Open the **Export to CCS IDE** dialog by selecting **Targets -> Export to Code Composer Studio(r) IDE** from the FDATool menu bar.



### Step 3—Set the Export Mode

Set **Export mode** to **Generate C header file**.



#### Step 4—Name the Filter Coefficient Variables

You must name the variables that store the filter coefficients in the generated C header file by setting the **Numerator**, **Denominator**, **Numerator length**, and **Denominator length** parameters. (These correspond to the four variables for the numerator filter coefficients, denominator filter coefficients, number of numerator coefficients, and number of denominator coefficients.) For this tutorial, use the default variable names, NUM, DEN, NL, and DL.

The generated C header file will define global arrays, NUM, DEN, NL, and DL, that correspond to static memory locations containing the filter coefficients in the final target program.

The dialog box titled "Variable names in C header file" contains four input fields. The "Numerator:" field contains "NUM", "Numerator length:" contains "NL", "Denominator:" contains "DEN", and "Denominator length:" contains "DL". A fifth field, "Number of sections:", contains "NS".

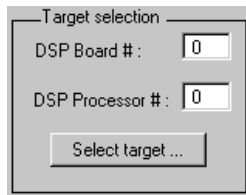
#### Step 5—Select a Data Type

Use the suggested data type to export your filter coefficients by selecting the **Export suggested** parameter.

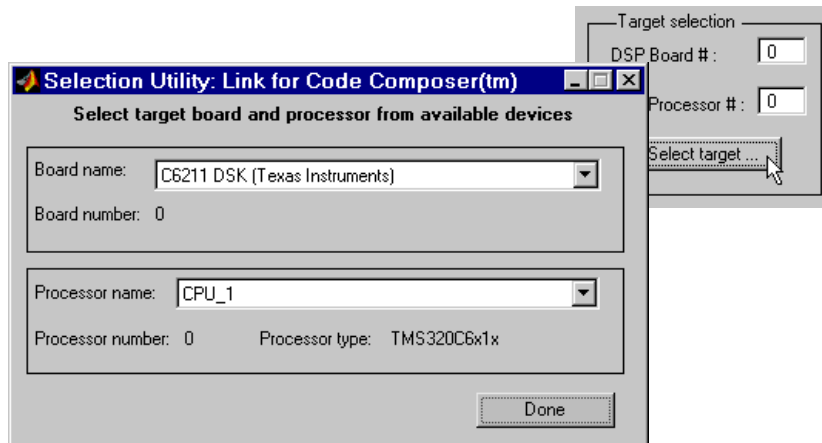
The dialog box titled "Data type to use in export" has two radio buttons. The "Export suggested:" radio button is selected and is next to the text "Double-precision floating point". The "Export as:" radio button is unselected and is next to a dropdown menu showing "Signed 32-bit integer". Below the dropdown menu, the text "Fractional length: 31" is visible.

#### Step 6—Select a Target

If you know the board number and processor number of your target DSP, select your target by setting the **DSP Board #** and **DSP Processor #** values.



Alternatively, click **Select target...**, which opens the **Selection Utility: Link for Code Composer(tm)** dialog. Select the board name and processor name of the DSP target and click **Done**. This automatically sets the **DSP Board #** and **DSP Processor #** values in the **Export to CCS IDE** dialog.



### Step 7—Generate the C Header File

Click **Apply** to generate the C header file. This opens the generated C header file in CCS IDE. (CCS IDE will be opened for you if you did not have it open.)

### Step 8—Export the Filter by Generating a Program File

Add the generated C header file to an appropriate project, generate a program file, and load the program file into your target DSP. The program file allocates static memory locations in the target, and writes the filter coefficients to these locations. See the following note.

By completing steps 1 through 8, you allocated target memory for the filter coefficients and exported the coefficients to these memory locations. Now you

can tune the filter in FDATool, then export the updated filter coefficients directly to the allocated memory locations as described in Task 2 of this tutorial.

---

**Note** You may want to edit the generated C header file so the associated program file allocates extra target memory. This allows you to change your filter and export the new filter coefficients directly to the allocated memory without having to worry about whether there is enough memory. For example, in the following header file, you could modify `const real64_T NUM[47] = {...}` to `const real64_T NUM[256] = {...}` to allow NUM to store up to 256 numerator filter coefficients rather than 47.

---

#### Contents of the C Header File Generated in Task 1

```
/*
 * Filter Design and Analysis Tool - Generated Filter Coefficients
 * - C Source
 * Generated by MATLAB - Signal Processing Toolbox
 */
/* General type conversion for MATLAB generated C-code */
#include "tmwtypes.h"
/*
 * Expected path to tmwtypes.h
 * D:\v5\extern\include\tmwtypes.h
 */
const int NL = 47;
const real64_T NUM[47] = {
 -0.001384463093657, -0.004518981980449, -0.004897044657617,
 0.003407148842561,
 0.01572838996192, 0.01654194333933,
 0.00164298284835, -0.008806408558624,
 0.002021262464639, 0.01578576956127, 0.004464610692757,
 -0.01727452424144,
 -0.008835593007042, 0.02164594139449, 0.0179008188858,
 -0.02459850261385,
 -0.03066089435881, 0.02764920456168, 0.05260956118871,
 -0.02977511581716,
```

```

 -0.09918534387346, 0.03121885582524, 0.3159846926607,
0.4683345369683,
 0.3159846926607, 0.03121885582524, -0.09918534387346,
-0.02977511581716,
 0.05260956118871, 0.02764920456168, -0.03066089435881,
-0.02459850261385,
 0.0179008188858, 0.02164594139449, -0.008835593007042,
-0.01727452424144,
 0.004464610692757, 0.01578576956127,
0.002021262464639, -0.008806408558624,
 0.00164298284835, 0.01654194333933, 0.01572838996192,
0.003407148842561,
 -0.004897044657617, -0.004518981980449, -0.001384463093657
};
const int DL = 1;
const real64_T DEN[1] = {
 1
};

```

## Task 2—Export Filter by Writing Directly to Target Memory

In Task 2 you export a filter by writing the filter coefficients directly to target memory. Before starting this task, you must allocate enough target memory for the filter coefficients by completing “Task 1—Export Filter by Generating a C Header File”. Once you have allocated enough target memory, you can tune your filter in FDATool and export the updated filter coefficients directly to the allocated target memory by following the steps in this task. For important guidelines on writing directly to target memory, see “Cautions Regarding Writing Directly to Memory” on page 3-4.

### Step 9—Tune Your Filter in FDATool

Tune your filter coefficients in FDATool to improve its performance. Set the numerical precision of your filter by using the **Quantized Filter** pane in FDATool, available when you install the Filter Design Toolbox. If you do not have the Filter Design Toolbox, your filters in FDATool have the default precision, double-precision floating point.

If you have the **Export to CCS IDE** dialog open from Task 1, the dialog automatically updates itself as you tune the filter in FDATool. If you closed the

dialog, reopen it as described in “Step 2—Open the Export to Code Composer Studio(r) IDE Dialog” on page 3-10.

---

**Note** If you allocated exactly enough memory for the filter coefficients in Task 1, you should not tune your filter such that it requires more memory than did the original filter (by increasing the filter order, for example). If you need more memory for your updated filter, allocate extra memory by editing the generated C header file from Task 1 (as described in the previous note), generating a program file, and loading the program file into your target.

---

#### Step 10—Set the Export Mode

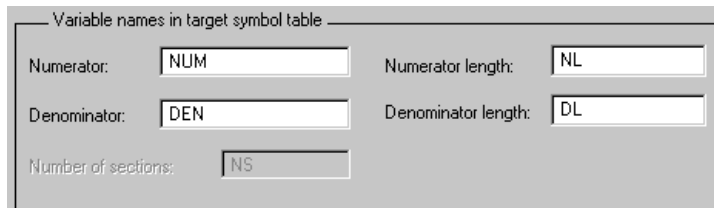
Set **Export mode** to Write directly to memory. Leave the parameter **Disable memory transfer warnings** unchecked so that you get a warning if your target does not support the export data type.



Export mode: Write directly to memory  Disable memory transfer warnings

#### Step 11—Input Filter Variable Names

To write to the memory allocated in Task 1, enter the names of the variables in the target symbol table corresponding to the allocated memory. These names are the same as the names of the filter coefficient variables in the C header file from Task 1: NUM, DEN, NL, and DL. You do not need to type these names in, since they are the default setting of the **Numerator**, **Denominator**, **Numerator length**, and **Denominator length** parameters. (These parameters correspond to the memory locations that store the numerator filter coefficients, denominator filter coefficients, number of numerator coefficients, and number of denominator coefficients.)



Variable names in target symbol table

Numerator: NUM Numerator length: NL

Denominator: DEN Denominator length: DL

Number of sections: NS



### Step 12—Set All Other Parameters for Export as in Task 1

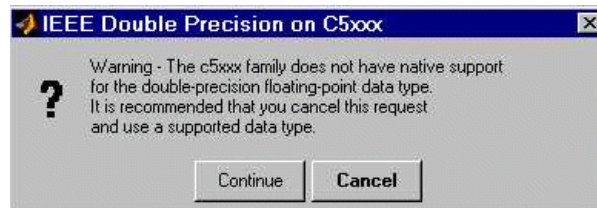
Select an export data type and indicate your target DSP as in Steps 5 and 6 of Task 1.

### Step 13—Load the Program File

Load the program file associated with your target into CCS IDE to activate the target symbol table. The program file must contain the global variables you entered in Step 11.

### Step 14—Export by Writing Directly to Target Memory

Click **Apply** to export your filter. Before the filter export begins, a warning dialog appears if your target does not support the export data type. You can choose to continue to export the filter, or to cancel the export. To prevent this warning dialog from appearing, you can select the parameter **Disable memory transfer warnings** in Step 10.



### Step 15 — Continue Optimizing Filter Performance

Continue to optimize filter performance by retuning your filter in FDATool and exporting the updated filter coefficients directly to target memory. Since you already set up the export process to write to specific memory locations, you can click **Apply** to export updated coefficients to these same memory locations.

When the **Export to CCS IDE** dialog is open, it automatically updates as you tune your filter in FDATool, and preserves the parameter settings from Steps 10 through 13. The dialog stays open as long as you do not click **Cancel** or **OK**. Keep the dialog open when exporting multiple times to the same memory locations so you do not have to repeat Steps 10 through 13, and can just click **Apply**.

### Where to Find More Information

For more information on exporting filters from FDATool to CCS IDE, see “Guidelines on Exporting Filters from FDATool to CCS IDE” on page 3-3, which contains the following sections:

- “Selecting the Export Mode”
- “Cautions Regarding Writing Directly to Memory”
- “Variables and Memory Necessary for Filter Export”
- “Selecting the Export Data Type”

To learn how to use FDATool, see the Filter Design and Analysis Tool section in the Signal Processing Toolbox documentation.

Also see the reference pages of the following Embedded Target for TI C6000 DSP functions:

- address
- ccsdsp
- write

# Link Functions Reference

---

|                                               |                                                                  |
|-----------------------------------------------|------------------------------------------------------------------|
| Using the Link Function Reference<br>(p. 4-2) | Explains the contents of the function reference pages            |
| Functions — Categorical List (p. 4-3)         | Lists of the functions in the product                            |
| Functions — Alphabetical List (p. 4-9)        | Provides an alphabetical listing of the functions in the product |

# Using the Link Function Reference

These sections provide complete information on each function in the links in Link for Code Composer Studio, in a structured format. Refer to these pages when you need details about a specific function. For help on a function, enter

```
help ccshelp/functionname or help rtdxhelp/functionname
```

or use the Help desk to access the function reference page.

## Contents of Function Reference Pages

Function reference pages are listed in alphabetical order by the function name. Each entry contains the following information:

- **Purpose** — describes why you use the block or function.
- **Syntax** — lists each syntax and option that applies to the function.
- **Description** — describes what the function does, by presenting all possible syntax structures for the function. Each syntax in the Syntax section appears in a description.
- **Examples** — shows the function in use and demonstrates some of the parameters and options for the function.
- **See Also** — lists related blocks and functions. This is an optional category.

## Functions — Categorical List

For quick reference purposes, the following tables list the functions available for the links for Code Composer Studio Integrated Development Environment (CCS IDE) and Real-Time Data Exchange (RTDX). Each table entry includes the function name as a link to its reference page; whether the function is overloaded; and a brief description of the function

### Functions Operating on Links for CCS IDE

| Function                     | Overloaded | Description                                                              |
|------------------------------|------------|--------------------------------------------------------------------------|
| <a href="#">activate</a>     |            | Change the active file or project in CCS IDE                             |
| <a href="#">add</a>          |            | Add a file to the active project in CCS IDE                              |
| <a href="#">animate</a>      |            | Run an application on the target processor until it reaches a breakpoint |
| <a href="#">build</a>        |            | Build the active project in CCS IDE                                      |
| <a href="#">ccsboardinfo</a> |            | Return information about the boards and simulators recognized by CCS IDE |
| <a href="#">ccsdsp</a>       |            | Create a link to CCS IDE                                                 |
| <a href="#">cd</a>           |            | Change the working directory that CCS IDE uses                           |
| <a href="#">clear</a>        | Yes        | Destroys the links to CCS IDE                                            |
| <a href="#">close</a>        | Yes        | Close open files in CCS IDE                                              |
| <a href="#">delete</a>       |            | Remove debug points in files in CCS IDE                                  |
| <a href="#">dir</a>          |            | List the files in the current CCS IDE working directory                  |
| <a href="#">disp</a>         | Yes        | Display the properties of a link to CCS IDE                              |

## Functions Operating on Links for CCS IDE

| Function      | Overloaded | Description                                                                   |
|---------------|------------|-------------------------------------------------------------------------------|
| display       | Yes        | Display the properties of a link to CCS IDE                                   |
| get           | Yes        | Returns the property values for a link to CCS IDE.                            |
| halt          |            | Terminate execution of a process running on the target processor              |
| info          | Yes        | Return information about the target processor                                 |
| isreadable    | Yes        | Determine if MATLAB can read the specified memory block                       |
| isrtdxcapable |            | Determine whether the target processor or board supports RTDX                 |
| isrunning     |            | Test whether the target processor is executing a process                      |
| isvisible     |            | Test whether CCS IDE is running on the PC                                     |
| iswritable    | Yes        | Determine if MATLAB can write to the specified memory block                   |
| load          |            | Transfer a program file (*.out, *.obj) to the target processor                |
| new           |            | Create and open a new text file, project, or build configuration in CCS IDE   |
| open          | Yes        | Load a file into CCS IDE                                                      |
| profile       |            | Return profile information from running a DSP/BIOS-enabled program in CCS IDE |

## Functions Operating on Links for CCS IDE

| Function | Overloaded | Description                                                                          |
|----------|------------|--------------------------------------------------------------------------------------|
| read     |            | Retrieve data from memory on the target processor                                    |
| regread  |            | Return a value from a specified register on the target processor                     |
| reload   |            | Resend the most recently loaded program file to the target processor                 |
| regwrite |            | Write a value to a specified register on the target processor                        |
| remove   |            | Remove a file from the active CCS IDE project                                        |
| reset    |            | Start to reset the target processor                                                  |
| restart  |            | Restore the program counter to the entry point for the current program on the target |
| resume   |            | Restart execution of a stopped or paused process                                     |
| run      |            | Execute the program loaded on the target processor                                   |
| set      | Yes        | Set the properties of links for CCS IDE.                                             |
| symbol   |            | Return the most recent program symbol table from CCS IDE                             |
| visible  |            | Set the visibility for CCS IDE window                                                |
| write    |            | Write data to memory on the target processor                                         |

## Functions Operating on Links for RTDX

| Function   | Overloaded | Description                                                                                         |
|------------|------------|-----------------------------------------------------------------------------------------------------|
| address    |            | Return the address and memory page for a symbol.                                                    |
| clear      | Yes        | Remove existing links for RTDX and CCS IDE. Uses a destructor method to eliminate the link objects. |
| close      | Yes        | Close an open RTDX channel.                                                                         |
| configure  |            | Define the size and number of RTDX channel buffers.                                                 |
| disable    |            | Disable the RTDX interface, a specified channel, or all RTDX channels.                              |
| disp       | Yes        | Display the properties of an RTDX link (default display).                                           |
| display    | Yes        | Display the properties of an RTDX link.                                                             |
| enable     |            | Enable the RTDX interface, a specified channel, or all RTDX channels.                               |
| flush      |            | Flush data or messages out of one or more specified RTDX channels.                                  |
| get        | Yes        | Return the property values for a link for RTDX.                                                     |
| info       | Yes        | Return information about specified RTDX links.                                                      |
| isenabled  |            | Determine whether the RTDX interface or one or all RTDX channels are enabled for communications.    |
| isreadable | Yes        | Determine whether MATLAB can read the specified RTDX channel.                                       |



## Functions Operating on Links for RTDX

| Function   | Overloaded | Description                                                       |
|------------|------------|-------------------------------------------------------------------|
| iswritable | Yes        | Determine whether MATLAB can write to the specified RTDX channel. |
| msgcount   |            | Return the number of messages in a read-enabled RTDX channel.     |
| open       | Yes        | Open an RTDX channel to a target processor.                       |
| readmat    |            | Read a matrix of data from specified RTDX channels.               |
| readmsg    |            | Read messages from the specified RTDX channel.                    |
| set        | Yes        | Set the properties of a link for RTDX.                            |
| writemsg   |            | Write a message to the target processor.                          |

## Functions for Data Manipulation

| Function  | Description                                                                                 |
|-----------|---------------------------------------------------------------------------------------------|
| cast      | Change the data type of an object in Link for CCS                                           |
| createobj | Create MATLAB objects that represent embedded data or functions in a program on your target |
| deref     | Return an object that accesses the object a pointer object points to                        |
| read      | Retrieve data from memory on the target processor or in CCS                                 |
| resize    |                                                                                             |
| write     | Write data to memory on the target processor                                                |

## Functions for Hardware-in-the-Loop Processing

| <b>Function</b>        | <b>Description</b>                                                                          |
|------------------------|---------------------------------------------------------------------------------------------|
| <code>createobj</code> | Create MATLAB objects that represent embedded data or functions in a program on your target |
| <code>declare</code>   | Define a C function declaration in MATLAB for your CCS application                          |
| <code>getinput</code>  | Return a specified input argument object from a function object                             |
| <code>getoutput</code> | Return the object that accesses the output from a function object                           |
| <code>read</code>      | Retrieve data from memory on the target processor or in CCS                                 |
| <code>run</code>       | Execute the program loaded on the target processor                                          |
| <code>write</code>     | Write data to memory on the target processor                                                |

## **Functions — Alphabetical List**

The following pages provide the reference information for every function in the link product, in alphabetical order by the name of the function.

# activate

---

**Purpose** Make the specified project, file, or build configuration active in CCS IDE

**Syntax** `activate(cc, 'objectname', 'type')`

**Description** `activate(cc, 'objectname', 'type')` makes the object specified by `objectname` and `type` the active document window or project in CCS IDE. While you must include the link `cc`, it does not identify the project or file you make active. `activate` accepts one of three strings for `type`

| String     | Description                                                                                                                                           |
|------------|-------------------------------------------------------------------------------------------------------------------------------------------------------|
| 'project'  | Makes an existing project in CCS IDE active (current). You must include the <code>.pj t</code> extension in <code>objectname</code> .                 |
| 'text'     | Makes the specified text file in CCS IDE the active document window. Include the file extension in <code>objectname</code> when you specify the file. |
| 'buildcfg' | Makes the specified build configuration in CCS IDE active. Note that build configuration is similar to project configuration.                         |

To specify the project file, text file, or build configuration, `objectname` must contain the full project name with the `.pj t` extension, or the full pathname and extension for the text file.

When you activate a build configuration, `activate` applies to the active project in CCS IDE. If the build configuration you specify in `activate` does not exist in the active project, MATLAB returns an error that the specified configuration does not exist in the project. Fix this error by using `activate` to make the correct project active, then use `activate` again to select the desired build configuration.

**Examples** Create two projects in CCS IDE and use `activate` to change the active project, build configuration, and document window:

```
cc=ccsdsp;
visible(cc,1)
```

Now make two projects in CCS IDE.

```
new(cc, 'myproject1.pjt')
new(cc, 'myproject2.pjt')
```

In CCS IDE, `myproject2` is now the active project, since you just created it. With two projects in CCS IDE, add a new build configuration to the second project.

```
new(cc, 'Testcfg', 'buildcfg')
```

If you switch to CCS IDE, you see `myproject2.pjt` in bold lettering in the project view, signaling it is the active project. When you check the active configuration list, you see three build configurations—**Debug**, **Release**, and **Testcfg**. Currently, **Testcfg** is the active build configuration in `myproject2`.

Finally, add a text file to `myproject1` and make it the active document window in CCS IDE. In this case, you add the source file for the ADC block.

```
activate(cc, 'myproject1.pjt') % Makes myproject1 the active
project
add(cc, 'c6701evm_adc.c')
activate(cc, 'c6701evm_adc.c', 'text')
```

## See Also

`build`, `new`, `remove`

# add

---

**Purpose** Add files to the active project in CCS or add a new typedef

**Syntax**  
`add(cc, 'filename')`  
`info = add(cc.type, 'typedefname', 'datatype')`

**Description** Use `add` when you have an existing file to add to your active project in CCS. You can have more than one CCS IDE open at the same time, such as C5000 and C6000 instances. `cc` identifies which CCS IDE instance gets the file, and it identifies your board or target. Note that `cc` does not identify your project in CCS—it identifies only your target hardware or simulator. `add` puts the file specified by `filename` in the active project in CCS. Files you add must exist and be one of the supported file types shown in the next table.

When you add files, CCS puts the files in the appropriate folder in the project, such as putting source files with the `.c` extension in the `Source` folder and adding `.lib` files to the `Libraries` folder. You cannot change the destination folder in your CCS project. Using `add` is identical to selecting **Project->Add Files to Project...** in CCS IDE.

To specify the file to add, `filename` must be the full pathname to the file, unless your file is in your CCS working directory or in a directory on your MATLAB path. The Link for Code Composer Studio searches for files first in your CCS IDE working directory, then in directories on your MATLAB path.

You can add the following file types to a project through `add`.

## File Types and Extensions Supported by `add` and CCS IDE

| File Type                | Extensions Supported                                                                           | CCS Project Folder |
|--------------------------|------------------------------------------------------------------------------------------------|--------------------|
| C/C++ source files       | <code>.c</code> , <code>.cpp</code> , <code>.cc</code> , <code>.ccx</code> , <code>.sa</code>  | Source             |
| Assembly source files    | <code>.a*</code> , <code>.s*</code> (excluding <code>.sa</code> , refer to C/C++ source files) | Source             |
| Object and library files | <code>.o*</code> , <code>.lib</code>                                                           | Libraries          |
| Linker command file      | <code>.cmd</code>                                                                              | Project Name       |

### File Types and Extensions Supported by add and CCS IDE

| File Type            | Extensions Supported | CCS Project Folder                                 |
|----------------------|----------------------|----------------------------------------------------|
| DSP/BIOS file        | .cdb*                | DSP/BIOS Config                                    |
| Visual Linker Recipe | .rcp                 | Replaces the .cmd file, or goes under Project Name |

Use `activate` to change your active project in CCS IDE or switch to the CCS IDE and change the active directory within CCS.

`info = add(cc.type, 'typedefname', 'datatype')` adds the new type definition `typedefname` to the type class in `cc`. Return value `info` contains the information about your custom data type. Your new data type `typedefname` has type `datatype`. As long as the `cc` object exists, the information about your new typedef exists as well. Including the left side argument is an option. Omitting the left side argument does not prevent `add` from making additions to the type objects.

## Examples

Create a new project and to it add a source file and a build configuration. To do this task from MATLAB, use `new` to make your project in CCS IDE, then use `add` to put the required files into your new project.

```
cc=ccsdsp
```

```
CCSDSP Object:
```

```
API version : 1.2
Processor type : TMS320C64127
Processor name : CPU_1
Running? : No
Board number : 0
Processor number : 0
Default timeout : 10.00 secs
```

```
RTDX channels : 0
```

```
cc.visible(1) % Optional. Makes CCS IDE visible on your desktop
new(cc, 'myproject', 'project');
```

# add

---

```
% Now add a C source file
```

```
add(cc, 'c6701evm_adc.c'); % Adds the source file for the ADC block
```

In CCS IDE, `c6701evm_adc.c` shows up in `myproject`, in the Source folder. Now add a new build configuration to `myproject`. After you add the new configuration, you can see it on the configurations list in CCS IDE, along with the usual Debug and Release configurations:

```
new(cc, 'Testcfg', 'buildcfg')
```

Adding a new type definition to the type object is straightforward:

```
cc=ccsdsp;
info = add(cc.type, 'mynew typedef', 'int32');
info =
```

```
 type: 'int32'
 size: 1
 uclass: 'numeric'
```

```
cc.type
```

```
Defined types : Void, Float, Double, Long, Int, Short, Char, mynewtypedef
```

## See Also

`activate`, `cd`, `open`, `remove`



**Purpose** Append one or more registers to the list of saved registers stored in the property `savedregs` of function objects

**Syntax** `addregister(ff,regname)`  
`addregister(ff,regnamelist)`

**Description** `addregister(ff,regname)` adds register `regname` to the list of registers that get preserved or reverted when a function is finished running. `ff` identifies the program function to which the register applies. You can add any register to the saved registers list.

When you issue the `createobj` call to create a handle to a function, the compiler creates the default list of saved registers. When you execute the function, the compiler saves the registers in the list, runs its process, and after completing its process, restores the saved registers to their initial state using the contents of the saved registers.

After a function generates a result, the execution process returns the saved registers to their initial states and values. When you add a register to the saved registers list, the added register is restored and saved with the other registers in the list.

For each processor family, the default list of saved registers changes, as shown in these sections. The default lists include registers that the compiler saves and that MATLAB requires for Link for Code Composer Studio to operate correctly.

### **Default Saved Registers for C28x Processors**

AL, AH, AR0, AR1, AR2, AR3, AR4, AR5, AR6, AR7, XAR0, XAR1, XAR2, XAR3, XAR4, XAR5, XAR6, XAR7, SP, T, TL, PL, PH, DP

### **Default Saved Registers for C54x Processors**

AR1, AR6, AR7, and SP (required by MATLAB, not the compiler)

### **Default Saved Registers for C55x Processors**

T0, T1, T2, T3, TRN0, TRN1, AR0, AR1, AR2, AR3, AR4, AR5, AR6, AR7, XAR0, XAR1, XAR2, XAR3, XAR4, XAR5, XAR6, XAR7, AC0, AC1, AC2, AC3

### **Default Saved Registers for C62x and C67x Processors**

A0, A2, A6, A7, A8, A9. Also B0, B1, B2, B4, B5, B6, B7, B8, B9. To support MATLAB requirements, B15 (the stack pointer) gets saved as well.

# addregister

---

Registers A3, A4, A5, and B3—your function must preserve these but they are not needed for reading function output.

## **Default Saved Registers for C64x Processors**

A0, A2, A6, A7, A8, A9, A16, A17, A19, A19, A20, A21, A22, A23, A24, A25, A26, A27, A28, A29, A30, A31. Also B0, B1, B2, B4, B5, B6, B7, B8, B9, B16, B17, B18, B19, B20, B21, B22, B23, B24, B25, B26, B27, B28, B29, B30, B31. To support MATLAB requirements, B15 (the stack pointer) gets saved as well.

Register B15—not required by the compiler, but is required by MATLAB and is saved.

Registers A3, A4, and A5—function must preserve these but they are needed for reading function output.

## **Default Saved Registers for R1x and R2x Processors**

R0, R1, R2, R3, R4, R5, R6, R7, R8, R9, R10, R11, R12, R13, R14,R15

`addregister(ff,reglist)` appends the register names in `reglist` to the list of registers that get preserved when a task is finished. `ff` identifies the function to which the register applies. `reglist` is a cell array that contains the names of registers on your processor that must be preserved during the changes that occur during operation.

## **See Also**

`deleteregister`

**Purpose** Return the address and page for an entry in the symbol table in CCS IDE

**Syntax** `a = address(cc, 'symbolstring')`

**Description** `a = address(cc, 'symbolstring')` returns the address and page values for the symbol identified by 'symbolstring' in CCS IDE. `address` returns the symbol from the most recently loaded program in CCS IDE. In some instances this might not be the program loaded on the target to which `cc` is linked. By returning the address and page values as a structure, your programs can use the values directly. If you provide an output argument, the output `a` contains the 1-by-2 vector of [address page]. For `address` to work, `symbolstring` must represent a valid entry in the symbol table. To ensure that `address` returns information for the correct symbol, use the proper case when you enter `symbolstring` because symbol names are case-sensitive; 'symbolstring' is not the same as 'Symbolstring'.

If `address` does not find a symbol table entry that matches `symbolstring`, the first cell of `a` is returned empty. Notice that this function returns only the first matching symbol in the symbol table. The output argument is a cell array where each row in `a` presents the symbol name and address in the table. Each returned symbol address comprises a two element vector with the symbol page as the second element. For example, this table shows a few possible elements of `a`, and their interpretation.

| <b>a Array Element</b> | <b>Contents of the Specified Element</b>                                                                                                                                                    |
|------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>a{1}</code>      | String reflecting the symbol name. If <code>address</code> found a symbol that matches <code>symbolstring</code> , this is the same as <code>symbolstring</code> . Otherwise this is empty. |
| <code>a{2}(1)</code>   | Address or value of symbol entry.                                                                                                                                                           |
| <code>a{2}(2)</code>   | Memory page value. For TI C6xxx processors, the page is 0.                                                                                                                                  |

**Examples** After you load a program to your target, `address` lets you read and write to specific entries in the symbol table for the program. For example, the following function reads the value of symbol 'ddat' from the symbol table in CCS IDE.

# address

---

```
ddatv = read(cc,address(cc,'ddat'),'double',4)
```

`ddat` is an entry in the current symbol table. `address` searches for the string `ddat` and returns a value when it finds a match. `read` returns `ddat` to MATLAB as a double-precision value as specified by the string `'double'`.

To change values in the symbol table, use `address` with `write`:

```
write(cc,address(cc,'ddat'),double([pi 12.3 exp(-1)...
sin(pi/4)]))
```

After executing this write operation, `ddat` contains double-precision values for  $\pi$ , 12.3,  $e^{-1}$ , and  $\sin(\pi/4)$ . Use `read` to check the contents of `ddat`:

```
ddatv = read(cc,address(cc,'ddat'),'double',4)
```

MATLAB returns

```
ddatv =

 3.1416 12.3 0.3679 0.7071
```

## See Also

`load`, `read`, `symbol`, `write`

**Purpose** Run an application on the target processor until it reaches a breakpoint

**Syntax** `animate(cc)`

**Description** `animate(cc)` starts the target application, which runs until it encounters a breakpoint in the code. At the breakpoint, application execution halts and CCS Debugger returns data to CCS IDE to update all windows that are not connected to probe points. After updating the display, the application resumes execution and runs until it encounters another breakpoint. The run-break-resume process continues until you stop the application from MATLAB with the `halt` function or from CCS IDE.

When you are running scripts or files in MATLAB, you might find that `animate` provides a useful way to update the CCS IDE with information as your script or program runs.

### **Using `animate` with multiprocessor boards**

When you use `animate` with a target object `cc` that comprises more than one processor, such as an OMAP target, the method applies to each processor in your `cc` object. This causes each processor to run a loaded program just as it does for the single processor case.

**See Also** `halt`, `restart`, `run`

# assignreturnstorage

---

**Purpose** Assign a storage location to property outputvar for a structure or union returned by a function on C6x processors

**Syntax** `assignreturnstorage(ff, 'address', address)`  
`assignreturnstorage(ff, 'handle', structure_object)`

**Description** `assignreturnstorage(ff, 'address', address)` sets the outputvar property of the function object `ff`. Setting outputvar determines where the process stores the results of executing the function. To specify the address for the output, enter `address` as a numeric value. The keyword **address** tells MATLAB that the next argument entry in the syntax is an address.

`assignreturnstorage(ff, 'handle', structure_object)` assigns the return storage to the structure reference by `structure_object`. To use this syntax, `structure_object` must refer to a structure object. **handle** tells MATLAB that the next argument in the list is the name of a handle to a structure object. The referenced structure contains the address to which you are assigning the return from the function.

---

**Note** `assignreturnstorage` works only with functions that return structures or unions. For functions that return other types of data, `assignreturnstorage` does not apply. You use `assignreturnstorage` only with C6x processors.

---

**See Also** `createobj`

---

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Build the active project in CCS IDE                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Syntax</b>      | <pre>build(cc,timeout) build(cc) build(cc,'all',timeout) build(cc,'all')</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>Description</b> | <p><code>build(cc,timeout)</code> incrementally rebuilds your active project in CCS IDE. In an incremental build:</p> <ul style="list-style-type: none"><li>• Files that you have changed since your last project build process get rebuilt or recompiled.</li><li>• Source files rebuild when the time stamp on the source file is later than the time stamp on the object file created by the last build.</li><li>• Files whose time stamps have not changed do not rebuild or recompile.</li></ul> <p>This incremental build is identical to the incremental build in CCS IDE, available from the CCS IDE toolbar.</p> <p>After building the files, CCS IDE relinks the files to create the program file with the <code>.out</code> extension. To determine whether to relink the output file, CCS IDE compares the time stamp on the output file to the time stamp on each object file. It relinks the output when an object file time stamp is later than the output file time stamp.</p> <p>To reduce the compile and build time, CCS IDE keeps a build information file for each project. CCS IDE uses this file to determine which file needs to be rebuilt or relinked during the incremental build. After each build, CCS IDE updates the build information file.</p> <hr/> <p><b>Note</b> CCS IDE opens a <b>Save As</b> dialog when the requested project build overwrites any files in the project. You must respond to the dialog before CCS IDE continues the build. The dialog may not be visible when it opens and CCS IDE, MATLAB, and other applications can appear to be frozen until you respond to the dialog. It may be hidden by open windows on your desktop.</p> <hr/> |

# build

---

To limit the time that `build` spends performing the build, the optional argument `timeout` stops the process after `timeout` seconds. `timeout` defines the number of seconds allowed to complete the required compile, build, and link operation. If the build process exceeds the time-out period, `build` returns an error in MATLAB. Generally, `build` causes the processor to initiate a restart even when the period specified by `timeout` passes. Exceeding the allotted time for the operation usually indicates that confirmation that the build was finished was not received before the time-out period passed. If you omit the `timeout` option in the syntax, `build` defaults to the global time-out defined in `cc`.

`build(cc)` is the same as `build(cc,timeout)` except that when you omit the `timeout` option, `build` defaults to the time-out for `build`, 1000 s. This time-out value overrides the default time-out setting for `cc`.

`build(cc, 'all', timeout)` completely rebuilds all of the files in the active project. This full build is identical to selecting **Project->Rebuild All** from the CCS menubar. After rebuilding all files in the project, `build` performs the link operation to create a new program file.

To limit the time that `build` spends performing the build, optional argument `timeout` stops the process after `timeout` seconds. `timeout` defines the number of seconds allowed to complete the required compile, build, and link operation.

If the build process exceeds the time-out period, `build` returns an error in MATLAB. Generally, `build` causes the processor to initiate a restart even when the period specified by `timeout` passes. Exceeding the allotted time for the operation usually indicates that confirmation that the build was finished was not received before the time-out period passed. If you omit the `timeout` option in the syntax, `build` defaults to the global time-out defined in `cc`.

`build(cc, 'all')` is the same as `build(cc, 'all', timeout)` except that when you omit the `timeout` option, `build` defaults to the time-out set for `build` only, 1000 s.

## Examples

To demonstrate building a project from MATLAB, use CCS IDE to load a project from the TI tutorials. For this example, open the project file `volume.pjt` from the `Tutorial` folder where you installed CCS IDE. (You can open any project you have for this example.)



Now use `build` to build the project:

```
cc=ccsdsp
```

```
CCSDSP Object:
```

```
API version : 1.2
Processor type : TMS320C64127
Processor name : CPU_1
Running? : No
Board number : 0
Processor number : 0
Default timeout : 10.00 secs
```

```
RTDX channels : 0
```

```
build(cc, 'all', 20)
```

You just completed a full build of the project in CCS IDE. On the Build pane in CCS IDE, you see the record of the build process and the results. Now, make a change to a file in the project in CCS IDE and save the file. Then rebuild the project with an incremental build.

```
build(cc, 20)
```

When you look at the Build pane in CCS IDE, the log shows that the build only occurred on the file or files that you changed and saved.

**See Also**

`activate`, `isrunning`, `open`

# cast

---

**Purpose** Change the data type of an object in Link for CCS

**Syntax**  
objname2 = cast(objname,datatype)  
objname2 = cast(objname,datatype,size)

**Description** objname2 = cast(objname,datatype) returns objname2, a copy of objname, whose represent, storagepervalue, and wordsize properties are changed so objname2 supports the data type specified by datatype. Input argument datatype can be any supported data type. After the cast operation, read or write operations apply the appropriate data conversion to implement on your target the data type specified by the represent, storagepervalue, and wordsize properties of objname2.

The following data types work as input arguments to cast.

| <b>datatype String</b> | <b>represent Property Value</b> |
|------------------------|---------------------------------|
| 'double'               | 'float'                         |
| 'single'               | 'float'                         |
| 'int32'                | 'signed'                        |
| 'int16'                | 'signed'                        |
| 'int8'                 | 'signed'                        |
| 'uint32'               | 'unsigned'                      |
| 'uint16'               | 'unsigned'                      |
| 'uint8'                | 'unsigned'                      |
| 'long double'          | 'float'                         |
| 'float'                | 'float'                         |
| 'long'                 | 'signed'                        |
| 'int'                  | 'signed'                        |
| 'char'                 | 'signed' / 'unsigned'           |

| <b>datatype String</b> | <b>represent Property Value</b> |
|------------------------|---------------------------------|
| 'unsigned long'        | 'signed'                        |
| 'unsigned int'         | 'unsigned'                      |
| 'unsigned char'        | 'unsigned'                      |
| 'Q0.15'                | 'fract'                         |
| 'Q0.31'                | 'fract'                         |

**Note** pointer and rpointer objects respond differently when you use cast. Refer to “Using cast with pointer and rpointer Objects” for more information about the supported data types for pointer or rpointer objects.

Various TI processors restrict the sizes of the data types used by objects in Link for Code Composer Studio. Shown in the next table, the processor families restrict the valid word sizes for the listed data types.

| <b>represent Property Value</b> | <b>C5x Processor Word Size Limits</b> | <b>C6x Processor Word Size Limits</b> |
|---------------------------------|---------------------------------------|---------------------------------------|
| 'float'                         | 32, 64 bits                           | 32,64 bits                            |
| 'signed'                        | 16, 24, 32, 40, 48, 56, 64 bits       | 8, 16, 24, 32, 40, 48, 56, 64 bits    |
| 'unsigned'                      | 16, 24, 32, 40, 48, 56, 64 bits       | 8, 16, 24, 32, 40, 48, 56, 64 bits    |
| 'binary'                        | 16, 24, 32, 40, 48, 56, 64 bits       | 8, 16, 24, 32, 40, 48, 56, 64 bits    |
| 'fract'                         |                                       |                                       |

Using the properties of the objects, you change the word size by changing the value of the storageunitspvalue property of the object. Note that you

cannot change the `bitsperstorageunit` property value, which depends on the processor and whether the object represents a memory location or a register.

`cast` applies to any object that has the `represent`, `storagepervalue`, and `wordsize` properties. `function`, `ccsdsp`, and `rtdx` objects do not use the `represent` property and do not support `cast`.

A note—you could change the properties for `objname2` directly with `set` when you work with less common data types. Generally, we recommend you use `cast` to change the data type for an object, and consider `convert` as well.

`objname2 = cast(objname, datatype, size)` returns `objname2`, a copy of `objname`, with the specified data type for the `represent`, `storagepervalue`, and `wordsize` properties, and the `size` property value set to `size`. For bitfield objects, `size` is always 1.

## Using cast with pointer and rpointer Objects

Working with pointer objects and register pointer (`rpointer`) objects is slightly different from using `cast` with numeric objects.

When you cast a pointer object, the results depend on the data type you specify to cast to in the syntax:

- When you specify a valid pointer type for your new pointer or `rpointer` object, `cast` creates the new pointer or `rpointer` object as a pointer type. Valid pointer data types are `datatype *`—you include the asterisk to indicate this is a pointer.
- When you specify a nonpointer data type for your new object, `cast` creates a new object that is no longer a pointer and does not access the referent that the original object accessed. Trying to cast to a nonpointer data type causes an error in MATLAB. Data types that do not support pointers are
  - All C native data types without the asterisk that indicates this is a pointer
  - `enum` (enumerated)
  - `string`
  - `struct`

## Examples

If your project includes the variables used in the three examples that follow, try them out to see `cast` at work. Without the specified variables, the examples do not run—read the examples to see the input and output from `cast`.

### Cast the Data Type from int16 to Q0.31

After you create a ccsdsp object, use cast to recast a variable from data type int16 to Q0.31.

Create the int16 indirectly since you cannot create handles to int16 data types in one step:

```
g_int16=createobj(cc,'g_float')
convert(g_int16,'int16')
cast(g_int16,'Q0.31')
```

### Cast the Data Type from signed char to Q0.15

After you create a ccsdsp object, use cast to recast a variable from data type signed char to Q0.15.

Create the unsigned char from a signed char and cast from there to Q0.15:

```
g_uchar=createobj(cc,'g_schar')
cast(g_uchar,'Q0.15')
```

### Cast the Data Type from double to uint32

After you create a ccsdsp object, use cast to recast a variable from data type double to uint32.

Create the double data type variable and cast it to a uint32:

```
g_double=createobj(cc,'double')
cast(g_double,'uint32')
```

### See Also

convert

# ccsboardinfo

---

**Purpose** Return information about all boards and simulators known to CCS IDE

**Syntax**  
`ccsboardinfo`  
`boards = ccsboardinfo`

**Description** `ccsboardinfo` returns configuration information about each board and processor installed and recognized by CCS. When you issue the function, `ccsboardinfo` returns the following information about each board or simulator.

| <b>Installed Board Configuration Data</b> | <b>Configuration Item Name</b> | <b>Description</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|-------------------------------------------|--------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Board number                              | boardnum                       | The number that CCS assigns to the board or simulator. Board numbering starts at 0 for the first board. This is also a property used when you create a new link to CCS IDE.                                                                                                                                                                                                                                                                                                                                                                                              |
| Board name                                | boardname                      | The name assigned to the board or simulator. Usually, the name is the board model name, such as TMS320C67xx evaluation module. If you are using a simulator, the name tells you which processor the simulator matches, such as C67xx simulator. If you renamed the board during setup, your assigned name appears here.                                                                                                                                                                                                                                                  |
| Processor number                          | procnum                        | The number assigned by CCS to the processor on the board or simulator. When the board contains more than one processor, CCS assigns a number to each processor, numbering from 0 for the first processor on the first board. For example, when you have two recognized boards, and the second has two processors, the first processor on the first board is <code>procnum=0</code> , and the first and second processors on the second board are <code>procnum=1</code> and <code>procnum=2</code> . This is also a property used when you create a new link to CCS IDE. |

| Installed Board Configuration Data | Configuration Item Name | Description                                                                                      |
|------------------------------------|-------------------------|--------------------------------------------------------------------------------------------------|
| Processor name                     | procname                | Provides the name of the processor. Usually the name is CPU, unless you assign a different name. |
| Processor type                     | proctype                | Gives the processor model, such as TMS320C6x1x for the C6xxx series processors.                  |

Each row in the table that you see displayed represents one digital signal processor, either on a board or simulator. As a consequence, you use the information in the table in the function `ccsdsp` to target a selected board in your PC.

`boards = ccsboardinfo` returns the configuration information about your installed boards in a slightly different manner. Rather than returning the table containing the information, you get a listing of the board names and numbers, where each board has an associated structure named `proc` that contains the information about each processor on the board. For example

```
boards = ccsboardinfo
```

returns

```
boards =
 name: 'C6xxx Simulator (Texas Instruments)'
 number: 0
 proc: [1x1 struct]
```

where the structure `proc` contains the processor information for the C6xxx simulator board:

```
boards.proc
ans =
 name: 'CPU'
 number: 0
 type: 'TMS320C6200'
```

# ccsboardinfo

Reviewing the output from both function syntaxes shows that the configuration information is the same.

When you combine this syntax with the dot notation used to access the elements in a structure, the result is a way to determine which board to connect to when you construct a link to CCS IDE. For example, when you are creating a link to a board in your PC, the dot notation provides the means to set the target board by issuing the command with the boardnum and procnum properties set to the entries in the structure boards. For example, when you enter

```
boards = ccsboardinfo;
```

`boards(1).name` returns the name of your second installed board and `boards(1).proc(2).name` returns the name of the second processor on the second board. To create a link to the second processor on the second board, use

```
cc = ccspd('boardnum',boards(1).number,'procnum',...
boards(1).proc(2).name);
```

## Examples

On a PC with both a simulator and a DSP Starter Kit (DSK) board installed,

```
ccsboardinfo
```

returns something similar to the following table. Your display may differ slightly based on what you called your boards when you configured them in CCS Setup Utility:

| Board Num | Board Name                         | Proc Num | Processor Name | Processor Type |
|-----------|------------------------------------|----------|----------------|----------------|
| 1         | C6xxx Simulator (Texas Instrum ... | 0        | CPU            | TMS320C6200    |
| 0         | DSK (Texas Instruments)            | 0        | CPU_3          | TMS320C6x1x    |

When you have one or more boards that have multiple CPUs, `ccsboardinfo` returns the following table, or one similar to it:

| Board Num | Board Name                         | Proc Num | Processor Name | Processor Type |
|-----------|------------------------------------|----------|----------------|----------------|
| 2         | C6xxx Simulator (Texas Instrum ... | 0        | CPU            | TMS320C6200    |
| 1         | C6xxx EVM (Texas Instrum ...       | 1        | CPU_Primary    | TMS320C6200    |
| 1         | C6xxx EVM (Texas Instrum ...       | 0        | CPU_Secondary  | TMS320C6200    |



```
0 C64xx Simulator (Texas Instru... 0 CPU TMS320C64xx
```

In this example, board number 1 returns two defined CPUs: CPU\_Primary and CPU\_Secondary. Note that the C6xxx does not in fact have two CPUs; we defined a second CPU for this example.

To demonstrate the syntax `boards = ccsboardinfo`, this example assumes a PC with two boards installed, one of which has three CPUs.

Type

```
ccsboardinfo
```

at the MATLAB prompt. You get

| Board Num | Board Name                         | Proc Num | Processor Name | Processor Type |
|-----------|------------------------------------|----------|----------------|----------------|
| 1         | C6xxx Simulator (Texas Instrum ... | 0        | CPU            | TMS320C6211    |
| 0         | C6211 DSK (Texas Instruments)      | 2        | CPU_3          | TMS320C6x1x    |
| 0         | C6211 DSK (Texas Instruments)      | 1        | CPU_4_1        | TMS320C6x1x    |
| 0         | C6211 DSK (Texas Instruments)      | 0        | CPU_4_2        | TMS320C6x1x    |

Now type

```
boards = ccsboardinfo
```

MATLAB returns

```
boards=
2x1 struct array with fields
 name
 number
 proc
```

showing that you have two boards in your PC.

Use the dot notation to determine the names of the boards:

```
boards.name
```

returns

```
ans=
C6xxx Simulator (Texas Instruments)
```

```
ans=
C6211 DSK (Texas Instruments)
```

To identify the processors on each board, again use the dot notation to access the processor information. You have two boards (numbered 0 and 1). Board 0 has three CPUs defined for it. To determine the type of the second processor on board 0 (the board whose boardnum = 0), enter

```
boards(2).proc(1)
```

which returns

```
ans=
 name: 'CPU_3'
 number: 1
 type: 'TMS320C6x1x'
```

Recall that

```
boards(2).proc
```

gives you this information about the board

```
ans=
3x1 struct array with fields:
 name
 number
 type
```

indicating that this board has three processors (the 3x1 array).

The dot notation is useful for accessing the contents of a structure when you create a link to CCS IDE. When you use `ccsdsp` to create your CCS link, you can use the dot notation to tell CCS IDE which processor you are targeting.

```
cc = ccsdsp('boardnum',boards(1).proc(1))
```

## See Also

`info`, `ccsdsp`

**Purpose** Create a link to CCS IDE

**Syntax**

```
cc = ccspdsp
cc = ccspdsp('propertyname', 'propertyvalue', ...)
```

**Description** `cc = ccspdsp` returns a handle (or object or link) in `cc` that MATLAB uses to communicate with the default processor. In the case of no input arguments, `ccspdsp` constructs the object with default values for all properties. CCS IDE handles the communications between MATLAB and the target CPU. When you use the function, `ccspdsp` starts CCS IDE if it is not running. If `ccspdsp` opened an instance of the CCS IDE when you issued the `ccspdsp` function, CCS IDE becomes invisible after Link for Code Composer Studio creates the new object.

---

**Note** When `ccspdsp` creates the link `cc`, it sets the working directory for CCS IDE to be the same as your MATLAB working directory. This can have consequences when you create files or projects in CCS IDE, or save files and projects.

---

Each link to CCS IDE you create comprises two objects—a `ccspdsp` object and an `rt dx` object—that include the following properties.

| Object                      | Property Name | Property       | Default | Description                                                         |
|-----------------------------|---------------|----------------|---------|---------------------------------------------------------------------|
| <code>ccspdsp</code> object | 'apiversion'  | API version    | N/A     | Defines the API version used to create the link                     |
|                             | 'proctype'    | Processor Type | N/A     | Specifies the kind of processor on the target board                 |
|                             | 'procname'    | Processor Name | CPU     | Name given to the processor on the board to which this object links |

| Object      | Property Name | Property                    | Default                                     | Description                                                                                            |
|-------------|---------------|-----------------------------|---------------------------------------------|--------------------------------------------------------------------------------------------------------|
|             | 'status'      | Running                     | No                                          | Status of the program currently loaded on the processor                                                |
|             | 'boardnum'    | Board Number                | 0                                           | Number that CCS assigns to the board. Used to identify the board                                       |
|             | 'procnum'     | Processor number            | 0                                           | Number the CCS assigns to a processor on a board                                                       |
|             | 'timeout'     | Default time-out            | 10.0 s                                      | Specifies how long MATLAB waits for a response from CCS after issuing a request                        |
| rtdx object | 'timeout'     | Time-out                    | 10.0 s                                      | Specifies how long CCS waits for a response from the processor after requesting data                   |
|             | 'numchannels' | Number of open channels     | 0                                           | The number of open channels using this link                                                            |
| type object | type          | Defined types in the object | Void, Float, Double, Long, Int, Short, Char | List of the C types in the project cc accesses. Use add to include your C type definitions to the list |

`cc = ccsdsp('propertyname', 'propertyvalue', ...)` returns a handle in `cc` that MATLAB uses to communicate with the specified processor. CCS handles the communications between MATLAB and the target CPU.

MATLAB treats input parameters to `ccsdsp` as property definitions. Each property definition consists of a property name/property value pair.

Two properties of the `ccsdsp` handle are read only after you create the handle:

- 'boardnum' — the identifier for the installed board selected from the active boards recognized by CCS. If you have one board, use the default property value 0 to access the board.
- 'procnum' — the identifier for the processor on the board defined by boardnum. On boards with more than one processor, use this value to specify the target processor on the board. On boards with one processor, use the default property value 0 to specify the processor.

Given these two properties, the most common forms of the `ccsdsp` method are

```
cc = ccsdsp('boardnum',value)
cc = ccsdsp('boardnum',value,'procnum',value)
```

which specify the target board, and processor in the second example, as the target.

You do not need to specify the `boardnum` and `procnum` properties when you have one board with one processor installed. The default property values refer correctly to the processor on the board.

---

**Note** Simulators count as boards. If you defined both boards and simulators in CCS IDE, specify the `boardnum` and `procnum` properties to connect to specific boards or simulators. Use `ccsboardinfo` to determine the values for the `boardnum` and `procnum` properties of your boards and simulators.

---

Because these properties are read only after you create the handle, you must set these property values as input arguments when you use `ccsdsp`. You cannot change these values after the handle exists. After you create the handle, use the `get` function to retrieve the `boardnum` and `procnum` property values.

### Using `ccsdsp` with multiple processor targets

When you create `ccsdsp` objects that access targets that contain more than one processor, such as the OMAP1510 platform, `ccsdsp` behaves a little differently.

For each of the `ccsdsp` syntaxes above, the result of the method changes in the multiple processor case, as follows.

```
cc = ccsdsp
cc = ccsdsp('propertyname',propertyvalue)
cc = ccsdsp('propertyname',propertyvalue,'propertyname',...
propertyvalue)
```

In the case where you do not specify a board or processor:

```
cc = ccsdsp
Array of CCSDSP Objects:
 API version : 1.2
 Board name : OMAP 3.0 Platform Simulator [Texas
Instruments]
 Board number : 0
 Processor 0 (element 1) : TMS470R2127 (MPU, Not Running)
 Processor 1 (element 2) : TMS320C5500 (DSP, Not Running)
```

Where you choose to identify your target as an input argument to `ccsdsp`, for example, when your target board contains two processors:

```
cc = ccsdsp('boardnum',2)
Array of CCSDSP Objects:
 API version : 1.2
 Board name : OMAP 3.0 Platform Simulator [Texas
Instruments]
 Board number : 2
 Processor 0 (element 1) : TMS470R2127 (MPU, Not Running)
 Processor 1 (element 2) : TMS320C5500 (DSP, Not Running)
```

`cc` returns a two element object handle with `cc(1)` corresponding to the first processor and `cc(2)` corresponding to the second.

You can include both the board number and the processor number in the `ccsdsp` syntax, as shown here:

```
cc = ccsdsp('boardnum',2,'procnum',[0 1])
Array of CCSDSP Objects:
 API version : 1.2
 Board name : OMAP 3.0 Platform Simulator [Texas
Instruments]
 Board number : 2
 Processor 0 (element 1) : TMS470R2127 (MPU, Not Running)
 Processor 1 (element 2) : TMS320C5500 (DSP, Not Running)
```

Enter `procnum` as either a single processor on the board (a single value in the input arguments to specify one processor) or a vector of processor numbers, as shown in the example, to select two or more processors.

## Support Co-emulation

Co-emulation, defined by Texas Instruments to mean simultaneous debugging of two or more CPUs, allows you to coordinate your debugging efforts between two or more processors within one device. Efficient development with OMAP™ hardware requires co-emulation support. Instead of creating one cc object when you issue the command

```
cc = ccsdsp
```

or your target that has multiple processors, the resulting cc object comprises a vector of cc objects cc(1), cc(2), and so on, each of which accesses one processor on your target device, say an OMAP1510. When your target has one processor, cc is a single object. With a multiprocessor target, the cc object returns the new vector of objects. For example, for board 2 with two processors,

```
cc = ccsdsp
```

returns the following information about the board and processors:

```
cc = ccsdsp('boardnum',2)
Array of CCSDSP Objects:
API version : 1.2
Board name : OMAP 3.0 Platform Simulator [Texas
Instruments]
Board number : 2
Processor 0 (element 1) : TMS470R2127 (MPU, Not Running)
Processor 1 (element 2) : TMS320C5500 (DSP, Not Running)
```

Checking the existing boards shows that board 2 does have two processors:

```
ccsboardinfo
```

| Board Num | Board Name                         | Proc Num | Processor Name | Processor Type |
|-----------|------------------------------------|----------|----------------|----------------|
| 2         | OMAP 3.0 Platform Simulator [T ... | 0        | MPU            | TMS470R2x      |
| 2         | OMAP 3.0 Platform Simulator [T ... | 1        | DSP            | TMS320C550     |
| 1         | MGS3 Simulator [Texas Instruments] | 0        | CPU            | TMS320C5500    |
| 0         | ARM925 Simulator [Texas Instru ... | 0        | CPU            | TMS470R2x      |

## Examples

On a system with three boards, where the third board has one processor and the first and second boards have two processors each, the function

```
cc = ccsdsp('boardnum',1,'procnum',0);
```

returns a handle to the first processor on the second board. Similarly, the function

```
cc = ccsdsp('boardnum',0,'procnum',1);
```

returns a handle to the second processor on the first board.

To access the processor on the third board, use

```
cc = ccsdsp('boardnum',2);
```

which sets the default property value `procnum=0` to connect to the processor on the third board.

When you use `get` with the object, MATLAB returns the properties for the object, and the property values.

```
cc = ccsdsp
CCSDSP Object:
 API version : 1.2
 Processor type : TMS320C6711
 Processor name : CPU_1
 Running? : No
 Board number : 1
 Processor number : 0
 Default timeout : 10.00 secs
```

```
RTDX channels : 0
```

```
get(cc)
 rtdx: [1x1 rtdx]
 apiversion: [1 2]
 ccsappexe: 'D:\Applications\ti\cc\bin\'
 boardnum: 1
 procnum: 0
 type: [1x1 type]
 timeout: 10
 page: 0
```

```
cc.type % Returns information about the type object
```



Defined types : Void, Float, Double, Long, Int, Short, Char

**See Also**

get, ccsboardinfo, createobj, set

# cd

---

**Purpose** Change the CCS IDE working directory

**Syntax**

```
cd(cc, 'directory')
wd = cd(cc, 'directory')
cd(cc, pwd)
```

**Description** `cd(cc, 'directory')` changes the CCS IDE working directory to the directory identified by the string `dir`. For the change to take effect, `dir` must refer to an existing directory. You can give the directory string either as a relative pathname or an absolute pathname including the drive letter. CCS IDE applies relative pathnames from the current working directory.

`wd = cd(c, 'directory')` returns the current CCS IDE working directory in `wd`.

Using `cc` to change the CCS IDE working directory does not affect your MATLAB working directory or any MATLAB paths. Use the following function syntax to set your CCS IDE working directory to match your MATLAB working directory.

`cd(cc, pwd)` where `pwd` calls the MATLAB function `pwd` that shows your present MATLAB working directory and changes your current CCS IDE working directory to match the pathname returned by `pwd`.

**Examples** When you open a project in CCS IDE, the folder containing the project becomes the current working folder in CCS IDE. Try opening the tutorial project `volume.mak` in CCS IDE. `volume.mak` is in the tutorial files from CCS IDE. When you check the working directory for CCS IDE in MATLAB, you see something like the following result

```
wd=cd(cc)

wd =

D:\ticcs\c6000\tutorial\volume1
```

where the drive letter `D` may be different based on where you installed CCS IDE.

Now check your MATLAB working directory:

```
pwd

ans =

J:\bin\win32
```

Your CCS IDE and MATLAB working directories are not the same. To make the directories the same, use the `cd(cc,pwd)` syntax:

```
cd(cc,pwd) % Set CCS IDE to use your MATLAB working directory.
pwd % Check your MATLAB working directory.
```

```
ans =

J:\bin\win32
```

```
cd(cc) % Check your CCS IDE working directory.
```

```
ans =

J:\bin\win32
```

You have set CCS IDE and MATLAB to use the same working directory.

## See Also

`dir`, `load`, `open`

**Purpose** Execute C or General Extension Language (GEL) expressions on the target

**Syntax**

```
result = cexpr(cc, 'expression', timeout)
result = cexpr(cc, 'expression')
```

**Description** `result = cexpr(cc, 'expression', timeout)` executes the specified expression on the target processor referred to by `cc` and returns a result. If your program includes data in complex data structures and arrays, `cexpr` offers one way to access the data.

To run `cexpr` on your target, you must load a program to the processor. Your target processor does not need to be running the loaded program to execute `cexpr`. In operation `cexpr` is equivalent to using the **CCS Command Line** dialog. Refer to your CCS documentation for more information about using the command line in CCS.

When you place single quotation marks around the expression argument, MATLAB ignores the enclosed string, passing it to your target. The target processor evaluates the expression and returns the result to MATLAB. Any part of the expression argument that is not in single quotation marks gets evaluated by MATLAB and sent to the target processor along with the quoted portion. Using single quotation marks, you can combine MATLAB, GEL, and C expressions within one `cexpr` command so that MATLAB sets a value on the target. The target uses the value and returns the result to your MATLAB workspace. Refer to “Examples” for a code example that mixes C and MATLAB functions in one command.

After you execute the function, MATLAB waits `timeout` seconds for CCS to confirm successful completion of the operation. If the wait exceeds `timeout` seconds, MATLAB returns an error. Often, the time-out error means the confirmation was delayed but the operation succeeded.

Enter `expression` as a string in single quotation marks defining either a C expression, a GEL command, or a combination of both C and GEL. CCS defines the syntax for `expression` as either

- A string with C syntax, whose variables reside in the local scope of the target processor
- A routine mapped to GEL functions defined in the current CCS project

`result = cexpr(cc, 'expression')` is the same as the preceding syntax except the timeout value defaults to the global time-out in `cc`. Use `get(cc)` to determine the global time-out value.

When you use `cexpr`, a few points can help you work effectively:

- `cexpr` returns a result in MATLAB when you use a C statement as the expression argument. In the first example syntax in “Examples”, `result = cexpr(cc, 'x.a')`, MATLAB returns `result =` the value of `x.a` on the target. In more concrete form, the syntax `result = cexpr(cc, 'x.b=10')` sets `x.b` to 10 on the target and returns `result = 10` to your MATLAB workspace.
- When your expression arguments are GEL functions, `cexpr` does not return results to MATLAB.
- Combining C and MATLAB expressions requires that you use single quotation marks around the C expressions to isolate them from the MATLAB interpreter. MATLAB performs the functions it understands and then passes the rest to the target for evaluation. The target returns the result to MATLAB.
- Pay attention to the scope of the program you are accessing. Only variables within the current scope of the program in CCS and on the target respond to `cexpr`. To access variables using `cexpr`, the variables must be either global or within the current scope. When you try to read or write to a variable outside the current scope, MATLAB returns errors like the following:
 

```
??? EvalC: identifier not found: variablename.
??? EvalC: line(1), unexpected token: variablename.
```

Generally, variables within the program main are available without extra effort. To get to variables defined locally in subprograms, use breakpoints and the `runtohalt` input option in `run` to set your program to the right scope, then use `cexpr` to return the information.

For more information on GEL and GEL files, refer to your CCS documentation.

## Examples

`cexpr` covers a broad range of uses. To introduce some of the possibilities, the following examples use both the C expression and GEL expression forms.

## cexpr

---

Because executing the examples requires that specific variables and functions exist on the target, you cannot execute the code shown.

| <b>cexpr Syntax</b>                                    | <b>Description</b>                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
|--------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <pre>result = cexpr(cc, 'x.a')</pre>                   | Returns the value of field <code>a</code> in structure <code>x</code> stored on your target. For this example, expression is <code>x.a</code> and <code>result</code> contains the value stored in <code>x.a</code> on the target.                                                                                                                                                                                                                                                            |
| <pre>result = cexpr(cc, 'StartUp()')</pre>             | Executes the GEL function <code>StartUp</code> on the target processor. expression is <code>'StartUp'</code> , a function in the GEL file that loads each time you start CCS. Note that GEL function names are case sensitive — <code>StartUp</code> is not the same as <code>startup</code> . In this example, <code>result</code> is <code>NULL</code> or empty because GEL functions do not generate return values. Do not use an output argument with GEL expressions as input arguments. |
| <pre>result = cexpr(cc, 'x.b = 10')</pre>              | Sets and returns the value of the field <code>b</code> in structure <code>x</code> . Here the assignment statement in single quotation marks replaces expression. <code>x.b</code> must be a structure in memory on your target and in the current program scope. After execution, <code>result</code> contains the value <code>10</code> returned from the target.                                                                                                                           |
| <pre>result = cexpr(cc, ['x.c[2] =' int2str(z)])</pre> | Sets the value of <code>x.c[2]</code> to the string represented by integer <code>z</code> . In MATLAB, <code>result</code> contains the value stored in <code>x.c[2]</code> as returned from the target. Notice that the C expression is in single quotation marks, and the MATLAB <code>int2str</code> is not. Using single quotation marks directs MATLAB to ignore the C string that applies to the target processor and to evaluate <code>int2str</code> .                                |

A note about the final example — the variable `z` must be in your MATLAB workspace for `int2str` to work. In contrast, `x.c[2]` defines a value on your target, not in MATLAB.

**See Also**

`address`, `read`, `write`

# cleanup

---

**Purpose** Return CCS to the state before running the function

**Syntax** `cleanup(ff)`

**Description** `cleanup(ff)` returns CCS to the state it was in before running or executing the function accessed by `ff`. After `cleanup`, the saved registers for your program are restored to their state before you ran `ff`. Using `cleanup` is entirely optional after `run` or `execute`.

**See Also** `execute`, `run`



---

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Remove links to CCS IDE and RTDX interface, or clear type entries in type objects                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>Syntax</b>      | <pre>clear(cc) clear('all') clear(cc.type, 'all') clear(cc.type, typedefname)</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Description</b> | <p><code>clear(cc)</code> clears the link associated with <code>cc</code>. This is the last step in any development effort that uses links. Clear links that you no longer need for your work to avoid unforeseen problems. Calling <code>clear</code> executes the object destructors that delete the link object and all associated memory and resources.</p> <p><code>clear('all')</code> clears all existing links to CCS IDE and RTDX interface. This is the final step in any development process that uses links. Clear links that you no longer need for your work to avoid unforeseen problems. Calling <code>clear</code> with the <code>'all'</code> option executes the object destructors to delete all the link objects and all associated memory and resources.</p> <hr/> <p><b>Note</b> If a link exists when you close CCS IDE, the application does not close. Microsoft Windows moves it to the background (it becomes invisible). Only after you clear all open links to CCS IDE, or close MATLAB, does closing CCS IDE actually close the application. You can check to see if CCS IDE is running by checking the Microsoft Windows Task Manager.</p> <hr/> |
|                    | <p><code>clear(cc.type, 'all')</code> clears all user-defined type entries in the type object <code>obj</code>.</p> <p><code>clear(cc.type, typedefname)</code> clears the information on the specified user-defined type entry <code>typedefname</code> in the type object <code>obj</code>.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                |
| <b>See Also</b>    | <code>add</code> , <code>ccsdsp</code> , <code>close</code> , <code>disable</code> , <code>gettypeinfo</code>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

# close

---

**Purpose** Close files in CCS IDE or an open RTDX channel

**Syntax**

```
close(cc, 'filename', 'type')
close(rx, 'channel1', 'channel2', ...)
close(rx, 'channel')
```

**Description** `close(cc, 'filename', 'type')` closes the file in CCS IDE identified by `filename` of type `'type'`. `type` identifies the type of file to close. This can be either project files when you use `'project'` for the type option, or text files when you use `'text'` for the type option. To close a specific file in CCS IDE, `filename` must match exactly the name of the file to close. If you replace `filename` with `'all'`, `close` terminates every open file whose type matches the type option. File types recognized by `close` include these extensions.

| <b>type String</b>     | <b>Affected files</b>                                                                                                                                                                                                                                                                                                             |
|------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>'project'</code> | Project files with the <code>.pjt</code> extension.                                                                                                                                                                                                                                                                               |
| <code>'text'</code>    | All files with these extensions — <code>.a*</code> , <code>.c</code> , <code>.cc</code> , <code>.ccx</code> , <code>.cdb</code> , <code>.cmd</code> , <code>.cpp</code> , <code>.lib</code> , <code>.o*</code> , <code>.rcp</code> , and <code>.s*</code> . Note that <code>'text'</code> does not close <code>.cfg</code> files. |

When you replace `filename` with the null entry `[]`, `close` shuts the current active file window in CCS IDE. When you specify `'project'` for the type option, it closes the active project.

---

**Note** `close` does not save files before shutting them. Closing files can result in lost data if you have changed the files since you last saved them. Use `save` to ensure that your changes are preserved before you close files that are open.

---

`close(rx, 'channel1', 'channel2', ...)` closes the channels specified by the strings `channel1`, `channel2`, and so on as defined in `rx`.

`close(rx, 'channel')` closes the specified channel. When you set `channel` to `'all'`, this function closes all the open channels associated with `rx`.

To avoid conflicts, do not name channels “all” or “ALL.”

**Examples****Using close with Files and Projects**

To clarify the different close options, here are six commands that close open files or projects in CCS IDE.

| <b>Command</b>                                  | <b>Result</b>                                                                               |
|-------------------------------------------------|---------------------------------------------------------------------------------------------|
| <code>close(cc, 'all', 'project')</code>        | Close all open projects in CCS IDE.                                                         |
| <code>close(cc, 'my.pjt', 'project')</code>     | Close the project <code>my.pjt</code> .                                                     |
| <code>close(cc, [], 'project')</code>           | Close the active project.                                                                   |
| <code>close(cc, 'all', 'text')</code>           | Close all open text files. This includes source file, libraries, command files, and others. |
| <code>close(cc, 'my_source.cpp', 'text')</code> | Close the text file <code>my_source.cpp</code> .                                            |
| <code>close(cc, [], 'text')</code>              | Close the active file window.                                                               |

**Using close with RTDX**

When you plan to use RTDX to communicate with a target, you open and enable channels to the board and processor. For example, to communicate with the processor on your installed board, you use `open` to set up a channel, as follows:

```
cc = cc dsp('boardnum',1,'procnum',0)
rx=cc.rtdx % Create an alias to the RTDX portion of this link.
open(rx,'ichan','w') % Open a channel for write access.
enable(rx,'ichan') % Enable the open channel for use.
```

After you finish using the open channel, you must close it to avoid difficulties later on.

```
close(rx,'ichan')
```

Or to close all open channels, you could use

```
close(rx,'all')
```

**See Also**

`disable`, `open`

# configure

---

**Purpose** Define the size and number of RTDX channel buffers

**Syntax** `configure(rx,length,num)`

**Description** `configure(rx,length,num)` sets the size of each main (host) buffer, and the number of buffers associated with `rx`. Input argument `length` is the size in bytes of each channel buffer and `num` is the number of channel buffers to create.

Main buffers must be at least 1024 bytes, with the maximum defined by the largest message. On 16-bit processors, the main buffer must be four bytes larger than the largest message. On 32-bit processors, set the buffer to be eight bytes larger than the largest message. By default, `configure` creates four, 1024-byte buffers. Independent of the value of `num`, CCS IDE allocates one buffer for each processor.

Use CCS to check the number of buffers and the length of each one.

**Examples** Create a default link to CCS and configure six main buffers of 4096 bytes each for the link.

```
cc=ccsdsp % Create the CCS link with default values.

CCSDSP Object:
 API version : 1.0
 Processor type : C67
 Processor name : CPU
 Running? : No
 Board number : 0
 Processor number : 0
 Default timeout : 10.00 secs

 RTDX channels : 0

rx=cc.rtdx % Create an alias to the rtdx portion.

RTDX channels : 0

configure(rx,4096,6) % Use the alias rx to configure the length
 % and number of buffers.
```

After you configure the buffers, use the RTDX tools in CCS IDE to verify the buffers.

**See Also**

readmat, readmsg, write, writemsg

# convert

---

**Purpose** Change the represent property for an object from one data type to another

**Syntax**  
`convert(objname, datatype)`  
`convert(objname, datatype, size)`

**Description** `convert(objname, datatype)` returns `objname` with the `represent` property changed to the data type specified by `datatype`. Input argument `datatype` can be any supported data type. After you change the data type specified in `represent`, read or write operations apply the appropriate data conversion to implement on the target the data type specified by the `represent` property.

---

**Note** `pointer` and `rpointer` objects respond differently when you use `convert`. Refer to “Using `convert` with `pointer` and `rpointer` Objects” for more information about the supported data types for `pointer` or `rpointer` objects and how `convert` behaves with different data types.

---

The following data types work as input arguments to `convert`.

| <b>datatype String</b> | <b>represent Property Value</b> |
|------------------------|---------------------------------|
| 'double'               | 'float'                         |
| 'single'               | 'float'                         |
| 'int32'                | 'signed'                        |
| 'int16'                | 'signed'                        |
| 'int8'                 | 'signed'                        |
| 'uint32'               | 'unsigned'                      |
| 'uint16'               | 'unsigned'                      |
| 'uint8'                | 'unsigned'                      |
| 'long double'          | 'float'                         |
| 'float'                | 'float'                         |

| <b>datatype String</b> | <b>represent Property Value</b> |
|------------------------|---------------------------------|
| 'long'                 | 'signed'                        |
| 'int'                  | 'signed'                        |
| 'char'                 | 'signed'/'unsigned'             |
| 'unsigned long'        | 'signed'                        |
| 'unsigned int'         | 'unsigned'                      |
| 'unsigned char'        | 'unsigned'                      |
| 'Q0.15'                | 'fract'                         |
| 'Q0.31'                | 'fract'                         |

Various TI processors restrict the sizes of the data types used by objects in Link for Code Composer Studio. Shown in the next table, the processor families restrict the valid word sizes for the listed data types.

#### Word size limits for supported processors

| <b>represent Property Value</b> | <b>C2x</b>  | <b>C54</b>  | <b>C55</b>          | <b>C6x</b>             |
|---------------------------------|-------------|-------------|---------------------|------------------------|
| 'float'                         | 32 bits     | 32 bits     | 32 bits             | 32, 64 bits            |
| 'signed'                        | 16, 32 bits | 16, 32 bits | 16, 32, 40, 64 bits | 8, 16, 32, 40, 64 bits |
| 'unsigned'                      | 16, 32 bits | 16, 32 bits | 16, 32, 40, 64 bits | 8, 16, 32, 40, 64 bits |
| 'fract'                         | 16, 32bits  | 16, 32 bits | 16, 32              | 16, 32 bits            |

Using the properties of the objects, you change the word size by changing the value of the `storageunitspervalue` property of the object. Note that you cannot change the `bitsperstorageunit` property value, which depends on the processor and whether the object represents a memory location or a register.

Pointer objects, both data and numeric, usually use fewer than 32 bits, such as 22 or 23 bits, but are incorporated in 32-bit words.

`convert` applies to any object that has the `represent` property. `function`, `ccdsp`, and `rt dx` objects do not use the `represent` property and do not support `convert`.

`convert(objname, datatype, size)` returns `objname` with the specified data type for the `represent` property, and the `size` property value set to `size`.

## Using `convert` with pointer and register pointer Objects

Working with pointer objects and register pointer (`rpointer`) objects is slightly different from using `convert` with numeric objects.

---

**Note** `convert` does not support pointers to `void`, that is, pointers of the form `void *`. Before you convert a pointer to `void`, change the pointer to a valid data type, such as `int *` or `char *`.

---

When you convert a pointer object, the results depend on the data type you specify to convert to in the syntax:

- When you specify a valid pointer type for your converted pointer or `rpointer` object, `convert` changes the data type of the pointer and it remains a pointer.
- When you specify a nonpointer data type for your converted object, `convert` changes the `referent` or `regstring` properties of your pointer object, changing the data type of the referent (the value the pointer refers to) and your object is no longer a pointer. Therefore, use `convert` to change pointer or `rpointer` objects to nonpointer objects. You can convert to any data type, such as:
  - All C native data types without the asterisk that indicates this is a pointer
  - `enum` (enumerated)
  - `string`
  - `struct`

## See Also

`cast`



**Purpose**            Make a copy of an object

**Syntax**            `objname2 = copy(objname)`

**Description**        `objname2 = copy(objname)` returns `objname2`, which is a copy of the input object specified by `objname`. All objects in the Link for Code Composer Studio support the `copy` function. Note that `objname2` is independent of the original; it is not an alias to the original `objname`. When you change a property of `objname2`, you are not changing the same property in `objname`.

**See Also**            `createobj`

# createobj

---

## Purpose

Create MATLAB objects that represent embedded data or functions in a program on your target

## Syntax

```
objname = createobj(cc,'symbolname');
objname = createobj(cc,'symbolname','option');
objname = createobj(cc,'functionname','function','funcdecl',...
 'function_declaration_string');
objname = createobj(cc,functionname,'function','allocate',...
 {'input',value1,'input2',value2, });
```

## Description

`objname = createobj(cc,'symbolname')` makes an object in your MATLAB workspace named `objname`. Your new object contains information about the program symbol defined by `symbolname`. To use `createobj` successfully, you must have loaded a `.out` file to your target in CCS, and the symbol must be in the current symbol table in CCS.

`symbolname` can be any variable name or function name. By default, the embedded variable object returned accesses a variable within the current program scope.

Depending on the variable type and the storage used (register, memory, structure, function) for the variable, `createobj` generates an object that is one of the following kinds of objects:

- Memory object—access any symbol that resides in DSP memory
- Register object—access any symbols that reside in DSP registers
- Structure object—container class that accesses any symbol stored as a C struct type or C union type
- Function object—access any callable C function or assembly function that has a C prototype

### Memory Objects

You do not create memory objects directly. Rather, you use `createobj` to make objects that are derived classes of memory objects:

- Numeric class objects—objects that access primitive data type variables, such as floats, ints, and shorts.  
Numeric class objects also have derived classes:

- Pointer class objects—objects that access pointer data types (unsigned integers)
- Enum class objects—objects that access enumerated data types (integers)
- String class objects—objects that access string data types (characters)
- Bitfield class objects—objects that access bitfield data types

### Register Objects

Like memory objects, you cannot instantiate a register object directly. Using `createobj`, you create a derived class object that accesses variables stored in registers on the processor.

- Rnumeric class objects—objects that access primitive data type variables, such as floats, ints, and shorts  
Rnumeric class objects have derived classes just like numeric objects:
  - Rpointer class objects—objects that access pointer data types (unsigned integers)
  - Renum class objects—objects that access enumerated data types (integers)
  - Rstring class objects—objects that access string data types (characters)

It should be clear that register objects differ from memory objects only in the kind of data storage they access—registers versus memory locations.

Otherwise, many of the properties and methods of the two object classes are the same.

### Structure Objects

Acting as a container class, structure objects hold either memory objects or register objects, as defined in the descriptions of both objects. Unlike memory or register objects, you create structure objects directly when you use `createobj` to access a C struct or C union data type variable.

### Function Objects

When you create an object that accesses a C function in your program, `createobj` returns a function object, whose properties and methods provide information about and the ability to manipulate the target function. Your target can be any function in your code, whether a library function, a subprogram in your code, or a function you create from the MATLAB command line.

To create objects for local variables, the program counter (PC) must be located within the function that contains the local variable of interest. Note also the static variables for which you are creating objects must be within the current scope as well.

To increase the accuracy of the information about global symbols in your project, use `run`, as shown here, to position the PC to the start of `main` in your application in CCS.

```
run(cc, 'main')
```

Note that `symbolname` can be the name of a function in your target code. Thus, `symbolname` can refer to data or a function present on the target.

`symbolname` can be either a static variable or a global variable.

`objname = createobj(cc, 'symbolname', 'option')` lets you declare more information about `symbolname`, such as whether it represents a static or global variable. Use one of the following strings to declare the type for `symbolname` in *option*:

- `static`—declares that `symbolname` refers to a static variable in your code.
- `local`—declares the symbol to be a local variable in your code.
- `global`—declares that `symbolname` refers to a global variable in your code.
- `function`—declares that `symbolname` refers to a function in your code. Refer to the next syntax for more information about this optional keyword.

`objname = createobj(cc, 'functionname', 'function', 'funcdecl', ... 'function_declaration_string')` creates a function object `objname` that accesses the function defined by `function_declaration_string`. Use the optional keywords **function** and **funcdecl** to specify that you are creating a function object, and the declaration string follows. This syntax is required to create function objects that access library functions, unless you use `declare` with an existing function object to provide the function declaration to MATLAB.

## Function Object Details

Working with function objects is more complicated than working with the other object classes. A number of limitations and considerations apply when you create objects that access functions in your project.

createobj works without modification for the following kinds of functions:

- Functions you write in C.
- Functions you write in assembly but for which you provide C prototypes. One example of this kind is library functions that you call from your C programs in your project.

Using createobj to construct an object that accesses a function of the kind listed causes MATLAB to search for the function declaration string in your project. When MATLAB finds the prototype, it uses the declaration to create the information it needs to be able to run the function from MATLAB, including

- Objects that access the input parameters for the function
- Objects that access the output parameter for the function
- Storage locations and addresses for the function

If MATLAB does not find the function, it creates the function object anyway, without the information it needs to run the function, and returns an error.

To respond to the error and provide MATLAB the information it needs, use declare to provide the declaration string to MATLAB.

You cannot create function objects for these kinds of functions:

- Assembly functions that do not have C prototypes
- Functions where the number of input arguments changes
- Functions that include non-ANSI C code

When you create a function object to access one of the above unsupported kinds, MATLAB returns an error that it could not find the function declaration.

## Allocating Memory For Function Objects

To allocate memory buffers for function objects that you create, use

```
objname = createobj(cc,functionname,'function','allocate',...
{'input',value1,'input2',value2, });
```

which lets you set aside memory for each function input, called input1, input2, and so on in the syntax. createobj assigns value1 and value2 to input1 and input2. **allocate** used here as a keyword specifies that this createobj syntax should perform memory allocation. So, to create memory buffers and assign

values (12, 8, and 15) to three input variables for a function named `filter`, use the following syntax for `createobj`:

```
objname = createobj(cc, 'filter', 'function', 'allocate', ...
{ 'input1', 12, 'input2', 8, 'input3', 15});
```

## Using Library Functions

Library functions present a special case of functions for Link for Code Composer Studio. `createobj` cannot find function declaration strings for library functions that you use in your project. While `createobj` does create the function object, it does not populate the function object with the information that enables MATLAB to run the target function. For library functions you must use `declare` to define explicitly the function declaration for objects that access library functions. Or, when you create the function object, use the syntax

```
objname = createobj(cc, 'functionname', 'function', 'funcdecl', ...
'function_declaration_string');
```

that passes the declaration string to MATLAB at creation time.

## Examples

The following examples cover many situations you may encounter when you create function objects:

- Run a C function.
- Run a library function.
- Run a function that includes a custom data type.
- Run code generated by the Real-Time Workshop.
- Run a function that uses input vectors.

Unless you have project code that supports the functions used here you cannot run these examples. They are for inspection only.

These examples refer to four functions—`sin_taylor`, `dotprod`, `adotprod`, and `cdotprod`. Here is the code for `sin_taylor`.

- `sin_taylor`

```
/*-----*
 * Taylor Series expansion of sin function - Fixed Point
 * Limitations: input range: -pi <x <pi;
 *
 * Input Datatype is:
```

```

* Q2.13 (or MATLAB sfix16_En13), scale factor = 2^13
* Output Datatype is:
* Q1.14 (or MATLAB sfix16_En14), scale factor = 2^14
*
* Taylor Expansion of sin function (first 4 terms)
* sin(x) =(approx) x[1 - (x^2/6)*[1 + (x^2/20)*[1 - (x^2/42)]]]

-----/
#define SFIX32_EN26_VAL_1 67108864 // Integer equivalent of
1.0 in Q5.26
#define SFIX32_EN28_VAL_1 268435456 // Integer equivalent of
1.0 in Q3.28
#define SFIX32_EN30_VAL_1 1073741824 // Integer equivalent of
1.0 in Q1.30

short sin_taylor(short x)
{

// Define 16/32 bit local variables depending on processor
#if INT_MAX == 0x7FFFFFFF
int acc,a1,a2,a3,xpow;
#elif LONG_MAX == 0x7FFFFFFF
long acc,a1,a2,a3,xpow;
#endif

 xpow = x*x; // x^2 sfix32_En26

 a1 = xpow/42; // x^2/42 sfix32_En26
 a2 = xpow/20; // x^2/20 sfix32_En26
 a3 = xpow/6; // x^2/6 sfix32_En26

 acc = SFIX32_EN26_VAL_1 - a1;
 acc >>= 11;
 acc *= (a2>>11);

 acc = SFIX32_EN30_VAL_1 - acc;
 acc >>= 14;
 acc *= (a3>>14);

```

```
 acc = SFIX32_EN28_VAL_1 - acc;
 acc >>= 11;
 acc *= x;

 return (acc>>16);
}
```

## Run a Standard C Function

In this example, we run function `sin_taylor` that computes the value for the sine of an input value. This function accepts one input, `x` (using data type `short`), and returns a `short`.

To get the correct values, the input data must be converted to `Q16.13` format before passing to the function. After execution, the output value must be converted from `Q16.14` to decimal representation.

Create a `ccsdsp` link:

```
cc = ccsdsp;
reset(cc);
pause(1); % wait for hardware reset to complete before proceeding
```

Run to start of main to ensure that your global variables are initialized:

```
run(cc, 'main', 1000);
```

Create a function object for `sin_taylor`:

```
ff = createobj(cc, 'sin_taylor')
inputdata = 0.5; % input value to be used
```

Set value of input `x`:

```
x_obj = getinput(ff, 'x');
write(x_obj, inputdata * 2^13);
```

Run the function:

```
outputdata = run(ff);
```

## Run a Library Function

For a library function, you pass the declaration string explicitly through `declare`.



This example runs the function `dotprod` that computes the dot product of two arrays. This function requires three inputs:

- `x`—a pointer to a vector of shorts
- `y`—a pointer to a vector of shorts
- `n`—the size of `x` and `y` vectors

We use the global variables `a` for input `x`, `b` for input `y`, and 4 for input `nx` (since `a` and `b` are four-element vectors). The function returns a short.

Create a `ccsdsp` link:

```
cc = ccsdsp;
reset(cc);
pause(1); % Wait for hardware reset to complete before proceeding
```

Run to start of `main` to ensure that you initialize the global variables:

```
run(cc, 'main', 1000);
a_addr = address(cc, 'a'); % global buffer for 'x'
b_addr = address(cc, 'b'); % global buffer for 'y'
```

Create the function object for the library function `dotprod`:

```
ff = createobj(cc, 'dotprod')
```

The previous step yields an incomplete function object `ff` because library functions always require that you provide the function declaration explicitly, as follows:

```
declare(ff, 'decl', 'int dotprod (short *x, short *y, int nx)')
```

Set the value for the input parameter `x`:

```
x_obj = getinput(ff, 'x');
write(x_obj, a_addr(1));
xRef_obj = deref(x_obj);
reshape(xRef_obj, 4);
x_inputval = read(xRef_obj) % Verify 'y' referent value
```

Set the value for `y`, the second input parameter:

```
y_obj = getinput(ff, 'y');
write(y_obj, b_addr(1));
```

```
yRef_obj = deref(y_obj);
reshape(yRef_obj,4);
y_inputval = read(yRef_obj) % Verify 'y' referent value
```

Pass the value for nx to the function:

```
nx_obj = getinput(ff,'nx');
write(nx_obj,4);
nx_inputval = read(nx_obj) % Verify 'nx' value
```

Now run the function:

```
run(ff);
```

## Run a Function That Has a Typedef in the Prototype

Having custom data types in your function declaration can cause problems when you run the functions from MATLAB.

### Case 1—Running a Function That Has a Typedef in the Function Prototype

This example runs the function `cdotprod` that computes the dot product of two matrices. This function requires three inputs:

- `x`—a pointer to a vector of shorts
- `y`—a pointer to a vector of shorts
- `n`—the size of `x` and `y` vectors

Both `n` and the return argument are defined as data type `INT`, a custom data type defined in the source code.

We use the global variables `a` for input `x`, `b` for input `y`, and 4 for input `n` (since `a` and `b` are four-element vectors). The function returns a short.

Create a `ccsdsp` link:

```
cc = ccsdsp;
reset(cc);
pause(1); % Wait for hardware reset to complete before proceeding
```

Run to start of main to ensure that CCS initializes all of the global variables:

```
run(cc,'main',1000);
a_addr = address(cc,'a'); % Global buffer for x
b_addr = address(cc,'b'); % Global buffer for y
```

Create a function object for the library function `cdotprod`:

```
ff = createobj(cc, 'cdotprod')
```

The previous call to `createobj` yields an incomplete function object because the function declaration includes an unresolved typedef—the type `INT`. To resolve this error, add the custom data type `INT` to the type object and use `declare` to pass the function declaration to MATLAB:

```
add(cc.type, 'INT', 'int'); % A warning mentions that data type
 % INT cannot be resolved.
declare(ff, 'decl', 'INT cdotprod (short x[], short y[], INT n)')
```

Set values for the inputs `x`, `y`, and `n`, and run the function, passing the input values in the run syntax. Input `x` is a pointer so pass an address. Input `y` is a pointer as well, so pass another address. Input `n` is an integer that specifies the size of `x` and `y`:

```
run(ff, 'x', a_addr(1), 'y', b_addr(1), 'n', 4);
```

## Case 2—A Second Approach to Solving the Typedef Problem

We are going to run the function `cdotprod` which computes the dot product of two matrices. This function accepts three inputs:

- `x`—a pointer to a vector of shorts
- `y`—a pointer to a vector of shorts
- `n`—the size of `x` and `y` vectors

We use the global variable `a` for input `x`, `b` for input `y`, and 4 for input `n` (since `a` and `b` are four-element vectors). The function returns a short.

Create `ccsdsp` link:

```
cc = ccsdsp;
reset(cc);
Pause(1); % Wait for hardware reset to complete before proceeding
```

Run to start of `main` to ensure that CCS initializes all of the global variables:

```
run(cc, 'main', 1000);
a_addr = address(cc, 'a'); % Global buffer for 'x'
b_addr = address(cc, 'b'); % Global buffer for 'y'
```

Create function object for library function `cdotprod`:

```
ff = createobj(cc, 'cdotprod')
```

Again `createobj` generates an incomplete function object because of the unresolved data type `INT` in the function declaration. In this case, fix the problem by adding the custom data type `INT` to the type object and create the object `ff` again, instead of using `declare` to pass the function declaration to MATLAB:

```
add(cc.type, 'INT', 'int'); % Warning mentioned that data type
 % INT cannot be resolved.
ff = createobj(cc, 'cdotprod')
```

Set values for the inputs `x`, `y`, and `n`, and run the function, passing the input values in the run syntax. Input `x` is a pointer so pass an address. Input `y` is a pointer as well, so pass another address. Input `n` is an integer that specifies the size of `x` and `y`:

```
run(ff, 'x', a_addr(1), 'y', b_addr(1), 'n', 4);
```

### Case 3—A Third Approach to Solving the Typedef Problem

Once more we are going to run the function `cdotprod` which computes the dot product of two matrices. This function accepts three inputs:

- `x`—a pointer to a vector of shorts
- `y`—a pointer to a vector of shorts
- `n`—the size of `x` and `y` vectors

We use the global variable `a` for input `x`, `b` for input `y`, and 4 for input `n` (since `a` and `b` are four-element vectors). `cdotprod` returns a short.

Create `ccsdsp` link:

```
cc = ccsdsp;
reset(cc);
pause(1); % wait for hardware reset to complete before proceeding
```

Run to start of main to ensure that CCS initializes all of the global variables:

```
run(cc, 'main', 1000);
a_addr = address(cc, 'a'); % Global buffer for x
b_addr = address(cc, 'b'); % Global buffer for y
```

Create a function object for the library function `cdotprod`:

```
ff = createobj(cc, 'cdotprod')
```

This attempt to create a new function object `ff` results in an incomplete function object because MATLAB could not resolve the data type `INT` in the function declaration. In this approach to overcoming the unresolved type error, use `declare` to pass to MATLAB a version of the `cdotprod` function declaration that does not include the offending type `INT`—you do not need to add the `typedef` to the type object:

```
declare(ff, 'decl', 'int cdotprod (short x[], short y[], short n)')
```

Notice that the data types for the return argument and for `n` now specify `int`. Set values for the inputs `x`, `y`, and `n`, and run the function, passing the input values in the run syntax. Input `x` is a pointer so pass an address. Input `y` is a pointer as well, so pass another address. Input `n` is an integer that specifies the size of `x` and `y`:

```
run(ff, 'x', a_addr(1), 'y', b_addr(1), 'n', 4);
```

### Run a Function Generated by the Real-Time Workshop

We are going to run the function `'mwdsp_fir_df_dd'` which applies a filter to a noisy input signal. This function accepts nine input parameters and returns the filtered signal in the input argument `y`.

Create a `ccsdsp` link:

```
cc = ccsdsp;
reset(cc);
pause(1); % Wait for hardware reset to complete before proceeding
```

Now run the Real-Time Workshop generated code from the beginning to `Md1Outputs`. You run from program start until `Md1Outputs` to ensure that all of the code configuration processes get done:

```
run(cc, 'runtofunc', Md1Outputs);
```

After running to `Md1Outputs`, you create the function object—pass the function declaration to avoid MATLAB returning an error when you create the function object. Due to the complexity of this function declaration, we have assigned the string to a variable `decl`. We use the variable in the `createobj` syntax.

```
decl = ['MWDSP_IDECL void MWDSP_FIR_DF_DD(const real_T *u,...
real_T *y, real_T * const mem_base,int_T *mem_offset,...
const int_T numDelays, const int_T sampsPerChan,...
const int_T numChans, const real_T * const b,...
const boolean_T one_fpf)'];
ff = createobj(cc,'MWDSP_FIR_DF_DD','function','funcdecl',decl);
```

Examine the function declaration above. This declaration causes MATLAB to fail to create the fully populated function object `ff` because of the `MWDSP_IDECL` macro at the beginning of the string. MATLAB cannot recognize this string. Since the information in `MWDSP_IDECL` is not relevant to creating the function object, you can remove this from the declaration string:

```
decl = ['void MWDSP_FIR_DF_DD(const real_T *u,...
real_T *y, real_T * const mem_base,int_T *mem_offset,...
const int_T numDelays, const int_T sampsPerChan,...
const int_T numChans, const real_T * const b,...
const boolean_T one_fpf)'];
ff = createobj(cc,'MWDSP_FIR_DF_DD','function','funcdecl',decl);
```

Now function object `ff` has all the information MATLAB needs.

---

**Note** You may not always be able to remove offending entries in a declaration string, as we did with the macro `MWDSP_IDECL`. Often you can try your declaration and see if it works. If not, use `add` to include typedefs in the type object when MATLAB complains about a data type, or try removing the problem portion of the declaration string if the function does not require the troublesome text.

---

With the function object in your MATLAB workspace, create objects for the inputs to `MWDSP_FIR_DF_DD`:

Create an object for `rtB`:

```
rtBobj = createobj(cc,'rtB');
```

Get the relevant `rtB` member objects:

```
SumObj = getmember(rtBobj,'Sum');
% Store Output of MWDSP_FIR_DF_DD in FilObj
```

```
FilObj = getmember(rtBobj, 'Digital_Lowpass_Fil');
```

Next, create an object for rtDWork:

```
rtDWorkObj = createobj(cc, 'rtDWork');
```

and again get the relevant member objects:

```
Fil_FILT_STATES = getmember(rtDWorkObj, ...
'Digital_Lowpass_Fil_FILT_STATES');
DF_INDX = getmember(rtDWorkObj, ...
'Digital_Lowpass_Fil_FILT_STATES');
```

Create one last object for filterCoeffs:

```
filterCoeffsObj = createobj(cc, 'filterCoeffs');
```

To run the function, you need to provide the input values:

```
u = SumObj.address(1); % Input 1
y = FilObj.address(1); % Input 2
mem_base = Fil_FILT_STATES.address(1); % Input 3
mem_offset = DF_INDX.address(1); % Input 4
numDelays = 65; % Input 5
sampsPerChan = 256; % Input 6
numChans = 1; % Input 7
b = filterCoeffsObj.address(1); % Input 8
one_fpf = 1; % Input 9
```

Run the function, providing the input argument values in input value/input name pairs, such as 3, membase and 6, sampPerChan:

```
run(ff, 1, u, 2, y, 3, mem_base, 4, mem_offset, 5, numDelays, 6, ...
sampsPerChan, 7, numChans, 8, b, 9, one_fpf)
```

### Run a Function That Has Vector Inputs

This example shows how to run a function that accepts vector inputs.

We are going to run the function `adotprod` that computes the dot product of two matrices. `adotprod` accepts two inputs,

- `x`—a four-element vector of shorts
- `y`—a four-element vector of shorts

The compiler converts the vector inputs into pointers to the vectors. We use the global variable `a` for input `x` and `b` for input `y`. The function returns a short.

Create a `ccsdsp` link:

```
cc = ccsdsp;
reset(cc);
pause(1); % Wait for hardware reset to complete before proceeding
```

Run to start of main to ensure that CCS initializes all of the global variables:

```
run(cc, 'main', 1000);
a_addr = address(cc, 'a'); % Global buffer for 'x'
b_addr = address(cc, 'b'); % Global buffer for 'y'
```

Create a function object `ff` to access `adotprod`:

```
ff = createobj(cc, 'adotprod')
```

The function prototype for `adotprod` is

```
int adotprod(short x[4], short y[4])
```

`adotprod` requires as input two vector arrays `x` and `y`. The compiler requires that you pass the addresses of `x[4]` and `y[4]`, not the actual vectors `x` and `y`. So instead of writing a data vector to input object `x_obj` and `y_obj`, you provide the addresses of existing four-element vectors:

```
display('INPUT VALUE 'x':')
x_obj = getinput(ff, 'x') % Note that this is a pointer to a vector
 % of shorts
display('INPUT VALUE 'y':')
y_obj = getinput(ff, 'y') % Note that this is a pointer to a vector
 % of shorts
```

Set value of inputs `x` and `y` and run the function. Pass addresses to `x` and `y` since both are pointers to other data:

```
write(x_obj, a_addr(1))
write(y_obj, b_addr(1))
x_inputval = read(reshape(deref(x_obj), 4));
y_inputval = read(reshape(deref(y_obj), 4));
```

Using the following commands to write data to `x` and `y` does not give you the expected result—the compiler cannot determine where to put array `[1:4]`:



```
write(x_obj,[1:4]);
write(y_obj,[1:4]);
```

Now run your function:

```
run(ff);
```

The preceding examples present a few of the wide variety of functions and conditions you may encounter when you construct function objects.

**See Also**

copy, ccspd, declare

# datatypemanager

---

**Purpose** Open the Data Type Manager to identify custom data types from a CCS project to MATLAB

**Syntax** `datatypemanager(cc)`  
`cc2 = datatypemanager(cc)`

**Description** `datatypemanager(cc)` opens the Data Type Manager (DTM) with data type information about the project to which `cc` refers. With the type manager open, you can add type definitions (typedefs) from your project to MATLAB so it can interpret them. You add your typedefs because MATLAB cannot determine or understand typedefs in your function prototypes remotely across the interface to Code Composer Studio.

Each custom type definition in your prototype must appear on the **Typedef name (Equivalent data type)** before you can use the typedef from MATLAB with a function object.

When the DTM opens, a variety of information and options displays in the **Data Type Manager** dialog:

- **Typedef name (Equivalent data type)**—provides a list of default data types. When you create a typedef, it appears added to this list.
- **Add typedef**—opens the **Add Typedef** dialog so you can add one or more typedefs to your project. Your added typedef appears on the **Typedef name (Equivalent data type)** list. Also, when you pass the `cc` object to the DTM, and then add a typedef, the command  
`cc.type`  
returns a list of the data types in the object including the typedefs you added.
- **Remove typedef**—removes a selected typedef from the **Typedef name (Equivalent data type)** list.
- **Load session**—loads a previously saved session so you can use the typedefs you defined earlier without reentering them.
- **Refresh list**—updates the list in **Typedef name (Equivalent data type)**. Refreshing the list ensures the contents are current. If you changed your project data type content or loaded a new project, this updates the type definitions in the DTM.

- **Close**—closes the DTM and prompts you to save the session information. This is the only way to save your work in this dialog. Saving the session creates an M-file you can reload into the DTM later.

Clicking **Close** in the DTM prompts you to save your session. Saving the session creates an M-file that contains operations that create your final list of data types, identical to the data types in the **Typedef name** list.

In the stored M-file, you find a function that includes the add and remove operations you used to create the list of data types in the DTM. For each time you added a typedef in the DTM, the M-file contains an add command that adds the new type definition to the `cc.type` property of the object. When you remove a data type, you see an equivalent `clear` command that removes a data type from the `cc.type` object.

An interesting note—all of your operations adding and removing data types in the DTM during the session are stored in the generated M-file that you save. This has the effect of storing any mistakes you make while creating or removing type definitions. One consequence of storing mistakes is that when you load your saved session into the DTM, you see the same error messages, if any, you saw when you created the data types in the session. You might find this a little disconcerting.

The first line of the M-file is a function definition, where the name of the function is the filename of the session you saved.

`cc2 = datatypemanager(cc)` returns the `cc2` `ccsdsp` object while it opens the DTM. `cc2` represents an alias to `cc`. Objects `cc` and `cc2` are not independent objects. When you change a property of either `cc` or `cc2`, the corresponding property in the other object changes as well.

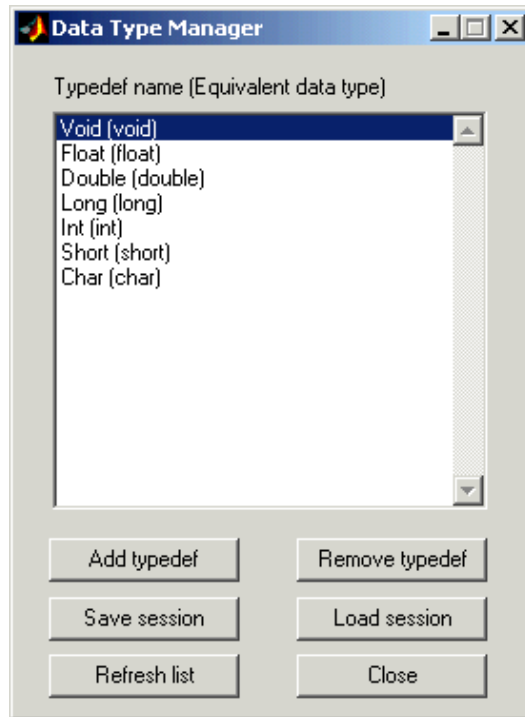
## Data Type Manager

When you create objects that access functions in a project, MATLAB can recognize most data types that you use in your project. However, if the functions use one or more custom type definitions, MATLAB cannot recognize the data type and cannot work with the function. To overcome this problem, the **Data Type Manager** provides the capability to define your typedefs to MATLAB.

Entering

```
datatypemanager(cc)
```

at the MATLAB prompt opens the DTM.



Before you add a type definition, the **Typedef name (Equivalent data type)** list shows a number of data types already defined:

- `Void(void)`—void return argument for a function
- `Float(float)`—float data type used in a function input or return argument
- `Double(double)`—double data type used in a function input or return argument
- `Long(long)`—long data type used in a function input or return argument
- `Int(int)`—integer data type used in a function input or return argument
- `Short(short)`—short data type used in a function input or return argument
- `Char(char)`—character data type used in a function input or return argument

The lowercase versions of the data types appear because MATLAB does not recognize the initial capital versions automatically. In the data type entry, the project data type with the initial capital letter is mapped to the lowercase MATLAB data type.

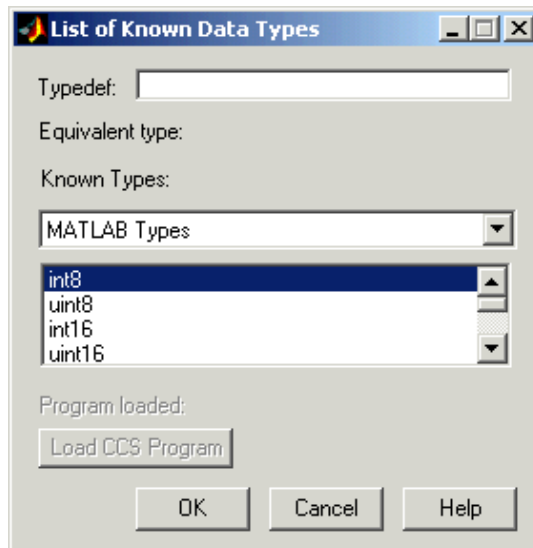
Although not recommended, you can use mixed case typedef names, so long as the equivalent data type uses lowercase. In particular, typedefs that refer to other typedefs should resolve to a data type in lowercase.

Adding a type definition adds the new data type to the list of typedefs.

Remove any existing or new type definitions with the **Remove typedef** option.

## Add Typedef Dialog

Clicking **Add typedef** in the DTM opens the **List of Known Data Types** dialog. As shown in this figure, you add your custom type definitions here.

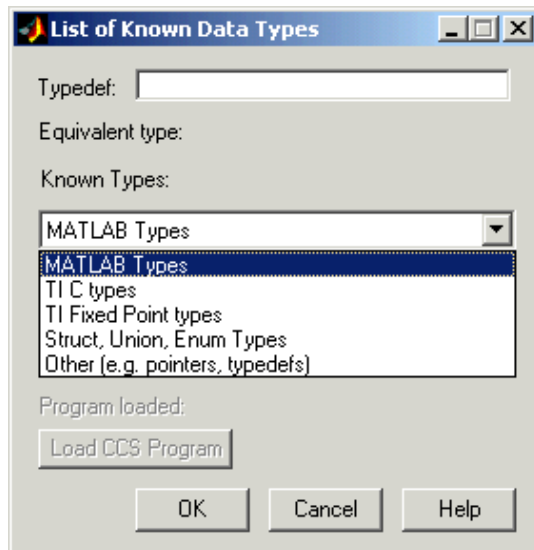


When you have used custom type definitions in your program or project, you must specify what they mean to MATLAB. The **Typedef** option lets you enter the name of the typedef in your program and select an equivalent type from the **Known Types** list. By defining your type definitions in this dialog, you enable

MATLAB can understand and work with them when you return the data to the MATLAB workspace or send data from the workspace to your project.

After you define each typedef, the **Equivalent type** option shows you the type you specified for each type definition, either when you enter it in the **Typedef** field or select it from the **Known Types** list.

Options in this dialog let you review the known data types currently in use or available in your projects. By selecting different data type categories from the **Known Types** list, you can see all of the supported data types.



From the list of known data types, choose one of the following data type categories:

- MATLAB Types

| <b>Data Type</b> | <b>Description</b>              |
|------------------|---------------------------------|
| int8             | 8-bit integer data              |
| uint8            | unsigned 8-bit integer data     |
| int16            | 16-bit integer data             |
| uint16           | unsigned 16-bit integer data    |
| int32            | 32-bit integer data             |
| uint32           | unsigned 32-bit integer data    |
| int64            | 64-bit integer data             |
| uint64           | unsigned 64-bit integer data    |
| single           | 32-bit IEEE floating-point data |
| double           | 64-bit IEEE floating-point data |

- TI C Types

| <b>Data Type</b> | <b>Description (For C6000 Compiler)</b>          |
|------------------|--------------------------------------------------|
| char             | 8-bit character data with a sign bit             |
| unsigned char    | 8-bit character data                             |
| signed char      | 8-bit character data                             |
| short            | 16-bit numeric data                              |
| unsigned short   | unsigned 16-bit numeric data                     |
| signed short     | 16-bit numeric data with sign designation        |
| int              | 32-bit integer numeric data                      |
| unsigned int     | 32-bit integer numerics without sign information |

# datatypemanager

| <b>Data Type</b> | <b>Description (For C6000 Compiler)</b>                                                                |
|------------------|--------------------------------------------------------------------------------------------------------|
| signed int       | 32-bit integer numerics with sign information                                                          |
| long             | 40-bit data with sign bit. Note that this is not the same as int.                                      |
| unsigned long    | 40-bit data without information about the sign of the number                                           |
| signed long      | 40-bit data without information about the sign of the number represented                               |
| float            | 32-bit numeric data                                                                                    |
| double           | 64-bit numeric data                                                                                    |
| long double      | On the C2xxx and C5xxx—32-bit IEEE floating-point data<br>On the C6xxx—64-bit IEEE floating-point data |

Numbers of bits change depending on the processor and compiler. For more information about TI data types and specific processors or compilers, refer to your compiler documentation from TI.

- TI Fixed Point Types

| <b>Data Type</b> | <b>Description</b>                                              |
|------------------|-----------------------------------------------------------------|
| Q0.15            | Numeric data with 16-bit word length and 15-bit fraction length |
| Q0.31            | 32-bit word length numeric data with fraction length of 31 bits |

- Struct, Union, Enum types

If the program you load on the processor includes one or more of struct, union, or enum data types, the type definitions show up on this list. Until you



load a program on the processor, this list is empty and trying to access the list generates an error message.

Load a program, if you have not already done so, by clicking **Load CCS Program** and selecting a .out file to load on your processor.

- When the load process works, you see the name of the file you loaded in **Loaded program**. Otherwise you get an error message that the load failed.

Only programs that you load from this dialog appear in **Program loaded**. Programs that you already loaded on your target do not appear in the **Loaded program** option. MATLAB cannot determine what program you have loaded.

- Others (e.g. pointers, typedefs)

Like struct, union, and enum data types, the Others list is empty until you define one or more typedefs. Unlike the Struct, Union, Enum types list, loading a program does not populate this list with typedefs from the program. You must define them explicitly in this dialog.

Custom type definitions can refer to other typedefs in your project. Nesting typedefs works once you have defined the necessary custom types. To create a typedef that uses another typedef, define the nested (inner) definition, and then define the outer definition as a pointer to the nested definition. Refer to “Examples” to see this in operation.

**Program loaded**—tells you the name of the program loaded on the processor, if you loaded the program from this dialog. If not, **Program loaded** does not report the program name.

**Load CCS Program**—opens the **Load Program** dialog so you can select and load a .out file to your processor.

## Examples

This set of examples, show how to create custom type definitions with the DTM. Each example shows the **List of Known Data Types** dialog with the selections or entries needed to create the typedef.

Start the examples by creating a ccstdsp object:

```
cc=ccstdsp;
```

Now start the DTM with the cc object. So far you have not loaded a file on the target.

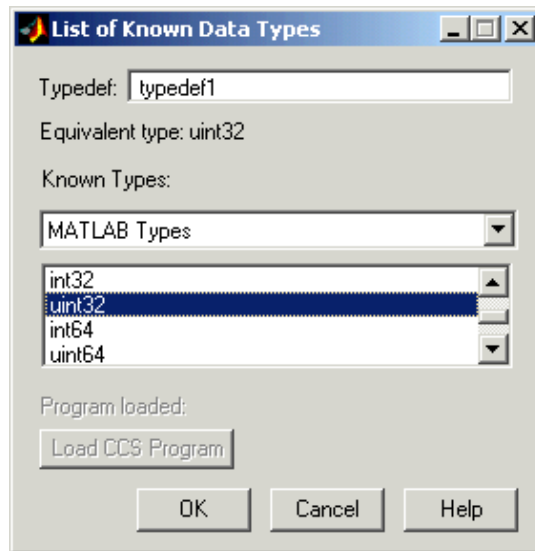
# datatypemanager

```
datatypemanager(cc);
```

With the DTM open, you can create a few custom data types.

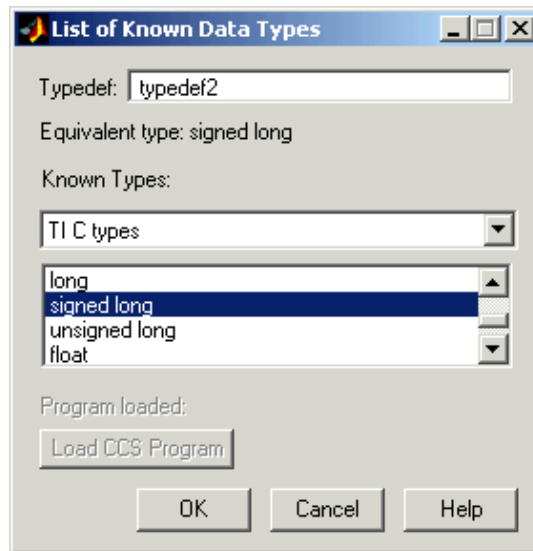
## First example

Create a typedef (typedef1) that uses a MATLAB data type. typedef1 uses the equivalent data type uint32.



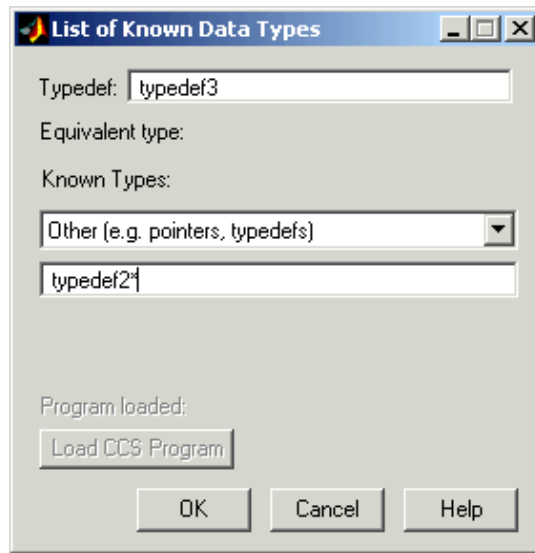
## Second example

Create a second typedef (typedef2) that uses one of the TI C data types. Define typedef2 to use the signed long data type.



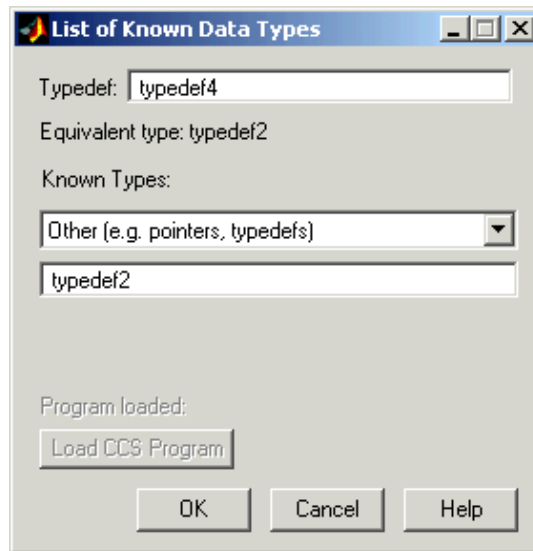
### Third example

Create a typedef (typedef3) that refers to another typedef (typedef2). Call this a nested typedef.



Notice that the referenced typedef, typedef2, is entered as a pointer (indicated by the added asterisk). Using the pointer form lets MATLAB recognize the data type that typedef2 represents. If you do not use the pointer, MATLAB converts typedef3 to a default value equivalent data type, in this case, int.

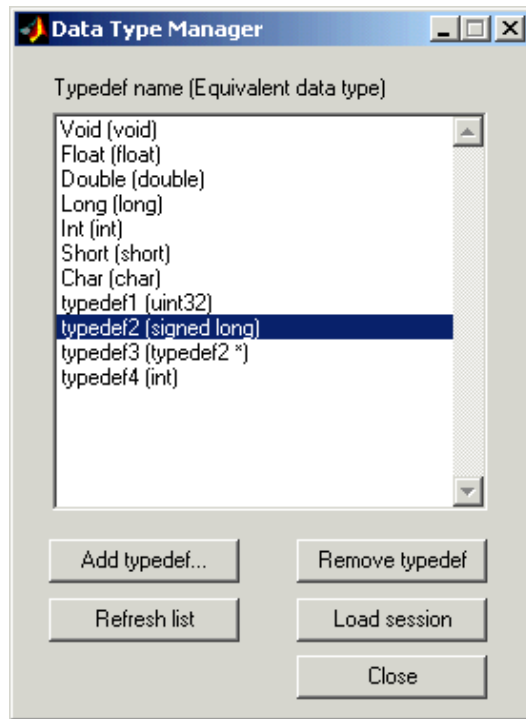
The next figure shows typedef4 created to use typedef2 rather than typedef2\* for a nested typedef. Under **Equivalent type**, typedef4 has an equivalent data type of typedef2, as specified. But, when you look at the list of known data types in the **Data Type Manager** dialog, you see that typedef4 maps to int, not typedef2, or eventually signed long.



Here is the DTM after you create all the example custom data types. Take note of `typedef4` in this listing. You see `typedef4` defaults to an equivalent data type `int`, where `typedef3`, also a nested type definition, retains the equivalent data type you assigned. Now you are ready to use a function that includes your custom type definitions in your hardware-in-the-loop development work.

# datatypemanager

---



**See Also** `createobj`

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Define a C function declaration in MATLAB for your CCS application                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <b>Syntax</b>      | <pre>declare(objname, 'filetype', 'filename') declare(objname, 'decl', 'funcdeclaration')</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Description</b> | <p>When <code>createobj</code> cannot construct a function object to access a function, either because MATLAB could not find the function declaration for the function, or could not create the function object properties, use <code>declare</code> to pass the function declaration to MATLAB.</p> <p><code>declare(objname, 'filetype', 'filename')</code> passes your function declaration string to <code>objname</code> by providing the path to the file specified in <code>filename</code>. To set the type of file you are providing, input argument <code>filetype</code> can be one of three strings:</p> <ul style="list-style-type: none"><li>• <b>'filename'</b>—specifies that <code>filename</code> contains the path and filename for your header file that contains the function declaration</li><li>• <b>'file'</b>—same as <code>filename</code></li><li>• <b>'header'</b>—specifies that <code>filename</code> is the path and name of a header file that contains the function declaration</li></ul> <p>When <code>declare</code> cannot find the declaration string because the specified header file or file is not available, use the next syntax to provide the complete declaration string explicitly.</p> <p><code>declare(objname, 'decl', 'funcdeclaration')</code> passes the declaration string in <code>funcdeclaration</code> to <code>objname</code>. To tell MATLAB that you are passing a declaration string, add the keyword <b>decl</b>, indicating that the next argument is the function declaration string. When you use <code>declare</code> to add a function declaration to <code>objname</code>, <code>declare</code> reads the input variables and return type for the declaration from <code>funcdeclaration</code> and populates the properties <code>inputvars</code>, <code>inputnames</code>, and <code>outputvar</code> of <code>objname</code>. When <code>declare</code> successfully determines the input and output variables, <code>objname</code> contains the updated property values.</p> |
| <b>Examples</b>    | <p>The following code passes the function declaration for <code>cdotprod</code> to MATLAB and updates the properties of <code>ff</code> to match the declaration:</p> <pre>declare(ff, 'decl', 'int cdotprod (short x[], short y[], short n)')</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |

# declare

---

In the case of a very complex function declaration, assign the declaration string to a variable and pass the variable in the declare syntax:

```
declstring=['int cdotprod (short x[], short y[], short n)']
declare(ff,'decl',declstring)
```

## See Also

assignreturnstorage, createobj, execute, getinput, getoutput, goto, resume, run



---

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Remove debug points in addresses or source files in CCS                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Syntax</b>      | <pre>delete(cc,addr,'type') delete(cc,addr) delete(cc,filename,line,'type') delete(cc,filename,line)</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                            |
| <b>Description</b> | <p><code>delete(cc,addr,'type')</code> removes a debug point located at the memory address identified by <code>addr</code> for your target digital signal processor. Object <code>cc</code> identifies which target has the debug point to delete. CCS provides several types of debug points. To learn more about the behavior of the various debugging points refer to your CCS documentation. Options for <code>type</code> include the following to remove breakpoints and probe points:</p> <ul style="list-style-type: none"><li>• <b>'break'</b> — removes a breakpoint. This is the default.</li><li>• <b>' '</b> — same as <b>'break'</b>.</li><li>• <b>'probe'</b> — removes a probe point.</li></ul> <p>Unlike deleting break and probe points in CCS, you cannot enter <code>addr</code> as a C function name, valid C expression, or a symbol name.</p> <p>When the type you specify does not match the debug point type at the selected location, or no debug point exists, Link for Code Composer Studio returns an error reporting that it could not find the specified debugging point.</p> <p><code>delete(cc,addr)</code> is the same as the previous syntax except the function defaults to <b>'break'</b> for removing a breakpoint.</p> <p><code>delete(cc,filename,line,'type')</code> lets you specify the line from which you are removing the debug point. Argument <code>line</code> specifies the line number in the source file <code>file</code> in CCS. <code>line</code>, in decimal notation, defines the line number of the debugging point to remove. To identify the source file, argument <code>filename</code> contains the name of the file in CCS, entered as a string in single quotation marks. <code>'type'</code> accepts one of two strings — <b>break</b> or <b>probe</b> — as defined previously. When the type of debugging point you specify with the <code>'type'</code> string does not match the debug point type at the specified location, or no debug point exists, Link for Code Composer Studio returns an error that it could not find the debug point.</p> |

# delete

---

`delete(cc, filename, line)` defaults to 'break' to remove a breakpoint.

## See Also

`address`, `insert`, `run`

**Purpose** Remove one or more registers from the list of saved registers stored in the property `savedregs` of function objects

**Syntax** `deleteregister(ff, 'regname')`  
`deleteregister(ff, 'reglist')`

**Description** `deleteregister(ff, regname)` removes register `regname` from the list of registers that get preserved or reverted when a function is finished running. `ff` identifies the program function to which the register applies. You can delete any register you added from the saved registers list. You cannot delete registers that are on the default list of saved registers—the must save registers.

When you issue the `createobj` call to create a handle to a function, the compiler creates the default list of saved registers. When you execute the function, the compiler saves the registers in the list, runs its process, and after completing its process, restores the saved registers to their initial state using the contents of the saved registers.

After a function generates a result, the execution process returns the saved registers to their initial states and values. When you delete a register you added to the saved registers list, the deleted register is not restored or saved with other registers in the list.

For each processor family, the default list of saved registers changes, as shown in these sections. The default lists include registers that the compiler saves and that MATLAB requires for Link for Code Composer Studio to operate correctly.

### **Default Saved Registers for C28x Processors**

AL, AH, AR0, AR1, AR2, AR3, AR4, AR5, AR6, AR7, XAR0, XAR1, XAR2, XAR3, XAR4, XAR5, XAR6, XAR7, SP, T, TL, PL, PH, DP

### **Default Saved Registers for C54x Processors**

AR1, AR6, AR7, and SP (required by MATLAB, not the compiler)

### **Default Saved Registers for C55x Processors**

T0, T1, T2, T3, TRN0, TRN1, AR0, AR1, AR2, AR3, AR4, AR5, AR6, AR7, XAR0, XAR1, XAR2, XAR3, XAR4, XAR5, XAR6, XAR7, AC0, AC1, AC2, AC3

### **Default Saved Registers for C62x and C67x Processors**

# deleteregister

---

A0, A2, A6, A7, A8, A9. Also B0, B1, B2, B4, B5, B6, B7, B8, B9. To support MATLAB requirements, B15 (the stack pointer) gets saved as well.

Registers A3, A4, A5, and B3—your function must preserve these but they are not needed for reading function output.

## **Default Saved Registers for C64x Processors**

A0, A2, A6, A7, A8, A9, A16, A17, A19, A19, A20, A21, A22, A23, A24, A25, A26, A27, A28, A29, A30, A31. Also B0, B1, B2, B4, B5, B6, B7, B8, B9, B16, B17, B18, B19, B20, B21, B22, B23, B24, B25, B26, B27, B28, B29, B30, B31. To support MATLAB requirements, B15 (the stack pointer) gets saved as well.

Register B15—not required by the compiler, but is required by MATLAB and is saved.

Registers A3, A4, and A5—function must preserve these but they are needed for reading function output.

## **Default Saved Registers for R1x and R2x Processors**

R0, R1, R2, R3, R4, R5, R6, R7, R8, R9, R10, R11, R12, R13, R14, R15

`deleteregister(ff,reglist)` deletes the register names in `reglist` from the list of registers that get preserved when a task is finished. `ff` identifies the function to which the register applies. `reglist` is a cell array that contains the names of registers to remove from the saved registers collection.

## **See Also**

`addregister`

**Purpose** Return an object that accesses the object a pointer object points to

**Syntax** `objname2 = deref(objname)`  
`objname2 = deref(objname, index)`

**Description** `objname2 = deref(objname)` creates `objname2`, an object that accesses the target of `objname`, which is either a pointer or `rpointer` object. `deref` does exactly what the dereferencing operator `*` does in C. Pointer and `rpointer` objects support using function `deref`.

`objname2 = deref(objname, index)` selects one member, specified by `index`, of an array of pointers. `objname2` accesses only the single array member that `index` specifies.

**See Also** `createobj`, `read`, `write`

# dir

---

**Purpose** List the files in the current CCS IDE working directory

**Syntax** `dir(cc)`

**Description** `dir(cc)` lists the files and directories in the current CCS IDE working directory. This does not reflect your MATLAB working directory or change the working directory.

Use `cd` to change your CCS IDE working directory.

**See Also** `cd`, `open`

**Purpose** Disable the RTDX interface, a specified channel, or all RTDX channels

**Syntax**

```
disable(rx, 'channel')
disable(rx, 'all')
disable(rx)
```

**Description** `disable(rx, 'channel')` disables the open channel specified by the string `channel`, for `rx`. Input argument `rx` represents the RTDX portion of the associated link to CCS IDE.

`disable(rx, 'all')` disables all the open channels associated with `rx`.

`disable(rx)` disables the RTDX interface for `rx`.

### Important Requirements for Using `disable`

On the target side, `disable` depends on RTDX to disable channels or the interface. You must meet the following requirements to use `disable`:

- 1 The target must be running a program when you use `disable` for channels or the RTDX interface.
- 2 You must have the enabled the RTDX interface.
- 3 Your target program must be polling periodically for `disable` to work.

**Examples** When you have opened and used channels to communicate with a target processor, you should disable the channels and RTDX before ending your session. Use `disable` to switch off open channels and disable RTDX, as follows:

```
disable(cc.rtdx, 'all') % Disable all open RTDX channels.
disable(cc.rtdx) % Disable RTDX interface.
```

**See Also** `close`, `enable`, `open`

# display

---

**Purpose** Display the properties of a link to CCS IDE or an RTDX link

**Syntax**

```
display(cc)
display(rx)
display(objectname)
display(cc.type)
```

**Description** This function is similar to omitting the closing semicolon from an expression on the command line, except that `display` does not display the variable name. `display` provides a formatted list of the property names and property values for a link to CCS IDE. To return the configuration data, `display` calls the function `disp`. To return a list of object properties, listed by the actual property names, use `get` with the object.

`display(cc)` returns the information about the `cc` object, listing the properties and values assigned to `cc`.

`display(rx)` returns the information about the `rtdx` object that is part of a `cc` object, listing the properties and values assigned to `cc.rtdx`.

`display(objectname)` returns the properties and property values for `objectname`. This syntax supports all objects except `cc`, `rtdx`, and `cc.type`.

`display(cc.type)` returns the properties and property values for the `cc.type` object. Note that the properties associate with the `cc` object.

The following example illustrates the default display for a link to CCS IDE:

```
cc = ccsdsp;

display(cc)
CCSDSP Object:

API version : 1.0
Processor type : C67
Processor name : CPU
Running? : No
Board number : 0
Processor number : 0
Default timeout : 10.00 secs
```



```
RTDX channels : 0
```

## Using display with multiprocessor targets

To support target boards that contain more than one processor, `display` behaves slightly differently when `cc` accesses multiprocessor boards.

The syntax

```
display(cc)
```

returns information about all of the members of the object. When the target has multiple processors, the information returned includes the details of all of the available processors on the target.

## Examples

Try this example to see the display for an RTDX link to a target processor:

```
cc = ccsdsp;
rx=(cc.rtdx) % Assign the RTDX portion of cc to rx.
```

```
RTDX channels : 0
```

```
display(rx)
```

```
RTDX channels : 0
```

## See Also

`get`, `set`

# enable

---

**Purpose** Enable the RTDX interface, a specified channel, or all RTDX channels

**Syntax**

```
enable(rx, 'channel')
enable(rx, 'all')
enable(rx)
```

**Description** `enable(rx, 'channel')` enables the open channel specified by the string `channel`, for RTDX link `rx`. The input argument `rx` represents the RTDX portion of the associated link to CCS IDE.

`enable(rx, 'all')` enables all the open channels associated with `rx`.

`enable(rx)` enables the RTDX interface for `rx`.

## Important Requirements for Using enable

On the target side, `enable` depends on RTDX to enable channels. Therefore the you must meet the following requirements to use `enable`:

- 1 The target must be running a program when you enable the RTDX interface. When the target is not running, the state defaults to disabled.
- 2 You must enable the RTDX interface before you enable individual channels.
- 3 Channels must be open before you can enable them.
- 4 Your target program must be polling periodically for `enable` to work.
- 5 Using code in the program running on the target to enable channels overrides the default disabled state of the channels.

**Examples** To use channels to RTDX, you must both open and enable the channels:

```
cc = cc dsp; % Create a new link.
enable(cc.rtdx) % Enable the RTDX interface.
open(cc.rtdx, 'inputchannel', 'w') % Open a channel for sending
 % data to the target processor.
enable(cc.rtdx, 'inputchannel') % Enable the channel so you can use
 % it.
```

**See Also** `disable`, `open`

**Purpose** Return the equivalent string or numeric value for an input argument

**Syntax** `value = equivalent(objname, input)`

**Description** `value = equivalent(objname, input)` returns value as either

- The decimal numeric equivalent of input when input is a string
- The string equivalent value of input when input is a numeric

input can be a single value, a single string, an array of values or strings, or a cell array of values or strings.

Numeric objects, string objects, rstring objects, and enum objects all support equivalent.

The conversion process depends on the setting of the `charconversion` property of the object and applies only to string and rstring objects. Currently, the only property value allowed for `charconversion` is 'ASCII' indicating that strings are treated as ASCII characters and numeric values get converted to the ASCII equivalents.

**See Also** `cast`, `convert`

# execute

---

## Purpose

Execute a function on a target through CCS

## Syntax

```
output_val = execute(ff)
output_val = execute(ff,input1,value1,...,inputn,value1)
```

## Description

`output_val = execute(ff)` runs the function specified by handle `ff` on your target hardware. When you do not specify values for the inputs to the function, `execute` uses the values stored in property `inputvars` for the arguments. The function runs until the end of the function, or until it reaches a breakpoint. After executing the function, the execution process puts the return value in the assigned location in property `outputvar` of `ff`. From MATLAB, use `read` to check the result stored in `outputvar`. In this form, `output_val` holds the return value from executing the function.

Before you use `execute` to run a function, use `goto` to position the program counter to the beginning of the function. `execute` assumes that you have completed this step; it does not search for the function. Execution starts from the program counter location and continues to the end of the function or an intervening breakpoint.

`output_val = execute(ff,input1,value1,...,inputn,value1)` runs the function identified by `ff`, first writing the input values assigned by the `inputn/value1` pairs to `inputvars`. Arguments `input1, input2,...,inputn` must be strings. `input1` through `inputn` can be either the names of the input arguments, or the number of the input argument in the argument list, such as 1 for the first argument, 2 for the second, up to `n` for the `n`th argument on the list. In this form, `output_val` holds the return value from executing the function. You must call `goto` before using this syntax, or `execute` fails.

## See Also

`goto`, `run`, `write`

---

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Flush data or messages out of one or more specified RTDX channels                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>Syntax</b>      | <pre>flush(rx, 'channel', num, timeout) flush(rx, 'channel', num) flush(rx, 'channel', [], timeout) flush(rx, 'channel') flush(rx, 'all')</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                   |
| <b>Description</b> | <p><code>flush(rx, channel, num, timeout)</code> removes <code>num</code> oldest data messages from the RTDX channel queue specified by <code>channel</code> in <code>rx</code>. To determine how long to wait for the function to complete, <code>flush</code> uses <code>timeout</code> (in seconds) rather than the global time-out period stored in <code>rx</code>. <code>flush</code> applies the time-out processing when it flushes the last message in the channel queue, since the flush function performs a read to advance the read pointer past the last message. Use this calling syntax only when you specify a channel configured for read access.</p> <p><code>flush(rx, channel, num)</code> removes the <code>num</code> oldest messages from the RTDX channel queue in <code>rx</code> specified by the string <code>channel</code>. <code>flush</code> uses the global time-out period stored in <code>rx</code> to determine how long to wait for the process to complete. Compare this to the previous syntax that specifies the time-out period. Use this calling syntax only when you specify a channel configured for read access.</p> <p><code>flush(rx, channel, [], timeout)</code> removes all data messages from the RTDX channel queue specified by <code>channel</code> in <code>rx</code>. To determine how long to wait for the function to complete, <code>flush</code> uses <code>timeout</code> (in seconds) rather than the global time-out period stored in <code>rx</code>. <code>flush</code> applies the time-out processing when it flushes the last message in the channel queue, since <code>flush</code> performs a read to advance the read pointer past the last message. Use this calling syntax only when you specify a channel configured for read access.</p> <p><code>flush(rx, channel)</code> removes all pending data messages from the RTDX channel queue specified by <code>channel</code> in <code>rx</code>. Unlike the preceding syntax options, you use this statement to remove messages for both read-configured and write-configured channels.</p> <p><code>flush(rx, 'all')</code> removes all data messages from all RTDX channel queues.</p> |

# flush

---

When you use `flush` with a write-configured RTDX channel, Link for Code Composer Studio sends all the messages in the write queue to the target. For read-configured channels, `flush` removes one or more messages from the queue depending on the input argument `num` you supply and disposes of them.

## Examples

To demonstrate `flush`, this example writes data to the target over the input channel, then uses `flush` to remove a message from the read queue for the output channel:

```
cc = ccdsp;
rx = cc.rtdx;
open(rx, 'ichan', 'w');
enable(rx, 'ichan');
open(rx, 'ochan', 'r');
enable(rx, 'ochan');
indata = 1:10;
writemsg(rx, 'ichan', int16(indata));
flush(rx, 'ochan', 1);
```

Now flush the remaining messages from the read channel:

```
flush(rx, 'ochan', 'all');
```

## See Also

`enable`, `open`

**Purpose** Return the properties of an object

**Syntax**

```
get(cc, 'propertyname')
get(cc)
v = get(cc, 'propertyname')
get(rx, 'propertyname')
get(rx)
v = get(rx)
get(objname, 'propertyname')
get(objname)
v = get(objname)
```

**Description** `get(cc, 'propertyname')` returns the property value associated with `propertyname` for link `cc`.

`get(cc)` returns all the properties and property values identified by the link `cc`.

`v = get(cc, 'propertyname')` returns a structure `v` whose field names are the link `cc` property names and whose values are the current values of the corresponding properties. `cc` must be a link. If you do not specify an output argument, MATLAB displays the information on the screen.

`get(rx, 'propertyname')` returns the property value associated with `propertyname` for link `rx`.

`get(rx)` returns all the properties and property values identified by the link `rx`.

`v = get(rx)` returns a structure `v` whose field names are the link `rx` property names and whose values are the current values of the corresponding properties. `rx` must be a link. If you do not specify an output argument, MATLAB displays the information on the screen.

`get(objname, 'propertyname')` returns the property value associated with `propertyname` for `objname`.

`get(objname)` returns all the properties and property values identified by `objname`.

# get

---

`v = get(objname)` returns a structure `v` whose field names are the `objname` property names and whose values are the current values of the corresponding properties. `objname` must be an object in your MATLAB workspace. If you do not specify an output argument, MATLAB displays the information on the screen.

## Examples

After you create a link for CCS IDE and RTDX, `get` provides a way to review the properties of the link.

```
cc=ccsdsp

CCSDSP Object:
 API version : 1.0
 Processor type : C67
 Processor name : CPU
 Running? : No
 Board number : 0
 Processor number : 0
 Default timeout : 10.00 secs

 RTDX channels : 0

get(cc)

ans =

 app: [1x1 activex]
 dspboards: [1x1 activex]
 dspboard: [1x1 activex]
 dsptasks: [1x1 activex]
 dsptask: [1x1 activex]
 dspuser: [1x1 activex]
 rtdx: [1x1 rtdx]
apiversion: [1 0]
ccsappexe: 'D:\ticcs\cc\bin\cc_app.exe'
 boardnum: 0
 procnum: 0
 timeout: 10
 page: 0
```



```

v=get(cc)

v =

 app: [1x1 activex]
 dspboards: [1x1 activex]
 dspboard: [1x1 activex]
 dsptasks: [1x1 activex]
 dsptask: [1x1 activex]
 dspuser: [1x1 activex]
 rtdx: [1x1 rtdx]
apiversion: [1 0]
ccsappexe: 'D:\ticcs\cc\bin\cc_app.exe'
boardnum: 0
procnum: 0
timeout: 10
page: 0

v.app

ans =
 activex object: 1-by-1

v.rtdx

 RTDX channels : 0

```

RTDX links work in the same way. Create an alias rx to the RTDX portion of cc, then use the alias with get:

```

rx=cc.rtdx

 RTDX channels : 0

get(rx)

ans =

 numChannels: 0
 Rtdx: [1x1 activex]
 RtdxChannel: {'' [] ''}

```

# get

---

```
 procType: 103
 timeout: 10

v=get(rx)

v =
 numChannels: 0
 Rtdx: [1x1 activex]
 RtdxChannel: {'' [] ''}
 procType: 103
 timeout: 10
v.timeout

ans =

 10

v.procType

ans =

 103
```

## See Also

set

**Purpose** Return a specified input argument object from a function object

**Syntax** `inputobj = getinput(ff,input_name)`

**Description** `inputobj = getinput(ff,input_name)` returns the input object that accesses `input_name`. Enter `input_name` in single quotation marks since it is a string.

---

**Note** After you execute a function, the information returned by `getinput` may not be the same as the information returned before you run the method.

This occurs because the compiler uses stack and register locations as temporary storage and may overwrite the contents of either the stack or registers during execution. In particular, when your function stores the function return value in one of the input variables, the compiler overwrites the value of the input with the output value. Refer to Examples to see this in use.

---

**Examples** Use `getinput` to see the properties of an input object in a function object:

```
sin_t=createobj(cc, 'sin_taylor')

FUNCTION Object
 Function name : sin_taylor
 File found : hiltut.c
 Start address : [12328 0]
 All variables : a1, a2, a3, acc, x, xpow
 Input variables : x
 Return type : short

sin_t.inputvars

ans =

 x: [1x1 ccs.rnumeric]

x_inobj=getinput(sin_t,'x')
```

```
NUMERIC Object stored in register(s):
 Symbol name : x
 Register : A4
 Datatype : Unknown
 Wordsize : 16 bits
 Register units per value : 1 ru
 Representation : signed
 Bit padding (post) : 16
 Size : [1]
 Total register units : 1 ru
 Array ordering : row-major
```

x\_inobj

```
NUMERIC Object stored in register(s):
 Symbol name : x
 Register : A4
 Datatype : Unknown
 Wordsize : 16 bits
 Register units per value : 1 ru
 Representation : signed
 Bit padding (post) : 16
 Size : [1]
 Total register units : 1 ru
 Array ordering : row-major
```

Demonstrate that the information from `getinput` may change after executing a function.

In your CCS project:

```
void fl2q15(double *x, short *r,int nx); % r is where the output
 % is stored
```

Now, in MATLAB, here is the code that demonstrates `getinput` changing.

```
% Create function class

cc = ccdsp;
ff = createobj(cc, 'fl2q15')
```

```
% Create objects that will be used as inputs to fl2q15

input_x = createobj(cc,'input_x') % Global variable an array of
% doubles
write(input_x,[0.1 2.5 8.0]) % Write data into input_x

input_r = createobj(cc,'input_r') % Global variable an array of
% shorts

% Get input objects and assign values

xobj = getinput(ff,'x')
write(xobj,input_x.address)

robj = getinput(ff,'r')
write(robj,input_r.address) % Also means 'set the result to point
% to the location of input_r'

nxobj = getinput(ff,'nx')
write(nxobj,3)

% Run the function

run(ff)

% Read the result

output_err = read(deref(robj)) % Returns the wrong result
% because robj now holds a
% different value

output_correct = read(input_r))
```

Gives the correct result because the address of input\_r where the function stored the output did not change.

## See Also

createobj, getoutput

# getmember

---

**Purpose** Return an object that accesses one member of a structure

**Syntax**

```
objname2 = getmember(objname,membername)
objname2 = getmember(objname,index,membername)
```

**Description** `objname2 = getmember(objname,membername)` returns the object `objname2` that represents `membername`, a member of the structure that `objname` accesses. `membername` must be a string and `objname` must represent a structure in memory. Once you create `objname2`, it becomes the object you use to read and write `membername`. Along with `createobj`, these are the only functions that create objects in the product.

The class of `objname2` depends on the data type of `membername`—numeric structure members return numeric objects, enumerated members return enum objects, pointers return pointer objects, and so on:

```
objname2 = getmember(objname,index,membername)
```

**Examples** Suppose you have declared a structure in your source code called `testdeepstr`, using code like this:

```
struct testdeepstr {
 int x_int;
 struct mystructa x_str;
 struct mystructa z_str[2];
} str_recur;
```

Now, `getmember` creates objects that directly access members of `str_recur`:

```
str_recur=createobj(cc,'str_recur')
```

STRUCTURE Object:

```
Symbol Name : str_recur
Address : [2147500816 0]
Address Units per value : 224 AU
Size : [1]
Total Address Units : 224 AU
Array ordering : row-major
Members : 'x_int', 'x_str', 'z_str'
```

```
x_str=getmember(structtest,'x_str')
```

STRUCTURE Object:

```
Symbol Name : x_str
Address : [2147500824 0]
Address Units per value : 72 AU
Size : [1]
Total Address Units : 72 AU
Array ordering : row-major
Members : 's_int', 'a_int', 's_double', 'a_char'
```

Even when the structure member is itself a structure, getmember provides access directly to the nested structure, or to members within the nested structure:

```
s_double=getmember(nestx_str, 's_double')
```

NUMERIC Object

```
Symbol Name : s_double
Address : [2147500872 0]
Wordsize : 64 bits
Address Units per value : 8 AU
Representation : float
Binary point position : 0
Size : [1]
Total address units : 8 AU
Array ordering : row-major
Endianness : little
```

Numeric object s\_double is now your handle to write to or read from member s\_double:

```
read(s_double)
```

```
ans =
```

```
-1.4938e+059
```

```
write(s_double,2)
```

```
read(s_double)
```

# getmember

---

```
ans =
```

```
2
```

## See Also

createobj, read, write



**Purpose** Return the object that accesses the output from a function object

**Syntax** `out_obj = getoutput(ff)`

**Description** `out_obj = getoutput(ff)` returns in `out_obj` the object that accesses the return from `ff`. The input argument `ff` must be a function object constructed either by `createobj` or a combination of `createobj` and `declare`. To return any value, `ff` must be a fully populated function object, with all the required input and output objects.

**Examples** Use `getoutput` to see the properties of the output object in a function object:

```
sin_t=createobj(cc,'sin_taylor')
```

```
FUNCTION Object
```

```
Function name : sin_taylor
File found : hiltut.c
Start address : [12328 0]
All variables : a1, a2, a3, acc, x, xpow
Input variables : x
Return type : short
```

```
getoutput(sin_t)
```

```
NUMERIC Object stored in register(s):
```

```
Symbol name :
Register : A4
Datatype : Unknown
Wordsize : 16 bits
Register units per value : 1 ru
Representation : signed
Bit padding (post) : 16
Size : [1]
Total register units : 1 ru
Array ordering : row-major
```

# getoutput

---

Note that you do not need the output variable name in `getoutput`. Since there can only be one output object (one output variable) you do not need to specify which object to display.

## **See Also**

`createobj`, `getinput`

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                   |
|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Return information about an existing type definition in a type object                                                                                                                                                                                                                                                                                                                                                             |
| <b>Syntax</b>      | <code>info = gettypeinfo(cc.type, 'typename')</code>                                                                                                                                                                                                                                                                                                                                                                              |
| <b>Description</b> | <code>gettypeinfo(cc.type, 'typename')</code> returns all the available information about the user defined data type <code>typename</code> in the type object <code>cc.type</code> .                                                                                                                                                                                                                                              |
| <b>Examples</b>    | <p>Here is what happens when you use <code>gettypeinfo</code> to learn about a type in the type class:</p> <pre>cc.type  Defined types      : Void, Float, Double, Long, Int, Short, Char, mynewtypedef  gettypeinfo(cc.type, 'Double')  ans =      type: 'double'     size: 1     uclass: 'numeric'</pre> <p>One important note—type names are case sensitive. <code>double</code> and <code>Double</code> are not the same.</p> |
| <b>See Also</b>    | <code>add</code> , <code>clear</code> , <code>createobj</code>                                                                                                                                                                                                                                                                                                                                                                    |

# goto

---

**Purpose** Position the program counter to the specified location in the project code

**Syntax**

```
goto(cc, 'functionname')
goto(ff)
goto(ff, 'input1', value1, ..., 'inputn', valuen)
```

**Description** `goto(cc, 'functionname')` opens the source file in CCS that contains `functionname` and positions the cursor at the beginning of `functionname`. Using `goto` can help you locate and work with a file that contains a specific function without searching through all the files.

`goto(ff)` positions the program counter to the beginning of the function accessed by `ff`. Using `goto` in this syntax prepares the function to be executed but does not place any information in the registers associated with the function. Before you use this form of `goto`, you can pass the necessary values for the function input arguments into the appropriate registers and stack locations. You can do this whether the function has input parameters or not.

In the following sections, you see the registers and memory locations on each processor that are affected by preparing to run the function.

## C2800 Family Input Argument Storage Allocation

C2800 processors interpret and store input argument data in a way quite different from the other TI processors.

The processor first checks the sizes of the function input arguments. After determining which inputs are 32-bit, pointers, and 16-bit arguments, the processors starts to allocate storage for the data.

Having sorted the input arguments by data size and type, the processor starts to allocate storage by handling the 32-bit arguments. The processor places the first 32-bit input argument (either long or float data types) into the accumulator, registers AH and AL. Other 32-bit input arguments, if any, get stored on the stack.

Next come the pointer input arguments. The first and second pointer input arguments go to registers XAR4 and XAR5. If the function prototype uses more than two pointers as input arguments, the remaining pointers go on the stack.

Finally, the processor treats the 16-bit input arguments. Where 16-bit arguments (ints) go depends on the number and kind of other input arguments to the function. The first four 16-bit inputs go into AH, AL, XAR4, and XAR5, in that order, if the registers are available.

But recall that 32-bit inputs go into AL and AH, and pointers go into XAR4 and XAR5. So, 16-bit input arguments go into any empty location among AL, AH, XAR4, and XAR5. Remaining 16-bit arguments go on the stack.

To make this a bit more clear, this short example uses five input arguments to function `function`. Input arguments `a` and `c` are 32-bit arguments, `b` is a pointer, and `d` and `e` are 16-bit arguments. For a function like this one

```
void function(a,b,c,d,e)
```

the compiler allocates the input arguments as shown here, in order.

- 1** `a` goes into register AH. It is the first 32-bit input argument.
- 2** `c` goes into register AL. It is the second 32-bit input argument.
- 3** `b`, the first pointer, goes into XAR4
- 4** `d`, the first 16-bit argument, goes into XAR5
- 5** `e`, the second 16-bit argument, goes on the stack, since AH, AL, XAR4, and XAR5 are full.

For this example, additional input arguments, if there were any, would go on the stack.

### C5400 Family Input Argument Storage Allocation

| Argument          | Register | For Long Arguments | Description                                                          |
|-------------------|----------|--------------------|----------------------------------------------------------------------|
| value1            | A        | A                  | First input value to function                                        |
| value2 and higher | Stack    | Stack              | All input arguments after the tenth argument get placed on the stack |
| Returned Argument | A        | A                  | Returned argument                                                    |

## C6000 Family Input Argument Storage Allocation

| Argument                      | Register | For Long Arguments | Description                                                           |
|-------------------------------|----------|--------------------|-----------------------------------------------------------------------|
| value1                        | A4       | A5:A4              | First input value to function                                         |
| value2                        | B4       | B5:B4              | Second input value to function                                        |
| value3                        | A6       | A7:A6              | Third input value to function                                         |
| value4                        | B6       | B7:B6              | Fourth input value to function                                        |
| value5                        | A8       | A9:A8              | Fifth input value to function                                         |
| value6                        | B8       | B9:B8              | Sixth input value to function                                         |
| value7                        | A10      | A11:A10            | Seventh input value to function                                       |
| value8                        | B10      | B11:B10            | Eighth input value to function                                        |
| value9                        | A12      | A13:A12            | Ninth input value to function                                         |
| value10                       | B12      | B13:B12            | Tenth input value to function                                         |
| value11 and higher            | Stack    | Stack              | All input arguments after the tenth argument get placed on the stack. |
| Pointer to returned structure | A3       | N/A                | Pointer                                                               |
| Return address register       | B3       | N/A                | Address of register                                                   |
| Returned argument             | A4       | A5:A4              | Returned argument                                                     |
| Data page pointer (DP)        | B14      | N/A                | Specifies the data page. Always 1 for the C6000 processor family.     |
| Frame Pointer (FP)            | A15      | N/A                | Specifies the frame pointer location                                  |
| Stack Pointer (SP)            | B15      | N/A                | Specifies the stack pointer location                                  |

`goto(ff, 'input1', value1, ..., 'inputn', valuen)` positions the PC to the beginning of the function accessed by `ff`, and sets the function input arguments

input1 through inputn to the values value1 through valuen, as provided in the goto syntax. The order of the input names and values is not important; it does not need to match the order of the input arguments in the function prototype or declaration. input1 through inputn can be either the names of the input arguments, or the number of the input argument in the argument list, such as 1 for the first argument, 2 for the second, up to n for the nth argument on the list.

---

**Note** goto must be followed by execute.

---

**See Also**

delete, execute, insert, run

**goto**

---



---

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                              |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Terminate execution of a process running on the target                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Syntax</b>      | <code>halt(cc, timeout)</code>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Description</b> | <p><code>halt(cc, timeout)</code> immediately stops program execution by the processor. After the processor stops, <code>halt</code> returns to the host. <code>timeout</code> defines, in seconds, how long the host waits for the target processor to stop running. To resume processing after you halt the processor, use <code>run</code>. Also, the <code>read(cc, 'pc')</code> function can determine the memory address where the processor stopped after you use <code>halt</code>.</p> <p><code>timeout</code> defines the maximum time the routine waits for the processor to stop. If the processor does not stop within the specified timeout period, the routine returns with a timeout error.</p> <p><code>halt(cc)</code> immediately stops program execution by the processor. After the processor stops, <code>halt</code> returns to the host. In this syntax, the timeout period defaults to the global timeout period specified in <code>cc</code>. Use <code>get(cc)</code> to determine the global timeout period.</p> |

### Using halt with multiple processor target boards

When you issue a `halt` from the command line, it applies to every processor that the `cc` object represents. Thus `halt` stops every running processor for the object. We call this process broadcasting the method.

### Examples

Use one of the provided demonstration programs to show how `halt` works. From the CCS IDE demonstration programs, load and run `volume.out`.

At the MATLAB prompt create a link to CCS IDE

```
cc = ccsdsp
```

Check whether the program `volume.out` is running on the processor.

```
isrunning(cc)
```

```
ans =
```

```
1
```

```
cc.isrunning % Alternate syntax for checking the run status.
```

# halt

---

```
ans =
 1
halt(cc) % Stop the running application on the processor.
isrunning(cc)

ans =
 0
```

Issuing the halt stopped the process on the target. Checking in CCS IDE shows that the process has stopped.

## See Also

ccsdsp, isrunning, run

**Purpose** Return information about the target processor

**Syntax**  
`info = info(cc)`  
`info = info(rx)`

**Description** `info = info(cc)` returns the property names and property values associated with the processor targeted by `cc`. `info` is a structure containing the following information elements and values:

| Structure Element             | Data Type | Description                                                                                                                                                                                                                                                                                                                                                                                               |
|-------------------------------|-----------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>info.procname</code>    | String    | Processor name as defined in the CCS setup utility. In multiprocessor systems, this name reflects the specific processor associated with <code>cc</code> .                                                                                                                                                                                                                                                |
| <code>info.isbigendian</code> | Boolean   | Value describing the byte ordering used by the target processor. When the processor is big-endian, this value is 1. Little-endian processors return 0.                                                                                                                                                                                                                                                    |
| <code>info.family</code>      | Integer   | Three-digit integer that identifies the processor family, ranging from 000 to 999. For example, 320 for Texas Instruments digital signal processors.                                                                                                                                                                                                                                                      |
| <code>info.subfamily</code>   | Decimal   | Decimal representation of the hexadecimal identification value that TI assigns to the processor to identify the processor subfamily. IDs range from 0x000 to 0x3822. Use <code>dec2hex</code> to convert the value in <code>info.subfamily</code> to standard notation. For example<br><code>dec2hex(info.subfamily)</code><br>produces '67' when the processor is a member of the 67xx processor family. |
| <code>info.timeout</code>     | Integer   | Default timeout value MATLAB uses when transferring data to and from CCS. All functions that use a timeout value have an optional timeout input argument. When you omit the optional argument, MATLAB uses this default value—10s.                                                                                                                                                                        |

`info = info(rx)` returns `info` as a cell array containing the names of your open RTDX channels.

## Using info with multiprocessor boards

Method `info` works with targets that have more than one processor by returning the information for each processor accessed by the `cc` object you created with `ccsdsp`. The structure of information returned is identical to the single processor case, for every included processor.

## Examples

On a PC with a simulator configured in CCS IDE, `info` returns the configuration for the processor being simulated:

```
info(cc)

ans =

 procname: 'CPU'
 isbigendian: 0
 family: 320
 subfamily: 103
 timeout: 10
```

In this example, we are simulating the TMS320C6211 processor running in little-endian mode. When you use CCS Setup Utility to change the processor from little-endian to big-endian, `info` shows the change.

```
info(cc)

ans =

 procname: 'CPU'
 isbigendian: 1
 family: 320
 subfamily: 103
 timeout: 10
```

If you have two open channels, `chan1` and `chan2`,

```
info = info(rx)
```

---

returns

```
info =
'chan1'
'chan2'
```

where `info` is a cell array. You can dereference the entries in `info` to manipulate the channels. For example, you can close a channel by dereferencing the channel in `info` in the `close` function syntax.

```
close(rx.info{1,1})
```

**See Also**

`ccsdsp`, `dec2hex`, `get`, `set`

# insert

---

## Purpose

Add a debug point to a source file or address in Code Composer Studio

```
insert(cc, addr, 'type')
insert(cc, addr)
insert(cc, filename, line, 'type')
insert(cc, filename, line)
```

## Description

`insert(cc, addr, type)` adds a debug point located at the memory address identified by `addr` for your target digital signal processor. The link `cc` identifies which target has the debug point to insert. CCS provides several types of debug points. Options for `type` include the following strings to define Breakpoints, Probe Points, and Profile points:

- 'break' — add a Breakpoint. It defines a point at which program execution stops.
- '' — same as 'break'.
- 'probe' — add a Probe Point that updates a CCS window during program execution. When CCS connects your probe point to a window, the window gets updated only when the executing program reaches the Probe Point.
- 'profile' — add a point in an executing program at which CCS gathers statistics about events that occurred since encountering the previous profile point, or from the start of your program.

Enter `addr` as a hexadecimal address, not as a C function name, valid C expression, or a symbol name.

To learn more about the behavior of the various debugging points refer to your CCS documentation.

`insert(cc, addr)` is the same as the previous syntax except the `type` string defaults to 'break' for inserting a Breakpoint.

`insert(cc, filename, line, 'type')` lets you specify the line where you are inserting the debug point. `line`, in decimal notation, specifies the line number in `filename` in CCS where you are adding the debug point. To identify the source file, `filename` contains the name of the file in CCS, entered as a string in single quotation marks. `type` accepts one of three strings — `break`, `probe`, or `profile` — as defined previously. When the line or file you specified does not

exist, the Link for Code Composer Studio returns an error explaining that it could not insert the debug point.

`insert(cc,filename,line)` defaults to type 'break' to insert a breakpoint.

## Example

Open a project in CCS IDE, such as `volume.pjt` in the **tutorial** folder where you installed CCS IDE. Although you can do this from CCS IDE, use the Link for Code Composer Studio functions to open the project and activate the appropriate source file where you add the breakpoint. Remember to load the program file `volume.out` so you can access symbols and their addresses.

```
cd(cc,'c:\ti\tutorial\sim62xx\volume1') % Default install;
wd=cd(cc);

wd =

c:\ti\tutorial\sim62xx\volume1

open(cc,'volume.pjt');

build(cc, 30);
```

Now add a breakpoint and a probe point.

```
insert(cc,15424,'break') % Adds a breakpoint at symbol main
insert(cc,'volume.c',47,'probe') % Adds a probe point on line 47
```

Switch to CCS IDE and open `volume.c`. Note the blue diamond and red circle in the left margin of the `volume.c` listing. Red circles indicate Breakpoints and blue diamonds indicate Probe Points.

Use `symbol` to return a structure listing the symbols and their addresses for the current program file. `symbol` returns a structure that contains all the symbols. To display all the symbols with addresses, use a loop construct like the following:

```
for k=1:length(s),disp(k),disp(s(k)),end
```

where structure `s` holds the symbols and addresses.

## See Also

`address`, `delete`, `run`

# isenabled

---

**Purpose** Determine whether an RTDX link is enabled for communications

**Syntax** `isenabled(rx, 'channel')`  
`isenabled(rx)`

**Description** `isenabled(rx, 'channel')` returns `ans=1` when the RTDX channel specified by string 'channel' is enabled for read or write communications. When 'channel' has not been enabled, `isenabled` returns `ans=0`.

`isenabled(rx)` returns `ans=1` when RTDX has been enabled, independent of any channel. When you have not enabled RTDX you get `ans=0` back.

## Important requirements for using isenabled

On the target side, `isenabled` depends on RTDX to determine and report the RTDX status. Therefore the you must meet the following requirements to use `isenabled`.

- 1 The target must be running a program when you query the RTDX interface.
- 2 You must enable the RTDX interface before you check the status of individual channels or the interface.
- 3 Your target program must be polling periodically for `isenabled` to work.

---

**Note** For `isenabled` to return reliable results, your target must be running a loaded program. When the target is not running, `isenabled` returns a status that may not represent the true state of the link or RTDX.

---

## Examples

With a program loaded on your target, you can determine whether RTDX channels are ready for use. restart your program to be sure it is running. The target must be running for `isenabled` to work, as well as for `enabled` to work. In this example, we created a link `cc` to begin.

```
cc.restart
cc.run('run');
cc.rtdx.enable('ichan');
cc.rtdx.isenabled('ichan')
```



MATLAB returns 1 indicating that your channel 'ichan' is enabled for RTDX communications. To determine the mode for the channel, use `cc.rtdx` to display the properties of link `cc.rtdx`.

**See Also**

`clear`, `disable`, `enable`

# isreadable

---

**Purpose** Determine if MATLAB can read the specified memory block

**Syntax**

```
isreadable(cc,address,'datatype', count)
isreadable(cc,address,'datatype')
isreadable(rx,'channel')
```

**Description** `isreadable(cc,address,'datatype',count)` returns 1 if the processor referred to by `cc` can read the memory block defined by the `address`, `count`, and `datatype` input arguments. When the processor cannot read any portion of the specified memory block, `isreadable` returns 0. Notice that you use the same memory block specification for this function as you use for the `read` function. The data block being tested begins at the memory location defined by `address`. `count` determines the number of values to be read. `datatype` defines the format of data stored in the memory block. `isreadable` uses the `datatype` string to determine the number of bytes to read per stored value. For details about each input parameter, read the following descriptions.

`address` — `isreadable` uses `address` to define the beginning of the memory block to read. You provide values for `address` as either decimal or hexadecimal representations of a memory location in the target processor. The full address at a memory location consists of two parts: the offset and the memory page, entered as a vector `[location, page]`, a string, or a decimal value. In cases where the processor has only one memory page, as is true for many digital signal processors, the page portion of the memory address is 0. By default, `ccsdsp` sets the page to 0 at creation if you omit the page property as an input argument to set the page parameter. For processors that have one memory page, setting the page value to 0 lets you specify all memory locations in the processor using just the memory location without the page value.

**Table 4-1: Examples of Address Property Values**

| Property Value | Address Type | Interpretation                                                           |
|----------------|--------------|--------------------------------------------------------------------------|
| '1F'           | String       | Location is 31 decimal on the page referred to by <code>cc</code> (page) |

**Table 4-1: Examples of Address Property Values**

| Property Value | Address Type | Interpretation                                                         |
|----------------|--------------|------------------------------------------------------------------------|
| 10             | Decimal      | Address is 10 decimal on the page referred to by <code>cc(page)</code> |
| [18,1]         | Vector       | Address location 10 decimal on memory page 1 ( $cc(page) = 1$ )        |

To specify the address in hexadecimal format, enter the address property value as a string. `isreadable` interprets the string as the hexadecimal representation of the desired memory location. To convert the hex value to a decimal value, the function uses `hex2dec`. Note that when you use the string option to enter the address as a hex value, you cannot specify the memory page. For string input, the memory page defaults to the page specified by `cc(page)`.

`count` — a numeric scalar or vector that defines the number of `datatype` values to test for being readable. To assure parallel structure with `read`, `count` can be a vector to define multidimensional data blocks. This function always tests a block of data whose size is the product of the dimensions of the input vector.

`datatype` — a string that represents a MATLAB data type. The total memory block size is derived from the value of `count` and the `datatype` you specify.

`datatype` determines how many bytes to check for each memory value.

`isreadable` supports the following data types:

| datatype String | Number of Bytes/Value | Description                            |
|-----------------|-----------------------|----------------------------------------|
| 'double'        |                       | Double-precision floating point values |
| 'int8'          |                       | Signed 8-bit integers                  |
| 'int16'         |                       | Signed 16-bit integers                 |
| 'int32'         |                       | Signed 32-bit integers                 |
| 'single'        |                       | Single-precision floating point data   |

# isreadable

---

| datatype String | Number of Bytes/Value | Description              |
|-----------------|-----------------------|--------------------------|
| 'uint8'         |                       | Unsigned 8-bit integers  |
| 'uint16'        |                       | Unsigned 16-bit integers |
| 'uint32'        |                       | Unsigned 32-bit integers |

Like the `iswritable`, `write`, and `read` functions, `isreadable` checks for valid address values. Illegal address values would be any address space larger than the available space for the processor— $2^{32}$  for the C6xxx processor family and  $2^{16}$  for the C5xxx series. When the function identifies an illegal address, it returns an error message stating that the address values are out of range.

`isreadable(cc, address, 'datatype')` returns 1 if the processor referred to by `cc` can read the memory block defined by the address, and 'datatype' input arguments. When the processor cannot read any portion of the specified memory block, `isreadable` returns 0. Notice that you use the same memory block specification for this function as you use for the `read` function. The data block being tested begins at the memory location defined by address. When you omit the count option, count defaults to one.

`isreadable(rx, 'channel')` returns a 1 when the RTDX channel specified by the string 'channel', associated with link `rx`, is configured for 'read' operation. When 'channel' is not configured for reading, `isreadable` returns 0.

Like the `iswritable`, `read`, and `write` functions, `isreadable` checks for valid address values. Illegal address values would be any address space larger than the available space for the processor— $2^{32}$  for the C6xxx processor family and  $2^{16}$  for the C5xxx series. When the function identifies an illegal address, it returns an error message stating that the address values are out of range.

---

**Note** `isreadable` relies on the memory map option in CCS IDE. If you did not properly define the memory map for the processor in CCS IDE, `isreadable` does not produce useful results. Refer to your Code Composer Studio documentation for more information on configuring memory maps.

---

## Examples

When you write scripts to run models in MATLAB and CCS IDE, the `isreadable` function is very useful. Use `isreadable` to check that the channel from which you are reading is configured properly.

```
cc = ccstdsp;
rx = cc.rtdx;

% Define read and write channels to the target linked by cc.
open(rx, 'ichannel', 'r');
open(rx, 'ochannel', 'w');
enable(rx, 'ochannel');
enable(rx, 'ichannel');

isreadable(rx, 'ochannel')
ans=
 0
isreadable(rx, 'ichannel')
ans=
 1
```

Now that your script knows that it can read from 'ichannel', it proceeds to read messages as required.

## See Also

`hex2dec`, `iswritable`, `read`

# isrtdxcapable

---

**Purpose** Determine whether the target processor supports RTDX

**Syntax** `b=isrtdxcapable(cc)`

**Description** `b=isrtdxcapable(cc)` returns `b=1` when the target processor referenced by link `cc` supports Real-Time Data Exchange (RTDX). When the target does not support RTDX, `isrtdxcapable` returns `b=0`.

## Using `isrtdxcapable` with multiprocessor boards

When your target board contains more than one processor, `isrtdxcapable` checks each processor on the target, as defined by the `cc` object, and returns the RTDX capability for each processor on the board. In the returned variable `b`, you see a vector that contains the information for each accessed processor.

**Examples** Create a link to your C6701EVM. Test to see if the processor on the board supports RTDX. It should.

```
cc=ccsdsp; %Assumes you have one board and it is the C6701 EVM
b=isrtdxcapable(cc)
b =
 1
```

**Purpose** Test whether the target processor is executing a process

**Syntax** `isrunning(cc)`

**Description** `isrunning(cc)` returns 1 when the target processor is executing a program. When the processor is halted, `isrunning` returns 0.

### Using `isrunning` with multiprocessor boards

When your target board contains more than one processor, `isrunning` checks each processor on the target, as defined by the `cc` object, and returns the state for each processor on the board. In the returned variable `b`, you see a vector that contains the information for each accessed processor.

By providing a return variable, as shown here

```
b = isrunning(cc)
```

`b` contains a vector that holds the information about the state of all processors accessed by `cc`.

### Examples

`isrunning` lets you determine whether the target processor is running. After you load a program to the target, use `isrunning` to be sure the program is running before you enable RTDX channels.

```
cc = ccdsp;

isrunning(cc)

ans =

 0
% Load a program to the target.

run(cc)
isrunning(cc)

ans =

 1
```

# isrunning

---

```
halt(cc)
isrunning(cc)
```

```
ans =
```

```
0
```

## See Also

halt, restart, isrunning



|                    |                                                                                                                                                                                                                                                                                |
|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Test whether CCS IDE is running on the PC                                                                                                                                                                                                                                      |
| <b>Syntax</b>      | <code>isvisible(cc)</code>                                                                                                                                                                                                                                                     |
| <b>Description</b> | <code>isvisible(cc)</code> determines whether CCS IDE is running on the desktop and the window is open. If CCS IDE window is open, <code>isvisible</code> returns 1. Otherwise, the result is 0 indicating that CCS IDE is either not running or is running in the background. |

**Examples** Test to see if CCS IDE is running. Start by launching CCS IDE. Then open MATLAB. At the prompt, enter

```
cc=ccsdsp

CCSDSP Object:
 API version = 1.0
 Processor type = C67
 Processor name = CPU
 Running? = No
 Board number = 0
 Processor number = 0
 Default timeout = 10.00 secs

RTDX Object:
 Timeout: 10.00 secs
 Number of open channels: 0
```

MATLAB creates a link to CCS IDE and leaves CCS IDE visible on your desktop.

```
isvisible(cc)

ans =

 1
```

Now, change the visibility state to 0, or invisible, and check the state.

```
visible(cc,0)
isvisible(cc)
```

# isvisible

---

```
ans =
```

```
0
```

Notice that CCS IDE is not visible on your desktop. Recall that MATLAB did not open CCS IDE. When you close MATLAB with CCS IDE in this invisible state, CCS IDE remains running in the background. The only ways to close it are either

- Launch MATLAB. Create a new link to CCS IDE. Use the new link to make CCS IDE visible. Close CCS IDE.
- Open Windows Task Manager. Click **Processes**. Find and highlight `cc_app.exe`. Click **End Task**.

## See Also

`info`, `visible`

**Purpose** Determine if MATLAB can write to the specified memory block

**Syntax** `iswritable(cc,address,'datatype',count)`  
`iswritable(cc,address,'datatype')`

**Description** `iswritable(cc,address,'datatype',count)` returns 1 if MATLAB can write to the memory block defined by the address, count, and datatype input arguments on the processor referred to by cc. When the processor cannot write to any portion of the specified memory block, `iswritable` returns 0. Notice that you use the same memory block specification for this function as you use for the write function. The data block being tested begins at the memory location defined by address. count determines the number of values to write. datatype defines the format of data stored in the memory block. `iswritable` uses the datatype parameter to determine the number of bytes to write per stored value. For details about each input parameter, read the following descriptions.

**address** — `iswritable` uses address to define the beginning of the memory block to write to. You provide values for address as either decimal or hexadecimal representations of a memory location in the target processor. The full address at a memory location consists of two parts: the offset and the memory page, entered as a vector [*location*, *page*], a string, or a decimal value. In cases where the processor has only one memory page, as is true for many digital signal processors, the page portion of the memory address is 0. By default, `ccsdsp` sets the page to 0 at creation if you omit the page property as an input argument to set the page parameter.

For processors that have one memory page, setting the page value to 0 lets you specify all memory locations in the processor using the memory location without the page value.

**Table 4-2: Examples of Address Property Values**

| Property Value | Address Type | Interpretation                                              |
|----------------|--------------|-------------------------------------------------------------|
| '1F'           | String       | Location is 31 decimal on the page referred to by cc (page) |

**Table 4-2: Examples of Address Property Values (Continued)**

| Property Value | Address Type | Interpretation                                                             |
|----------------|--------------|----------------------------------------------------------------------------|
| 10             | Decimal      | Address is 10 decimal on the page referred to by <code>cc(page)</code>     |
| [18,1]         | Vector       | Address location 10 decimal on memory page 1 ( <code>cc(page) = 1</code> ) |

To specify the address in hexadecimal format, enter the address property value as a string. `iswritable` interprets the string as the hexadecimal representation of the desired memory location. To convert the hex value to a decimal value, the function uses `hex2dec`. Note that when you use the string option to enter the address as a hex value, you cannot specify the memory page. For string input, the memory page defaults to the page specified by `cc(page)`.

`count`—a numeric scalar or vector that defines the number of `datatype` values to test for being writable. To assure parallel structure with `write`, `count` can be a vector to define multidimensional data blocks. This function always tests a block of data whose size is the total number of elements in matrix specified by the input vector. If `count` is the vector [10 10 10]

```
iswritable(cc,31,[10 10 10])
```

`iswritable` writes 1000 values (10\*10\*10) to the target processor. For a 2-dimensional matrix defined with `count` as

```
iswritable(cc,31,[5 6])
```

`iswritable` writes 30 values to the processor.

`datatype`—a string that represents a MATLAB data type. The total memory block size is derived from the value of `count` and the specified `datatype`.

`datatype` determines how many bytes to check for each memory value. `iswritable` supports the following data types:

| <b>datatype String</b> | <b>Description</b>                     |
|------------------------|----------------------------------------|
| 'double'               | Double-precision floating point values |
| 'int8'                 | Signed 8-bit integers                  |
| 'int16'                | Signed 16-bit integers                 |
| 'int32'                | Signed 32-bit integers                 |
| 'single'               | Single-precision floating point data   |
| 'uint8'                | Unsigned 8-bit integers                |
| 'uint16'               | Unsigned 16-bit integers               |
| 'uint32'               | Unsigned 32-bit integers               |

`iswritable(cc, address, 'datatype')` returns 1 if the processor referred to by `cc` can write to the memory block defined by the address, and count input arguments. When the processor cannot write any portion of the specified memory block, `iswritable` returns 0. Notice that you use the same memory block specification for this function as you use for the write function. The data block tested begins at the memory location defined by address. When you omit the count option, count defaults to one.

---

**Note** `iswritable` relies on the memory map option in CCS IDE. If you did not properly define the memory map for the processor in CCS IDE, this function does not produce useful results. Refer to your Code Composer Studio documentation for more information on configuring memory maps.

---

Like the `isreadable`, `read`, and `write` functions, `iswritable` checks for valid address values. Illegal address values would be any address space larger than the available space for the processor— $2^{32}$  for the C6xxx processor family and  $2^{16}$  for the C5xxx series. When the function identifies an illegal address, it returns an error message stating that the address values are out of range.

# iswritable

---

## Examples

When you write scripts to run models in MATLAB and CCS IDE, the `iswritable` function is very useful. Use `iswritable` to check that the channel to which you are writing to is indeed configured properly.

```
cc = ccstdsp;
rx = cc.rtdx;

% Define read and write channels to the target linked by cc.
open(rx, 'ichannel', 'r');
open(rx, 'ochannel', 'w');
enable(rx, 'ochannel');
enable(rx, 'ichannel');

iswritable(rx, 'ochannel')
ans=
 1
iswritable(rx, 'ichannel')
ans=
 0
```

Now that your script knows that it can write to 'ichannel', it proceeds to write messages as required.

## See Also

`hex2dec`, `iswritable`, `read`

---

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Return various information listings from Code Composer Studio                                                                                                                                                                                                                                                                                                                                                                                               |
| <b>Syntax</b>      | <pre>list(ff,varname) infolist = list(cc,type) infolist = list(cc,type,option)</pre>                                                                                                                                                                                                                                                                                                                                                                        |
| <b>Description</b> | <p><code>list(ff,varname)</code> lists the local variables associated with the function accessed by function object <code>ff</code>. Compare to <code>list(cc,'variable','varname')</code> which works the same way to return variables from link object <code>cc</code>.</p> <hr/> <p><b>Note</b> <code>list</code> does not recognize or return information about variables that you declare in your code but that are not used or initialized.</p> <hr/> |

Some restrictions apply when you use `list` with function objects. `list` generates an error in the following circumstances:

- when `varname` is not a valid input argument for the function accessed by `ff`  
For example, if your function declaration is

```
int foo(int a)
```

but you request information about input argument `b`, which is not defined

```
list(ff,'b')
```

MATLAB returns an error.

- when `varname` is the same as a variable assigned by MATLAB. Usually this happens when you use `declare` to pass a function declaration to MATLAB and the declaration string does not match the declaration for `ff` as determined when you created `ff`.

In an example that demonstrates this problem, the function declaration has a name for the first input, `a`. In the `declare` call, the declaration string does not provide a name for the first input, just a data type, `int`. When you issue the `declare` call, MATLAB names the first input `ML_Input1`. If you try to use `list` to get information about the input named `ML_Input`, `list` returns an error. Here is the code, starting with the function declaration in your code:

```
int foo(int a) % Function declaration in your source code
declare(ff,'decl','int foo(int)')
```

```
% MATLAB generates a warning that it has assigned the name
% ML_Input to the first input argument
list(ff,'ML_Input') % list returns an error for this call
```

- when varname does not match the input name in the function declaration provided in your source code, as compared to the declaration string you used in a declare operation.

Assume your source code includes a function declaration for foo:

```
int foo(int a);
```

Now pass a declaration for foo to MATLAB:

```
declare(ff,'decl','int foo(int b)')
```

MATLAB issues a warning that the input names do not match. When you use list on the input argument b

```
list(ff,'b')
```

list returns an error.

- when varname is an input to a library function. list always fails in this case. It does not matter whether you use declare to provide the declaration string for the library function.

---

**Note** When you call list for a variable in a function object

```
list(ff,varname)
```

the address field may contain an incorrect address if the program counter is not within the scope of the function that includes varname when you call list.

---

infolist = list(cc,type) reads information about your Code Composer Studio session and returns it in infolist. Different types of information and return formats are possible depending on the input arguments you supply to the list function call. The type argument specifies which information listing to return. To determine the information that list returns, use one of the following as the type parameter string:

- **project**—tell list to return information about the current project in CCS.



- **variable**—tell `list` to return information about one or more embedded variables.
- **globalvar**—tell `list` to return information about one or more global embedded variables.
- **function**—tell `list` to return details about one or more functions in your project.
- **type**—tell `list` to return information about one or more defined data types, including struct, enum, and union. C data type typedefs are excluded from the list of data types.

Note, the `list` function returns dynamic Code Composer information that can be altered by the user. Returned listings represent snapshots of the current Code Composer studio configuration only. Be aware that earlier copies of `infolist` might contain stale information.

`infolist = list(cc, 'project')` returns a vector of structures containing project information in the format shown here when you specify option `type` as **project**.

| <b>infolist Structure Element</b>   | <b>Description</b>                                                                                                                                                  |
|-------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>infolist(1).name</code>       | Project file name (with path).                                                                                                                                      |
| <code>infolist(1).type</code>       | Project type—'project','projlib', or 'projext', see <code>new</code>                                                                                                |
| <code>infolist(1).targettype</code> | String Description of Target CPU                                                                                                                                    |
| <code>infolist(1).srcfiles</code>   | Vector of structures that describes project source files. Each structure contains the name and path for each source file—<br><code>infolist(1).srcfiles.name</code> |

# list

| <b>infolist Structure Element</b> | <b>Description</b>                                                                                                                                                                                                                                                                                                      |
|-----------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>infolist(1).buildcfg</code> | Vector of structures that describe build configurations, each with the following entries: <ul style="list-style-type: none"><li>• <code>infolist(1).buildcfg.name</code>—the build configuration name</li><li>• <code>infolist(1).buildcfg.outpath</code>—the default directory for storing the build output.</li></ul> |
| <code>infolist(2).</code>         | ...                                                                                                                                                                                                                                                                                                                     |
| <code>infolist(n).</code>         | ...                                                                                                                                                                                                                                                                                                                     |

`infolist = list(cc,'variable')` returns a structure of structures that contains information on all local variables within scope. The list also includes information on all global variables. Note, however, that if a local variable has the same symbol name as a global variable, `list` returns the information about the local variable.

`infolist = list(cc,'variable',varname)` returns information about the specified variable `varname`.

`infolist = list(cc,'variable',varnamelist)` returns information about variables in a list specified by `varnamelist`. The returned information in each structure follows the format below when you specify option type as **variable**:

| <b>infolist Structure Element</b>         | <b>Description</b>                           |
|-------------------------------------------|----------------------------------------------|
| <code>infolist.varname(1).name</code>     | Symbol name                                  |
| <code>infolist.varname(1).isglobal</code> | Indicates whether symbol is global or local  |
| <code>infolist.varname(1).location</code> | Information about the location of the symbol |
| <code>infolist.varname(1).size</code>     | Size per dimension                           |

| <b>infolist Structure Element</b>        | <b>Description</b>                                                                     |
|------------------------------------------|----------------------------------------------------------------------------------------|
| <code>infolist.varname(1).uclass</code>  | ccsdsp object class that matches the type of this symbol                               |
| <code>infolist.varname(1).bitsize</code> | Size in bits. More information is added to the structure depending on the symbol type. |
| <code>infolist.(varname1).type</code>    | data type of symbol                                                                    |
| <code>infolist.varname(2).</code>        | ...                                                                                    |
| <code>infolist.varname(n).</code>        | ...                                                                                    |

`list` uses the variable name as the fieldname to refer to the structure information for the variable.

`infolist = list(cc,'globalvar')` returns a structure that contains information on all global variables.

`infolist = list(cc,'globalvar',varname)` returns a structure that contains information on the specified global variable.

`infolist = list(cc,'globalvar',varnamelist)` returns a structure that contains information on global variables in the list. The returned information follows the same format as the syntax `infolist = list(cc,'variable',...)`.

`infolist = list(cc,'function')` returns a structure that contains information on all functions in the embedded program.

`infolist = list(cc,'function',functionname)` returns a structure that contains information on the specified function `functionname`.

`infolist = list(cc,'function',functionnamelist)` returns a structure that contains information on the specified functions in `functionnamelist`. The

# list

returned information follows the format below when you specify option type as **function**:

| <b>infolist Structure Element</b>               | <b>Description</b>                                                                   |
|-------------------------------------------------|--------------------------------------------------------------------------------------|
| <code>infolist.functionname(1).name</code>      | Function name                                                                        |
| <code>infolist.functionname(1).filename</code>  | Name of file where function is defined                                               |
| <code>infolist.functionname(1).address</code>   | Relevant address information such as start address and end address                   |
| <code>infolist.functionname(1).funcvar</code>   | Variables local to the function                                                      |
| <code>infolist.functionname(1).uclass</code>    | ccsdsp object class that matches the type of this symbol - <b>'function'</b>         |
| <code>infolist.functionname(1).funcdecl</code>  | Function declaration—where information such as the function return type is contained |
| <code>infolist.functionname(1).islibfunc</code> | Is this a library function?                                                          |
| <code>infolist.functionname(1).linepos</code>   | Start and end line positions of function                                             |
| <code>infolist.functionname(1).funcinfo</code>  | Miscellaneous information about the function                                         |
| <code>infolist.functionname(2).</code>          | ...                                                                                  |
| <code>infolist.functionname(n).</code>          | ...                                                                                  |

To refer to the function structure information, `list` uses the function name as the field name.

`infolist = list(cc,'type')` returns a structure that contains information on all defined data types in the embedded program. This method includes `struct`,

enum and union data types and excludes typedefs. The name of a defined type is its C struct tag, enum tag or union tag. If the C tag is not defined, it is referred to by the Code Composer Studio compiler as '\$faken' where n is an assigned number.

`infolist = list(cc,'type',typename)` returns a structure that contains information on the specified defined data type.

`infolist = list(cc,'type',typenamelist)` returns a structure that contains information on the specified defined data types in the list. The returned information follows the format below when you specify option `type` as **type**:

| <b>infolist Structure Element</b>        | <b>Description</b>                                                                                              |
|------------------------------------------|-----------------------------------------------------------------------------------------------------------------|
| <code>infolist.typename(1).type</code>   | Type name                                                                                                       |
| <code>infolist.typename(1).size</code>   | Size of this type                                                                                               |
| <code>infolist.typename(1).uclass</code> | ccsdsp object class that matches the type of this symbol. Additional information is added depending on the type |
| <code>infolist.typename(2).</code>       | ...                                                                                                             |
| <code>infolist.typename(n).</code>       | ...                                                                                                             |

For the field name, `list` uses the type name to refer to the type structure information.

Important—when a variable name, type name, or function name is not a valid MATLAB structure field name, `list` replaces or modifies the name so it becomes valid.

---

**Note** In fieldnames that contain the invalid dollar character '\$', `list` replaces the '\$' with 'DOLLAR.'

---

---

**Note** Changing the MATLAB field name does not change the name of the embedded symbol or type.

---

## Examples

This first example shows `list` used with a variable, providing information about the variable `varname`. Notice that the invalid fieldname `'_with_underscore'` gets changed to `'Q_with_underscore'`. To make the invalid name valid, `list` inserts the character 'Q' before the name.

```
varname1 = '_with_underscore'; % invalid fieldname
list(cc,'variable',varname1);
ans =

 Q_with_underscore : [varinfo]
ans. Q_with_underscore
ans=

 name: '_with_underscore'
 isglobal: 0
 location: [1x62 char]
 size: 1
 uclass: 'numeric'
 type: 'int'
 bitsize: 16
```

To demonstrate using `list` with a defined C type, variable `typename1` includes the type argument. Since valid fieldnames cannot contain the \$ character, `list` changes the \$ to `DOLLAR`.

```
typename1 = '$fake3'; % name of defined C type with no tag
list(cc,'type',typename1);
ans =

 DOLLARfake0 : [typeinfo]

ans.DOLLARfake0=

 type: 'struct $fake0'
 size: 1
```

```
 uclass: 'structure'
 sizeof: 1
 members: [1x1 struct]
```

When you request information about a project in CCS, you see a listing like the following that includes structures containing details about your project.

```
projectinfo=list(cc,'project')
```

```
projectinfo =
```

```
 name: 'D:\Work\c6711dskafxr_c6000_rtw\c6711dskafxr.pjt'
 type: 'project'
targettype: 'TMS320C67XX'
 srcfiles: [69x1 struct]
 buildcfg: [3x1 struct]
```

## See Also

info

# load

---

**Purpose** Transfer a program file (\*.out, \*.obj) to the target processor in the active project

**Syntax**

```
load(cc, 'filename', timeout)
load(cc, 'filename')
load(cc, 'gelfilename', timeout)
```

**Description** `load(cc, 'filename', timeout)` loads the file specified by `filename` into the target processor. `filename` can include a full path to a file, or just the name of a file that resides in the Code Composer Studio (CCS) working directory. Use `cd` to check or modify the working directory. Only use `load` with program files that are created by the Code Composer Studio build process.

`timeout` defines the upper limit on how long MATLAB waits for the load process to be complete. If this period is exceeded, `load` returns immediately with a timeout error.

`load(cc, 'filename')` loads the file specified by `filename` into the target processor. `filename` can include a full path to a file, or just the name of a file that resides in the Code Composer Studio (CCS) working directory. Use `cd` to check or modify the working directory. Only use `load` with program files that are created by the Code Composer Studio build process. `timeout` defaults to the global value you set when you created link `cc`.

---

**Note** `load` disables all open channels. Open channels revert to disabled.

---

`load(cc, 'gelfilename', timeout)` loads and opens the general extension language (GEL) file named `gelfilename` into CCS, in the active project. `gelfilename` needs to be the full path to the file, or just the file name if the file already shows up in your CCS workspace or project. `load` adds the GEL file to the active project only. To make a different project active so you can add your GEL file to it, use `active`.

The `timeout` option is not required, as is true for most methods in the product. Using `load` to add a GEL file is identical to using the **File->Load GEL...** option in Code Composer Studio IDE. Your loaded GEL file appears in the GEL files folder in CCS. To remove GEL files, use `remove`. You can load any GEL file—



you must be sure the GEL file is the correct one. `load` does not attempt to verify whether the GEL file is appropriate for your hardware or project.

## Examples

Taken from the CCS link tutorial, this code prepares for and loads an object file `filename.out` to a target processor.

```
projfile = ...
fullfile(matlabroot, 'directoryname', 'directoryname', 'filename')
projpath = fileparts(projfile)
open(cc,projfile) % Open project file
cd(cc,projpath) % Change Code Composer working directory
```

Now use CCS IDE to build your file. Select **Project->Build** from the menu bar in CCS IDE.

With the project build complete, load your `.out` file by typing

```
load(cc, 'filename.out')
```

## See Also

`cd`, `dir`, `open`

# msgcount

---

**Purpose** Return the number of messages in a read-enabled channel queue

**Syntax** `msgcount(rx, 'channel')`

**Description** `msgcount(rx, 'channel')` returns the number of unread messages in the read-enabled queue specified by `channel` for the RTDX link `rx`. You cannot use `msgcount` on channels configured for write access.

**Examples** If you have created and loaded a program to the target processor, you can write data to the target, then use `msgcount` to determine the number of messages in the read queue.

- 1** Create and load a program to the target.
- 2** Write data to the target from MATLAB.

```
indata=1:100;
writemsg(cc.rtdx, 'ichannel', int32(indata));
```
- 3** Use `msgcount` to determine the number of messages available in the queue.

```
num_of_msgs = msgcount(cc.rtdx, 'ichannel')
```

**See Also** `read`, `readmat`, `readmsg`

**Purpose** Create and open a new text file, project, or build configuration in CCS IDE

**Syntax**  
`new(cc, 'objectname', 'type')`  
`new(cc, 'objectname')`

**Description** `new(cc, 'objectname', 'type')` creates and opens an empty object of type named `objectname` in the active project in CCS IDE. The new object can be a text file, a project, or a build configuration. String `objectname` specifies the name of the new object. When you create new text files or projects, `objectname` can include a full path description. When you save your new project or file, CCS IDE stores the file at the target of the full path.

If you do not provide a full path for your file, `new` stores the file in the CCS IDE working directory when you save it. New files open as active windows in CCS IDE; they are not placed in the active project folders based on their file extension (compare to `add`).

New build configurations always become part of the active project in CCS IDE. Since build configurations always become part of a project, you only need to enter a name to distinguish your new configuration from existing configurations in the project, such as `Debug` and `Release`.

To specify the text file or project to create, `objectname` must be the full pathname to the file, unless your file is in a directory on your MATLAB path, or the file is in your CCS working directory. Also, when you create new text files or projects, you must include the file extension in `objectname`.

`type` accepts one of four strings or entries listed in the following table.

| <b>type String</b> | <b>Description</b>                                                                                                                                                                              |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 'text'             | Create a new text file in the active project.                                                                                                                                                   |
| 'project'          | Create a new project.                                                                                                                                                                           |
| 'projext'          | Create a new CCS external make project. Using this option indicates that your project uses and external makefile. Refer to your CCS documentation for more information about external projects. |

## new

| <b>type String</b> | <b>Description</b>                                                                                                                      |
|--------------------|-----------------------------------------------------------------------------------------------------------------------------------------|
| 'projlib'          | Create a new library project with the .lib file extension. Refer to your CCS documentation for more information about library projects. |
| []                 | Create a new project. The [] indicate that you are creating a .pjt file.                                                                |
| 'buildcfg'         | Create a new build configuration in the active project.                                                                                 |

Use new to create the following file types listed in the following table.

### **File Types and Extensions Supported by new and CCS IDE**

| <b>File Type Created</b> | <b>Supported Extensions</b>                           | <b>type String Used</b> |
|--------------------------|-------------------------------------------------------|-------------------------|
| C/C++ source files       | .c, .cpp, .cc, .ccx, .sa                              | 'text'                  |
| Assembly source files    | .a*, .s* (excluding .sa, refer to C/C++ source files) | 'text'                  |
| Object and Library files | .o*, .lib                                             | 'text'                  |
| Linker command file      | .cmd                                                  | 'text'                  |
| Project file             | .pjt                                                  | 'project'               |
| Build configuration      | No extension                                          | 'buildcfg'              |

**Caution** After you create an object in CCS IDE, save the file in CCS IDE. new does not automatically save the file. Failing to save the file can cause you to lose your changes when you close CCS IDE.

new(cc, 'objectname') creates a project in CCS IDE, making it the active project. When you omit the type option, new assumes you are creating a new

project and appends the .pjt extension to objectname to create the project objectname.pjt. The .pjt extension is the only extension new recognizes.

**Examples**

When you need a new project, create a link to CCS IDE and use the link to make a new project in CCS IDE.

```
cc=ccsdsp;
cc.visible(1) % Make CCS IDE visible on your desktop (optional).
new(cc, 'my_new_project.pjt', 'project');
```

New files of various types result from using new to create new active windows in CCS IDE. For instance, make a new C source file in CCS IDE with the following command:

```
new(cc, 'new_source.c', 'text');
```

In CCS IDE you see your new file as the active window.

**See Also**

activate, close, save

# open

---

**Purpose** Open a channel to a target processor or load a file into CCS IDE

**Syntax**

```
open(rx, 'channel1', 'mode1', 'channel2', 'mode2', ...)
open(rx, 'channel', 'mode')
open(cc, filename, filetype, timeout)
open(cc, filename, filetype)
open(cc, filename)
```

**Description** `open(rx, 'channel1', 'mode1', 'channel2', 'mode2', ...)` opens new RTDX channels associated with the link `rx`. Each new channel uses the string name `channel1`, `channel2`, and so on. For each channel, `open` configures the channel according to the associated mode string. `channel1` uses `mode1`; `channel2` uses `mode2`, and so forth. Mode strings are either:

- `'r'` — configure the channel to read data from the target processor.
- `'w'` — configure the channel for writing data to the target processor.

`open(rx, channel, mode)` opens a new channel to the processor associated with the link `rx`. The new channel uses the `channel` string and is configured for reading or writing according to the `mode` string.

`open(cc, filename, filetype, timeout)` loads `filename` into CCS IDE. `filename` can be the full path to the file or, if the file is in the current CCS IDE working directory, you can use a relative path, such as the name of the file. Use `cd` to determine or change the CCS IDE working directory. You use the `filetype` option to override the default file extension. Four `filetype` strings work in this function syntax.

| <b>filetype String</b>   | <b>Extension</b>                                 | <b>Description</b>                           |
|--------------------------|--------------------------------------------------|----------------------------------------------|
| <code>'program'</code>   | <code>.out</code>                                | Executable programs for the target processor |
| <code>'project'</code>   | <code>.c, .a*, .s*, .o*, .lib, .cmd, .mak</code> | CCS IDE project files                        |
| <code>'text'</code>      | <code>any</code>                                 | All text files                               |
| <code>'workspace'</code> | <code>.wks</code>                                | CCS IDE workspace files                      |

To let you determine how long MATLAB waits for `open` to load the file into CCS IDE, `timeout` sets the upper limit, in seconds, for the period MATLAB waits for the load. If MATLAB waits more than `timeout` seconds, `load` returns immediately with a timeout error. Returning a timeout error does not suspend the operation; it stops MATLAB from waiting for confirmation for the operation completion.

`open(cc, filename, filetype)` loads `filename` into CCS IDE. `filename` can be the full path to the file or, if the file is in the current CCS IDE working directory, you can use a relative path, such as the name of the file. Use the `cd` function to determine or change your CCS IDE working directory. You use the `filetype` option to override the default file extension. Refer to the previous syntax for more information about `filetype`. When you omit the `timeout` option in this syntax, MATLAB uses the global timeout set in `cc`.

`open(cc, filename)` loads `filename` into CCS IDE. `filename` can be the full path to the file or, if the file is in the current CCS IDE working directory, you can use a relative path, such as the name of the file. Use the `cd` function to determine or change the CCS IDE working directory. You use the `filetype` option to override the default file extension. Refer to the previous syntax for more information about `filetype`. When you omit the `filetype` and `timeout` options in this syntax, MATLAB uses the global timeout set in `cc`, and derives the file type from the extension in `filename`. Refer to the previous syntax descriptions for more information on the input options.

Channels must be opened and enabled before you use them. You cannot write to or read from channels that you opened but did not enable.

---

**Note** program files (.out extension) and project files (.mak extension) get loaded on the target processor referenced by your CCS IDE link. Workspace files are coupled to a specific target processor. As a result, `open` loads workspace files to the target processor that was active when you created the workspace file. This may not be the processor referred to by the CCS IDE link.

---

## Examples

For RTDX use, `open` forms part of the function pair you use to open and enable a communications channel between MATLAB and your target processor.

## open

---

```
cc = cc dsp;
rx = cc.rtdx;
open(rx, 'ichannel', 'w');
enable(rx, 'ichannel');
```

When you are working with CCS IDE, `open` adopts a different operational form based on your input arguments for *filename* and the optional arguments *filetype* and *timeout*. In the CCS IDE variant, `open` loads the specified file into CCS IDE. For example, to load the tutorial program used in “Tutorial 1-1—Using Links and Embedded Objects”, use the following syntax

```
cc = cc dsp;
cc.load(tutorial_6xevm.out);
```

### See Also

`cd`, `dir`, `load`



**Purpose** Return code profiling information from executing code with or without DSP/BIOS

**Syntax**

```
ps=profile(cc, 'option', timeout)
ps=profile(cc, 'option')
ps=profile(cc)
```

**Description** `ps=profile(cc, 'option', timeout)` returns generated code profile measurements from the statistics timing objects (STS) that you defined in CCS IDE. Structure `ps` contains the information in either raw form or filtered and formatted into fields. STS objects are a service provided by the DSP/BIOS real-time kernel that can help you profile and track the way your code runs. For details about STS objects and DSP/BIOS, refer to your Texas Instruments documentation that came with CCS IDE.

To let you to define how to return the information from your STS objects, `profile` supports three formatting options for the contents of structure `ps`.

| <b>option String</b> | <b>Description</b>                                                                                                    |
|----------------------|-----------------------------------------------------------------------------------------------------------------------|
| <code>'raw'</code>   | Returns an unformatted list of the STS timing objects information. All time-based objects get returned and formatted. |

| option String | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|---------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 'report'      | Returns the same data as the 'raw' option, formatted into an HTML report. Works only on projects that include DSP/BIOS. If you own Embedded Target for TI C6000 DSP, <code>profile(cc, 'report')</code> provides more information about code you generate from Simulink models, using data from the STS objects that are part of DSP/BIOS instrumentation. Refer to “Profiling Code” in your Embedded Target for TI C6000 DSP documentation for more information. |
| 'tic'         | Returns a formatted list of the STS timing objects information. Filters out some of the information returned with the 'raw' option. To be returned by this option, the object must be time-based. User-defined objects are not returned. Use <b>raw</b> to see user-defined objects.                                                                                                                                                                              |

When you choose 'raw', variable `ps` contains an undocumented list of the information provided by CCS IDE. The 'tic' option provides the same information in `ps`, as a collection of fields.

| Fields in ps                 | Description                                                                                                                            |
|------------------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| <code>ps.cpuload</code>      | Execution time in percent of total time spent out of the idle task.                                                                    |
| <code>ps.sts</code>          | Vector of defined STS objects in the project.                                                                                          |
| <code>ps.sts(n).name</code>  | User-defined name for an STS object <code>sts(n)</code> . Value for <code>n</code> ranges from 1 to the number of defined STS objects. |
| <code>ps.sts(n).units</code> | Either 'Hi Time' or 'Low Time.' Describes the timer applied by this STS object, whether high- or low-resolution time based.            |
| <code>ps,sts(n).max</code>   | Maximum measured profile period for <code>sts(n)</code> , in seconds.                                                                  |

| Fields in ps    | Description                                                   |
|-----------------|---------------------------------------------------------------|
| ps.sts(n).avg   | Average measured profile period for sts(n), in seconds.       |
| ps.sts(n).count | Number of STS measurements taken while executing the program. |

**Note** For the information gathered during the reporting periods to be accurate, your CLK and STS must be configured correctly for your target. Use the DSP/BIOS configuration file to add and configure CLK and STS objects for your project.

With projects that you generate that use DSP/BIOS, the report option creates a report that contains all of the information provided by the other options, plus additional data that comes from DSP/BIOS instrumentation in the project. You enable the DSP/BIOS report capability with the **Profile performance at atomic subsystem boundaries** option on the TI C6000 Code Generation option on the **Real-Time Workshop** pane of the **Simulink Parameters** dialog.

ps=profile(cc, 'option') defaults to the timeout period specified in the link cc.

ps=profile(cc) returns the profile information in ps as a formatted structure of fields.

## Example

Since you use profile to view information about your application running on your target, this example presents both forms of the data returned in ps. Open and build one of the DSP/BIOS-enabled projects from the TI DSP/BIOS Tutorial Module, such as volume.pjt located in the folder ti\tutorial\target\volume2. When you specify the project to open, enter the full pathname to the project file.

```
cc=ccsdsp;
open(cc, '..\tutorial\sim62xx\volume2\volume.pjt');
build(cc, 'all')
```

In CCS IDE, open the file `volume.cdb` that contains the DSP/BIOS configuration. For details about STS and CLK objects, refer to your TI documentation.

Review the settings for the existing CLK and STS objects already in place in the project. When you use `profile`, the information returned comes from these objects. Make any changes you require and save the DSP/BIOS configuration file. Now rebuild your project, either in CCS IDE or from MATLAB, then load the file `volume.out` generated by the build process. If you get a timeout error, add the timeout option to the build command, specifying a long timeout period, such as 60 seconds. Often, when you receive the timeout error the build has been completed successfully.

```
build(cc, 'all')
load(cc, '..\tutorial\sim62xx\volume2\debug\volume.out')
```

With the project built and loaded, run your program.

```
run(cc) % Assumes that volume2 is the active project.
```

Running `profile` returns structure `ps` containing STS and CLK information that DSP/BIOS gathered while your program ran.

```
ps=profile(cc)

ps =

 cpuload: 0
 obj: [3x1 struct]

ps.obj(1)

ans =

 name: 'KNL_swi'
 units: 'Hi Time'
 max: 1.1759e-005
 avg: 2.7597e-006
 count: 29

for k=1:length(ps.obj), disp(k), disp(ps.obj(k)), end;
1
```

```

name: 'KNL_swi'
units: 'Hi Time'
 max: 1.1759e-005
 avg: 2.7597e-006
count: 29

```

2

```

name: 'processing_SWI'
units: 'Hi Time'
 max: 1.1489e-005
 avg: 1.1474e-005
count: 2

```

3

```

name: 'TSK_idle'
units: 'Hi Time'
 max: -16.1465
 avg: 0
count: 0

```

Omitting the format option caused profile to return the data fully formatted and slightly filtered. Adding the 'raw' option to profile returns the same information without filtering out any of the returned data.

```

ps=profile(cc,'raw')

ps =

 cputime: 0
 error: 0
 avgperiod: 1000
 rate: 1000
 obj: [4x1 struct]

for k=1:length(ps.obj),disp(k),disp(ps.obj(k)),end;
1

```

# profile

---

```
 name: 'KNL_swi'
 units: 'Hi Time'
 max: 1564
 total: 10644
 avg: 367.0345
pdfactor: 0.0075
 count: 29
```

2

```
 name: 'processing_SWI '
 units: 'Hi Time'
 max: 1528
 total: 3052
 avg: 1526
pdfactor: 0.0075
 count: 2
```

3

```
 name: 'TSK_idle'
 units: 'Hi Time'
 max: -2.1475e+009
 total: 0
 avg: 0
pdfactor: 0.0075
 count: 0
```

4

```
 name: 'IDL_busyObj '
 units: 'User Def '
 max: -2.1475e+009
 total: 0
 avg: 0
pdfactor: 0
 count: 0
```

Your results can differ from this example depending on your computer and target. In the raw data in this example, one extra timing object appears —

IDL\_busyObj. As defined in the .cdb file, this is not a time based object (**Units** is 'User Def ') and is not returned by specifying 'tic' as the format option in profile.

## See Also

ccsdsp

# read

---

**Purpose** Retrieve data from memory on the target processor or in CCS

**Syntax**

```
mem = read(cc,address,'datatype',count,timeout)
mem = read(cc,address,'datatype',count)
mem = read(cc,address,'datatype')
data = read(objname)
data = read(objname,index)
data = read(objname,structindex)
data = read(objname,structindex,member)
data = read(objname,member)
data = read(objname,structindex,member,memberindex)
data = read()
```

**Description** **Link Object Syntaxes**

`mem = read(cc,address,count,datatype,timeout)` returns data from the processor referred to by `cc`. The `address`, `count`, and `datatype` input arguments define the memory block to be read. The data block to be read begins at the memory location defined by `address`. `count` determines the number of values to be read, starting at `address`. `datatype` defines the format of the raw data stored in the referenced memory block.

`read` uses the `datatype` parameter to determine the number of bytes to read per stored value. `timeout` is an optional input argument you use to specify when to terminate long read processes and data transfers. For details about each input parameter, read the following descriptions.

`address` — `read` uses `address` to define the beginning of the memory block to read. You provide values for `address` as either decimal or hexadecimal representations of a memory location in the target processor. The full address at a memory location consists of two parts: the offset and the memory page, entered as a vector [*location, page*], a string, or a decimal value. In cases where the processor has only one memory page, as is true for many digital signal processors, the page portion of the memory address is 0. By default, `ccsdsp` sets the page to 0 at creation if you omit the page property as an input argument to set the page parameter.



For processors that have one memory page, setting the page value to 0 lets you specify all memory locations in the processor using just the memory location without the page value.

**Table 4-3: Examples of Address Property Values**

| Property Value | Address Type | Interpretation                                            |
|----------------|--------------|-----------------------------------------------------------|
| '1F'           | String       | Offset is 31 decimal on the page referred to by cc (page) |
| 10             | Decimal      | Offset is 10 decimal on the page referred to by cc (page) |
| [18,1]         | Vector       | Offset is 18 decimal on memory page 1 (cc (page) = 1)     |

To specify the address in hexadecimal format, enter the address property value as a string. `read` interprets the string as the hexadecimal representation of the desired memory location. To convert the hex value to a decimal value, the function uses `hex2dec`. Note that when you use the string option to enter the address as a hex value, you cannot specify the memory page. For string input, the memory page defaults to the page specified by `cc (page)`.

`count` — a numeric scalar or vector that defines the number of `datatype` values to read. Entering a scalar for `count` causes `read` to return `mem` as a column vector which has `count` elements. `count` can be a vector to define multidimensional data blocks. The elements of `count` define the dimensions of the data matrix returned in `mem`. The following table shows examples of input arguments to `count` and how `read` responds.

| Input          | Response                                                                                 |
|----------------|------------------------------------------------------------------------------------------|
| <code>n</code> | Read <code>n</code> values into a column vector. Return the vector in <code>mem</code> . |

# read

| <b>Input</b> | <b>Response</b>                                                                                                                                                        |
|--------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| [m,n]        | Read (m*n) values from memory into an m-by-n matrix in column major order. Return the matrix in mem.                                                                   |
| [m,n,p,...]  | Read (m*n*p*...) values from the processor memory in column major order. Return the data in an m-by-n-by-p-by... multidimensional matrix and return the matrix in mem. |

`datatype` — a string that represents a MATLAB data type. The total memory block size is derived from the value of `count` and the specified `datatype`. `datatype` determines how many bytes to check for each memory value. `read` supports the following data types:

| <b>datatype String</b> | <b>Description</b>                     |
|------------------------|----------------------------------------|
| 'double'               | Double-precision floating point values |
| 'int8'                 | Signed 8-bit integers                  |
| 'int16'                | Signed 16-bit integers                 |
| 'int32'                | Signed 32-bit integers                 |
| 'single'               | Single-precision floating point data   |
| 'uint8'                | Unsigned 8-bit integers                |
| 'uint16'               | Unsigned 16-bit integers               |
| 'uint32'               | Unsigned 32-bit integers               |

To limit the time that `read` spends transferring data from the target processor, the optional argument `timeout` tells the data transfer process to stop after `timeout` seconds. `timeout` is defined as the number of seconds allowed to complete the read operation. You might find this useful for limiting prolonged data transfer operations. If you omit the `timeout` option in the syntax, `read` defaults to the global timeout defined in `cc`.

`mem = read(cc,address,'datatype',count)` reads data from memory on the processor referred to by `cc` and defined by the `address`, and `datatype` input

arguments. The data block being read begins at the memory location defined by `address`. `count` determines the number of values to be read. When you omit the `timeout` option, `timeout` defaults to the value specified by the `timeout` property in `cc`.

`mem = read(cc, address, 'datatype')` reads the memory location defined by the `address` input argument from the processor memory referred to by `cc`. The data block being read begins at the memory location defined by `address`. When you omit the `count` option, `count` defaults to 1. This syntax reads one memory location of `datatype`.

---

**Note** `read` does not coerce data type alignment in your processor memory. You can write and read data of any type (`datatype`) to and from any memory location (`address`). Certain combinations of `address` and `datatype` are difficult for some processors to use. To ensure seamless read operation, use the `address` function to extract address values that are compatible with the alignment required by your target processor.

---

Like the `isreadable`, `iswritable`, and `write` functions, `read` checks for valid address values. Illegal address values are any address space larger than the available space for the processor— $2^{32}$  for the C6xxx processor family and  $2^{16}$  for the C5xxx series. When `read` identifies an illegal address, it returns an error message stating that the address values are out of range.

### Reading Structures

Reading data from structures in memory represents a special subset of general read. In each syntax, `objname` accesses a structure in memory on the target or in CCS.

`data = read(objname, structindex)` reads the structure element referred to by `structindex`.

`data = read(objname, structindex, member)` returns the value of the specified member of the structure as identified by `structindex`.

`data = read(objname, member)` returns the value of `member` from the structure accessed by `objname`, for all indexes—the entire structure variable.

`data = read(objname, structindex, member, memberindex)` returns the index for member in the accessed structure.

## Embedded Object Syntaxes

`read` works with all of the objects you create with `createobj`. To transfer data from Code Composer Studio to MATLAB, use the `read` function—`read`—depending on the data to access. Note that `read` and its variants are the only way to get data from CCS to MATLAB as objects.

`data = read(objname)` reads all the data in memory at the location accessed by object `objname`, and converts the data into a numeric representation. Properties of `objname`, such as `wordsize`, `storageunitspvalue`, `size`, `represent`, and `binarypt`—determine how `read` performs the numeric conversion. `data` is a numeric array whose dimensions are defined by the `size` property of `objname`. Object property `size` is the *dimensions* vector. Each element in the dimensions vector contains the size of the data array in that dimension. When `size` is a scalar, `data` is a column vector of the length specified by `size`.

For example, when `size` is `[2 3]`, `data` is a 2-by-3 array.

## Properties of the Object

`objname`, the object that accesses the data, has the following properties, if the object is a numeric object. The properties differ for different types of objects, such as structure objects or register objects.

| Property                | Options                                          | Description                                                                                                                                                                            |
|-------------------------|--------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>size</code>       | Greater than 1                                   | Specifies the dimensions of the output numeric array.                                                                                                                                  |
| <code>arrayorder</code> | <code>col-major</code> or <code>row-major</code> | Defines how to map sequential memory locations into arrays. ' <code>col-major</code> ' is the default, and the MATLAB standard. C uses ' <code>row-major</code> ' ordering most often. |

| Property  | Options                        | Description                                                                                                                                                                                                                                                                                                                    |
|-----------|--------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| represent | float, signed, unsigned, fract | Determines the numeric representation used in the output data. <ul style="list-style-type: none"> <li>• float—IEEE floating point representation, either 32- or 64 bits</li> <li>• signed—two's complement signed integers</li> <li>• unsigned—unsigned binary integer</li> <li>• fract—fractional fixed-point data</li> </ul> |
| wordsize  | Greater than 1                 | (Read-only) Calculated from other object properties such as storageunitspvalue                                                                                                                                                                                                                                                 |
| binarypt  | 0 to wordsize                  | Determines the position of the binary point in a word to specify its interpretation                                                                                                                                                                                                                                            |

`data = read(objname, index)` reads the specified element in the memory location accessed by `objname`. `index` is a scalar or a vector that identifies the particular data element to return. When you enter `[]` for `index`, `read` returns all the data stored at the memory location. When you enter a scalar for `index`, `read` returns a column vector of length `size` containing the data from the memory space. When `index` is a vector, `read` returns the element in the array specified by the entries in the vector. For example, if you are reading data from a 3-by-3-by-3 array, setting `index` to be `[2 2 2]` returns the element `data(2,2,2)`. To return more than one element, use MATLAB standard range notation for the vector elements in `index`. As an example, when `index` is `[1:6]`, `read` returns the first six elements of `data`. You must remember that the number of elements in the vector in `index` must be either one (a scalar) or the same as the number of dimensions in `data` and specified by the property `size`. When `data` is a four dimensional array, your vector in `index` must have four elements, one for each array dimension. Otherwise, `read` cannot determine which elements to return.

`data = read(objname, member, memberindex, structindex)` reads the members of the structure that `objname` accesses. When you omit all of the input

# read

---

arguments except `objname`, `read` returns the entire structure. `member`, `memberindex`, and `structindex` (an optional input argument) specify which structure member to read:

- `member`—specifies the name of the member of the structure to read.
- `memberindex`—provides the index of the data element to read.
- `structindex`—identifies the structure to read when `objname` accesses a structure containing structures or a vector.

Note that the class of the object data from the `read` operation depends on the class of the member being read—numeric values return numeric objects, string values return string objects, and so on.

`data = read( , timeout)` During `read` operations, the `timeout` property of `objname` determines the time allowed to complete the read. Including a value for the `timeout` input argument in the `read` syntax lets you override the `timeout` property setting for `objname` with the value you enter for argument `timeout`. For reading large data arrays, being able to explicitly set the `timeout` value as an input option may be necessary to let `read` run to completion. Note that using the `timeout` input option does not change the `timeout` property value for `objname`.

When you need to read one member of a structure or to do individual read operations, consider using `getmember`.

## Examples

In its most straightforward form, `read` reads data that you wrote to the target processor.

```
cc = ccsdsp;
indata = 1:25;
write(cc,0,indata,30);
outdata=read(cc,0,25,'double',10)
```

```
outdata =
```

```
Columns 1 through 13
```

```
1 2 3 4 5 6 7 8 9 10 11 12 13
```

```
Columns 14 through 25
```

```
14 15 16 17 18 19 20 21 22 23 24 25
```

outdata now contains the values in indata, returned from the target processor.

As a further demonstration of read, try the following functions after you create a link cc and load an appropriate program to your target. To perform the first example, 'var' must exist in the symbol table loaded in CCS.

- Read one 16-bit integer at the location of target symbol 'var'.
 

```
m1var = read(cc, address(cc, 'var'), 'int16')
```
- Read 100 32-bit integers from address f000 (hexadecimal) and plot the data.
 

```
m1plt = read(cc, 'f000', 'int32', 100)
plot(double(m1plt))
```
- Increment the integer value stored at address 10 (decimal) of the target processor.
 

```
cc = ccsdsp;
ainc = 10
mlinc = read(cc, ainc, 'int32')
mlinc = int32(double(mlinc)+1)
cc.write(ainc, mlinc)
```

### Reading String Variables

Using read to return a string creates a string object. Within the string object, the property charconversion controls the read operation. When you set charconversion to ASCII, read recognizes only the ASCII characters from 0 to 127. ASCII is the only accepted type for the charconversion property value.

While reading strings from memory, read continues until it encounters a null character, then it stops.

For example, if memory contains the string “Hello World” in the following format in memory (each block represents one memory location)

|   |   |   |   |   |  |   |   |   |   |   |    |   |
|---|---|---|---|---|--|---|---|---|---|---|----|---|
| H | e | l | l | o |  | W | o | r | l | d | \0 | M |
|---|---|---|---|---|--|---|---|---|---|---|----|---|

read does not return the M because it stops at the null character \0.

To return a string from memory as a numeric object in MATLAB, use `readnumeric`.

## Reading Enumerated Variables

If you read an enumerated data type from memory, the returned entry is a string object.

## Reading Structures

The following examples show various structure read syntaxes at work. Start with a structure definition.

```
struct tag {
 float re;
 float im;
} st[2] = {1,2,3,4};
```

Use `read` to return the information stored in the structure `st`.

```
st = createobj(cc, 'st')
```

```
answer = read(st)
```

```
ans =
 [1x2 struct]
```

```
answer{1}
```

```
 re: 1
```

```
 im: 2
```

```
answer{2}
```

```
 re: 3
```

```
 im: 4
```

```
answer = read(st,2)
```

```
answer =
```

```
 re: 3
```

```
 im: 4
```

```
answer = read(st,2, 're')
```

```
answer =
```

```
 3
```



```
answer = read(st, 're')
answer =
 1 3
```

**See Also** [getmember](#), [isreadable](#), [symbol](#), [write](#)

# readbin

---

**Purpose** Retrieve a block of data from DSP memory as binary strings

**Syntax**

```
data = readbin(nn)
data = readbin(nn, [], timeout)
data = readbin(nn, index)
data = readbin(nn,)
```

**Description** `data = readbin(nn)` returns, as binary strings, the data accessed by numeric object `nn`. When `nn` refers to an array, the returned values stored in `data` compose a cell array of binary strings. If the `size` property of `nn` is 1, indicating that `nn` accesses a scalar, the output in `data` is an array of binary characters.

`data = readbin(nn, [], timeout)` returns all the values accessed by `nn`, as indicated by the empty square brackets, `[]`. During read operations, the `timeout` property of `nn` determines the time allowed to complete the read. Including a value for the `timeout` input argument in the `readbin` syntax lets you override the `timeout` property setting for `nn` with the value you enter for argument `timeout`. For reading large data arrays, being able to explicitly set the `timeout` value as an input option may be necessary to let `readbin` run to completion. Note that using the `timeout` input option does not change the `timeout` property value for `nn`.

`data = readbin(nn, index)` returns the data element at the index specified by `index` from the data block accessed by `nn`. Enter `index` as a scalar to return one data value, or a vector to return two or more values from the data array.

`data = readbin(nn, )` returns binary strings as specified by your combination of all the optional input arguments.

## Examples

**See Also** `cast`, `numeric`, `read`, `write`, `writebin`

---

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
|--------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Retrieve a block of data from DSP memory as hexadecimal strings                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Syntax</b>      | <pre>data = readhex(nn) data = readhex(nn,[],timeout) data = readhex(nn,index) data = readhex(nn, )</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                             |
| <b>Description</b> | <p><code>data = readhex(nn)</code> returns, as hexadecimal strings, the data accessed by numeric object <code>nn</code>. When <code>nn</code> refers to an array, the returned values stored in <code>data</code> compose a cell array of hexadecimal strings. If the size property of <code>nn</code> is 1, indicating that <code>nn</code> accesses a scalar, the output in <code>data</code> is an array of hexadecimal characters.</p> <p><code>data = readhex(nn,[],timeout)</code> returns all the values accessed by <code>nn</code>, as indicated by the empty square brackets, <code>[]</code>. During read operations, the <code>timeout</code> property of <code>nn</code> determines the time allowed to complete the read. Including a value for the <code>timeout</code> input argument in the <code>readhex</code> syntax lets you override the <code>timeout</code> property setting for <code>nn</code> with the value you enter for argument <code>timeout</code>. For reading large data arrays, being able to explicitly set the <code>timeout</code> value as an input option may be necessary to let <code>readhex</code> run to completion. Note that using the <code>timeout</code> input option does not change the <code>timeout</code> property value for <code>nn</code>.</p> <p><code>data = readhex(nn,index)</code> returns the data element at the index specified by <code>index</code> from the data block accessed by <code>nn</code>. Enter <code>index</code> as a scalar to return one data value, or a vector to return two or more values from the data array.</p> <p><code>data = readhex(nn, )</code> returns hexadecimal strings as specified by your combination of all the optional input arguments.</p> |
| <b>Examples</b>    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>See Also</b>    | <code>cast</code> , <code>numeric</code> , <code>readbin</code> , <code>write</code> , <code>writehex</code>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |

# readmat

---

**Purpose** Read a matrix of values from an RTDX channel

**Syntax**  
`data = readmat(rx,channelname,datatype,siz,timeout)`  
`data = readmat(rx,channelname,datatype,siz)`

**Description** `data = readmat(rx,channelname,datatype,siz,timeout)` reads a matrix of data from an RTDX channel configured for read access. `datatype` defines the type of data to read, and `channelname` specifies the queue to read. `readmat` reads the desired data from the RTDX link specified by `rx`. Before you try to read from a channel, open and enable the channel for read access. Replace `channelname` with the string you specified when you opened the desired channel. `channelname` must identify a channel that you defined in the program loaded on the target processor. You cannot read data from a channel you have not opened and configured for read access. If necessary, use the RTDX tools provided in CCS IDE to determine which channels exist for the loaded program.

`data` contains a matrix whose dimensions are given by the input argument vector `siz`, where `siz` can be a vector of two or more elements. To operate properly, the number of elements in the output matrix `data` must be an integral number of channel messages.

When you omit the `timeout` input argument, `readmat` reads messages from the specified channel until the output matrix is full or the global timeout period specified in `rx` elapses.

---

**Caution** If the timeout period expires before the output data matrix is fully populated, you lose all the messages read from the channel to that point.

---

MATLAB supports reading five data types with `readmat`:

| <b>datatype String</b> | <b>Data Format</b>                               |
|------------------------|--------------------------------------------------|
| 'double'               | Double-precision floating point values. 64 bits. |
| 'int16'                | 16-bit signed integers                           |

| <b>datatype String</b> | <b>Data Format</b>                               |
|------------------------|--------------------------------------------------|
| 'int32'                | 32-bit signed integers                           |
| 'single'               | Single-precision floating point values. 32 bits. |
| 'uint8'                | Unsigned 8-bit integers                          |

`data = readmat(rx,channelname,datatype,siz)` reads a matrix of data from an RTDX channel configured for read access. `datatype` defines the type of data to read, and `channelname` specifies the queue to read. `readmat` reads the desired data from the RTDX link specified by `rx`. Before you try to read from a channel, open and enable the channel for read access. Replace `channelname` with the string you specified to open and enable the desired channel. You cannot read data from a channel you have not opened and configured for read access. `data` contains a matrix whose dimensions are given by the input argument vector `siz`, where `siz` can be a vector of two or more elements. To operate properly, the number of elements in the output matrix `data` must be an integral number of channel messages.

When you include the `timeout` input argument, `readmat` reads messages from the specified channel until the output matrix is full or the `timeout` period elapses.

---

**Caution** If the timeout period expires before the output data matrix is fully populated, you lose all the messages read from the channel to that point.

---

MATLAB supports reading five data types with `readmat`:

| <b>datatype String</b> | <b>Data Format</b>                               |
|------------------------|--------------------------------------------------|
| 'double'               | Double-precision floating point values, 64 bits. |
| 'int16'                | 16-bit signed integers.                          |
| 'int32'                | 32-bit signed integers.                          |

# readmat

| <b>datatype String</b> | <b>Data Format</b>                               |
|------------------------|--------------------------------------------------|
| 'single'               | Single-precision floating point values. 32 bits. |
| 'uint8'                | Unsigned 8-bit integers.                         |

## Examples

In this data read and write example, you write data to the target through the CCS IDE. You can then read the data back in two ways—either through `read` or through `readmsg`. To duplicate this example you need to have a program loaded on the target. The channels listed in this example, `ichannel` and `ochannel`, must be defined in the loaded program. If the current program on the target defines different channels, you can replace the listed channels with your current ones.

```
cc = ccspdsp;
rx = cc.rtdx;
open(rx,'ichannel','w');
enable(rx,'ichannel');
open(rx,'ochannel','r');
enable(rx,'ochannel');
indata = 1:25; % Set up some data.
write(cc,0,indata,30);
outdata=read(cc,0,25,'double',10)
```

```
outdata =
```

```
Columns 1 through 13
```

```
1 2 3 4 5 6 7 8 9 10 11 12 13
```

```
Columns 14 through 25
```

```
14 15 16 17 18 19 20 21 22 23 24 25
```

Now use `RTDX` to read the data into a 5-by-5 array called `out_array`.

```
out_array = readmat('ochannel','double',[5 5])
```

## See Also

`readmsg`, `writemsg`

**Purpose** Read messages from the specified RTDX channel

**Syntax**

```
data = readmsg(rx, channelname, datatype, siz, nummsgs, timeout)
data = readmsg(rx, channelname, datatype, siz, nummsgs)
data = readmsg(rx, channelname, datatype, siz)
data = readmsg(rx, channelname, datatype, nummsgs)
data = readmsg(rx, channelname, datatype)
```

**Description** `data = readmsg(rx, channelname, datatype, siz, nummsgs, timeout)` reads `nummsgs` from a channel associated with `rx`. `channelname` identifies the channel queue, which must be configured for read access. Each message is the same type, defined by `datatype`. `nummsgs` can be an integer that defines the number of messages to read from the specified queue, or 'all' to read all the messages present in the queue when you call the `readmsg` function. Each read message becomes an output matrix in `data`, with dimensions specified by the elements in vector `siz`. Thus, when `siz` is `[m n]`, reading 10 messages (`nummsgs` equal 10) creates 10 `m`-by-`n` matrices in `data`. Each output matrix in `data` must have the same number of elements (`m x n`) as the number of elements in each message. You must specify the type of messages you are reading by including the `datatype` argument. `datatype` supports six strings that define the type of data you are expecting.

| <b>datatype String</b> | <b>Specified Data Type</b>                        |
|------------------------|---------------------------------------------------|
| 'double'               | Floating point data, 64-bits (double-precision).  |
| 'int16'                | Signed 16-bit integer data.                       |
| 'int32'                | Signed 32-bit integers.                           |
| 'single'               | Floating point data, 32-bits (single- precision). |
| 'uint8'                | Unsigned 8-bit integers.                          |

When you include the `timeout` input argument in the function, `readmsg` reads messages from the specified queue until it receives `nummsgs`, or until the period defined by `timeout` expires while `readmsg` waits for more messages to be available. When the desired number of messages is not available in the queue, `readmsg` enters a 'wait' loop and stays there until more messages become

available or timeout seconds elapse. The timeout argument overrides the global timeout specified when you create rx.

`data = readmsg(rx, channelname, datatype, siz, nummsgs)` reads `nummsgs` from a channel associated with `rx`. `channelname` identifies the channel queue, which must be configured for read access. Each message is the same type, defined by `datatype`. `nummsgs` can be an integer that defines the number of messages to read from the specified queue, or 'all' to read all the messages present in the queue when you call the `readmsg` function. Each read message becomes an output matrix in `data`, with dimensions specified by the elements in vector `siz`. Thus, when `siz` is `[m n]`, reading 10 messages (`nummsgs` equal 10) creates 10 `n`-by-`m` matrices in `data`. Each output matrix in `data` must have the same number of elements (`m x n`) as the number of elements in each message. You must specify the type of messages you are reading by including the `datatype` argument. `Datatype` supports six strings that define the type of data you are expecting.

`data = readmsg(rx, channelname, datatype, siz)` reads one data message because `nummsgs` defaults to one when you omit the input argument. `readmsg` returns the message as a row vector in `data`.

`data = readmsg(rx, channelname, datatype, nummsgs)` reads the number of messages defined by `nummsgs`. `data` becomes a cell array of row matrices, `data = {msg1, msg2, ..., msg(nummsgs)}`, because `siz` defaults to `[1, nummsgs]`; each returned message becomes one row matrix in the cell array. Each row matrix contains one element for each data value in the current message — `msg# = [element(1), element(2), ..., element(l)]` where `l` is the number of data elements in message. In this syntax, the read messages can have different lengths, unlike the previous syntax options.

`data = readmsg(rx, channelname, datatype)` reads one data message, returning a row vector in `data`. All of the optional input arguments, `nummsgs`, `siz`, and `timeout`, use their default values.

In all calling syntaxes for `readmsg`, you can set `siz` and `nummsgs` to empty matrixes, causing them to use their default settings — `nummsgs = 1` and `siz = [1, l]`, where `l` is the number of data elements in the read message.



---

**Caution** If the timeout period expires before the output data matrix is fully populated, you lose all the messages read from the channel to that point.

---

## Examples

```
cc = ccstdsp;
rx = cc.rtdx;
open(rx,'ichannel','w');
enable(rx,'ichannel');
open(rx,'ochannel','r');
enable(rx,'ochannel');
indata = 1:25; % Set up some data.
write(cc,0,indata,30);
outdata=read(cc,0,25,'double',10)
```

```
outdata =
```

```
Columns 1 through 13
```

```
1 2 3 4 5 6 7 8 9 10 11 12 13
```

```
Columns 14 through 25
```

```
14 15 16 17 18 19 20 21 22 23 24 25
```

Now use `RTDX` to read the messages into a 4-by-5 array called `out_array`.

```
number_msgs = msgcount(rx,'ochannel') % Check number of msgs
% in read queue.
out_array = cc.rtdx.readmsg('ochannel','double',[4 5])
```

## See Also

`read`, `readmat`, `writemsg`

# readnumeric

---

**Purpose** Read an object in memory and convert to the numeric equivalent in MATLAB

**Syntax**

```
data = readnumeric(objname)
data = readnumeric(objname,index)
data = readnumeric(,timeout)
```

**Description** `data = readnumeric(objname)` returns all data from the memory area specified by `objname` and converts it into a numeric representation. The properties of `objname` control the numeric conversion process. Output data is a numeric array that has dimensions defined by `objname.size`, which is the `dimensions` array. Each element in the `dimensions` array specifies the size of the `objname` array in that dimension. When `size` is a scalar, data is a column vector of the specified length.

`data = readnumeric(objname,index)` returns a subset of the numeric values from the numeric array specified by `objname`. Each row of `index` is applied as a subscript into the full `objname` array. Output data composes a column vector with one value per entry in the data. Array indices start at one and range up to the maximum value defined by the value of the property `size` for `objname`. When `index` is a vector, each row is a single index that defines one entry from the defined numeric array. `data` is a column vector of values corresponding to the specified indices. You can pass a new `timeout` value to modify temporarily the default `timeout` property of `objname`.

`data = readnumeric( ,timeout)` adds the optional input argument `timeout` that lets you specify how long MATLAB waits for the `readnumeric` operation to return a completion message. When MATLAB does not receive notification that the operation finished within the allotted time, you get a time out error. You may find that the operation did complete successfully in spite of the error message.

## objname Array Properties

| Property Name                   | Description                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|---------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>objname.size</code>       | Dimensions of output numeric array. This defines the size of the output.                                                                                                                                                                                                                                                                                                                                                                                                                     |
| <code>objname.arrayorder</code> | Defines how sequential memory locations are mapped into matrices in MATLAB. The default is column major ordering, which is the default arrangement in MATLAB. Alternatively, you can use row major ordering, which is the memory organization used in C numeric representations.                                                                                                                                                                                                             |
| <code>objname.represent</code>  | Defines the numeric representation in <code>objname</code> . Valid data types for <code>represent</code> are: <ul style="list-style-type: none"> <li>• <code>float</code>—IEEE floating point representation (32 or 64 bits)</li> <li>• <code>signed</code>—two's complement signed integers</li> <li>• <code>unsigned</code>—unsigned binary integers</li> <li>• <code>fract</code>—fractional fixed-point representation. For more information, refer to <code>objname.p</code></li> </ul> |
| <code>objname.wordsize</code>   | Number of valid bits in the numeric representation. <code>wordsize</code> is computed from other properties such as <code>storageunitspvalue</code> and therefore this property is read-only.                                                                                                                                                                                                                                                                                                |
| <code>objname.binarypt</code>   | Other properties of <code>objname</code> control the placement and arrangement of the numeric values in memory.                                                                                                                                                                                                                                                                                                                                                                              |

## readnumeric

---

Changes to the numeric representation are possible by modifying the class properties. However, the CONVERT method implements the adjusting the properties to implement some common data types.

**See Also**      convert, getmember, read, write

**Purpose** Return a value from a specified target processor register

**Syntax**

```
reg = regread(cc, 'regname', 'represent', timeout)
reg = regread(cc, 'regname', 'represent')
reg = regread(cc, 'regname')
```

**Description** `reg = regread(cc, 'regname', 'represent', timeout)` reads the data value in the `regname` register of the target processor and returns the value in `reg` as a double-precision value. For convenience, `regread` converts each return value to the MATLAB `double` datatype independent of the datatype defined by `represent`. Making this conversion lets you manipulate the data in MATLAB. String `regname` specifies the name of the source register on the target. Link `cc` defines the target to read from. Valid entries for `regname` depend on your target processor. Register names are not case-sensitive — `a0` is the same as `A0`. For example, the TMS320C6xxx processor family provides the following register names that are valid entries for `regname`:

| Register Names                    | Register Contents                      |
|-----------------------------------|----------------------------------------|
| A0, A1, A2,..., A15               | General purpose A registers            |
| B0, B1, B2,..., B15               | General purpose B registers            |
| PC, ISTR, IFR, IRP, NRP, AMR, CSR | Other general purpose 32-bit registers |
| A1:A0, A2:A1,..., B15:B14         | 64-bit general purpose register pairs  |

Other processors provide other register sets. Refer to the documentation for your target processor to determine the registers for the processor.

**Note** Use `read` (called a direct memory read) to read memory-mapped registers. For the TMS320C5xxx processor family, register `PC` is memory

# regread

mapped and thus available using `read`, not `regread`. Use `regread` to read from all other registers.

The `represent` input argument defines the format of the data stored in `regname`. Input argument `represent` takes one of three input strings:

| <b>represent string</b> | <b>Description</b>                                                                                                                                                             |
|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>2scomp</b>           | Source register contains a signed integer value in two's complement format. This is the default setting when you omit the <code>represent</code> argument.                     |
| <b>binary</b>           | Source register contains an unsigned binary integer.                                                                                                                           |
| <b>ieee</b>             | Source register contains a floating point 32-bit or 64-bit value in IEEE floating-point format. Use this only when you are reading from 32 and 64 bit registers on the target. |

To limit the time that `regread` spends transferring data from the target processor, the optional argument `timeout` tells the data transfer process to stop after `timeout` seconds. `timeout` is defined as the number of seconds allowed to complete the read operation. You might find this useful for limiting prolonged data transfer operations. If you omit the `timeout` option in the syntax, `regread` defaults to the global `timeout` defined in `cc`.

`reg = regread(cc, 'regname', 'represent')` reads the data value in the `regname` register of the target processor and returns the value in `reg` as a double-precision value. String `regname` specifies the name of the source register on the target. Link `cc` defines the target to read from. For convenience, `regread` converts each return value to the MATLAB `double` datatype independent of the datatype defined by `represent`. Making this conversion lets you manipulate the data in MATLAB. The `represent` input argument defines the format of the data stored in `regname`.

`reg = regread(cc, 'regname')` reads the data value in the `regname` register of the target processor and returns the value in `reg`. String `regname` specifies the name of the source register on the target. Link `cc` defines the target to read

from. For convenience, `regread` converts each return value to the MATLAB `double` datatype independent of the datatype of the source. Making this conversion lets you manipulate the data in MATLAB.

## Examples

For the C5xxx processor family, most registers are memory-mapped and consequently are available using `read` and `write`. However, the PC register is not memory-mapped. The following command demonstrates how to read the PC register. To identify the target, `cc` is a link for CCS IDE.

```
cc.regread('PC','binary')
```

To tell MATLAB what datatype you are reading, the string `binary` indicates that the PC register contains a value stored as an unsigned binary integer.

In response, MATLAB displays

```
ans =

 33824
```

For processors in the C6xxx family, `regread` lets you access processor registers directly. To read the value in general purpose register A0, type the following function.

```
treg = cc.regread('A0','2scomp');
```

`treg` now contains the two's complement representation of the value in A0.

Now read the value stored in register B2 as an unsigned binary integer, by typing

```
cc.regread('B2','binary');
```

## See Also

`read`, `regwrite`, `write`

# regwrite

---

**Purpose** Write data values to specified registers on a target processor

**Syntax**

```
regwrite(cc,'regname',value,'represent',timeout)
regwrite(cc,'regname',value,'represent')
regwrite(cc,'regname',value,)
```

**Description** `regwrite(cc,'regname',value,'represent',timeout)` writes the data in `value` to the `regname` register of the target processor. `regwrite` converts `value` from its representation in the MATLAB workspace to the representation specified by `represent`. The `represent` input argument defines the format of the data when it is stored in `regname`. Input argument `represent` takes one of three input strings:

| <b>represent string</b> | <b>Description</b>                                                                                                                                                                               |
|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>2scomp</b>           | Write value to the destination register as a signed integer value in two's complement format. This is the default setting when you omit the <code>represent</code> argument.                     |
| <b>binary</b>           | Write value to the destination register as an unsigned binary integer.                                                                                                                           |
| <b>ieee</b>             | Write value to the destination registers as a floating point 32-bit or 64-bit value in IEEE floating-point format. Use this only when you are writing to 32- and 64-bit registers on the target. |

String `regname` specifies the name of the destination register on the target. Link `cc` defines the target to write `value` to. Valid entries for `regname` depend on your target processor. Register names are not case-sensitive — `a0` is the



same as A0. For example, the TMS320C6xxx processor family provides the following register names that are valid entries for regname:

| Register Names                     | Register Contents                      |
|------------------------------------|----------------------------------------|
| A0, A1, A2,..., A15                | General purpose A registers            |
| B0, B1, B2,..., B15                | General purpose B registers            |
| PC, ISTEP, IFR, IRP, NRP, AMR, CSR | Other general purpose 32-bit registers |
| A1:A0, A2:A1,..., B15:B14          | 64-bit general purpose register pairs  |

Other processors provide other register sets. Refer to the documentation for your target processor to determine the registers for the processor.

---

**Note** Use `write` (called a direct memory write) to write memory-mapped registers. For the TMS320C5xxx processor family, register PC is memory mapped and thus available using `write`, not `regwrite`. Use `regwrite` to write to all other registers.

---

To limit the time that `regwrite` spends transferring data to the target processor, the optional argument `timeout` tells the data transfer process to stop after `timeout` seconds. `timeout` is defined as the number of seconds allowed to complete the write operation. You might find this useful for limiting prolonged data transfer operations. If you omit the `timeout` option in the syntax, `regwrite` defaults to the global timeout defined in `cc`. If the write operation exceeds the time specified, `regwrite` returns with a timeout error. Generally, timeout errors do not stop the register write process. They stop while waiting for CCS IDE to respond that the write operation is complete.

`regwrite(cc, 'regname', value, 'represent')` writes the data in `value` to register `regname` of the target processor. `regwrite` converts `value` from its representation in the MATLAB workspace to the representation specified by

# regwrite

represent. The represent input argument defines the data format when it is stored in regname. Input argument represent takes one of three input strings:

| <b>represent string</b> | <b>Description</b>                                                                                                                                                                               |
|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>2scomp</b>           | Write value to the destination register as a signed integer value in two's complement format. This is the default setting when you omit the represent argument.                                  |
| <b>binary</b>           | Write value to the destination register as an unsigned binary integer.                                                                                                                           |
| <b>ieee</b>             | Write value to the destination registers as a floating point 32-bit or 64-bit value in IEEE floating-point format. Use this only when you are writing to 32- and 64-bit registers on the target. |

String regname specifies the name of the destination register on the target. Link cc defines the target to write value to. Valid entries for regname depend on your target processor. Register names are not case-sensitive — a0 is the same as A0. For example, the TMS320C6xxx processor family provides the following register names that are valid entries for regname:

| <b>Register Names</b>             | <b>Register Contents</b>               |
|-----------------------------------|----------------------------------------|
| A0, A1, A2,..., A15               | General purpose A registers            |
| B0, B1, B2,..., B15               | General purpose B registers            |
| PC, ISTR, IFR, IRP, NRP, AMR, CSR | Other general purpose 32-bit registers |
| A1:A0, A2:A1,..., B15:B14         | 64-bit general purpose register pairs  |

Other processors provide other register sets. Refer to the documentation for your target processor to determine the registers for the processor.

---

**Note** Use `write` (called a direct memory write) to write memory-mapped registers. For the TMS320C5xxx processor family, register PC is memory mapped and thus available using `write`, not `regwrite`. Use `regwrite` to write to all other registers.

---

`regwrite(cc, 'regname', value,)` writes the data in `value` to the `regname` register of the target processor. `regwrite` converts `value` from its representation in the MATLAB workspace to the representation specified by `represent`. The `represent` input argument defines the format of the data when it is stored in `regname`. Input argument `represent` takes one of three input strings:

| <b>represent string</b> | <b>Description</b>                                                                                                                                                                               |
|-------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>2scomp</b>           | Write value to the destination register as a signed integer value in two's complement format. This is the default setting when you omit the <code>represent</code> argument.                     |
| <b>binary</b>           | Write value to the destination register as an unsigned binary integer.                                                                                                                           |
| <b>ieee</b>             | Write value to the destination registers as a floating point 32-bit or 64-bit value in IEEE floating-point format. Use this only when you are writing to 32- and 64-bit registers on the target. |

String `regname` specifies the name of the destination register on the target. Link `cc` defines the target to write `value` to. Valid entries for `regname` depend on your target processor. Register names are not case-sensitive — `a0` is the

# regwrite

---

same as A0. For example, the TMS320C6xxx processor family provides the following register names that are valid entries for regname:

| Register Names                    | Register Contents                      |
|-----------------------------------|----------------------------------------|
| A0, A1, A2,..., A15               | General purpose A registers            |
| B0, B1, B2,..., B15               | General purpose B registers            |
| PC, ISTR, IFR, IRP, NRP, AMR, CSR | Other general purpose 32-bit registers |
| A1:A0, A2:A1,..., B15:B14         | 64-bit general purpose register pairs  |

Other processors provide other register sets. Refer to the documentation for your target processor to determine the registers for the processor.

When you omit the represent argument, regwrite takes value from the function and writes it to the designated register as a two's complement value signed integer.

---

**Note** Use write (called a direct memory write) to write to memory-mapped registers. For the TMS320C5xxx processor family, register PC is memory mapped and thus available using write, not regwrite. Use regwrite to write to all other registers.

---

## Examples

To write a new value to the PC register on a C5xxx family processor, type

```
regwrite(cc, 'pc', hex2dec('100'), 'binary')
```

specifying that you are writing the value 256 (the decimal value of 0x100) to register pc as binary data.

To write a 64-bit value to a register pair, such as B1:B0, the following syntax specifies the value as a string, representation, and target registers.

```
regwrite(cc, 'b1:b0', hex2dec('1010'), 'iee')
```

Registers B1:B0 now contain the value 4112 in double-precision format.

**See Also**

read, regread, write

# reload

---

**Purpose** Reload to the target signal processor the most recently loaded program file

**Syntax**

```
s = reload(cc,timeout)
s = reload(cc)
```

**Description** `s = reload(cc,timeout)` resends the most recently loaded program file to the target processor. If you have not loaded a program file in the current session (so there is no previously loaded file), `reload` returns the null entry `[]` in `s` indicating that it could not load a file to the target. Otherwise, `s` contains the full pathname to the program file. After you reset your target processor or after any event produces changes in your target processor memory, use `reload` to restore the program file to the target for execution.

To limit the time CCS IDE spends trying to reload the program file to the target, `timeout` specifies how long the load process can take. If the load process exceeds the timeout limit, CCS IDE stops trying to load the program file and returns an error stating that the time period expired. Exceeding the allotted time for the reload operation usually indicates that the reload was successful but CCS IDE did not receive confirmation before the timeout period passed.

`s = reload(cc)` reloads the most recent program file, using the `timeout` value set when you created link `cc`, the global timeout setting.

## Using reload with multiprocessor boards

When your target board contains more than one processor, `reload` calls the reloading function for each processor represented by `cc`, reloading the most recently loaded program on each processor.

This is the same as calling `reload` for each processor individually through `ccsdsp` objects for each one.

## Examples

After you create a link, use the link to reload your most recently loaded project. If you have not loaded a project in this session, `reload` returns an error and an empty value for `s`. Loading a project eliminates the error.

```
cc=ccsdsp;
s=reload(cc,23)
Warning: No action taken - First load a valid Program file before
you reload
```

```
> In E:\nightly\toolbox\tiddk\tiddk\@ccs\ccsdsp\reload.m at line
23

s =

 ''

open(cc,'D:\ti\tutorial\sim62xx\gelsolid\hellodsp.pjt',...
'project')

build(cc)

load(cc,'hellodsp.pjt')
halt(cc)
s=reload(cc,23)

s =

D:\ti\tutorial\sim62xx\gelsolid\Debug\hellodsp.out
```

## See Also

cd, load, open

# remove

---

**Purpose** Remove a file from the active CCS IDE project

**Syntax**

```
remove(cc, 'filename')
remove(cc, 'gelfilename')
```

**Description** `remove(cc, 'filename')` deletes the file specified by `filename` from the active project in CCS IDE. You can remove files that exist in the active project only. `filename` must match the name of an existing file exactly to remove the file.

`remove(cc, 'gelfilename')` deletes the file specified by `gelfilename` from the active project in CCS IDE. You can remove files that exist in the active project only. `gelfilename` must match the name of an existing file exactly to remove the file.

**Examples** After you have a project in CCS IDE, you can delete files from it using `remove` from the MATLAB command line. For example, build a project and load the resulting `.out` file. With the project build complete, load your `.out` file by typing

```
load(cc, 'filename.out')
```

Now remove one file from your project, such as the GEL file.

```
remove(cc, 'gelfilename')
```

You see in CCS IDE that the GEL file no longer appears in the GEL files folder in CCS.

**See Also** `activate`, `add`, `cd`, `open`



**Purpose** Initiate a reset of the target processor

**Syntax** `reset(cc, timeout)`  
`reset(cc)`

**Description** `reset(cc, timeout)` stops program execution on the target processor and asynchronously performs a processor reset, returning all processor register contents to their power up settings. The reset function returns after the processor halts. To allow you to determine how long reset waits for the processor to halt, input option `timeout` lets you set the waiting period in seconds. After you use `reset`, the routine returns after the processor halts or after `timeout` seconds elapses, whichever comes first.

`reset(cc)` stops program execution on the target processor and asynchronously performs a processor reset, returning all processor register contents to their power up settings. The reset function returns after the processor halts. `reset` uses the global timeout setting defined in `cc` to determine how long to wait for the processor to halt before returning. Use `get` to examine the global timeout value for the link.

Use `run` to restart the program loaded on the target.

Compare to `halt` which does not reset the processor after the program stops running.

### Using reset with multiprocessor boards

When your target board contains more than one processor, `reset` calls the processor resetting function for each processor represented by `cc`, resetting each processor.

This is the same as calling `reset` for each processor individually through `ccsdsp` objects for each one.

Note that the `run` and `halt` methods still apply as mentioned earlier in this section.

**See Also** `halt`, `restart`, `run`

# reshape

---

**Purpose** Change the shape of an array maintaining the same number of elements

**Syntax**

```
reshape(x, [m,n])
reshape(x, [m,n,p])
reshape(x, [m n p])
reshape(x, [,[],])
```

**Description** `reshape(x, [m,n])` returns the m-by-n array whose elements are taken columnwise from x. If x does not have m\*n elements, reshape returns an error from the operation.

Generally, `reshape(x, siz)` returns an n-dimensional array with the same elements as x, but reshaped to `size(siz)`. Note that `prod(siz)` must be the same as `prod(size(x))`.

`reshape(x, [m,n,p ])` returns an n-dimensional array with the same number of elements as x, but reshaped to have size m-by-n-by-p-by-.... For the reshape operation to work,  $m*n*p*...$  must equal `prod(size(x))`.

`reshape(x, [m n p ])` is the same as the preceding syntax.

`reshape(x, [ ,[], ])` calculates the length of the dimension replaced by `[]` in the command, so that the product of the dimensions equals `prod(size(x))`. For the length calculation to succeed, `prod(size(x))` must be evenly divisible by the product of the known dimensions (all the dimensions exclusive of the unknown dimension). Within the function call, you are allowed to use only one set of square brackets, `[]`, for one unknown dimension.

---

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                  |
|--------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Restore the program counter to the entry point for the current program                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                           |
| <b>Syntax</b>      | <pre>restart(cc, timeout) restart(cc)</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>Description</b> | <p><code>restart(cc, timeout)</code> halts the processor immediately and resets the program counter (PC) to the program entry point for the loaded program. Use <code>run</code> to execute the program after you use <code>restart</code>. <code>restart</code> does not execute the program after resetting the PC. <code>timeout</code> allows you to specify how long <code>restart</code> waits for the processor to stop and return the PC to the program entry point. Specify <code>timeout</code> in seconds. After you use <code>restart</code>, the <code>restart</code> routine returns after resetting the PC or after <code>timeout</code> seconds elapse, whichever comes first. If the timeout period expires, <code>restart</code> returns a timeout error.</p> <p><code>restart(cc)</code> halts the processor immediately and resets the program counter (PC) to the program entry point for the loaded program. Use <code>run</code> to execute the program after you use <code>restart</code>. <code>restart</code> does not execute the program after resetting the PC. When you omit the <code>timeout</code> argument, <code>restart</code> uses the global default timeout period defined in <code>cc</code> to determine how long to wait for the processor to stop and the PC to be reset to the program entry point.</p> <h3>Using restart with multiprocessor boards</h3> <p>When your target board contains more than one processor, <code>restart</code> calls the processor restarting function for each processor represented by <code>cc</code>, restarting the program loaded on each processor.</p> <p>This is the same as calling <code>restart</code> for each processor individually through <code>ccsdsp</code> objects for each one.</p> |
| <b>Examples</b>    | <p>When you are developing algorithms for your target processor, <code>restart</code> becomes a particularly useful function. Rather than resetting the target after each algorithm test, use the <code>restart</code> function to return the program counter to the program entry point. Since <code>restart</code> restores your local variables to their initial settings, but does not reset the processor, you are ready to rerun your algorithm with new values. Also, in the case where your process gets lost or halts, <code>restart</code> is a quick way to restore your program.</p>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |
| <b>See Also</b>    | <code>halt</code> , <code>isrunning</code> , <code>run</code>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                    |

# resume

---

**Purpose** Resume execution of a stopped or paused function

**Syntax** `resume(ff)`

**Description** `resume(ff)` restarts the function `ff` from where you stopped it or paused it. The function runs until completion or until it encounters a breakpoint.

**See Also** `restart`, `run`

**Purpose** Execute the program loaded on the target processor

**Syntax**

```
run(cc, state, timeout)
run(cc, 'main')
run(cc, 'tofunc', 'functionname')
run(ff)
run(ff, input1, value1, input2, value2, , inputn, valuen)
output = run(ff)
```

**Description** `run(cc, state, timeout)` starts to execute the program loaded on the target processor referred to by `cc`. Program execution starts from the location of the program counter. After starting program execution, the input argument `state` determines when you regain program control.

To define the action of `run`, `state` accepts five strings that set the state of the processor:

| State String | Run Action                                                                                                                                                                                                                                                                                                                                                   |
|--------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 'main'       | Reset the program counter then run the program until the PC reaches <code>main</code> . Stop at <code>main</code> .                                                                                                                                                                                                                                          |
| 'run'        | Start to execute the program. Wait until the program is running, then return. The program continues to run. If you omit the <code>option</code> argument, <code>run</code> defaults to this setting. Sets the processor to the running state and returns. This is useful when you want to continue to work in MATLAB while the processor executes a program. |
| 'runtohalt'  | Start to execute the program. Wait to return until the program encounters a breakpoint or the program execution terminates. Sets the processor to the running state and returns when the processor halts.                                                                                                                                                    |

## run

---

| State String | Run Action                                                                                                                                                                                                                                                                        |
|--------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| 'tofunc'     | Run the program from the current position of the program counter to the start of a specified function <code>functionname</code> .                                                                                                                                                 |
| 'tohalt'     | Changes the state of a running process to 'runtohalt', and waits for the processor to halt before returning. Use this when you want to stop a running process cleanly. If the processor is already stopped when you use this state setting, <code>run</code> returns immediately. |

To allow you to specify how long `run` waits for the processor to start executing the loaded program before returning, the input argument `timeout` lets you set the waiting period in seconds. After you use `run`, the routine returns after confirming that the program started to execute, or after `timeout` seconds elapses, whichever comes first. If the time-out period expires, `run` returns a time-out error.

`run(cc, 'main')` resets the program counter in your project then runs the program linked to `cc` until the counter reaches the start of `main`.

`run(cc, 'tofunc', 'functionname')` runs the program from the current position of the program counter until the counter reaches the function `functionname`. Compare this to `run(cc, 'main')` which resets the program counter before executing the program. Using the `tofunc` option does not reset the program counter.

`run(ff)` runs the function `ff` and puts the return value in the appropriate location. `run` performs a `goto` followed by `execute` to run `ff`.

`run(ff, input1, value1, input2, value2, , inputn, valuen)` writes the input values for `ff` before running the function, where `valuen` is the value for the input argument `inputn`. You can pass up to 10 input arguments and their values when you call `run`.

`output = run(ff)` puts the return value from running `ff` in `output`.

## Using run with multiprocessor boards

When your target board contains more than one processor, run calls the program running function for each processor represented by cc, running the program loaded on each processor.

This is the same as calling run for each processor individually through ccstdsp objects for each one. The other information about run on a single processor applies to each processor in the multiple processor target cases.

## Examples

After you build and load a program to your target, use run to start execution.

```
cc = ccstdsp('boardnum',0,'procnum',0); % Create a link to CCS
 % IDE.
cc.load('tutorial_6xevm.out'); % Load an executable file to the
 % target.
cc.rtdx.configure(1024,4); % Configure four buffers for data
 % transfer needs.

cc.rtdx.open('ichan','w'); % Open RTDX channels for read and
 % write.

cc.rtdx.enable('ichan');
cc.rtdx.open('ochan','r');
cc.rtdx.enable('ochan');

cc.restart; % Return the PC to the beginning of the current
 % program.

cc.run('run'); % Run the program to completion.
```

This example uses a tutorial program included with Link for Code Composer Studio. Set your CCS IDE working directory to be the one that holds your project files. The load function uses the current working directory unless you provide a full pathname in the input arguments.

Rather than using the dot notation to access the RTDX functions, you can create an alias to the cc link and use the alias in later commands. Thus, if you add the line

```
rx = cc.rtdx;
```

to the program, you can replace

## run

---

```
cc.rtdx.configure(1024,4);
```

with

```
configure(rx,1024,4);
```

### See Also

halt, isrunning, restart



**Purpose** Save files and projects in CCS IDE

**Syntax**  
`save(cc, 'filename', 'type')`  
`save(cc, 'filename')`

**Description** `save(cc, 'filename', 'type')` save the file in CCS IDE identified by `filename` of type `'type'`. `type` identifies the type of file to save, either project files when you use `'project'` for `type`, or text files when you use `'text'` for the `type` option. To save a specific file in CCS IDE, `filename` must match the name of the file to save exactly. If you replace `filename` with `'all'`, `save` writes every open file whose type matches the `type` option. File types recognized by `save` include these extensions.

| <b>type String</b>     | <b>Affected files</b>                                                                                                                                                                                                                                                                                                            |
|------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>'project'</code> | Project files with the <code>.pjt</code> extension.                                                                                                                                                                                                                                                                              |
| <code>'text'</code>    | All files with these extensions — <code>.a*</code> , <code>.c</code> , <code>.cc</code> , <code>.ccx</code> , <code>.cdb</code> , <code>.cmd</code> , <code>.cpp</code> , <code>.lib</code> , <code>.o*</code> , <code>.rcp</code> , and <code>.s*</code> . Note that <code>'text'</code> does not save <code>.cfg</code> files. |

When you replace `filename` with the null entry `[]`, `save` writes to storage the current active file window in CCS IDE, or the active project when you specify `'project'` for the `type` option.

**Examples** To clarify the different `save` options, here are six commands that save open files or projects in CCS IDE.

| <b>Command</b>                             | <b>Result</b>                                                                              |
|--------------------------------------------|--------------------------------------------------------------------------------------------|
| <code>save(cc, 'all', 'project')</code>    | Save all open projects in CCS IDE.                                                         |
| <code>save(cc, 'my.pjt', 'project')</code> | Save the project <code>my.pjt</code> .                                                     |
| <code>save(cc, [], 'project')</code>       | Save the active project.                                                                   |
| <code>save(cc, 'all', 'text')</code>       | Save all open text files. This includes source file, libraries, command files, and others. |

## save

---

| Command                                        | Result                                          |
|------------------------------------------------|-------------------------------------------------|
| <code>save(cc, 'my_source.cpp', 'text')</code> | Save the text file <code>my_source.cpp</code> . |
| <code>save(cc, [], 'text')</code>              | Save the active file window.                    |

### See Also

`add`, `cd`, `close`, `open`

**Purpose**

Set the properties of links for CCS IDE and RTDX interface

**Syntax**

```
set(cc, 'propertyname', 'propertyvalue')
set(cc, 'propname1', 'propvalue1', 'propname2', 'propvalue2')
v = set(cc)
cc.propertyname = 'propertyvalue'
set(rx, 'propertyname', 'propertyvalue')
set(rx, 'propname1', 'propvalue1', 'propname2', 'propvalue2')
v = set(rx)
rx.propertyname = 'propertyvalue'
```

**Description**

`set(cc, 'propertyname', 'propertyvalue')` sets the specified property of `cc` to the specified value.

`set(cc, 'propname1', 'propvalue1', 'propname2', 'propvalue2')` sets multiple properties (`propname1`, `propname2`) of `cc` to corresponding property values (`propvalue1`, `propvalue2`) with a single statement. `cc` must be a link.

`v = set(cc)` returns the properties and range of acceptable values of link `cc`. When the range of values for a property is not finite, `set` returns `{}` for the property value. When you omit the output argument, MATLAB displays the results on the screen.

`cc.propertyname = propertyvalue` uses the dot notation to set `propertyname` to `propertyvalue`.

`set(rx, 'propertyname', 'propertyvalue')` sets the specified property of `rx` to the specified value.

`set(rx, 'propname1', 'propvalue1', 'propname2', 'propvalue2')` sets multiple properties (`propname1`, `propname2`) of `rx` to corresponding property values (`propvalue1`, `propvalue2`) with a single statement.

`v = set(rx)` returns the properties and range of values of link `rx`. `rx` is the RTDX portion of a link for CCS IDE. When the range of values for a property is not finite, `set` returns `{}` for the property value. When you omit the output argument, MATLAB displays the results on the screen.

`rx.propertyname = propertyvalue` uses the dot notation to set `propertyname` to `propertyvalue` for link `rx`.

# set

---

## Examples

Create a link to CCS IDE

```
cc = ccspd;
```

Now review the properties of cc to see the acceptable values for each property.

```
v=set(cc)
```

```
v =
```

```
 timeout: {}
 page: {}
eventwaitms: {}
```

The properties accept any input value, as shown by the {} entries returned.

Set timeout to 10 s and page to 2. Property eventwaitms cannot be set. It is read-only.

```
set(cc,'timeout',10,'page',2)
get(cc)
```

```
ans =
```

```
 app: [1x1 activex]
dspboards: [1x1 activex]
 dspboard: [1x1 activex]
 dsptasks: [1x1 activex]
 dsptask: [1x1 activex]
 dspuser: [1x1 activex]
 rtdx: [1x1 rtdx]
apiversion: [1 0]
ccsappexe: 'D:\ticcs\cc\bin\cc_app.exe'
 boardnum: 0
 procnum: 0
 timeout: 10
 page: 2
```

Reset page to 0 since this is a C6xxx processor.

```
cc.page = 0
get(cc)
```

```
ans =

 app: [1x1 activex]
 dspboards: [1x1 activex]
 dspboard: [1x1 activex]
 dsptasks: [1x1 activex]
 dsptask: [1x1 activex]
 dspuser: [1x1 activex]
 rtdx: [1x1 rtdx]
apiversion: [1 0]
ccsappexe: 'D:\ticcs\cc\bin\cc_app.exe'
boardnum: 0
procnum: 0
timeout: 10
page: 0
```

**See Also**

get

# symbol

---

**Purpose** Return the most recent program symbol table from CCS IDE

**Syntax** `s = symbol(cc)`

**Description** `s = symbol(cc)` returns the symbol table for the program loaded in CCS IDE. `symbol` only applies after you load a target program file. `s` is an array of structures where each row in `s` presents the symbol name and address in the table. Therefore, `s` has two columns; one is the symbol name, the other is the symbol address and symbol page. For example, this table shows a few possible elements of `s`, and their interpretation.

| <b>s Structure Field</b>     | <b>Contents of the Specified Field</b>                                    |
|------------------------------|---------------------------------------------------------------------------|
| <code>s(1).name</code>       | String reflecting the symbol entry name.                                  |
| <code>s(1).address(1)</code> | Address or value of symbol entry.                                         |
| <code>s(1).address(2)</code> | Memory page for the symbol entry. For TI C6xxx processors, the page is 0. |

You can use field address in `s` as the address input argument to read and write.

If you use `symbol` and the symbol table does not exist, `s` returns empty and you get a warning message.

Symbol tables are a portion of a COFF object file that contains information about the symbols that are defined and used by the file. When you load a program to the target, the symbol table resides in CCS IDE. While CCS IDE may contain more than one symbol table at a time, `symbol` accesses the symbol table belonging to the program you last loaded on the target.

**Examples** Demonstrating this function requires that you load a program file to your target. In this example, build and load the Link for Code Composer Studio demo program `c6701evmafxr`. Start by entering `c6701evmafxr` at the MATLAB prompt.

```
c6701evmafxr;
```

Now set the simulation parameters for the model and build the model to your target. With the model loaded on your target, use `symbol` to return the entries stored in the symbol table in CCS IDE.

```
cc = ccstdsp;
s = symbol(cc);
```

`s` contains all the symbols and their addresses, in a structure you can display with the following code:

```
for k=1:length(s),disp(k),disp(s(k)),end;
```

MATLAB lists the symbols from the symbol table in a column.

## See Also

`load`, `run`

# visible

---

**Purpose** Set whether CCS IDE window is visible while CCS is running

**Syntax** `visible(cc, state)`

**Description** `visible(cc, state)` sets CCS IDE to be visible or not visible on the desktop. Input argument `state` accepts either 0 or 1 to set the visibility. Setting `state` equal to 0 makes CCS IDE not visible on the desktop. However, the CCS IDE process runs in the background while the window is not visible. Running CCS IDE without making it visible lets you use the CCS IDE functions from MATLAB, without interacting with CCS IDE. If you need to interact with CCS IDE, set `state` equal to 1. This makes CCS IDE visible and you can use the features of the user window.

An important feature of `visible` is that it creates a new link to CCS IDE when you change the IDE visibility. As a result, after you use

```
visible(cc, state)
```

to make CCS IDE show on your desktop, the MATLAB `clear all` function does not remove the visibility handle. You must remove the handle explicitly before you use `clear`.

To see the visibility difference, open Code Composer Studio and use Windows Task Manager to look at the applications and processes running on your computer. When CCS IDE is visible (the normal startup and operating mode for the IDE), CCS IDE appears listed on the **Applications** page of Task Manager. And the process `cc_app.exe` shows up on the **Processes** page as a running process. When you set CCS IDE to not visible (`state` equal 0), CCS IDE disappears from the **Applications** page, but remains on the **Processes** page, with a Process ID (PID), using CPU and memory resources.

---

**Note** When you close MATLAB while CCS IDE is not visible, MATLAB closes CCS if it launched the IDE. This happens because the operating system treats CCS as a subprocess in MATLAB when CCS is not visible. By having MATLAB close the invisible IDE when you close MATLAB, you do not need to worry about CCS being left open with no way to close it without using Windows Task Manager. If CCS IDE is not visible when you open MATLAB, closing MATLAB leaves CCS IDE running in as invisible state. More directly,



MATLAB leaves CCS IDE in the visibility and operating state in which it finds it.

---

## Examples

Test to see whether CCS IDE is running. Then change the visibility and check again. Start by launching CCS IDE. Then open MATLAB and at the prompt, type

```
cc=ccsdsp

CCSDSP Object:
 API version = 1.0
 Processor type = C67
 Processor name = CPU
 Running? = No
 Board number = 0
 Processor number = 0
 Default timeout = 10.00 secs

RTDX Object:
 Timeout: 10.00 secs
 Number of open channels: 0
```

MATLAB creates a link to CCS IDE and leaves CCS IDE visible on your desktop.

```
isVisible(cc)

ans =
 1
```

Now, change the visibility state to 0, or invisible, and check the state.

```
visible(cc,0)
isVisible(cc)

ans =
 0
```

Notice that CCS IDE is not visible on your desktop. Recall that MATLAB did not open CCS IDE. When you close MATLAB with CCS IDE in this invisible

# visible

---

state, CCS IDE remains running in the background. The only ways to close it are either

- **Launch MATLAB.** Create a new link to CCS IDE. Use the new link to make CCS IDE visible. Close CCS IDE.
- **Open Windows Task Manager.** Click **Processes**. Find and highlight `cc_app.exe`. Click **End Task**.

## See Also

`isvisible`, `load`

**Purpose** Write data to memory on the target processor

**Syntax**

```
write(cc,address,data,timeout)
write(cc,address,data)
write(objname)
write(objname,index)
write(objname,structindex,member1,value1, ,membern,valuen,memindex)
write(,timeout)
```

**Description** **Link Object Syntaxes**

`write(cc,address,data,timeout)` sends a block of data to memory on the processor referred to by `cc`. The `address` and `data` input arguments define the memory block to be written—where the memory starts and what data is being written. The memory block to be written to begins at the memory location defined by `address`. `data` is the data to be written, and can be a scalar, a vector, a matrix, or a multidimensional array. Data get written to memory in column-major order. `timeout` is an optional input argument you use to terminate long write processes and data transfers. For details about each input parameter, read the following descriptions.

`address` — `write` uses `address` to define the beginning of the memory block to write to. You provide values for `address` as either decimal or hexadecimal representations of a memory location in the target processor. The full address at a memory location consists of two parts: the offset and the memory page, entered as a vector [*location*, *page*], a string, or a decimal value. In cases where the processor has only one memory page, as is true for many digital signal processors, the page portion of the memory address is 0. By default, `ccsdsp` sets the page to 0 at creation if you omit the page property as an input argument to set the page parameter.

For processors that have one memory page, setting the page value to 0 lets you specify all memory locations in the processor using just the memory location without the page value.

**Table 4-4: Examples of Address Property Values**

| Property Value | Address Type | Interpretation                                            |
|----------------|--------------|-----------------------------------------------------------|
| '1F'           | String       | Offset is 31 decimal on the page referred to by cc (page) |
| 10             | Decimal      | Offset is 10 decimal on the page referred to by cc (page) |
| [18,1]         | Vector       | Offset is 18 decimal on memory page 1 (cc (page) = 1)     |

To specify the address in hexadecimal format, enter the address property value as a string. `write` interprets the string as the hexadecimal representation of the desired memory location. To convert the hex value to a decimal value, the function uses `hex2dec`. Note that when you use the string option to enter the address as a hex value, you cannot specify the memory page. For string input, the memory page defaults to the page specified by `cc (page)`.

`data` — the scalar, vector, or array of values that are written to memory on the processor. `write` supports the following data types:

| datatype String | Description                            |
|-----------------|----------------------------------------|
| 'double'        | Double-precision floating point values |
| 'int8'          | Signed 8-bit integers                  |
| 'int16'         | Signed 16-bit integers                 |
| 'int32'         | Signed 32-bit integers                 |
| 'single'        | Single-precision floating point data   |
| 'uint8'         | Unsigned 8-bit integers                |

| <b>datatype String (Continued)</b> | <b>Description</b>       |
|------------------------------------|--------------------------|
| 'uint16'                           | Unsigned 16-bit integers |
| 'uint32'                           | Unsigned 32-bit integers |

To limit the time that `write` spends transferring data from the target processor, the optional argument `timeout` tells the data transfer process to stop after `timeout` seconds. `timeout` is defined as the number of seconds allowed to complete the write operation. You may find this useful for limiting prolonged data transfer operations. If you omit the `timeout` option in the syntax, `write` defaults to the global timeout defined in `cc`.

`write(cc, address, data)` ends a block of data to memory on the processor referred to by `cc`. The `address` and `data` input arguments define the memory block to be written—where the memory starts and what data is being written. The memory block to be written to begins at the memory location defined by `address`. `data` is the data to be written, and can be a scalar, a vector, a matrix, or a multidimensional array. Data get written to memory in column-major order. Refer to the preceding syntax for details about the input arguments. In this syntax, `timeout` defaults to the global timeout period defined in `cc.timeout`. Use `get` to determine the default timeout value.

Like the `isreadable`, `iswritable`, and `read` functions, `write` checks for valid address values. Illegal address values would be any address space larger than the available space for the processor— $2^{32}$  for the C6xxx processor family and  $2^{16}$  for the C5xxx series. When the function identifies an illegal address, it returns an error message stating that the address values are out of range.

### Embedded Object Syntaxes

`write` works with all of the objects you create with `createobj`. To transfer data from MATLAB to Code Composer Studio, use one of the `write` functions—`write`—depending on the data to write. Note that `write` and its variants are the only way to get data from MATLAB to CCS from objects.

`write(objname)` writes all the data in `objname` to the location accessed by object `objname`. Properties of `objname`, such as `wordsize`, `storageunitspvalue`, `size`, `represent`, and `binarypt`—determine how `write` performs the numeric conversion. `data` is a numeric array whose

dimensions are defined by the `size` property of `objname`. Object property `size` is the *dimensions* vector. Each element in the dimensions vector contains the size of the data array in that dimension. When `size` is a scalar, data is a column vector of the length specified by `size`.

For example, when `size` is `[2 3]`, data is a 2-by-3 array.

## Properties of the Object

`objname`, the object that accesses the data, has the following properties, if the object is a numeric object. The properties differ for different types of objects, such as structure objects or register objects.

| Property                | Options                                                                               | Description                                                                                                                                                                                                                                                                                                                                                                   |
|-------------------------|---------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <code>size</code>       | Greater than 1                                                                        | Specifies the dimensions of the output numeric array.                                                                                                                                                                                                                                                                                                                         |
| <code>arrayorder</code> | <code>col-major</code> or <code>row-major</code>                                      | Defines how to map sequential memory locations into arrays. 'col-major' is the default, and the MATLAB standard. C uses 'row-major' ordering most often.                                                                                                                                                                                                                      |
| <code>represent</code>  | <code>float</code> , <code>signed</code> , <code>unsigned</code> , <code>fract</code> | Determines the numeric representation used in the output data. <ul style="list-style-type: none"><li>• <code>float</code>—IEEE floating point representation, either 32- or 64 bits</li><li>• <code>signed</code>—two's complement signed integers</li><li>• <code>unsigned</code>—unsigned binary integer</li><li>• <code>fract</code>—fractional fixed-point data</li></ul> |
| <code>wordsize</code>   | Greater than 1                                                                        | (Read-only) Calculated from other object properties such as <code>storageunitspervalue</code>                                                                                                                                                                                                                                                                                 |
| <code>binarypt</code>   | 0 to <code>wordsize</code>                                                            | Determines the position of the binary point in a word to specify its interpretation                                                                                                                                                                                                                                                                                           |

`write(objname, index)` reads the specified element in the memory location accessed by `objname`. `index` is a scalar or a vector that identifies the particular data element to return. When you enter `[]` for `index`, `write` returns all the data stored at the memory location. When you enter a scalar for `index`, `write` returns a column vector of length `size` containing the data from the memory space. When `index` is a vector, `write` returns the element in the array specified by the entries in the vector. For example, if you are reading data from a 3-by-3-by-3 array, setting `index` to be `[2 2 2]` returns the element `data(2,2,2)`. To return more than one element, use MATLAB standard range notation for the vector elements in `index`. As an example, when `index` is `[1:6]`, `write` returns the first six elements of data. You must remember that the number of elements in the vector in `index` must be either one (a scalar) or the same as the number of dimensions in data and specified by the property size. When data is a four dimensional array, your vector in `index` must have four elements, one for each array dimension. Otherwise, `write` cannot determine which elements to return.

`write(objname, structindex, member1, value1, , membern, valuen, memindex)` reads the members of the structure that `objname` accesses. When you omit all of the input arguments except `objname`, `write` returns the entire structure. `membern`, `valuen`, `memindex`, and `stindex` (an optional input argument) specify which structure member to read:

- `membern`—specifies the name of the member of the structure to write
- `valuen`—specifies the value to write to `membern`
- `memberindex`—provides the index of the data element to write
- `structindex`—identifies the structure to write when `objname` accesses a structure containing structures or a vector

Note that the class of the object data from the `write` operation depends on the class of the member being read—numeric values return numeric objects, string values return string objects, and so on.

`write( , timeout)` During `write` operations, the `timeout` property of `objname` determines the time allowed to complete the write. Including a value for the `timeout` input argument in the `write` syntax lets you override the `timeout` property setting for `objname` with the value you enter for argument `timeout`. For reading large data arrays, being able to explicitly set the `timeout` value as an input option may be necessary to let `write` run to completion. Note that

using the `timeout` input option does not change the `timeout` property value for `objname`.

When you need to write one member of a structure or to do individual write operations, consider using `getmember`.

## Notes About Using `write` With Embedded Objects

When you are writing data into memory on your target, consider a number of points that affect how `write` performs the write operation.

- The data you write to the target can be either numeric or hexadecimal format.
- When the data you are writing contains values that exceed the representable range for the variable data type and word size, the value written saturates to the maximum or minimum representable value for the variable representation. For example, if you try to write the value 70000 into an unsigned, 16-bit variable, the write operation stores 65535 into memory. 65535 is the maximum representable value for unsigned, 16-bit integers. Similarly, if you try to write -3 to the same variable, the stored value will be 0. You cannot represent negative numbers in the unsigned format.
- When you write more data elements to memory than fit in the specified size of the memory block, only the number of elements that fit in the memory block get written to the target. Excess elements do not get stored and are lost.
- When you write fewer data elements to memory than fit in the specified size of the memory block, all the elements get written to the memory block on the target. Memory space in the block which does not receive new elements is not affected by the write operation and remains unchanged.
- Use separate `write` operations to write multiple data elements to different locations within the memory block accessed by an object. For example, to write to the fifth and eighth elements of a 1-by-10 array in memory accessed by an object, use `write` twice—once to write to the fifth memory location and the again to write to the eighth location. You cannot combine the write operations in a single command unless the memory locations are contiguous. Refer to the next item in this list for information about writing to contiguous memory locations within a memory block.



- To write a block of data into contiguous locations in the memory block accessed by the object, supply just the starting index for the locations in the memory block.

### Notes About Writing Strings to Memory

Writing strings to memory has some idiosyncrasies. Recall the following points when you use `write` with string data.

- Data that you write to memory can be numeric or string data
- When your data is strings or characters, the `write` operation is controlled by the `charconversion` property value for the object. `write` accepts and writes only characters with ASCII values from 0 to 127 when the `charconversion` property value is ASCII.
- Numeric data is not restricted in any way when you use `write`.
- `write` appends a null character as the last element written to memory, except when
  - you write numeric data
  - the object points to a single C character (size equals 1)
  - the amount of data you are writing exceeds the allocated space
- When the string data you write does not fill the allotted space in memory, `write` does not fill the extra space with zeros—no zero padding.

### Notes About Writing to Structures

When you are writing data to a particular index within the structure, consider using `getmember` to create an object that accesses the desired member. Then use your new object as `objname` in the `write` function call.

Refer to the section “Embedded Object Examples” for samples of `write` in use.

## Examples

### Link Object Examples

Create a link to a target processor and write data to the target. In this example, CCS IDE recognizes one board having one processor.

```
cc = ccsdsp;
cc.visible(1);
write(cc, '50', 1:250);
mem = read(cc, 0, 50, 'double') % Returns 50 values as a column
 % vector in mem.
```

It may be more convenient to return the data in an array. If you enter a vector for count, mem contains a matrix of dimensions the same as vector count.

```
write(cc,10,1:100);
mem=read(cc,10,[10 10],'double')
```

mem =

|    |    |    |    |    |    |    |    |    |     |
|----|----|----|----|----|----|----|----|----|-----|
| 1  | 11 | 21 | 31 | 41 | 51 | 61 | 71 | 81 | 91  |
| 2  | 12 | 22 | 32 | 42 | 52 | 62 | 72 | 82 | 92  |
| 3  | 13 | 23 | 33 | 43 | 53 | 63 | 73 | 83 | 93  |
| 4  | 14 | 24 | 34 | 44 | 54 | 64 | 74 | 84 | 94  |
| 5  | 15 | 25 | 35 | 45 | 55 | 65 | 75 | 85 | 95  |
| 6  | 16 | 26 | 36 | 46 | 56 | 66 | 76 | 86 | 96  |
| 7  | 17 | 27 | 37 | 47 | 57 | 67 | 77 | 87 | 97  |
| 8  | 18 | 28 | 38 | 48 | 58 | 68 | 78 | 88 | 98  |
| 9  | 19 | 29 | 39 | 49 | 59 | 69 | 79 | 89 | 99  |
| 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 | 100 |

## Embedded Object Examples

The following examples show you some of the details about using write with embedded objects. Also, you can find an example or two for each of the items in the list from the section “Notes About Using write With Embedded Objects”.

When you try to write more elements to the memory space than the space can hold, write ignores the extra elements, storing only the ones that fit. In this example, mm is an object that access a 1-by-10 variable in memory.

- Writing 15 elements to the 1-by-10 array

```
write(mm,[1:15])
```

results in elements 1 through 10 (or [1:10]) being written to memory. Elements 11 through 15 are ignored.

- Writing 5 element to the 1-by-10 array

```
write(mm,[1:5])
```

results in elements [1:5] being written to memory without changing the values in memory for element [6:10].

To write multiple element to different indices in the 1-by-10 array, use multiple write calls.

```
write(mm,5,6)
```

writes value 6 to the fifth index in the array. Now to write another value to a different index, use

```
write(mm,7,9)
```

which writes value 9 to the seventh element of the array. Trying to use one call like

```
write(mm,[5 7],[6 9])
```

to write 6 into index 5 and 9 into index 7 does not work.

### Examples That Write Strings

Embedded object mm accesses a 1-by-12 array in memory on the target.

To write a string to target memory, use

```
write(mm, 'Hello World')
```

which writes 11 characters to memory plus the additional null character at the end of the string.

|   |   |   |   |   |  |   |   |   |   |   |    |   |
|---|---|---|---|---|--|---|---|---|---|---|----|---|
| H | e | l | l | o |  | W | o | r | l | d | \0 | M |
|---|---|---|---|---|--|---|---|---|---|---|----|---|

Notice that the M at the end of the memory space is not affected by the write operation. Now write a new string to memory, such as “Ciao.”

```
write(mm, 'Ciao')
```

After writing to memory, the stored string looks like:

|   |   |   |   |    |  |   |   |   |   |   |    |   |
|---|---|---|---|----|--|---|---|---|---|---|----|---|
| C | i | a | o | \0 |  | W | o | r | l | d | \0 | M |
|---|---|---|---|----|--|---|---|---|---|---|----|---|

where the fifth element now holds the null character that resulted from writing 'Ciao' to indices 1 through 4, plus the null character in index 5. All the characters after index 5 remain the same. Recall that if you now read the

# write

---

memory, the read operation stops at the first null character and does not return “World” or “M.”

## See Also

read, symbol

---

|                    |                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                        |
|--------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Purpose</b>     | Writes binary data to DSP memory                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                       |
| <b>Syntax</b>      | <pre>writebin(mm,data) writebin(mm,data,[]) writebin(mm,data,index) writebin( ,timeout)</pre>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                          |
| <b>Description</b> | <p><code>writebin(mm,data)</code> writes a block of binary strings data into the memory block described by <code>mm</code>. <code>data</code> is string containing 0 or 1 or a cell array of binary strings of 0s and 1s. Writing to the target fails when data has more entries than the memory range covers as specified by <code>mm</code>. Conversely, when data has fewer elements than the memory range allows, <code>writebin</code> starts writing data at the first address in the memory location.</p> <p><code>writebin(mm,data,[])</code> same as <code>writebin(mm,data)</code>.</p> <p><code>writebin(mm,data,index)</code> Writes a single binary string data to the specified index (the address offset).</p> <p><code>writebin( ,timeout)</code> adds the optional <code>timeout</code> input argument to specify the time allowed for the write operation to finish. Changing the default time out value may be necessary when you write large arrays to memory. Note that when MATLAB returns an error that the time-out period expired, it does not necessarily mean the write failed. Only that MATLAB did not receive notification about the write operation finishing before the allotted time passed. The write operation usually works correctly in spite of the message.</p> |
| <b>See Also</b>    | <code>read</code> , <code>write</code>                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                                 |

# writemsg

---

**Purpose** Write messages to the specified RTDX channel

**Syntax**  
`data = writemsg(rx,channelname,data,timeout)`  
`data = writemsg(rx,channelname,data)`

**Description** `data = writemsg(rx,channelname,data)` writes data to a channel associated with `rx`. `channelname` identifies the channel queue, which must be configured for write access. All messages must be the same type for a single write operation. `writemsg` takes the elements of matrix data in column-major order.

To limit the time that `writemsg` spends transferring messages from the target processor, the optional argument `timeout` tells the message transfer process to stop after `timeout` seconds. `timeout` is defined as the number of seconds allowed to complete the write operation. You may find this useful for limiting prolonged data transfer operations. If you omit the `timeout` option in the syntax, write defaults to the global timeout defined in `cc`.

`writemsg` supports the following data types: `uint8`, `int16`, `int32`, `single`, and `double`.

`data = writemsg(rx,channelname,data)` uses the global timeout setting assigned to `cc` when you create the link.

**Examples** After you load a program to your target, configure a link in RTDX for write access and use `writemsg` to write data to the target. Recall that the program loaded on the target must define `'ichannel'` and the channel must be configured for write access.

```
cc=ccsdsp;
rx = cc.rtdx;
open(rx,'ichannel','w'); % Could use rx.open('ichannel','w')
enable(rx,'ichannel');
inputdata(1:25);
writemsg(rx,'ichannel',int16(inputdata));
```

As a further illustration, the following code snippet writes the messages in matrix `indata` to the write-enabled channel specified by `ichan`. Note again that this example works only when `ichan` is defined by the program on the target and enabled for write access.

```
indata = [1 4 7; 2 5 8; 3 6 9];
```

```
writemsg(cc.rtdx, 'ichan', indata);
```

The matrix `indata` is written column-wise to `ichan`. The preceding function syntax is equivalent to:

```
writemsg(cc.rtdx, 'ichan', [1:9]);
```

## See Also

`readmat`, `readmsg`, `write`

**writemsg**

---



# Reference — Supported Hardware

---

This appendix provides the details about the hardware and simulators that work with the Link for Code Composer Studio.

Supported Hardware and Simulators  
(p. A-2)

Describes the hardware that works with the links, embedded objects, and RTDX

Link Features Supported By Each  
Processor or Family (p. A-4)

Outlines which link features, such as debugging or manipulating data, work with each supported target

OMAP Coemulation Support (p. A-6)

Describes the support for coemulation on OMAP

Custom Hardware Support (p. A-6)

Discusses support for custom hardware based on supported processors

## Introduction to Supported Platforms

This appendix contains the latest listings for the hardware that works with Link for Code Composer Studio version 1.3.1. Generally the product supports both boards and simulators from a given family. In some cases, only the simulators work, as noted in the tables in the next sections.

### Supported Hardware and Simulators

The Link for Code Composer Studio Development Tools supports the following processors and boards produced by TI and others.

| Supported Hardware And Simulators | Description                             |
|-----------------------------------|-----------------------------------------|
| <b>C2000</b>                      |                                         |
| Simulators (C24x, C27x, C28x)     | Simulators for the C2000 DSP family     |
| C2401 eZdsp                       | Starter kit for the C2401 processor     |
| C2407 eZdsp                       | Starter kit for the C2407 processor     |
| C2812 eZdsp                       | Starter kit for the C2812 processor     |
| <b>C5000</b>                      |                                         |
| Simulators (C54x, C5x)            | Simulators for the C5000 DSP family     |
| C5402 DSK                         | DSP starter kit for the C5402 processor |
| C5416 DSK                         | DSP starter kit for the C5416 processor |
| C5510 DSK                         | DSP starter kit for the C5510 processor |

| <b>Supported Hardware And Simulators</b> | <b>Description</b>                                      |
|------------------------------------------|---------------------------------------------------------|
| <b>C6000</b>                             |                                                         |
| Simulators (C62x, C64x, C67x)            | Simulators for the C6000 DSP family                     |
| C6211 DSK                                | DSP starter kit for the C6211 processor                 |
| C6416 DSK                                | DSP starter kit for the C6216 processor                 |
| DM64x                                    | C6400 processor-based video card                        |
| C6701 EVM                                | Evaluation module for the C6211 processor               |
| C6711 DSK                                | DSP starter kit for the C6711 processor                 |
| C6713 DSK                                | DSP starter kit for the C6713 processor                 |
| <b>OMAP</b>                              |                                                         |
| OMAP1510                                 | Boards and simulators based on the OMAP1510.            |
| OMAP5910                                 | Boards and simulators based on the OMAP5910.            |
| <b>TMS470</b>                            |                                                         |
| TMS470R1x                                | Boards and simulators based on the TMS470R1x processor. |
| TMS470R1x                                | Boards and simulators based on the TMS470R2x processor. |

## Link Features Supported By Each Processor or Family

### Specific Link Features Supported For Each Processor Family

Within the collection of hardware that Link for Code Composer Studio supports, some features of the link do not apply. In the next table, each processor family appears with headings that specify the support provided.

**Processor Family Support for Link for Code Composer Studio Functions**

| Processor Family | Debug Mode | Embedded Objects<br>(data manipulation) | HIL Function | RTDX |
|------------------|------------|-----------------------------------------|--------------|------|
| C24xx            | Yes        | No                                      | No           | No   |
| C27xx            | Yes        | No                                      | No           | No   |
| C28xx            | Yes        | Yes                                     | Yes          | Yes  |
| C54xx            | Yes        | Yes                                     | Yes          | Yes  |
| C55xx            | Yes        | Yes                                     | No           | Yes  |
| C62xx            | Yes        | Yes                                     | Yes          | Yes  |
| C64xx            | Yes        | Yes                                     | Yes          | Yes  |
| C67xx            | Yes        | Yes                                     | Yes          | Yes  |
| OMAP1510         |            |                                         |              |      |
| • C55x DSP       | Yes        | Yes                                     | No           | Yes  |
| • TMS470R2x      | Yes        | Yes                                     | No           | No   |
| OMAP5910         |            |                                         |              |      |
| • C55x DSP       | Yes        | Yes                                     | No           | Yes  |
| • TMS470R2x      | Yes        | Yes                                     | No           | No   |
| TMS470R1x        | Yes        | Yes                                     | No           | No   |
| TMS470R2x        | Yes        | Yes                                     | No           | No   |

Debug mode includes operations that CCS handles and that Link for Code Composer Studio enables you to use from MATLAB—a “Yes” tells you that the listed hardware supports MATLAB interaction with CCS. Embedded Objects support indicates that the board family supports using objects in MATLAB to work with symbol table entries in CCS. A “Yes” in the Hardware-in-the-Loop column means the board family supports using function objects to run functions on your target from MATLAB.

Link for Code Composer Studio provides components that work with and use CCS IDE and TI Real-Time Data Exchange (RTDX™):

- **Debug Mode**— lets you use objects to create links between CCS IDE and MATLAB®. From the command window, you can run applications in CCS IDE, send to and receive data from target memory, and check the processor status, as well as other functions such as starting and stopping applications running on your digital signal processors.
- **Embedded Objects**—provides object methods and properties that let you access and manipulate information stored in memory and registers on digital signal processors, or in your Code Composer Studio project. From MATLAB you gather information from you project, work with the information in MATLAB, doing things like converting data types, creating function declarations, or changing values, and return the information to your project—all from the MATLAB command line.
- **Hardware-in-the-Loop**—enables you to write scripts in MATLAB that exercise functions from your project on your target processor. From MATLAB, you can generate data, send the data to your target and use a C function in your program to manipulate the data on your hardware or simulator. Afterwards, you return the output to MATLAB so you can analyze the results.
- **Link for Real-Time Data Exchange Interface (RTDX)**— provides a communications pathway between MATLAB and digital signal processors installed on your PC. Using objects in the Link for Code Composer Studio, you open channels to processors on boards in your computer and send and retrieve data about the processors and executing applications, as well as send data to the processes for use and get data from the applications.

## **OMAP Coemulation Support**

An added feature for OMAP processors is coemulation for the two processors that comprise the OMAP. Link for Code Composer Studio supports coemulation or direct multiprocessor support for the TMS470R2x (TI-enhanced ARM925) and TMS320C55x DSP in OMAP 1510 and OMAP 5910.

## **Custom Hardware Support**

Link for Code Composer Studio supports processors as shown in the previous tables. If your custom hardware

- uses one or more of the processors shown in the preceding tables
- you are able to use Code Composer Studio IDE to interact with your board/processor combination

Link for Code Composer Studio should work with your hardware.

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