Instrument Control Toolbox

For Use with MATLAB® and Simulink®

- Computation

- Visualization

- Programming

- Simulation

User's Guide

Version 2

The MathWorks

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Instrument Control Toolbox User's Guide

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Getting Started

This chapter provides a brief overview of the Instrument Control Toolbox and its documentation. Also provided is the information you need to get started with the Instrument Control Toolbox. The sections are as follows.

What Is the Instrument Control Toolbox?

The Instrument Control Toolbox is a collection of M-file functions built on the MATLAB® technical computing environment. The toolbox provides you with these features:

- A framework for communicating with instruments that support the GPIB interface (IEEE-488), the VISA standard, and the TCP/IP and UDP protocols. Note that the toolbox extends the basic serial port features included with MATLAB.

- Support for IVI, VXI*plug&play*, and MATLAB instrument drivers

- Functions for transferring data between MATLAB and your instrument:
  - The data can be binary (numerical) or text.
  - The transfer can be synchronous and block the MATLAB command line, or asynchronous and allow access to the MATLAB command line.

- Event-based communication

- Functions for recording data and event information to a text file

- Tools that facilitate instrument control in an easy-to-use graphical environment

The MathWorks provides several related products that are especially relevant to the kinds of tasks you can perform with the Instrument Control Toolbox. For more information about any of these products, see

http://www.mathworks.com/products/instrument/related.jsp

Exploring the Instrument Control Toolbox

A list of the toolbox functions is available to you by typing

```
help instrument
```

You can view the code for any function by typing

```
type function_name
```

You can view the help for any function by typing

```
instrhelp function_name
```

You can change the way any toolbox function works by copying and renaming the M-file, then modifying your copy. You can also extend the toolbox by adding your own M-files, or by using it in combination with other products such as the MATLAB Report Generator or the Data Acquisition Toolbox.

To use the Instrument Control Toolbox, you should have some familiarity with

- The basic features of MATLAB

- The appropriate commands used to communicate with your instrument. These commands might use the SCPI language or they might be methods associated with an IVI, VXI*plug&play*, or MATLAB instrument driver.

- The features of the interface associated with your instrument

Learning About Instrument Control Toolbox

Start with this chapter, which describes how to examine your hardware resources, how to communicate with your instrument, how to get online help, and so on. Then read Chapter 2, "The Instrument Control Session" which provides a framework for constructing instrument control applications. Depending on the interface used by your instrument, you might then want to read the appropriate interface-specific chapter.

If you want detailed information about a specific function, refer to Chapter 18, "Functions — Alphabetical List". If you want detailed information about a specific property, refer to Chapter 20, "Properties — Alphabetical List".

Using the Documentation Examples

The examples in this guide use specific instruments such as a Tektronix TDS 210 two-channel oscilloscope or an Agilent 33120A function generator. Additionally, the GPIB examples use a National Instruments GPIB controller and the serial port examples use the COM1 serial port. The string commands written to these instruments are often unique to the vendor, and the address information such as the board index or primary address associated with the hardware reflects a specific configuration.

These documentation examples are collected in the example index, which is available through the Help browser. You should modify the examples to work with your specific hardware configuration.

Toolbox Components

The Instrument Control Toolbox consists of two distinct components: M-file functions and interface driver adaptors. These components allow you to pass information between MATLAB and your instrument. For example, the following diagram shows how information passes from MATLAB to an instrument via the GPIB driver and the GPIB controller.
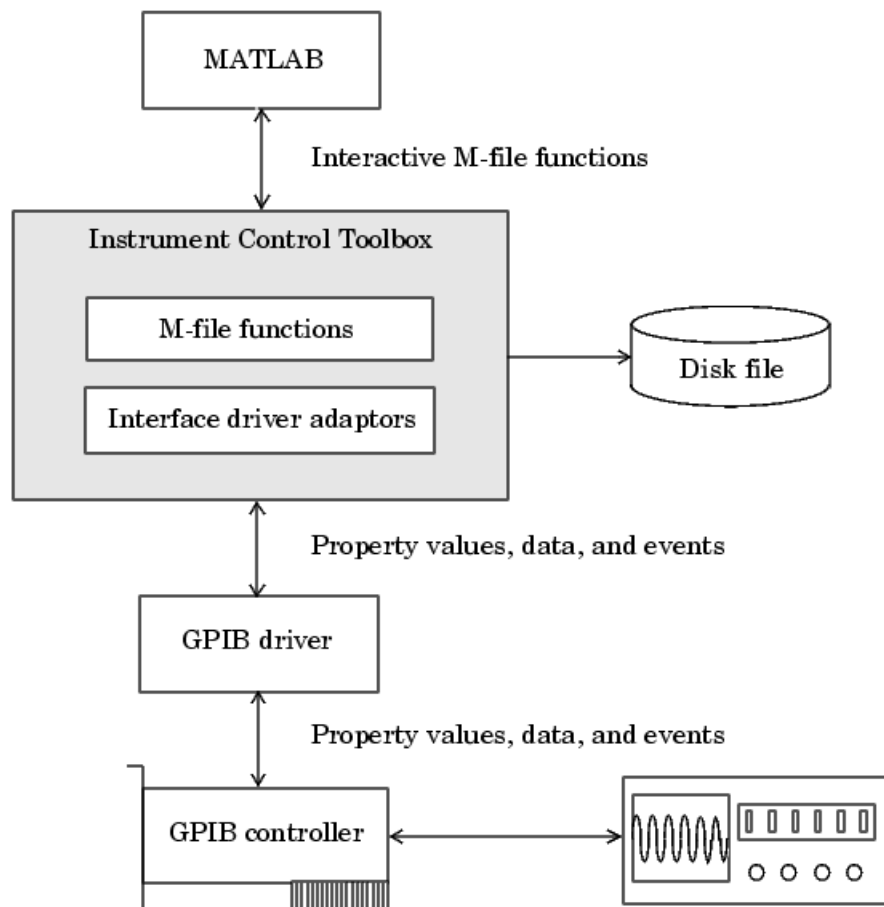
The preceding diagram illustrates how information flows from component to component. Information consists of

- **Property values**

  You define the behavior of your instrument control application by configuring property values. In general, you can think of a property as a characteristic of the toolbox or of the instrument that can be configured to suit your needs.

- **Data**

  You can write data to the instrument and read data from the instrument. Data can be binary (numerical) or formatted as text. Writing text often involves writing string commands that change hardware settings, or prepare the instrument to return data or status information, while writing binary data involves writing numerical values such as calibration or waveform data.

- **Events**

  An event occurs after a condition is met and might result in one or more callbacks. Events can be generated only after you configure the associated properties. For example, you can use events to analyze data after a certain number of bytes are read from the instrument, or display a message to the MATLAB command line after an error occurs.

M-File Functions

To perform any task within your instrument control application, you must call M-file functions from the MATLAB environment. Among other things, these functions allow you to

- Create instrument objects, which provide a gateway to your instrument's capabilities and allow you to control the behavior of your application.

- Connect the object to the instrument.

- Configure property values.

- Write data to the instrument, and read data from the instrument.

- Examine your hardware resources and evaluate your application status.

For a listing of all Instrument Control Toolbox functions, refer to Chapter 18, "Functions — Alphabetical List". You can also display the toolbox functions by typing

```
help instrument
```

The Interface Driver Adaptor

The interface driver adaptor (or just *adaptor*) is the link between the toolbox and the interface driver. The adaptor's main purpose is to pass information between MATLAB and the interface driver. Interface drivers are provided by your instrument vendor. For example, if you are communicating with an instrument using a National Instruments GPIB controller, then an interface driver such as NI-488.2 must be installed on your platform. Note that interface drivers are not installed as part of the Instrument Control Toolbox.

The Instrument Control Toolbox provides adaptors for the GPIB interface and the VISA standard. The serial port, TCP/IP, and UDP interfaces do not require an adaptor. The supported interfaces and the adaptor names are listed below.

Supported Interfaces and Adaptor Names

Interface	Adaptor Name
GPIB	`advantech`, `agilent`, `cec`, `contec`, `ics`, `iotech`, `keithley`, `mcc`, `ni`
Serial port	N/A
TCP/IP	N/A
UDP	N/A
VISA standard	`agilent`, `ni`, `tek`

As described in "Examining Your Hardware Resources" on page 1-12, you can list the supported interfaces and adaptor names with the `instrhwinfo` function. For a list of vendor driver requirements and limitations, refer to Appendix A, "Vendor Driver Requirements and Limitations".

Understanding the Toolbox Capabilities

In addition to the printed and online documentation, the Instrument Control Toolbox provides these resources to help you understand the product capabilities:

- "Overview Help" on page 1-8
- "Documentation Examples" on page 1-8
- "Demos" on page 1-8

Overview Help

The overview help lists the toolbox functions grouped by usage. You can display this information by typing

```
help instrument
```

You can view the code for many functions by typing

```
type function_name
```

Documentation Examples

This guide provides detailed examples that show you how to communicate with all supported interface types. These examples are collected in the example index, which is available through the Help browser.

The examples use specific peripheral instruments, GPIB controllers, string commands, address information, and so on. If your instrument accepts different string commands, or if your hardware is configured to use different address information, you should modify the examples accordingly.

Demos

The toolbox includes a large collection of tutorial demos, which you can access through the Help browser **Demos** pane. Use the following command to open the Help browser to the toolbox demos.

```
demo toolbox 'Instrument Control'
```

Note that the tutorials use prerecorded data. Therefore, you do not need an instrument connected to your computer to use these demos.

Installation Information

To communicate with your instrument from the MATLAB environment, these components must be installed:

- MATLAB 7
- Instrument Control Toolbox

Additionally, you might need to install hardware such as a GPIB controller and vendor-specific software such as drivers, support libraries, and so on. For a complete list of all supported vendors, refer to "The Interface Driver Adaptor" on page 1-7.

Toolbox Installation

To determine if the Instrument Control Toolbox is installed on your system, type

```
ver
```

at the MATLAB prompt. MATLAB displays information about the version of MATLAB you are running, including a list of installed add-on products and their version numbers. Check the list to see if the Instrument Control Toolbox appears.

For information about installing the toolbox, refer to the Installation Guide for your platform. If you experience installation difficulties, look for the installation and license information at the MathWorks Web site (http://www.mathworks.com/support).

Hardware and Driver Installation

Installation of hardware devices such as GPIB controllers, instrument drivers, support libraries, and so on is described in the documentation provided by the instrument vendor. Many vendors provide the latest drivers through their Web site. For a list of vendor driver requirements and limitations, refer to Appendix A, "Vendor Driver Requirements and Limitations".

Note You must install all necessary device-specific software provided by the instrument vendor in addition to the Instrument Control Toolbox.

Examining Your Hardware Resources

instrhwinfo

You can examine the hardware-related resources visible to the toolbox with the instrhwinfo function. The specific information returned by instrhwinfo depends on the supplied arguments, and is divided into these categories:

- "General Toolbox Information" on page 1-12
- "Interface Information" on page 1-12
- "Adaptor Information" on page 1-13
- "Instrument Object Information" on page 1-15
- "Installed Driver Information" on page 1-15

General Toolbox Information

To display general information about the Instrument Control Toolbox,

```
instrhwinfo

         MATLABVersion: '7.0 (R14)'
   SupportedInterfaces: {'gpib'  'serial'  'visa'  'tcpip'  'udp'}
      SupportedDrivers: {'matlab'  'vxipnp'  'ivi'}
           ToolboxName: 'Instrument Control Toolbox'
        ToolboxVersion: '2.0 (R14)'
```

Note that the SupportedInterfaces and SupportedDrivers fields list the interfaces and drivers supported by the toolbox, not necessarily those installed on your computer.

Interface Information

To display information about a specific interface, you supply the interface name as an argument to instrhwinfo. The interface name can be gpib, serial, tcpip, udp, or visa.

For the GPIB and VISA interfaces, the information includes installed adaptors. For the serial port interface, the information includes the available

ports. For the TCP/IP and UDP interfaces, the information includes the local host address. For example, to display the GPIB interface information,

```
out = instrhwinfo('gpib')
out =

    InstalledAdaptors: {'mcc' 'ni'}
       JarFileVersion: 'Version 2.0 (R14)'
```

The InstalledAdaptors field indicates that the Measurement Computing Corporation and National Instruments drivers are installed. Therefore, you can communicate with instruments using GPIB controllers from these vendors.

Adaptor Information

To display information about a specific installed adaptor, you supply the interface name and the adaptor name as arguments to instrhwinfo. The supported interface and adaptor names are given below.

Interface Name	Adaptor Name
gpib	advantech, agilent, cec, contec, ics, iotech, keithley, mcc, ni
visa	agilent, ni, tek

The returned information describes the adaptor, the vendor driver, and the object constructors. For example, to display information for the National Instruments GPIB adaptor,

```
ghwinfo = instrhwinfo('gpib','ni')

ghwinfo =

            AdaptorDllName: [1x82 char]
         AdaptorDllVersion: 'Version 2.0 (R14)'
               AdaptorName: 'NI'
          InstalledBoardIds: 0
      ObjectConstructorName: {'gpib('ni', 0, 2);'}
```

```
                  VendorDllName: 'gpib-32.dll'
          VendorDriverDescription: 'NI-488'
```

The `ObjectConstructorName` field provides the syntax for creating a GPIB object for the National Instruments adaptor. In this example, the GPIB controller has board index 0 and the instrument has primary address 2.

```
g = gpib('ni',0,2);
```

To display information for the Tektronix VISA adaptor,

```
vhwinfo = instrhwinfo('visa','tek')
vhwinfo =

               AdaptorDllName: [1x83 char]
            AdaptorDllVersion: 'Version 2.0 (R14 Beta 1)'
                  AdaptorName: 'TEK'
             AvailableChassis: []
         AvailableSerialPorts: {2x1 cell}
             InstalledBoardIds: 0
        ObjectConstructorName: {3x1 cell}
                  SerialPorts: {2x1 cell}
                VendorDllName: 'visa32.dll'
      VendorDriverDescription: 'Tektronix VISA Driver'
          VendorDriverVersion: 2.0500
```

The available VISA object constructor names are shown below.

```
vhwinfo.ObjectConstructorName
ans =

    'visa('tek', 'ASRL1::INSTR');'
    'visa('tek', 'ASRL2::INSTR');'
    'visa('tek', 'GPIB0::1::INSTR');'
```

The `ObjectConstructorName` field provides the syntax for creating a VISA object for the GPIB and serial port interfaces. In this example, the GPIB controller has board index 0 and the instrument has primary address 1.

```
vg = visa('tek','GPIB0::1::INSTR');
```

Instrument Object Information

To display information about a specific instrument object, you supply the object as an argument to instrhwinfo. For example, to display information for the GPIB object created in the preceding section ("Adaptor Information" on page 1-13),

```
ghwinfo = instrhwinfo(g)
ghwinfo =

              AdaptorDllName: [1x82 char]
           AdaptorDllVersion: 'Version 2.0 (R14)'
                 AdaptorName: 'NI'
               VendorDllName: 'gpib-32.dll'
       VendorDriverDescription: 'NI-488'
```

To display information for the VISA-GPIB object created in the preceding section ("Adaptor Information" on page 1-13),

```
vghwinfo = instrhwinfo(vg)
vghwinfo =

              AdaptorDllName: [1x83 char]
           AdaptorDllVersion: 'Version 2.0 (R14)'
                 AdaptorName: 'TEK'
               VendorDllName: 'visa32.dll'
       VendorDriverDescription: 'Tektronix VISA Driver'
          VendorDriverVersion: 2.0500
```

Alternatively, you can return hardware information via the Workspace browser by right-clicking an instrument object, and selecting **Display Hardware Info** from the context menu.

Installed Driver Information

To display information about a supported driver type, you supply the driver type as an argument to instrhwinfo. For example, to display information for the IVI configuration,

```
instrhwinfo('ivi')
ans =
              LogicalNames: {'MyIviCLogical'  'MyScope'  'TekScope'}
```

```
                    ProgramIDs: {'TekScope.TekScope'}
                       Modules: {'ag3325b'}
     ConfigurationServerVersion: '1.3.1.0'
      MasterConfigurationStore: 'D:\Apps\IVI\Data\IviConfigurationStore.xml'
                   IVIRootPath: 'D:\Apps\IVI\'
```

To display information about a specific driver or resource, you supply the
driver name in addition to the type as an argument to instrhwinfo. For
example, to display information about the ag3325b VXI*plug&play* driver,

```
instrhwinfo('vxipnp', 'ag3325b')
ans =
     Manufacturer: 'Agilent Technologies'
            Model: 'Agilent 3325B Synthesizer/Func. Gen.'
    DriverVersion: '4.1'
    DriverDllName: 'C:\VXIPNP\WINNT\bin\ag3325b_32.dll'
```

The Test & Measurement Tool (tmtool)

You can use the Test & Measurement Tool to manage the resources of your
instrument control session. Some of the tool's features enable you to

- Search for installed adaptors

- Examine available hardware

- Examine installed drivers

- Examine instrument objects

You open the Test & Measurement Tool by typing

```
tmtool
```

Hardware

Expand the Hardware node in the tree to list the supported interfaces.

Right-click on the Hardware node to scan for instrument hardware. The
interface nodes expand to include entries for each instrument found by the
scan.
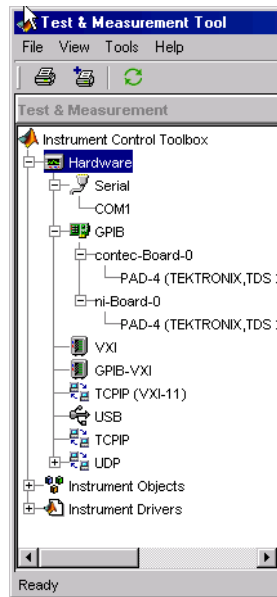
Installed Drivers

The Test & Measurement Tool can display your installed drivers. The three categories of drivers are MATLAB Instrument Drivers, VXIplug&play Drivers, and IVI, as shown below under the expanded Instrument Drivers node.

Right-click on the Instrument Drivers node to scan for installed drivers. The driver-type nodes expand to include entries for each driver found by the scan. Note that for MATLAB instrument drivers and VXI*plug&play* drivers, the installation of a driver requires only the presence of a driver file. For IVI, installation involves an IVI configuration store; see "Viewing the IVI Configuration Store" on page 1-18.
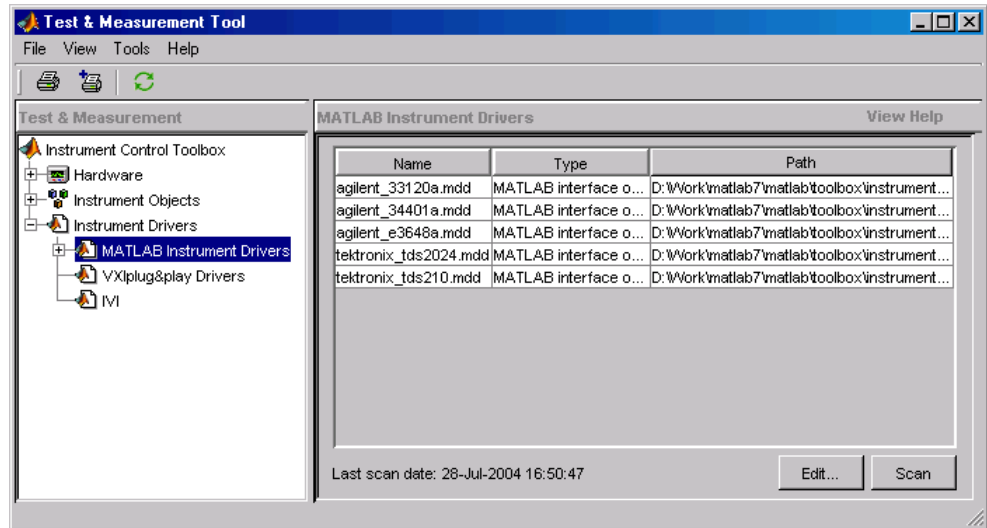
The Test & Measurement Tool GUI includes embedded help. For further details about the Test & Measurement Tool and its capabilities, see Chapter 13, "The Test & Measurement Tool".

Viewing the IVI Configuration Store

An IVI configuration store greatly enhances instrument interchangeability by providing the means to configure the relationship between drivers and I/O interface references outside of the application. For details of the components of an IVI configuration store, see "IVI Configuration Store" on page 10-11.

Command-Line Configuration

You can use command-line functions to examine and configure your IVI configuration store. To see what IVI configuration store elements are available, use instrhwinfo to identify the existing logical names.

```
instrhwinfo('ivi')
ans =
                 LogicalNames: {'MainScope', 'FuncGen'}
                   ProgramIDs: {'TekScope.TekScope','Agilent33250'}
                      Modules: {'ag3325b', 'hpe363xa'}
ConfigurationServerVersion: '1.3.1.0'
```

```
           MasterConfigurationStore: 'C:\Program Files\IVI\Data\
                                      IviConfigurationStore.xml'
                       IVIRootPath: 'C:\Program Files\IVI\'
```

Use instrhwinfo with a logical name as an argument to see the details of that logical name's configuration.

```
instrhwinfo('ivi','MainScope')
ans =
              DriverSession: 'TekScope.DriverSession'
              HardwareAsset: 'TekScope.Hardware'
             SoftwareModule: 'TekScope.Software'
      IOResourceDescriptor: 'GPIB0::13::INSTR'
 SupportedInstrumentModels: 'TekScope 5000, 6000 and 7000 series'
         ModuleDescription: 'TekScope software module desc'
             ModuleLocation: ''
```

You create and configure elements in the IVI configuration store by using the IVI configuration store object functions add, commit, remove, and update. For further details, see the reference pages for these functions.

Test & Measurement Tool

You can use the Test & Measurement Tool to examine or configure your IVI configuration store. Open the tool by typing

```
tmtool
```

Expand the Instrument Drivers node and click IVI.

You see a tab for each type of IVI configuration store element. This figure shows the available driver sessions in the current IVI configuration store. For the selected driver session, you can use any available software module or hardware asset. This figure shows the configuration for the driver session `TekScope.DriverSession`, which uses the software module `TekScope.Software` and the hardware asset `TekScope.Hardware`.

Communicating with Your Instrument

This section provides basic examples that show you how to communicate with a

- GPIB instrument
- GPIB-VXI instrument
- Serial port instrument
- GPIB instrument using a device object

Each example illustrates a typical *instrument control session*. The instrument control session comprises all the steps you are likely to take when communicating with a supported instrument. You should keep these steps in mind when constructing your own instrument control applications.

The examples also use specific instrument addresses, SCPI commands, and so on. If your instrument requires different parameters, or if it does not support the SCPI language, you should modify the examples accordingly.

If you want detailed information about any functions that are used, refer to Chapter 17, "Functions — By Category". If you want detailed information about any properties that are used, refer to Chapter 19, "Properties — By Category".

Communicating with a GPIB Instrument

This example illustrates how to communicate with a GPIB instrument. The GPIB controller is a National Instruments AT-GPIB card. The instrument is an Agilent 33120A Function Generator, which is generating a 2-volt peak-to-peak signal.

You should modify this example to suit your specific instrument control application needs. If you want detailed information about communicating with an instrument via GPIB, refer to Chapter 4, "Controlling Instruments Using the GPIB".

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1 **Create an interface object —** Create the GPIB object g associated with a National Instruments GPIB board with board index 0, and an instrument with primary address 1.

```
g = gpib('ni',0,1);
```

2 **Connect to the instrument —** Connect g to the instrument.

```
fopen(g)
```

3 **Configure property values —**Configure g to assert the EOI line when the line feed character is written to the instrument, and to complete read operations when the line feed character is read from the instrument.

```
set(g,'EOSMode','read&write')
set(g,'EOSCharCode','LF')
```

4 **Write and read data —** Change the instrument's peak-to-peak voltage to three volts by writing the Volt 3 command, query the peak-to-peak voltage value, and then read the voltage value.

```
fprintf(g,'Volt 3')
fprintf(g,'Volt?')
data = fscanf(g)
data =
+3.00000E+00
```

5 **Disconnect and clean up —** When you no longer need g, you should disconnect it from the instrument, remove it from memory, and remove it from the MATLAB workspace.

```
fclose(g)
delete(g)
clear g
```

Communicating with a GPIB-VXI Instrument

This example illustrates how to communicate with a VXI instrument via a GPIB controller using the VISA standard provided by Agilent Technologies.

The GPIB controller is an Agilent E1406A command module in VXI slot 0. The instrument is an Agilent E1441A Function/Arbitrary Waveform

Generator in VXI slot 1, which is outputting a 2 volt peak-to-peak signal. The GPIB controller communicates with the instrument over the VXI backplane.

You should modify this example to suit your specific instrument control application needs. If you want detailed information about communicating with an instrument using VISA, refer to Chapter 5, "Controlling Instruments Using VISA".

1 **Create an instrument object —** Create the VISA-GPIB-VXI object v associated with the E1441A instrument located in chassis 0 with logical address 80.

```
v = visa('agilent','GPIB-VXI0::80::INSTR');
```

2 **Connect to the instrument —** Connect v to the instrument.

```
fopen(v)
```

3 **Configure property values —** Configure v to complete a read operation when the line feed character is read from the instrument.

```
set(v,'EOSMode','read')
set(v,'EOSCharCode','LF')
```

4 **Write and read data —** Change the instrument's peak-to-peak voltage to three volts by writing the Volt 3 command, query the peak-to-peak voltage value, and then read the voltage value.

```
fprintf(v,'Volt 3')
fprintf(v,'Volt?')
data = fscanf(v)
data =
+3.00000E+00
```

5 **Disconnect and clean up —** When you no longer need v, you should disconnect it from the instrument, remove it from memory, and remove it from the MATLAB workspace.

```
fclose(v)
delete(v)
clear v
```

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Communicating with a Serial Port Instrument

This example illustrates how to communicate with an instrument via the serial port. The instrument is a Tektronix TDS 210 two-channel digital oscilloscope connected to the COM1 port of a PC, and configured for a baud rate of 4800 and a carriage return (CR) terminator.

You should modify this example to suit your specific instrument control application needs. If you want detailed information about communicating with an instrument connected to the serial port, refer to Chapter 6, "Controlling Instruments Using the Serial Port".

1 Create an instrument object — Create the serial port object s associated with the COM1 serial port.

```
s = serial('COM1');
```

2 Configure property values — Configure s to match the instrument's baud rate and terminator.

```
set(s,'BaudRate',4800)
set(s,'Terminator','CR')
```

3 Connect to the instrument — Connect s to the instrument. This step occurs after property values are configured because serial port instruments can transfer data immediately after the connection is established.

```
fopen(s)
```

4 Write and read data — Write the *IDN? command to the instrument and then read back the result of the command. *IDN? queries the instrument for identification information.

```
fprintf(s,'*IDN?')
out = fscanf(s)
out =
TEKTRONIX,TDS 210,0,CF:91.1CT FV:v1.16 TDS2CM:CMV:v1.04
```

5 Disconnect and clean up — When you no longer need s, you should disconnect it from the instrument, remove it from memory, and remove it from the MATLAB workspace.

```
fclose(s)
```

```
delete(s)
clear s
```

Communicating with a GPIB Instrument Using a Device Object

This example illustrates how to communicate with a GPIB instrument through a device object. The GPIB controller is a Keithley card, and the instrument is an Agilent 33120A Function Generator, which you set to produce a 1 volt peak-to-peak sine wave at 1,000 Hz. Device objects make use of instrument drivers; this example uses the driver agilent_33120a.mdd.

You should modify this example to suit your specific instrument control application needs. If you want detailed information about communicating through device objects, see Chapter 8, "Using Device Objects".

1 **Create instrument objects** — Create the GPIB object g associated with a Keithley GPIB board with board index 0, and an instrument with primary address 4. Then create the device object d associated with the interface object g, and with the instrument driver agilent_33120a.mdd.

```
g = gpib('keithley',0,4);
d = icdevice('agilent_33120a.mdd',g);
```

2 **Connect to the instrument** — Connect d to the instrument.

```
connect(d)
```

3 **Call device object method** — Use the devicereset method to set the generator to a known configuration. The behavior of the generator for this method is defined in the instrument driver.

```
devicereset(d)
```

4 **Configure property values** — Configure d to set the amplitude and frequency for the signal from the function generator.

```
set(d,'Amplitude',1.00,'AmplitudeUnits','vpp')
set(d,'Frequency',1000)
```

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5 Disconnect and clean up — When you no longer need d and g, you should disconnect from the instrument, remove the objects from memory, and remove them from the MATLAB workspace.

```
disconnect(d)
delete([d g])
clear d g
```

General Preferences for Instrument Control

You access the general preferences from your MATLAB desktop environment by selecting **File > Preferences**. The **Preferences** dialog box appears. Select Instrument Control in the tree, as shown below.
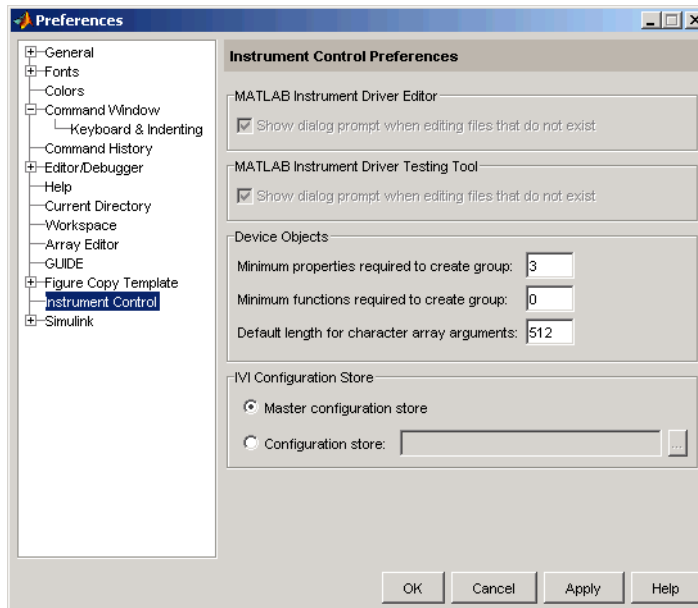
MATLAB Instrument Driver Editor

This section of the dialog box contains preferences related to the midedit tool.

There is a check box labeled **Show dialog prompt when editing files that do not exist**. This grayed out option can be unchecked by acting on the prompt itself.

If you open the MATLAB Instrument Driver Editor while specifying a driver file that does not exist, you get a dialog prompt asking if you want to create a new driver file.

For example, the command

```
midedit ('newdriver')
```

generates the prompt
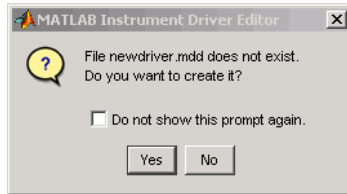
If you check **Do not show this prompt again**, then the corresponding check box in the **Preferences** dialog box is unselected. To reactivate the prompt, check the option on the **Preferences** dialog box.

MATLAB Instrument Driver Testing Tool

This section of the dialog box contains preferences related to the midtest tool.

There is a check box labeled **Show dialog prompt when editing files that do not exist**. This grayed out option can be unchecked by acting on the prompt itself.

If you open the MATLAB Instrument Driver Testing tool while specifying a driver test file that does not exist, you get a dialog prompt asking if you want to create a new test file.

For example, the command

```
midtest ('newtest')
```

generates the prompt
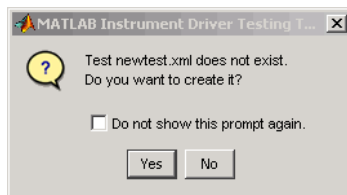
If you check **Do not show this prompt again**, then the corresponding check box in the **Preferences** dialog box is selected. To reactivate the prompt, check the option on the **Preferences** dialog box.

Device Objects

This section of the dialog box contains preferences related to the construction and use of device objects for VXI*plug&play* and IVI-C drivers.

Here you set the minimum number of properties and functions required to create a device object group, and the default size of character arrays passed as output arguments to device object functions.

Set the default size for these character arrays in the **Preferences** dialog box to ensure that they are large enough to accommodate any string returned to them by any device object functions. You can reduce the default character array size to avoid unnecessary memory usage, as long as they are still large enough to accommodate any expected strings.

IVI Configuration Store

This section of the dialog box contains preferences related to the construction and use of IVI configuration store objects when working in the Command Window or in the Test & Measurement Tool (`tmtool`).

You may select between a master configuration store or a user-defined configuration store. If you choose a user-defined configuration store, you must provide its filename.

Getting Help

In addition to this guide, the Instrument Control Toolbox provides you with these help resources:

- "The instrhelp Function" on page 1-30
- "The propinfo Function" on page 1-31
- "Online Support" on page 1-32

The instrhelp Function

You can use the instrhelp function to

- Display command line help for functions and properties
- List all the functions and properties associated with a specific instrument object

An instrument object does not need to exist for you to obtain this information. For example, to display all the functions and properties associated with a GPIB object, as well as the constructor M-file help,

```
instrhelp gpib
```

To display help for the EOIMode property,

```
instrhelp EOIMode
```

You can also display help for an existing instrument object. For example, to display help for the MemorySpace property associated with a VISA-GPIB-VXI object,

```
v = visa('agilent','GPIB-VXI0::80::INSTR');
out = instrhelp(v,'MemorySpace');
```

Alternatively, you can display help via the Workspace browser by right-clicking an instrument object and selecting **Instrument Help** from the context menu.

The propinfo Function

You can use the `propinfo` function to return the characteristics of Instrument Control Toolbox properties. For example, you can find the default value for any property using this function. `propinfo` returns a structure containing the fields shown below.

Field Name	Description
Type	The property data type. Possible values are `any`, `ASCII value`, `callback`, `double`, `string`, and `struct`.
Constraint	The type of constraint on the property value. Possible values are `ASCII value`, `bounded`, `callback`, `enum`, and `none`.
ConstraintValue	The property value constraint. The constraint can be a range of values or a list of string values.
DefaultValue	The property default value.
ReadOnly	The condition under which a property is read only. Possible values are `always`, `never`, `whileOpen`, and `whileRecording`.
InterfaceSpecific	If the property is interface-specific, a `1` is returned. If the property is supported for all interfaces, a `0` is returned.

For example, to display the property characteristics for the `EOIMode` property associated with the GPIB object g,

```
g = gpib('ni',0,2);
EOIinfo = propinfo(g,'EOIMode')

EOIinfo =
                Type: 'string'
          Constraint: 'enum'
     ConstraintValue: {2x1 cell}
        DefaultValue: 'on'
            ReadOnly: 'never'
   InterfaceSpecific: 1
```

This information tells you that

- The property value data type is a string.

- The property value is constrained as an enumerated list of values.

- There are two possible property values.

- The default value is on.

- The property can be configured at any time (it is never read-only).

- The property is not supported for all interfaces.

To display the property value constraints,

```
EOIinfo.ConstraintValue
ans =
    'on'
    'off'
```

Online Support

For online support of the Instrument Control Toolbox, visit the Web site `http://www.mathworks.com/support/product/IC/`. This site includes documentation, examples, solutions, downloads, system requirements, and contact information.

The Instrument Control Session

The instrument control session consists of the steps you are likely to take when communicating with your instrument. This chapter highlights some of the differences between interface objects and device objects for each of these steps, to help you decide which to use in communicating with your instrument. Whether you use interface objects or device objects, the basic steps of the instrument control session remain the same, as outlined by the sections of this chapter.

Disconnect the object, and remove
the object from memory and from
the workspace.

Choose whether to use interface
objects or device objects for your
application.

Creating Instrument Objects

Instrument objects are the toolbox components you use to access your instrument. They provide a gateway to the functionality of your instrument and allow you to control the behavior of your application. The toolbox supports two types of instrument objects:

- Interface objects — Interface objects are associated with a specific interface standard such as GPIB or VISA. They allow you to communicate with any instrument connected to the interface.

- Device objects — Device objects are associated with a MATLAB instrument driver. They allow you to communicate with your instrument using properties and functions defined in the driver for a specific instrument model.

Interface Objects

An interface object represents a channel of communication. For example, an interface object might represent a device at address 4 on the GPIB, even though there is nothing specific about what kind of instrument this may be.

To create an instrument object, you call the constructor for the type of interface (`gpib`, `serial`, `tcpip`, `udp`, or `visa`), and provide appropriate interface information, such as address for GPIB, remote host for TCP/IP, or port number for serial.

For detailed information on interface objects and how to create and use them, see Chapter 3, "Using Interface Objects".

Device Objects

A device object represents an instrument rather than an interface. As part of that representation, a device object must also be aware of the instrument driver.

You create a device object with the `icdevice` function. A device object requires a MATLAB instrument driver and some form of instrument interface, which can be an interface object, a VISA resource name, or an interface implied in an IVI configuration.

For detailed information on device objects and how to create and use them, see Chapter 8, "Using Device Objects".

Connecting to the Instrument

Before you can use an instrument object to write or read data, you must connect it to the instrument. You connect an interface object to the instrument with the fopen function; you connect a device object to the instrument with the connect function.

You can examine the Status property to verify that the instrument object is connected to the instrument.

```
obj.Status
ans =
open
```

Some properties of the object are read-only while the object is connected and must be configured before connecting. Examples of interface object properties that are read-only when the object is connected include InputBufferSize and OutputBufferSize. You can determine when a property is configurable with the propinfo function, or by referring to Chapter 20, "Properties — Alphabetical List".

Configuring and Returning Properties

You establish the desired instrument object behavior by configuring property values. You can configure property values using the set function or the dot notation, or by specifying property name/property value pairs during object creation. You can return property values using the get function or the dot notation.

Interface objects possess two types of properties: *base properties* and *interface-specific properties*. (These properties pertain only to the interface object itself and to the interface, *not* to the instrument.) Base properties are supported for all interface objects (serial port, GPIB, VISA-VXI, and so on), while interface-specific properties are supported only for objects of a given interface type. For example, the BaudRate property is supported only for serial port and VISA-serial objects.

Device objects also possess two types of properties: *base properties* and *device-specific properties*. While device objects possess base properties pertaining to the object and interface, they also possess any number of device-specific properties as defined in the instrument driver for configuring the instrument. For example, a device object representing an oscilloscope might posses such properties as DisplayContrast, InputRange, and MeasurementMode. When you set these properties you are directly configuring the oscilloscope settings.

Returning Property Names and Property Values

Once the instrument object is created, you can use the set function to return all its configurable properties to a variable or to the command line. Additionally, if a property has a finite set of string values, set returns these values.

The Property Inspector

The Property Inspector enables you to inspect and set properties for one or more instrument objects. It provides a list of all properties and displays their current values.

Settable properties in the list are associated with an editing device that is appropriate for the values accepted by the particular property. For

example, a callback configuration GUI to set `ErrorFcn`, a pop-up menu to set `RecordMode`, and a text field to specify the `TimerPeriod`. The values for read-only properties are grayed out.

You open the Property Inspector with the `inspect` function. Alternatively, you can open the Property Inspector via the Workspace browser by right-clicking an instrument object and selecting **Call Property Inspector** from the context menu, or by double-clicking the object.

Below is a **Property Inspector** window for a GPIB interface object.
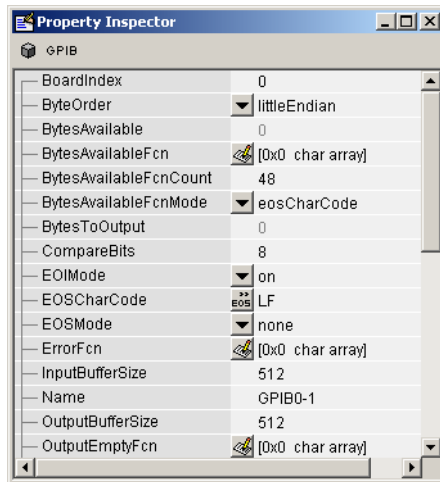
Communicating with Your Instrument

Communicating with your instrument involves sending and receiving commands, settings, responses, and data. The level of communication depends on the type of instrument object you use.

Interface Objects and Instrument Commands

To communicate through the interface object, you need to send instrument commands, and you receive information as the instrument sends it. Therefore, you have to know the syntax specific to the instrument itself. For example, if the instrument requires the command `'*RST'` to initiate its action, then that is exactly the command that must be sent to the interface object.

Text commands and binary data are sent directly to the instrument and received from the instrument with such functions as `fprintf`, `fwrite`, `fgets`, `fread`, and others.

Device Objects and Instrument Drivers

To communicate through a device object, you access object properties with the `set` and `get` commands, and you execute driver functions with the `invoke` command. The `invoke` command for a device object employs methods and arguments defined by the instrument driver. So using device objects does not require you to use instrument-specific commands and syntax.

For information on creating, editing, and importing instrument drivers, see Chapter 14, "The Instrument Driver Editor".

Disconnecting and Cleaning Up

When you no longer need an instrument object, you should disconnect it from the instrument, and clean up the MATLAB environment by removing the object from memory and from the workspace. These are the steps you take to end an instrument control session.

Disconnecting an Instrument Object

When you no longer need to communicate with the instrument, you should disconnect the object. Interface objects are disconnected with the `fclose` function; device objects are disconnected with the `disconnect` function.

You can examine the `Status` property to verify that the object is disconnected from the instrument.

```
obj.Status
ans =
closed
```

Cleaning Up the MATLAB Environment

When you no longer need the instrument object, you should remove it from memory with the `delete` function.

```
delete(obj)
```

A deleted instrument object is *invalid*, which means that you cannot connect it to the instrument. In this case, you should remove the object from the MATLAB workspace. To remove instrument objects and other variables from the MATLAB workspace, use the `clear` command.

```
clear obj
```

If you use `clear` on an object that is connected to an instrument, the object is removed from the workspace but remains connected to the instrument. You can restore cleared instrument objects to MATLAB with the `instrfind` function.

Summary

Should you use interface objects or device objects to communicate with your instrument? Generally, device objects make instrument control easier and they offer greater flexibility to the user compared to using interface objects.

Advantages of Using Device Objects

Because of the advantages offered by using device objects for communicating with your instrument, you should use device objects whenever possible. Some of these advantages are

- You do not need to know instrument-specific commands

- You can use standard VXI*plug&play* or IVI instrument drivers provided by your instrument vendor or other party

- You can use a MATLAB instrument driver to control your instrument. To get a MATLAB instrument driver, you can

  - Convert a VXI*plug&play* or IVI driver

  - Use a MATLAB driver that is shipped with the toolbox

  - Create it yourself or modify a similar driver

  - Install it from a third party, such as MATLAB Central

  You can create, convert, or customize a MATLAB instrument driver with the MATLAB Instrument Driver Editor tool (`midedit`).

When to Use Interface Objects

In some circumstances, using device objects to communicate with your instrument would be impossible or impractical. You might need to use interface objects if

- Your instrument does not have a standard instrument driver supported by the Instrument Control Toolbox.

- You are using a streaming application (typically serial, UDP, or TCP/IP interface) to notify you of some occurrence.

- Your application requires frequent changes to communication channel settings.

Using Interface Objects

The instrument control session using interface objects consists of all the steps described in the following sections.

The instrument control session is used in many of the documentation examples included in this guide.

Creating an Interface Object

To create an interface object, you call M-file functions called *object creation functions* (or *object constructors*). These M-files are implemented using the MATLAB object-oriented programming capabilities, which are described in "Classes and Objects" in the MATLAB documentation. The interface object creation functions are listed below.

Interface Object Creation Functions

Constructor	Description
gpib	Create a GPIB object.
serial	Create a serial port object.
tcpip	Create a TCPIP object.
udp	Create a UDP object.
visa	Create a VISA-GPIB, VISA-VXI, VISA-GPIB-VXI, or VISA-serial object.

You can find out how to create an interface object for a particular interface and adaptor with the ObjectConstructorName field of the instrhwinfo function. For example, to find out how to create a GPIB object for a National Instruments GPIB controller,

```
out = instrhwinfo('gpib','ni');
out.ObjectConstructorName
ans =
    'gpib('ni', 0, 1);'
```

Configuring Properties During Object Creation

Instrument objects contain properties that reflect the functionality of your instrument. You control the behavior of your instrument control application by configuring values for these properties.

As described in "Configuring and Returning Properties" on page 3-6, you configure properties using the set function or the dot notation. You can also configure properties during object creation by specifying property

name/property value pairs. For example, the following command configures the EOSMode and EOSCharCode properties for the GPIB object g.

```
g = gpib('ni',0,1,'EOSMode','read','EOSCharCode','CR');
```

If you specify an invalid property name or property value, the object is not created. For detailed property descriptions, refer to Chapter 20, "Properties — Alphabetical List".

Creating an Array of Instrument Objects

In MATLAB, you can create an array from existing variables by concatenating those variables. The same is true for instrument objects. For example, suppose you create the GPIB objects g1 and g2:

```
g1 = gpib('ni',0,1);
g2 = gpib('ni',0,2);
```

You can now create an instrument object array consisting of g1 and g2 using the usual MATLAB syntax. To create the row array x,

```
x = [g1 g2]
Instrument Object Array

   Index:   Type:        Status:       Name:
   1        gpib         closed        GPIB0-1
   2        gpib         closed        GPIB0-2
```

To create the column array y,

```
y = [g1;g2];
```

Note that you cannot create a matrix of instrument objects. For example, you cannot create the matrix

```
z = [g1 g2;g1 g2];
??? Error using ==> gpib/vertcat
Only a row or column vector of instrument objects can be created.
```

Depending on your application, you might want to pass an array of instrument objects to a function. For example, using one call to the set function, you can configure both g1 and g2 to the same property value.

```
set(x,'EOSMode','read')
```

Refer to Chapter 18, "Functions — Alphabetical List" to see which functions accept an instrument object array as an input argument.

Connecting to the Instrument

Before you can use the instrument object to write or read data, you must connect it to the instrument whose address or port is specified in the creation function. You connect an interface object to the instrument with the fopen function.

```
fopen(g)
```

Some properties are read-only while the object is connected and must be configured before using fopen. Examples include the InputBufferSize and the OutputBufferSize properties. You can determine when a property is configurable with the propinfo function, or by referring to Chapter 20, "Properties — Alphabetical List".

Note You can create any number of instrument objects. However, at any time, you can connect only one instrument object to an instrument with a given address or port.

You can examine the Status property to verify that the instrument object is connected to the instrument.

```
g.Status
ans =
open
```

As illustrated below, the connection between the instrument object and the instrument is complete, and you can write and read data.
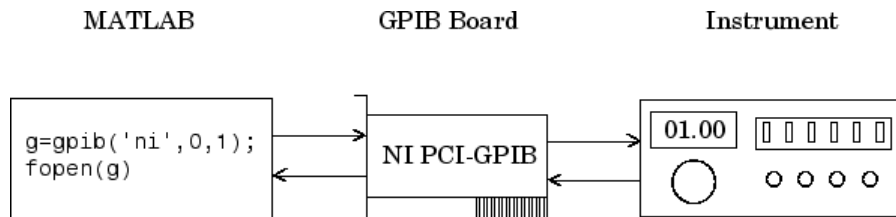
Configuring and Returning Properties

You establish the desired instrument object behavior by configuring property values. You can configure property values using the set function or the dot notation, or by specifying property name/property value pairs during object creation. You can return property values using the get function or the dot notation.

Interface objects possess two types of properties: *base properties* and *interface-specific properties*. Base properties are supported for all interface objects (serial port, GPIB, VISA-VXI, and so on). For example, the BytesToOutput property is supported for all interface objects. Interface-specific properties are supported only for objects of a given interface type. For example, the BaudRate property is supported only for serial port and VISA-serial objects.

Returning Property Names and Property Values

Once the instrument object is created, you can use the set function to return all configurable properties to a variable or to the command line. Additionally, if a property has a finite set of string values, then set also returns these values.

For example, the configurable properties for the GPIB object g are shown below. The base properties are listed first, followed by the GPIB-specific properties.

```
g = gpib('ni',0,1);
set(g)
    ByteOrder: [ {littleEndian} | bigEndian ]
    BytesAvailableFcn
    BytesAvailableFcnCount
    BytesAvailableFcnMode: [ {eosCharCode} | byte ]
    ErrorFcn
    InputBufferSize
    Name
    OutputBufferSize
    OutputEmptyFcn
    RecordDetail: [ {compact} | verbose ]
    RecordMode: [ {overwrite} | append | index ]
```

```
RecordName
Tag
Timeout
TimerFcn
TimerPeriod
UserData

GPIB specific properties:
BoardIndex
CompareBits
EOIMode: [ {on} | off ]
EOSCharCode
EOSMode: [ {none} | read | write | read&write ]
PrimaryAddress
SecondaryAddress
```

You can use the get function to return one or more properties and their current values to a variable or to the command line.

For example, all the properties and their current values for the GPIB object g are shown below. The base properties are listed first, followed by the GPIB-specific properties.

```
get(g)
    ByteOrder = littleEndian
    BytesAvailable = 0
    BytesAvailableFcn =
    BytesAvailableFcnCount = 48
    BytesAvailableFcnMode = eosCharCode
    BytesToOutput = 0
    ErrorFcn =
    InputBufferSize = 512
    Name = GPIB0-1
    OutputBufferSize = 512
    OutputEmptyFcn =
    RecordDetail = compact
    RecordMode = overwrite
    RecordName = record.txt
    RecordStatus = off
    Status = closed
```

```
        Tag =
        Timeout = 10
        TimerFcn =
        TimerPeriod = 1
        TransferStatus = idle
        Type = gpib
        UserData = []
        ValuesReceived = 0
        ValuesSent = 0

        GPIB specific properties:
        BoardIndex = 0
        BusManagementStatus = [1x1 struct]
        CompareBits = 8
        EOIMode = on
        EOSCharCode = LF
        EOSMode = none
        HandshakeStatus = [1x1 struct]
        PrimaryAddress = 1
        SecondaryAddress = 0
```

To display the current value for one property, you supply the property name to get.

```
get(g,'OutputBufferSize')
ans =
    512
```

To display the current values for multiple properties, you include the property names as elements of a cell array.

```
get(g,{'BoardIndex','TransferStatus'})
ans =
    [0]     'idle'
```

You can also use the dot notation to display a single property value.

```
g.PrimaryAddress
ans =
     1
```

Configuring Property Values

You can configure property values using the `set` function

```
set(g,'EOSMode','read')
```

or the dot notation.

```
g.EOSMode = 'read';
```

To configure values for multiple properties, you can supply multiple property name/property value pairs to `set`.

```
set(g,'EOSCharCode','CR','Name','Test1-gpib')
```

Note that you can configure only one property value at a time using the dot notation.

In practice, you can configure many of the properties at any time while the instrument object exists — including during object creation. However, some properties are not configurable while the object is connected to the instrument or when recording information to disk. Use the `propinfo` function, or refer to Chapter 20, "Properties — Alphabetical List" for information about when a property is configurable.

Specifying Property Names

Instrument object property names are presented using mixed case. While this makes property names easier to read, you can use any case you want when specifying property names. Additionally, you need use only enough letters to identify the property name uniquely, so you can abbreviate most property names. For example, you can configure the `EOSMode` property in any of these ways.

```
set(g,'EOSMode','read')
set(g,'eosmode','read')
set(g,'EOSM','read')
```

However, when you include property names in an M-file, you should use the full property name. This practice can prevent problems with future releases of the Instrument Control Toolbox if a shortened name is no longer unique because of the addition of new properties.

Default Property Values

If you do not explicitly define a value for a property, then the default value is used. All configurable properties have default values.

Note Default values are provided for all instrument object properties. For serial port objects, the default values are provided by your operating system. For GPIB and VISA instrument objects, the default values are provided by vendor-supplied tools. However, these settings are overridden by your MATLAB code, and will have no effect on your instrument control application.

If a property has a finite set of string values, then the default value is enclosed by {} (curly braces). For example, the default value for the EOSMode property is none.

```
set(g,'EOSMode')
[ {none} | read | write | read&write ]
```

You can also use the propinfo function, or refer to Chapter 20, "Properties — Alphabetical List" to find the default value for any property.

The Property Inspector

The Property Inspector enables you to inspect and set properties for one or more instrument objects. It provides a list of all properties and displays the current value.

Settable properties in the list are associated with an editing device that is appropriate for the values accepted by the particular property. For example, a callback configuration GUI to set ErrorFcn, a pop-up menu to set RecordMode, and a text field to specify the TimerPeriod. The values for read-only properties are grayed out.

You open the Property Inspector with the inspect function. Alternatively, you can open the Property Inspector via the Workspace browser by right-clicking an instrument object and selecting **Call Property Inspector** from the context menu, or by double-clicking the object.

Below is a **Property Inspector** window for a GPIB interface object.
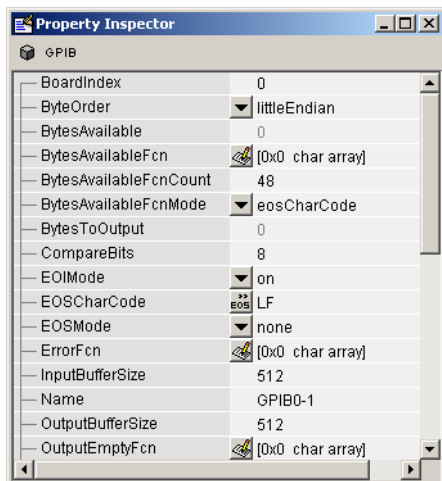
Writing and Reading Data

Communicating with your instrument involves writing and reading data. For example, you might write a text command to a function generator that queries its peak-to-peak voltage, and then read back the voltage value as a double-precision array.

Before performing a write or read operation, you should consider these three questions:

- What is the process by which data flows from MATLAB to the instrument, and from the instrument to MATLAB?

  The Instrument Control Toolbox automatically manages the data transferred between MATLAB and the instrument. For many common applications, you can ignore the buffering and data flow process. However, if you are transferring a large number of values, executing an asynchronous read or write operation, or debugging your application, you might need to be aware of how this process works.

- Is the data to be transferred binary (numerical) or text (ASCII)?

  For many instruments, writing text data means writing string commands that change instrument settings, prepare the instrument to return data or status information, and so on. Writing binary data means writing numerical values to the instrument such as calibration or waveform data.

- Will the write or read function block access to the MATLAB command line?

  You control access to the MATLAB command line by specifying whether a read or write operation is *synchronous* or *asynchronous*. A synchronous operation blocks access to the command line until the read or write function completes execution. An asynchronous operation does not block access to the command, and you can issue additional commands while the read or write function executes in the background.

Note that there are other issues to consider when reading and writing data such as the conditions under which a read or write operation completes. Because these issues vary among the supported interfaces, they are described in the respective interface-specific chapters.

Writing Data

The functions associated with writing data are given below.

Functions Associated with Writing Data

Function Name	Description
binblockwrite	Write binblock data to the instrument.
fprintf	Write text to the instrument.
fwrite	Write binary data to the instrument.
stopasync	Stop asynchronous read and write operations.

The properties associated with writing data are given below.

Properties Associated with Writing Data

Property Name	Description
BytesToOutput	Indicate the number of bytes currently in the output buffer.
OutputBufferSize	Specify the size of the output buffer in bytes.
Timeout	Specify the waiting time to complete a read or write operation.
TransferStatus	Indicate if an asynchronous read or write operation is in progress.
ValuesSent	Indicate the total number of values written to the instrument.

The Output Buffer and Data Flow

The output buffer is computer memory allocated by the instrument object to store data that is to be written to the instrument. The flow of data from MATLAB to your instrument follows these steps:

1 The data specified by the write function is sent to the output buffer.

2 The data in the output buffer is sent to the instrument.

The `OutputBufferSize` property specifies the maximum number of bytes that you can store in the output buffer. The `BytesToOutput` property indicates the number of bytes currently in the output buffer. The default values for these properties are given below.

```
g = gpib('ni',0,1);
get(g,{'OutputBufferSize','BytesToOutput'})
ans =
    [512]    [0]
```

If you attempt to write more data than can fit in the output buffer, an error is returned and no data is written.

Note When writing data, you might need to specify a *value*, which can consist of one or more bytes. This is because some write functions allow you to control the number of bits written for each value and the interpretation of those bits as character, integer or floating point values. For example, if you write one value from an instrument using the `int32` format, then that value consists of four bytes.

For example, suppose you write the string command `*IDN?` to an instrument using the `fprintf` function. As shown below, the string is first written to the output buffer as six values.
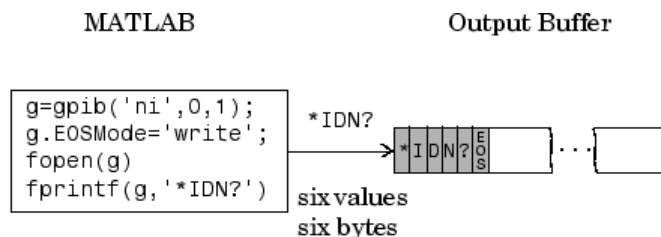
The `*IDN?` command consists of six values because the End-Of-String character is written to the instrument, as specified by the `EOSMode` and

`EOSCharCode` properties. Moreover, the default data format for the `fprintf` function specifies that one value corresponds to one byte.

As shown below, after the string is stored in the output buffer, it is then written to the instrument.
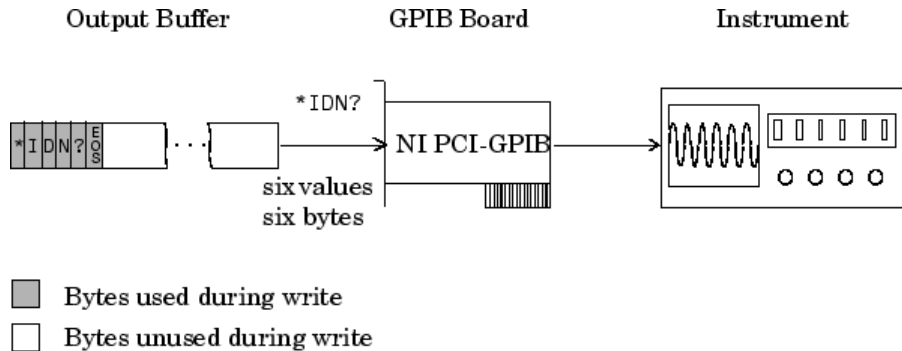
Writing Text Data Versus Writing Binary Data

For many instruments, writing text data means writing string commands that change instrument settings, prepare the instrument to return data or status information, and so on. Writing binary data means writing numerical values to the instrument such as calibration or waveform data.

You can write text data with the `fprintf` function. By default, `fprintf` uses the `%s\n` format, which formats the data as a string and includes the terminator. You can write binary data with the `fwrite` function. By default, `fwrite` writes data using the `uchar` precision, which translates the data as unsigned 8-bit characters. Both of these functions support many other formats and precisions, as described in their reference pages.

The following example illustrates writing text data and binary data to a Tektronix TDS 210 oscilloscope. The text data consists of string commands, while the binary data is a waveform that is to be downloaded to the scope and stored in its memory:

1 **Create an instrument object** — Create the GPIB object g associated with a National Instruments GPIB controller with board index 0, and an instrument with primary address 1. The size of the output buffer is increased to accommodate the waveform data. You must configure the

3-15

OutputBufferSize property while the GPIB object is disconnected from the instrument.

```
g = gpib('ni',0,1);
g.OutputBufferSize = 3000;
```

2 Connect to the instrument — Connect g to the instrument.

```
fopen(g)
```

3 Write and read data — Write string commands that configure the scope to store binary waveform data in memory location A.

```
fprintf(g,'DATA:DESTINATION REFA');
fprintf(g,'DATA:ENCDG SRPbinary');
fprintf(g,'DATA:WIDTH 1');
fprintf(g,'DATA:START 1');
```

Create the waveform data.

```
t = linspace(0,25,2500);
data = round(sin(t)*90 + 127);
```

Write the binary waveform data to the scope.

```
cmd = double('CURVE #42500');
fwrite(g,[cmd data]);
```

The ValuesSent property indicates the total number of values that were written to the instrument.

```
g.ValuesSent
ans =
        2577
```

4 Disconnect and clean up — When you no longer need g, you should disconnect it from the instrument, remove it from memory, and remove it from the MATLAB workspace.

```
fclose(g)
delete(g)
clear g
```

Synchronous Versus Asynchronous Write Operations

By default, all write functions operate synchronously and block the MATLAB command line until the operation completes. To perform an asynchronous write operation, you supply the `async` input argument to the `fprintf` or `fwrite` function.

For example, you use the following syntax to modify the `fprintf` commands used in the preceding example to write text data asynchronously.

```
fprintf(g,'DATA:DESTINATION REFA','async');
```

Similarly, you use the following syntax to modify the `fwrite` command used in the preceding example to write binary data asynchronously.

```
fwrite(g,[cmd data],'async');
```

You can monitor the status of the asynchronous write operation with the `TransferStatus` property. A value of `idle` indicates that no asynchronous operations are in progress.

```
g.TransferStatus
ans =
write
```

You can use the `BytesToOutput` property to indicate the numbers of bytes that exist in the output buffer waiting to be written to the instrument.

```
g.BytesToOutput
ans =
        2512
```

Reading Data

The functions associated with reading data are given below.

Functions Associated with Reading Data

Function Name	Description
binblockread	Read binblock data from the instrument.
fgetl	Read one line of text from the instrument and discard the terminator.
fgets	Read one line of text from the instrument and include the terminator.
fread	Read binary data from the instrument.
fscanf	Read data from the instrument, and format as text.
readasync	Read data asynchronously from the instrument.
scanstr	Read data from the instrument, format as text, and parse
stopasync	Stop asynchronous read and write operations.

The properties associated with reading data are given below.

Properties Associated with Reading Data

Property Name	Description
BytesAvailable	Indicate the number of bytes available in the input buffer.
InputBufferSize	Specify the size of the input buffer in bytes.
ReadAsyncMode	Specify whether an asynchronous read is continuous or manual (serial port, TCPIP, UDP, and VISA-serial objects only).
Timeout	Specify the waiting time to complete a read or write operation.

Properties Associated with Reading Data (Continued)

Property Name	Description
TransferStatus	Indicate if an asynchronous read or write operation is in progress.
ValuesReceived	Indicate the total number of values read from the instrument.

The Input Buffer and Data Flow

The input buffer is computer memory allocated by the instrument object to store data that is to be read from the instrument. The flow of data from your instrument to MATLAB follows these steps:

1 The data read from the instrument is stored in the input buffer.

2 The data in the input buffer is returned to the MATLAB variable specified by the read function.

The InputBufferSize property specifies the maximum number of bytes that you can store in the input buffer. The BytesAvailable property indicates the number of bytes currently available to be read from the input buffer. The default values for these properties are given below.

```
g = gpib('ni',O,1);
get(g,{'InputBufferSize','BytesAvailable'})
ans =
    [512]    [0]
```

If you attempt to read more data than can fit in the input buffer, an error is returned and no data is read.

For example, suppose you use the fscanf function to read the text-based response of the *IDN? command previously written to the instrument. As shown below, the data is first read into the input buffer.

Instrument   GPIB Board   Input Buffer

data

NI PCI-GPIB
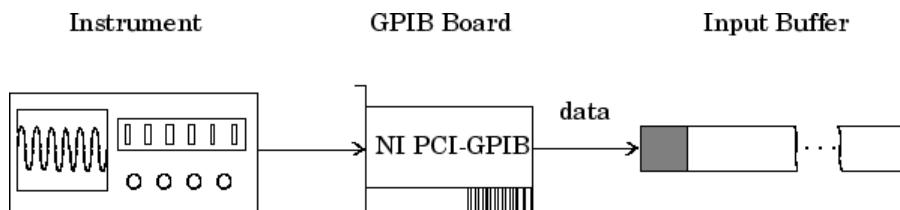
▣ Bytes used during read
☐ Bytes unused during read

Note that for a given read operation, you might not know the number of bytes returned by the instrument. Therefore, you might need to preset the `InputBufferSize` property to a sufficiently large value before connecting the instrument object.

As shown below, after the data is stored in the input buffer, it is then transferred to the output variable specified by `fscanf`.

Input Buffer   MATLAB

data

```
out=fscanf(g)
```
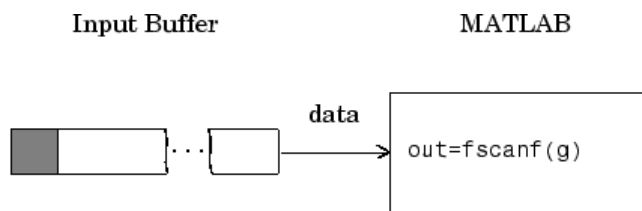
▣ Bytes used during read
☐ Bytes unused during read

Reading Text Data Versus Reading Binary Data

For many instruments, reading text data means reading string data that reflect instrument settings, status information, and so on. Reading binary data means reading numerical values from the instrument.

You can read text data with the `fgetl`, `fgets`, and `fscanf` functions. By default, these functions return data using the `%c` format. You can read binary data with the `fread` function. By default, `fread` returns numerical values as

double-precision arrays. Both the fscanf and fread functions support many
other formats and precisions, as described in their reference pages.

The following example illustrates reading text data and binary data from a
Tektronix TDS 210 oscilloscope, which is displaying a periodic input signal
with a nominal frequency of 1.0 kHz.

1 Create an instrument object — Create the GPIB object g associated
with a National Instruments GPIB controller with board index 0, and an
instrument with primary address 1.

```
g = gpib('ni',0,1);
```

2 Connect to the instrument — Connect g to the instrument.

```
fopen(g)
```

3 Write and read data — Write the *IDN? command to the scope, and read
back the identification information as text.

```
fprintf(g,'*IDN?')
idn = fscanf(g)
idn =
TEKTRONIX,TDS 210,0,CF:91.1CT FV:v1.16 TDS2CM:CMV:v1.04
```

Configure the scope to return the period of the input signal, and then read
the period as a binary value. The output display format is configured to use
short exponential notation for doubles.

```
fprintf(g,'MEASUREMENT:MEAS1:TYPE PERIOD')
fprintf(g,'MEASUREMENT:MEAS1:VALUE?')
format short e
period = fread(g,9)'
period =
    49    46    48    48    54    69    45    51    10
```

period consists of positive integers representing character codes, where 10
is a line feed. To convert the voltage value to a string, use the char function.

```
char(period)
ans =
1.006E-3
```

The ValuesReceived property indicates the total number of values that were read from the instrument.

```
g.ValuesReceived
ans =
     65
```

4 Disconnect and clean up — When you no longer need g, you should disconnect it from the instrument, remove it from memory, and remove it from the MATLAB workspace.

```
fclose(g)
delete(g)
clear g
```

Synchronous Versus Asynchronous Read Operations

The fgetl, fgets, fscanf, and fread functions operate synchronously and block the MATLAB command line until the operation completes. To perform an asynchronous read operation, you use the readasync function. readasync asynchronously reads data from the instrument and stores it in the input buffer. To transfer the data from the input buffer to a MATLAB variable, you use one of the synchronous read functions.

Note For serial port, TCPIP, UDP, and VISA-serial objects, you can also perform an asynchronous read operation by configuring the ReadAsyncMode property to continuous.

For example, to modify the preceding example to asynchronously read the scope's identification information, you would issue the readasync function after the *IDN? command is written.

```
fprintf(g,'*IDN?')
readasync(g)
```

You can monitor the status of the asynchronous read operation with the TransferStatus property. A value of idle indicates that no asynchronous operations are in progress.

```
g.TransferStatus
ans =
read
```

You can use the `BytesAvailable` property to indicate the number of bytes that exist in the input buffer waiting to be transferred to MATLAB.

```
g.BytesAvailable
ans =
     56
```

When the read completes, you can transfer the data as text to a MATLAB variable using the `fscanf` function.

```
idn = fscanf(g);
```

Disconnecting and Cleaning Up

When you no longer need an instrument object, you should disconnect it from the instrument, and clean up the MATLAB environment by removing the object from memory and from the workspace. These are the steps you take to end an instrument control session.

Disconnecting an Instrument Object

When you no longer need to communicate with the instrument, you should disconnect it with the `fclose` function.

```
fclose(g)
```

You can examine the `Status` property to verify that the object and the instrument are disconnected.

```
g.Status
ans =
closed
```

After `fclose` is issued, the resources associated with `g` are made available, and you can once again connect an instrument object to the instrument with `fopen`.

Cleaning Up the MATLAB Environment

When you no longer need the instrument object, you should remove it from memory with the `delete` function.

```
delete(g)
```

A deleted instrument object is *invalid*, which means that you cannot connect it to the instrument. In this case, you should remove the object from the MATLAB workspace. To remove instrument objects and other variables from the MATLAB workspace, use the `clear` command.

```
clear g
```

If you use `clear` on an object that is connected to an instrument, the object is removed from the workspace but remains connected to the instrument.

You can restore cleared instrument objects to MATLAB with the `instrfind` function.

Controlling Instruments Using the GPIB

This chapter describes specific issues related to controlling instruments that use the GPIB interface. The sections are as follows.

GPIB Overview (p. 4-3)   Basic features of the General
                                          Purpose Interface Bus (GPIB).

Creating a GPIB Object (p. 4-15)   The GPIB object establishes a
                                          connection between MATLAB
                                          and the instrument via its GPIB
                                          interface.

Configuring the GPIB Address   The GPIB address consists of the
(p. 4-18)   board index of the GPIB controller,
                                          and the primary address and
                                          (optionally) the secondary address of
                                          the instrument.

Writing and Reading Data (p. 4-19)   Interface-specific issues related to
                                          writing and reading data with a
                                          GPIB object.

Events and Callbacks (p. 4-29)   Enhance your instrument control
                                          application using events and
                                          callbacks.

Triggers (p. 4-37)

Send the GET (Group Execute Trigger) GPIB command to the instrument. This command instructs all addressed Listeners to perform a specified action.

Serial Polls (p. 4-39)

Execute a serial poll where the Controller asks (polls) each addressed Listener to send back a status byte that indicates whether it has asserted the SRQ line and needs servicing.

GPIB Overview

This section provides an overview of the General Purpose Interface Bus (GPIB). Topics include

- "What Is GPIB?" on page 4-3
- "Important GPIB Features" on page 4-4
- "GPIB Lines" on page 4-5
- "Status and Event Reporting" on page 4-10

For many GPIB applications, you can communicate with your instrument without detailed knowledge of how GPIB works. Communication is established through a GPIB object, which you create in the MATLAB workspace.

If your application is straightforward, or if you are already familiar with the topics mentioned above, you might want to begin with "Creating a GPIB Object" on page 4-15. If you want a high-level description of all the steps you are likely to take when communicating with your instrument, refer to Chapter 2, "The Instrument Control Session".

What Is GPIB?

The GPIB is a standardized interface that allows you to connect and control multiple devices from various vendors. GPIB is also referred to by its original name HP-IB, or by its IEEE designation IEEE-488. The GPIB functionality has evolved over time, and is described in several specifications:

- The IEEE 488.1-1975 specification defines the electrical and mechanical characteristics of the interface and its basic functional characteristics.
- The IEEE-488.2-1987 specification builds on the IEEE 488.1 specification to define an acceptable minimum configuration and a basic set of instrument commands and common data formats.
- The Standard Commands for Programmable Instrumentation (SCPI) specification builds on the commands given by the IEEE 488.2 specification to define a standard instrument command set that can be used by GPIB or other interfaces.

Some of the GPIB functionality is required for all GPIB devices, while other GPIB functionality is optional. Additionally, many devices support only a subset of the SCPI command set, or use a different vendor-specific command set. Refer to your device documentation for a complete list of its GPIB capabilities and its command set.

Important GPIB Features

The important GPIB features are described below. For detailed information about GPIB functionality, see the appropriate references in Appendix B, "Bibliography".

Bus and Connector

The GPIB bus is a cable with two 24-pin connectors that allow you to connect multiple devices to each other. The bus and connector have these features and limitations:

- You can connect up to fifteen devices to a bus.

- You can connect devices in a star configuration, a linear configuration, or a combination of configurations.

- To achieve maximum data transfer rates, the cable length should not exceed 20 meters total or an average of 2 meters per device. You can eliminate these restrictions by using a bus extender.

GPIB Devices

Each GPIB device must be some combination of a *Talker*, a *Listener*, or a *Controller*. A Controller is typically a board that you install in your computer. Talkers and Listeners are typically instruments such as oscilloscopes, function generators, multimeters, and so on. Most modern instruments are both Talkers and Listeners.

- Talkers — A Talker transmits data over the interface when addressed to talk by the Controller. There can be only one Talker at a given time.

- Listeners — A Listener receives data over the interface when addressed to listen by the Controller. There can be up to 14 Listeners at a given time. Typically, the Controller is a Talker while one or more instruments on the GPIB are Listeners.

- Controllers — The Controller specifies which devices are Talkers or Listeners. A GPIB system can contain multiple Controllers — one of which is designated the System Controller. However, only one Controller can be active at a given time. The current active controller is the Controller-In-Charge (CIC). The CIC can pass control to an idle Controller, but only the System Controller can make itself the CIC.

  When the Controller is not sending messages, then a Talker can send messages. Typically, the CIC is a Listener while another device is enabled as a Talker.

Each Controller is identified by a unique board index number. Each Talker/Listener is identified by a unique primary address ranging from 0 to 30, and by an optional secondary address, which can be 0 or can range from 96 to 126.

GPIB Data

There are two types of data that can be transferred over the GPIB: *instrument data* and *interface message*s:

- Instrument data — Instrument data consists of vendor-specific commands that configure your instrument, return measurement results, and so on. For a complete list of commands supported by your instrument, refer to its documentation.

- Interface messages — Interface messages are defined by the GPIB standard and consist of commands that clear the GPIB bus, address devices, return self-test results, and so on.

Data transfer consists of one byte (8 bits) sent in parallel. The data transfer rate across the interface is limited to 1 megabyte per second. However, this data rate is usually not achieved in practice, and is limited by the slowest device on the bus.

GPIB Lines

The GPIB consists of 24 lines, which are shared by all instruments connected to the bus. 16 lines are used for signals, while 8 lines are for ground. The signal lines are divided into these groups:

- Eight data lines

- Five interface management lines

- Three handshake lines

The signal lines use a low-true (negative) logic convention with TTL levels. This means that a line is low (true or asserted) when it is a TTL low level, and a line is high (false or unasserted) when it is a TTL high level. The pin assignment scheme for a GPIB connector is shown below.
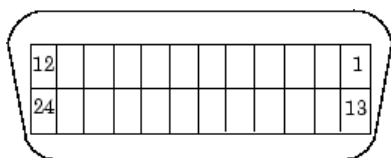
The pins and signals associated with the GPIB connector are described below.

GPIB Pin and Signal Assignments

Pin	Label	Signal Name	Pin	Label	Signal Name
1	DIO1	Data transfer	13	DIO5	Data transfer
2	DIO2	Data transfer	14	DIO6	Data transfer
3	DIO3	Data transfer	15	DIO7	Data transfer
4	DIO4	Data transfer	16	DIO8	Data transfer
5	EOI	End Or Identify	17	REN	Remote Enable
6	DAV	Data Valid	18	GND	DAV ground
7	NRFD	Not Ready For Data	19	GND	NRFD ground
8	NDAC	Not Data Accepted	20	GND	NDAC ground
9	IFC	Interface Clear	21	GND	IFC ground
10	SRQ	Service Request	22	GND	SRQ ground

GPIB Pin and Signal Assignments (Continued)

Pin	Label	Signal Name	Pin	Label	Signal Name
11	ATN	Attention	23	GND	ATN ground
12	Shield	Chassis ground	24	GND	Signal ground

Data Lines

The eight data lines, DIO1 through DIO8, are used for transferring data one byte at a time. DIO1 is the least significant bit, while DIO8 is the most significant bit. The transferred data can be an instrument command or a GPIB interface command.

Data formats are vendor-specific and can be text-based (ASCII) or binary. GPIB interface commands are defined by the IEEE 488 standard.

Interface Management Lines

The interface management lines control the flow of data across the GPIB interface, and are described below.

GPIB Interface Management Lines

Line	Description
ATN	Used by the Controller to inform all devices on the GPIB that bytes are being sent. If the ATN line is high, the bytes are interpreted as an instrument command. If the ATN line is low, the bytes are interpreted as an interface message.
IFC	Used by the Controller to initialize the bus. If the IFC line is low, the Talker and Listeners are unaddressed, and the System Controller becomes the Controller-In-Charge.
REN	Used by the Controller to place instruments in remote or local program mode. If REN is low, all Listeners are placed in remote mode, and you cannot change their settings from the front panel. If REN is high, all Listeners are placed in local mode.

GPIB Interface Management Lines (Continued)

Line	Description
SRQ	Used by Talkers to asynchronously request service from the Controller. If SRQ is low, then one or more Talkers require service (for example, an error such as invalid command was received). You issue a serial poll to determine which Talker requested service. The poll automatically sets the SRQ line high.
EOI	If the ATN line is high, the EOI line is used by Talkers to identify the end of a byte stream such as an instrument command. If the ATN line is low, the EOI line is used by the Controller to perform a parallel poll (not supported by the toolbox).

You can examine the state of the interface management lines with the BusManagementStatus property.

Handshake Lines

The three handshake lines, DAV, NRFD, and NDAC, are used to transfer bytes over the data lines from the Talker to one or more addressed Listeners.

Before data is transferred, all three lines must be in the proper state. The active Talker controls the DAV line and the Listener(s) control the NRFD and NDAC lines. The handshake process allows for error-free data transmission. The handshake lines are described below.

GPIB Handshake Lines

Line	Description
DAV	Used by the Talker to indicate that a byte can be read by the Listeners.
NRFD	Indicates whether the Listener is ready to receive the byte.
NDAC	Indicates whether the Listener has accepted the byte.

The handshaking process follows these steps:

1 Initially, the Talker holds the DAV line high indicating no data is available, while the Listeners hold the NRFD line high and the NDAC line low indicating they are ready for data and no data is accepted, respectively.

2 When the Talker puts data on the bus, it sets the DAV line low, which indicates that the data is valid.

3 The Listeners set the NRFD line low, which indicates that they are not ready to accept new data.

4 The Listeners set the NDAC line high, which indicates that the data is accepted.

5 When all Listeners indicate that they have accepted the data, the Talker asserts the DAV line indicating that the data is no longer valid. The next byte of data can now be transmitted.

6 The Listeners hold the NRFD line high indicating they are ready to receive data again, and the NDAC line is held low indicating no data is accepted.

Note If the ATN line is high during the handshaking process, the information is considered data such as an instrument command. If the ATN line is low, the information is considered a GPIB interface message.

The handshaking steps are shown below.
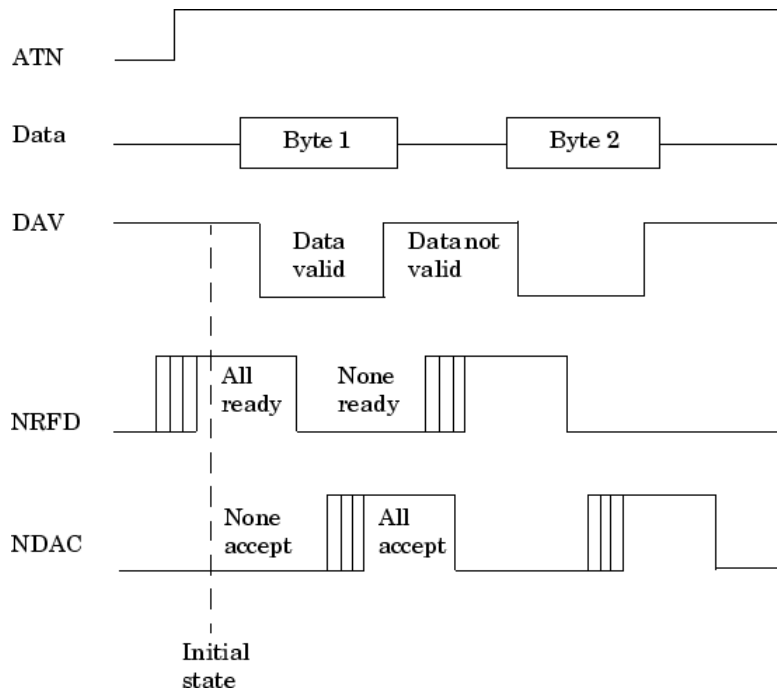
You can examine the state of the handshake lines with the `HandshakeStatus` property.

Status and Event Reporting

GPIB provides a system for reporting status and event information. With this system, you can find out if your instrument has data to return, whether a command error occurred, and so on. For many instruments, the reporting system consists of four 8-bit registers and two queues (output and event). The four registers are grouped into these two functional categories:

- Status Registers — The Status Byte Register (SBR) and Standard Event Status Register (SESR) contain information about the state of the instrument.

- Enable Registers — The Event Status Enable Register (ESER) and the Service Request Enable Register (SRER) determine which types of events

are reported to the status registers and the event queue. ESER enables SESR, while SRER enables SBR.

The status registers, enable registers, and output queue are shown below.

Standard Event

bit 7   bit 0

| PON | URQ | CME | EXE | DDE | QYE | RQC | OPC |

Standard Event Status Register

| PON | URQ | CME | EXE | DDE | QYE | RQC | OPC |

Standard Event Status Enable Register

Logical OR

Output Queue

Data available on instrument ready to be sent across the bus

bit 7   bit 0

| — | RQS / MSS | ESB | MAV | — | — | — | — |

Status Byte Register

| — | ⊠ | ESB | MAV | — | — | — | — |

Service Request Enable Register

Logical OR
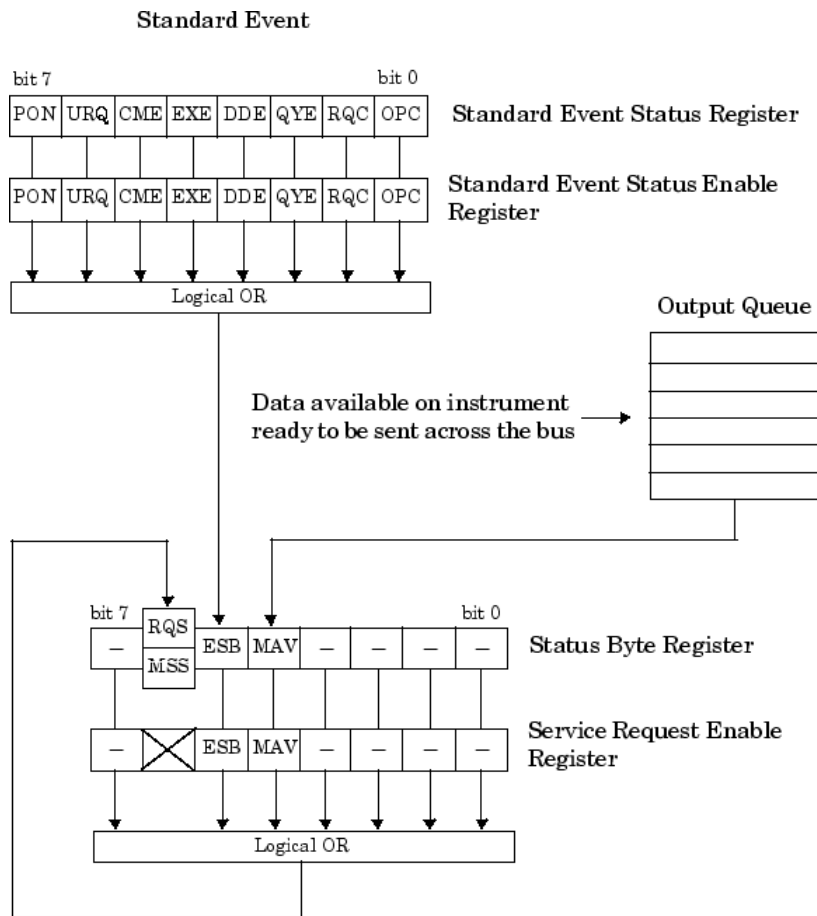
Status Byte Register

Each bit in the Status Byte Register (SBR) is associated with a specific type of event. When an event occurs, the instrument sets the appropriate bit to 1. You can enable or disable the SBR bits with the Service Request Enable Register (SRER). You can determine which events occurred by reading the enabled SBR bits. The SBR bits are described below.

Status Byte Register Bits

Bit	Label	Description
0-3	–	Instrument-specific summary messages.
4	MAV	The Message Available bit indicates if data is available in the Output Queue. MAV is 1 if the Output Queue contains data. MAV is 0 if the Output Queue is empty.
5	ESB	The Event Status bit indicates if one or more enabled events have occurred. ESB is 1 if an enabled event occurs. ESB is 0 if no enabled events occur. You enable events with the Standard Event Status Enable Register.
6	MSS	The Master Summary Status summarizes the ESB and MAV bits. MSS is 1 if either MAV or ESB is 1. MSS is 0 if both MAV and ESB are 0. This bit is obtained from the `*STB?` command.
	RQS	The Request Service bit indicates that the instrument requests service from the GPIB controller. This bit is obtained from a serial poll.
7	–	Instrument-specific summary message.

For example, if you want to know when a specific type of instrument error occurs, you would enable bit 5 of the SRER. Additionally, you would enable the appropriate bit of the Standard Event Status Enable Register (see "Standard Event Status Register" on page 4-13) so that the error event of interest is reported by the ESB bit of the SBR.

Standard Event Status Register

Each bit in the Standard Event Status Register (SESR) is associated with a specific state of the instrument. When the state changes, the instrument sets the appropriate bits to 1. You can enable or disable the SESR bits with the Standard Event Status Enable Register (ESER). You can determine the state of the instrument by reading the enabled SESR bits. The SESR bits are described below.

Standard Event Status Register Bits

Bit	Label	Description
0	OPC	The Operation Complete bit indicates that all commands have completed.
1	RQC	The Request Control bit is not used by most instruments.
2	QYE	The Query Error bit indicates that the instrument attempted to read an empty output buffer, or that data in the output buffer was lost.
3	DDE	The Device Dependent Error bit indicates that a device error occurred (such as a self-test error).
4	EXE	The Execution Error bit indicates that an error occurred when the device was executing a command or query.
5	CME	The Command Error bit indicates that a command syntax error occurred.
6	URQ	The User Request bit is not used by most instruments.
7	PON	The Power On bit indicates that the device is powered on.

For example, if you want to know when an execution error occurs, you would enable bit 4 of the ESER. Additionally, you would enable bit 5 of the SRER (see "Status Byte Register" on page 4-12) so that the error event of interest is reported by the ESB bit of the SBR.

Reading and Writing Register Information

This section describes the common GPIB commands used to read and write status and event register information.

GPIB Commands for Reading and Writing Register Information

Register	Operation	Command	Description
SESR	Read	*ESR?	Return a decimal value that corresponds to the weighted sum of all the bits set in the SESR register.
	Write	N/A	You cannot write to the SESR register.
ESER	Read	*ESE?	Return a decimal value that corresponds to the weighted sum of all the bits enabled by the *ESE command.
	Write	*ESE	Write a decimal value that corresponds to the weighted sum of all the bits you want to enable in the SESR register.
SBR	Read	*STB?	Return a decimal value that corresponds to the weighted sum of all the bits set in the SBR register. This command returns the same result as a serial poll except that the MSS bit is not cleared.
	Write	N/A	You cannot write to the SBR register.
SRER	Read	*SRE?	Return a decimal value that corresponds to the weighted sum of all the bits enabled by the *SRE command.
	Write	*SRE	Write a decimal value that corresponds to the weighted sum of all the bits you want to enable in the SBR register.

For example, to enable bit 4 of the SESR, you write the command *ESE 16. To enable bit 4 and bit 5 of the SESR, you write the command *ESE 48. To enable bit 5 of the SBR, you write the command *SRE 32.

To see how to use many of these commands in the context of an instrument control session, refer to "Example: Executing a Serial Poll" on page 4-39.

Creating a GPIB Object

You create a GPIB object with the gpib function. gpib requires the adaptor name, the GPIB board index, and the primary address of the instrument. As described in "Connecting to the Instrument" on page 2-5, you can also configure property values during object creation. For a list of supported adaptors, refer to "The Interface Driver Adaptor" on page 1-7.

Each GPIB object is associated with one controller and one instrument. For example, to create a GPIB object associated with a National Instruments controller with board index 0, and an instrument with primary address 1,

```
g = gpib('ni',0,1);
```

Note You do not use the GPIB board primary address in the GPIB object constructor syntax. You use the board index, and the instrument address.

The GPIB object g now exists in the MATLAB workspace. You can display the class of g with the whos command.

```
whos g
  Name      Size          Bytes  Class

  g         1x1             636  gpib object

Grand total is 14 elements using 636 bytes
```

Once the GPIB object is created, the properties listed below are automatically assigned values. These general purpose properties provide descriptive information about the object based on its class type and address information.

GPIB Descriptive Properties

Property Name	Description
Name	Specify a descriptive name for the GPIB object.
Type	Indicate the object type.

You can display the values of these properties for g with the get function.

```
get(g,{'Name','Type'})
ans =
    'GPIB0-1'     'gpib'
```

The GPIB Object Display

The GPIB object provides you with a convenient display that summarizes important address and state information. You can invoke the display summary these ways:

- Type the GPIB object at the command line.

- Exclude the semicolon when creating a GPIB object.

- Exclude the semicolon when configuring properties using the dot notation.

You can also display summary information via the Workspace browser by right-clicking an instrument object and selecting **Display Summary** from the context menu.

The display summary for the GPIB object g is given below.

```
GPIB Object Using NI Adaptor : GPIB0-1

Communication Address
   BoardIndex:        0
   PrimaryAddress:    1
   SecondaryAddress:  0

Communication State
   Status:            closed
   RecordStatus:      off
```

```
Read/Write State
   TransferStatus:    idle
   BytesAvailable:    0
   ValuesReceived:    0
   ValuesSent:        0
```

Configuring the GPIB Address

Each GPIB object is associated with one controller and one instrument. The GPIB address consists of the board index of the GPIB controller, and the primary address and (optionally) the secondary address of the instrument. The term "board index" is equivalent to the term "logical unit" as used by Agilent Technologies.

Note that some vendors place limits on the allowed board index values. Refer to Appendix A, "Vendor Driver Requirements and Limitations" for a list of these limitations. You can usually find the instrument addresses through a front panel display or by examining dip switch settings. Valid primary addresses range from 0 to 30. Valid secondary addresses range from 96 to 126, or can be 0, indicating that no secondary address is used.

The properties associated with the GPIB address are given below.

GPIB Address Properties

Property Name	Description
BoardIndex	Specify the index number of the GPIB board.
PrimaryAddress	Specify the primary address of the GPIB instrument.
SecondaryAddress	Specify the secondary address of the GPIB instrument.

You must specify the board index and instrument primary address values during GPIB object creation. The BoardIndex and PrimaryAddress properties are automatically updated with these values. If the instrument has a secondary address, you can specify its value during or after object creation by configuring the SecondaryAddress property.

You can display the address property values for the GPIB object g created in "Creating a GPIB Object" on page 4-15 with the get function.

```
get(g,{'BoardIndex','PrimaryAddress','SecondaryAddress'})
ans =
    [0]    [1]    [0]
```

Writing and Reading Data

This section describes interface-specific issues related to writing and reading data with a GPIB object. Topics include

- "Rules for Completing Write and Read Operations" on page 4-19
- "Example: Writing and Reading Text Data" on page 4-20
- "Example: Reading Binary Data" on page 4-22
- "Example: Parsing Input Data Using scanstr" on page 4-25
- "Example: Understanding EOI and EOS" on page 4-26

For a general overview about writing and reading data, as well as a list of all associated functions and properties, refer to "Communicating with Your Instrument" on page 2-8.

Rules for Completing Write and Read Operations

The rules for completing synchronous and asynchronous read and write operations are described below.

Completing Write Operations

A write operation using `fprintf` or `fwrite` completes when one of these conditions is satisfied:

- The specified data is written.
- The time specified by the `Timeout` property passes.

Additionally, you can stop an asynchronous write operation at any time with the `stopasync` function.

An instrument determines if a write operation is complete based on the `EOSMode`, `EOIMode`, and `EOSCharCode` property values. If `EOSMode` is configured to either `write` or `read&write`, each occurrence of `\n` in a text command is replaced with the End-Of-String (EOS) character specified by the `EOSCharCode` value. Therefore, when you use the default `fprintf` format of `%s\n`, all text commands written to the instrument will end with that value.

The default `EOSCharCode` value is `LF`, which corresponds to the line feed character. The EOS character required by your instrument will be described in its documentation.

If `EOIMode` is on, then the End Or Identify (EOI) line is asserted when the last byte is written to the instrument. The last byte can be part of a binary data stream or a text data stream. If `EOSMode` is configured to either `write` or `read&write`, then the last byte written is the `EOSCharCode` value and the EOI line is asserted when the instrument receives this byte.

Completing Read Operations

A read operation with `fgetl`, `fgets`, `fread`, `fscanf`, or `readasync` completes when one of these conditions is satisfied:

- The EOI line is asserted.
- The terminator specified by the `EOSCharCode` property is read. This can occur only when the `EOSMode` property is configured to either `read` or `read&write`.
- The time specified by the `Timeout` property passes.
- The specified number of values is read (`fread`, `fscanf`, and `readasync` only).
- The input buffer is filled (if the number of values is not specified).

In addition to these rules, you can stop an asynchronous read operation at any time with the `stopasync` function.

Example: Writing and Reading Text Data

This example illustrates how to communicate with a GPIB instrument by writing and reading text data.

The instrument is a Tektronix TDS 210 two-channel oscilloscope. Therefore, many of the commands used are specific to this instrument. A sine wave is input into channel 2 of the oscilloscope, and your job is to measure the peak-to-peak voltage of the input signal:

1 **Create an instrument object** — Create the GPIB object g associated with a National Instruments GPIB controller with board index 0, and an instrument with primary address 1.

```
g = gpib('ni',0,1);
```

2 **Connect to the instrument** — Connect g to the oscilloscope, and return the default values for the EOSMode and EOIMode properties.

```
fopen(g)
get(g,{'EOSMode','EOIMode'})
ans =
    'none'     'on'
```

Using these property values, write operations complete when the last byte is written to the instrument, and read operations complete when the EOI line is asserted by the instrument.

3 **Write and read data** — Write the *IDN? command to the instrument using fprintf, and then read back the result of the command using fscanf.

```
fprintf(g,'*IDN?')
idn = fscanf(g)
idn =
TEKTRONIX,TDS 210,0,CF:91.1CT FV:v1.16 TDS2CM:CMV:v1.04
```

Determine the measurement source. Possible measurement sources include channel 1 and channel 2 of the oscilloscope.

```
fprintf(g,'MEASUREMENT:IMMED:SOURCE?')
source = fscanf(g)
source =
CH1
```

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The scope is configured to return a measurement from channel 1. Because the input signal is connected to channel 2, you must configure the instrument to return a measurement from this channel.

```
fprintf(g,'MEASUREMENT:IMMED:SOURCE CH2')
fprintf(g,'MEASUREMENT:IMMED:SOURCE?')
source = fscanf(g)
source =
CH2
```

You can now configure the scope to return the peak-to-peak voltage, request the value of this measurement, and then return the voltage value to MATLAB using fscanf.

```
fprintf(g,'MEASUREMENT:MEAS1:TYPE PK2PK')
fprintf(g,'MEASUREMENT:MEAS1:VALUE?')
ptop = fscanf(g)
ptop =
2.0199999809E0
```

4 Disconnect and clean up — When you no longer need g, you should disconnect it from the instrument, and remove it from memory and from the MATLAB workspace.

```
fclose(g)
delete(g)
clear g
```

Example: Reading Binary Data

This example illustrates how you can download the TDS 210 oscilloscope screen display to MATLAB. The screen display data is transferred to MATLAB and saved to disk using the Windows bitmap format. This data provides a permanent record of your work, and is an easy way to document important signal and scope parameters:

1 Create an instrument object — Create the GPIB object g associated with a National Instruments GPIB controller with board index 0, and an instrument with primary address 1.

```
g = gpib('ni',0,1);
```

2 Configure property values — Configure the input buffer to accept a reasonably large number of bytes, and configure the timeout value to two minutes to account for slow data transfer.

```
g.InputBufferSize = 50000;
g.Timeout = 120;
```

3 Connect to the instrument — Connect g to the oscilloscope.

```
fopen(g)
```

4 Write and read data — Configure the scope to transfer the screen display as a bitmap.

```
fprintf(g,'HARDCOPY:PORT GPIB')
fprintf(g,'HARDCOPY:FORMAT BMP')
fprintf(g,'HARDCOPY START')
```

Asynchronously transfer the data from the instrument to the input buffer.

```
readasync(g)
```

Wait until the read operation completes, and then transfer the data to the MATLAB workspace as unsigned 8-bit integers.

```
g.TransferStatus
ans =
idle
out = fread(g,g.BytesAvailable,'uint8');
```

5 Disconnect and clean up — When you no longer need g, you should disconnect it from the instrument, and remove it from memory and from the MATLAB workspace.

```
fclose(g)
delete(g)
clear g
```

Viewing the Bitmap Data

To view the bitmap data, you should follow these steps:

1 Open a disk file.

2 Write the data to the disk file.

3 Close the disk file.

4 Read the data using the `imread` function.

5 Scale and display the data using the `imagesc` function.

Note that the MATLAB file I/O versions of the `fopen`, `fwrite`, and `fclose` functions are used.

```
fid = fopen('test1.bmp','w');
fwrite(fid,out,'uint8');
fclose(fid)
a = imread('test1.bmp','bmp');
imagesc(fliplr(a'))
```

Because the scope returns the screen display data using only two colors, an appropriate colormap is selected.

```
mymap = [0 0 0; 1 1 1];
colormap(mymap)
```

The resulting bitmap image is shown below.
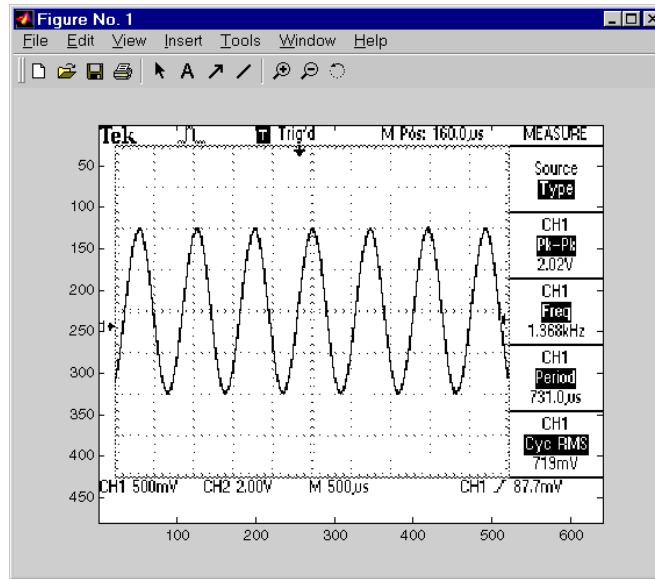
Example: Parsing Input Data Using scanstr

This example illustrates how to use the scanstr function to parse data that
you read from a Tektronix TDS 210 oscilloscope. scanstr is particularly
useful when you want to parse a string into one or more cell array elements,
where each element is determined to be either a double or a string:

1 **Create an instrument object** — Create the GPIB object g associated
   with a National Instruments GPIB controller with board index 0, and an
   instrument with primary address 1.

   ```
   g = gpib('ni',0,1);
   ```

2 **Connect to the instrument** — Connect g to the oscilloscope.

   ```
   fopen(g)
   ```

3 **Write and read data** — Return identification information to separate
   elements of a cell array using the default delimiters.

   ```
   fprintf(g,'*IDN?');
   idn = scanstr(g)
   ```

```
idn =
    'TEKTRONIX'
    'TDS 210'
    [        0]
    'CF:91.1CT FV:v1.16 TDS2CM:CMV:v1.04'
```

4 Disconnect and clean up — When you no longer need g, you should disconnect it from the instrument, and remove it from memory and from the MATLAB workspace.

```
fclose(g)
delete(g)
clear g
```

Example: Understanding EOI and EOS

This example illustrates how the EOI line and the EOS character are used to complete read and write operations, and how the EOIMode, EOSMode, and EOSCharCode properties are related to each other. In most cases, you can successfully communicate with your instrument by accepting the default values for these properties.

The default value for EOIMode is on, which means that the EOI line is asserted when the last byte is written to the instrument. The default value for EOSMode is none, which means that the EOSCharCode value is not written to the instrument, and read operations will not complete when the EOSCharCode value is read. Therefore, when you use the default values for EOIMode and EOSMode,

- Write operations complete when the last byte is written to the instrument.

- Read operations complete when the EOI line is asserted by the instrument.

1 Create an instrument object — Create the GPIB object g associated with a National Instruments GPIB controller with board index 0, and an instrument with primary address 1.

```
g = gpib('ni',0,1);
```

2 Connect to the instrument — Connect g to the oscilloscope.

```
fopen(g)
```

3 **Write and read data** — Configure g so that the EOI line is not asserted after the last byte is written to the instrument, and the EOS character is used to complete write operations. The default format for fprintf is %s\n, where \n is replaced by the EOS character as given by EOSCharCode.

```
g.EOIMode = 'off';
g.EOSMode = 'write';
fprintf(g,'*IDN?')
out = fscanf(g)
out =

TEKTRONIX,TDS 210,0,CF:91.1CT FV:v1.16 TDS2CM:CMV:v1.04
```

Although EOSMode is configured so that read operations will not complete after receiving the EOS character, the preceding read operation succeeded because the EOI line was asserted.

Now configure g so that the EOS character is not used to complete read or write operations. Because the EOI line is not asserted and the EOS character is not written, the instrument cannot interpret the *IDN? command and a timeout occurs.

```
g.EOSMode = 'none';
fprintf(g,'*IDN?')
out = fscanf(g)

Warning: GPIB: NI: An I/O operation has been canceled mostly
likely due to a timeout.
```

Now configure g so that the read operation terminates after the "X" character is read. The EOIMode property is configured to on so that the EOI line is asserted after the last byte is written. The EOSMode property is configured to read so that the read operation completes when the EOSCharCode value is read.

```
g.EOIMode = 'on';
g.EOSMode = 'read';
g.EOSCharCode = 'X';
fprintf(g,'*IDN?')
out = fscanf(g)
out =

TEKTRONIX
```

Note that the rest of the identification string remains in the instrument's hardware buffer. If you do not want to return this data during the next read operation, you should clear it from the instrument buffer with the `clrdevice` function.

```
clrdevice(g)
```

4 **Disconnect and clean up** — When you no longer need g, you should disconnect it from the instrument, and remove it from memory and from the MATLAB workspace.

```
fclose(g)
delete(g)
clear g
```

Events and Callbacks

You can enhance the power and flexibility of your instrument control application by using *events*. An event occurs after a condition is met, and might result in one or more callbacks.

While the instrument object is connected to the instrument, you can use events to display a message, display data, analyze data, and so on. Callbacks are controlled through *callback properties* and *callback functions*. All event types have an associated callback property. Callback functions are M-file functions that you construct to suit your specific application needs.

You execute a callback when a particular event occurs by specifying the name of the M-file callback function as the value for the associated callback property.

Example: Introduction to Events and Callbacks

This example uses the M-file callback function instrcallback to display a message to the command line when a bytes-available event occurs. The event is generated when the EOSCharCode property value is read.

```
g = gpib('ni',O,1);
g.BytesAvailableFcnMode = 'eosCharCode';
g.BytesAvailableFcn = @instrcallback;
fopen(g)
fprintf(g,'*IDN?')
readasync(g)
```

The resulting display from instrcallback is shown below.

```
BytesAvailable event occurred at 17:30:11 for the object: GPIBO-1.
```

End the GPIB session.

```
fclose(g)
delete(g)
clear g
```

You can use the type command to display instrcallback at the command line.

Event Types and Callback Properties

The GPIB event types and associated callback properties are described below.

GPIB Event Types and Callback Properties

Event Type	Associated Property Name
Bytes-available	`BytesAvailableFcn`
	`BytesAvailableFcnCount`
	`BytesAvailableFcnMode`
Error	`ErrorFcn`
Output-empty	`OutputEmptyFcn`
Timer	`TimerFcn`
	`TimerPeriod`

Bytes-Available Event

A bytes-available event is generated immediately after a predetermined number of bytes are available in the input buffer or the End-Of-String character is read, as determined by the `BytesAvailableFcnMode` property.

If `BytesAvailableFcnMode` is `byte`, the bytes-available event executes the callback function specified for the `BytesAvailableFcn` property every time the number of bytes specified by `BytesAvailableFcnCount` is stored in the input buffer. If `BytesAvailableFcnMode` is `eosCharCode`, then the callback function executes every time the character specified by the `EOSCharCode` property is read.

This event can be generated only during an asynchronous read operation.

Error Event

An error event is generated immediately after an error, such as a timeout, occurs. A timeout occurs if a read or write operation does not successfully complete within the time specified by the `Timeout` property. An error event is not generated for configuration errors such as setting an invalid property value.

This event executes the callback function specified for the `ErrorFcn` property. It can be generated only during an asynchronous read or write operation.

Output-Empty Event

An output-empty event is generated immediately after the output buffer is empty.

This event executes the callback function specified for the `OutputEmptyFcn` property. It can be generated only during an asynchronous write operation.

Timer Event

A timer event is generated when the time specified by the `TimerPeriod` property passes. Time is measured relative to when the object is connected to the instrument.

This event executes the callback function specified for the `TimerFcn` property. Note that some timer events might not be processed if your system is significantly slowed or if the `TimerPeriod` value is too small.

Storing Event Information

You can store event information in a callback function or in a record file. Event information stored in a callback function uses two fields: `Type` and `Data`. The `Type` field contains the event type, while the `Data` field contains event-specific information. As described in "Creating and Executing Callback Functions" on page 4-32, these two fields are associated with a structure that you define in the callback function header. Refer to "Debugging: Recording Information to Disk" on page 12-6 to learn about storing event information in a record file.

The event types and the values for the `Type` and `Data` fields are given below.

GPIB Event Information

Event Type	Field	Field Value
Bytes available	Type	BytesAvailable
	Data.AbsTime	day-month-year hour:minute:second
Error	Type	Error
	Data.AbsTime	day-month-year hour:minute:second
	Data.Message	An error string
Output empty	Type	OutputEmpty
	Data.AbsTime	day-month-year hour:minute:second
Timer	Type	Timer
	Data.AbsTime	day-month-year hour:minute:second

The Data field values are described below.

The AbsTime Field
AbsTime is defined for all events, and indicates the absolute time the event occurred. The absolute time is returned using the MATLAB clock format:

day-month-year hour:minute:second

The Message Field
Message is used by the error event to store the descriptive message that is generated when an error occurs.

Creating and Executing Callback Functions
You specify the callback function to be executed when a specific event type occurs by including the name of the M-file as the value for the associated callback property. You can specify the callback function as a function handle

or as a string cell array element. Function handles are described in the
MATLAB function_handle reference page. Note that if you are executing
a local callback function from within an M-file, then you must specify the
callback as a function handle.

For example, to execute the callback function mycallback every time the
EOSCharCode property value is read from your instrument,

```
g.BytesAvailableFcnMode = 'eosCharCode';
g.BytesAvailableFcn = @mycallback;
```

Alternatively, you can specify the callback function as a cell array.

```
g.BytesAvailableFcn = {'mycallback'};
```

M-file callback functions require at least two input arguments. The first
argument is the instrument object. The second argument is a variable that
captures the event information given in the preceding table, GPIB Event
Information on page 4-32. This event information pertains only to the
event that caused the callback function to execute. The function header for
mycallback is shown below.

```
function mycallback(obj,event)
```

You pass additional parameters to the callback function by including both the
callback function and the parameters as elements of a cell array. For example,
to pass the MATLAB variable time to mycallback,

```
time = datestr(now,0);
g.BytesAvailableFcnMode = 'eosCharCode';
g.BytesAvailableFcn = {@mycallback,time};
```

Alternatively, you can specify mycallback as a string in the cell array.

```
g.BytesAvailableFcn = {'mycallback',time};
```

The corresponding function header is

```
function mycallback(obj,event,time)
```

If you pass additional parameters to the callback function, then they must be
included in the function header after the two required arguments.

> **Note** You can also specify the callback function as a string. In this case, the callback is evaluated in the MATLAB workspace and no requirements are made on the input arguments of the callback function.

Enabling Callback Functions After They Error

If an error occurs while a callback function is executing, then

- The callback function is automatically disabled.
- A warning is displayed at the command line, indicating that the callback function is disabled.

If you want to enable the same callback function, you can set the callback property to the same value or you can disconnect the object with the `fclose` function. If you want to use a different callback function, the callback will be enabled when you configure the callback property to the new value.

Example: Using Events and Callbacks to Read Binary Data

This example extends "Example: Reading Binary Data" on page 4-22 by using the M-file callback function `instrcallback` to display event-related information to the command line when a bytes-available event occurs during a binary read operation:

1 **Create an instrument object** — Create the GPIB object g associated with a National Instruments GPIB controller with board index 0, and an instrument with primary address 1.

```
g = gpib('ni',0,1);
```

2 **Configure properties** — Configure the input buffer to accept a reasonably large number of bytes, and configure the timeout value to two minutes to account for slow data transfer.

```
g.InputBufferSize = 50000;
g.Timeout = 120;
```

Configure g to execute the callback function instrcallback every time 5000 bytes is stored in the input buffer. Because instrcallback requires an instrument object and event information to be passed as input arguments, the callback function is specified as a function handle.

```
g.BytesAvailableFcnMode = 'byte';
g.BytesAvailableFcnCount = 5000;
g.BytesAvailableFcn = @instrcallback;
```

3 Connect to the instrument — Connect g to the oscilloscope.

```
fopen(g)
```

4 Write and read data — Configure the scope to transfer the screen display as a bitmap.

```
fprintf(g,'HARDCOPY:PORT GPIB')
fprintf(g,'HARDCOPY:FORMAT BMP')
fprintf(g,'HARDCOPY START')
```

Initiate the asynchronous read operation, and begin generating events.

```
readasync(g)
```

instrcallback is called every time 5000 bytes is stored in the input buffer. The resulting displays are shown below.

```
BytesAvailable event occurred at 09:41:42 for the object: GPIB0-1.
BytesAvailable event occurred at 09:41:50 for the object: GPIB0-1.
BytesAvailable event occurred at 09:41:58 for the object: GPIB0-1.
BytesAvailable event occurred at 09:42:06 for the object: GPIB0-1.
BytesAvailable event occurred at 09:42:14 for the object: GPIB0-1.
BytesAvailable event occurred at 09:42:22 for the object: GPIB0-1.
BytesAvailable event occurred at 09:42:30 for the object: GPIB0-1.
```

Wait until all the data is sent to the input buffer, and then transfer the data to MATLAB as unsigned 8-bit integers.

```
g.TransferStatus
ans =
idle
out = fread(g,g.BytesAvailable,'uint8');
```

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5 Disconnect and clean up — When you no longer need g, you should disconnect it from the instrument, and remove it from memory and from the MATLAB workspace.

```
fclose(g)
delete(g)
clear g
```

Triggers

You can execute a trigger with the `trigger` function. This function is equivalent to writing the GET (Group Execute Trigger) GPIB command to the instrument.

`trigger` instructs all the addressed Listeners to perform some instrument-specific function such as taking a measurement. Refer to your instrument documentation to learn how to use its triggering capabilities.

Example: Executing a Trigger

This example illustrates GPIB triggering using an Agilent 33120A function generator. The output of the function generator is displayed with an oscilloscope so that the trigger can be observed:

1 **Create an instrument object** — Create the GPIB object g associated with a National Instruments GPIB controller with board index 0, and an instrument with primary address 1.

```
g = gpib('ni',0,1);
```

2 **Connect to the instrument** — Connect g to the function generator.

```
fopen(g)
```

3 **Write and read data** — Configure the function generator to produce a 5000 Hz sine wave, with 6 volts peak-to-peak.

```
fprintf(g,'Func:Shape Sin')
fprintf(g,'Volt 3')
fprintf(g,'Freq 5000')
```

Configure the burst of the trigger to display the sine wave for five seconds, configure the function generator to expect the trigger from the GPIB board, and enable the burst mode.

```
fprintf(g,'BM:NCycles 25000')
fprintf(g,'Trigger:Source Bus')
fprintf(g,'BM:State On')
```

Trigger the instrument.

```
trigger(g)
```

Disable the burst mode.

```
fprintf(g,'BM:State Off')
```

While the function generator is triggered, the sine wave is saved to the Ref A memory location of the oscilloscope. The saved waveform is shown below.
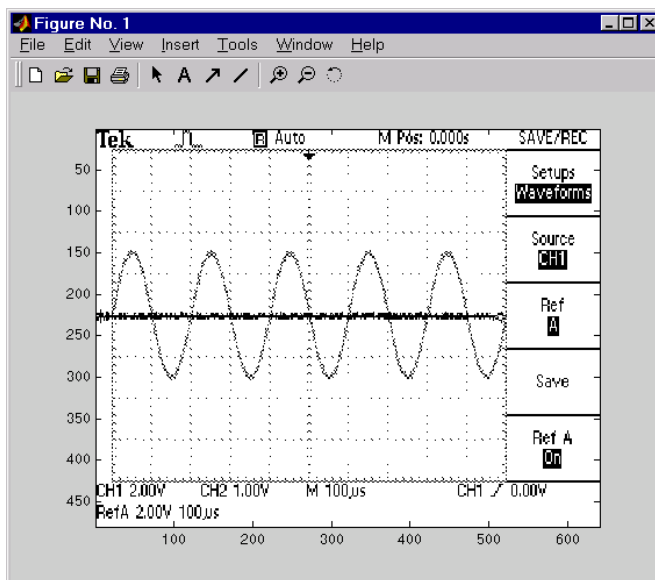
4 **Disconnect and clean up** — When you no longer need g, you should disconnect it from the instrument, and remove it from memory and from the MATLAB workspace.

```
fclose(g)
delete(g)
clear g
```

Serial Polls

You can execute a serial poll with the `spoll` function. In a serial poll, the Controller asks (polls) each addressed Listener to send back a status byte that indicates whether it has asserted the SRQ line and needs servicing. The seventh bit of this byte (the RQS bit) is set if the instrument is requesting service.

The Controller performs the following steps for every addressed Listener:

1 The Listener is addressed to talk and the Serial Poll Enable (SPE) command byte is sent.

2 The ATN line is set high and the Listener returns the status byte.

3 The ATN line is set low and the Serial Poll Disable (SPD) command byte is sent to end the poll sequence.

Refer to "Status and Event Reporting" on page 4-10 for more information on the GPIB bus lines and the RQS bit.

Example: Executing a Serial Poll

This example shows you how to execute a serial poll for an Agilent 33120A function generator and a Tektronix TDS 210 oscilloscope. In doing so, the example shows you how to configure many of the status bits described in "Standard Event Status Register" on page 4-13:

1 **Create instrument objects** — Create a GPIB object associated with an Agilent 33120A function generator at primary address 1.

```
g1 = gpib('ni',0,1);
```

Create a GPIB object associated with a Tektronix TDS 210 oscilloscope at primary address 2.

```
g2 = gpib('ni',0,2);
```

2 **Connect to the instrument** — Connect g1 to the function generator and connect g2 to the oscilloscope.

```
fopen([g1 g2])
```

3 **Configure property values** — Configure both objects to time out after 1 second.

```
set([g1 g2],'Timeout',1)
```

4 **Write and read data** — Configure the function generator to request service when a command error occurs.

```
fprintf(g1,'*CLS');
fprintf(g1,'*ESE 32');
fprintf(g1,'*SRE 32');
```

Configure the oscilloscope to request service when a command error occurs.

```
fprintf(g2,'*CLS')
fprintf(g2,'*PSC 0')
fprintf(g2,'*ESE 32')
fprintf(g2,'DESE 32')
fprintf(g2,'*SRE 32')
```

Determine if any instrument needs servicing.

```
spoll([g1 g2])
ans =
[]
```

Query the voltage value for each instrument.

```
fprintf(g1,'Volt?')
fprintf(g2,'Volt?')
```

Determine if either instrument produced an error due to the preceding query.

```
out = spoll([g1 g2]);
```

Because Volt? is an invalid command for the oscilloscope, it is requesting service.

```
out == [g1 g2]
ans =
0 1
```

Because Volt? is a valid command for the function generator, the value is read back successfully.

```
volt1 = fscanf(g1)
volt1 =
+1.00000E-01
```

However, the oscilloscope read operation times out after 1 second.

```
volt2 = fscanf(g2)
Warning: GPIB: NI: An I/O operation has been canceled, most likely
due to a timeout.

volt2 =
''
```

5 **Disconnect and clean up** — When you no longer need g1 and g2, you should disconnect them from the instruments, and remove them from memory and from the MATLAB workspace.

```
fclose([g1 g2])
delete([g1 g2])
clear g1 g2
```

5

Controlling Instruments Using VISA

This chapter describes specific issues related to controlling instruments that use the VISA standard. The sections are as follows.

VISA Overview

Virtual Instrument Standard Architecture (VISA) is a standard defined by Agilent Technologies and National Instruments for communicating with instruments regardless of the interface.

The Instrument Control Toolbox supports the GPIB, VXI, GPIB-VXI, and serial port interfaces using the VISA standard. Communication is established through a VISA instrument object, which you create in the MATLAB workspace. For example, a VISA-GPIB object allows you to use the VISA standard to communicate with an instrument that possesses a GPIB interface.

Note Most features associated with VISA instrument objects are identical to the features associated with GPIB and serial port objects. Therefore, this chapter presents only interface-specific functions and properties. For example, register-based communication is discussed for VISA-VXI objects, but message-based communication is not discussed as this topic is covered elsewhere in this guide.

For many VISA applications, you can communicate with your instrument without detailed knowledge of how the interface works. In this case, you might want to begin with one of these topics:

- "The GPIB Interface" on page 5-5
- "The VXI Interface" on page 5-9
- "The GPIB-VXI Interface" on page 5-22
- "The Serial Port Interface" on page 5-27
- "The USB Interface" on page 5-31
- "The TCP/IP Interface" on page 5-35
- "The RSIB Interface" on page 5-39

If you want a high-level description of all the steps you are likely to take when communicating with your instrument, refer to Chapter 2, "The Instrument Control Session".

Note The Instrument Control Toolbox does not support secondary VISA installations. The vendor that you specify when creating a VISA object should refer to the primary VISA installation only. Referring to a secondary VISA installation could generate unpredictable results.

The GPIB Interface

The GPIB interface is supported through a VISA-GPIB object. The features associated with a VISA-GPIB object are similar to the features associated with a GPIB object. Therefore, only functions and properties that are unique to VISA's GPIB interface are discussed in this section. These unique features are associated with

- "Creating a VISA-GPIB Object" on page 5-5
- "The VISA-GPIB Address" on page 5-7

Refer to Chapter 4, "Controlling Instruments Using the GPIB" to learn about the GPIB interface, writing and reading text and binary data, using events and callbacks, using triggers, and so on.

Note The VISA-GPIB object does not support the `spoll` function, or the `BusManagementStatus`, `CompareBits`, and `HandshakeStatus` properties.

Creating a VISA-GPIB Object

You create a VISA-GPIB object with the `visa` function. Each VISA-GPIB object is associated with

- A GPIB controller installed in your computer
- An instrument with a GPIB interface

`visa` requires the vendor name and the resource name as input arguments. The vendor name can be `agilent`, `ni`, or `tek`. The resource name consists of the GPIB board index, the instrument primary address, and the instrument secondary address. You can find the VISA-GPIB resource name for a given instrument with the configuration tool provided by your vendor, or with the `instrhwinfo` function. (In place of the resource name, you can use an alias as defined with your VISA vendor configuration tool.) As described in "Connecting to the Instrument" on page 2-5, you can also configure properties during object creation.

For example, to create a VISA-GPIB object associated with a National Instruments controller with board index 0, and a Tektronix TDS 210 digital oscilloscope with primary address 1 and secondary address 0,

```
vg = visa('ni','GPIB0::1::0::INSTR');
```

The VISA-GPIB object vg now exists in the MATLAB workspace. You can display the class of vg with the whos command.

```
whos vg
  Name      Size          Bytes  Class

  vg        1x1             884  visa object

Grand total is 16 elements using 884 bytes
```

After you create the VISA-GPIB object, the properties listed below are automatically assigned values. These properties provide descriptive information about the object based on its class type and address information.

VISA-GPIB Descriptive Properties

Property Name	Description
Name	Specify a descriptive name for the VISA-GPIB object.
RsrcName	Indicate the resource name for a VISA instrument.
Type	Indicate the object type.

You can display the values of these properties for vg with the get function.

```
get(vg,{'Name','RsrcName','Type'})
ans =
 'VISA-GPIB0-1'    'GPIB0::1::0::INSTR'    'visa-gpib'
```

The VISA-GPIB Object Display

The VISA-GPIB object provides you with a convenient display that summarizes important address and state information. You can invoke the display summary these three ways:

- Type the VISA-GPIB object at the command line.
- Exclude the semicolon when creating a VISA-GPIB object.
- Exclude the semicolon when configuring properties using the dot notation.

You can also display summary information via the Workspace browser by right-clicking an instrument object and selecting **Display Summary** from the context menu.

The display summary for the VISA-GPIB object vg is given below.

```
VISA-GPIB Object Using NI Adaptor : VISA-GPIB0-1

Communication Address
   BoardIndex:        0
   PrimaryAddress:    1
   SecondaryAddress:  0

Communication State
   Status:            closed
   RecordStatus:      off

Read/Write State
   TransferStatus:    idle
   BytesAvailable:    0
   ValuesReceived:    0
   ValuesSent:        0
```

The VISA-GPIB Address

The VISA-GPIB address consists of

- The board index of the GPIB controller installed in your computer.
- The primary address and secondary address of the instrument. Valid primary addresses range from 0 to 30. Valid secondary addresses range from 0 to 30, where the value 0 indicates that the secondary address is not used.

You must specify the primary address value via the resource name during VISA-GPIB object creation. Additionally, you must include the board index

and secondary address values as part of the resource name if they differ from the default value of 0.

The properties associated with the GPIB address are given below.

VISA-GPIB Address Properties

Property Name	Description
BoardIndex	Specify the index number of the GPIB board.
PrimaryAddress	Specify the primary address of the GPIB instrument.
SecondaryAddress	Specify the secondary address of the GPIB instrument.

The BoardIndex, PrimaryAddress, and SecondaryAddress properties are automatically updated with the specified resource name values when you create the VISA-GPIB object.

You can display the address property values for the VISA-GPIB object vg created in "Creating a VISA-GPIB Object" on page 5-5 with the get function.

```
get(vg,{'BoardIndex','PrimaryAddress','SecondaryAddress'})
ans =
    [0]    [1]    [0]
```

The VXI Interface

The VXI interface is associated with a VXI controller that you install in slot 0 of a VXI chassis. This interface, along with the other relevant hardware, is shown below.
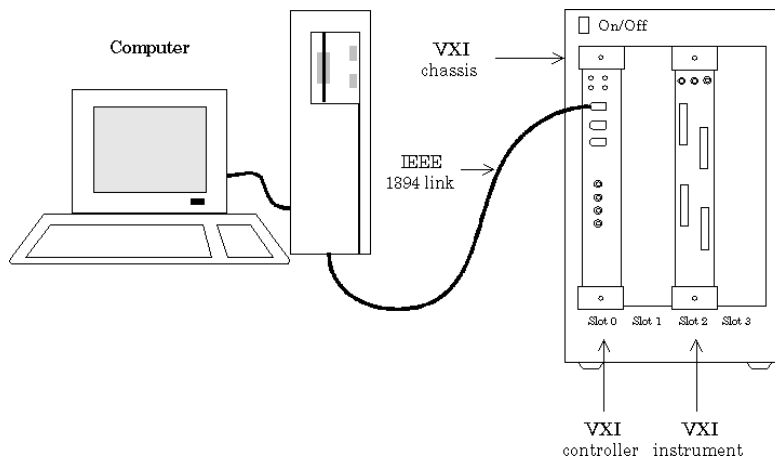
The VXI interface is supported through a VISA-VXI object. Many of the features associated with a VISA-VXI object are similar to the features associated with other instrument objects. Therefore, only functions and properties that are unique to VISA's VXI interface are discussed in this section. These unique features are associated with

- "Creating a VISA-VXI Object" on page 5-10
- "The VISA-VXI Address" on page 5-12
- "Register-Based Communication" on page 5-13

Refer to Chapter 4, "Controlling Instruments Using the GPIB" to learn about general toolbox capabilities such as writing and reading text and binary data, using events and callbacks, and so on.

Creating a VISA-VXI Object

You create a VISA-VXI object with the visa function. Each object is associated with

- A VXI chassis

- A VXI controller in slot 0 of the VXI chassis

- An instrument installed in the VXI chassis

visa requires the vendor name and the resource name as input arguments. The vendor name is either agilent or ni. The resource name consists of the VXI chassis index and the instrument logical address. You can find the VISA-VXI resource name for a given instrument with the configuration tool provided by your vendor, or with the instrhwinfo function. (In place of the resource name, you can use an alias as defined with your VISA vendor configuration tool.) As described in "Connecting to the Instrument" on page 2-5, you can also configure property values during object creation.

For example, to create a VISA-VXI object associated with a VXI chassis with index 0 and an Agilent E1432A 16-channel digitizer with logical address 32,

```
vv = visa('agilent','VXI0::32::INSTR');
```

The VISA-VXI object vv now exists in the MATLAB workspace. You can display the class of vv with the whos command.

```
whos vv
  Name        Size          Bytes  Class

  vv          1x1             882  visa object

Grand total is 15 elements using 882 bytes
```

After you create the VISA-VXI object, the properties listed below are automatically assigned values. These properties provide descriptive information about the object based on its class type and address information.

VISA-VXI Descriptive Properties

Property Name	Description
Name	Specify a descriptive name for the VISA-VXI object.
RsrcName	Indicate the resource name for a VISA instrument.
Type	Indicate the object type.

You can display the values of these properties for vv with the get function.

```
get(vv,{'Name','RsrcName','Type'})
ans =
    'VISA-VXI0-32'    'VXI0::32::INSTR'    'visa-vxi'
```

The VISA-VXI Object Display

The VISA-VXI object provides you with a convenient display that summarizes important address and state information. You can invoke the display summary these three ways:

- Type the VISA-VXI object at the command line.

- Exclude the semicolon when creating a VISA-VXI object.

- Exclude the semicolon when configuring properties using the dot notation.

The display summary for the VISA-VXI object vv is given below.

```
VISA-VXI Object Using AGILENT Adaptor : VISA-VXI0-32

Communication Address
   ChassisIndex:      0
   LogicalAddress:    32

Communication State
   Status:            closed
   RecordStatus:      off

Read/Write State
   TransferStatus:    idle
   BytesAvailable:    0
```

```
            ValuesReceived:      0
            ValuesSent:          0
```

The VISA-VXI Address

The VISA-VXI address consists of

- The chassis index of the VXI chassis

- The logical address of the instrument installed in the VXI chassis

You must specify the logical address value via the resource name during VISA-VXI object creation. Additionally, you must include the chassis index value as part of the resource name if it differs from the default value of 0. The properties associated with the chassis and instrument address are given below.

VISA-VXI Address Properties

Property Name	Description
ChassisIndex	Indicate the index number of the VXI chassis.
LogicalAddress	Specify the logical address of the VXI instrument.
Slot	Indicate the slot location of the VXI instrument.

The ChassisIndex and LogicalAddress properties are automatically updated with the specified resource name values when you create the VISA-VXI object. The Slot property is automatically updated after the object is connected to the instrument with the fopen function.

You can display the address property values for the VISA-VXI object vv created in "Creating a VISA-VXI Object" on page 5-10 with the get function.

```
fopen(vv)
get(vv,{'ChassisIndex','LogicalAddress','Slot'})
ans =
    [0]    [32]    [2]
```

Register-Based Communication

VXI instruments are either message-based or register-based. Generally, it is assumed that message-based instruments are easier to use, while register-based instruments are faster. A message-based instrument has its own processor that allows it to interpret high-level commands such as a SCPI command. Therefore, to communicate with a message-based instrument, you can use the read and write functions `fscanf`, `fread`, `fprintf`, and `fwrite`. For detailed information about these functions, refer to "Communicating with Your Instrument" on page 2-8.

If the message-based instrument also contains shared memory, then you can access the shared memory through register-based read and write operations. A register-based instrument usually does not have its own processor to interpret high-level commands. Therefore, to communicate with a register-based instrument, you need to use read and write functions that access the register.

There are two types of register-based write and read functions: *low-level* and *high-level*. The main advantage of the high-level functions is ease of use. Refer to "Example: Using High-Level Memory Functions" on page 5-16 for more information. The main advantage of the low-level functions is speed. Refer to "Example: Using Low-Level Memory Functions" on page 5-19 for more information.

The functions associated with register-based write and read operations are given below.

VISA-VXI Register-Based Write and Read Functions

Function Name	Description
memmap	Map memory for low-level memory read and write operations.
mempeek	Low-level memory read from VXI register.
mempoke	Low-level memory write to VXI register.
memread	High-level memory read from VXI register.
memunmap	Unmap memory for low-level memory read and write operations.
memwrite	High-level memory write to VXI register.

The properties associated with register-based write and read operations are given below.

VISA-VXI Register-Based Write and Read Properties

Property Name	Description
MappedMemoryBase	Indicate the base memory address of the mapped memory.
MappedMemorySize	Indicate the size of the mapped memory for low-level read and write operations.
MemoryBase	Indicate the base address of the A24 or A32 space.
MemoryIncrement	Specify if the VXI register offset increments after data is transferred.
MemorySize	Indicate the size of the memory requested in the A24 or A32 address space.
MemorySpace	Define the address space used by the instrument.

Example: Understanding Your Instrument's Register Characteristics

This example explores the register characteristics for an Agilent E1432A 16-channel 51.2 kSa/s digitizer with a DSP module.

All VXI instruments have an A16 memory space consisting of 64 bytes. It is known as an A16 space because the addresses are 16 bits wide. Register-based instruments provide a memory map of the address space that describes the information contained within the A16 space. Some VXI instruments also have an A24 or A32 space if the 64 bytes provided by the A16 space are not enough to perform the necessary tasks. A VXI instrument cannot use both the A24 and A32 space:

1 **Create an instrument object** — Create the VISA-VXI object vv associated with a VXI chassis with index 0, and an Agilent E1432A digitizer with logical address 130.

```
vv = visa('agilent','VXI0::130::INSTR');
```

2 **Connect to the instrument** — Connect vv to the instrument.

```
fopen(vv)
```

The `MemorySpace` property indicates the type of memory space the instrument supports. By default, all instruments support A16 memory space. However, this property can be A16/A24 or A16/A32 if the instrument also supports A24 or A32 memory space, respectively.

```
get(vv,'MemorySpace')
ans =
A16/A24
```

If the VISA-VXI object is not connected to the instrument, `MemorySpace` always returns the default value of `A16`.

The `MemoryBase` property indicates the base address of the A24 or A32 space, and is defined as a hexadecimal string. The `MemorySize` property indicates the size of the A24 or A32 space. If the VXI instrument supports only the A16 memory space, `MemoryBase` defaults to `0H` and `MemorySize` defaults to `0`.

```
get(vv,{'MemoryBase','MemorySize'})
ans =
    '200000H'    [262144]
```

3 Disconnect and clean up — When you no longer need vv, you should disconnect it from the instrument, and remove it from memory and from the MATLAB workspace.

```
fclose(vv)
delete(vv)
clear vv
```

Example: Using High-Level Memory Functions

This example uses the high-level memory functions, `memread` and `memwrite`, to access register information for an Agilent E1432A 16-channel 51.2 kSa/s digitizer with a DSP module. The main advantage of these high-level functions is ease of use — you can access multiple registers with one function call, and the memory that is to be accessed is automatically mapped for you. The main disadvantage is the lack of speed — they are slower than the low-level memory functions.

Each register contains 16 bits, and is associated with an offset value that you supply to memread or memwrite. The first four registers of the digitizer are accessed in this example, and are described below.

Agilent E1432A Register Information

Register	Offset	Description
ID	0	This register provides instrument configuration information and is always defined as CFFF. Bits 15 and 14 are 1, indicating that the instrument is register-based. Bits 13 and 12 are 0, indicating that the instrument supports the A24 memory space. The remaining bits are all 1, indicating the device ID.
Device Type	2	This register provides instrument configuration information. Bits 15-12 indicate the memory required by the A24 space. The remaining bits indicate the model code for the instrument.
Status	4	This register provides instrument status information. For example, bit 15 indicates whether you can access the A24 registers, and bit 6 indicates whether a DSP communication error occurred.
Offset	6	This register defines the base address of the instrument's A24 registers. Bits 15-12 map the VME Bus address lines A23-A20 for A24 register access. The remaining bits are all 0.

For more detailed information about these registers, refer to the *HP E1432A User's Guide*.

1 Create an instrument object — Create the VISA-VXI object vv associated with a VXI chassis with index 0, and an Agilent E1432A digitizer with logical address is 130.

```
vv = visa('agilent','VXI0::130::INSTR');
```

2 Connect to the instrument — Connect vv to the instrument.

```
fopen(vv)
```

3 **Write and read data** — The following command performs a high-level read of the ID Register, which has an offset of 0.

```
reg1 = memread(vv,0,'uint16','A16')
reg1 =
      53247
```

Convert `reg1` to a hexadecimal value and a binary string. Note that the hex value is CFFF and the least significant 12 bits are all 1, as expected.

```
dec2hex(reg1)
ans =
CFFF
dec2bin(reg1)
ans =
1100111111111111
```

You can read multiple registers with `memread`. The following command reads the next three registers. An offset of 2 indicates that the read operation begins with the Device Type Register.

```
reg24 = memread(vv,2,'uint16','A16',3)
reg24 =
      20993
      50012
      40960
```

The following commands write to the Offset Register and then read the value back. Note that if you change the value of this register, you will not be able to access the A24 space.

```
memwrite(vv,45056,6,'uint16','A16');
reg4 = memread(vv,6,'uint16','A16')
reg4 =
      45056
```

Note that the least significant 12 bits are all 0, as expected.

```
dec2bin(reg4,16)
ans =
1011000000000000
```

Restore the original register value, which is stored in the `reg24` variable.

```
memwrite(vv,reg24(3),6,'uint16','A16');
```

4 Disconnect and clean up — When you no longer need vv, you should disconnect it from the instrument, and remove it from memory and from the MATLAB workspace.

```
fclose(vv)
delete(vv)
clear vv
```

Example: Using Low-Level Memory Functions

This example uses the low-level memory functions `mempeek` and `mempoke` to access register information for an Agilent E1432A 16-channel 51.2 kSa/s digitizer with a DSP module. The main advantage of these low-level functions is speed — they are faster than the high-level memory functions. The main disadvantages include the inability to access multiple registers with one function call, errors are not reported, and you must map the memory that is to be accessed.

For information about the digitizer registers accessed in this example, refer to "Example: Using High-Level Memory Functions" on page 5-16:

1 Create an instrument object — Create the VISA-VXI object vv associated with a VXI chassis with index 0, and an Agilent E1432A digitizer with logical address 130.

```
vv = visa('agilent','VXI0::130::INSTR');
```

2 Connect to the instrument — Connect vv to the instrument.

```
fopen(vv)
```

3 Write and read data — Before you can use the low-level memory functions, you must first map the memory space with the `memmap` function. If the memory requested by `memmap` does not exist, an error is returned. The following command maps the first 16 registers of the A16 memory space.

```
memmap(vv,'A16',0,16);
```

The `MappedMemoryBase` and `MappedMemorySize` properties indicate if memory has been mapped. `MappedMemoryBase` is the base address of the mapped memory and is defined as a hexadecimal string. `MappedMemorySize` is the size of the mapped memory. These properties are similar to the `MemoryBase` and `MemorySize` properties that describe the A24 or A32 memory space.

```
get(vv,{'MappedMemoryBase','MappedMemorySize'})
ans =
    '16737610H'    [16]
```

The following command performs a low-level read of the ID Register, which has an offset of 0.

```
reg1 = mempeek(vv,0,'uint16')
reg1 =
     53247
```

The following command performs a low-level read of the Offset Register, which has an offset of 6.

```
reg4 = mempeek(vv,6,'uint16')
reg4 =
     40960
```

The following commands write to the Offset Register and then read the value back. Note that if you change the value of this register, you will not be able to access the A24 space.

```
mempoke(vv,45056,6,'uint16');
mempeek(vv,6,'uint16')
ans =
     45056
```

Restore the original register value.

```
mempoke(vv,reg4,6,'uint16');
```

When you have finished accessing the registers, you should unmap the memory with the `memunmap` function.

```
memunmap(vv)
```

```
get(vv,{'MappedMemoryBase','MappedMemorySize'})
ans =
    'OH'    [0]
```

If memory is still mapped when the object is disconnected from the instrument, the memory is automatically unmapped for you.

4 Disconnect and clean up — When you no longer need vv, you should disconnect it from the instrument, and remove it from memory and from the MATLAB workspace.

```
fclose(vv)
delete(vv)
clear vv
```

The GPIB-VXI Interface

The GPIB-VXI interface is associated with a GPIB-VXI command module that you install in slot 0 of a VXI chassis. This interface, along with the other relevant hardware, is shown below.
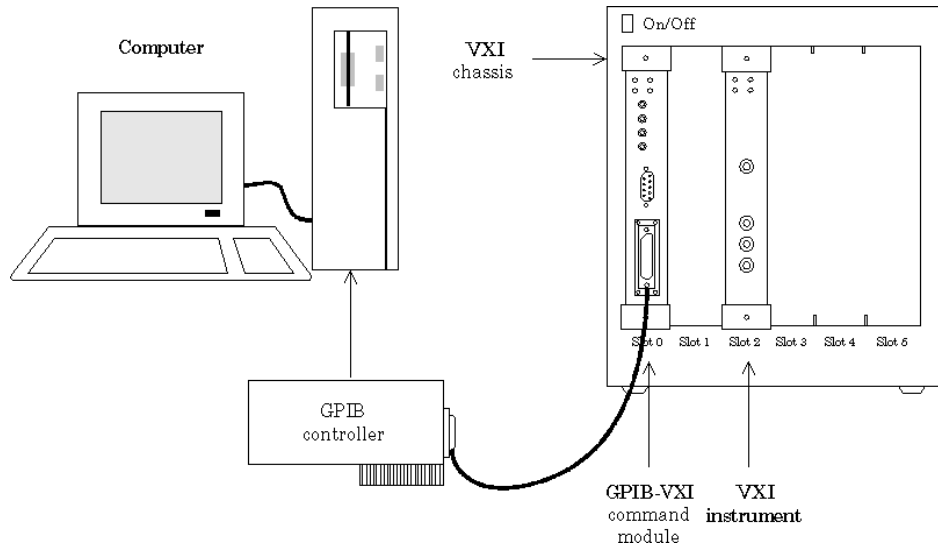
The GPIB-VXI interface is supported through a VISA-GPIB-VXI object. The features associated with a VISA-GPIB-VXI object are similar to the features associated with GPIB and VISA-VXI objects. Therefore, only functions and properties that are unique to VISA's GPIB-VXI interface are discussed in this section. These unique features are associated with

- "Creating a VISA-GPIB-VXI Object" on page 5-23
- "The VISA-GPIB-VXI Address" on page 5-25

Refer to Chapter 4, "Controlling Instruments Using the GPIB" to learn about writing and reading text and binary data, using events and callbacks, using triggers, and so on. Refer to "Register-Based Communication" on page 5-13 to learn about accessing VXI registers.

Note The VISA-GPIB-VXI object does not support the `spoll` and `trigger` functions, or the `BusManagementStatus`, `HandshakeStatus`, `InterruptFcn`, `TriggerFcn`, `TriggerLine`, and `TriggerType` properties.

Creating a VISA-GPIB-VXI Object

You create a VISA-GPIB-VXI object with the `visa` function. As shown in the preceding figure, each object is associated with

- A GPIB controller installed in your computer
- A VXI chassis
- A GPIB-VXI command module in slot 0 of the VXI chassis
- An instrument installed in the VXI chassis

`visa` requires the vendor name and the resource name as input arguments. The vendor name is either `agilent` or `ni`. The resource name consists of the VXI chassis index and the instrument logical address. You can find the VISA-GPIB-VXI resource name for a given instrument with the configuration tool provided by your vendor, or with the `instrhwinfo` function. (In place of the resource name, you can use an alias as defined with your VISA vendor configuration tool.) As described in "Connecting to the Instrument" on page 2-5, you can also configure property values during object creation.

For example, to create a VISA-GPIB-VXI object associated with a VXI chassis with index 0, an Agilent E1406A Command Module in slot 0, and an Agilent E1441A Arbitrary Waveform Generator in slot 2 with logical address 80,

```
vgv = visa('agilent','GPIB-VXI0::80::INSTR');
```

The VISA-GPIB-VXI object `vgv` now exists in the MATLAB workspace. You can display the class of `vgv` with the `whos` command.

```
whos vgv
  Name      Size          Bytes  Class

  vgv       1x1             892  visa object

Grand total is 20 elements using 892 bytes
```

After you create the VISA-GPIB-VXI object, the properties listed below are automatically assigned values. These properties provide descriptive information about the object based on its class type and address information.

VISA-GPIB-VXI Descriptive Properties

Property Name	Description
Name	Specify a descriptive name for the VISA-GPIB-VXI object.
RsrcName	Indicate the resource name for a VISA instrument.
Type	Indicate the object type.

You can display the values of these properties for vgv with the get function.

```
get(vgv,{'Name','RsrcName','Type'})
ans =
'VISA-GPIB-VXI0-80'    'GPIB-VXI0::80::INSTR'    'visa-gpib-vxi'
```

Note The GPIB-VXI communication interface is a combination of the GPIB and VXI interfaces. Therefore, you can also use a VISA-GPIB object to communicate with instruments installed in the VXI chassis, or to communicate with non-VXI instruments connected to the slot 0 controller.

The VISA-GPIB-VXI Object Display

The VISA-GPIB-VXI object provides you with a convenient display that summarizes important address and state information. You can invoke the display summary these three ways:

- Type the VISA-GPIB-VXI object at the command line.

- Exclude the semicolon when creating a VISA-GPIB-VXI object.

- Exclude the semicolon when configuring properties using the dot notation.

The display summary for the VISA-GPIB-VXI object vgv is given below.

```
VISA-GPIB-VXI Object Using AGILENT Adaptor : VISA-GPIB-VXI0-80
```

```
Communication Address
   ChassisIndex:      0
   LogicalAddress:    80

Communication State
   Status:            closed
   RecordStatus:      off

Read/Write State
   TransferStatus:    idle
   BytesAvailable:    0
   ValuesReceived:    0
   ValuesSent:        0
```

The VISA-GPIB-VXI Address

The VISA-GPIB-VXI address consists of a VXI component and a GPIB component. The VXI component includes

- The chassis index of the VXI chassis

- The logical address of the VXI instrument; the logical address must be 0, or it must be divisible by 8

- The slot of the VXI instrument

The GPIB component includes

- The board index of the GPIB controller installed in your computer

- The primary address of the GPIB-VXI command module in slot 0

- The secondary address of the VXI instrument

You must specify the logical address value via the resource name during VISA-GPIB-VXI object creation. Additionally, you must include the chassis index value as part of the resource name if it differs from the default value of 0. The properties associated with the VISA-GPIB-VXI address are given below.

VISA-GPIB-VXI Address Properties

Property Name	Description
BoardIndex	Indicate the index number of the GPIB board.
ChassisIndex	Specify the index number of the VXI chassis.
LogicalAddress	Specify the logical address of the VXI instrument.
PrimaryAddress	Indicate the primary address of the GPIB-VXI command module.
SecondaryAddress	Indicate the secondary address of the VXI instrument.
Slot	Indicate the slot location of the VXI instrument.

The ChassisIndex and LogicalAddress properties are automatically updated with the specified resource name values when you create the VISA-GPIB-VXI object. The BoardIndex, PrimaryAddress, SecondaryAddress, and Slot properties are automatically updated after the object is connected to the instrument with the fopen function.

You can display the address property values for the VISA-GPIB-VXI object vgv created in "Creating a VISA-GPIB-VXI Object" on page 5-23 with the get function.

```
fopen(vgv)
get(vgv,{'BoardIndex','ChassisIndex','LogicalAddress',...
'PrimaryAddress','SecondaryAddress','Slot'})
ans =
    [0]    [0]    [80]    [9]    [10]    [2]
```

The Serial Port Interface

The serial port interface is supported through a VISA-serial object. The features associated with a VISA-serial object are similar to the features associated with a serial port object. Therefore, only functions and properties that are unique to VISA's serial port interface are discussed in this section. These unique features are associated with

- "Creating a VISA-Serial Object" on page 5-27
- "Configuring Communication Settings" on page 5-29

Refer to Chapter 6, "Controlling Instruments Using the Serial Port" to learn about writing and reading text and binary data, using events and callbacks, using serial port control lines, and so on.

Note The VISA-serial object does not support the `serialbreak` function, the `BreakInterruptFcn` property, and the `PinStatusFcn` property.

Creating a VISA-Serial Object

You create a VISA-serial object with the `visa` function. Each VISA-serial object is associated with an instrument connected to a serial port on your computer.

`visa` requires the vendor name and the resource name as input arguments. The vendor name can be `agilent`, `ni`, or `tek`. The resource name consists of the name of the serial port connected to your instrument. You can find the VISA-serial resource name for a given instrument with the configuration tool provided by your vendor, or with the `instrhwinfo` function. (In place of the resource name, you can use an alias as defined with your VISA vendor configuration tool.) As described in "Connecting to the Instrument" on page 2-5, you can also configure property values during object creation.

For example, to create a VISA-serial object that is associated with the COM1 port, and that uses National Instruments VISA,

```
vs = visa('ni','ASRL1::INSTR');
```

The VISA-serial object vs now exists in the MATLAB workspace. You can display the class of vs with the whos command.

```
whos vs
  Name      Size          Bytes  Class

  vs        1x1             888  visa object

Grand total is 18 elements using 888 bytes
```

After you create the VISA-serial object, the properties listed below are automatically assigned values. These properties provide descriptive information about the object based on its class type and address information.

VISA-Serial Descriptive Properties

Property Name	Description
Name	Specify a descriptive name for the VISA-serial object.
Port	Indicate the serial port name.
RsrcName	Indicate the resource name for a VISA instrument.
Type	Indicate the object type.

You can display the values of these properties for vs with the get function.

```
get(vs,{'Name','Port','RsrcName','Type'})
ans =
'VISA-Serial-ASRL1'    'ASRL1'    'ASRL1::INSTR'    'visa-serial'
```

The VISA-Serial Object Display

The VISA-serial object provides you with a convenient display that summarizes important address and state information. You can invoke the display summary these three ways:

- Type the VISA-serial object at the command line.

- Exclude the semicolon when creating a VISA-serial object.

- Exclude the semicolon when configuring properties using the dot notation.

The display summary for the VISA-serial object vs is given below.

```
VISA-Serial Object Using NI Adaptor : VISA-Serial-ASRL1

Communication Settings
   Port:              ASRL1
   BaudRate:          9600
   Terminator:        'LF'

Communication State
   Status:            closed
   RecordStatus:      off

Read/Write State
   TransferStatus:    idle
   BytesAvailable:    0
   ValuesReceived:    0
   ValuesSent:        0
```

Configuring Communication Settings

Before you can write or read data, both the VISA-serial object and the instrument must have identical communication settings. Configuring serial port communications involves specifying values for properties that control the baud rate and the "Serial Data Format" on page 6-8. These properties are given below.

VISA-Serial Communication Properties

Property Name	Description
BaudRate	Specify the rate at which bits are transmitted.
DataBits	Specify the number of data bits to transmit.
Parity	Specify the type of parity checking.
StopBits	Specify the number of bits used to indicate the end of a byte.
Terminator	Specify the character used to terminate commands written to the instrument.

Refer to your instrument documentation for an explanation of its supported communication settings. Note that the valid values for StopBits are 1 and 2 and the valid values for Terminator do not include CR/LF and LF/CR. These property values differ from the values supported for the serial port object.

You can display the default communication property values for the VISA-serial object vs created in "Creating a VISA-Serial Object" on page 5-27 with the get function.

```
get(vs,{'BaudRate','DataBits','Parity','StopBits','Terminator'})
ans =
    [9600]    [8]    'none'    [1]    'LF'
```

The USB Interface

The USB interface is supported through a VISA-USB object. The unique features of a VISA-USB object are associated with

- "Creating a VISA-USB Object" on page 5-31
- "The VISA-USB Address" on page 5-33

Creating a VISA-USB Object

You create a VISA-USB object with the `visa` function. Each VISA-USB object is associated with an instrument connected to a USB port on your computer.

`visa` requires the vendor name and the resource name as input arguments. The vendor name can be `agilent`, `ni`, or `tek`. The resource name consists of the USB board index, manufacturer ID, model code, serial number, and interface number of the connected instrument. You can find the VISA-USB resource name for a given instrument with the configuration tool provided by your vendor, or with the `instrhwinfo` function. (In place of the resource name, you can use an alias as defined with your VISA vendor configuration tool.) As described in "Connecting to the Instrument" on page 2-5, you can also configure property values during object creation.

For example, to create a VISA-USB object that uses National Instruments VISA,

```
vu = visa('ni','USB::0x1234::125::A22-5::INSTR');
```

The VISA-USB object `vu` now exists in the MATLAB workspace. You can display the class of `vu` with the `whos` command.

```
whos vu
  Name      Size          Bytes  Class

  vu        1x1             882  visa object

Grand total is 15 elements using 882 bytes
```

After you create the VISA-USB object, the properties listed below are automatically assigned values. These properties provide descriptive information about the object based on its class type and address information.

VISA-USB Descriptive Properties

Property Name	Description
Name	Specify a descriptive name for the VISA-USB object.
RsrcName	Indicate the resource name for a VISA instrument.
Type	Indicate the object type.

You can display the values of these properties for vs with the get function.

```
get(vu,{'Name','RsrcName','Type'})
ans =
'VISA-USB-0-0x1234-125-A22-5-0'  'USB::0x1234::125::A22-5::INSTR'
'visa-usb'
```

The VISA-USB Object Display

The VISA-USB object provides you with a convenient display that summarizes important address and state information. You can invoke the display summary these three ways:

- Type the VISA-USB object at the command line.
- Exclude the semicolon when creating a VISA-USB object.
- Exclude the semicolon when configuring properties using the dot notation.

The display summary for the VISA-USB object vs is given below.

```
VISA-USB Object Using NI Adaptor : VISA-USB-0-0x1234-125-A22-5-0

Communication Address
   ManufacturerID:    0x1234
   ModelCode:         125
   SerialNumber:      A22-5
```

```
Communication State
   Status:              closed
   RecordStatus:        off

Read/Write State
   TransferStatus:      idle
   BytesAvailable:      0
   ValuesReceived:      0
   ValuesSent:          0
```

The VISA-USB Address

The VISA-USB address consists of

- Board index (optional, from the VISA configuration)

- Manufacturer ID of the instrument

- Model code of the instrument

- Serial number of the instrument

- Interface number (optional, from the VISA configuration)

You specify these address property values via the resource name during VISA-USB object creation. The instrument address properties are given below.

VISA-USB Address Properties

Property Name	Description
BoardIndex	Specify the index number of the USB board in VISA configuration (optional — defaults to 0).
InterfaceIndex	Specify the USB interface number (optional).
ManufacturerID	Specify the manufacturer ID of the USB instrument.
ModelCode	Specify the model code of the USB instrument.
SerialNumber	Specify the index of the USB instrument on the USB hub.

The properties are automatically updated with the specified resource name values when you create the VISA-USB object.

With the get function, you can display the address property values for the VISA-USB object vu, created in "Creating a VISA-USB Object" on page 5-31.

```
fopen(vu)
get(vu,{'ManufacturerID','ModelCode','SerialNumber'})
ans =
    [0x1234]    [125]    [A22-5]
```

The TCP/IP Interface

The TCP/IP interface is supported through a VISA-TCPIP object. The features associated with a VISA-TCPIP object are similar to the features associated with a `tcpip` object. Therefore, only functions and properties that are unique to VISA's TCP/IP interface are discussed in this section. These unique features are associated with

- "Creating a VISA-TCPIP Object" on page 5-35
- "The VISA-TCPIP Address" on page 5-37

Refer to Chapter 7, "Controlling Instruments Using TCP/IP and UDP" to learn about writing and reading text and binary data, using events and callbacks, and so on.

Creating a VISA-TCPIP Object

You create a VISA-TCPIP object with the `visa` function. Each VISA-TCPIP object is associated with an instrument connected to your computer.

`visa` requires the vendor name and the resource name as input arguments. The vendor name can be `agilent`, `ni`, or `tek`. The resource name consists of the TPC/IP board index, IP address or host name, and LAN device name of your instrument. You can find the VISA-TCPIP resource name for a given instrument with the configuration tool provided by your vendor, or with the `instrhwinfo` function. (In place of the resource name, you can use an alias as defined with your VISA vendor configuration tool.) As described in "Connecting to the Instrument" on page 2-5, you can also configure property values during object creation.

For example, to create a VISA-TCPIP object that uses National Instruments VISA associated with an instrument at IP address 216.148.60.170,

```
vt = visa('ni','TCPIP::216.148.60.170::INSTR');
```

The VISA-TCPIP object vs now exists in the MATLAB workspace. You can display the class of vs with the whos command.

```
whos vt
  Name       Size           Bytes  Class

  vt         1x1              886  visa object

Grand total is 17 elements using 886 bytes
```

After you create the VISA-TCPIP object, the properties listed below are automatically assigned values. These properties provide descriptive information about the object based on its class type and address information.

VISA-TCPIP Descriptive Properties

Property Name	Description
Name	Specify a descriptive name for the VISA-TCPIP object.
RsrcName	Indicate the resource name for a VISA instrument.
Type	Indicate the object type.

You can display the values of these properties for vs with the get function.

```
get(vt,{'Name','RsrcName','Type'})
ans =
'VISA-TCPIP-216.148.60.170'  'TCPIP::216.148.60.170::INSTR'
'visa-tcpip'
```

The VISA-TCPIP Object Display

The VISA-TCPIP object provides you with a convenient display that summarizes important address and state information. You can invoke the display summary these three ways:

- Type the VISA-TCPIP object at the command line.

- Exclude the semicolon when creating a VISA-TCPIP object.

- Exclude the semicolon when configuring properties using the dot notation.

The display summary for the VISA-TCPIP object vs is given below.

```
VISA-TCPIP Object Using NI Adaptor : VISA-TCPIP-216.148.60.170

Communication Address
   RemoteHost:        216.148.60.170

Communication State
   Status:            closed
   RecordStatus:      off

Read/Write State
   TransferStatus:    idle
   BytesAvailable:    0
   ValuesReceived:    0
   ValuesSent:        0
```

The VISA-TCPIP Address

The VISA-TCPIP address consists of

- Board index (optional, from the VISA configuration)
- Remote host of the instrument
- LAN device name of the instrument (optional)

You specify these address property values via the resource name during VISA-TCPIP object creation. The instrument address properties are given below.

VISA-TCPIP Address Properties

Property Name	Description
BoardIndex	Specify the index number of the TCP/IP board in VISA configuration (optional — defaults to 0).

VISA-TCPIP Address Properties (Continued)

Property Name	Description
RemoteHost	Specify the remote host name or IP address of the instrument.
LANName	Specify the LAN device name of the instrument.

The properties are automatically updated with the specified resource name values when you create the VISA-TCPIP object.

With the get function, you can display the address property values for the VISA-TCPIP object vt, created in "Creating a VISA-TCPIP Object" on page 5-35.

```
fopen(vt)
get(vt,{'RemoteHost'})
ans =
    [216.148.60.170]
```

The RSIB Interface

The RSIB interface is supported through a VISA-RSIB object. The unique features of a VISA-RSIB object are associated with

- "Creating a VISA-RSIB Object" on page 5-39
- "The VISA-RSIB Address" on page 5-41

Creating a VISA-RSIB Object

You create a VISA-RSIB object with the visa function. Each VISA-RSIB object is associated with an instrument connected to your computer.

visa requires the vendor name and the resource name as input arguments. The only supported vendor name is ni. The resource name consists of the IP address or host name of the instrument. You can find the VISA-RSIB resource name for a given instrument with the configuration tool provided by your vendor, or with the instrhwinfo function. (In place of the resource name, you can use an alias as defined with your VISA vendor configuration tool.) As described in "Connecting to the Instrument" on page 2-5, you can also configure properties during object creation.

For example, to create a VISA-RSIB object that uses National Instruments VISA and associated with an instrument with IP address 192.168.1.33,

```
vr = visa('ni','RSIB::192.168.1.33::INSTR');
```

The VISA-RSIB object vr now exists in the MATLAB workspace. You can display the class of vr with the whos command.

```
whos vr
  Name      Size          Bytes  Class

  vr        1x1             884  visa object

  Grand total is 16 elements using 884 bytes
```

After you create the VISA-RSIB object, the properties listed below are automatically assigned values. These properties provide descriptive information about the object based on its class type and address information.

VISA-RSIB Descriptive Properties

Property Name	Description
Name	Specify a descriptive name for the VISA-RSIB object.
RsrcName	Indicate the resource name for a VISA instrument.
Type	Indicate the object type.

You can display the values of these properties for vr with the get function.

```
get(vr,{'Name','RsrcName','Type'})
ans =
    'VISA-RSIB0-192.168.1.33'    'RSIB0::192.168.1.33::INSTR'
    'visa-RSIB'
```

The VISA-RSIB Object Display

The VISA-RSIB object provides you with a convenient display that summarizes important address and state information. You can invoke the display summary these three ways:

- Type the VISA-RSIB object at the command line.

- Exclude the semicolon when creating a VISA-RSIB object.

- Exclude the semicolon when configuring properties using the dot notation.

You can also display summary information via the Workspace browser by right-clicking an instrument object and selecting **Display Summary** from the context menu.

The display summary for the VISA-RSIB object vr is given below.

```
VISA-RSIB Object Using NI Adaptor : VISA-RSIB-192.168.1.33

Communication Address
   RemoteHost:       192.168.1.33

Communication State
   Status:           closed
   RecordStatus:     off
```

```
Read/Write State
   TransferStatus:     idle
   BytesAvailable:     0
   ValuesReceived:     0
   ValuesSent:         0
```

The VISA-RSIB Address

The VISA-RSIB address consists of

- Remote host of the instrument

You specify the address property value via the resource name during VISA-RSIB object creation. The instrument address property is given below.

VISA-RSIB Address Property

Property Name	Description
RemoteHost	Specify the remote host name or IP address of the instrument

The property is automatically updated with the specified resource name value when you create the VISA-RSIB object.

With the get function, you can display the address property value for the VISA-RSIB object vr, created in "Creating a VISA-RSIB Object" on page 5-39.

```
fopen(vr)
get(vr,{'RemoteHost'})
ans =
    [192.168.1.33]
```

6

Controlling Instruments Using the Serial Port

This chapter describes specific issues related to controlling instruments that use the serial port. The sections are as follows.

Serial Port Overview (p. 6-2)	Basic features of the serial port.
Creating a Serial Port Object (p. 6-15)	The serial port object establishes a connection between MATLAB and the instrument via serial port.
Configuring Communication Settings (p. 6-17)	Communication settings are associated with the baud rate and serial data format.
Writing and Reading Data (p. 6-18)	Port-specific issues related to writing and reading data with a serial port object.
Events and Callbacks (p. 6-23)	Enhance your instrument control application using events and callbacks.
Using Control Pins (p. 6-28)	The control pins allow you to signal the presence of connected devices and to control the flow of data.

Serial Port Overview

This section provides an overview of the serial port. Topics include

- "What Is Serial Communication?" on page 6-2
- "The Serial Port Interface Standard" on page 6-2
- "Connecting Two Devices with a Serial Cable" on page 6-3
- "Serial Port Signals and Pin Assignments" on page 6-4
- "Serial Data Format" on page 6-8
- "Finding Serial Port Information for Your Platform" on page 6-12

For many serial port applications, you can communicate with your instrument without detailed knowledge of how the serial port works. Communication is established through a serial port object, which you create in the MATLAB workspace.

If your application is straightforward, or if you are already familiar with the topics mentioned above, you might want to begin with "Creating a Serial Port Object" on page 6-15. If you want a high-level description of all the steps you are likely to take when communicating with your instrument, refer to Chapter 2, "The Instrument Control Session".

What Is Serial Communication?

Serial communication is the most common low-level protocol for communicating between two or more devices. Normally, one device is a computer, while the other device can be a modem, a printer, another computer, or a scientific instrument such as an oscilloscope or a function generator.

As the name suggests, the serial port sends and receives bytes of information in a serial fashion — one bit at a time. These bytes are transmitted using either a binary format or a text (ASCII) format.

The Serial Port Interface Standard

Over the years, several serial port interface standards for connecting computers to peripheral devices have been developed. These standards

include RS-232, RS-422, and RS-485 — all of which are supported by the serial port object. Of these, the most widely used standard is RS-232, which stands for Recommended Standard number 232.

The current version of this standard is designated as TIA/EIA-232C, which is published by the Telecommunications Industry Association. However, the term "RS-23" is still in popular use, and is used in this guide when referring to a serial communication port that follows the TIA/EIA-232 standard. RS-232 defines these serial port characteristics:

• The maximum bit transfer rate and cable length

• The names, electrical characteristics, and functions of signals

• The mechanical connections and pin assignments

Primary communication is accomplished using three pins: the Transmit Data pin, the Receive Data pin, and the Ground pin. Other pins are available for data flow control, but are not required.

Note In this guide, it is assumed you are using the RS-232 standard. Refer to your device documentation to see which interface standard you can use.

Connecting Two Devices with a Serial Cable

The RS-232 standard defines the two devices connected with a serial cable as the Data Terminal Equipment (DTE) and Data Circuit-Terminating Equipment (DCE). This terminology reflects the RS-232 origin as a standard for communication between a computer terminal and a modem.

Throughout this guide, your computer is considered a DTE, while peripheral devices such as modems and printers are considered DCEs. Note that many scientific instruments function as DTEs.

Because RS-232 mainly involves connecting a DTE to a DCE, the pin assignments are defined such that straight-through cabling is used, where pin 1 is connected to pin 1, pin 2 is connected to pin 2, and so on. A DTE to DCE serial connection using the transmit data (TD) pin and the receive data

(RD) pin is shown below. Refer to "Serial Port Signals and Pin Assignments" on page 6-4 for more information about serial port pins.

Computer   Instrument

```
              TD                    RD
      Pin 3 ─────────────────────► Pin 3
  DTE                                        DCE
      Pin 2 ◄───────────────────── Pin 2
              RD                    TD
```
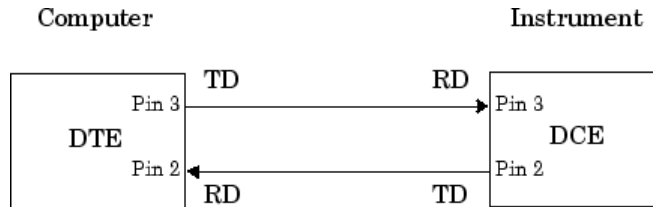
If you connect two DTEs or two DCEs using a straight serial cable, then the TD pin on each device is connected to the other, and the RD pin on each device is connected to the other. Therefore, to connect two like devices, you must use a *null modem* cable. As shown below, null modem cables cross the transmit and receive lines in the cable.

Computer   Computer

```
              TD                    TD
      Pin 3 ───────────┐   ┌─────► Pin 3
  DTE                   ╲ ╱           DTE
      Pin 2 ◄───────────╳ ╲─────► Pin 2
              RD        ╱   ╲  RD
```
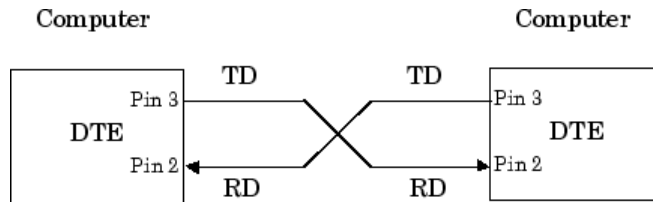
Note You can connect multiple RS-422 or RS-485 devices to a serial port. If you have an RS-232/RS-485 adaptor, then you can use the serial port object with these devices.

Serial Port Signals and Pin Assignments

Serial ports consist of two signal types: *data signals* and *control signals*. To support these signal types, as well as the signal ground, the RS-232 standard defines a 25-pin connection. However, most PCs and UNIX platforms use a 9-pin connection. In fact, only three pins are required for serial port communications: one for receiving data, one for transmitting data, and one for the signal ground.

The pin assignment scheme for a 9-pin male connector on a DTE is given below.
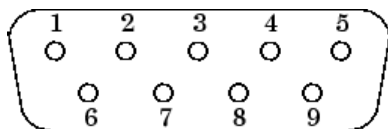
The pins and signals associated with the 9-pin connector are described below. Refer to the RS-232 standard for a description of the signals and pin assignments used for a 25-pin connector.

Serial Port Pin and Signal Assignments

Pin	Label	Signal Name	Signal Type
1	CD	Carrier Detect	Control
2	RD	Received Data	Data
3	TD	Transmitted Data	Data
4	DTR	Data Terminal Ready	Control
5	GND	Signal Ground	Ground
6	DSR	Data Set Ready	Control
7	RTS	Request to Send	Control
8	CTS	Clear to Send	Control
9	RI	Ring Indicator	Control

The term "data set" is synonymous with "modem" or "device," while the term "data terminal" is synonymous with "computer."

Note The serial port pin and signal assignments are with respect to the DTE. For example, data is transmitted from the TD pin of the DTE to the RD pin of the DCE.

Signal States

Signals can be in either an *active state* or an *inactive state*. An active state corresponds to the binary value 1, while an inactive state corresponds to the binary value 0. An active signal state is often described as *logic 1*, *on*, *true*,

or a *mark*. An inactive signal state is often described as *logic 0*, *off*, *false*, or a *space*.

For data signals, the "on" state occurs when the received signal voltage is more negative than -3 volts, while the "off" state occurs for voltages more positive than 3 volts. For control signals, the "on" state occurs when the received signal voltage is more positive than 3 volts, while the "off" state occurs for voltages more negative than -3 volts. The voltage between -3 volts and +3 volts is considered a transition region, and the signal state is undefined.

To bring the signal to the "on" state, the controlling device *unasserts* (or *lowers*) the value for data pins and *asserts* (or *raises*) the value for control pins. Conversely, to bring the signal to the "off" state, the controlling device asserts the value for data pins and unasserts the value for control pins.

The "on" and "off" states for a data signal and for a control signal are shown below.
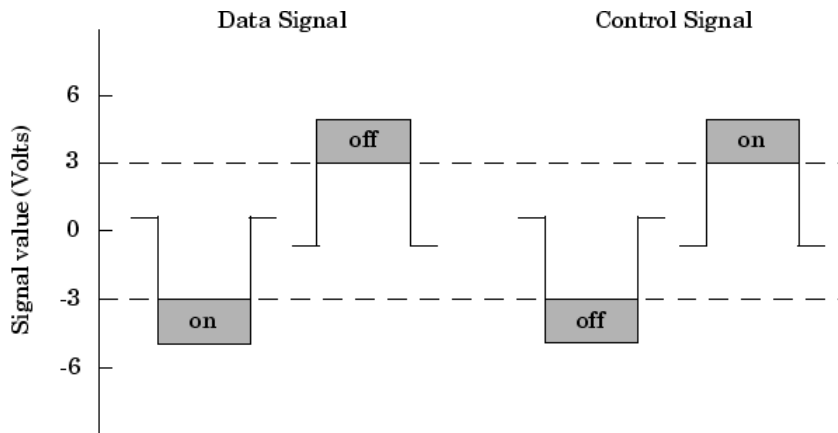
The Data Pins

Most serial port devices support *full-duplex* communication meaning that they can send and receive data at the same time. Therefore, separate pins are used for transmitting and receiving data. For these devices, the TD, RD, and GND pins are used. However, some types of serial port devices support only one-way or *half-duplex* communications. For these devices, only the

TD and GND pins are used. In this guide, it is assumed that a full-duplex serial port is connected to your device.

The TD pin carries data transmitted by a DTE to a DCE. The RD pin carries data that is received by a DTE from a DCE.

The Control Pins

9-pin serial ports provide several control pins that

- Signal the presence of connected devices
- Control the flow of data

The control pins include RTS and CTS, DTR and DSR, CD, and RI.

The RTS and CTS Pins. The RTS and CTS pins are used to signal whether the devices are ready to send or receive data. This type of data flow control — called hardware handshaking — is used to prevent data loss during transmission. When enabled for both the DTE and DCE, hardware handshaking using RTS and CTS follows these steps:

1 The DTE asserts the RTS pin to instruct the DCE that it is ready to receive data.

2 The DCE asserts the CTS pin indicating that it is clear to send data over the TD pin. If data can no longer be sent, the CTS pin is unasserted.

3 The data is transmitted to the DTE over the TD pin. If data can no longer be accepted, the RTS pin is unasserted by the DTE and the data transmission is stopped.

To enable hardware handshaking, refer to "Controlling the Flow of Data: Handshaking" on page 6-31.

The DTR and DSR Pins. Many devices use the DSR and DTR pins to signal if they are connected and powered. Signaling the presence of connected devices using DTR and DSR follows these steps:

1 The DTE asserts the DTR pin to request that the DCE connect to the communication line.

2 The DCE asserts the DSR pin to indicate that it is connected.

3 DCE unasserts the DSR pin when it is disconnected from the communication line.

The DTR and DSR pins were originally designed to provide an alternative method of hardware handshaking. However, the RTS and CTS pins are usually used in this way, and not the DSR and DTR pins. However, you should refer to your device documentation to determine its specific pin behavior.

The CD and RI Pins. The CD and RI pins are typically used to indicate the presence of certain signals during modem-modem connections.

CD is used by a modem to signal that it has made a connection with another modem, or has detected a carrier tone. CD is asserted when the DCE is receiving a signal of a suitable frequency. CD is unasserted if the DCE is not receiving a suitable signal.

RI is used to indicate the presence of an audible ringing signal. RI is asserted when the DCE is receiving a ringing signal. RI is unasserted when the DCE is not receiving a ringing signal (for example, it's between rings).

Serial Data Format

The serial data format includes one start bit, between five and eight data bits, and one stop bit. A parity bit and an additional stop bit might be included in the format as well. The diagram below illustrates the serial data format.

The format for serial port data is often expressed using the following notation:

   number of data bits - parity type - number of stop bits

For example, 8-N-1 is interpreted as eight data bits, no parity bit, and one stop bit, while 7-E-2 is interpreted as seven data bits, even parity, and two stop bits.

The data bits are often referred to as a *character* because these bits usually represent an ASCII character. The remaining bits are called *framing bits* because they frame the data bits.

Bytes Versus Values

The collection of bits that compose the serial data format is called a *byte*. At first, this term might seem inaccurate because a byte is 8 bits and the serial data format can range between 7 bits and 12 bits. However, when serial data is stored on your computer, the framing bits are stripped away, and only the data bits are retained. Moreover, eight data bits are always used regardless of the number of data bits specified for transmission, with the unused bits assigned a value of 0.

When reading or writing data, you might need to specify a *value*, which can consist of one or more bytes. For example, if you read one value from a device using the int32 format, then that value consists of four bytes. For more information about reading and writing values, refer to "Writing and Reading Data" on page 6-18.

Synchronous and Asynchronous Communication

The RS-232 standard supports two types of communication protocols: synchronous and asynchronous.

Using the synchronous protocol, all transmitted bits are synchronized to a common clock signal. The two devices initially synchronize themselves to each other, and then continually send characters to stay synchronized. Even when actual data is not really being sent, a constant flow of bits allows each device to know where the other is at any given time. That is, each bit that is sent is either actual data or an idle character. Synchronous communications allows faster data transfer rates than asynchronous methods, because additional bits to mark the beginning and end of each data byte are not required.

Using the asynchronous protocol, each device uses its own internal clock resulting in bytes that are transferred at arbitrary times. So, instead of using time as a way to synchronize the bits, the data format is used.

In particular, the data transmission is synchronized using the start bit of the word, while one or more stop bits indicate the end of the word.

The requirement to send these additional bits causes asynchronous communications to be slightly slower than synchronous. However, it has the advantage that the processor does not have to deal with the additional idle characters. Most serial ports operate asynchronously.

Note When used in this guide, the terms "synchronous" and "asynchronous" refer to whether read or write operations block access to the MATLAB command line.

How Are the Bits Transmitted?

By definition, serial data is transmitted one bit at a time. The order in which the bits are transmitted follows these steps:

1 The start bit is transmitted with a value of 0.

2 The data bits are transmitted. The first data bit corresponds to the least significant bit (LSB), while the last data bit corresponds to the most significant bit (MSB).

3 The parity bit (if defined) is transmitted.

4 One or two stop bits are transmitted, each with a value of 1.

The number of bits transferred per second is given by the *baud rate*. The transferred bits include the start bit, the data bits, the parity bit (if defined), and the stop bits.

Start and Stop Bits

As described in "Synchronous and Asynchronous Communication" on page 6-9, most serial ports operate asynchronously. This means that the transmitted byte must be identified by start and stop bits. The start bit indicates when the data byte is about to begin and the stop bit(s) indicates when the data byte has been transferred. The process of identifying bytes with the serial data format follows these steps:

1 When a serial port pin is idle (not transmitting data), then it is in an "on" state.

2 When data is about to be transmitted, the serial port pin switches to an "off" state due to the start bit.

3 The serial port pin switches back to an "on" state due to the stop bit(s). This indicates the end of the byte.

Data Bits

The data bits transferred through a serial port might represent device commands, sensor readings, error messages, and so on. The data can be transferred as either binary data or as text (ASCII) data.

Most serial ports use between five and eight data bits. Binary data is typically transmitted as eight bits. Text-based data is transmitted as either seven bits or eight bits. If the data is based on the ASCII character set, then a minimum of seven bits is required because there are 2^7 or 128 distinct characters. If an eighth bit is used, it must have a value of 0. If the data is based on the extended ASCII character set, then eight bits must be used because there are 2^8 or 256 distinct characters.

The Parity Bit

The parity bit provides simple error (parity) checking for the transmitted data. The types of parity checking are given below.

Parity Types

Parity Type	Description
Even	The data bits plus the parity bit produce an even number of 1s.
Mark	The parity bit is always 1.
Odd	The data bits plus the parity bit produce an odd number of 1s.
Space	The parity bit is always 0.

Mark and space parity checking are seldom used because they offer minimal error detection. You might choose not to use parity checking at all.

The parity checking process follows these steps:

1 The transmitting device sets the parity bit to 0 or to 1 depending on the data bit values and the type of parity checking selected.

2 The receiving device checks if the parity bit is consistent with the transmitted data. If it is, then the data bits are accepted. If it is not, then an error is returned.

Note Parity checking can detect only 1 bit errors. Multiple-bit errors can appear as valid data.

For example, suppose the data bits 01110001 are transmitted to your computer. If even parity is selected, then the parity bit is set to 0 by the transmitting device to produce an even number of 1s. If odd parity is selected, then the parity bit is set to 1 by the transmitting device to produce an odd number of 1s.

Finding Serial Port Information for Your Platform

This section describes how to find serial port information using the resources provided by Windows and UNIX platforms.

Note Your operating system provides default values for all serial port settings. However, these settings are overridden by your MATLAB code, and will have no effect on your serial port application.

You can also use the instrhwinfo function to return the available serial ports programmatically.

Windows Platform

You can access serial port information through the **System Properties** dialog box. To access this in Window XP,

1 Right-click **My Computer** on the desktop, and select **Properties**.

2 In the **System Properties** dialog box, click the **Hardware** tab.

3 Click **Device Manager**.

4 In the **Device Manager** dialog box, expand the `Ports` node.

5 Double-click the `Communications Port (COM1)` node.

6 Select the **Port Settings** tab.

The resulting **Ports** dialog box is shown below.
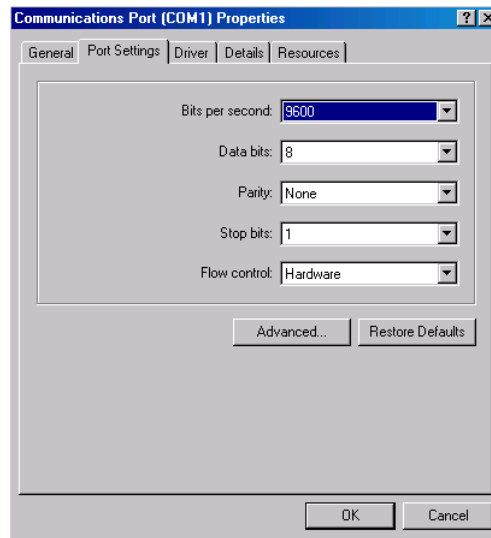
UNIX Platform

To find serial port information for UNIX platforms, you need to know the serial port names. These names might vary between different operating systems.

On Linux, serial port devices are typically named `ttyS0`, `ttyS1`, and so on. You can use the `setserial` command to display or configure serial port information. For example, to display which serial ports are available,

```
setserial -bg /dev/ttyS*
/dev/ttyS0 at 0x03f8 (irq = 4) is a 16550A
```

```
/dev/ttyS1 at 0x02f8 (irq = 3) is a 16550A
```

To display detailed information about ttyS0,

```
setserial -ag /dev/ttyS0
/dev/ttyS0, Line 0, UART: 16550A, Port: 0x03f8, IRQ: 4
       Baud_base: 115200, close_delay: 50, divisor: 0
       closing_wait: 3000, closing_wait2: infinte
       Flags: spd_normal skip_test session_lockout
```

Note If the setserial -ag command does not work, make sure that you have read and write permission for the port.

For all supported UNIX platforms, you can use the stty command to display or configure serial port information. For example, to display serial port properties for ttyS0,

```
stty -a < /dev/ttyS0
```

To configure the baud rate to 4800 bits per second,

```
stty speed 4800 < /dev/ttyS0 > /dev/ttyS0
```

Creating a Serial Port Object

You create a serial port object with the `serial` function. `serial` requires the name of the serial port connected to your device as an input argument. As described in "Configuring Properties During Object Creation" on page 3-2, you can also configure property values during object creation.

Each serial port object is associated with one serial port. For example, to create a serial port object associated with the COM1 port,

```
s = serial('COM1');
```

The serial port object s now exists in the MATLAB workspace. You can display the class of s with the `whos` command.

```
whos s
  Name      Size          Bytes  Class

   s         1x1             512  serial object

  Grand total is 11 elements using 512 bytes
```

Once the serial port object is created, the properties listed below are automatically assigned values. These general purpose properties provide descriptive information about the serial port object based on the object type and the serial port.

Serial Port Descriptive Properties

Property Name	Description
Name	Specify a descriptive name for the serial port object.
Port	Indicate the platform-specific serial port name.
Type	Indicate the object type.

You can display the values of these properties for s with the `get` function.

```
get(s,{'Name','Port','Type'})
ans =
```

```
'Serial-COM1'    'COM1'    'serial'
```

Note The serial port is not locked by MATLAB, so other applications or other instances of MATLAB can access the same serial port. This might result in a conflict, with unpredicatable results.

The Serial Port Object Display

The serial port object provides you with a convenient display that summarizes important configuration and state information. You can invoke the display summary these three ways:

- Type the serial port object variable name at the command line.

- Exclude the semicolon when creating a serial port object.

- Exclude the semicolon when configuring properties using the dot notation.

You can also display summary information via the Workspace browser by right-clicking an instrument object and selecting **Display Summary** from the context menu.

The display summary for the serial port object s is given below.

```
Serial Port Object : Serial-COM1

Communication Settings
   Port:            COM1
   BaudRate:        9600
   Terminator:      'LF'

Communication State
   Status:          closed
   RecordStatus:    off

Read/Write State
   TransferStatus:  idle
   BytesAvailable:  0
   ValuesReceived:  0
   ValuesSent:      0
```

Configuring Communication Settings

Before you can write or read data, both the serial port object and the instrument must have identical communication settings. Configuring serial port communications involves specifying values for properties that control the baud rate and the "Serial Data Format" on page 6-8. These properties are given below.

Serial Port Communication Properties

Property Name	Description
BaudRate	Specify the rate at which bits are transmitted.
DataBits	Specify the number of data bits to transmit.
Parity	Specify the type of parity checking.
StopBits	Specify the number of bits used to indicate the end of a byte.
Terminator	Specify the terminator character.

Note If the serial port object and the instrument communication settings are not identical, you cannot successfully read or write data.

Refer to your instrument documentation for an explanation of its supported communication settings.

You can display the communication property values for the serial port object s created in "Creating a Serial Port Object" on page 6-15 with the get function.

```
get(s,{'BaudRate','DataBits','Parity','StopBits','Terminator'})
ans =
[9600]    [8]     'none'    [1]      'LF'
```

Writing and Reading Data

This section describes interface-specific issues related to writing and reading data with a serial port object. Topics include

- Asynchronous write and read operations
- Rules for completing write and read operations
- An example that illustrates writing and reading text data

For a general overview about writing and reading data, as well as a list of all associated functions and properties, refer to "Communicating with Your Instrument" on page 2-8.

Asynchronous Write and Read Operations

Asynchronous write and read operations do not block access to the MATLAB command line. Additionally, while an asynchronous operation is in progress you can

- Execute a read (write) operation while an asynchronous write (read) operation is in progress. This is because serial ports have separate pins for reading and writing.
- Make use of all supported callback properties. Refer to "Events and Callbacks" on page 6-23 for more information about the callback properties supported by serial port objects.

The process of writing data asynchronously is given in "Synchronous Versus Asynchronous Write Operations" on page 3-17.

Asynchronous Read Operations

For serial port objects, you specify whether read operations are synchronous or asynchronous with the ReadAsyncMode property. You can configure ReadAsyncMode to continuous or manual.

If ReadAsyncMode is continuous (the default value), the serial port object continuously queries the instrument to determine if data is available to be read. If data is available, it is asynchronously stored in the input buffer.

To transfer the data from the input buffer to MATLAB, you use one of the synchronous (blocking) read functions such as fgetl, fgets, fscanf, or fread. If data is available in the input buffer, these functions will return quickly.

```
s = serial('COM1');
fopen(s)
s.ReadAsyncMode = 'continuous';
fprintf(s,'*IDN?')
s.BytesAvailable
ans =
    56
out = fscanf(s);
```

If ReadAsyncMode is manual, the serial port object does not continuously query the instrument to determine if data is available to be read. To read data asynchronously, you use the readasync function. You then use one of the synchronous read functions to transfer data from the input buffer to MATLAB.

```
s.ReadAsyncMode = 'manual';
fprintf(s,'*IDN?')
s.BytesAvailable
ans =
    0
readasync(s)
s.BytesAvailable
ans =
    56
out = fscanf(s);
```

Rules for Completing Write and Read Operations

The rules for completing synchronous and asynchronous read and write operations are described below.

Completing Write Operations

A write operation using fprintf or fwrite completes when one of these conditions is satisfied:

- The specified data is written.

- The time specified by the Timeout property passes.

In addition to these rules, you can stop an asynchronous write operation at any time with the `stopasync` function.

A text command is processed by the instrument only when it receives the required terminator. For serial port objects, each occurrence of `\n` in the ASCII command is replaced with the `Terminator` property value. Because the default format for `fprintf` is `%s\n`, all commands written to the instrument will end with the `Terminator` value. The default value of `Terminator` is the line feed character. The terminator required by your instrument will be described in its documentation.

Completing Read Operations

A read operation with `fgetl`, `fgets`, `fscanf`, or `readasync` completes when one of these conditions is satisfied:

- The terminator specified by the `Terminator` property is read.
- The time specified by the `Timeout` property passes.
- The input buffer is filled.
- The specified number of values is read (`fscanf` and `readasync` only).

A read operation with `fread` completes when one of these conditions is satisfied:

- The time specified by the `Timeout` property passes.
- The specified number of values is read.

In addition to these rules, you can stop an asynchronous read operation at any time with the `stopasync` function.

Example: Writing and Reading Text Data

This example illustrates how to communicate with a serial port instrument by writing and reading text data.

The instrument is a Tektronix TDS 210 two-channel oscilloscope connected to the serial port COM1. Therefore, many of the commands given below are specific to this instrument. A sine wave is input into channel 2 of the

oscilloscope, and your job is to measure the peak-to-peak voltage of the input signal.

1 **Create a serial port object** — Create the serial port object s associated with serial port COM1.

```
s = serial('COM1');
```

2 **Connect to the instrument** — Connect s to the oscilloscope. Because the default value for the ReadAsyncMode property is continuous, data is asynchronously returned to the input buffer as soon as it is available from the instrument.

```
fopen(s)
```

3 **Write and read data** — Write the *IDN? command to the instrument using fprintf, and then read back the result of the command using fscanf.

```
fprintf(s,'*IDN?')
s.BytesAvailable
ans =
    56
idn = fscanf(s)
idn =
TEKTRONIX,TDS 210,0,CF:91.1CT FV:v1.16 TDS2CM:CMV:v1.04
```

You need to determine the measurement source. Possible measurement sources include channel 1 and channel 2 of the oscilloscope.

```
fprintf(s,'MEASUREMENT:IMMED:SOURCE?')
source = fscanf(s)
source =
CH1
```

The scope is configured to return a measurement from channel 1. Because the input signal is connected to channel 2, you must configure the instrument to return a measurement from this channel.

```
fprintf(s,'MEASUREMENT:IMMED:SOURCE CH2')
fprintf(s,'MEASUREMENT:IMMED:SOURCE?')
source = fscanf(s)
source =
CH2
```

You can now configure the scope to return the peak-to-peak voltage, and then request the value of this measurement.

```
fprintf(s,'MEASUREMENT:MEAS1:TYPE PK2PK')
fprintf(s,'MEASUREMENT:MEAS1:VALUE?')
```

Transfer data from the input buffer to MATLAB using fscanf.

```
ptop = fscanf(s)
ptop =
2.0199999809E0
```

4 **Disconnect and clean up** — When you no longer need s, you should disconnect it from the instrument, and remove it from memory and from the MATLAB workspace.

```
fclose(s)
delete(s)
clear s
```

Events and Callbacks

This section describes interface-specific issues related to using events and callbacks with a serial port object. Topics include

- Event types and callback properties
- Storing event information
- An example that uses the bytes-available event, the output-empty event, and the `instrcallback` function

For a general overview of events and callbacks, including how to create and execute callback functions, refer to "Events and Callbacks" on page 4-29.

Event Types and Callback Properties

The event types and associated callback properties supported by serial port objects are listed below.

Serial Port Event Types and Callback Properties

Event Type	Associated Properties
Break interrupt	`BreakInterruptFcn`
Bytes available	`BytesAvailableFcn`
	`BytesAvailableFcnCount`
	`BytesAvailableFcnMode`
Error	`ErrorFcn`
Output empty	`OutputEmptyFcn`
Pin status	`PinStatusFcn`
Timer	`TimerFcn`
	`TimerPeriod`

The break-interrupt and pin-status events are described below. For a description of the other event types, refer to "Event Types and Callback Properties" on page 4-30.

Break-Interrupt Event

A break-interrupt event is generated immediately after a break interrupt is generated by the serial port. The serial port generates a break interrupt when the received data has been in an inactive state longer than the transmission time for one character.

This event executes the callback function specified for the BreakInterruptFcn property. It can be generated for both synchronous and asynchronous read and write operations.

Pin-Status Event

A pin-status event is generated immediately after the state (pin value) changes for the CD, CTS, DSR, or RI pins. Refer to "Serial Port Signals and Pin Assignments" on page 6-4 for a description of these pins.

This event executes the callback function specified for the PinStatusFcn property. It can be generated for both synchronous and asynchronous read and write operations.

Storing Event Information

You can store event information in a callback function or in a record file. Event information stored in a callback function uses two fields: Type and Data. The Type field contains the event type, while the Data field contains event-specific information. As described in "Creating and Executing Callback Functions" on page 4-32, these two fields are associated with a structure that you define in the callback function header. Refer to "Debugging: Recording Information to Disk" on page 12-6 to learn about storing event information in a record file.

The event types and the values for the Type and Data fields are given below.

Serial Port Event Information

Event Type	Field	Field Value
Break interrupt	`Type`	`BreakInterrupt`
	`Data.AbsTime`	day-month-year hour:minute:second
Bytes available	`Type`	`BytesAvailable`
	`Data.AbsTime`	day-month-year hour:minute:second
Error	`Type`	`Error`
	`Data.AbsTime`	day-month-year hour:minute:second
	`Data.Message`	An error string
Output empty	`Type`	`OutputEmpty`
	`Data.AbsTime`	day-month-year hour:minute:second
Pin status	`Type`	`PinStatus`
	`Data.AbsTime`	day-month-year hour:minute:second
	`Data.Pin`	`CarrierDetect`, `ClearToSend`, `DataSetReady`, or `RingIndicator`
	`Data.PinValue`	on or off
Timer	`Type`	`Timer`
	`Data.AbsTime`	day-month-year hour:minute:second

The `Data` field values are described below.

The AbsTime Field

AbsTime is defined for all events, and indicates the absolute time the event occurred. The absolute time is returned using the MATLAB clock format.

day-month-year hour:minute:second

The Pin Field

Pin is used by the pin status event to indicate if the CD, CTS, DSR, or RI pins changed state. Refer to "Serial Port Signals and Pin Assignments" on page 6-4 for a description of these pins.

The PinValue Field

PinValue is used by the pin status event to indicate the state of the CD, CTS, DSR, or RI pins. Possible values are on or off.

The Message Field

Message is used by the error event to store the descriptive message that is generated when an error occurs.

Example: Using Events and Callbacks

This example uses the M-file callback function instrcallback to display event-related information to the command line when a bytes-available event or an output-empty event occurs:

1 **Create an instrument object** — Create the serial port object s associated with serial port COM1.

```
s = serial('COM1');
```

2 **Connect to the instrument** — Connect s to the Tektronix TDS 210 oscilloscope. Because the default value for the ReadAsyncMode property is continuous, data is asynchronously returned to the input buffer as soon as it is available from the instrument.

```
fopen(s)
```

3 Configure properties — Configure s to execute the callback function instrcallback when a bytes-available event or an output-empty event occurs.

```
s.BytesAvailableFcnMode = 'terminator';
s.BytesAvailableFcn = @instrcallback;
s.OutputEmptyFcn = @instrcallback;
```

4 Write and read data — Write the RS232? command asynchronously to the oscilloscope. This command queries the RS-232 settings and returns the baud rate, the software flow control setting, the hardware flow control setting, the parity type, and the terminator.

```
fprintf(s,'RS232?','async')
```

instrcallback is called after the RS232? command is sent, and when the terminator is read. The resulting displays are shown below.

```
OutputEmpty event occurred at 17:37:21 for the object:
Serial-COM1.

BytesAvailable event occurred at 17:37:21 for the object:
Serial-COM1.
```

Read the data from the input buffer.

```
out = fscanf(s)
out =
9600;0;0;NONE;LF
```

5 Disconnect and clean up — When you no longer need s, you should disconnect it from the instrument, and remove it from memory and from the MATLAB workspace.

```
fclose(s)
delete(s)
clear s
```

Using Control Pins

As described in "Serial Port Signals and Pin Assignments" on page 6-4, 9-pin serial ports include six control pins. These control pins allow

- "Signaling the Presence of Connected Devices" on page 6-28
- "Controlling the Flow of Data: Handshaking" on page 6-31

The properties associated with the serial port control pins are given below.

Serial Port Control Pin Properties

Property Name	Description
DataTerminalReady	Specify the state of the DTR pin.
FlowControl	Specify the data flow control method to use.
PinStatus	Indicate the state of the CD, CTS, DSR, and RI pins.
RequestToSend	Specify the state of the RTS pin.

Signaling the Presence of Connected Devices

DTEs and DCEs often use the CD, DSR, RI, and DTR pins to indicate whether a connection is established between serial port devices. Once the connection is established, you can begin to write or read data.

You can monitor the state of the CD, DSR, and RI pins with the PinStatus property. You can specify or monitor the state of the DTR pin with the DataTerminalReady property.

The following example illustrates how these pins are used when two modems are connected to each other.

Example: Connecting Two Modems

This example connects two modems to each other via the same computer, and illustrates how you can monitor the communication status for the computer-modem connections, and for the modem-modem connection. The

first modem is connected to COM1, while the second modem is connected to COM2:

1 **Create the instrument objects** — After the modems are powered on, the serial port object s1 is created for the first modem, and the serial port object s2 is created for the second modem.

```
s1 = serial('COM1');
s2 = serial('COM2');
```

2 **Connect to the instruments** — s1 and s2 are connected to the modems. Because the default value for the ReadAsyncMode property is continuous, data is asynchronously returned to the input buffers as soon as it is available from the modems.

```
fopen(s1)
fopen(s2)
```

Because the default value of the DataTerminalReady property is on, the computer (data terminal) is now ready to exchange data with the modems. You can verify that the modems (data sets) are ready to communicate with the computer by examining the value of the Data Set Ready pin using thePinStatus property.

```
s1.Pinstatus
ans =
     CarrierDetect: 'off'
       ClearToSend: 'on'
      DataSetReady: 'on'
     RingIndicator: 'off'
```

The value of the DataSetReady field is on because both modems were powered on before they were connected to the objects.

3 **Configure properties —** Both modems are configured for a baud rate of 2400 bits per second and a carriage return (CR) terminator.

```
s1.BaudRate = 2400;
s1.Terminator = 'CR';
s2.BaudRate = 2400;
s2.Terminator = 'CR';
```

4 Write and read data — Write the atd command to the first modem. This command puts the modem "off the hook," which is equivalent to manually lifting a phone receiver.

```
fprintf(s1,'atd')
```

Write the ata command to the second modem. This command puts the modem in "answer mode," which forces it to connect to the first modem.

```
fprintf(s2,'ata')
```

After the two modems negotiate their connection, you can verify the connection status by examining the value of the Carrier Detect pin using the PinStatus property.

```
s1.PinStatus
ans =
    CarrierDetect: 'on'
      ClearToSend: 'on'
     DataSetReady: 'on'
    RingIndicator: 'off'
```

You can also verify the modem-modem connection by reading the descriptive message returned by the second modem.

```
s2.BytesAvailable
ans =
    25
out = fread(s2,25);
char(out)'
ans =
ata
CONNECT 2400/NONE
```

Now break the connection between the two modems by configuring the DataTerminalReady property to off. You can verify that the modems are disconnected by examining the Carrier Detect pin value.

```
s1.DataTerminalReady = 'off';
s1.PinStatus
ans =
    CarrierDetect: 'off'
```

```
    ClearToSend: 'on'
    DataSetReady: 'on'
   RingIndicator: 'off'
```

5 Disconnect and clean up — Disconnect the objects from the modems, and remove the objects from memory and from the MATLAB workspace.

```
fclose([s1 s2])
delete([s1 s2])
clear s1 s2
```

Controlling the Flow of Data: Handshaking

Data flow control or *handshaking* is a method used for communicating between a DCE and a DTE to prevent data loss during transmission. For example, suppose your computer can receive only a limited amount of data before it must be processed. As this limit is reached, a handshaking signal is transmitted to the DCE to stop sending data. When the computer can accept more data, another handshaking signal is transmitted to the DCE to resume sending data.

If supported by your device, you can control data flow using one of these methods:

- "Hardware Handshaking" on page 6-32
- "Software Handshaking" on page 6-32

Note Although you might be able to configure your device for both hardware handshaking and software handshaking at the same time, the Instrument Control Toolbox does not support this behavior.

You can specify the data flow control method with the FlowControl property. If FlowControl is hardware, then hardware handshaking is used to control data flow. If FlowControl is software, then software handshaking is used to control data flow. If FlowControl is none, then no handshaking is used.

Hardware Handshaking

Hardware handshaking uses specific serial port pins to control data flow. In most cases, these are the RTS and CTS pins. Hardware handshaking using these pins is described in "The RTS and CTS Pins" on page 6-7.

If `FlowControl` is `hardware`, then the RTS and CTS pins are automatically managed by the DTE and DCE. You can return the CTS pin value with the `PinStatus` property. You can configure or return the RTS pin value with the `RequestToSend` property.

Note Some devices also use the DTR and DSR pins for handshaking. However, these pins are typically used to indicate that the system is ready for communication, and are not used to control data transmission. For the Instrument Control Toolbox, hardware handshaking always uses the RTS and CTS pins.

If your device does not use hardware handshaking in the standard way, then you might need to manually configure the `RequestToSend` property. In this case, you should configure `FlowControl` to `none`. If `FlowControl` is `hardware`, then the `RequestToSend` value that you specify might not be honored. Refer to the device documentation to determine its specific pin behavior.

Software Handshaking

Software handshaking uses specific ASCII characters to control data flow. These characters, known as Xon and Xoff (or XON and XOFF), are described below.

Software Handshaking Characters

Character	Integer Value	Description
Xon	17	Resume data transmission.
Xoff	19	Pause data transmission.

When using software handshaking, the control characters are sent over the transmission line the same way as regular data. Therefore you need only the TD, RD, and GND pins.

The main disadvantage of software handshaking is that you cannot write the Xon or Xoff characters while numerical data is being written to the instrument. This is because numerical data might contain a 17 or 19, which makes it impossible to distinguish between the control characters and the data. However, you can write Xon or Xoff while data is being asynchronously read from the instrument because you are using both the TD and RD pins.

Example: Using Software Handshaking. Suppose you want to use software flow control in conjunction with your serial port application. To do this, you must configure the instrument and the serial port object for software flow control. For a serial port object s connected to a Tektronix TDS 210 oscilloscope, this configuration is accomplished with the following commands.

```
fprintf(s,'RS232:SOFTF ON')
s.FlowControl = 'software';
```

To pause data transfer, you write the numerical value 19 (Xoff) to the instrument.

```
fwrite(s,19)
```

To resume data transfer, you write the numerical value 17 (Xon) to the instrument.

```
fwrite(s,17)
```

Controlling Instruments Using TCP/IP and UDP

This chapter describes specific features related to controlling instruments that use the TCP/IP or UDP protocols. The sections are as follows.

TCP/IP and UDP Overview

Transmission Control Protocol (TCP or TCP/IP) and User Datagram Protocol (UDP or UDP/IP) are both transport protocols layered on top of the Internet Protocol (IP). TCP/IP and UDP are compared below:

- **Connection Versus Connectionless** — TCP/IP is a connection-based protocol, while UDP is a connectionless protocol. In TCP/IP, the two ends of the communication link must be connected at all times during the communication. An application using UDP prepares a packet and sends it to the receiver's address without first checking to see if the receiver is ready to receive a packet. If the receiving end is not ready to receive a packet, the packet is lost.

- **Stream Versus Packet** — TCP/IP is a stream-oriented protocol, while UDP is a packet-oriented protocol. This means that TCP/IP is considered to be a long stream of data that is transmitted from one end of the connection to the other end, and another long stream of data flowing in the opposite direction. The TCP/IP stack is responsible for breaking the stream of data into packets and sending those packets while the stack at the other end is responsible for reassembling the packets into a data stream using information in the packet headers. UDP, on the other hand, is a packet-oriented protocol where the application itself divides the data into packets and sends them to the other end. The other end does not have to reassemble the data into a stream. Note, some applications might present the data as a stream when the underlying protocol is UDP. However, this is the layering of an additional protocol on top of UDP, and it is not something inherent in the UDP protocol itself.

- **TCP/IP Is a Reliable Protocol, While UDP Is Unreliable** — The packets that are sent by TCP/IP contain a unique sequence number. The starting sequence number is communicated to the other side at the beginning of communication. The receiver acknowledges each packet, and the acknowledgment contains the sequence number so that the sender knows which packet was acknowledged. This implies that any packets lost on the way can be retransmitted (the sender would know that they did not reach their destination because it had not received an acknowledgment). Also, packets that arrive out of sequence can be reassembled in the proper order by the receiver.

Further, timeouts can be established because the sender knows (from the first few packets) how long it takes on average for a packet to be sent and its acknowledgment received. UDP, on the other hand, sends the packets and does not keep track of them. Thus, if packets arrive out of sequence, or are lost in transmission, the receiving end (or the sending end) has no way of knowing.

Note that "unreliable" is used in the sense of "not guaranteed to succeed" as opposed to "will fail a lot of the time." In practice, UDP is quite reliable as long as the receiving socket is active and is processing data as quickly as it arrives.

Creating a TCPIP Object

You create a TCPIP object with the `tcpip` function. `tcpip` requires the name of the remote host as an input argument. In most cases, you need to specify the remote port value. If you do not specify the remote port, then 80 is used. As described in "Configuring Properties During Object Creation" on page 3-2, you can also configure property values during object creation.

Each TCPIP object is associated with one instrument. For example, to create a TCPIP object for a Sony/Tektronix AWG520 Arbitrary Waveform Generator,

```
t = tcpip('sonytekawg.mathworks.com',4000);
```

Note that the port number is fixed and is found in the instrument's documentation.

The TCPIP object `t` now exists in the MATLAB workspace. You can display the class of `t` with the `whos` command.

```
whos t
  Name       Size                  Bytes  Class

  t          1x1                     640  tcpip object

  Grand total is 16 elements using 640 bytes
```

Once the TCPIP object is created, the properties listed below are automatically assigned values. These general purpose properties provide descriptive information about the TCPIP object based on the object type, the remote host, and the remote port.

TCPIP Descriptive Properties

Property Name	Description
Name	Specify a descriptive name for the TCPIP object.
RemoteHost	Specify the remote host.
RemotePort	Specify the remote host port for the connection.
Type	Indicate the object type.

You can display the values of these properties for t with the get function.

```
get(t,{'Name','RemoteHost','RemotePort','Type'})
ans =
    [1x31 char]    [1x24 char]    [4000]    'tcpip'
```

The TCPIP Object Display

The TCPIP object provides you with a convenient display that summarizes important configuration and state information. You can invoke the display summary these three ways:

- Type the TCPIP object variable name at the command line.

- Exclude the semicolon when creating a TCPIP object.

- Exclude the semicolon when configuring properties using the dot notation.

You can also display summary information via the Workspace browser by right-clicking an instrument object and selecting **Display Summary** from the context menu.

The display summary for the TCPIP object t is given below.

```
TCPIP Object : TCPIP-sonytekawg.mathworks.com

Communication Settings
   RemotePort:        4000
   RemoteHost:        sonytekawg.mathworks.com
   Terminator:        'LF'

Communication State
```

```
Status:              closed
RecordStatus:        off

Read/Write State
   TransferStatus:   idle
   BytesAvailable:   0
   ValuesReceived:   0
   ValuesSent:       0
```

Example: Communicating with a Remote Host

In this example, you read a page from the MathWorks Web site using a TCPIP object:

1 **Create and configure an instrument object** — First you create a TCPIP object in MATLAB. Port 80 is the standard port for Web servers.

   ```
   t = tcpip('www.mathworks.com', 80);
   ```

   By default, the TCPIP object has an InputBufferSize of 512, which means it can only read 512 bytes at a time. The MathWorks Web page data is much greater than 512 bytes, so you need to set a larger value for this property.

   ```
   set(t, 'InputBufferSize', 30000);
   ```

2 **Connect the object** — Next, you open the connection to the server. If the server is not present or is not accepting connections you would get an error here.

   ```
   fopen(t);
   ```

3 **Write and read data** — You can now communicate with the server using the functions fprintf, fscanf, fwrite, and fread.

   To ask a Web server to send a Web page, you use the GET command. You can ask for the main Web page from www.mathworks.com using 'GET /'.

   ```
   fprintf(t, 'GET /');
   ```

The server receives the command and sends back the Web page. You can see if any data was sent back by looking at the BytesAvailable property of the object.

```
get(t, 'BytesAvailable')
```

Now you can start to read the Web page data. By default, fscanf reads one line at a time. You can read lines of data until the BytesAvailable value is 0. Note that you will not see a rendered web page; just the HTML file data will scroll by on the screen.

```
while (get(t, 'BytesAvailable') > 0)    A = fscanf(t)end
```

4 Disconnect and clean up — If you want to do more communication, you can continue to read and write data here. If you are done with the object, close it and delete it.

```
fclose(t);
delete(t);
clear t
```

Example: Server Drops the Connection

This example shows what happens when a TCPIP object loses its connection with a remote server. The server is a Sony/Tektronix AWG520 Arbitrary Waveform Generator (AWG). Its address is sonytekawg.mathworks.com and its port is 4000. The AWG's host IP address is 192.168.1.10 and is user configurable in the instrument. The associated host name is given by your network administrator. The port number is fixed and is found in the instrument's documentation.

The AWG can drop the connection because it is taken off line, it is powered down, and so on:

1 Create an instrument object — Create a TCPIP object for the AWG.

```
t = tcpip('sonytekawg.mathworks.com', 4000);
```

2 Connect to the instrument — Connect to the remote instrument.

```
fopen(t)
```

3 Write and read data — Write a command to the instrument and read back the result.

```
fprintf(t,'*IDN?')
fscanf(t)
ans =
SONY/TEK,AWG520,0,SCPI:95.0 OS:2.0 USR:2.0
```

Assume that the server drops the connection. If you attempt to read from the instrument, a timeout occurs and a warning is displayed.

```
fprintf(t,'*IDN?')
fscanf(t)

Warning: A timeout occurred before the Terminator was reached.
(Type "warning off instrument:fscanf:unsuccessfulRead" to
suppress this warning.)
ans =
     ''
```

At this point, the object and the instrument are still connected.

```
get(t,'Status')
ans =
open
```

If you attempt to write to the instrument again, an error message is returned and the connection is automatically closed.

```
fprintf(t,'*IDN?')
??? Error using ==> fprintf
Connection closed by RemoteHost. Use FOPEN to connect to
RemoteHost.
```

Note that if the TCPIP object is connected to the local host, the warning message is not displayed. Instead, the error message is displayed following the next read operation after the connection is dropped.

4 Disconnect and clean up — When you no longer need t, you should disconnect it from the host, and remove it from memory and from the MATLAB workspace.

```
fclose(t)
delete(t)
clear t
```

Creating a UDP Object

You create a UDP object with the udp function. udp does not require the name of the remote host as an input argument. However, if you are using the object to communicate with a specific instrument, you should specify the remote host and the port number. As described in "Configuring Properties During Object Creation" on page 3-2, you can also configure property values during object creation.

For example, to create a UDP object associated with the remote host 127.0.0.1 and the remote port 4012,

```
u = udp('127.0.0.1',4012);
```

The UDP object u now exists in the MATLAB workspace. You can display the class of u with the whos command.

```
whos u
  Name      Size                   Bytes  Class

  u         1x1                      632  udp object

  Grand total is 12 elements using 632 bytes
```

Once the UDP object is created, the properties listed below are automatically assigned values. These general purpose properties provide descriptive information about the UDP object based on the object type, the remote host, and the remote port.

UDP Descriptive Properties

Property Name	Description
Name	Specify a descriptive name for the UDP object.
RemoteHost	Specify the remote host.
RemotePort	Specify the remote host port for the connection.
Type	Indicate the object type.

You can display the values of these properties for t with the get function.

```
get(u,{'Name','RemoteHost','RemotePort','Type'})
ans =
    'UDP-127.0.0.1'    '127.0.0.1'    [4012]    'udp'
```

The UDP Object Display

The UDP object provides you with a convenient display that summarizes important configuration and state information. You can invoke the display summary these three ways:

- Type the UDP object variable name at the command line.

- Exclude the semicolon when creating a UDP object.

- Exclude the semicolon when configuring properties using the dot notation.

You can also display summary information via the Workspace browser by right-clicking an instrument object and selecting **Display Summary** from the context menu.

The display summary for the UDP object u is given below.

```
UDP Object : UDP-127.0.0.1

Communication Settings
   RemotePort:        4012
   RemoteHost:        127.0.0.1
   Terminator:        'LF'

Communication State
```

```
Status:              closed
RecordStatus:        off

Read/Write State
    TransferStatus:      idle
    BytesAvailable:      0
    ValuesReceived:      0
    ValuesSent:          0
```

Example: Communicating Between Two Hosts

This example illustrates how you can use UDP objects to communicate between two dedicated hosts. In this example, you know the names of both hosts and the ports they use for communication with each other. One host has the name doejohn.dhpc, using local port 8844; and the other host is doetom.dhpc, using local port 8866. Note that each host regards the other host's port as the RemotePort:

1 **Create interface objects** — Create a UDP object on each host, referencing the other as the remote host.

   On host doejohn.dhpc, create u1. The object constructor specifies the name of the remote host, the remote port on that other host, and the local port to use on the machine where this object is created:

   ```
   u1 = udp('doetom.dhpc', 'RemotePort', 8866, 'LocalPort', 8844)
   ```

   On host doetom.dhpc, create u2:

   ```
   u2 = udp('doejohn.dhpc', 'RemotePort', 8844, 'LocalPort', 8866)
   ```

2 **Connect the objects** — Open both UDP objects, so that each can communicate with the other host.

   On host doejohn.dhpc, open u1:

   ```
   fopen(u1)
   ```

   On host doetom.dhpc, open u2:

   ```
   fopen(u2)
   ```

3 Write and read data — Communication between the two hosts is now a matter of sending and receiving data. Write a message from `doejohn.dhpc` to `doetom.dhpc`.

On host `doejohn.dhpc`, write data to the remote host via u1:

```
fprintf(u1, 'Ready for data transfer.')
```

On host `doetom.dhpc`, read data coming in from the remote host via u2:

```
fscanf(u2)
ans =
Ready for data transfer.
```

4 Disconnect and clean up — When you no longer need u1 on host `doejohn.dhpc`, you should disconnect it and remove it from memory and from the MATLAB workspace.

```
fclose(u1)
delete(u1)
clear u1
```

When u2 is no longer needed, perform a similar cleanup on the host `doetom.dhpc`.

```
fclose(u2)
delete(u2)
clear u2
```

Writing and Reading Data

This section describes interface-specific issues related to writing and reading data with TCPIP and UDP objects. Topics include

- "Rules for Completing Write and Read Operations" on page 7-14
- "Example: Writing and Reading Data with a TCPIP Object" on page 7-15
- "Example: Writing and Reading Data with a UDP Object" on page 7-18

For a general overview about writing and reading data, as well as a list of all associated functions and properties, refer to "Communicating with Your Instrument" on page 2-8.

Rules for Completing Write and Read Operations

The rules for completing synchronous and asynchronous read and write operations are described below.

Completing Write Operations

A write operation using fprintf or fwrite completes when one of these conditions is satisfied:

- The specified data is written.
- The time specified by the Timeout property passes.

In addition to these rules, you can stop an asynchronous write operation at any time with the stopasync function.

A text command is processed by the instrument only when it receives the required terminator. For TCPIP and UDP objects, each occurrence of \n in the ASCII command is replaced with the Terminator property value. Because the default format for fprintf is %s\n, all commands written to the instrument will end with the Terminator value. The default value of Terminator is the line feed character. The terminator required by your instrument will be described in its documentation.

Completing Read Operations

A read operation with `fgetl`, `fgets`, `fscanf`, or `readasync` completes when one of these conditions is satisfied:

• The terminator specified by the `Terminator` property is read. For UDP objects, `DatagramTerminateMode` must be `off`.

• The time specified by the `Timeout` property passes.

• The input buffer is filled.

• The specified number of values is read (`fscanf` and `readasync` only). For UDP objects, `DatagramTerminateMode` must be `off`.

• A datagram is received (for UDP objects, only when `DatagramTerminateMode` is `on`).

A read operation with `fread` completes when one of these conditions is satisfied:

• The time specified by the `Timeout` property passes.

• The input buffer is filled.

• The specified number of values is read. For UDP objects, `DatagramTerminateMode` must be `off`.

• A datagram is received (for UDP objects, only when `DatagramTerminateMode` is `on`).

In addition to these rules, you can stop an asynchronous read operation at any time with the `stopasync` function.

Example: Writing and Reading Data with a TCPIP Object

This example illustrates how to use text and binary read and write operations with a TCPIP object connected to a remote instrument. In this example, you create a vector of waveform data in MATLAB, upload the data to the instrument, and then read back the waveform.

The instrument is a Sony/Tektronix AWG520 Arbitrary Waveform Generator (AWG). Its address is `sonytekawg.mathworks.com` and its port is 4000.

The AWG's host IP address is 192.168.1.10 and is user configurable in the instrument. The associated host name is given by your network administrator. The port number is fixed and is found in the instrument's documentation:

1 **Create an instrument object** — Create a TCPIP object associated with the AWG.

```
t = tcpip('sonytekawg.mathworks.com',4000);
```

2 **Connect to the instrument** — Before establishing a connection, the OutputBufferSize must be large enough to hold the data being written. In this example, 2577 bytes are written to the instrument. Therefore, the OutputBufferSize is set to 3000.

```
set(t,'OutputBufferSize',3000)
```

You can now connect t to the instrument.

```
fopen(t)
```

3 **Write and read data** — Since the instrument's byte order is little-endian, configure the ByteOrder property to littleEndian.

```
set(t,'ByteOrder','littleEndian')
```

Create the sine wave data.

```
x = (0:499).*8*pi/500;
data = sin(x);
marker = zeros(length(data),1);
marker(1) = 3;
```

Instruct the instrument to write the file sin.wfm with Waveform File format, a total length of 2544 bytes, and a combined data and marker length of 2500 bytes.

```
fprintf(t,'%s',['MMEMORY:DATA "sin.wfm",#42544MAGIC 1000' 13 10])
fprintf(t,'%s','#42500')
```

Write the sine wave to the instrument.

```
for (i = 1:length(data)),
 fwrite(t,data(i),'float32');
 fwrite(t,marker(i));
end
```

Instruct the instrument to use a clock frequency of 100 MS/s for the waveform.

```
fprintf(t,'%s',['CLOCK 1.0000000000e+008' 13 10 10])
```

Read the waveform stored in the function generator's hard drive. The waveform contains 2000 bytes plus markers, header, and clock information. To store this data, close the connection and configure the input buffer to hold 3000 bytes.

```
fclose(t)
set(t,'InputBufferSize',3000)
```

Reopen the connection to the instrument.

```
fopen(t)
```

Read the file sin.wfm from the function generator.

```
fprintf(t,'MMEMORY:DATA? "sin.wfm" ')
data = fread(t,t.BytesAvailable);
```

The next set of commands reads the same waveform as a float32 array. To begin, write the waveform to the AWG.

```
fprintf(t,'MMEMORY:DATA? "sin.wfm" ')
```

Read the file header as ASCII characters.

```
header1 = fscanf(t)
header1 =
#42544MAGIC 1000
```

Read the next six bytes, which specify the length of data.

```
header2 = fscanf(t,'%s',6)
header2 =
#42500
```

Read the waveform using `float32` precision and read the markers using `uint8` precision. Note that one `float32` value consists of four bytes. Therefore, the following commands read 2500 bytes.

```
data = zeros(500,1);
marker = zeros(500,1);
for i = 1:500,
 data(i) = fread(t,1,'float32');
 marker(i) = fread(t,1,'uint8');
end
```

Read the remaining data, which consists of clock information and termination characters.

```
clock = fscanf(t);
cleanup = fread(t,2);
```

4 Disconnect and clean up — When you no longer need t, you should disconnect it from the host, and remove it from memory and from the MATLAB workspace.

```
fclose(t)
delete(t)
clear t
```

Example: Writing and Reading Data with a UDP Object

This example illustrates how to use text read and write operations with a UDP object connected to a remote instrument.

The instrument used is an echo server on a Linux-based PC. An echo server is a service available from the operating system that returns (echoes) received data to the sender. The host name is daqlab11 and the port number is 7. The host name is assigned by your network administrator.

1 Create an instrument object — Create a UDP object associated with daqlab11.

```
u = udp('daqlab11',7);
```

2 Connect to the instrument — Connect u to the echo server.

```
fopen(u)
```

3 Write and read data — You use the fprintf function to write text data to the instrument. For example, write the following string to the echo server.

```
fprintf(u,'Request Time')
```

UDP sends and receives data in blocks that are called datagrams. Each time you write or read data with a UDP object, you are writing or reading a datagram. For example, the string sent to the echo server constitutes a datagram with 13 bytes — 12 ASCII bytes plus the line feed terminator.

You use the fscanf function to read text data from the echo server.

```
fscanf(u)
ans =
Request Time
```

The DatagramTerminateMode property indicates whether a read operation terminates when a datagram is received. By default, DatagramTerminateMode is on and a read operation terminates when a datagram is received. To return multiple datagrams in one read operation, set DatagramTerminateMode to off.

The following commands write two datagrams. Note that only the second datagram sends the terminator character.

```
fprintf(u,'%s','Request Time')
fprintf(u,'%s\n','Request Time')
```

Since `DatagramTerminateMode` is `off`, `fscanf` reads across datagram boundaries until the terminator character is received.

```
set(u,'DatagramTerminateMode','off')
data = fscanf(u)
data =
Request TimeRequest Time
```

4 **Disconnect and clean up** — When you no longer need u, you should disconnect it from the host, and remove it from memory and from the MATLAB workspace.

```
fclose(u)
delete(u)
clear u
```

Events and Callbacks

This section describes interface-specific issues related to using events and callbacks with a TCPIP or UDP object. Topics include

- Event types and callback properties
- Storing event information
- An example that uses the datagram-received event and the `instrcallback` function

For a general overview of events and callbacks, including how to create and execute callback functions, refer to "Events and Callbacks" on page 4-29.

Event Types and Callback Properties

The event types and associated callback properties supported by TCPIP and UDP objects are listed below.

TCPIP and UDP Event Types and Callback Properties

Event Type	Associated Properties
Bytes available	`BytesAvailableFcn`
	`BytesAvailableFcnCount`
	`BytesAvailableFcnMode`
Datagram received	`DatagramReceivedFcn` (UDP objects only)
Error	`ErrorFcn`
Output empty	`OutputEmptyFcn`
Timer	`TimerFcn`
	`TimerPeriod`

The datagram-received event is described below. For a description of the other event types, refer to "Event Types and Callback Properties" on page 4-30.

Datagram-Received Event

A datagram-received event is generated immediately after a complete datagram is received in the input buffer.

This event executes the callback function specified for the DatagramReceivedFcn property. It can be generated for both synchronous and asynchronous read operations.

Storing Event Information

You can store event information in a callback function or in a record file. Event information stored in a callback function uses two fields: Type and Data. The Type field contains the event type, while the Data field contains event-specific information. As described in "Creating and Executing Callback Functions" on page 4-32, these two fields are associated with a structure that you define in the callback function header. Refer to "Debugging: Recording Information to Disk" on page 12-6 to learn about storing event information in a record file.

The event types and the values for the Type and Data fields are given below.

TCPIP and UDP Event Information

Event Type	Field	Field Value
Bytes available	Type	BytesAvailable
	Data.AbsTime	day-month-year hour:minute:second
Datagram received	Type	DatagramReceived
	Data.AbsTime	day-month-year hour:minute:second
	Data.DatagramAddress	IP address string
	Data.DatagramLength	Number of bytes received as double
	Data.DatagramPort	Port number of sender as double

TCPIP and UDP Event Information (Continued)

Event Type	Field	Field Value
Error	Type	Error
	Data.AbsTime	day-month-year hour:minute:second
	Data.Message	An error string
Output empty	Type	OutputEmpty
	Data.AbsTime	day-month-year hour:minute:second
Timer	Type	Timer
	Data.AbsTime	day-month-year hour:minute:second

The Data field values are described below.

The AbsTime Field

AbsTime is defined for all events, and indicates the absolute time the event occurred. The absolute time is returned using the MATLAB clock format.

    day-month-year hour:minute:second

The DatagramAddress Field

DatagramAddress is the IP address of the datagram sender.

The DatagramLength Field

DatagramLength is the length of the datagram in bytes.

The DatagramPort Field

DatagramPort is the sender's port number from which the datagram originated.

The Message Field

Message is used by the error event to store the descriptive message that is generated when an error occurs.

Example: Using Events and Callbacks

This example extends "Example: Communicating Between Two Hosts" on page 7-12 to include a datagram received callback. The callback function is instrcallback, which displays information to the command line indicating that a datagram has been received.

The following command configures the callback for the UDP object u2.

```
u2.DatagramReceivedFcn = @instrcallback;
```

When a datagram is received, the following message is displayed.

```
DatagramReceived event occurred at 10:26:20 for the object:
UDP-doetom.dhpc.
25 bytes were received from address 192.168.1.12, port 8844.
```

Using Device Objects

This chapter describes specific features and actions related to using device objects. The sections are as follows.

Device Object Overview

This section provides an overview of device objects in MATLAB.

Topics include

- "What Are Device Objects?" on page 8-2
- "Device Objects for MATLAB Instrument Drivers" on page 8-3

All instruments attached to your computer must communicate through an interface. Popular interface protocols include GPIB, VISA, and RS-232 (serial). While Instrument Control interface objects allow you to communicate with your equipment at a low (instrument command) level, the Instrument Control Toolbox also allows you to communicate with your equipment without detailed knowledge of how the hardware interface operates.

Programmable devices understand a specific language, sometimes referred to as its command set. One common set is called SCPI (Standard Commands for Programmable Instruments).

Device objects allow you to configure and query an instrument without knowledge of its command set. This chapter covers the basic functionality of device objects that use MATLAB instrument drivers.

If your application is straightforward, or if you are already familiar with the topics mentioned above, you might want to begin with "Creating and Connecting Device Objects" on page 8-5. If you want a high-level description of all the steps you are likely to take when communicating with your instrument, refer to Chapter 2, "The Instrument Control Session".

What Are Device Objects?

Device objects are used to represent instruments in MATLAB. Properties and methods specific to an instrument are encapsulated within device objects. Device objects also free you from the specific underlying commands required to communicate with your hardware.

You can use device objects at the MATLAB command prompt, inside M-Functions, M-Scripts, and graphical user interface callbacks. The low-level communication is performed through a MATLAB instrument driver.
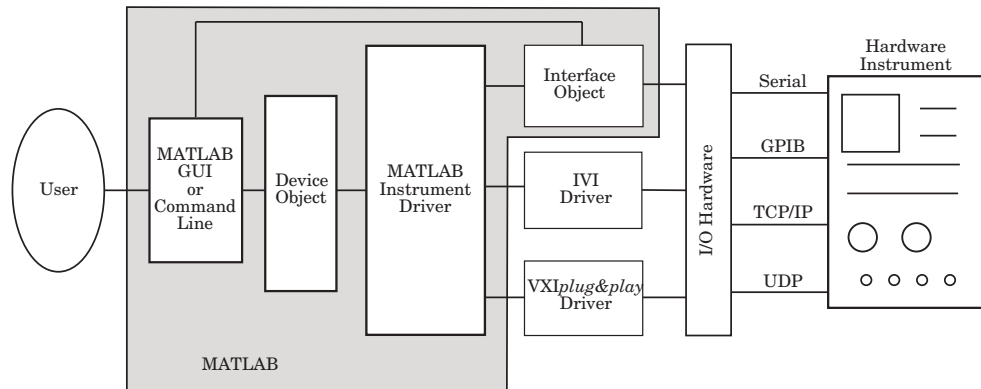
Device Objects for MATLAB Instrument Drivers

There are three types of MATLAB instrument drivers:

- MATLAB interface instrument driver

- MATLAB IVI instrument driver

- MATLAB VXI*plug&play* instrument driver

Instrument Control Toolbox device objects support all these types of MATLAB drivers, so that by using a device object, you can interface with any of these drivers in the same way. However, each of these drivers interfaces differently with the hardware. While MATLAB IVI and MATLAB VXI*plug&play* drivers interface directly through standard drivers and the hardware port to the instrument, the MATLAB interface driver requires an interface object to communicate with the instrument.

The Instrument Control Toolbox supports the following interface objects:

- gpib

- serial

- tcpip

- udp

- visa

To learn how to create and use interface objects, see Chapter 3, "Using Interface Objects".

Note If you are using an interface object with a device object and a MATLAB interface driver, you do not need to connect the interface object to the interface using the fopen command. You need to connect the device object only.

Available MATLAB Instrument Drivers

Several drivers ship with the Instrument Control Toolbox. You can find these drivers by looking in the directory

    matlabroot\toolbox\instrument\instrument\drivers

where *matlabroot* is the MATLAB installation directory, as seen when you type

    matlabroot

at the MATLAB command prompt.

Many other drivers are available on the MathWorks Web site at

    http://www.mathworks.com/matlabcentral/fileexchange

including drivers specifically for the Instrument Control Toolbox.

Creating and Connecting Device Objects

You create a device object with the `icdevice` command. For MATLAB interface instrument drivers, the `icdevice` command requires the device driver name and an interface object. As described in "Connecting to the Instrument" on page 2-5, you can also configure property values during object creation.

Device Objects for MATLAB Interface Drivers

Create a MATLAB device object to communicate with a Tektronix TDS 210 Oscilloscope. To communicate with the scope you will use a National Instruments GBIB controller.

1 First create an interface object for the GPIB hardware. The following command creates a GPIB object for a National Instruments GPIB board at index 0 with an instrument at primary address 1.

```
g = gpib('ni',0,1);
```

2 Now that you have created the interface object, you can construct a device object that uses it. The command to use is `icdevice`. You need to supply the name of the instrument driver, `tektronix_tds210`, and the interface object created for the GPIB controller, g.

```
d = icdevice('tektronix_tds210', g);
```

You can use the `whos` command to display the size and class of d.

```
whos d
  Name       Size                   Bytes  Class

  d          1x1                      652  icdevice object

Grand total is 22 elements using 652 bytes
```

Device Object Properties
A device object has a set of base properties and a set of properties defined by the driver. All device objects have the same base properties, regardless of the

driver being used. The driver properties are defined by the driver specified in the `icdevice` constructor.

You can display the current values of all properties for `d` with the `get` command.

```
get(d)
```

The Device Object Display

Device objects provide you with a convenient display that summarizes important object information. You can invoke the display in these ways:

- Type the name of the device object at the command line.

- Exclude the semicolon when creating the device object.

- Exclude the semicolon when configuring properties using dot notation.

- Pass the object to the `disp` or `display` function.

The `display` summary for device object `d` is given below.

```
Instrument Device Object Using Driver : tektronix_tds210.mdd

   Instrument Information
     Type:               Oscilloscope
     Manufacturer:       Tektronix
     Model:              TDS210

   Driver Information
     DriverType:         MATLAB interface object
     DriverName:         tektronix_tds210.mdd
     DriverVersion:      1.0

   Communication State
     Status:             open
```

You can also display summary information via the Workspace browser by right-clicking a device object and selecting **Display Summary** from the context menu.

Device Objects for VXI*plug&play* and IVI Drivers

Creating the MATLAB Instrument Driver

The command-line function `makemid` creates a MATLAB instrument driver from a VXI*plug&play*, IVI-C, or IVI-COM driver, saving the new driver in a file on disk. The syntax is

```
makemid('driver','filename')
```

where `driver` is the original VXI*plug&play*, IVI-C, or IVI-COM driver name (identified by `instrhwinfo` or the Test & Measurement Tool), and `filename` is the file containing the newly created MATLAB instrument driver. See the `makemid` reference page for a full description of the function and all its options.

You can open the new driver in the MATLAB Instrument Driver Editor, and then modify and save it as required.

Creating the Device Object

After you create the MATLAB instrument driver by conversion, you create the device object with the filename of the new driver as an argument for `icdevice`.

For example, if the driver is created from a VXI*plug&play*, IVI-C, or directly from an IVI-COM driver,

```
obj = icdevice('ConvertedDriver.mdd','GPIB0::2::INSTR')
```

If the driver is created from an IVI-COM logical name,

```
obj = icdevice('ConvertedDriver.mdd')
```

Connecting the Device Object

Now that you have created the device object, you can connect it to the instrument with the `connect` function. To connect the device object, d, created in the last example, use the following command:

```
connect(d);
```

By default, the property settings are updated to reflect the current state of the instrument. You can modify the instrument settings to reflect the device

object's property values by passing an optional update parameter to `connect`. The update parameter can be either `object` or `instrument`. To have the instrument updated to the object's property values, the `connect` function from the previous example would be

```
connect(d, 'instrument');
```

If `connect` is successful, the device object's status property is set to `open`; otherwise it remains as `closed`. You can check the status of this property with the `get` function or by looking at the object display.

```
get(d, 'status')

ans =

    open
```

Communicating with Instruments

This section describes how to configure and communicate with instruments by using device objects.

Topics include

- "Configuring Instrument Settings" on page 8-9
- "Calling Device Object Methods" on page 8-10
- "Control Commands" on page 8-12

Once a device object has been created and connected, it can be used as the interface to an instrument. This chapter shows you how to access and configure your instrument's settings, as well as how to read and write data to the instrument.

Configuring Instrument Settings

Every device object contains properties specific to the instrument it represents. These properties are defined by the instrument driver used during device object creation. For example, there may be properties for an oscilloscope that allow you to adjust trigger parameters, or the contrast of the screen display.

Properties are assigned default values at device object creation. On execution of `connect` the object is updated to reflect the state of the instrument or vice versa, depending on the second argument given to `connect`.

You can obtain a full listing of configurable properties by calling the `set` command and passing the device object.

Example: Configuring Settings on an Oscilloscope

This example illustrates how to configure an instrument using a device object.

The instrument used is a Tektronix TDS 210 two-channel oscilloscope. A square wave is input into channel 1 of the oscilloscope. The task is to adjust the scope's settings so that triggering occurs on the falling edge of the signal:

1 **Create the device object —** Create a GPIB interface object, and then a device object for a TDS 210 oscilloscope.

```
g = gpib('ni',0,1);
d = icdevice('tektronix_tds210', g);
```

2 **Connect the device object** — Use the `connect` function to connect the device object to the instrument.

```
connect(d);
```

3 **Check the current `TriggerSlope` settings —** Use the `get` function to obtain the current value for the oscilloscope `TriggerSlope` property.

```
get(d, 'TriggerSlope')

ans =

    rising
```

The `TriggerSlope` is currently set to `rising`.

4 **Change the `TriggerSlope` setting** — If you want triggering to occur on the falling edge, you need to modify that setting in the device object. This can be accomplished with the `set` command.

```
set(d, 'TriggerSlope', 'falling');
```

This changes `TriggerSlope` to `falling`.

5 **Disconnect and clean up** — When you no longer need the device object, disconnect it from the instrument and remove it from memory. Remove the device object and interface object from the MATLAB workspace.

```
disconnect(d);
delete(d);
clear d g;
```

Calling Device Object Methods

Device objects contain methods specific to the instruments they represent. Implementation details are hidden behind a single function. Instrument-specific functions are defined in the MATLAB instrument driver.

The `methods` function displays all available driver-defined functions for the device object. The display is divided into two sections:

- Generic object functions
- Driver-specific object functions

To view the available methods, type

```
methods(obj)
```

Use the `instrhelp` function to get help on the device object functions.

```
instrhelp(obj, methodname);
```

To call instrument-specific methods you use the `invoke` function. `invoke` requires the device object and the name of the function. You must also provide input arguments, when appropriate. The following example demonstrates how to use `invoke` to obtain measurement data from an oscilloscope.

Example: Using Device Object Functions

This example illustrates how to call an instrument-specific device object function. Your task is to obtain the frequency measurement of a waveform. The instrument is a Tektronix TDS 210 two-channel oscilloscope.

The scope has been preconfigured with a square wave input into channel 1 of the oscilloscope. The hardware supports four different measurements: frequency, mean, period, and peak-to-peak. The requested measurement is signified with the use of an index variable from 1 to 4.

For demonstration purposes, the oscilloscope in this example has been preconfigured with the correct measurement settings:

1 **Create the device object** — Create a GPIB interface object and a device object for the oscilloscope.

```
g = gpib('ni',0,1);
d = icdevice('tektronix_tds210', g);
```

2 Connect the device object — Use the `connect` command to open the GPIB object and update the settings in the device object.

```
connect(d);
```

3 Obtain the frequency measurement — Use the `invoke` command and call `measure`. The `measure` function requires that an index parameter be specified. The value of the index specifies which measurement the oscilloscope should return. For the current setup of the Tektronix TDS 210 oscilloscope, an index of 1 indicates that frequency is to be measured.

```
invoke(d, 'measure', 1)

ans =

    999.9609
```

The frequency returned is 999.96 Hz, or nearly 1 kHz.

4 Disconnect and clean up — You no longer need the device object so you can disconnect it from the instrument. You should also delete it from memory and remove it from the MATLAB workspace.

```
disconnect(d);
delete(d);
clear d g;
```

Control Commands

Control commands are special functions and properties that exist for all device objects. You use control commands to identify an instrument, reset hardware settings, perform diagnostic routines, and retrieve instrument errors. The set of control commands consists of

- "InstrumentModel" on page 8-13
- "devicereset" on page 8-13
- "selftest" on page 8-13
- "geterror" on page 8-13

All control commands are defined within the MATLAB instrument driver for your device.

InstrumentModel

InstrumentModel is a device object property. When queried, the instrument identification command is sent to the instrument.

For example, for a Tektronix TDS 210 oscilloscope,

```
get(d, 'InstrumentModel')

ans =

TEKTRONIX,TDS 210,0,CF:91.1CT FV:v2.03 TDS2MM:MMV:v1.04
```

devicereset

To restore the factory settings on your instrument, use the devicereset function. When devicereset is called, the appropriate reset instruction is sent to your instrument.

The command accepts a connected device object and has no output arguments.

```
devicereset(obj);
```

selftest

This command requests that your instrument perform a self-diagnostic. The actual operations performed and output arguments are specific to the instrument your device object is connected to. selftest accepts a connected device object as an input argument.

```
result = selftest(obj);
```

geterror

You can retrieve error messages generated by your instrument with the geterror function. The returned messages are instrument specific. geterror accepts a connected device object as an input argument.

```
msg = geterror(obj);
```

Device Groups

Device groups are used to group several related properties. For example, a channel group might contain the input channels of an oscilloscope, and the properties and methods specific to the input channels on the instrument.

MATLAB instrument drivers specify the type and quantity of device groups for device objects.

Group objects can be accessed via the `get` command. For the Tektronix TDS 210 oscilloscope, there is a channel group that contains two group objects. The device property to access a group is always the group name.

```
chans = get(d, 'Channel')

   HwIndex:    HwName:    Type:           Name:
   1           CH1        scope-channel   Channel1
   2           CH2        scope-channel   Channel2
```

To display the functions that a device group object supports, use the `methods` function.

```
methods(chans(1))
```

You can also display a list of the group object's properties and their current settings with the `get` function.

```
get(chans(2))
```

To get help on a driver-specific property or function, use the `instrhelp` function, with the name of the function or property.

```
instrhelp(chans(1),'Coupling')
```

Example: Using Device Groups to Access Instrument Data

This example shows how to obtain waveform data from a Tektronix TDS 210 oscilloscope with a square wave signal input on channel 1. The methods used are specific to this instrument:

1 **Create and connect** — First, create the device object for the oscilloscope and then connect to the instrument.

```
g = gpib('ni',0,1);
d = icdevice('tektronix_tds210', g);
connect(d);
```

2 **Get the device group** — To retrieve waveform data, first gain access to the channel group for the device object.

```
c = get(d, 'Channel');
```

This group is specific for the hardware you are using. The TDS 210 oscilloscope has two input channels; therefore the channel group contains two channel group objects.

```
HwIndex:    HwName:    Type:            Name:
1           CH1        scope-channel    Channel1
2           CH2        scope-channel    Channel2
```

3 **Obtain the waveform** — Now that you have access to the channel group objects, you can call the getWaveform function to acquire the data. For this example, channel 1 of the oscilloscope is reading the signal. To access this channel, call getWaveform on the first object in the channel group array.

```
wave = invoke(c(1), 'getWaveform');
```

4 **View the data** — The wave variable now contains the waveform data from the oscilloscope. Use the plot command to view the data.

```
plot(wave);
```

5 **Disconnect and clean up** — Once the task is done, disconnect the hardware and free the memory used by the objects.

```
disconnect(d)
delete([d s])
clear d, s, c, wave;
```

Using VXI*plug&play* Drivers

This chapter describes the use of VXI*plug&play* drivers for instrument control. The sections are as follows.

Overview

The Instrument Control Toolbox can communicate with hardware using VXI*plug&play* drivers. The instrument manufacturers are most often the suppliers of these drivers.

For definitions and specifications of VXI*plug&play* drivers , see the Web site of the VXI*plug&play* Systems Alliance at `http://www.vxipnp.org`.

VISA Setup

A system must have VISA installed in order for VXI*plug&play* drivers to work. The driver installer software might specify certain VISA or other connectivity requirements.

To determine whether your system is properly configured with the necessary version of VISA, at the MATLAB prompt, type

```
instrhwinfo visa
ans =
    InstalledAdaptors: {'agilent'}
       JarFileVersion: 'Version 2.0 (R14)'
```

The cell array returned for `InstalledAdaptors` indicates which VISA software is installed. A 1x0 cell array indicates that no VISA is installed. Possible `InstalledAdaptors` values are `agilent`, `tek`, and `ni`.

If you do not have VISA installed, you need to install it. The software installation disk provided with your instrument might include VISA along with the instrument's VXI*plug&play* driver, or you might be able to download VISA from the instrument manufacturer's Web site.

Other Software Requirements

An instrument driver can have other software requirements in addition to or instead of VISA. Consult the driver documentation. The installer software itself might specify these requirements.

VXI*plug&play* Drivers

Installation

The VXI*plug&play* driver particular to a piece of equipment is usually provided by the equipment manufacturer as either an installation disk or as a Web download. Once the driver is installed, you can determine whether the configuration is visible to MATLAB by using the Test & Measurement Tool to view the current driver installations. Open the tool with

```
tmtool
```

Expand the `Instrument Drivers` node, and click `VXIplug&play Drivers`. Click the **Scan** button to update the display. All installed VXI*plug&play* drivers will be listed.
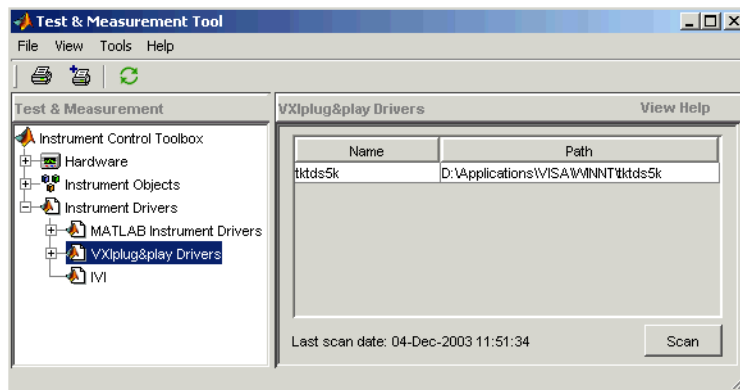
Alternatively, you can use the MATLAB command-line function `instrhwinfo` to find out which drivers are installed.

```
instrhwinfo ('vxipnp')
ans =
     InstalledDrivers: {'tktds5k', 'ag3325b', 'hpe363xa'}
        VXIPnPRootPath: 'C:\VXIPNP\WINNT'
```

The cell array returned for `InstalledDrivers` contains the names of all the installed VXI*plug&play* drivers. The string returned for `VXIPnPRootPath` indicates where the drivers are installed.

Creating a *MATLAB VXIplug&play* Instrument Driver

To use a VXI*plug&play* driver with a device object, you must have a MATLAB VXI*plug&play* instrument driver based upon the information in the original VXI*plug&play* driver. The MATLAB VXI*plug&play* instrument driver, whether modified or not, acts as a wrapper to the VXI*plug&play* driver. You can download or create the MATLAB instrument driver.

Downloading a Driver from the MathWorks Web Site

You might find an appropriate MATLAB driver wrapper for your instrument on the MathWorks Web site, on the Supported Hardware page for the Instrument Control Toolbox, at

```
http://www.mathworks.com/products/supportedio.html?prodCode=IC
```

On this page, click the **Instrument Drivers** link. You then have a choice to go to the **MATLAB Central File Exchange**, where you can look for the driver you need, or you can submit a request to the MathWorks for your particular driver with the **Instrument Driver Request Form**.

To use the downloaded MATLAB VXI*plug&play* driver, you must also have the instrument's VXI*plug&play* driver installed. This driver is probably available from the instrument manufacturer's Web site.

Creating a Driver with makemid

The command-line function makemid creates a MATLAB VXI*plug&play* instrument driver from a VXI*plug&play* driver, saving the new driver in a file on disk. The syntax is

```
makemid('driver','filename')
```

where driver is the original VXI*plug&play* instrument driver name (identified by instrhwinfo), and filename is the file containing the resulting MATLAB instrument driver. See the makemid reference page for details on this function.

If you need to customize the driver, open the new driver in the MATLAB Instrument Driver Editor, modify it as required, and save it.
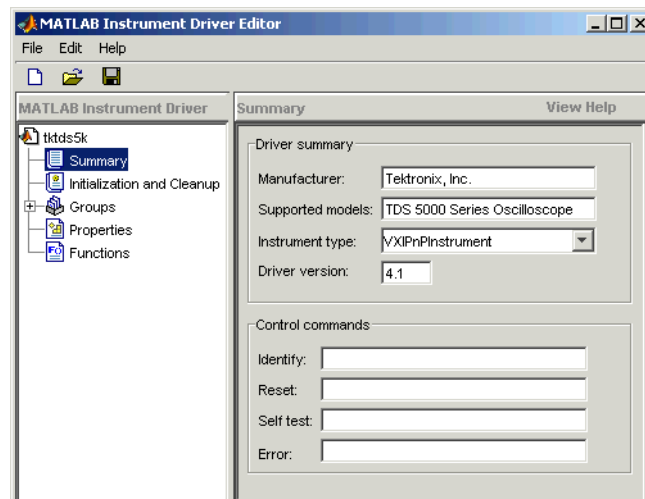
> **Note** When you create a MATLAB instrument driver based on a VXI*plug&play* driver, the original driver must remain installed on your system for you to use the new MATLAB instrument driver.

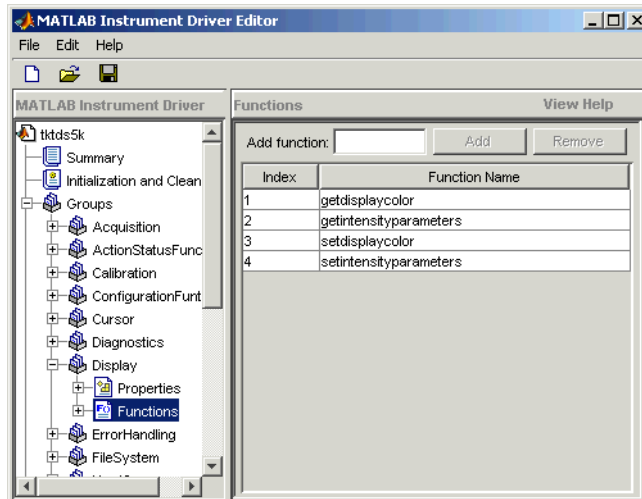### Importing with the MATLAB Instrument Driver Editor (midedit)

The MATLAB Instrument Driver Editor can import a VXI*plug&play* driver, thereby creating a MATLAB VXI*plug&play* instrument driver. You can evaluate or set the driver's functions and properties, and you can save the modified MATLAB instrument driver for further use:

1 Open the MATLAB Instrument Driver Editor with `midedit`.

2 Click the **File** menu and select the **Import** menu item.

3 In the **Import Driver** dialog box, select the VXI*plug&play* driver that you want to import and click **Import**.

The MATLAB Instrument Driver Editor loads the driver and displays the components of the driver, as shown in the following figures.

MATLAB Instrument Driver Editor Showing tktds5k MATLAB Instrument Driver Summary

tktds5k MATLAB Instrument Driver Display Group Functions

With the MATLAB Instrument Driver Editor, you can

- Create, delete, modify, and rename properties, functions, or groups

- Add M-code around instrument commands for analysis

- Add create, connect, and disconnect code

- Save the driver as a MATLAB VXI*plug&play* instrument driver

For more information, see Chapter 14, "The Instrument Driver Editor"

Note When you create a MATLAB instrument driver based on a VXI*plug&play* driver, the original driver must remain installed on your system for you to use the new MATLAB instrument driver.

Constructing Device Objects Using a MATLAB VXI*plug&play* Instrument Driver

Once you have the MATLAB VXI*plug&play* instrument driver, you create the device object with the filename of the driver and a VISA resource name as arguments for icdevice. For example,

```
obj = icdevice('MATLABVXIpnpDriver.mdd','GPIB0::2::INSTR')
connect(obj)
```

See the `icdevice` reference page for full details on this function.

Using IVI Drivers

This chapter describes the use of IVI drivers for instrument control. The sections are as follows.

Overview

The Instrument Control Toolbox can communicate with instruments using Interchangeable Virtual Instrument (IVI) drivers. The toolbox supports both IVI-C and IVI-COM drivers, provided by various instrument manufacturers.

For definitions and specifications of IVI drivers and their components, see the Web site of the IVI Foundation at http://www.ivifoundation.org.

VISA Setup

Most IVI drivers require that VISA be installed on your system. The driver installer software might specify certain VISA or other connectivity requirements.

To determine whether your system is properly configured with the necessary version of VISA, at the MATLAB prompt, type

```
instrhwinfo visa
ans =
    InstalledAdaptors: {'agilent'}
       JarFileVersion: 'Version 2.0 (R14)'
```

The cell array returned for `InstalledAdaptors` indicates which VISA software is installed. A 1x0 cell array indicates that no VISA is installed. Possible `InstalledAdaptors` values are `agilent`, `tek`, and `ni`.

If you need to install VISA, the software installation disk provided with your instrument might include VISA along with the instrument's IVI driver, or you might be able to download VISA from the instrument manufacturer's Web site.

An instrument driver can have other software requirements in addition to or instead of VISA. Consult the driver documentation. The installer software itself might specify these requirements.

IVI Shared Components

Many driver elements are common to a wide variety of instruments, so are not contained in the driver itself. Instead, these elements are delivered as *shared components*. Sharing components keeps the drivers themselves as small and

interchangeable as possible. You can use `instrhwinfo` to determine whether shared components are installed on your system; see "Installation" on page 10-4.

IVI Configuration Store Overview

An IVI configuration store is a configured arrangement of instrument drivers and I/O port references. For an overview of IVI configuration stores and their components, see "IVI Configuration Store" on page 10-11.

IVI Drivers

After your IVI driver is installed, you create a MATLAB IVI driver based on the IVI driver. With the MATLAB IVI driver, you construct a device object, which you use to communicate with your instrument.

IVI-C and IVI-COM

The Instrument Control Toolbox supports both IVI-C and IVI-COM drivers, with class-compliant and instrument-specific functionality. IVI class-compliant drivers are those that support common functionality across a family of related instruments. Class-compliant drivers might be appropriate if you want to use the basic functionality of an instrument, with the ability to swap instruments without changing the code in your application. An IVI instrument-specific driver or interface provides access to the instrument's unique functionality, and therefore generally does not accommodate instrument substitution.

In the case of IVI-C drivers, you can use IVI-C class drivers and IVI-C specific drivers. Device objects that are constructed to call IVI-C class drivers offer interchangeability between similar instruments, and will work with all instruments consistent with that class driver. Device objects constructed to directly call IVI-C specific drivers generally offer less interchangeability, but provide access to the unique methods and properties of a specific instrument.

Device objects that are constructed to use IVI-COM drivers might have access to both class-compliant and instrument-specific functionality. Most IVI-COM drivers contain instrument-specific properties and methods. Many also contain properties and methods that comply with IVI class specifications. This allows you to choose between interchangeability and instrument-specific functionality with the same driver. An application that uses only the class-compliant functionality of a driver works with all drivers that comply with the same IVI class. Applications that employ instrument-specific functionality might work only with that driver on that instrument.

Installation

The IVI driver particular to a piece of equipment is usually provided by the equipment manufacturer, either on an installation disk or as a Web download.

Required VISA software and IVI shared components might also come with the driver.

You can use the MATLAB command-line function `instrhwinfo` to find information on installed IVI drivers and shared components.

```
instrhwinfo ('ivi')
ans =
                 LogicalNames: {'MainScope', 'FuncGen'}
                   ProgramIDs: {'TekScope.TekScope','Agilent33250'}
                      Modules: {'ag3325b', 'hpe363xa'}
    ConfigurationServerVersion: '1.3.1.0'
      MasterConfigurationStore: 'C:\Program Files\IVI\Data\
                                 IviConfigurationStore.xml'
                   IVIRootPath: 'C:\Program Files\IVI\'
```

The `LogicalNames` are associated with particular IVI drivers, but they do not necessarily imply that the drivers are currently installed. Drivers can be installed that do not have a `LogicalName` property set yet, or drivers that had `LogicalName` set might have been removed.

`ConfigurationServerVersion`, `MasterConfigurationStore`, and `IVIRootPath` all convey information related to installed shared components. The `ConfigurationServerVersion` indicates whether IVI shared components are installed. If its value is an empty string, then no shared components were found.

Alternatively, you can use the Test & Measurement Tool to view the installation of IVI drivers and the setup of the IVI configuration store. Open the Test & Measurement Tool with

```
tmtool
```

Expand the `Instrument Drivers` node and click `IVI`. Click the **Software Modules** tab. (For information on the other IVI driver tabs and settings in the Test & Measurement Tool, see "IVI Configuration Store" on page 10-11.)
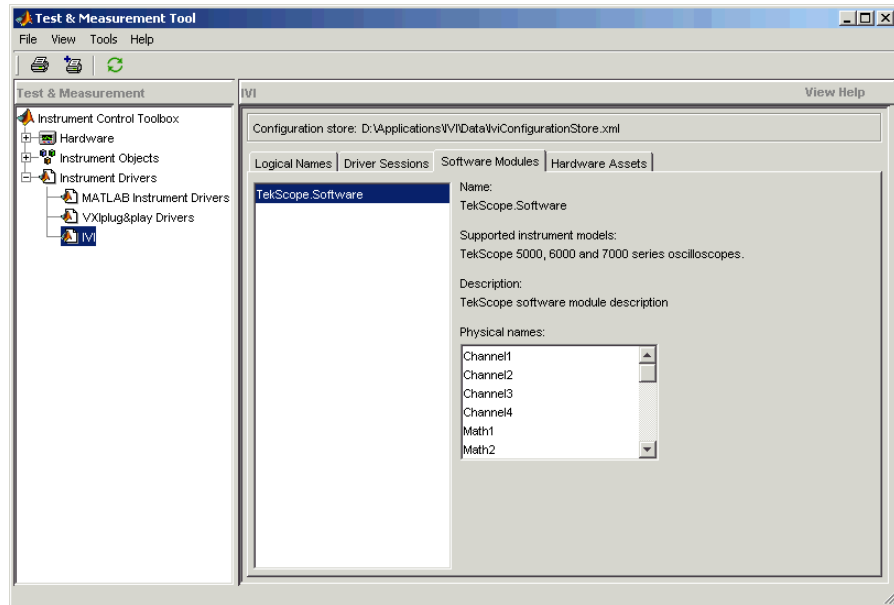
MATLAB IVI Instrument Drivers

To use an IVI driver with a device object, you must have a MATLAB IVI instrument driver based upon the information in the original IVI driver. The MATLAB IVI instrument driver, whether modified or not, acts as a wrapper to the IVI driver. You can download or create the MATLAB instrument driver.

Downloading a Driver from the MathWorks Web Site

You might find an appropriate MATLAB driver wrapper for your instrument on the MathWorks Web site, on the Supported Hardware page for the Instrument Control Toolbox, at

`http://www.mathworks.com/products/supportedio.html?prodCode=IC`

On this page, click the **Instrument Drivers** link. You then have a choice to go to the **MATLAB Central File Exchange**, where you can look for the driver you need, or you can submit a request to the MathWorks for your particular driver with the **Instrument Driver Request Form**.

To use the downloaded MATLAB IVI driver, you must also have the instrument's IVI driver installed. This driver might be available from the instrument manufacturer's Web site.

Creating a Driver with makemid

The command-line function `makemid` creates a MATLAB IVI instrument driver from an IVI driver, saving the new driver in a file on disk. The syntax is

```
makemid('driver','filename')
```

where `driver` is the original IVI driver name (identified by `instrhwinfo` or the Test & Measurement Tool), and `filename` is the file containing the conversion result. For `driver` you can use a `Module` (for IVI-C), a `ProgramID` (for IVI-COM), or a `LogicalName` (for either IVI-C or IVI-COM). See the `makemid` reference page for full details on this function.

If you need to customize the driver, open the new driver in the MATLAB Instrument Driver Editor, modify it as required, and save it.
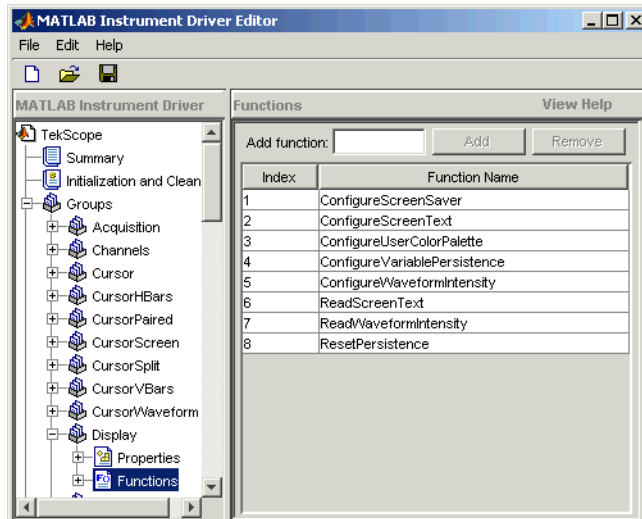

Note When you create a MATLAB instrument driver based on an IVI driver, the original driver must remain installed on your system for you to use the new MATLAB instrument driver.

Importing with the MATLAB Instrument Driver Editor (midedit)

The MATLAB Instrument Driver Editor can import an IVI driver, thereby creating a MATLAB IVI instrument driver. You can evaluate or set the driver's functions and properties, and you can save the modified MATLAB instrument driver for further use:

1 Open the MATLAB Instrument Driver Editor by typing `midedit`.

2 Click the **File** menu and select the **Import** menu item.

3 In the **Import Driver** dialog box, select the IVI driver that you want to import, and click **Import**.

The MATLAB Instrument Driver Editor loads the driver and displays its components, as shown in the following figure.

MATLAB Instrument Driver Editor Showing TekScope MATLAB Instrument Driver Display Group Functions

With the MATLAB Instrument Driver Editor, you can

- Create, delete, modify, and rename properties, functions, or groups

- Add M-code around instrument commands for analysis

- Add create, connect, and disconnect code

- Save the driver as a MATLAB IVI instrument driver

For more information, see Chapter 14, "The Instrument Driver Editor".

Note When you create a MATLAB instrument driver based on an IVI driver, the original driver must remain installed on your system for you to use the new MATLAB instrument driver.

Constructing Device Objects Using a MATLAB IVI Instrument Driver

Once you have the MATLAB IVI instrument driver, you create the device object with the filename of the MATLAB instrument driver as an argument for `icdevice`. The following examples show the creation of MATLAB IVI instrument drivers (all with `.mdd` extensions) and the construction of device objects to use them.

See the `icdevice` and `makemid` reference pages for full details on these functions.

In the following example, `makemid` uses a `LogicalName` to identify an IVI driver, then creates a MATLAB IVI driver. Because `LogicalName` is associated with a driver session and hardware asset, you do not need to pass a `RsrcName` to `icdevice` when constructing the device object.

```
makemid('MainScope','MainScope.mdd')
obj = icdevice('MainScope.mdd')
```

In the next example, `makemid` uses a `ProgramID` to reference an IVI-COM driver, then creates a MATLAB IVI instrument driver. The device object requires a `RsrcName` in addition to the filename of the MATLAB IVI instrument driver.

```
makemid('TekScope.TekScope','TekScopeML.mdd')
obj = icdevice('TekScopeML.mdd','GPIB0::13::INSTR')
```

In the next example, `makemid` uses a software `Module` to reference an IVI-C driver, then creates a MATLAB IVI instrument driver. The device object requires a `RsrcName` in addition to the filename of the MATLAB IVI instrument driver.

```
makemid('ag3325b','Ag3325bML.mdd')
obj = icdevice('Ag3325bML.mdd','ASRL1::INSTR')
```

In the next example, makemid creates a MATLAB IVI instrument driver based on the IVI-C class driver ivifgen. The device object uses the MATLAB IVI instrument driver filename and the logical name of the driver from the IVI configuration store.

```
makemid('ivifgen','FgenML.mdd')
obj = icdevice('FgenML.mdd','FuncGen')
```

IVI Configuration Store

This section describes the components of an IVI configuration store and how to examine or configure the IVI configuration store from MATLAB.

By providing a way outside of the application to configure the relationship between drivers and I/O interface references, an IVI configuration store greatly enhances instrument interchangeability.

Suppose your application uses only a specified driver to communicate with one type of instrument at a fixed location. If you change the instrument model, instrument location, or driver, you would have to modify the application to accommodate that change.

An IVI configuration store offers the ability to accommodate different instrument models, drivers, or ports, without having to modify your application. This is especially useful when using a compiled application that you cannot easily modify.

Components

The components of the IVI configuration store identify the locations of the instruments to communicate with, the software modules used to control the instruments, and the associations of which software modules are used with instruments at which locations.
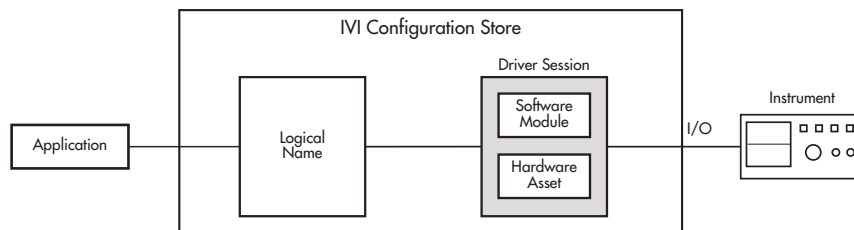
Components of an IVI Configuration Store

Software Module

A software module is instrument-specific, and contains the commands and functions necessary to communicate with the instrument. Software modules

are commonly provided by the instrument vendor, and they are not editable from within MATLAB.

Hardware Asset

A hardware asset is an identification of a communication port to which the instrument is connected. This component is configured with an `IOResourceDescriptor`. Usually you have one hardware asset per connection location (protocol type, bus address, etc.).

Driver Session

A driver session makes the association between a software module and a hardware asset. Generally, you have a driver session for each instrument at each of its possible locations.

Identical instruments connected at different locations can use the same software module, but because they have different hardware assets, they require different driver sessions.

Different kinds of instruments that are connected to the same location (at different times) can use the same hardware asset, but because they have different software modules, they require different driver sessions.
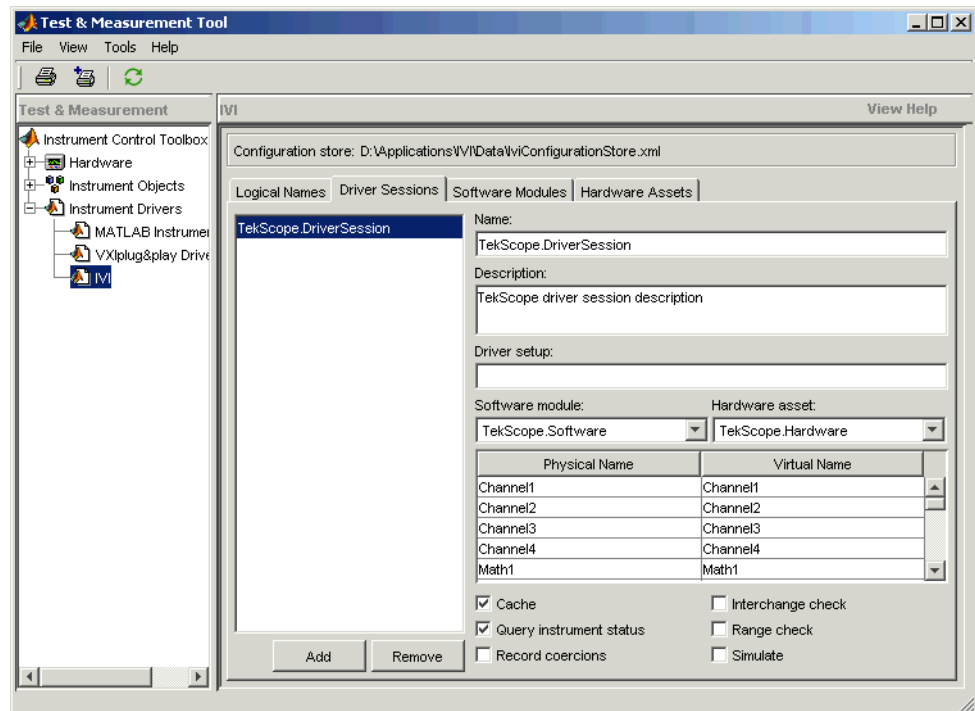
Logical Name

A logical name is a configuration store component that provides access to a driver session. A logical name can be thought of as a configurable pointer to a driver session. In a typical setup, the application communicates with an instrument via a logical name. If the application needs to communicate with a different instrument (for example, the same kind of scope at a different location), only the logical name within the IVI configuration store needs to be updated to point to the new driver session; there is no need to rewrite any code in the application, because it uses the same logical name.

Configuring

You can use the Test & Measurement Tool to examine or configure your IVI configuration store. Open the tool by typing

```
tmtool
```

Expand the `Instrument Drivers` node and click `IVI`.

You see a tab for each type of IVI configuration store element. This figure shows the available driver sessions in the current IVI configuration store. For the selected driver session, you can use any available software module or hardware asset. This figure shows the configuration for the driver session `TekScope.DriverSession`, which uses the software module `TekScope.Software` and the hardware asset `TekScope.Hardware`.

Alternatively, you can use command-line functions to examine and configure your IVI configuration store. To see what IVI configuration store elements are available, use `instrhwinfo` to identify the existing logical names.

```
instrhwinfo('ivi')
ans =
            LogicalNames: {'MainScope', 'FuncGen'}
```

```
                    ProgramIDs: {'TekScope.TekScope','Agilent33250'}
                        Modules: {'ag3325b', 'hpe363xa'}
    ConfigurationServerVersion: '1.3.1.0'
      MasterConfigurationStore: 'C:\Program Files\IVI\Data\
                                 IviConfigurationStore.xml'
                    IVIRootPath: 'C:\Program Files\IVI\'
```

Use instrhwinfo with a logical name as an argument to see the details of
that logical name's configuration.

```
    instrhwinfo('ivi','MainScope')
    ans =
                 DriverSession: 'TekScope.DriverSession'
                 HardwareAsset: 'TekScope.Hardware'
                SoftwareModule: 'TekScope.Software'
         IOResourceDescriptor: 'GPIB0::13::INSTR'
    SupportedInstrumentModels: 'TekScope 5000, 6000 and 7000 series'
             ModuleDescription: 'TekScope software module desc'
                ModuleLocation: ''
```

The configuration of this example is shown below, used by the application
data_analyzer.m.

You create and configure elements in the IVI configuration store by using the
IVI configuration store object methods add, commit, remove, and update. For
further details, see the reference pages for these methods.
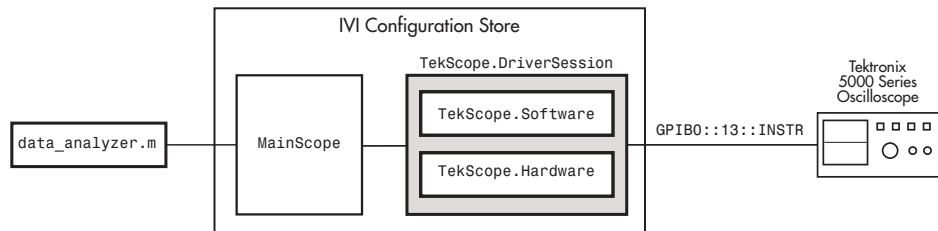
Basic IVI Configuration Store Example

The following figure shows an example of an IVI configuration store with
several interchangeable components. Application 1 requires access to the
oscilloscopes at two different locations (hardware asset X and hardware
asset Y). The scopes are similar, so they use the same software module S.

Because the scopes are at different locations (or perhaps it is the same scope connected to two different locations at different times), each configuration requires its own driver session, in this example, driver session A and driver session B.

The code of application 1 is written to access logical name 1, which is configured in the IVI configuration store to access driver session A or driver session B (but not both at the same time). Because the selection of driver session is performed in the IVI configuration store, there is no need to alter the code of the application to change access from one scope to the other.
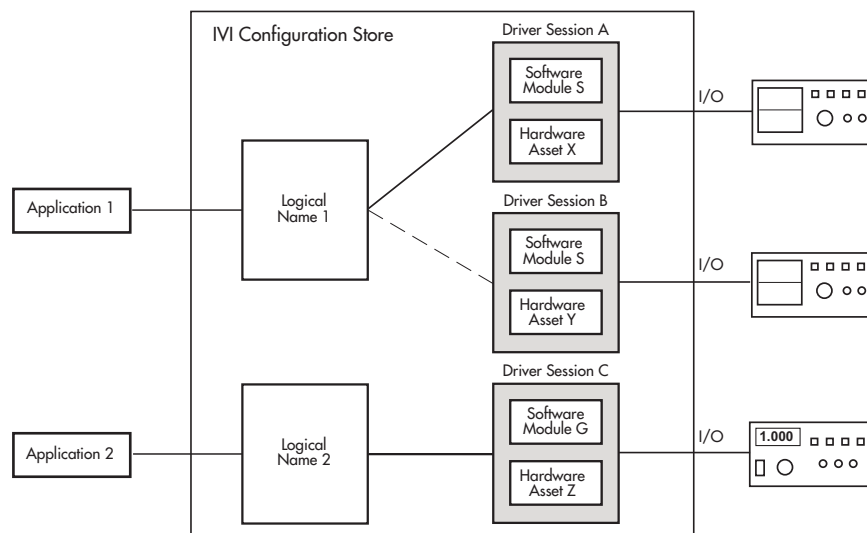
IVI Configuration Store with Several Interchangeable Elements

Using Generic Instrument Drivers

This chapter describes the use of generic drivers for controlling instruments from MATLAB with the Instrument Control Toolbox. The sections are as follows.

Overview

Generic drivers allow the Instrument Control Toolbox to communicate with devices or software that do not use industry-standard drivers or protocols.

Typical cases, but not the only possibilities, are instruments that offer access through a COM interface (where the instrument can be accessed as an ActiveX object from MATLAB), that use proprietary libraries, or that use custom MEX-files.

Because the generic nature of this feature does not lend itself to detailed discussion of specific instructions that work in all cases, the following sections of this chapter use an example to illustrate how to create and use a MATLAB generic instrument driver:

- "Example — Writing a Generic Driver" on page 11-3

- "Example — Using a Generic Driver with the Test & Measurement Tool" on page 11-9

- "Example — Using a Generic Driver at the Command Line" on page 11-13

Example — Writing a Generic Driver

In this example, the generic "instrument" that you control is Microsoft Internet Explorer (IE), which is represented by a COM object. (This example works only on Windows systems.) Working through the example, you write a simple MATLAB instrument generic driver that allows the Instrument Control Toolbox to communicate with a COM object. Using both a graphical interface and command-line code, with your driver you create an IE browser window, control its size, and specify what Web page it displays. The principles demonstrated in this example can be applied when writing a generic driver for any kind of instrument.

The steps to create a driver are described in the following sections:

- "Creating the Driver and Defining Its Initialization Behavior" on page 11-3
- "Defining Properties" on page 11-5
- "Defining Functions" on page 11-8

Creating the Driver and Defining Its Initialization Behavior

In this section, you create a new driver and specify what happens when an object is created for this driver.

1 Open the MATLAB Instrument Driver Editor from the MATLAB command line.

   midedit

2 To make it known that this driver is a generic driver, in the MATLAB Instrument Driver Editor, click **File > New > Generic driver**, as shown in the following figure.
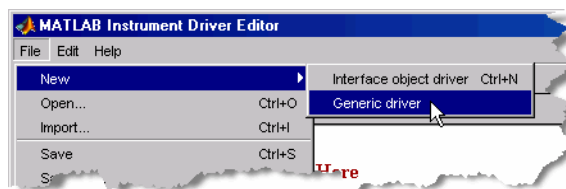
3 Select **File > Save as**.

Navigate to the directory where you want to save your driver, and give
it any name you want. This example uses the name ie_drv. Remember
where you have saved your driver.

4 Select the Summary node in the driver editor window. Set the fields of this
pane with any values you want. This example uses the following settings:

Manufacturer	Microsoft
Supported models	IE
Instrument type	Browser
Driver version	1.0

5 Select the node Initialization and Cleanup.

6 Click the **Create** tab.

This is where you define the M-code to execute when this driver is used to
create a device object. This example identifies the COM object for Internet
Explorer, and assigns the handle to that object as the Interface property
of the device object being created.

7 Add the following lines of code to the **Create** tab.

```
ie = actxserver('internetexplorer.application');
set(obj, 'Interface', ie);
```

8 Click the **Connect** tab.

This is where you define the M-code to execute when you connect your
device object to your instrument or software.

9 Add the following lines of code to the **Connect** tab.

```
ie = get(obj, 'Interface');
set(ie, 'Visible', 1);
set(ie, 'FullScreen', 0);
```

The first line gets ie as a handle to the COM object, based on the assignment in the **Create** code. The two lines after that set the window visibility and size.

Defining Properties

Writing properties for generic drivers in the MATLAB Instrument Driver Editor is a matter of writing straight M-code.

In this example, you define two properties. The first property uses the same name as the corresponding property of the COM object; the second property uses a different name from its corresponding COM object property.

Using the Same Name for a Property

The position of the IE browser window is determined by the Top and Left properties of its COM object. In the following steps, you make the Top property available to your device object through your generic driver. For this property, the name of the property is the same in both the COM object and in your device object.

1 Select the Properties node in the driver editor tree.

2 In the **Add property** field, enter the text Top, and click **Add**.

3 Expand the Properties node in the tree, and select the new node Top.

4 Click the **Property Values** tab. Your property can have a numeric value corresponding to screen pixels. For the sake of example, you can limit the value of the property from 0 to 200.

5 Make sure the **Data Type** field indicates Double. In the **Constraint** field, click the pull-down menu and select Bounded.

6 Keep the **Minimum** value of 0.0, and enter a **Maximum** value of 200.

Your driver editor window should look like the following figure.
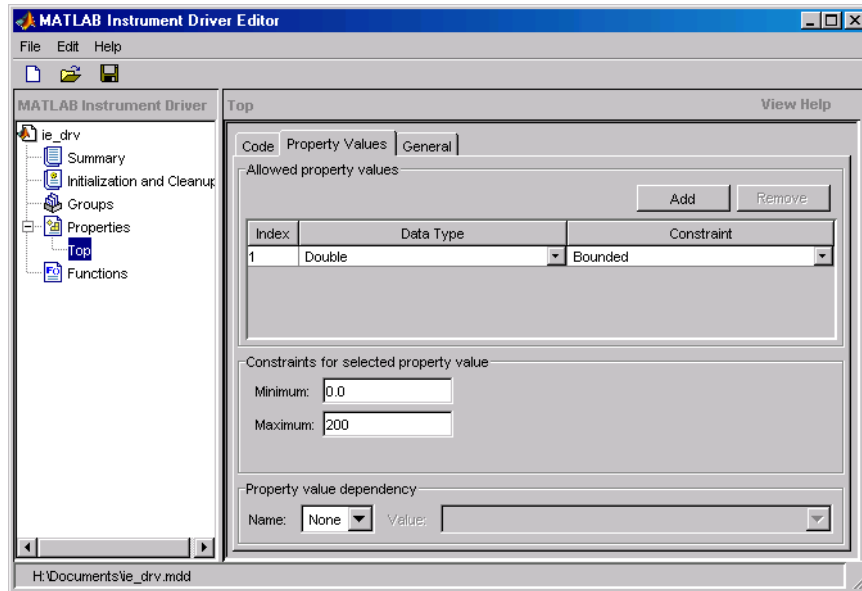
Now that you have defined the data type and acceptable values of the property, you can write the code to be executed whenever the device object property is accessed by get or set.

7 Click the **Code** tab.

The concept of reading the property is rather straightforward. When you get the Top property of the device object, the driver merely gets the value of the COM object's corresponding Top property. So all you need in the Get code function is to identify the COM object to get the information from.

8 Add the following code at the bottom of the function in the **Get code** pane.

```
ie = get(obj, 'Interface');
propertyValue = get(ie, PropertyName);
```

The first line gets ie as a handle to the COM object. Remember that the Interface property of the device object is set to this value back in the driver's **Create** code. The second line retrieves the value of the COM object's Top property, and assigns it to propertyValue, which is returned to the get function for the device object.

9 Add the following code at the bottom of the function in the **Set code** pane:

```
ie = get(obj, 'Interface');
set(ie, propertyName, propertyValue);
```

Using a Different Name for a Property

In the steps above, you created in your driver a device object property that has the same name as the property of the COM object representing your instrument. You can also create properties with names that do not match those of the COM object properties. In the following steps, you create a property called Vsize that corresponds to the IE COM object property Height.

1 Select the Properties node in the driver editor tree.

2 In the **Add property** field, enter the text Vsize, and click **Add**.

3 Expand the Properties node in the tree, and select the new node Vsize.

4 Click the **Property Values** tab. This property can have a numeric value corresponding to screen pixels, whose range you define as 200 to 800.

5 Make sure the **Data Type** field indicates Double. In the **Constraint** field, click the pull-down menu and select Bounded.

6 Enter a **Minimum** value of 200, and enter a **Maximum** value of 800.

7 Click the **Code** tab.

8 Add the following code at the bottom of the function in the **Get code** pane:

```
ie = get(obj,'Interface');
propertyValue = get(ie,'Height');
```

9 Add the following code at the bottom of the function in the **Set code** pane:

```
ie = get(obj, 'Interface');
set(ie, 'Height', propertyValue);
```

10 Save your driver.

Defining Functions

A common function for Internet Explorer is to download a Web page. In the following steps, you create a function called `goTo` that allows you to navigate the Web with the browser.

1 Select the `Functions` node in the driver editor tree.

2 In the **Add property** field, enter the text `goTo`, and click **Add**.

3 Expand the `Functions` node in the tree, and select the new node `goTo`.

Writing functions for generic drivers in the MATLAB Instrument Driver Editor is a matter of writing straight M-code.

Your `goTo` function requires only one input argument: the URL of the Web page to navigate to. You can call that argument `site`.

4 Change the first line of the MATLAB code pane to read

```
function goTo(obj, site)
```

The variable `obj` is the device object using this driver. The value of `site` is a string passed into this function when you are using this driver. Your function then must pass the value of `site` on to the IE COM object. So your function must create a handle to the COM object, then call the IE COM method `Navigate2`, passing to it the value of `site`.

5 Add the following code at the bottom of the function in the MATLAB code pane.

```
ie = get(obj, 'Interface');
invoke(ie, 'Navigate2', site);
```

6 Save your driver, and close the MATLAB Instrument Driver Editor.

Now that your generic driver is ready, you can use it with the Test & Measurement Tool (`tmtool`) or at the MATLAB command line.

Example — Using a Generic Driver with the Test & Measurement Tool

With the Test & Measurement Tool you can scan for your driver, create a device object that uses that driver, set and get properties of the object, and execute functions.

The steps you take to use a driver with the Test & Measurement Tool are illustrated in the following sections:

- "Creating and Connecting the Device Object" on page 11-9
- "Accessing Properties" on page 11-10
- "Using Functions" on page 11-11

Creating and Connecting the Device Object

This example illustrates how to use the generic driver you created in "Example — Writing a Generic Driver" on page 11-3.

1 In the MATLAB Command Window, make sure that the directory containing your driver is on the MATLAB path.

```
path
```

If you do not see the directory in the path listing, add the directory to the path with the command

```
addpath <directory>
```

where `<directory>` is the pathname to the directory containing your driver.

2 Open the Test & Measurement Tool.

```
tmtool
```

3 In the Test & Measurement Tool tree, expand the `Instrument Drivers` node.

4 Select the `MATLAB Instrument Drivers` node.

5 Your driver might not be listed yet, so click **Scan** in the lower-right corner of the tool. If the tool found your driver, it is listed in the tree as ie_drv.mdd.

6 Select the ie_drv.mdd node in the tree.

7 Right-click the ie_drv.mdd node in the tree, and select **Create Device Object Using Driver**. The following dialog box appears.
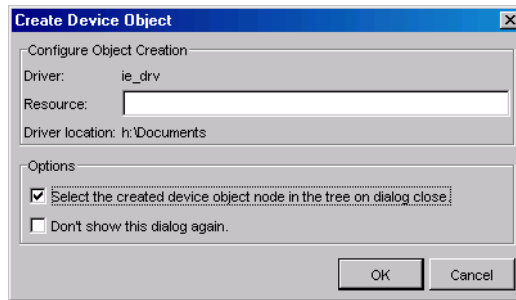
8 Check the box to **Select the created device object in the tree on dialog close**, as shown. The device object in this example does not need a resource, so keep that field empty.

9 Click **OK**.

When the Test & Measurement Tool creates the device object, an entry for the object appears as a node in the tree. The Browser-ie_drv node should already be selected in the tree. This refers to the device object you just created.

10 Click **Connect** in the upper-right corner of the Test & Measurement Tool. This establishes a communication channel between the tool and the IE browser window, and an empty IE window appears on your screen. Remember that the **Create** code for your driver creates an object for the IE browser, and the **Connect** code and makes its window visible.

Accessing Properties

The driver you created allows you to specify where the browser window appears on your screen and how large it is.

1 Click the **Properties** tab, and then select Top in the **Device object properties** list.

The first value displayed for setting this property is 0.0.

2 Click **Set**. The IE browser window shifts upward to the top edge of your screen.

3 With the mouse, grab the IE window, and drag it down some distance from the top of the screen.

4 Now return to the Test & Measurement Tool window, and click **Get** for the Top property. Notice in the **Response** pane how many pixels down you have moved the window.

Use your driver Vsize property to change the size of the browser window.

1 Select Vsize in the **Device object properties** list.

2 Enter a property value of 200, and click **Set**. Notice the IE window size.

3 Enter a property value of 400 and click **Set**. Notice the IE window size.

4 Try resizing the IE browser window directly with the mouse. Then in the Test & Measurement Tool, click **Get** for the Vsize property. Notice the value returned to the **Response** pane.

Using Functions

Use the goTo function of your generic driver to control the Web page that the browser displays.

1 In the Test & Measurement Tool, click the **Functions** tab for your device object.

2 Select goTo in the list of **Device object functions**.

3 In the **Input argument(s)** field, enter 'www.mathworks.com'. Be sure to include the single quotes.

4 Click **Execute**. Observe the IE browser and see that it displays the MathWorks Web site.

5 Experiment freely. When you are finished, right-click the `Browser-ie_drv` `node` in the tree and select **Delete Object**. Close the Test & Measurement Tool, and close the IE browser window you created in this example.

Example — Using a Generic Driver at the Command Line

The Instrument Control Toolbox provides MATLAB commands you can use in the Command Window or in M-files to create a device object that uses an driver, set and get properties of the object, and execute functions.

The steps you take to use a driver at the MATLAB command line are illustrated in the following sections:

- "Creating and Connecting the Device Object" on page 11-13
- "Accessing Properties" on page 11-14
- "Using Functions" on page 11-15

Creating and Connecting the Device Object

This example illustrates how to use the generic driver you created in "Example — Writing a Generic Driver" on page 11-3.

1 In the MATLAB Command Window, make sure that the directory containing your driver is on the MATLAB path.

```
path
```

If you do not see the directory in the path listing, add the directory to the path with the command

```
addpath <directory>
```

where `<directory>` is the pathname to the directory containing your driver.

2 Create a device object using your driver. For the driver used in this example, the `icdevice` function does not require an argument for a resource when using a generic driver. What the object connects to and how it makes that connection are defined in the **Create** code of your driver.

```
ie_obj = icdevice('ie_drv');
```

11-13

3 Connect the object.

```
connect(ie_obj);
```

When the device object is connected, an empty IE window appears on your screen. Now you can communicate directly with the IE browser from MATLAB.

Accessing Properties

The driver you created allows you to specify where the browser window appears on your screen and how large it is. You read and write the properties of your device object with the get and set functions, respectively.

1 View all of the properties of your device object.

```
get(ie_obj)
    ConfirmationFcn =
    DriverName = ie_drv.mdd
    DriverType = MATLAB generic
    InstrumentModel =
    Interface = [1x1 COM.internetexplorer_application]
    LogicalName =
    Name = Browser-ie_drv
    ObjectVisibility = on
    RsrcName =
    Status = open
    Tag =
    Timeout = 10
    Type = Browser
    UserData = []

    BROWSER specific properties:
    Top = 47
    Vsize = 593
```

2 Most of the properties listed belong to all device objects. For this example, the properties of interest are those listed as BROWSER specific properties, that is, Top and Vsize.

The Top property defines the IE browser window position in pixels from the top of the screen. Vsize defines the vertical size of the window in pixels.

3 Shift the IE browser window to the top of the screen.

```
set(ie_obj, 'Top', 0);
```

4 With the mouse, grab and drag the IE browser window down away from the top of the screen.

5 Find the window's new position by examining the Top property.

```
get(ie_obj, 'Top')
ans =
    120
```

Adjust the size of the window by setting the Vsize property.

```
set(ie_obj, 'Vsize', 200);
```

6 Make the window larger by increasing the property value.

```
set(ie_obj, 'Vsize', 600);
```

Using Functions

By using the goTo function of your generic driver, you can control the Web page displayed in the IE browser window.

1 View all of the functions (methods) of your device object.

```
methods(ie_obj)

Methods for class icdevice:

Contents    disp       icdevice      instrnotify methods   size
class       display    igetfield     instrument  ne        subsasgn
close       end        inspect       invoke      obj2mfile subsref
connect     eq         instrcallback isa         open      vertcat
ctranspose  fieldnames instrfind     isequal     openvar
delete      get        instrfindall  isetfield   propinfo
devicereset geterror   instrhelp     isvalid     selftest
disconnect  horzcat    instrhwinfo   length      set

Driver specific methods for class icdevice:

goTo
```

Most of the methods listed apply to all device objects. For this example, the method of interest is the one listed under `Driver specific methods`, that is, `goTo`.

2 Use the `goTo` function to specify the page for the IE browser to display.

```
invoke(ie_obj, 'goTo', 'www.mathworks.com');
```

If you have access to the Internet, the IE window should display the MathWorks Web site.

3 When you are finished with your example, clean up the MATLAB workspace by removing the object.

```
disconnect(ie_obj);
delete(ie_obj);
clear ie_obj;
```

4 Close the IE browser window you created in this example.

Saving and Loading the Session

This chapter describes how to save and load information associated with an instrument control session. The sections are as follows.

Saving and Loading Instrument Objects (p. 12-2)	Save instrument objects and their associated property values to disk as an M-file or as a MAT-file.
Debugging: Recording Information to Disk (p. 12-6)	Save information to disk as a text file. The saved information includes the data transferred to and from the instrument, and event information.

Saving and Loading Instrument Objects

You can save an instrument object to disk using two possible formats:

- As an M-file using the `obj2mfile` function
- As a MAT-file using the `save` command

You can also save data transferred between the object and the instrument using these two functions. However, it is easier to use the `record` function for this purpose, as described in "Debugging: Recording Information to Disk" on page 12-6.

Saving Instrument Objects to an M-File

You can save an instrument object to an M-file using the `obj2mfile` function. `obj2mfile` provides you with these options:

- Save all property values or save only those property values that differ from their default values.

  Read-only property values are not saved. Therefore, read-only properties use their default values when you load the instrument object into the MATLAB workspace. To determine if a property is read-only, use the `propinfo` function or examine the property reference pages.

- Save property values using the `set` syntax or the dot notation.

  If the `UserData` property is not empty, or if a callback property is set to a cell array of values or a function handle, then the data stored in these properties is written to a MAT-file when the instrument object is saved. The MAT-file has the same name as the M-file containing the instrument object code.

For example, suppose you create the GPIB object g, return instrument identification information to the variable `out`, and store `out` in the `UserData` property.

```
g = gpib('ni',0,1);
g.Tag = 'My GPIB object';
fopen(g)
cmd = '*IDN?';
```

```
fprintf(g,cmd)
out = fscanf(g);
g.UserData = out;
```

The following command saves g and the modified property values to the M-file mygpib.m. Because the UserData property is not empty, its value is automatically written to the MAT-file mygpib.mat.

```
obj2mfile(g,'mygpib.m');
```

Use the type command to display mygpib.m at the command line.

Loading the Instrument Object

To load an instrument object that was saved as an M-file into the MATLAB workspace, type the name of the M-file at the command line. For example, to load g from the M-file mygpib.m,

```
g = mygpib
```

The display summary for g is shown below. Note that the read-only properties such as Status, BytesAvailable, ValuesReceived, and ValuesSent are restored to their default values.

```
GPIB Object Using NI Adaptor : GPIB0-1

Communication Address
   BoardIndex:        0
   PrimaryAddress:    1
   SecondaryAddress:  0

Communication State
   Status:            closed
   RecordStatus:      off

Read/Write State
   TransferStatus:    idle
   BytesAvailable:    0
   ValuesReceived:    0
   ValuesSent:        0
```

When loading g into the workspace, the MAT-file `mygpib.mat` is automatically loaded and the `UserData` property value is restored.

```
g.UserData
ans =
TEKTRONIX,TDS 210,0,CF:91.1CT FV:v1.16 TDS2CM:CMV:v1.04
```

Saving Objects to a MAT-File

You can save an instrument object to a MAT-file just as you would any workspace variable — using the `save` command. For example, to save the GPIB object g and the variables `cmd` and `out`, defined in "Saving Instrument Objects to an M-File" on page 12-2, to the MAT-file `mygpib1.mat`,

```
save mygpib1 g cmd out
```

Read-only property values are not saved. Therefore, read-only properties use their default values when you load the instrument object into the MATLAB workspace. To determine if a property is read-only, use the `propinfo` function or examine the property reference pages.

Loading the Instrument Object

To load an instrument object that was saved to a MAT-file into the MATLAB workspace, use the `load` command. For example, to load g, `cmd`, and `out` from MAT-file `mygpib1.mat`,

```
load mygpib1
```

The display summary for g is shown below. Note that the read-only properties such as `Status`, `BytesAvailable`, `ValuesReceived`, and `ValuesSent` are restored to their default values.

```
GPIB Object Using NI Adaptor : GPIB0-1

Communication Address
   BoardIndex:        0
   PrimaryAddress:    1
   SecondaryAddress:  0

Communication State
   Status:            closed
```

```
        RecordStatus:      off

Read/Write State
   TransferStatus:    idle
   BytesAvailable:    0
   ValuesReceived:    0
   ValuesSent:        0
```

Debugging: Recording Information to Disk

Recording information to disk provides a permanent record of your instrument control session, and is an easy way to debug your application. While the instrument object is connected to the instrument, you can record this information to a disk file:

- The number of values written to the instrument, the number of values read from the instrument, and the data type of the values
- Data written to the instrument, and data read from the instrument
- Event information

You record information to a disk file with the record function. The properties associated with recording information to disk are given below.

Recording Properties

Property Name	Description
RecordDetail	Specify the amount of information saved to a record file.
RecordMode	Specify whether data and event information are saved to one record file or to multiple record files.
RecordName	Specify the name of the record file.
RecordStatus	Indicate if data and event information are saved to a record file.

Example: Introduction to Recording Information

This example creates the GPIB object g, records the number of values transferred between g and the instrument, and stores the information to the file text myfile.txt.

```
g = gpib('ni',O,1);
g.RecordName = 'myfile.txt';
fopen(g)
record(g)
fprintf(g,'*IDN?')
```

```
out = fscanf(g);
```

End the instrument control session.

```
fclose(g)
delete(g)
clear g
```

Use the `type` command to display `myfile.txt` at the command line.

Creating Multiple Record Files

When you initiate recording with the `record` function, the `RecordMode` property determines if a new record file is created or if new information is appended to an existing record file.

You can configure `RecordMode` to `overwrite`, `append`, or `index`. If `RecordMode` is `overwrite`, then the record file is overwritten each time recording is initiated. If `RecordMode` is `append`, then the new information is appended to the file specified by `RecordName`. If `RecordMode` is `index`, a different disk file is created each time recording is initiated. The rules for specifying a record filename are discussed in "Specifying a Filename" on page 12-7.

Specifying a Filename

You specify the name of the record file with the `RecordName` property. You can specify any value for `RecordName`, including a directory path, provided the filename is supported by your operating system. Additionally, if `RecordMode` is `index`, then the filename follows these rules:

- Indexed filenames are identified by a number. This number precedes the filename extension and is increased by 1 for successive record files.

- If no number is specified as part of the initial filename, then the first record file does not have a number associated with it. For example, if `RecordName` is `myfile.txt`, then `myfile.txt` is the name of the first record file, `myfile01.txt` is the name of the second record file, and so on.

- `RecordName` is updated after the record file is closed.

- If the specified filename already exists, then the existing file is overwritten.

The Record File Format

The record file is an ASCII file that contains a record of one or more instrument control sessions. You specify the amount of information saved to a record file with the RecordDetail property.

RecordDetail can be compact or verbose. A compact record file contains the number of values written to the instrument, the number of values read from the instrument, the data type of the values, and event information. A verbose record file contains the preceding information as well as the data transferred to and from the instrument.

Binary data with precision given by uchar, schar, (u)int8, (u)int16, or (u)int32 is recorded as hexadecimal values. For example, if the integer value 255 is read from the instrument as a 16-bit integer, the hexadecimal value 00FF is saved in the record file. Single- and double-precision floating-point numbers are recorded as decimal values using the %g format, and as hexadecimal values using the format specified by the IEEE Standard 754-1985 for Binary Floating-Point Arithmetic.

The IEEE floating-point format includes three components — the sign bit, the exponent field, and the significant field. Single-precision floating-point values consist of 32 bits, and the value is given by

$$value = (-1)^{sign}(2^{exp-127})(1.significand)$$

Double-precision floating-point values consist of 64 bits, and the value is given by

$$value = (-1)^{sign}(2^{exp-1023})(1.significand)$$

The floating-point format component and the associated single-precision and double-precision bits are given below.

Format Component	Single-Precision Bits	Double-Precision Bits
sign	1	1
exp	2-9	2-12
significand	10-32	13-64

For example, suppose you record the decimal value 4.25 using the single-precision format. The record file stores 4.25 as the hex value 40880000, which is calculated from the IEEE single-precision floating-point format. To reconstruct the original value, convert the hex value to a decimal value using hex2dec:

```
dval = hex2dec('40880000')
dval =
    1.082654720000000e+009
```

Convert the decimal value to a binary value using dec2bin:

```
bval = dec2bin(dval,32)
bval =
01000000100010000000000000000000
```

The interpretation of bval is given by the preceding table. The leftmost bit indicates the value is positive because $(-1)^0 = 1$. The next 8 bits correspond to the exponent, which is given by

```
exp = bval(2:9)
exp =
10000001
```

The decimal value of exp is $2^7 + 2^0 = 129$. The remaining bits correspond to the significand, which is given by

```
significand = bval(10:32)
significand =
0001000000000000000000
```

The decimal value of significand is $2^{-4} = 0.0625$. You reconstruct the original value by plugging the decimal values of exp and significand into the formula for IEEE singles:

```
value = (-1)^0(2^(129 - 127))(1.0625)
value = 4.25
```

Example: Recording Information to Disk

This example extends "Example: Reading Binary Data" on page 4-22 by recording the associated information to a record file. Additionally, the structure of the resulting record file is presented:

1 Create an instrument object — Create the GPIB object g associated with a National Instruments GPIB controller with board index 0, and an instrument with primary address 1.

```
g = gpib('ni',0,1);
```

2 Configure properties — Configure the input buffer to accept a reasonably large number of bytes, and configure the timeout value to two minutes to account for slow data transfer.

```
g.InputBufferSize = 50000;
g.Timeout = 120;
```

Configure g to execute the callback function instrcallback every time 5000 bytes are stored in the input buffer.

```
g.BytesAvailableFcnMode = 'byte';
g.BytesAvailableFcnCount = 5000;
g.BytesAvailableFcn = @instrcallback;
```

Configure g to record information to multiple disk files using the verbose format. The first disk file is defined as WaveForm1.txt.

```
g.RecordMode = 'index';
g.RecordDetail = 'verbose';
g.RecordName = 'WaveForm1.txt';
```

3 Connect to the instrument — Connect g to the oscilloscope.

```
fopen(g)
```

4 Write and read data — Initiate recording.

```
record(g)
```

Configure the scope to transfer the screen display as a bitmap.

```
fprintf(g,'HARDCOPY:PORT GPIB')
fprintf(g,'HARDCOPY:FORMAT BMP')
fprintf(g,'HARDCOPY START')
```

Initiate the asynchronous read operation, and begin generating events.

```
readasync(g)
```

instrcallback is called every time 5000 bytes are stored in the input buffer. The resulting displays are shown below.

```
BytesAvailable event occurred at 09:04:33 for the object: GPIB0-1.
BytesAvailable event occurred at 09:04:42 for the object: GPIB0-1.
BytesAvailable event occurred at 09:04:51 for the object: GPIB0-1.
BytesAvailable event occurred at 09:05:00 for the object: GPIB0-1.
BytesAvailable event occurred at 09:05:10 for the object: GPIB0-1.
BytesAvailable event occurred at 09:05:19 for the object: GPIB0-1.
BytesAvailable event occurred at 09:05:28 for the object: GPIB0-1.
```

Wait until all the data is stored in the input buffer, and then transfer the data to MATLAB as unsigned 8-bit integers.

```
out = fread(g,g.BytesAvailable,'uint8');
```

Toggle the recording state from on to off. Because the RecordMode value is index, the record filename is automatically updated.

```
record(g)
g.RecordStatus
ans =
off
g.RecordName
ans =
WaveForm2.txt
```

5 Disconnect and clean up — When you no longer need g, you should disconnect it from the instrument, and remove it from memory and from the MATLAB workspace.

```
fclose(g)
delete(g)
clear g
```

The Record File Contents

To display the contents of the WaveForm1.txt record file,

```
type WaveForm1.txt
```

The record file contents are shown below. Note that data returned by the fread function is in hex format (most of the bitmap data is not shown).

```
Legend:
  * - An event occurred.
  > - A write operation occurred.
  < - A read operation occurred.

1     Recording on 18-Jun-2000 at 09:03:53.529. Binary data in
      little endian format.
2   > 18 ascii values.
      HARDCOPY:PORT GPIB
3   > 19 ascii values.
      HARDCOPY:FORMAT BMP
4   > 14 ascii values.
      HARDCOPY START
5   * BytesAvailable event occurred at 18-Jun-2000 at 09:04:33.334
6   * BytesAvailable event occurred at 18-Jun-2000 at 09:04:41.775
7   * BytesAvailable event occurred at 18-Jun-2000 at 09:04:50.805
8   * BytesAvailable event occurred at 18-Jun-2000 at 09:04:00.266
9   * BytesAvailable event occurred at 18-Jun-2000 at 09:05:10.306
10  * BytesAvailable event occurred at 18-Jun-2000 at 09:05:18.777
11  * BytesAvailable event occurred at 18-Jun-2000 at 09:05:27.778
12  < 38462 uint8 values.
      42 4d cf 03 00 00 00 00 00 00 3e 00 00 00 28 00
      00 00 80 02 00 00 e0 01 00 00 01 00 01 00 00 00
      00 00 00 96 00 00 00 00 00 00 00 00 00 00 00 00
      .
      .
      .
      ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
      ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff ff
      ff ff ff ff ff ff ff ff ff ff ff ff ff ff
13  Recording off.
```

The Test & Measurement Tool

This chapter describes how to use the Test & Measurement Tool to access your hardware interfaces and instrument drivers. The sections are as follows.

Overview

The Test & Measurement Tool displays the resources (hardware, drivers, interfaces, etc.) accessible to the toolboxes that support the tool, and enables you to configure and communicate with those resources.

Instrument Control Toolbox Support

You can use the Test & Measurement Tool to manage your instrument control session. This tool enables you to

- Search for available hardware and drivers
- Create instrument objects
- Connect to an instrument
- Configure instrument settings
- Write data to an instrument
- Read data from an instrument
- Save a log of your session as an M-file

The Tree

You start the Test & Measurement Tool by typing

```
tmtool
```

You navigate to the various hardware control panes using the tool's tree. Start by selecting the toolbox you want to work with, which displays a set of instructions in the right-hand pane. These instructions explain the basic steps to establishing communication with an instrument.

For example, the following figure shows the pane displayed when you select the Instrument Control Toolbox.
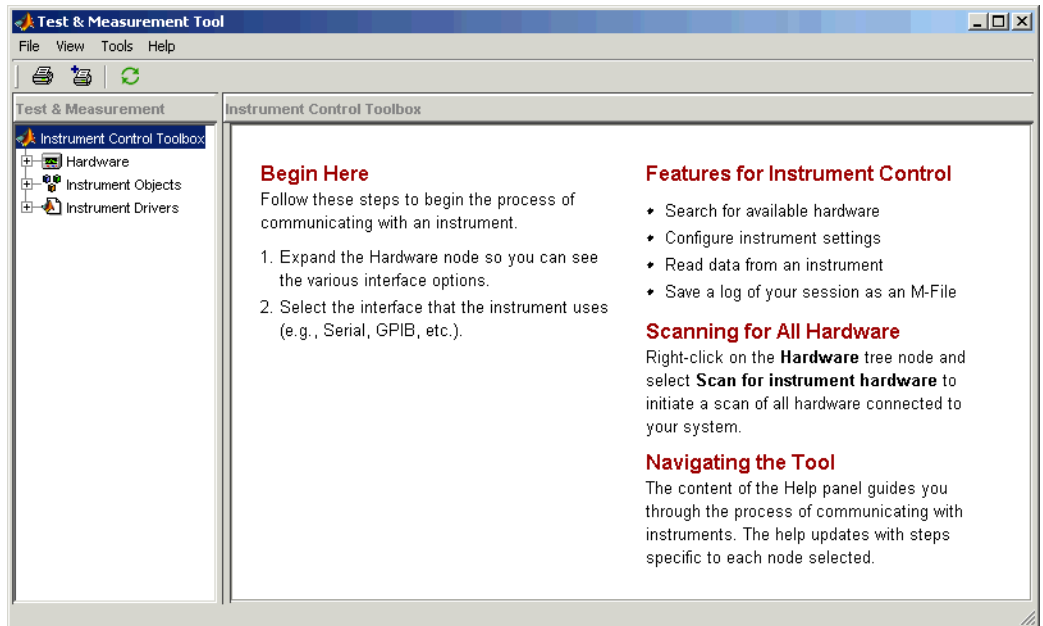
Using the Test & Measurement Tool

This example illustrates a typical session using the Test & Measurement Tool for instrument control. The session entails communicating with a Tektronix TDS 210 oscilloscope via a GPIB interface.

To start the tool, type

    tmtool

on the MATLAB command line.

Hardware

When the tool displays, expand (click on the **+**) the Instrument Control Toolbox node in the tree. Next, expand the Hardware node. The tree now looks like this.
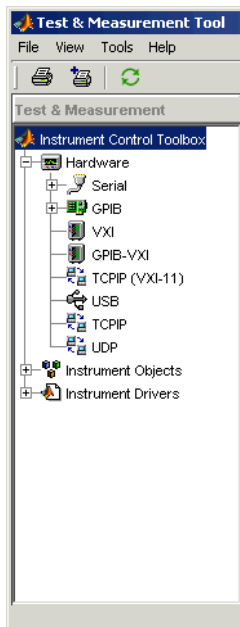
Selecting the Interface and Scanning for GPIB Boards

Next, scan for installed GPIB boards by selecting the GPIB node. The right
pane changes to the **Installed GPIB Board** list. Click **Scan** to see what
boards are installed. The following figure shows the scan result from a system
with one Capital Equipment Corp and one Keithley GPIB board.
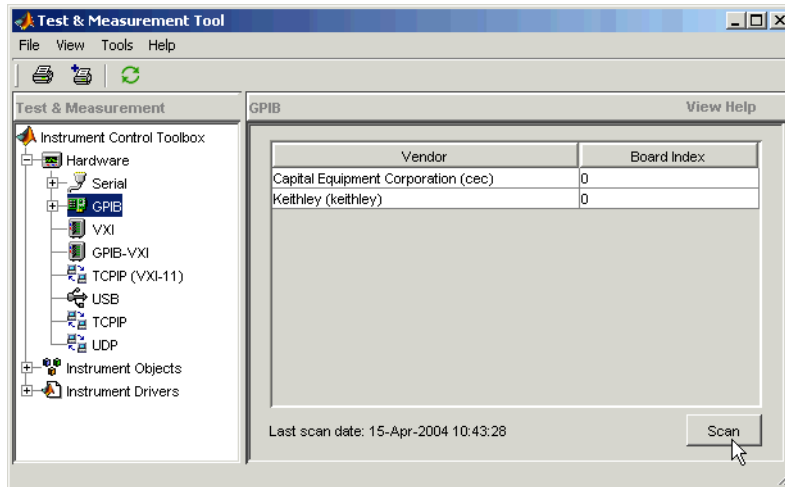
### Scanning for Instruments Connected to GPIB Boards

After determining what GPIB boards are installed, you must determine what instruments are connected to those boards. Expand the GPIB node and select a board.

The right pane changes to the **GPIB Instruments** list. Click **Scan** to see what instruments are connected to this board. The following figure shows the scan result from a system with a Tektronix TDS 210 connected at primary address 4.
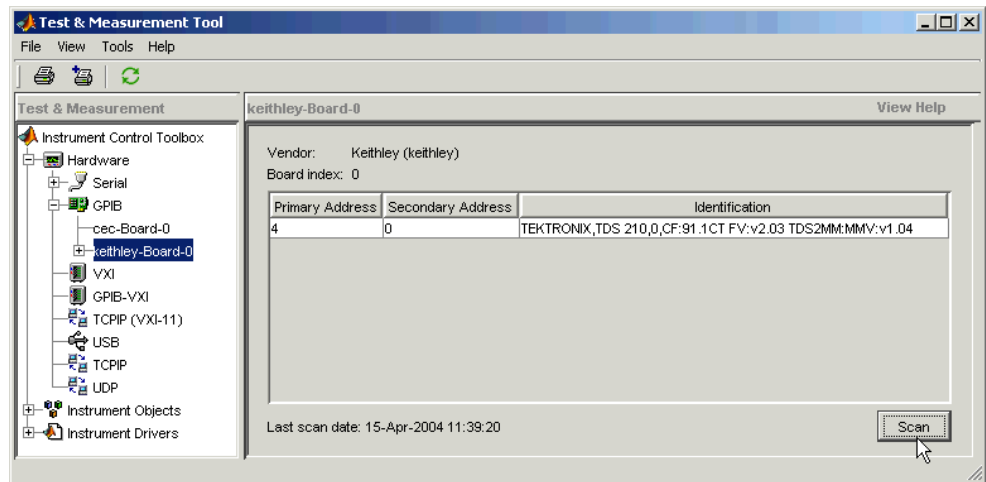
Configuring the Interface

You can change the configuration of the interface by clicking the **Configure** tab. This pane displays properties you can set to configure the instrument communication settings. In the following view of the **Configure** pane, the Timeout property value has been set to 15 seconds.
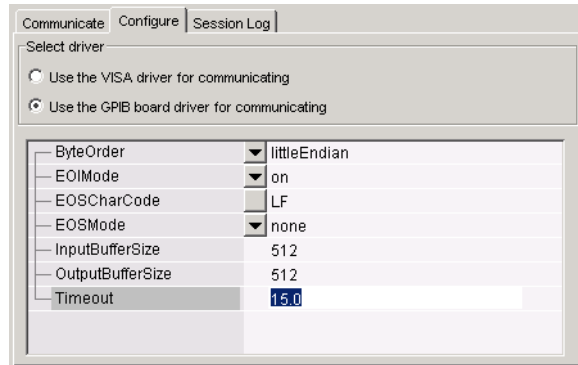
Establishing the Connection

Expand the `keithley-Board-0` node and select the instrument at primary address 4: `PAD-4 (TEKTRONIX,TDS 210...`. The right pane changes to the control pane you use for writing and reading data to and from that instrument.
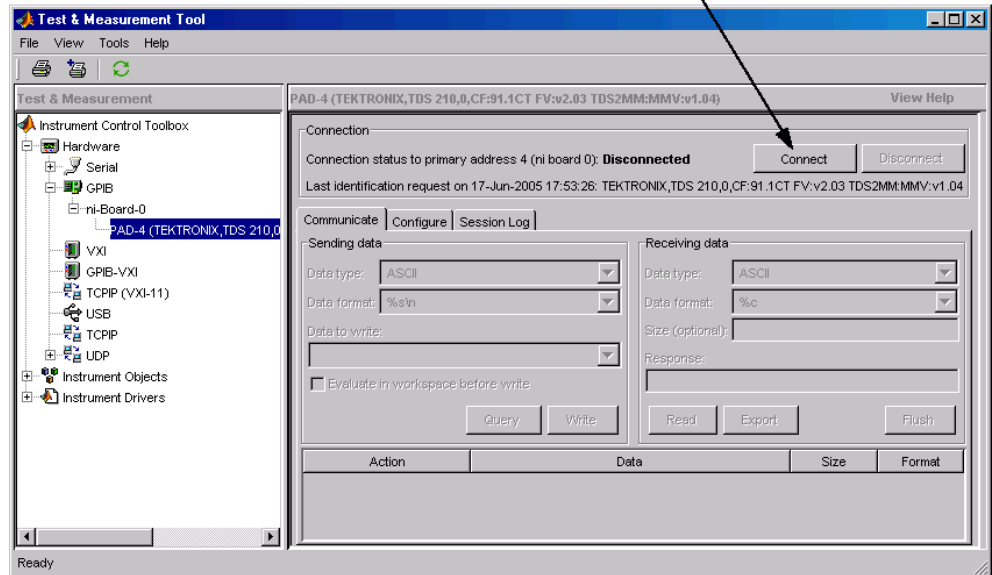

Click **Connect** to establish communication with the instrument. The tool creates an interface object representing the communication channel to the instrument.

Writing and Reading Data

Selecting the **Communicate** tab displays the pane you use to write and read data. You can write and read data separately using the **Write** and **Read** buttons, or you can use the **Query** button to write and read in a single operation.

The following figure shows the pane after a brief session involving the following steps:

1 Open communication with the instrument.

2 Enter `*IDN?` as **Data to Write**, and click **Query** (write/read). This executes the identify command.

3 Enter `CURVE?` as **Data to Write**, and click **Query**. This retrieves the waveform data from the scope.

Exporting Instrument Data

You can export the data acquired from instruments to any of the following:

- MATLAB workspace as a variable

- Figure window as a plot

- MAT-file for storage in a file

- MATLAB array editor for modification

To export data, select **File > Export > Instrument Response(s)** from the menu bar. When the **Data Exporter** dialog box displays, choose the variables to export. The following figure shows the **Data Exporter** set to export the curve data to the MATLAB workspace as the variable data2.
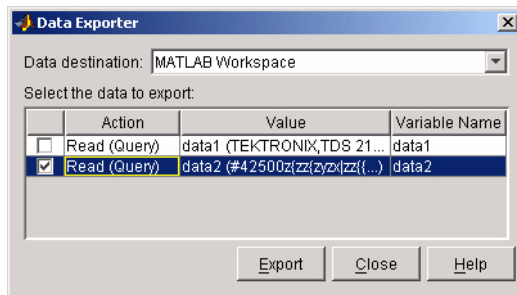
Exporting the GPIB Object

When you open a connection to an instrument, the Test & Measurement Tool creates an instrument object automatically. You can export the GPIB instrument object created in this example as any of the following:

- MATLAB workspace object that you can use as an argument in instrument control commands

- M-file containing the call to the GPIB constructor and the commands to set object properties

- MAT-file for storage in a file

To export the object, select **File > Export > Instrument Object** from the menu bar. When the **Object Exporter** dialog box displays, choose the object

to export. The following figure shows the **Object Exporter** set to export the
object to an M-file. (When you run that M-file, it creates a new object with the
equivalent settings.)
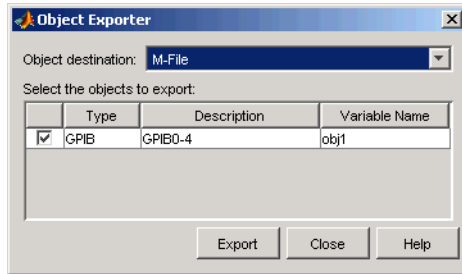
Saving Your Instrument Control Session. The **Session Log** tab
displays the M-code equivalent of your instrument control session. You can
save this code to an M-file so that you can execute the same commands
programmatically.

Select **File > Save Session Log** from the menu bar or click **Save Session** on
the **Session Log** pane. This displays the **Export to M-File** dialog box, which
enables you to specify a filename and directory location for the M-file.

Instrument Objects

Interface Objects

The Test & Measurement Tool creates interface objects automatically when you open a communication channel to an instrument by clicking the **Communication Status** button. You can explicitly create and configure an interface object using the following steps:

1 Expand the `Instrument Objects` node in the tree, and select `Interface Objects`. The **Interface Objects** pane appears on the right.

2 Click **New Object** to display the **New Object Creation** dialog box.
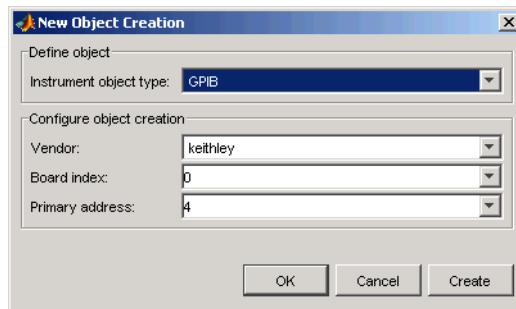
3 Specify the object parameters and click **OK** to create the new object.

Device Objects

You can create and configure a device object using the following steps:

1 Expand the `Instrument Objects` node in the tree, and select `Device Objects`. The **Device Objects** pane appears on the right.

2 Click **New Object** to display the **New Object Creation** dialog box. In this case, the **Instrument object type** is already set for `device`.
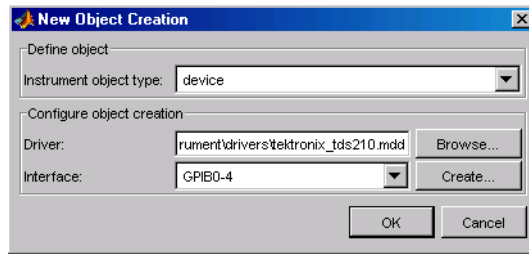
3 Specify or browse for the instrument driver you want to use; then choose from among the available interface objects, or create one if necessary.

**4** Click **OK** to create the new device object.

Setting Instrument Object Properties

Whether the instrument objects are created automatically, created through the **New Object Creation** dialog box, or created on the MATLAB command line, the Test & Measurement Tool enables you to set the properties of these objects. To change object properties in the Test & Measurement Tool, follow these steps:

1 Expand the `Instrument Objects` node in the tree, then either `Interface Objects` or `Device Objects`, and select the object whose properties you want to set.

2 Select the **Configure** tab in the right-hand pane.

3 Set properties displayed in this pane, as shown in the following figures.
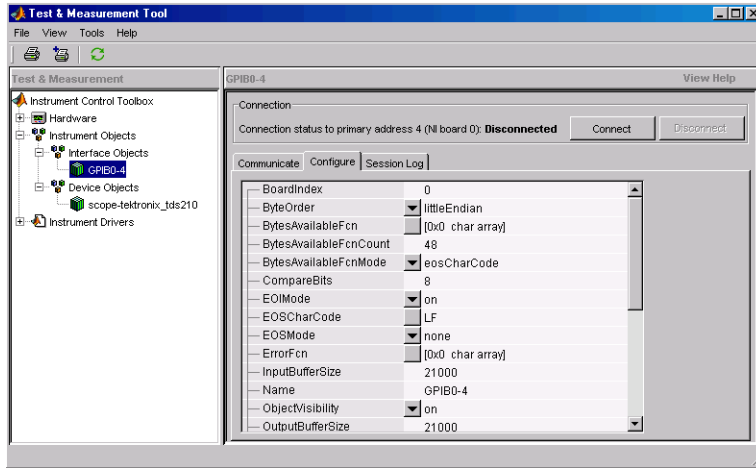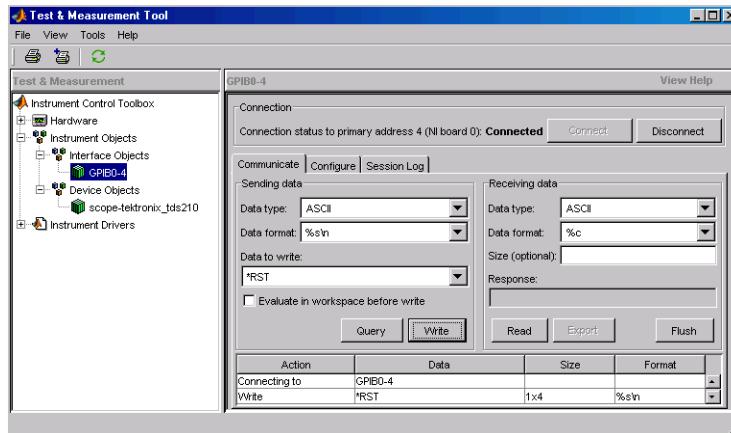
Configuring Interface Object Properties
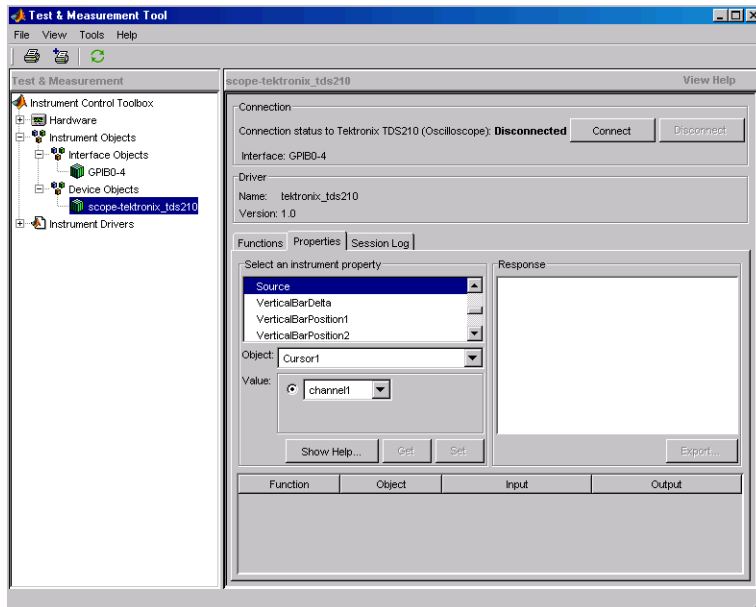
Configuring Device Object Properties
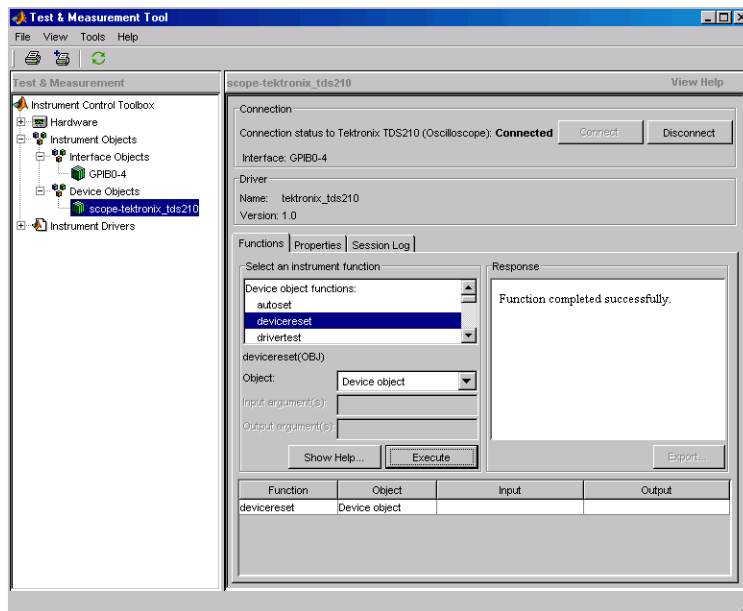
Communicating with Your Instrument

Using an Interface Object. When communicating with your instrument using an interface object, you send data to instrument in the form of raw instrument commands. In the following figure, the Test & Measurement Tool sends the *RST string to the TDS 210 oscilloscope via an interface object. *RST is the oscilloscope's reset command.

Communicating via an Interface Object

Using a Device Object. When communicating with your instrument using a device object, instead of employing instrument commands, you invoke device object methods (functions) or you set device object properties as provided by the MATLAB instrument driver for that instrument.

In the following figure, the Test & Measurement Tool resets a TDS 210 oscilloscope by issuing a call to the `devicereset` function of the instrument driver. Communicating this way, you don't need to know what the actual oscilloscope reset command is.

Communicating via a Device Object
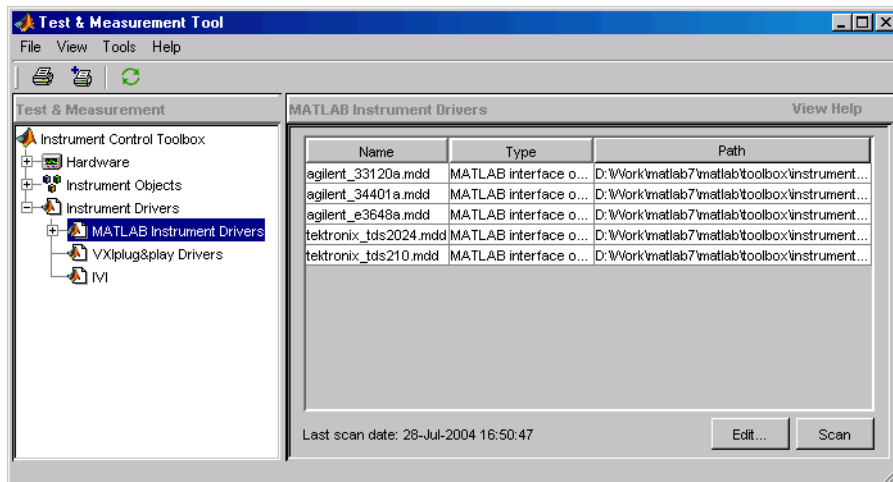
Instrument Drivers

The Test & Measurement Tool enables you to scan for installed drivers, and to use those drivers when creating device objects.

MATLAB Instrument Drivers

MATLAB instrument drivers include

- MATLAB interface drivers
- MATLAB VXI*plug&play* drivers
- MATLAB IVI drivers

Select the MATLAB Instrument Drivers node in the tree. Then click **Scan** to get an updated display of all the installed MATLAB instrument drivers found on the MATLAB path.

When the Test & Measurement Tool scans for drivers, it makes them available as nodes under the driver type node. Expand the `MATLAB Instrument Drivers` node to reveal the installed drivers. Select one of them to see the driver's details.
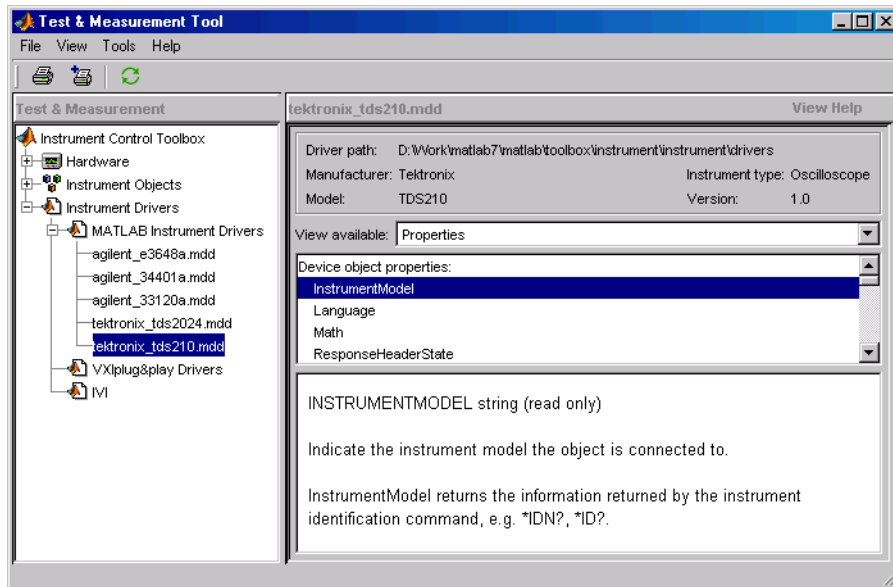
You can choose to see the driver's properties or functions. When you select the particular property or function, the tool displays that item's description.

VXI*plug&play* Drivers

For an example of scanning for installed XVI*plug&play* drivers with the Test & Measurement Tool, see "VXI*plug&play* Drivers" on page 9-3.

IVI Drivers

For an example of scanning for installed IVI-C or IVI-COM drivers with the Test & Measurement Tool, see "IVI Drivers" on page 10-4. For using the Test & Measurement Tool to examine or configure an IVI configuration store, see "Configuring" on page 10-12.

14

The Instrument Driver Editor

This chapter describes how to use the Instrument Driver Editor to create, import, or modify instrument drivers. The sections are as follows.

Overview

This section provides an overview of the MATLAB Instrument Driver Editor. Topics include

- "What Is a MATLAB Instrument Driver?" on page 14-2
- "How Does a MATLAB Instrument Driver Work?" on page 14-3
- "Why Use a MATLAB Instrument Driver?" on page 14-3

For many instruments, a MATLAB instrument driver already exists and you will not need to create a MATLAB instrument driver for your instrument. For other instruments, there may be a similar MATLAB instrument driver and you will need to edit it. If you would like more information on how to edit a MATLAB instrument driver, you may want to begin with "Modifying MATLAB Instrument Drivers" on page 14-66.

What Is a MATLAB Instrument Driver?

The Instrument Control Toolbox provides the means of communicating directly with a hardware instrument through an interface object. If you are programming directly through an interface object, you need to program with the command language of the instrument itself. Any substitution of instrument, such as make or model, may require a change to the appropriate MATLAB code.
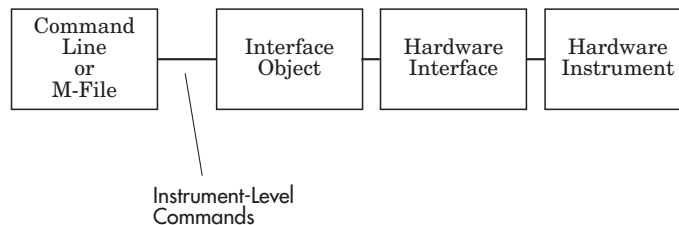
A MATLAB instrument driver offers a layer of interpretation between the user and the instrument. The instrument driver contains all the necessary commands for programming the instrument, so that you do not need to be aware of the specific instrument commands. Instead, you can program the instrument with familiar or consistent device object properties and functions.

The following figure shows how a device object and instrument driver offer a layer between the command line and the interface object. The instrument driver handles the instrument-level commands, so that as you program from the command line, you need only manipulate device object properties and functions, rather than instrument commands.
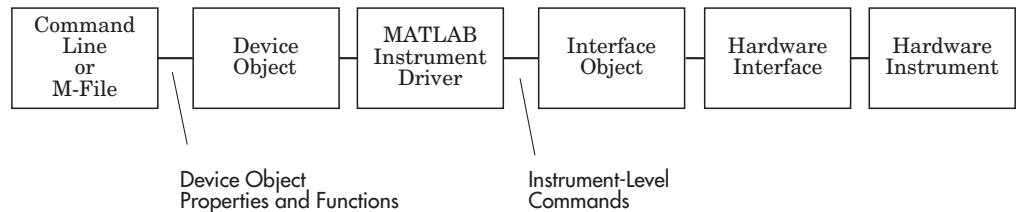
In addition to containing instrument commands, the instrument driver can also contain MATLAB code to provide analysis based upon instrument setup or data.

How Does a MATLAB Instrument Driver Work?

A MATLAB instrument driver contains information on the functionality supported by an instrument. You access this functionality through a device object's properties and functions.

When you query or configure a property of the device object using the `get` or `set` function, or when you call (`invoke`) a function on the device object, the MATLAB instrument driver provides a translation to determine what instrument commands are written to the instrument or what MATLAB code is executed.

Why Use a MATLAB Instrument Driver?

Using a MATLAB instrument driver isolates you from the instrument commands. Therefore, you do not need to be aware of the instrument syntax, but can use the same code for a variety of related instruments, ignoring the differences in syntax from one instrument to the next.

For example, suppose you have two different oscilloscopes in your shop, each with its own set of commands. If you want to perform the same tasks with the two different instruments, you can create an instrument driver for each

scope so that you can control each with the same code. Then substitution of one instrument for another does not require a change in the MATLAB code being used to control it, but only a substitution of the instrument driver.

Creating MATLAB Instrument Drivers

This section tells how to create a MATLAB instrument driver using the MATLAB Instrument Driver Editor. Topics include

- "Driver Components" on page 14-5
- "MATLAB Instrument Driver Editor Features" on page 14-6
- "Saving MATLAB Instrument Drivers" on page 14-6
- "Driver Summary and Control Commands" on page 14-6
- "Initialization and Cleanup" on page 14-11

Driver Components

A MATLAB instrument driver contains information about an instrument and defines the functionality supported by the instrument. The components of a MATLAB instrument driver are described below.

Driver Component	Description
Driver Summary and Control Commands	Basic information about the instrument, e.g., manufacturer or model number.
Initialization and Cleanup	Code that is executed at various stages in the instrument control session, e.g., code that is executed upon connecting to the instrument.
Properties	A property is generally used to configure or query an instrument's state information.
Functions	A function is generally used to control or configure an instrument.
Groups	A group combines common functionality of the instrument into one component.

Depending on the instrument and the application for which the driver is being used, all components of the driver may not be defined. The necessary driver components needed for your application can be defined with the MATLAB Instrument Driver Editor.

MATLAB Instrument Driver Editor Features

The MATLAB instrument driver editor is a tool that creates or edits a MATLAB instrument driver. Specifically, it allows you to

- Add/remove/modify properties
- Add/remove/modify functions
- Define MATLAB code to wrap around commands sent to instrument

The MATLAB Instrument Driver Editor can be launched with the `midedit` command.

```
midedit
```

Throughout the remainder of this section, each driver component will be described and examples will be shown on how to add the driver component information to a new MATLAB instrument driver called `tektronix_tds210_ex.mdd`. The `tektronix_tds210_ex.mdd` driver will define basic information and instrument functionality for a Tektronix TDS 210 oscilloscope.

Saving MATLAB Instrument Drivers

An instrument driver can be saved to any directory with any name. It is recommended that the instrument driver be saved to a directory in the MATLAB path and that the name follows the format `manufacturer_model.mdd`. For example, an instrument that is used with a Tektronix TDS 210 oscilloscope should be saved with the name `tektronix_tds210.mdd`.

Driver Summary and Control Commands

You can assign basic information about the instrument to the MATLAB instrument driver. Summary information can be used to identify the MATLAB instrument driver and the instrument that it represents. Control commands can be used to reset, test, and read error messages from the instrument. Together, this information can be used to initialize and verify the instrument.

Topics in this section include

Driver Summary

You can assign basic information that describes your instrument in the instrument driver. This information includes the manufacturer of the instrument, the model number of the instrument and the type of the instrument. A version can also be assigned to the driver to assist in revision control.

Control Commands

You can define basic control commands supported by the instrument. The control commands can be accessed through device object properties and functions. The control commands and how they can be accessed are described below.

Control Command	Accessed with Device Object's	Example Instrument Command	Description
Identify	`InstrumentModel` property	`*IDN?`	Returns the identification string of the instrument
Reset	`devicereset` function	`*RST`	Returns the instrument to a known state
Self test	`selftest` function	`*TST?`	Tests the instrument's interface
Error	`geterror` function	`ErrLog:Next?`	Retrieves the next instrument error message

The MATLAB instrument driver editor assigns default values for the control commands. The control commands should be modified appropriately to match the instrument's command set.

Example — Defining Driver Summary and Control Commands

This example defines the basic driver information and control commands for a
Tektronix TDS 210 oscilloscope using the MATLAB instrument driver editor.
In the MATLAB Instrument Driver Editor,

1 Select the Summary node in the tree.

2 In the **Driver summary** pane

    1 Enter Tektronix in the **Manufacturer** field.

    2 Enter TDS 210 in the **Model** field.

    3 Select Oscilloscope in the **Instrument type** field.

    4 Enter 1.0 in the **Driver version** field.

3 In the **Control commands** pane

    1 Leave the **Identify** field with *IDN?.

    2 Leave the **Reset** field with *RST.

    3 Leave the **Self test** field with *TST?

    4 Update the **Error** field with ErrLog:Next?

4 Click the **Save** button. Specify the name of the instrument driver as
tektronix_tds210_ex.mdd.
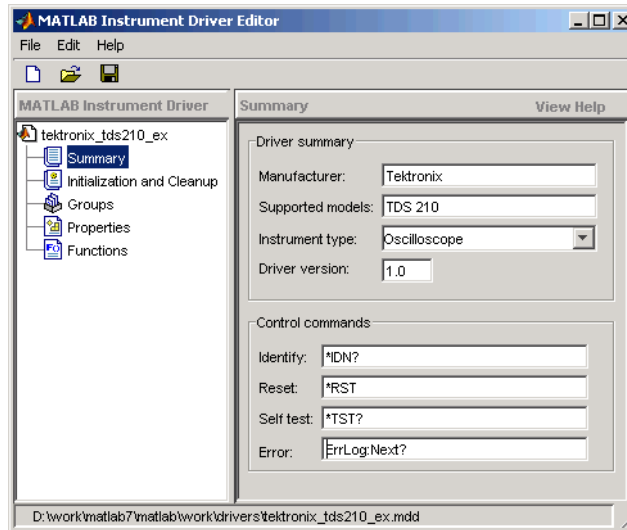
Note For additional information on instrument driver nomenclature, refer to "Saving MATLAB Instrument Drivers" on page 14-6.

Verifying Driver Summary and Control Commands

This procedure verifies the summary information defined in the Driver Summary and Control Commands panes. In this example, the driver name is tektronix_tds210_ex.mdd. Communication with the Tektronix TDS 210 oscilloscope at primary address 2 is done via a Keithley GPIB board at board index 0. From the MATLAB command line,

1 Create the device object, obj, using the icdevice function.

```
g = gpib('keithley', 0, 2);
obj = icdevice('tektronix_tds210_ex.mdd', g);
```

2 View the defined driver information.

```
obj

Instrument Device Object Using Driver : tektronix_tds210_ex.mdd
```

```
Instrument Information
    Type            Oscilloscope
    Manufacturer    Tektronix
    Model           TDS 210

Driver Information
    DriverType      MATLAB Instrument Driver
    DriverName      tekronix_tds210_ex.mdd
    DriverVersion   1.0

Communication State
    Status          closed

instrhwinfo(obj)
ans =
    Manufacturer: 'Tektronix'
           Model: 'TDS 210'
            Type: 'Oscilloscope'
      DriverName: 'h:\documents\tektronix_tds210_ex.mdd'
```

3 Connect to the instrument.

```
connect(obj)
```

4 Verify the control commands.

```
get(obj, 'InstrumentModel')
ans =
    TEKTRONIX,TDS 210,0,CF:91.1CT FV:v2.03 TDS2MM:MMV:v1.04

devicereset(obj)
selftest(obj)
ans =
    0

geterror(obj)
ans =
    ''
```

5 Disconnect from the instrument and delete the objects.

```
disconnect(obj)
delete([obj g])
```

Initialization and Cleanup

This section describes how to define code that is executed at different stages in the instrument control session, so that the instrument can be set to a desired state at particular times. Specifically, you can define code that is executed after the device object is created, after the device object is connected to the instrument, or before the device object is disconnected from the instrument. Depending on the stage, the code can be defined as a list of instrument commands that will be written to the instrument or as MATLAB code.

Topics in this section include

- Definitions of the types of code that can be defined

- Examples of code for each supported stage

- Steps used to verify the code

Create Code

You define create code to ensure that the device object is configured to support the necessary properties and functions:

- Create code is evaluated immediately after the device object is created.

- Create code can only be defined as MATLAB code.

Example — Defining Create Code

This examples defines the create code that ensures that the device object can transfer the maximum waveform size, 2500 data points, supported by the Tektronix TDS 210 oscilloscope. In the MATLAB instrument driver editor,

1 Select the `Initialization and Cleanup` node in the tree.

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2 Select the **Create** tab and enter the MATLAB code to execute on device object creation.

```
% Get the interface object and disconnect from instrument.
g = get(obj, 'Interface');
fclose(g);

% Configure the interface object's buffers to handle up to
% 2500 points (two bytes per point requires 5000 bytes).
set(g, 'InputBufferSize', 5000);
set(g, 'OutputBufferSize', 5000);
```

3 Click the **Save** button.
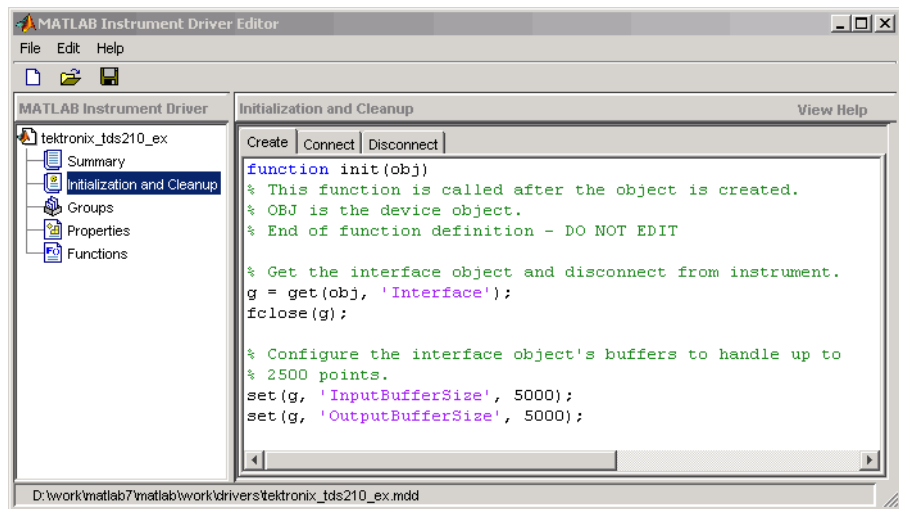
Verifying Create Code

This procedure verifies the MATLAB create code defined. In this example, the driver name is tektronix_tds210_ex.mdd. Communication with the Tektronix TDS 210 oscilloscope at primary address 2 is done via a Keithley GPIB board at board index 0. From the MATLAB command line,

1 Create the interface object, g; and verify the default input and output buffer size values.

```
g = gpib('keithley', 0, 2);
get(g, {'InputBufferSize', 'OutputBufferSize'})
ans =
    [512] [512]
```

2 Create the device object, obj, using the icdevice function.

```
obj = icdevice('tektronix_tds210_ex.mdd', g);
```

3 Verify the create code by querying the interface object's buffer sizes.

```
get(g, {'InputBufferSize', 'OutputBufferSize'})
ans =
    [5000] [5000]
```

4 Delete the objects.

```
delete([obj g])
```

Connect Code

In most cases you need to know the state or configuration of the instrument when you connect the device object to it. You can define connect code to ensure that the instrument is properly configured to support the device object's properties and functions.

Connect code is evaluated immediately after the device object is connected to the instrument with the connect function. The connect code can be defined as a series of instrument commands that will be written to the instrument or as MATLAB code.

Example — Defining Connect Code

This examples defines the connect code that ensures the Tektronix TDS 210 oscilloscope is configured to support the device object properties and functions. Specifically, the instrument will be returned to a known set of instrument settings (instrument reset) and the instrument will be configured to omit headers on query responses. In the MATLAB instrument driver editor,

1 Select the Initialization and Cleanup node in the tree.

2 Select the **Connect** tab and enter the instrument commands to execute when the device object is connected to the instrument.

- Select Instrument Commands from the **Function style** menu.

- Enter the *RST command in the **Command** text field, then click **Add**.

- Enter the HEADER OFF command in the **Command** text field, and then click **Add**.

3 Click the **Save** button.
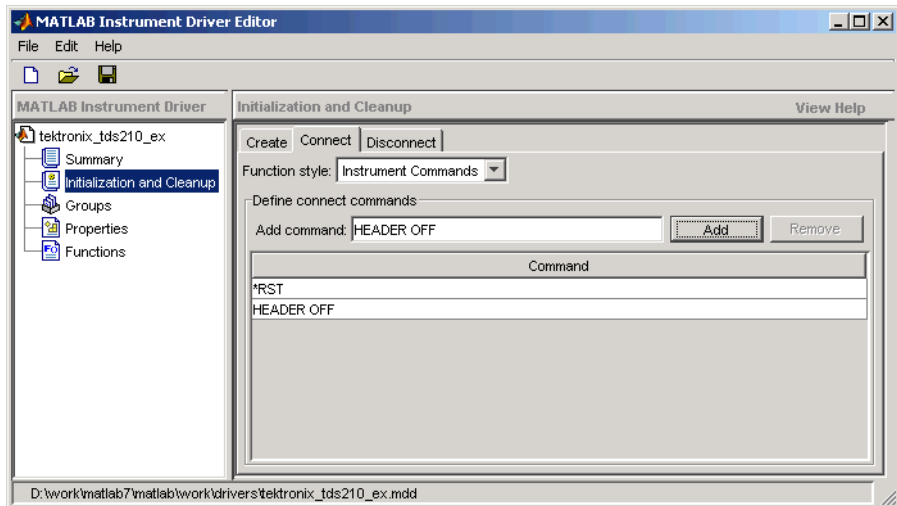
Verifying Connect Code

This procedure verifies the instrument commands defined in the connect code. In this example, the driver name is tektronix_tds210_ex.mdd. Communication with the Tektronix TDS 210 oscilloscope at primary address 2 is done via a Keithley GPIB board at board index 0. From the MATLAB command line,

1 Create the device object, obj, using the icdevice function.

```
g = gpib('keithley', 0, 2);
obj = icdevice('tektronix_tds210_ex.mdd', g);
```

2 Connect to the instrument.

```
connect(obj)
```

3 Verify the connect code by querying the Header state of the instrument.

```
query(g, 'Header?')
ans =
    0
```

4 Disconnect from the instrument and delete the objects.

```
disconnect(obj)
delete([obj g])
```

Disconnect Code

By defining disconnect code, you can ensure that the instrument and the device object are returned to a known state after communication with the instrument is completed.

Disconnect code is evaluated prior to the device object's being disconnected from the instrument with the `disconnect` function. This allows the disconnect code to communicate with the instrument. Disconnect code can be defined as a series of instrument commands that will be written to the instrument or it can be defined as MATLAB code.

Example — Defining Disconnect Code

This example defines the disconnect code that ensures that the Tektronix TDS 210 oscilloscope is returned to a known state after communicating with the instrument using the device object. In the MATLAB instrument driver editor,

1 Select the `Initialization and Cleanup` node in the tree.

2 Select the **Disconnect** tab and enter the MATLAB code to execute when the device object is disconnected from the instrument.

- Select `M-Code` from the **Function style** menu.

- Define the MATLAB code that will reset the instrument and configure the interface object's buffers to their default values.

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```
% Get the interface object.
g = get(obj, 'Interface');

% Reset the instrument to a known state.
fprintf(g, '*RST');
```

3 Click the **Save** button.
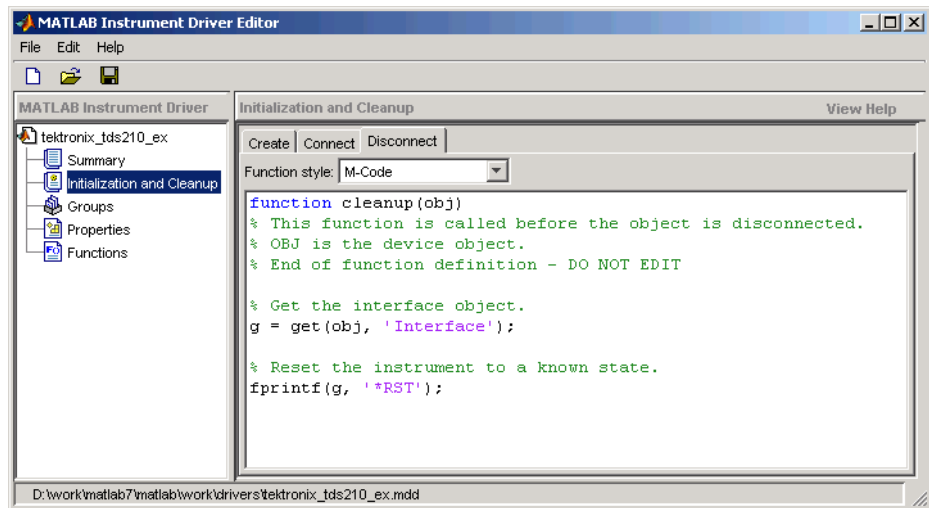
Verifying Disconnect Code

This procedure verifies the MATLAB code defined in the disconnect code. In this example, the driver name is tektronix_tds210_ex.mdd. Communication with the Tektronix TDS 210 oscilloscope at primary address 2 is done via a Keithley GPIB board at board index 0. From the MATLAB command line,

1 Create the device object, obj, using the icdevice function.

```
g = gpib('keithley', 0, 2);
obj = icdevice('tektronix_tds210_ex.mdd', g);
```

2 Connect to the instrument.

```
connect(obj)
```

3 Alter some setting on the instrument so that a change can be observed when you disconnect. For example, the oscilloscope's contrast can be changed by pressing its front pane **Display** button, and then the **Contrast Decrease** button.

4 Disconnect from the instrument and observe that its display resets.

```
disconnect(obj)
```

5 Delete the objects.

```
delete([obj g])
```

Properties

You can make the programming of instruments through device objects easier and more consistent by using properties. A property can be used to query or set an instrument setting or attribute. For example, an oscilloscope's trigger level may be controlled with a property called `TriggerLevel`, which you can read or control with the `get` or `set` function. Even if two different scopes have different trigger syntax, you can use the same property name, `TriggerLevel`, to control them, because each scope will have its own instrument driver.

Another advantage of properties is that you can define them with certain acceptable values (enumerated) or limits (bounded) that can be checked before the associated commands are sent to the instrument.

Topics in this section include

- "Property Components" on page 14-18
- "Examples of Properties" on page 14-21

Property Components

The behavior of the property is defined by the components described below.

Set Code

The `set` code defines the code that is executed when the property is configured with the `set` function. The `set` code can be defined as an instrument command that will be written to the instrument or it can be defined as MATLAB code.

If the `set` code is M-code, it can include any number of commands or MATLAB code wrapped around instrument commands to provide additional processing or analysis.

If the `set` code is defined as an instrument command, then the command written to the instrument will be the instrument command concatenated with a space and the value specified in the call to `set`. For example, the `set` code for the `DisplayContrast` property is defined as the instrument command `DISplay:CONTRast`. When the `set` function below is evaluated, the instrument command sent to the instrument will be `DISplay:CONTRast 54`.

```
set(obj, 'DisplayContrast', 54);
```

Get Code

The `get` code defines the code that is executed when the property value is queried with the `get` function. The `get` code can be defined as an instrument command that will be written to the instrument or it can be defined as MATLAB code.

Note The M-code used for your property's `get` code and `set` code cannot include calls to the `fclose` or `fopen` functions on the interface object being used to access your instrument.

Accepted Property Values

You can define the values that the property can be set to so that only valid values are written to the instrument and an error would be returned before an invalid value could be written to the instrument.

- A property value can be defined as a double, a string, or a Boolean.

- A property value that is defined as a double can be restricted to accept only doubles within a certain range or a list of enumerated doubles. For example, a property could be defined to accept a double within the range of [0 10] or a property could be defined to accept one of the values [1,7,8,10].

- A property value that is defined as a string can be restricted to accept a list of enumerated strings. For example, a property could be defined to accept the strings `min` and `max`.

Additionally, a property can be defined to accept multiple property value definitions. For example, a property could be defined to accept a double ranging between [0 10] or the strings `min` and `max`.

Property Value Dependencies

A property value can be dependent upon another property's value. For example, in controlling a power supply, the property `VoltageLevel` can be configured to the following values:

- A double ranging between 0 and 10 when the value of property `VoltageOutputRange` is `high`

- A double ranging between 0 and 5 when the value of property `VoltageOutputRange` is `low`

When `VoltageLevel` is configured, the value of `VoltageOutputRange` is queried. If the value of `VoltageOutputRange` is `high`, then `VoltageLevel` can be configured to a double ranging between 0 and 10. If the value of `VoltageOutputRange` is `low`, then `VoltageLevel` can be configured to a double ranging between 0 and 5.

Default Value

The default value of the property is the value that the property is configured to when the object is created.

Read-Only Value

The read-only value of the property defines when the property can be configured. Valid options are described below.

Read-Only Value	Description
Never	The property can be configured at all times with the `set` function.
While Open	The property can only be configured with the `set` function when the device object is not connected to the instrument. A device object is disconnected from the instrument with the `disconnect` function.
Always	The property cannot be configured with the `set` function.

Help Text

The help text provides information on the property. This information is returned with the `instrhelp` function.

```
instrhelp(obj, 'PropertyName')
```

Examples of Properties

This section includes several examples of creating, setting, and reading properties, with steps for verifying the behavior of these properties.

Example — Creating a Double-Bounded Property

This example creates a property that will configure the Tektronix TDS 210 oscilloscope's LCD display contrast. The oscilloscope display can be configured to a value in the range `[1 100]`. In the MATLAB instrument driver editor,

1 Select the `Properties` node in the tree.

2 Enter the property name, `DisplayContrast`, in the **Name** text field and click the **Add** button. The new property's name, `DisplayContrast`, appears in the **Property Name** table.

3 Expand the `Properties` node in the tree to display all the defined properties.

4 Select the `DisplayContrast` node from the properties displayed in the tree.

5 Select the **Code** tab to define the `set` and `get` commands for the `DisplayContrast` property.

- Select `Instrument Commands` in the **Property style** field.

- Enter `DISplay:CONTRast?` in the **Get Command** text field.

- Enter `DISplay:CONTRast` in the **Set Command** text field.

6 Select the **Property Values** tab to define the allowed property values.

- Select `Double` in the **Data Type** field.

- Select `Bounded` in the **Constraint** field.

- Enter `1.0` in the **Minimum** field.

- Enter `100.0` in the **Maximum** field.
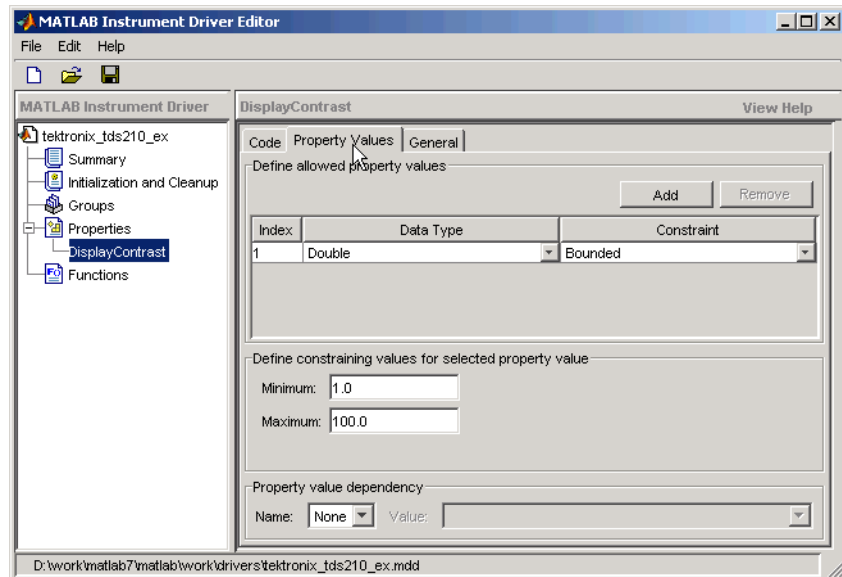
7 Select the **General** tab to finish defining the property behavior.

- Enter `50` in the **Default value** text field.

- Select `never` in the **Read only** field.

- In the **Help text** field, enter `Sets or queries the contrast of the LCD display.`

8 Click the **Save** button.
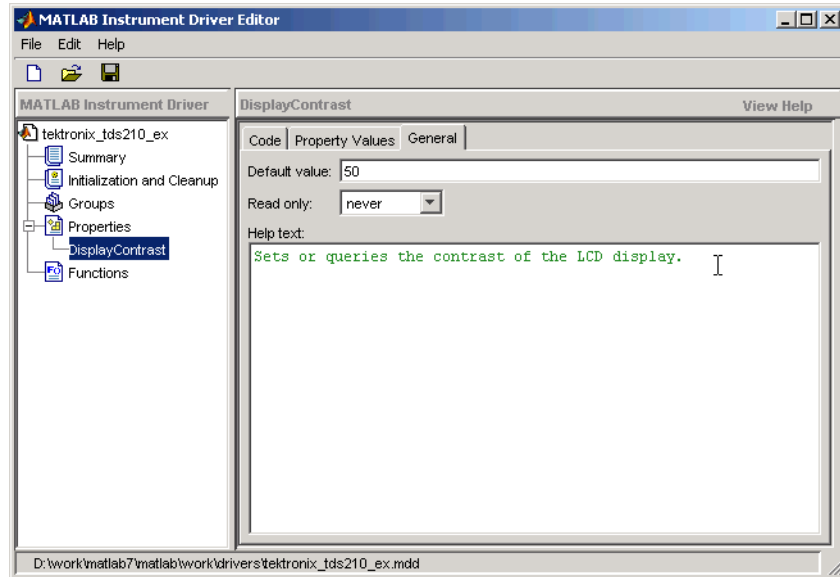
Verifying the Behavior of the Property. This procedure verifies the behavior of the property. In this example, the driver name is `tektronix_tds210_ex.mdd`. Communication with the Tektronix TDS 210 oscilloscope at primary address 2 is done via a Keithley GPIB board at board index 0. From the MATLAB command line,

1 Create the device object, `obj`, using the `icdevice` function.

```
g = gpib('keithley', 0, 2);
obj = icdevice('tektronix_tds210_ex.mdd', g);
```

2 View the `DisplayContrast` property's current value. Calling `get` on the object lists all its properties.

```
get(obj)
```

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Calling `get` on the `DisplayContrast` property lists its current value.

```
get(obj, 'DisplayContrast ')
ans =
    50
```

3 View acceptable values for the `DisplayContrast` property. Calling `set` on the object lists all its settable properties.

```
set(obj)
```

Calling `set` on the `DisplayContrast` property lists the values to which you can set the property.

```
set(obj, 'DisplayContrast')
[ 1.0 to 100.0 ]
```

4 Try setting the property to values inside and outside of the specified range.

```
set(obj, 'DisplayContrast', 17)
get(obj, 'DisplayContrast')
ans =
    17
set(obj, 'DisplayContrast', 120)
??? Invalid value for DisplayContrast. Valid values: a value
between 1.0 and 100.0.
```

5 View the help you wrote.

```
instrhelp(obj,'DisplayContrast')
DISPLAYCONTRAST  [ 1.0 to 100.0 ]
Sets or queries the contrast of the LCD display.
```

6 List the `DisplayContrast` characteristics that you defined in the **Property Values** and **General** tabs.

```
info = propinfo(obj,'DisplayContrast')
info =
                 Type: 'double'
           Constraint: 'bounded'
      ConstraintValue: [1 100]
         DefaultValue: 50
```

```
                     ReadOnly: 'never'
          InterfaceSpecific: 1
```

7 Connect to your instrument to verify the set and get code.

```
connect(obj)
```

When you issue the get function in MATLAB, the
tektronix_tds210_ex.mdd driver actually sends the DISplay:CONTRast?
command to the instrument.

```
get(obj, 'DisplayContrast')
ans =
    17
```

When you issue the set function in MATLAB, the
tektronix_tds210_ex.mdd driver actually sends the DISplay:CONTRast
34 command to the instrument.

```
set(obj, 'DisplayContrast', 34)
```

8 Finally, disconnect from the instrument and delete the objects.

```
disconnect(obj)
delete([obj g])
```

Example — Creating an Enumerated Property

This example creates a property that will select and display the Tektronix
TDS 210 oscilloscope's cursor. The oscilloscope allows two types of cursor.
It supports a horizontal cursor that measures the vertical units in volts,
divisions, or decibels, and a vertical cursor that measures the horizontal units
in time or frequency. In the MATLAB instrument driver editor,

1 Select the Properties node in the tree.

2 Enter the property name, CursorType, in the **Name** text field and click
the **Add** button. The new property's name CursorType appears in the
Property Name table.

3 Expand the Properties node to display all the defined properties.

4 Select the CursorType node from the properties displayed in the tree.

5 Select the **Code** tab to define the set and get commands for the CursorType property.

- Select Instrument Commands in the **Property style** field.

- Enter CURSor:FUNCtion? in the **Get Command** text field.

- Enter CURSor:FUNCtion in the **Set Command** text field.

6 Select the **Property Values** tab to define the allowed property values.

- Select String in the **Data Type** field.

- Select Enumeration in the **Constraint** field.

- Enter none in the **New property value** text field and click the **Add** button. Then enter OFF in the **Instrument Value** table field.

- Similarly add the property value voltage, with instrument value HBArs.

- Similarly add the property value time, with instrument value VBArs.
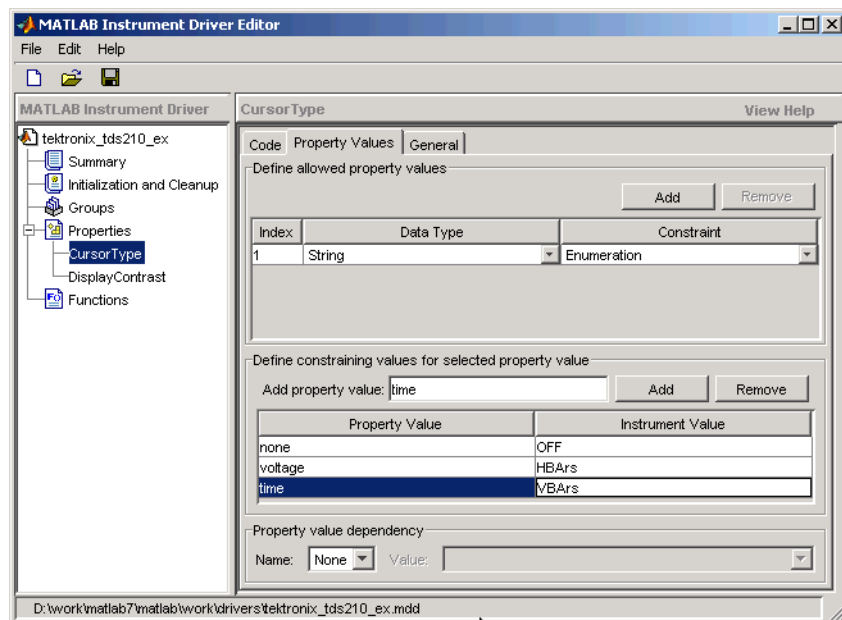
7 Select the **General** tab to finish defining the property behavior.

  - Enter none in the **Default value** text field.

  - Select never in the **Read only** field.

  - In the **Help text** field, enter Specifies the type of cursor.

8 Click the **Save** button.

Verifying the Behavior of the Property. This procedure verifies
the behavior of the property. In this example, the driver name is
tektronix_tds210_ex.mdd. Communication with the Tektronix TDS 210
oscilloscope at primary address 2 is done via a Keithley GPIB board at board
index 0. From the MATLAB command line,

1 Create the device object, obj, using the icdevice function.

```
g = gpib('keithley', 0, 2);
obj = icdevice('tektronix_tds210_ex.mdd', g);
```

2 View the CursorType property's current value. Calling get on the object
lists all its properties.

```
get(obj)
```

Calling get on the CursorType property lists its current value.

```
get(obj, 'CurosrType')
ans =
    none
```

3 View acceptable values for the CursorType property. Calling set on the
object lists all its settable properties.

```
set(obj)
```

Calling set on the CursorType property lists the values to which you can
set the property.

```
set(obj, 'CursorType')
[ {none} | voltage | time ]
```

4 Try setting the property to valid and invalid values.

```
set(obj, 'CursorType', 'voltage')
get(obj, 'CursorType')
ans =
    voltage
set(obj, 'CursorType', 'horizontal')
??? The 'horizontal' enumerated value is invalid.
```

5 View the help you wrote.

```
instrhelp(obj,'CursorType')
CURSORTYPE [ {none} | voltage | time ]
Specifies the type of cursor.
```

6 List the `CursorType` characteristics that you defined in the **Property Values** and **General** tabs.

```
info = propinfo(obj,'CursorType')
info =
                  Type: 'string'
            Constraint: 'enum'
       ConstraintValue: {3x1 cell}
          DefaultValue: 'none'
              ReadOnly: 'never'
     InterfaceSpecific: 1

info.ContraintValue
ans =
'none'
'voltage'
'time'
```

7 Connect to your instrument to verify the `set` and `get` code.

```
connect(obj)
```

When you issue the `set` function in MATLAB, the tektronix_tds210_ex.mdd driver actually sends the `CURSor:FUNCtion VBArs` command to the instrument.

```
set(obj, 'CursorType', 'time')
```

When you issue the `get` function in MATLAB, the
`tektronix_tds210_ex.mdd` driver actually sends the `CURSor:FUNCtion?`
command to the instrument.

```
get(obj,'CursorType')
ans =
time
```

8 Finally disconnect from the instrument and delete the objects.

```
disconnect(obj)
delete([obj g])
```

Example — An M-Code Style Property

This example creates a property that will return the difference between two
cursors of the Tektronix TDS 210 oscilloscope. The oscilloscope allows two
types of cursor. It supports a horizontal cursor that measures the vertical
units in volts, divisions, or decibels, and a vertical cursor that measures
the horizontal units in time or frequency. The previous example created a
property, `CursorType`, that selects and displays the oscilloscope's cursor. In
the MATLAB instrument driver editor,

1 Select the `Properties` node in the tree.

2 Enter the property name, `CursorDelta`, in the **New Property** text field
and click **Add**. The new property's name, `CursorDelta`, appears in the
Property Name table.

3 Expand the `Properties` node to display all the defined properties.

4 Select the `CursorDelta` node from the properties displayed in the tree.

5 Select the **Code** tab to define the set and get commands for the
`CursorDelta` property.

- Select `M-Code` in the **Property style** field.

- Since the `CursorDelta` property is read-only, no MATLAB code will be
  added to the **MATLAB Set Function** text field.

- The following MATLAB code is added to the **MATLAB Get Function**
  text field.

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```
% Extract the interface object.
interface = get(obj, 'Interface');

% Determine the type of cursor being displayed.
type = get(obj, 'CursorType')

% Based on the cursor type, query the instrument.
switch (type)
case 'none'
    propertyValue = O;
case 'voltage'
    propertyValue = query(interface, 'CURSor:HBArs:DELTa?');
    propertyValue = str2double(propertyValue);
case 'time'
    propertyValue = query(interface, 'CURSor:VBArs:DELTa?');
    propertyValue = str2double(propertyValue);
end
```
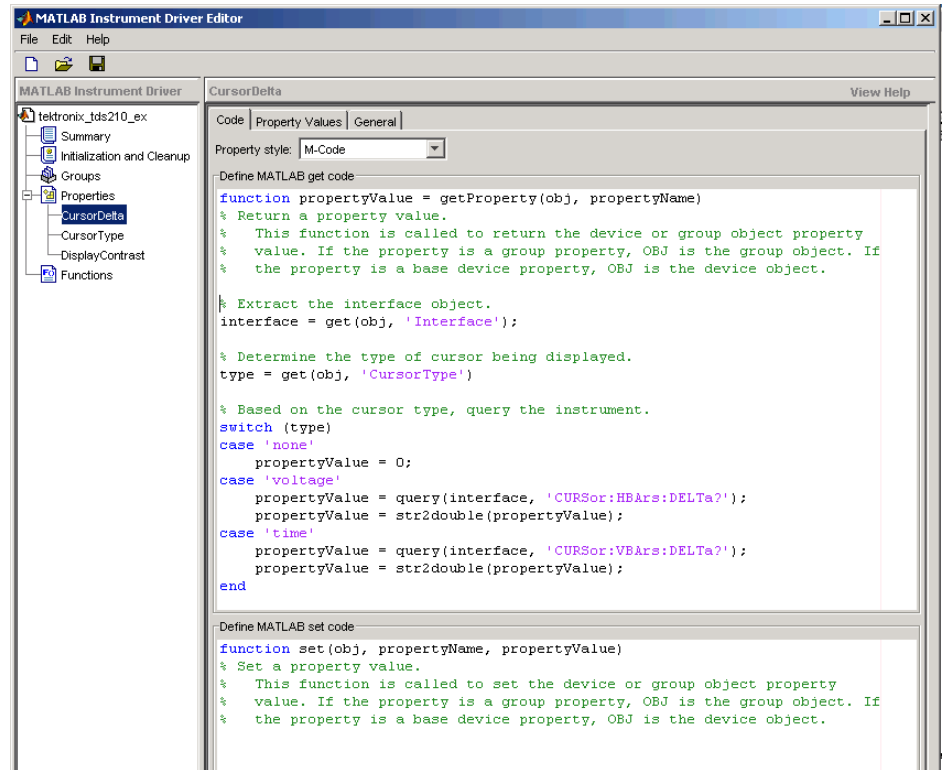
6 Select the **Property Values** tab to define the allowed property values.

- Select Double in the **Data Type** field.
- Select None in the **Constraint** field.

7 Select the **General** tab to finish defining the property behavior.

- Enter 0 in the **Default value** text field.
- Select always in the **Read only** field.
- In the **Help text** field, enter Returns the difference between the two cursors.

8 Click the **Save** button.

Verifying the Behavior of the Property. This procedure verifies the behavior of the property. In this example, the driver name is tektronix_tds210_ex.mdd. Communication with the Tektronix TDS 210 oscilloscope at primary address 2 is done via a Keithley GPIB board at board index 0. From the MATLAB command line,

1 Create the device object, obj, using the icdevice function.

```
g = gpib('keithley', 0, 2);
obj = icdevice('tektronix_tds210_ex.mdd', g);
```

2 View the CursorDelta property's current value. Calling get on the object lists all its properties.

```
get(obj)
```

3 Calling get on the CursorDelta property lists its current value.

```
get(obj, 'CursorDelta')
ans =
    0
```

4 Calling set on the object lists all its settable properties. Note that as a read-only property, CursorDelta is not listed in the output.

```
set(obj)
```

5 Calling set on the CursorDelta property results in an error message.

```
set(obj, 'CursorDelta')
??? Attempt to modify read-only device property: 'CursorDelta'.
```

6 Setting the property to a value results in an error message.

```
set(obj, 'CursorDelta', 4)
??? Changing the 'CursorDelta' property of device objects is not
allowed.
```

7 View the help you wrote.

```
instrhelp(obj,'CursorDelta')
CURSORDELTA  (double)  (read only)
Returns the difference between the two cursors.
```

8 List the `CursorDelta` characteristics that you defined in the **Property Values** and **General** tabs.

```
info = propinfo(obj,'CursorDelta')
info =
                    Type: 'double'
              Constraint: 'none'
         ConstraintValue: []
            DefaultValue: 0
                ReadOnly: 'always'
       InterfaceSpecific: 1
```

9 Connect to your instrument to verify the `get` code.

```
connect(obj)
```

When you issue the `get` function in MATLAB, the `tektronix_tds210_ex.mdd` driver actually executes the MATLAB code that was specified.

```
get(obj, 'CursorDelta')
ans =
    1.6000
```

10 Finally, disconnect from the instrument and delete the objects.

```
disconnect(obj)
delete([obj g])
```

Functions

Functions allow you to call the instrument to perform some task or tasks, which may return results as text data or numeric data. The function may involve a single command to the instrument, or a sequence of instrument commands. A function may include MATLAB code to determine what commands are sent to the instrument or to perform analysis on data returned from the instrument. For example, a function may request that a meter run its self-calibration, returning the status as a result. Another function may read a meter's scaling, request a measurement, adjust the measured data according to the scale reading, and then return the result.

Topics in this section include

- "Function Components" on page 14-34
- "Examples of Functions" on page 14-35

Function Components

The behavior of the function is defined by the components described below.

Code

The code defines the code that is executed when the function is evaluated with the `invoke` function. The code can be defined as an instrument command that will be written to the instrument or it can be defined as MATLAB code.

If the code is defined as an instrument command, the instrument command can be defined to take an input argument. All occurrences of `<input argument name>` in the instrument command are substituted with the input value passed to the `invoke` function. For example, if a function is defined with an input argument, `start`, and the instrument command is defined as `Data:Start <start>`, and a start value of `10` is passed to the `invoke` function, the command `Data:Start 10` is written to the instrument.

If the code is defined as an instrument command, the instrument command can also be defined to return an output argument. The output argument can be returned as numeric data or as text data.

If the code is defined as MATLAB code, you can determine which commands are sent to the instrument, and the data results from the instrument can be manipulated, adjusted, or analyzed as needed.

Note The M-code used for your function's MATLAB code cannot include calls to the `fclose` or `fopen` functions on the interface object being used to access your instrument.

Help Text
The help text provides information on the function.

Examples of Functions
This section includes several examples of functions, and steps to verify the behavior of these functions.

|	
Example — A Simple Function (p. 14-36)	Create a simple function that requires no arguments and returns no data. The function sends the autoset command to the oscilloscope to stabilize a waveform display.
Example — A Function with Instrument Commands that Use Input and Output Arguments (p. 14-38)	Create a function that requires input arguments and returns results. The function configures the oscilloscope's waveform setup with source, start address, and stop address information; and then reads back the waveform setup data from the scope.
Example — An M-Code Style Function (p. 14-41)	Create an M-code style function. The function reads a waveform from the oscilloscope, then adjusts the waveform with scaling and offset factors.

Example — A Simple Function

This example creates a function that will cause the Tektronix TDS 210 oscilloscope to adjust its vertical, horizontal and trigger controls to display a stable waveform. In the MATLAB instrument driver editor,

1 Select the Functions node in the tree.

2 Enter the function name, autoset, in the **Add function** text field and click the **Add** button. The new function's name, autoset, appears in the **Function Name** table.

3 Expand the Functions node to display all the defined functions.

4 Select the autoset node from the functions displayed in the tree.

5 Select the **Code** tab to define commands executed for this function.

- Select Instrument Commands in the **Function style** field.

- In the **Define function commands** pane, enter AUTOSet EXECute in the **Add command** field and click the **Add** button.
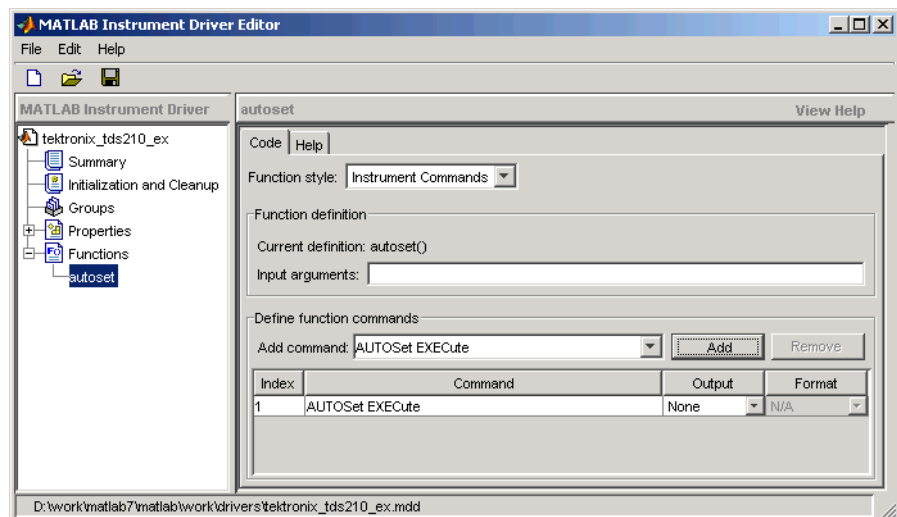
6 Select the **Help** tab to define the help text for this function.

- In the **Help text** field, enter INVOKE(OBJ, 'autoset') causes the
  oscilloscope to adjust its vertical, horizontal, and trigger
  controls to display a stable waveform.

7 Click the **Save** button.

Verifying the Behavior of the Function. This procedure verifies
the behavior of the function. In this example, the driver name is
tektronix_tds210_ex.mdd. Communication with the Tektronix TDS 210
oscilloscope at primary address 2 is done via a Keithley GPIB board at board
index 0. From the MATLAB command line,

1 Create the device object, obj, using the icdevice function.

```
g = gpib('keithley', 0, 2);
obj = icdevice('tektronix_tds210_ex.mdd', g);
```

2 View the method you created.

```
methods(obj)

Methods for class icdevice:

Contents          error            instrhwinfo      open
class             fieldnames       instrnotify      openvar
close             get              instrument       propinfo
connect           geterror         invoke           selftest
ctranspose        horzcat          isa              set
delete            icdevice         isequal          sim
devicereset       igetfield        isetfield        size
disconnect        inspect          isvalid          subsasgn
disp              instrcallback    length           subsref
display           instrfind        methods          vertcat
end               instrfindall     ne
eq                instrhelp        obj2mfile

Driver specific methods for class icdevice:

autoset
```

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3 View the help you wrote.

```
instrhelp(obj, 'autoset')
INVOKE(OBJ, 'autoset') causes the oscilloscope to adjust its
vertical, horizontal, and trigger controls to display a stable
waveform.
```

4 Using the controls on the instrument, set the scope so that its display is unstable. For example, set the trigger level outside the waveform range so that the waveform scrolls across the display.

5 Connect to your instrument and execute the function. Observe how the display of the waveform stabilizes.

```
connect(obj)
invoke(obj, 'autoset')
```

**6** Disconnect from your instrument and delete the object.

```
disconnect(obj)
delete([obj g])
```

Example — A Function with Instrument Commands that Use Input and Output Arguments

This example creates a function that configures which waveform will be transferred from the Tektronix TDS 210 oscilloscope, and configures the waveform's starting and ending data points. In the MATLAB instrument driver editor,

1 Select the Functions node in the tree.

2 Enter the function name, configureWaveform, in the **New function** text field and click the **Add** button. The new function's name, configureWaveform, appears in the **Function Name** table.

3 Expand the Functions node to display all the defined functions.

4 Select the configureWaveform node from the functions displayed in the tree.

5 Select the **Code** tab to define commands executed for this function.

- Select `Instrument Commands` in the **Function style** field.

- Enter the input arguments `source, start, stop` in the **Input arguments** field.

- Enter `Data:Source <source>` in the **New command** field and click the **Add** button. In the table, select an **Output** type of `None` and a **Format** type of `N/A`.

- Similarly, add the command: `Data:Source?` with `ASCII` **Output** and `text` **Format**.

- Similarly, add the command: `Data:Start <start>` with `NONE` **Output** and `N/A` **Format**.

- Similarly, add the command: `Data:Start?` with `ASCII` **Output** and `numeric` **Format**.

- Similarly, add the command: `Data:Stop <stop>` with `NONE` **Output** and `N/A` **Format**.

- Similarly, add the command: `Data:Stop?` with `ASCII` **Output** and `numeric` **Format**.
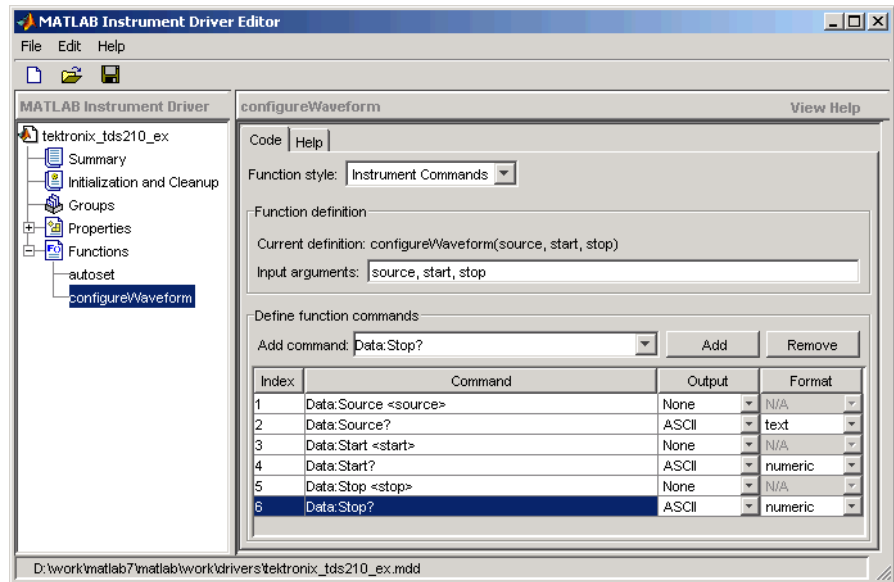
6 Select the **Help** tab to define the help text for this function.

- In the **Help text** field, enter [SOURCE, START, STOP] = INVOKE(OBJ, 'configureWaveform', SOURCE, START, STOP) configures the waveform that will be transferred from the oscilloscope.

7 Click the **Save** button.

Verifying the Behavior of the Function. This procedure verifies the behavior of the function. In this example, the driver name is tektronix_tds210_ex.mdd. Communication with the Tektronix TDS 210 oscilloscope at primary address 2 is done via a Keithley GPIB board at board index 0. From the MATLAB command line,

1 Create the device object, obj, using the icdevice function.

```
g = gpib('keithley', 0, 2);
obj = icdevice('tektronix_tds210_ex.mdd', g);
```

2 View the method you created.

```
methods(obj)

Methods for class icdevice:

Contents          error           instrhwinfo     open
class             fieldnames      instrnotify     openvar
close             get             instrument      propinfo
connect           geterror        invoke          selftest
ctranspose        horzcat         isa             set
delete            icdevice        isequal         sim
devicereset       igetfield       isetfield       size
disconnect        inspect         isvalid         subsasgn
disp              instrcallback   length          subsref
display           instrfind       methods         vertcat
end               instrfindall    ne
eq                instrhelp       obj2mfile

Driver specific methods for class icdevice:

autoset configureWaveform
```

3 View the help you wrote.

```
instrhelp(obj, 'configureWaveform')

[SOURCE, START, STOP] = INVOKE(OBJ, 'configureWaveform', SOURCE,
START, STOP) configures the waveform that will be transferred from
the oscilloscope.
```

4 Connect to your instrument and execute the function.

```
connect(obj)
[source, start, stop] = invoke(obj, 'configureWaveform', 'CH1',
1, 500)
source =
CH1

start =
     1

stop =
   500
[source, start, stop] = invoke(obj, 'configureWaveform', 'CH2',
0, 3500)
source =
CH2

start =
     1

stop =
      2500
```

5 Disconnect from your instrument and delete the object.

```
disconnect(obj)
delete([obj g])
```

Example — An M-Code Style Function

This example creates a function that will transfer and scale the waveform from
the Tektronix TDS 210 oscilloscope. In the MATLAB instrument driver editor,

1 Select the Functions node in the tree.

2 Enter the function name, getWaveform, in the **Add function** text field and click the **Add** button. The new function's name, getWaveform, appears in the **Function Name** table.

3 Expand the Functions node to display all the defined functions.

4 Select the getWaveform node from the functions displayed in the tree.

5 Select the **Code** tab to define commands executed for this function.

- Select M-Code in the **Function style** field.

- Update the function line in the **Define MATLAB function** text field to include an output argument.

  ```
  function yout = getWaveform(obj)
  ```

- Add the following MATLAB code to the **Define MATLAB function** text field. (The instrument may require a short pause before any statements that read a waveform, to allow its completion of the data collection.)

  ```
  % Get the interface object.
  g = get(obj, 'Interface');

  % Configure the format of the data transferred.
  fprintf(g, 'Data:Encdg SRIBinary');
  fprintf(g, 'Data:Width 1');

  % Determine which waveform is being transferred.
  source = query(g, 'Data:Source?');

  % Read the waveform.
  fprintf(g, 'Curve?');
  ydata = binblockread(g, 'int8');

  % Read the trailing terminating character.
  fscanf(g);

  % Scale the data.
  fprintf(g, ['WFMPre:' source ':Yoff?']);
  ```
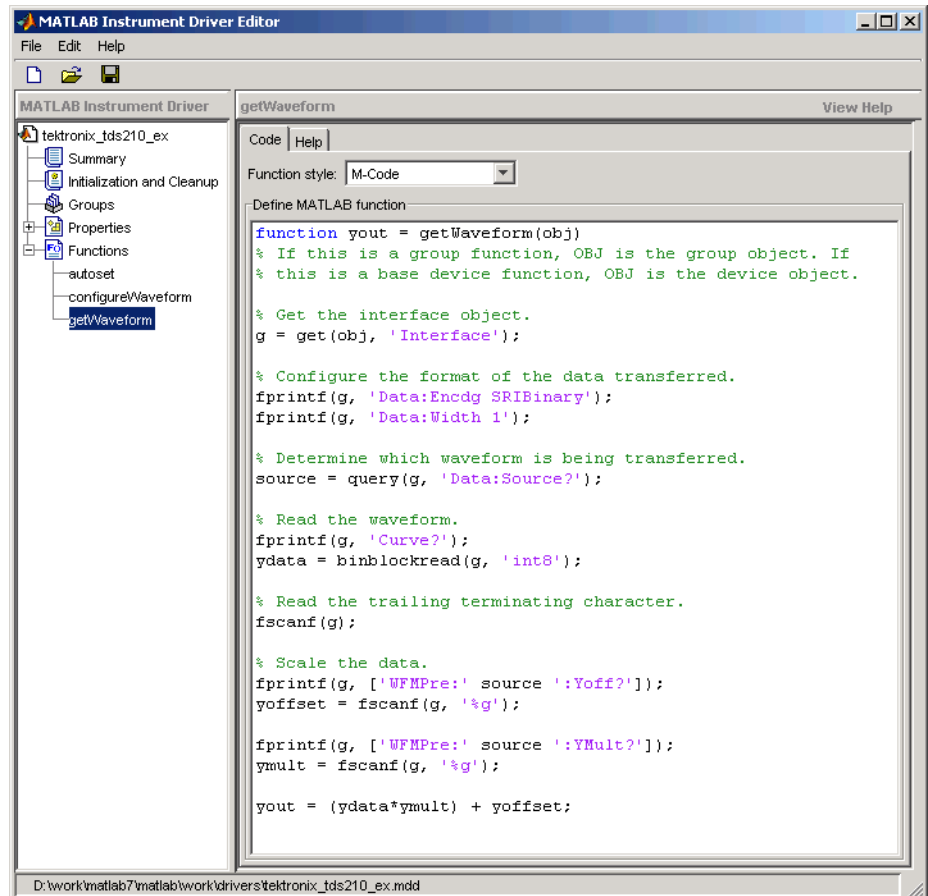
```
yoffset = fscanf(g, '%g');

fprintf(g, ['WFMPre:' source ':YMult?']);
ymult = fscanf(g, '%g');

yout = (ydata*ymult) + yoffset;
```


6 Click the **Help** tab to define the help text for this function.

- In the **Help text** field, enter DATA = INVOKE(OBJ, 'getWaveform') transfers and scales the waveform from the oscilloscope.

7 Click the **Save** button.

Verifying the Behavior of the Function. This procedure verifies
the behavior of the function. In this example, the driver name is
tektronix_tds210_ex.mdd. Communication with the Tektronix TDS 210
oscilloscope at primary address 2 is done via a Keithley GPIB board at board
index 0. From the MATLAB command line,

1 Create the device object, obj, using the icdevice function.

```
g = gpib('keithley', 0, 2);
obj = icdevice('tektronix_tds210_ex.mdd', g);
```

2 View the method you created.

```
methods(obj)

Methods for class icdevice:

Contents        error           instrhwinfo     open
class           fieldnames      instrnotify     openvar
close           get             instrument      propinfo
connect         geterror        invoke          selftest
ctranspose      horzcat         isa             set
delete          icdevice        isequal         sim
devicereset     igetfield       isetfield       size
disconnect      inspect         isvalid         subsasgn
disp            instrcallback   length          subsref
display         instrfind       methods         vertcat
end             instrfindall    ne
eq              instrhelp       obj2mfile

Driver specific methods for class icdevice:

autoset configureWaveform getWaveform
```

3 View the help you wrote.

```
instrhelp(obj, 'getWaveform')
DATA = INVOKE(OBJ, 'getWaveform') transfers and scales the
waveform from the oscilloscope.
```

4 Connect to your instrument and execute the function.

```
connect(obj)
```

Configure the waveform that is going to be transferred.

```
invoke(obj, 'configureWaveform', 'CH1', 1, 500);
```

Transfer the waveform.

```
data = invoke(obj, 'getWaveform');
```

Analyze and view the waveform.

```
size(data)
ans =
   500     1

plot(data)
```

5 Disconnect from your instrument and delete the object.

```
disconnect(obj)
delete([obj g])
```

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Groups

A group may be used to set or query the same property on several elements, or to query several related properties, at the same time. For example, all input channels on an oscilloscope can be scaled to the same value with a single command; or all current measurement setups can be retrieved and viewed at the same time.

Topics in this section include

- "Group Components" on page 14-46
- "Examples of Groups" on page 14-47

Group Components

A group consists of one or more group objects. The objects in the group share a set of properties and functions. Using these properties and functions you can control the features of the instrument represented by the group. In order for the group objects to control the instrument correctly, the group must define a selection command for the group and an identification string for each object in the group.

Selection Command

The selection command is an instrument command that configures the instrument to use the capability or physical component represented by the current group object. Note, the instrument might not have a selection command.

Identification String

The identification string identifies an object in the group. The number of identification strings listed by the group defines the number of objects in the group. The identification string can be substituted into the instrument commands written to the instrument.

When a group object instrument command is written to the instrument, the following steps occur:

1 The selection command for the group is determined by the driver.

2 The identification string for the group object is determined by the driver.

3 If the selection command contains the string `<ID>`, it is replaced with the identification string.

4 The selection command is written to the instrument. If empty, nothing is written to the instrument.

5 If the instrument command contains the string `<ID>`, it is replaced with the identification string.

6 The instrument command is written to the instrument.

Examples of Groups

This section includes several examples of groups, with steps to verify the code.

Example — Creating a One-Element Group (p. 14-47)	Create a one-element group object. You define and view the oscilloscope's trigger group information.
Example — Defining the Group Object Properties for a One-Element Group (p. 14-49)	Define group object properties for a one-element group. You create several properties for the trigger group object of the first example.
Example — Creating a Four-Element Group (p. 14-55)	Creates a four-element group object. You define and view the oscilloscope's measurement group information.
Example — Defining the Group Object Properties for a Four-Element Group (p. 14-57)	Define group object properties for a four-element group. You create several properties for the measurement group object of the previous example.

Example — Creating a One-Element Group

This example combines the trigger capabilities of the Tektronix TDS 210 oscilloscope into a trigger group. The oscilloscope allows the trigger source and slope settings to be configured. In the MATLAB instrument driver editor,

1 Select the `Groups` node in the tree.

2 Enter the group name, `Trigger`, in the **New Group** text field and click **Add**.

3 Expand the `Groups` node to display all the defined groups.

4 Select the `Trigger` node in the tree.

5 Select the **Definition** tab.

Since the oscilloscope has only one trigger, there is not a command that will select the current trigger. The **Selection command** text field will remain empty.
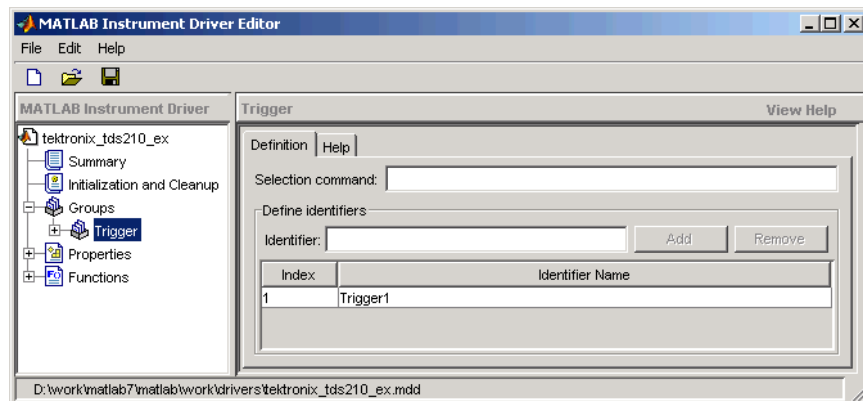
6 Select the **Help** tab to finish defining the group behavior.

In the **Help text** field, enter `Trigger is a trigger group.  The trigger group object contains properties that configure and query the oscilloscope's triggering capabilities.`

7 Click the **Save** button.

Verifying the Group Behavior.   This procedure verifies the group information defined. In this example, the driver name is `tektronix_tds210_ex.mdd`. Communication with the Tektronix TDS 210 oscilloscope at primary address 2 is done via a Keithley GPIB board at board index 0. From the MATLAB command line,

1 Create the device object, `obj`, using the `icdevice` function.

```
g = gpib('keithley', 0, 2);
obj = icdevice('tektronix_tds210_ex.mdd', g);
```

2 View the group you created. Note that the `HwName` property is the group object identification string.

```
get(obj)
get(obj, 'Trigger')
HwIndex:   HwName:      Type:             Name:
1          Trigger1     scope-trigger     Trigger1
```

3 View the help.

```
instrhelp(obj, 'Trigger')
TRIGGER (object) (read only)
Trigger is a trigger group. The trigger group object contains
properties that configure and query the oscilloscope's triggering
capabilities.
```

4 Delete the objects.

```
delete([obj g])
```

Example — Defining the Group Object Properties for a One-Element Group

This example defines the properties for the `Trigger` group object created in the previous example. The Tektronix TDS 210 oscilloscope can trigger from CH1 or CH2 when the data has a rising or falling slope.

First, the properties `Source` and `Slope` are added to the trigger group object. In the MATLAB instrument driver editor,

1 Expand the `Trigger` group node to display the group object's properties and functions.

2 Select the `Properties` node to define the `Trigger` group object properties.

3 Enter the property name `Source` in the **Add property** text field and click the **Add** button

4 Enter the property name `Slope` in the **Add property** text field and click the **Add** button.

**5** Expand the `Properties` node to display the group object's properties.

Next, define the behavior of the `Source` property:

1 Select the `Source` node in the tree.

2 Select the **Code** tab to define the `set` and `get` commands for the `Source` property.

- Select `Instrument Commands` in the **Property style** field.

- Enter `TRIGger:MAIn:EDGE:SOUrce?` in the **Get command** text field.

- Enter `TRIGger:MAIn:EDGE:SOUrce` in the **Set command** text field.

3 Select the **Property Values** tab to define the allowed property values.

- Select `String` in the **Data Type** field.

- Select `Enumeration` in the **Constraint** field.

- Enter `CH1` in the **Add property value** text field and click the **Add** button. Then enter `CH1` in the **Instrument Value** table field.

- Similarly, add the enumeration: `CH2`, `CH2`.

4 Select the **General** tab to finish defining the property behavior.

- Enter CH1 in the **Default value** text field.

- Select never in the **Read only** field.

- In the **Help text** field, enter Specifies the source for the main edge trigger.

Next, define the behavior of the Slope property:

1 Select the Slope node in the tree.

2 Select the **Code** tab to define the set and get commands for the Slope property.

- Select Instrument Commands in the **Property style** field.

- Enter TRIGger:MAIn:EDGE:SLOpe? in the **Get command** text field.

- Enter TRIGger:MAIn:EDGE:SLOpe in the **Set command** text field.

3 Select the **Property Values** tab to define the allowed property values.

- Select String in the **Data Type** field.

- Select Enumeration in the **Constraint** field.

- Enter falling in the **Add property value** text field and click the **Add** button. Then enter FALL in the **Instrument Value** table field.

- Similarly add the enumeration: rising, RISe.
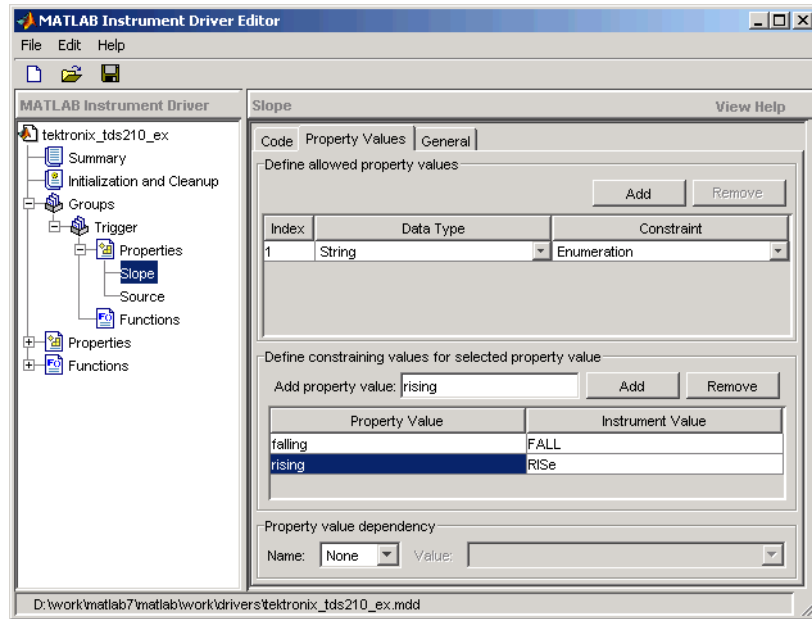
4 Select the **General** tab to finish defining the property behavior.

- Enter falling in the **Default value** text field.

- Select never in the **Read only** field.

- In the **Help text** field, enter Specifies a rising or falling slope for the main edge trigger.

5 Click the **Save** button.

Verifying Properties of the Group Object in MATLAB. This procedure verifies the properties of the Trigger group object. In this example, the driver name is tektronix_tds210_ex.mdd. Communication with the Tektronix TDS 210 oscilloscope at primary address 2 is done via a Keithley GPIB board at board index 0. From the MATLAB command line,

1 Create the device object, obj, using the icdevice function.

```
g = gpib('keithley', 0, 2);
obj = icdevice('tektronix_tds210_ex.mdd', g);
```

2 Extract the trigger group objects, t, from the device object.

```
t = get(obj, 'Trigger')
    HwIndex:   HwName:      Type:              Name:
    1          Trigger1     scope-trigger      Trigger1
```

3 View the current values for the properties of the trigger group object. Calling get on the object lists all its properties.

```
get(t)
```

4 Calling get on a specific property lists its current value.

```
get(t, {'Source', 'Slope'})
ans =
    'CH1' 'falling'
```

5 View the acceptable values for the properties of the group object. Calling set on the object lists all its settable properties.

```
set(t)
```

6 Calling set on a specific property lists the values to which you can set the property.

```
set(t, 'Source')
[ {CH1} | CH2 ]

set(t, 'Slope')
[ {falling} | rising ]
```

7 Try setting the property to valid and invalid values.

```
set(t, 'Source', 'CH2', 'Slope', 'rising')
get(t, {'Source', 'Slope'})
ans =
    'CH2' 'rising'
set(t, 'Source', 'CH3')
??? The 'CH3' enumerated value is invalid.
set(t, 'Slope', 'steady')
??? The 'steady' enumerated value is invalid.
```

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8 View the help you wrote.

```
instrhelp(t, 'Source')
SOURCE [ {CH1} | CH2 ]
Specifies the source for the main edge trigger.

instrhelp(t, 'Slope')
SLOPE [ {falling} | rising ]
Specifies a rising or falling slope for the main edge trigger.
```

9 List the group object characteristics that you defined in the **Property Values** and **General** tabs.

```
propinfo(t, 'Source')
ans =
                    Type: 'string'
              Constraint: 'enum'
         ConstraintValue: {2x1 cell}
            DefaultValue: 'CH1'
                ReadOnly: 'never'
       InterfaceSpecific: 1

propinfo(t, 'Slope')
ans =
                    Type: 'string'
              Constraint: 'enum'
         ConstraintValue: {2x1 cell}
            DefaultValue: 'falling'
                ReadOnly: 'never'
       InterfaceSpecific: 1
```

10 Connect to your instrument to verify the set and get code.

```
connect(obj)
```

Note When you issue the get function on the Source property for the trigger object, the textronix_tds210_ex.mdd driver actually sends the TRIGger:MAIn:EDGE:SOUrce? command to the instrument.

```
get(t, 'Source')
ans =
CH1
```

Note When you issue the set function on the Slope property for the trigger object, the textronix_tds210_ex.mdd driver actually sends the TRIGger:MAIn:EDGE:SLOpe RISe command to the instrument.

```
set(t, 'Slope', 'rising')
```

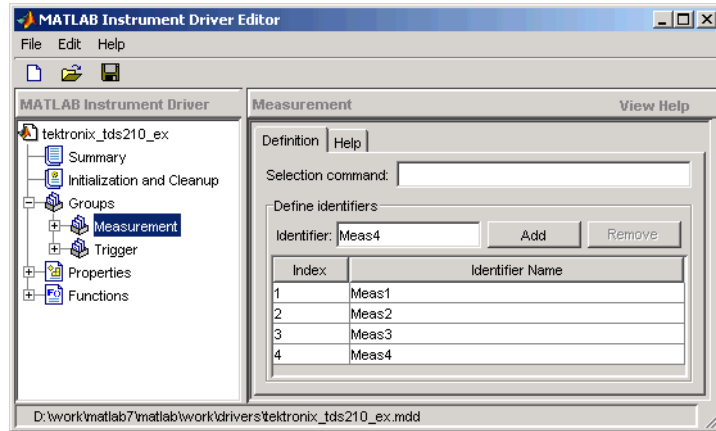**11** Disconnect from your instrument and delete the objects.

```
disconnect(obj)
delete([obj g])
```

Example — Creating a Four-Element Group

This example combines the measurement capabilities of the Tektronix TDS 210 oscilloscope into a measurement group. The oscilloscope allows four measurements to be taken at a time. In the MATLAB instrument driver editor,

1 Select the Groups node in the tree.

2 Enter the group name, Measurement, in the **Add group** text field and click **Add**.

3 Expand the Groups node to display all the defined groups.

4 Select the Measurement node in the tree.

5 Select the **Definition** tab.

  • The oscilloscope does not define an instrument command that will define the measurement that is currently being calculated. The **Selection command** text field will remain empty.

  • In the **Identifier Name** listing, change Measurement1 to Meas1 to define the identification string for the first measurement group object in the group.

- Enter the identifiers Meas2, Meas3, and Meas4 for the remaining measurement group objects by typing each in the **Identifier** text field and clicking **Add** after each.

6 Select the **Help** tab to finish defining the group behavior.

- In the **Help text** field, enter Measurement is an array of measurement group objects. A measurement group object contains properties related to each supported measurement on the oscilloscope.

7 Click the **Save** button.

Verifying the Group Behavior. This procedure verifies the group information defined. In this example, the driver name is tektronix_tds210_ex.mdd. Communication with the Tektronix TDS 210 oscilloscope at primary address 2 is done via a Keithley GPIB board at board index 0. From the MATLAB command line,

1 Create the device object, obj, using the icdevice function.

```
g = gpib('keithley', 0, 2);
obj = icdevice('tektronix_tds210_ex.mdd', g);
```

2 View the group you created. Note that the HwName property is the group object get(obj).

```
get(obj, 'Measurement')

HwIndex:    HwName:    Type:                  Name:
1           Meas1      scope-measurement      Measurement1
2           Meas2      scope-measurement      Measurement2
3           Meas3      scope-measurement      Measurement3
4           Meas4      scope-measurement      Measurement4
```

3 View the help.

```
instrhelp(obj, 'Measurement')
MEASUREMENT (object) (read only)
Measurement is an array of measurement group objects. A
measurement group object contains properties related to each
supported measurement on the oscilloscope.
```

4 Delete the objects.

```
delete([obj g])
```

Example — Defining the Group Object Properties for a Four-Element Group

This example defines the properties for the Measurement group object created in the previous example. The Tektronix TDS 210 oscilloscope can calculate the frequency, mean, period, peak to peak value, root mean square, rise time, fall time, positive pulse width, or negative pulse width of the waveform of Channel 1 or Channel 2.

First, the properties MeasurementType, Source, Value, and Units will be added to the Measurement group object.

1 Expand the Measurement group node to display the group object's properties and methods.

2 Select the Properties node to define the Measurement group object properties.

3 Enter the property name MeasurementType in the **Add property** text field and click the **Add** button.

4 Enter the property name Source in the **Add property** text field and click the **Add** button.

5 Enter the property name Value in the **Add property** text field and click the **Add** button.

6 Enter the property name Units in the **Add property** text field and click the **Add** button.

7 Expand the Properties node to display the group object's properties.
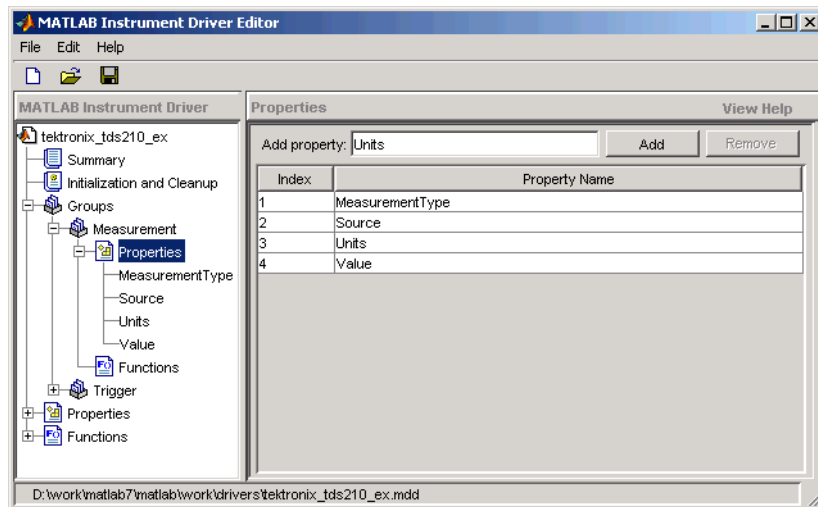
Next, define the behavior of the MeasurementType property:

1 Select the MeasurementType node in the tree.

2 Select the **Code** tab to define the set and get commands for the MeasurementType property.

- Select Instrument Commands in the **Property style** field.

- Enter Measurement:<ID>:Type? in the **Get command** text field.

- Enter Measurement:<ID>:Type in the **Set command** text field.

3 Select the **Property Values** tab to define the allowed property values.

- Select String in the **Data Type** field.

- Select Enumeration in the **Constraint** field.

- Enter frequency in the **Add property value** text field and click the **Add** button. Then enter FREQuency in the **Instrument Value** table field.

- Add the enumeration: mean, MEAN.

- Add the enumeration: period, PERIod.

- Add the enumeration: pk2pk, PK2pk.

- Add the enumeration: rms, CRMs.

- Add the enumeration: riseTime, RISe.

- Add the enumeration: fallTime, FALL.

- Add the enumeration: posWidth, PWIdth.

- Add the enumeration: negWidth, NWIdth.

- Add the enumeration: none, NONE.
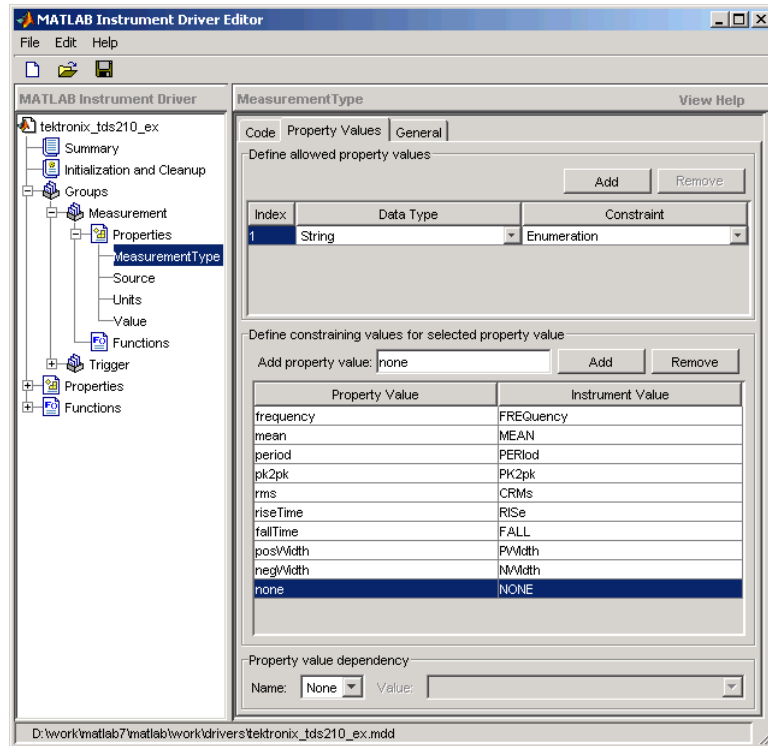
4 Select the **General** tab to finish defining the property behavior.

- Enter none in the **Default value** text field.
- Select never in the **Read only** field.
- In the **Help text** field, enter Specifies the measurement type.

Next, define the behavior of the Source property.

1 Select the Source node in the tree.

2 Select the **Code** tab to define the `set` and `get` commands for the `Source` property.

- Select `Instrument Commands` in the **Property style** field.

- Enter `Measurement:<ID>:Source?` in the **Get command** field.

- Enter `Measurement:<ID>:Source` in the **Set command** field.

3 Select the **Property Values** tab to define the allowed property values.

- Select `String` in the **Data Type** field.

- Select `Enumeration` in the **Constraint** field.

- Enter `CH1` in the **Add property value** text field and click the **Add** button. Then enter `CH1` in the **Instrument Value** table field.

- Similarly add the enumeration: `CH2`, `CH2`.

4 Select the **General** tab to finish defining the property behavior.

- Enter `CH1` in the **Default value** text field.

- Select `never` in the **Read only** field.

- In the **Help text** field, enter `Specifies the source of the measurement.`

Next, define the behavior of the `Units` property.

1 Select the `Units` node in the tree.

2 Select the **Code** tab to define the `set` and `get` commands for the `Units` property.

- Select `Instrument Commands` in the **Property style** field.

- Enter `Measurement:<ID>:Units?` in the **Get command** text field.

- Since the `Units` property is read-only, leave the **Set command** text field empty.

3 Select the **Property Values** tab to define the allowed property values.

- Select String in the **Data Type** field.
- Select None in the **Constraint** field.

4 Select the **General** tab to finish defining the property behavior.

- Enter volts in the **Default value** text field.
- Select always in the **Read only** field.
- In the **Help text** field, enter Returns the measurement units.

Finally, define the behavior of the Value property.

1 Select the Value node in the tree.

2 Select the **Code** tab to define the set and get commands for the Value property.

- Select Instrument Commands in the **Property style** field.
- Enter Measurement:<ID>:Value? in the **Get command** text field.
- Since the Value property is read-only, leave the **Set command** text field empty.

3 Select the **Property Values** tab to define the allowed property values.

- Select Double in the **Data Type** field.
- Select None in the **Constraint** field.

4 Select the **General** tab to finish defining property behavior.

- Enter 0 in **Default value** field.
- Select always in the **Read only** field.
- In the **Help text** field, enter Returns the measurement value.

5 Click the **Save** button.

Verifying the Properties of the Group Object in MATLAB. This procedure verifies the properties of the measurement group object. In this example, the driver name is tektronix_tds210_ex.mdd. Communication with the Tektronix TDS 210 oscilloscope at primary address 2 is done via a Keithley GPIB board at board index 0. From the MATLAB command line,

1 Create the device object, obj, using the icdevice function.

```
g = gpib('keithley', 0, 2);
obj = icdevice('tektronix_tds210_ex.mdd', g);
```

2 Extract the measurement group objects, m, from the device object.

```
m = get(obj, 'Measurement')
```

HwIndex:	HwName:	Type:	Name:
1	Meas1	scope-measurement	Measurement1
2	Meas2	scope-measurement	Measurement2
3	Meas3	scope-measurement	Measurement3
4	Meas4	scope-measurement	Measurement4

3 View the current values for the properties of the first group object. Calling get on the object lists all its properties.

```
get(m(1))
```

4 Calling get on a specific property lists its current value.

```
get(m(1), {'MeasurementType', 'Source', 'Units', 'Value'})

ans =
'none' 'CH1' 'volts' [0]
```

5 View the acceptable values for the properties of the group object. Calling set on the object lists all its settable properties.

```
set(m(1))

set(m(1), 'MeasurementType')
[ frequency | period | {none} | mean | pk2pk | rms | riseTime |
fallTime | posWidth | negWidth ]
```

```
set(m(1), 'Source')
[ {CH1} | CH2 ]
```

6 Try setting the property to valid and invalid values.

```
set(m(1), 'Source', 'CH2')
get(m(1), 'Source')
ans =
CH2
set(m(1), 'Source', 'CH5')
??? The 'CH5' enumerated value is invalid.
```

7 View the help you wrote.

```
instrhelp(m(1), 'Value')
VALUE (double) (read only)
Returns the measurement value.
```

8 List the group object characteristics that you defined in the **Property
Values** and **General** tabs.

```
propinfo(m(1), 'Units')
ans =
                   Type: 'string'
             Constraint: 'none'
        ConstraintValue: []
           DefaultValue: 'volts'
               ReadOnly: 'always'
       InterfaceSpecific: 1
```

9 Connect to your instrument to verify the set and get code.

```
connect(obj)
```

Note When you issue the get function on the MeasurementType property for
the first measurement object in the group, the textronix_tds210_ex.mdd
driver actually sends the Measurement:Meas1:Type? command to the
instrument.

```
get(m(1), 'MeasurementType')
```

```
ans =
frequency
```

Note When you issue the `set` function on the `Source` property for the second measurement object in the group, the `textronix_tds210_ex.mdd` driver actually sends the `Measurement:Meas2:Source CH2` command to the instrument.

```
set(m(2), 'Source', 'CH2')
```

10 Disconnect from your instrument and delete the objects.

```
disconnect(obj)
delete([obj g])
```

Using Existing Drivers

Modifying MATLAB Instrument Drivers

If a MATLAB instrument driver does not exist for your instrument, it may be that a MATLAB instrument driver for an instrument similar to yours does exist. Rather than creating a new MATLAB instrument driver, you may choose to edit an existing MATLAB instrument driver. An existing MATLAB instrument driver can be opened in the MATLAB instrument driver editor with the `midedit` function.

```
midedit('drivername')
```

Deleting an Existing Property, Function, or Group

1 Select the property, function, or group in the tree.

2 Select the **Edit** menu.

3 Select the **Delete** menu item.

Renaming an Existing Property, Function, or Group

1 Select the property, function, or group in the tree.

2 Select the **Edit** menu.

3 Select the **Rename** menu item.

Other Settings and Tasks

Refer to "Creating MATLAB Instrument Drivers" on page 14-5 for information on

- Defining summary information
- Defining initialization and cleanup code
- Creating a new property

- Creating a new function

- Creating a new group

Importing VXI*plug&play* and IVI Drivers

The MATLAB Instrument Driver Editor can import a VXI*plug&play* or IVI driver. You can evaluate or set the driver's functions and properties, and the modified driver can be saved for further use:

1 Open the MATLAB Instrument Driver Editor with `midedit`.

2 Click the **File** menu, and select **Import**.

The **Import Driver** dialog box appears, showing the installed VXI*plug&play* and IVI drivers.
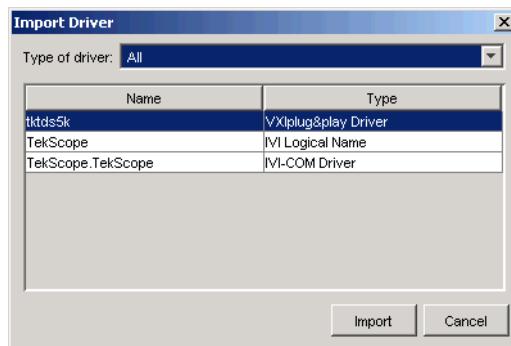
3 Select the desired driver and click **Import**.

The MATLAB Instrument Driver Editor creates a MATLAB instrument driver based on the properties and/or functions in the original VXI*plug&play* or IVI driver. The editor displays the new driver's summary information, groups, properties, and functions.

With the MATLAB Instrument Driver Editor, you can

- Create, delete, modify, or rename properties, functions, or groups

- Add M-code around instrument commands for analysis

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- Add create, connect, and disconnect code
- Save the driver as a separate MATLAB VXI*plug&play* instrument driver or MATLAB IVI instrument driver

The Instrument Driver Testing Tool

This chapter describes how to use the Instrument Driver Testing Tool to verify the functionality of your instrument drivers. The sections are as follows.

Overview

This section provides an overview of the MATLAB Instrument Driver Testing Tool and examples showing its capabilities and usage.

The MATLAB Instrument Driver Testing Tool provides a graphical environment for creating a test to verify the functionality of a MATLAB instrument driver.

The MATLAB Instrument Driver Testing Tool provides a way to

- Verify property behavior
- Verify function behavior
- Save the test as a test file, MATLAB code, or driver function
- Export the test results to MATLAB workspace, figure window, MAT-file, or the MATLAB array editor
- Save test results as an HTML page

Drivers

The MATLAB Instrument Driver Testing Tool can be used to test any MATLAB instrument driver. These include

- MATLAB interface drivers
- MATLAB VXI*plug&play* drivers
- MATLAB IVI drivers

MATLAB VXI*plug&play* drivers and MATLAB IVI drivers can be created from VXI*plug&play* and IVI drivers, respectively, using the MATLAB Instrument Driver Editor or the `makemid` function.

Test Structure

The driver test structure is composed of setup information and test steps.

Setup

When setting up or initializing the test, you provide a test name and description, identify the driver to test, define the interface to the instrument, and set the test preferences. This information remains unchanged throughout the execution of the test, and applies to every step.

Test Steps

The executable portion of the test is divided into any number of test steps. A test step can perform one of four verifications:

- Set property — Verify that the set command or set code of a single device object or group object property in the driver does not error, and that the driver supports the defined range for the property value. You can use one value or all supported values for the property. You may also use invalid property values to check the driver's response.

- Get property — Verify the reading of a single device object or group object property from the driver.

- Properties sweep — Verify several properties in a single step.

- Function — Verify the execution of a driver function.

After configuring your test steps, you can execute the steps individually, or run a complete test that executes all the steps in the test.

Starting

You start the MATLAB Instrument Driver Testing Tool by typing the MATLAB command

```
midtest
```

This opens the tool without any test file loaded.

You may specify a test file (usually created in an earlier session of the tool) when you start the tool so that it opens up with a test file already loaded.

```
midtest('MyDriverTestfile')
```

Example

For the examples in this chapter, you will create a test for the Tektronix TDS210 oscilloscope driver that you created in Chapter 14, "The Instrument Driver Editor".

You will create each kind of step in your test: set property, get property, sweep properties, and function.

Setting Up Your Test

The Test File

You can specify a test file to load when you start `midtest`, open a test file after the MATLAB Instrument Driver Testing Tool is already up, or create a new test. You may find it convenient to keep the driver and test file together in the same directory. For easy use in the MATLAB Command Window, you can put that directory in the MATLAB path with the `addpath` command.

Providing a Name and Description

The **Name** field allows a one-line text definition for your test. This name appears in the header of the test results in the **Output Window**.

The **Description** field allows a full definition of the text with as much descriptive text as you need.

Specifying the Driver

In the **Driver** text field, you specify the driver to be tested. This is any MATLAB instrument driver, usually with the `.mdd` extension. Enter the full pathname to the driver, or use the **Browse** button to navigate to the driver's directory.

Specifying an Interface

You specify the interface with the instrument for the testing of the driver. The instrument object type may be `GPIB`, `VISA`, `TCPIP`, `UDP`, or `serial port`. Depending on the type you choose, the **New Object Creation** dialog box prompts you for further configuration information.

The tool then creates a device object based on interface and driver.

Setting Test Preferences

The **Test Preferences** dialog box allows you to set certain behaviors of the tool when running a test.

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Run Mode

This specifies whether the test runs all the steps or only one step in the test.

Fail Action

This specifies what happens if a step within the test fails. The test may stop after the failed step or continue, with or without resetting the instrument.

No-error String

This field specifies the expected string returned from the instrument *when there is no error*. If you indicate that a step passes when no error is returned from the instrument, the tool compares the string returned from the instrument via the geterror function, to the string given here in the Preferences dialog box. If the strings match, then the tool assumes there is no error from the instrument.

Number of Values to Test

A double-precision property can be tested using all supported values. You can request this when testing it as a single step, or the tool does it automatically when the property is tested as part of a property sweep step. This field specifies how many values are tested for such a property.

The number of values includes the defined minimum and maximum for the property, and integer values equally spaced between these limits.

If your property requires noninteger values for testing, then create a separate test step for that property instead of including it in a sweep.

Example — Setting Up a Driver Test

This example identifies the driver to be tested, and defines global setup information for the test. You will be testing the driver created in the examples of Chapter 14, "The Instrument Driver Editor"

1 Open the MATLAB Instrument Driver Testing Tool from the command line with the command midtest.
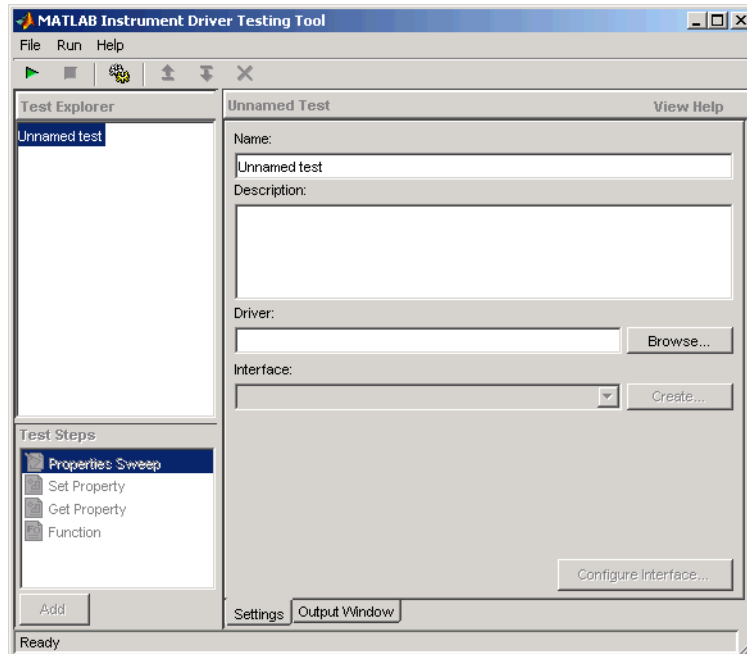
2 In the **Name** text field, enter TDS 210 Driver Sample Test.

3 In the **Description** text field, enter A test to check some of the
properties and functions of the TDS 210 oscilloscope driver.

4 In the **Driver** field, enter the name of the driver you created in Chapter
14, "The Instrument Driver Editor". The text field will display the whole
pathname, with the driver file tektronix_tds210_ex.mdd.

5 Click the **Create** button to create an instrument interface.
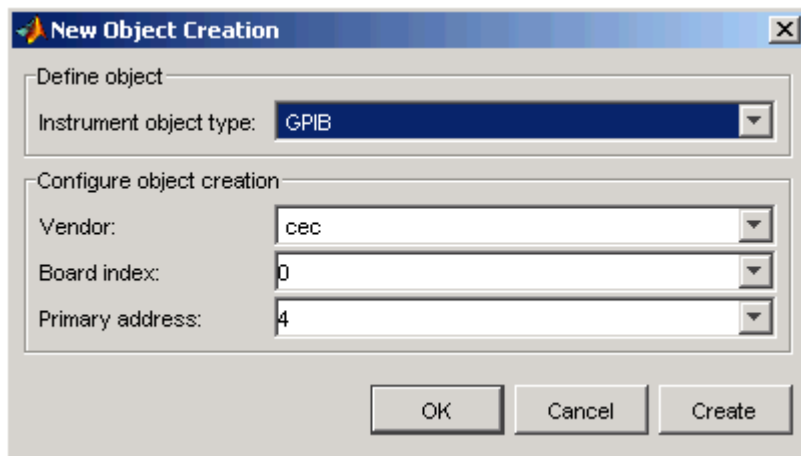
6 In the **New Object Creation** dialog box,

   1 Select your **Instrument object type**, **Vendor**, **Board index**, and **Primary address** of your instrument.

       The example illustrations in this chapter use a CEC GPIB board with index 0 and the instrument at address 4. Your configuration may be different.

   2 Click **OK**.

7 Click the **File** menu and select **Test Preferences**.

8 In the **Test Preferences** dialog box,

  1 For **Select run mode**, click **Run all steps**.

  2 For **Select fail action**, click **Continue test**.

  3 For **Message returned from instrument when no error occurred**, enter `""`. (This is an empty string in double quotes.)

  4 For **Number of values to test for double properties**, enter 5.

  5 Click **OK**.
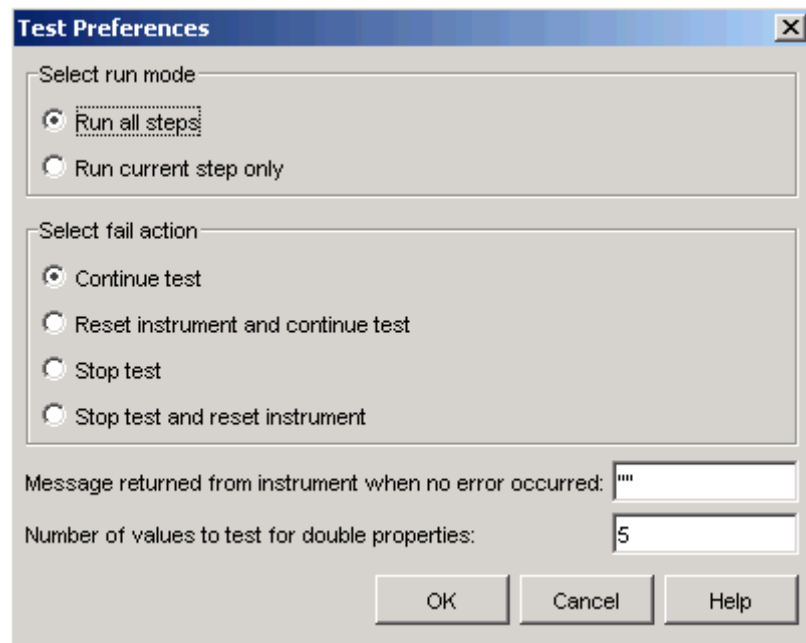
The MATLAB Instrument Driver Testing Tool now displays all your setup information.
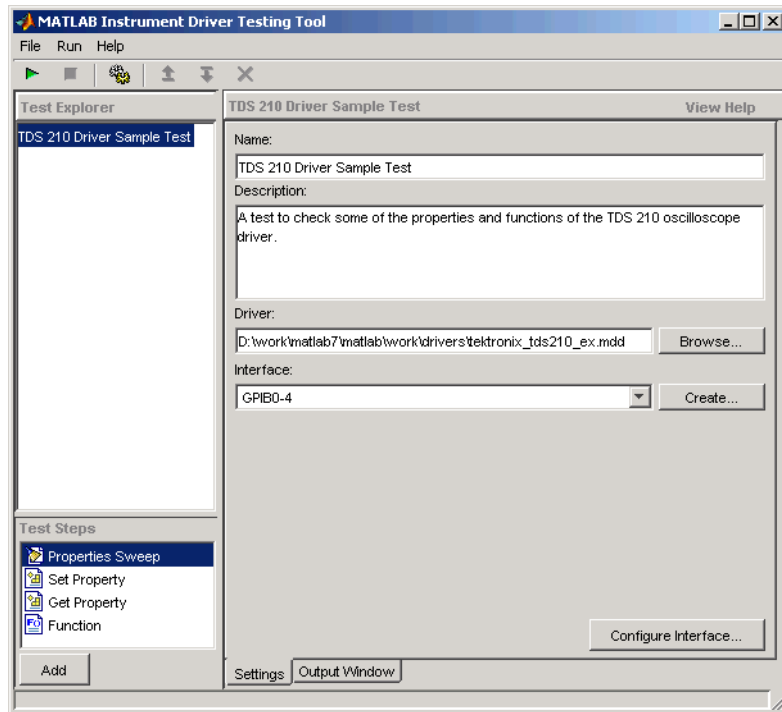
9 Click **File** and select **Save**. Enter tektronix_tds210_ex_test as the filename for your test. The tool automatically adds the .xml file extension.

Defining Test Steps

Test Step: Set Property

You use a set property test step to verify a driver's set code or set command for a property. You provide a name for the step, select the driver property to test and the values to test it with, and define the conditions for the step's passing.

Settings

Name. You provide a name for each test step. The name appears in the **Test Explorer** tree as well as in the results output.

Property to Test. A set property step can test only one property. You choose the property from the Property to Test list. Additional properties can be tested with additional steps, or with a sweep step.

Object(s) to Test. A property may be defined for the instrument or for a group object. If you are testing a group object property, you select which object you want tested in the Object(s) to Test list.

Define the Values to Test. If the property is has enumerated values, you can select one of the defined values, all of the supported values, or some other value. If the property's value is a double-precision number, you can select a value within its defined range, all supported values, or some other value. For a double, you set the number of values tested for all supported values in the Preferences dialog box (see "Number of Values to Test" on page 15-6).

Select When this Step Passes. The step passes when one or both of two conditions are met:

- If no instrument or MATLAB error occurs as a result of attempting to set the property with its test value

- If a query of the property after it is set returns a specified value

If you select more than one of these conditions, then both conditions must be met for the step to pass. If no boxes are selected, the test will pass.

Example — Creating a Test Step: Set Property

1 Click the Set Property option in the **Test Steps** list box.

2 Click the **Add** button.

3 In the **Name** field, enter Set Display Contrast.

4 In the **Property to test** list, select DisplayContrast.

5 For **Define the value(s) to test**, select All supported values.

6 For **Select when this step passes**,

- Select **If no MATLAB or instrument error occurs**.
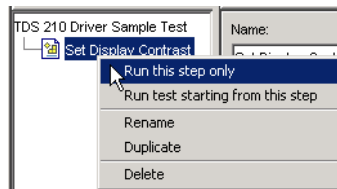- Select **If current value matches configured value**.
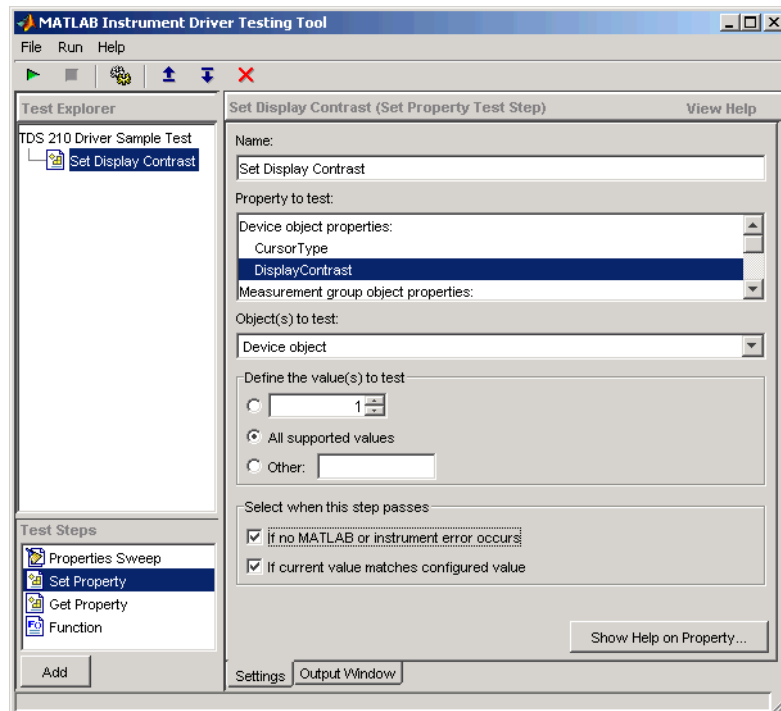
7 Click **File** and select **Save**.

Running a Test Step to Set a Property

You can run an individual test step to verify its behavior:

1 Select Set Display Contrast in the **Test Explorer** tree.

2 With the cursor on the selected name, right-click to bring up the context menu.

3 In the context menu, select **Run this step only**.

You may want to repeat this step as you observe the oscilloscope display. The test sets the display contrast to five different values: lowest acceptable value (1%), highest acceptable value (100%), and three approximately equally spaced integer values between these limits.

The tool automatically displays the **Output Window** with the test results.
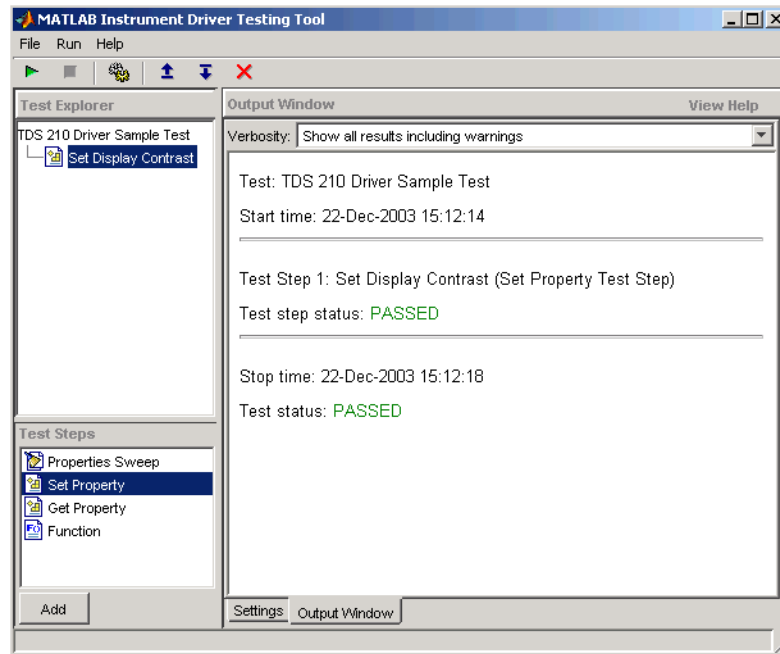
This test step passed because, for each of the five display contrast settings, the tool read back a value that was equal to the configured value.

Test Step: Get Property

You use a get property test step to verify a driver's ability to read a property. You provide a name for the step, select the driver property to test, and define the conditions for the step's passing.

Settings

The settings for the get property step are the same as for a "Test Step: Set Property" on page 15-11, except that instead of providing a value to write, you can provide an output argument variable.

Output Argument. The test step assigns the optional output argument variable the value that results from reading the property. The variable is available for "Exporting Results" on page 15-29, after the test step has executed.

Example — Creating a Test Step: Get Property

1 Click the `Get Property` option in the **Test Step** field.

2 Click the **Add** button.

3 In the **Name** field, enter `Getting Display Contrast`.

4 In the **Property to test** list, select `DisplayContrast`.

5 In the **Output argument** field, enter `DispContr`.

6 For **Select when this step passes**,

- Unselect the box for **If no MATLAB or instrument error occurs**.

- Select **If property value is**, and enter a value of 80.

  This value is chosen to generate a failure. If this step follows the previous step in the example, the display contrast is still set at 100. If this step is run by itself, the display contrast is set to 50 by the `*RST` command that is executed as part of your connect code for the driver.
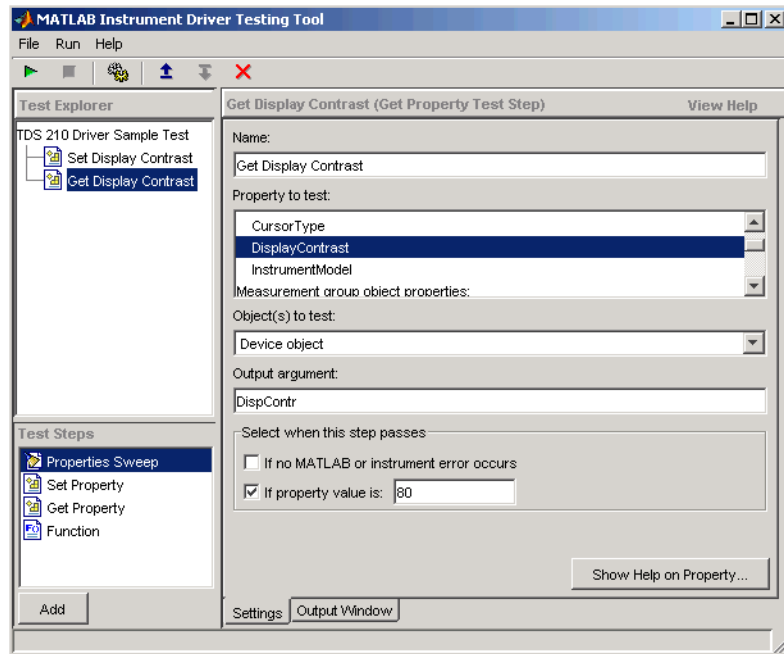
7 Click **File** and select **Save**.

Running a Test Step to Get a Property

You run the individual test step to verify its behavior.

1 Select `Get Display Contrast` in the **Test Explorer** tree.

2 With the cursor on the selected name, click the right mouse button to bring up the context menu.

3 In the context menu, select **Run this step only**.

Note that the test fails, reading a value of 50 while expecting a value of 80.
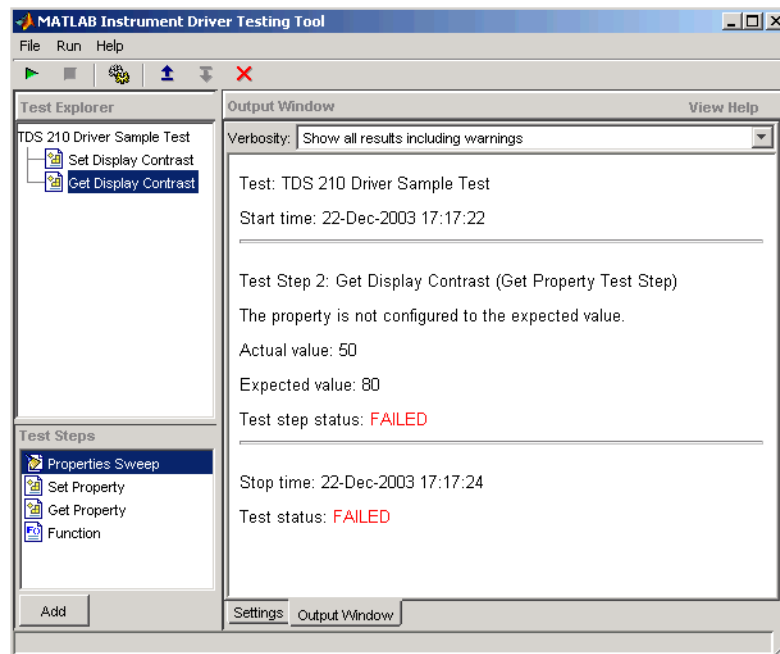
Test Step: Properties Sweep

A properties sweep step allows you to test several properties in a single step. All selected properties are tested for all supported values. (In the case of properties with double-precision values, you determine the "Number of Values to Test" on page 15-6, in the **Test Preferences** dialog box.)

Settings

The fields for name and passing conditions are the same as other types of test steps. The sweep step also requires that you select which properties and groups to test.

Select the Properties to Test. You may select any or all of the properties for testing in a sweep step. You may find it convenient to create several sweep steps for testing related groups properties together.

Select the Group Object to Use on Sweep. For those properties defined for group objects, you can select a particular group object to test, or all the group objects. You can also define different sweep steps for different group objects.

Example — Creating a Sweep Step to Test All Properties

1 Click the `Properties Sweep` option in the **Test Step** field.

2 Click the **Add** button.

3 In the **Name** field, enter `All Properties Sweep`.

4 For **Select the properties to test**, click **Select All**.

5 In the Select the group object(s) field,

- For the **Measurement** group, select `All Measurement group objects`.
- For the **Trigger** group, select `All Trigger group objects`.

6 For **Select when this step passes**,

- Select **If no MATLAB or instrument error occurs**, and
- Select **If current value matches configured value**

**7** Click **File** and select **Save**.
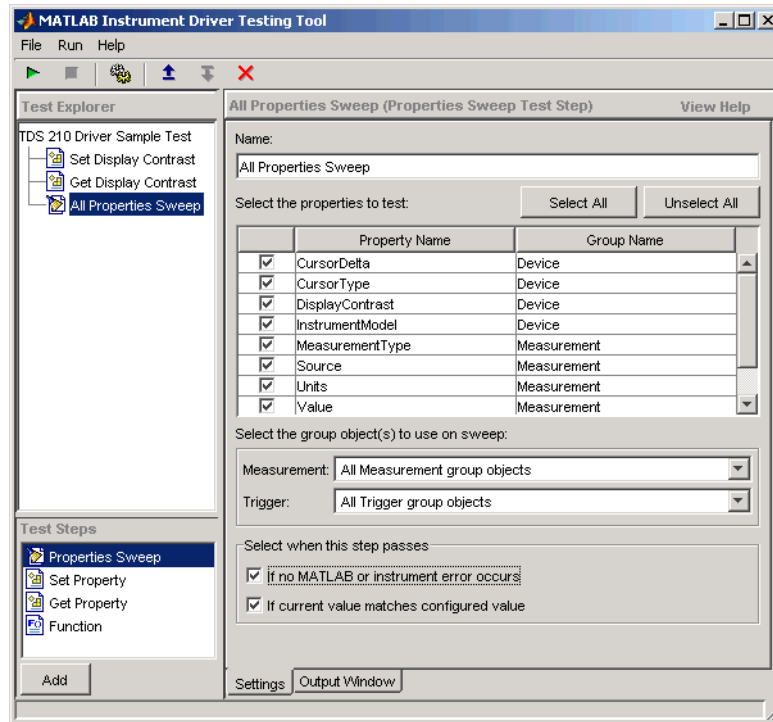
Running a Sweep Step to Test All Properties

You run the sweep test step to verify its behavior.

1 Select All Properties Sweep in the **Test Explorer** tree.

2 With the cursor on the selected name, click the right mouse button to bring up the context menu.

3 In the context menu, select **Run this step only**.

The **Output Window** is updated as each property in the sweep is tested. Note that the entire sweep is only one step in the overall test.
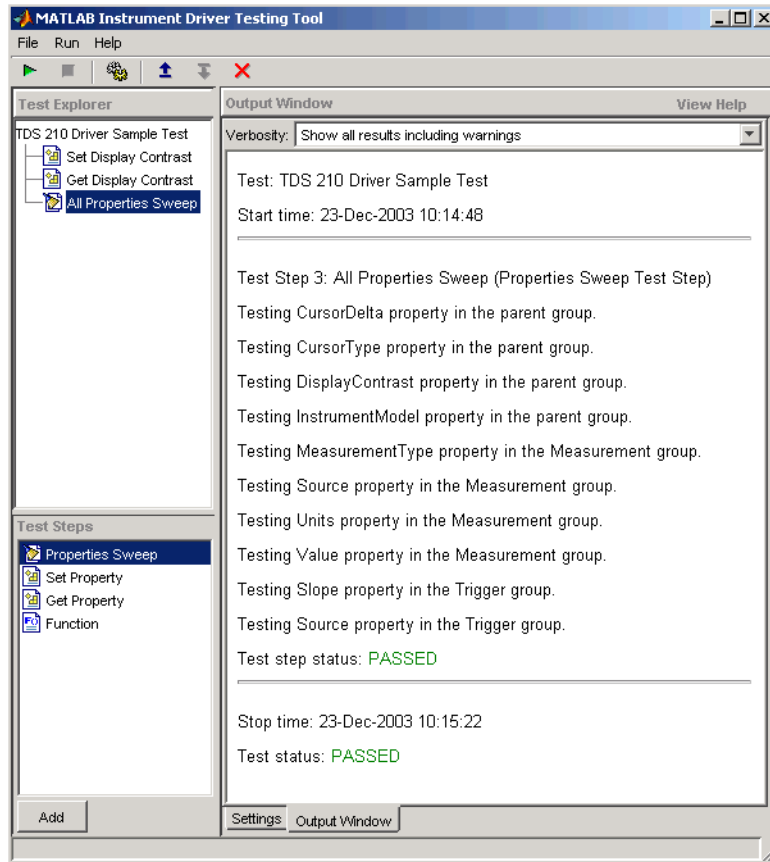
Test Step: Function

A function test step sends a function call to the instrument. You select the function called, the input data and output arguments (if required), and the conditions for passing.

Settings

Name. You provide a name for each test step. The name appears in the **Test Explorer** tree as well as in the results output.

Function to test. A function step can test only one function. You choose the function from the **Function to test** list. Additional functions can be tested with additional steps.

Function definition. The tool displays below the selected function what the call command for the function looks like. This helps you when deciding what input and output arguments to supply.

Input argument(s) and Output argument(s). You provide input arguments as a comma-separated list of data, strings, or whatever the function is expecting.

You provide output argument variable for any data returned from the function. The output arguments can be used to determine if the test step passes, or for "Exporting Results" on page 15-29 after the test step has executed.

Select when this step passes. The step passes when any of three conditions is met:

- If no instrument or MATLAB error occurs as a result of attempting to execute the function

- If the returned output arguments match expected values

- If the output of a specified function is true

If you select more than one of these conditions, then all selected conditions must be met for the step to pass. If no boxes are selected, the test will pass.

Example — Creating a Test Step: Function

1 Click the Function option in the **Test Step** field.

2 Click the **Add** button.

3 In the **Name** field, enter Config Waveform.

4 In the **Function to test** list, select configureWaveform.

5 In the **Input argument(s)** field, type 'CH1', 1, 3000.

6 In the **Output argument(s)** field, type Channel, StartAdr, StopAdr.

7 For **Select when this step passes**,

- Select **If no MATLAB or instrument error occurs**.
- Select **If output arguments are**, and enter in its field 'CH1', 1, 2500.
- Unselect **If output of function ... is true**.

8 Click **File** and select **Save**.

Note that you set the input argument for the stop address to 3000, but you set the expected value for its output argument, StopAdr, to 2500. This is because the maximum address of the oscilloscope is 2500. If you attempt to exceed that value, the oscilloscope address is set to the maximum.
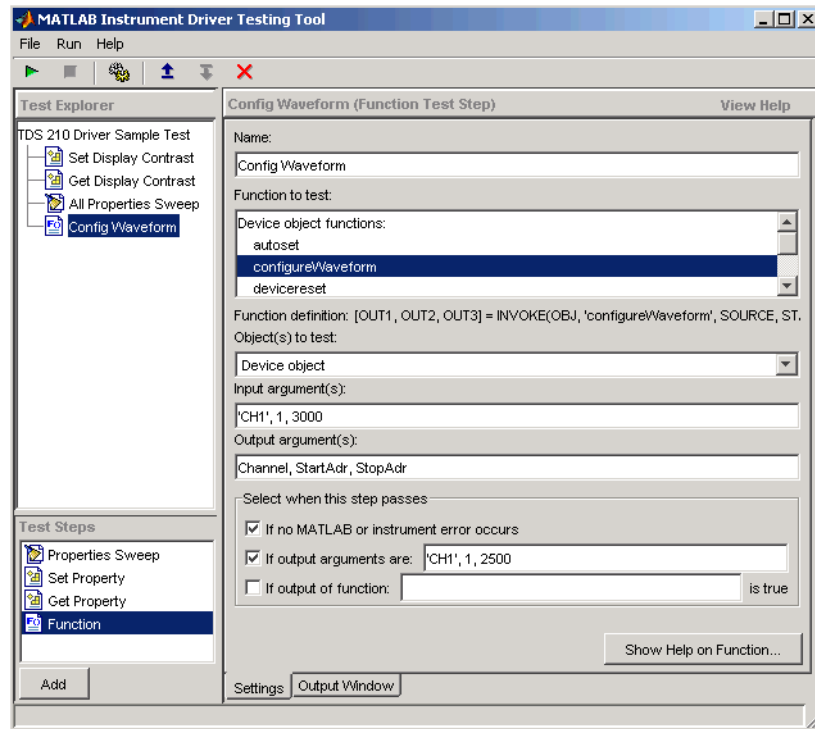
Running a Test Step to Test a Function

You can run an individual test step to verify its behavior

1 Select `Config Waveform` in the **Test Explorer** tree.

2 With the cursor on the selected name, click the right mouse button to bring up the context menu.

3 In the context menu, select **Run this step only**.
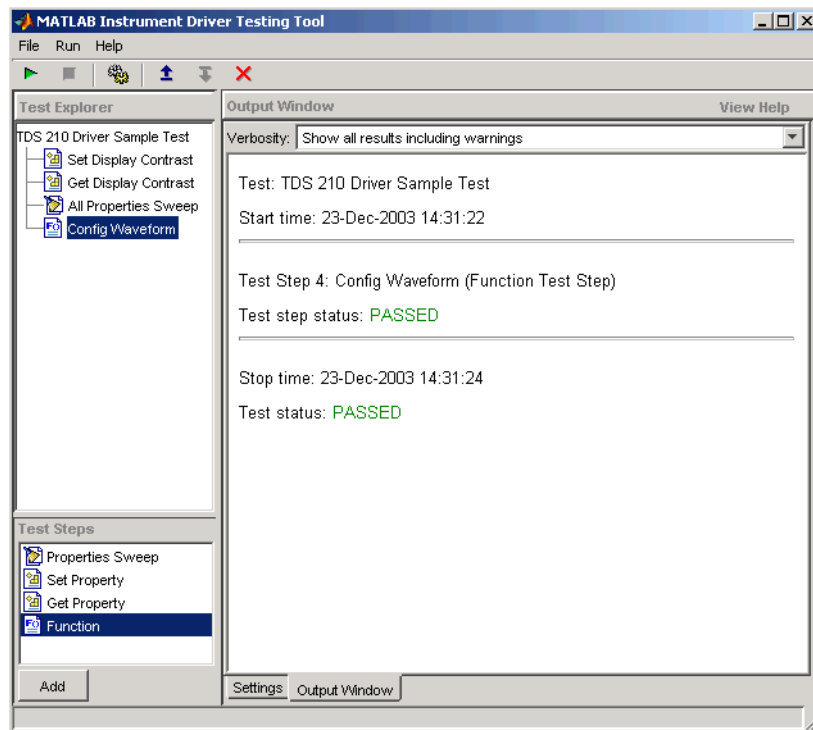
Saving Your Test

Saving the Test File

In the preceding examples of this chapter, you have been saving the test file after creating each step. The test file is saved in XML format.

Saving the Test as M-Code

You save the test file as M-code by clicking the **File** menu and selecting **Save Test as M-Code**.

You can execute the test by calling this M-file from the MATLAB command line.

For example, you can save the test file you created in this chapter as tektronix_tds210_ex_test.m. Then you execute the test from the MATLAB command line by typing

```
tektronix_tds210_ex_test
```

The test results are displayed in the MATLAB Command Window.

Saving the Test as a Driver Function

You save your test as a driver function by clicking the **File** menu and selecting **Save Test as Driver Function**.
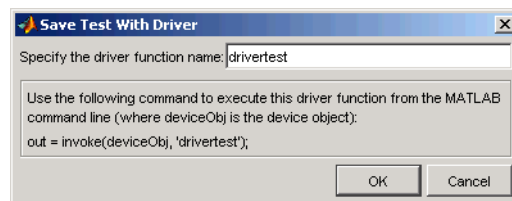
When you enter a name for the driver test function, the invoke command at the bottom of the dialog box reflects that name. You use that invoke command to execute the driver function from the MATLAB command line or in an M-file.

Example — Creating a Driver Test Function

1 Click the **File** menu and select **Save Test as Driver Function**.

2 Enter `drivertest` in the **Specify the driver function name** field.

3 Click **OK**.

A function called `drivertest` is created and saved as part of the instrument driver file. You can open the driver file in the MATLAB Instrument Driver Editor tool (`midedit`) to verify that the `drivertest` function is included.

Example — Calling a Driver Test Function from MATLAB

Now that the test function is included in the driver, you access it with the `invoke` command from the MATLAB command line.

In the MATLAB Command Window,

1 Create an interface object.

```
g = gpib('cec',0,4)
```

2 Create a device object, specifying the driver with the `drivertest` function saved in it.

```
obj = icdevice('tektronix_tds210_ex.mdd',g)
```

3 Connect to the device.

```
connect(obj)
```

4 Execute the driver test.

```
out = invoke(obj, 'drivertest')
```

5 When the test is complete, disconnect from the instrument and delete the objects.

```
disconnect(obj)
delete ([g obj])
```

Testing and Results

Running All Steps

So far in this chapter, you have only run individual test steps after each was created.

When you run the entire test, all the test steps run in the order listed in the **Test Explorer** tree. Using the mouse, you may drag the nodes of the tree to alter their sequence.

The **Output Window** displays the results of each step, along with a final result of the complete test.

Example — Running a Complete Test

1 Select Get Display Contrast in the **Test Explorer** tree.

2 In the **Select when this step passes** field, change the **If property value is** entry from 80 to 100.

   Earlier you entered a value of 80 to illustrate what a failure looks like. The display contrast is left at 100 from the Set Display Contrast test step, so that is what you will test for in the next step.

3 Click **File** and select **Save**.

4 Click the green arrow button to start a test run.
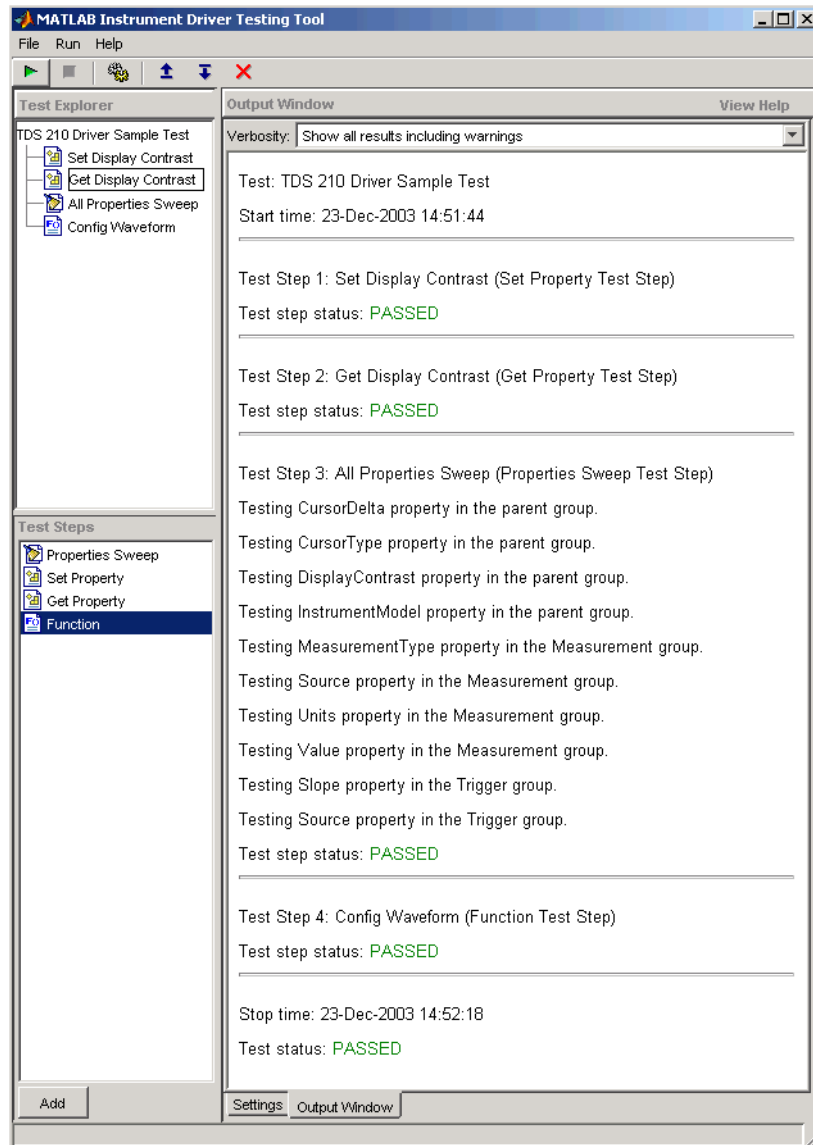
Partial Testing

Using the context menu in the **Test Explorer** tree, you can run a partial test of either an individual test step, or from the chosen test step through the end of the test.

Exporting Results

You can export the test results to many locations:

- MATLAB workspace

- MATLAB figure window

- MAT-file

- MATLAB Array Editor

The results you can export are those assigned to output variables in the settings for a test step.

Example — Exporting Test Results to the MATLAB Workspace

1 Click the **File** menu and select **Export Test Results**.

2 In the **Test Results Exporter** dialog box, select MATLAB Workspace as the **Data destination**.

By default, all the variables are selected. You may unselect any.

3 Click the **Export** button.
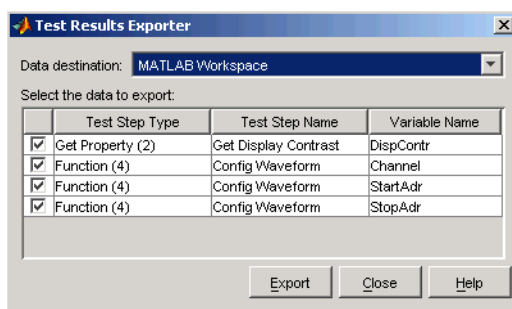
The variables are now available in the MATLAB workspace, with values that were established by the test run.
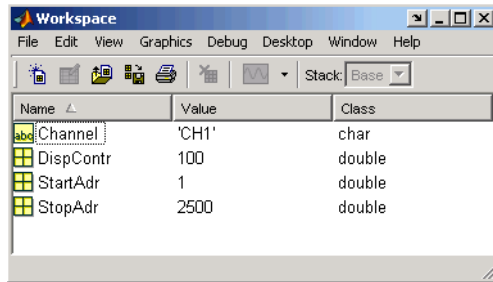
Saving Results

You save your test results in an HTML file by clicking the **File** menu and selecting **Save Test Results**. The format of the results in this file reflects their appearance in the tester tool's **Output Window**.

Using the Instrument Control Toolbox Block Library

The Instrument Control Toolbox includes a Simulink® interface called the Instrument Control Toolbox block library. You can use the blocks of this library in a Simulink model to communicate with an instrument.

Overview

This chapter describes how to use the Instrument Control Toolbox block library.

The Instrument Control Toolbox block library is a tool for sending live data from your model to an instrument, or querying an instrument to receive live data into your model. You use blocks from the block library with blocks from other Simulink libraries to create sophisticated models.

The Instrument Control Toolbox block library requires Simulink, a tool for simulating dynamic systems. Simulink is a model definition environment. Use Simulink blocks to create a block diagram that represents the computations of your system or application. Simulink is also a model simulation environment. Run the block diagram to see how your system behaves. If you are new to Simulink, read "Getting Started with Simulink" in the Simulink documentation to better understand its functionality.

The best way to learn about the Instrument Control Toolbox block library is to see an example. "Example: Sending and Receiving Data Through a Serial Port Loopback" on page 16-3 provides a simple example. For more detailed information about the blocks in the Instrument Control Toolbox block library, see Chapter 21, "Blocks — Alphabetical List".

Example: Sending and Receiving Data Through a Serial Port Loopback

To illustrate how to use the Instrument Control Toolbox block library, this section provides a step-by-step example. The example builds a simple model using the blocks in the block library in conjunction with blocks from other Simulink libraries.

The instrument in this example is a simple loopback device connected to the computer's COM1 serial port. You will use the To Instrument block to send data to the instrument from your model, and then use the Query Instrument block to read that same data back into your model.

The steps described in this example include

Step 1: Open the Block Library

To open the Instrument Control block library, start the Simulink Library Browser and choose the Instrument Control Toolbox from the list of available libraries displayed in the browser.

To start the Simulink Library Browser, enter

```
simulink
```

at the MATLAB prompt. MATLAB opens the **Simulink Library Browser** window. The left pane contains a list of available libraries in alphabetical order. To open the Instrument Control Toolbox block library, click its entry in the tree. When you open a library, Simulink loads the library and displays the blocks in the library.
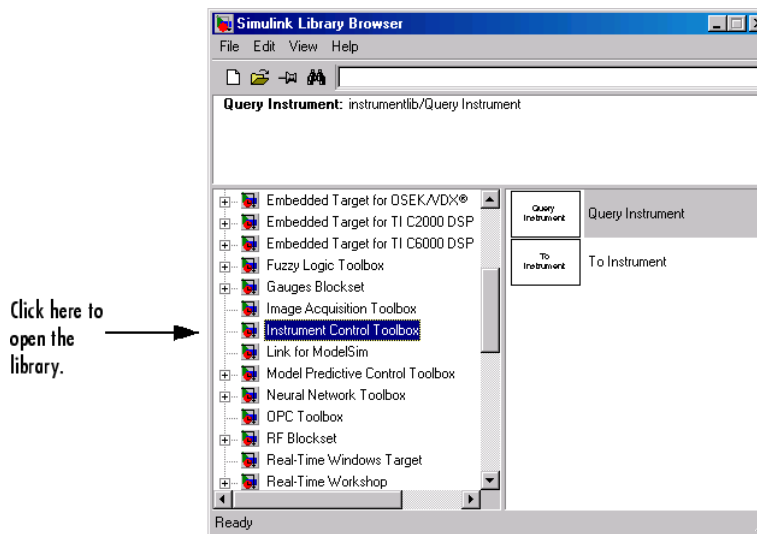
Selecting the Library in the Simulink Library Browser

Step 2: Create a New Model

To use a block, you must add it to an existing model or create a new model.

To create a new model, click the **File** menu in the Simulink Library Browser and select **New > Model**. Simulink opens an empty model window on the display. To assign the new model a name, use the **Save** option.

Step 3: Drag the Instrument Control Toolbox Blocks into the Model

The Instrument Control Toolbox block library contains two blocks: To Instrument and Query Instrument. You can use these blocks to send and receive live data between your instruments and your simulation.

To use the blocks in a model, click each block in the library and, holding the mouse button down, drag it into the model window. You will need one instance of each block in your model.
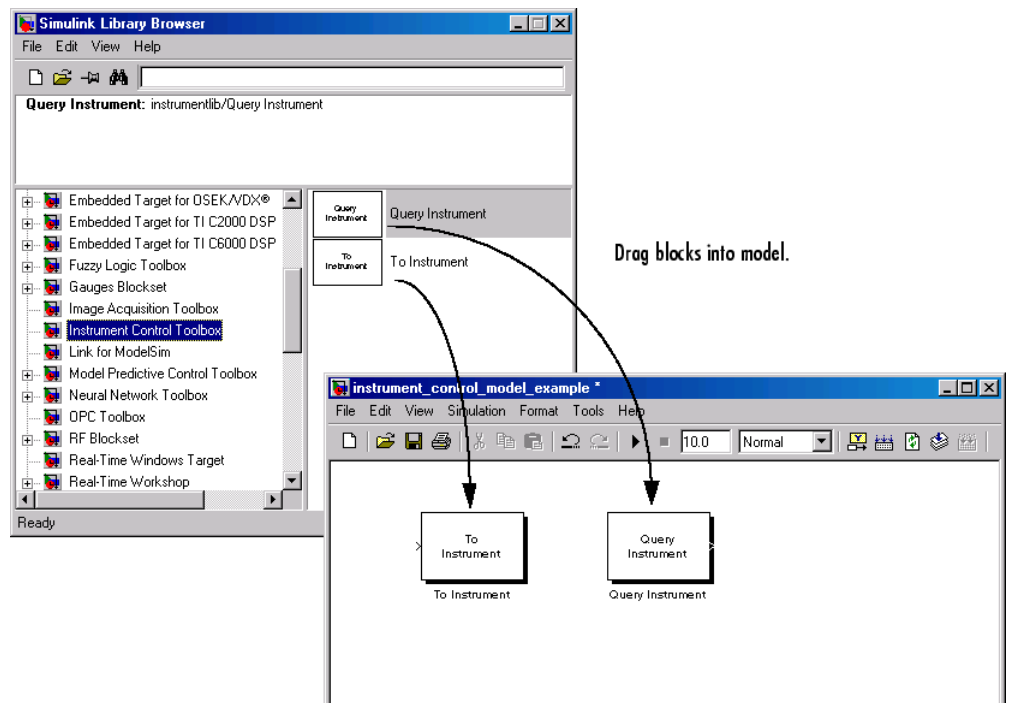
Drag Instrument Control Toolbox Blocks into Model Window

Step 4: Drag Other Blocks to Complete the Model

Your model requires two more blocks. One block provides the data that is sent to the instrument; the other block displays the data received from the instrument.

Because the data sent to the instrument will be a constant, you can use the Constant block for this purpose. To access the Constant block, expand the Simulink node in the browser tree, and click on the Source library entry. From the blocks displayed in the right pane, drag the Constant block into the model and place it to the left of the To Instrument block.
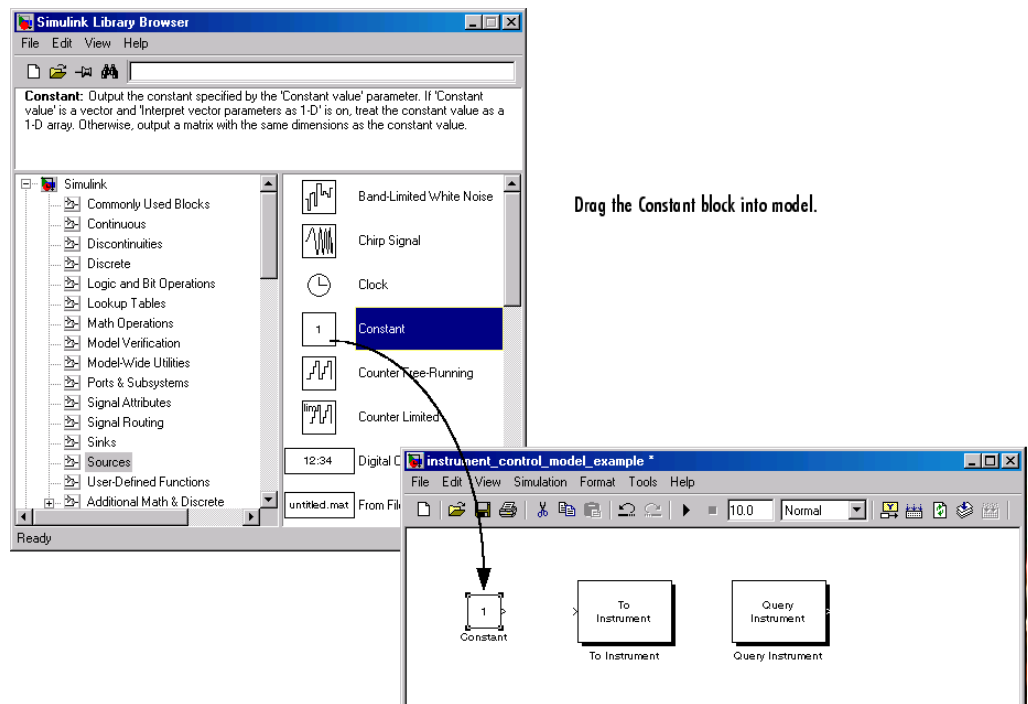
Drag Constant Block to Model Window

To display the data received from the instrument, you can use the Display block. To access the Display block, click the Sinks library entry in the expanded Simulink node in the browser tree. From the blocks displayed in

the right pane, drag the Display block into the model and place it to the right of the Query Instrument block.
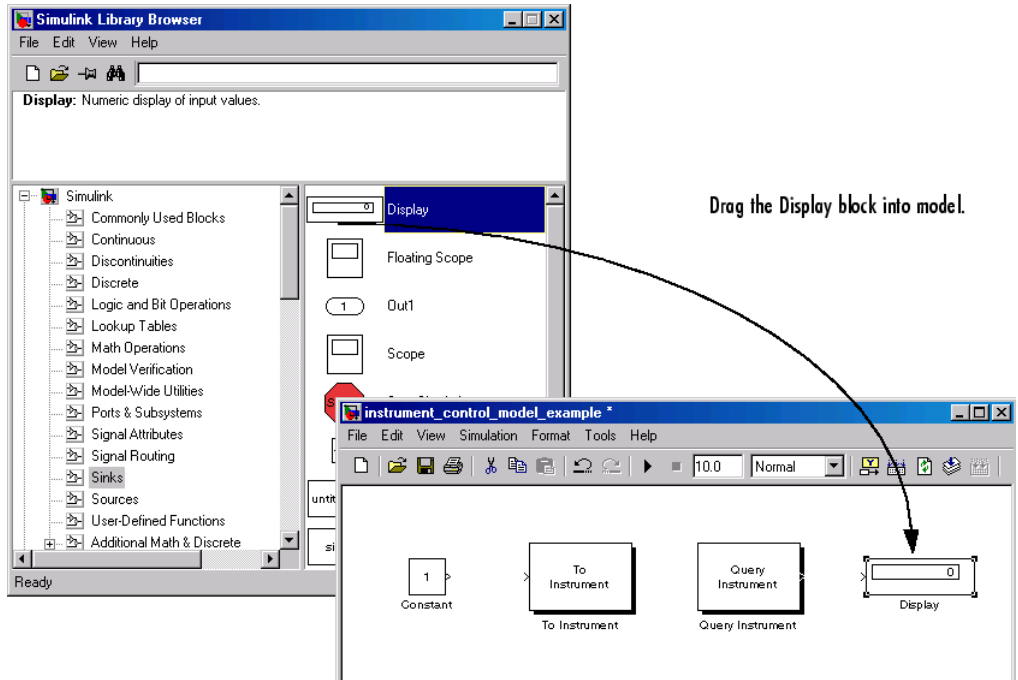
Drag Display Block to Model Window

Step 5: Connect the Blocks

Make a connection between the Constant block and the To Instrument block. When you move the cursor near the output port of the Constant block, the cursor become a cross hair. Click on the Constant output port and hold the mouse button, drag to the input port of the To Instrument block, and release the button.

In the same way, make the connection between the output port of the Query Instrument block and the input port of the Display block.

Note that the two Instrument Control Toolbox blocks do not directly connect together within the model. The only communication between them is through the instrument, which is the loopback connected to the COM1 serial port. Because there is no direct connection between these two blocks, you must consider their timing when running the model. The Query Instrument block does not get its input from the To Instrument block, so it has no way to know when the data from the instrument is available. Therefor, you must set the block parameters to write the data to the loopback before the model attempts to receive data from the loopback.
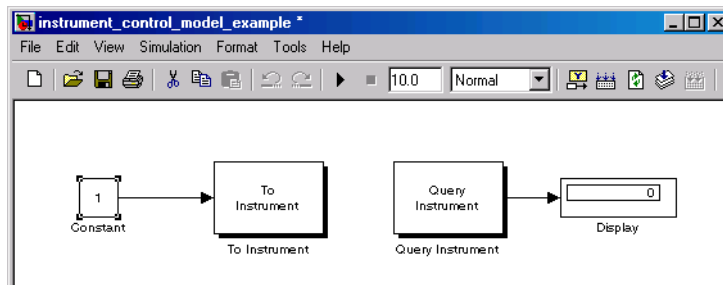
Step 6: Specify the Block Parameter Values

You set parameters for the blocks in your model by double-clicking on the block.

Double-click the To Instrument block to open its parameters dialog box. Set the block sample time to 0.8. In the **Hardware Configuration** tab, specify new hardware configuration with the values shown in the following figure.
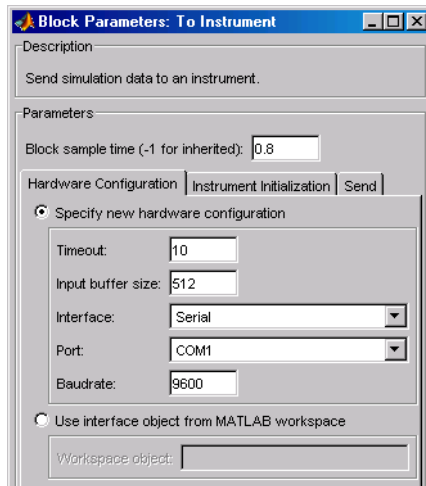
The model uses the default values on the **Instrument Initialization** and **Send** tabs of this block, so you do not need to modify any of their values.

Double-click the Query Instrument block to open its parameters dialog box. Set the block sample time to 1. Note that this time is slightly longer than the setting for the To Instrument block. This is to assure that the To Instrument is complete in writing data to the loopback before the Query Instrument block reads it.

In the **Hardware Configuration** tab, specify new hardware configuration with values to match the settings in the To Instrument block as shown in the following figure.
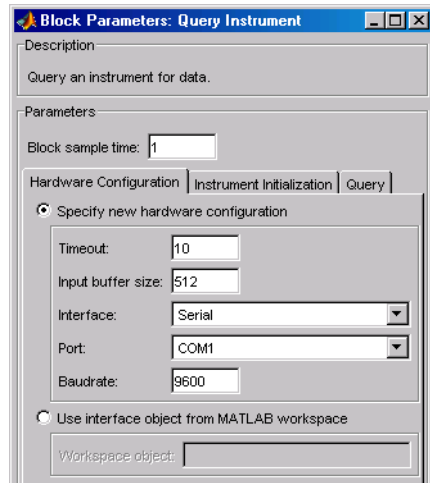
The model uses the default values on the **Instrument Initialization** and **Query** tabs of this block, so you do not need to modify any of their values.

Double-click the Constant block to open its parameters dialog box. Change the Constant value to whatever value you want to send to the instrument. This example uses 25, as shown. You can leave other setting in this dialog box at their default values.
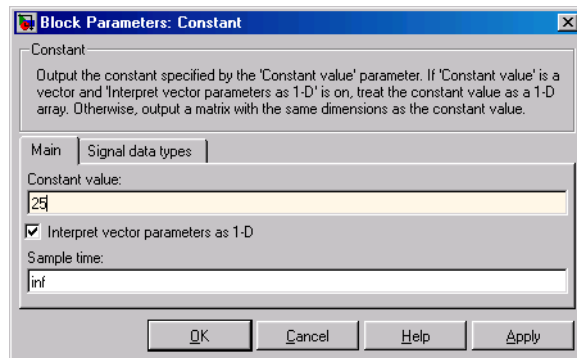
For the Display block, you can use its default parameters.

Step 7: Run the Simulation

To run the simulation, click the Start button on the model window toolbar. Alternatively, you can use the **Simulation** menu in the model window and choose the **Start** option.

Your specified constant value of 25 is written to the instrument (the serial loopback), received from the instrument, and shown in the Display block.
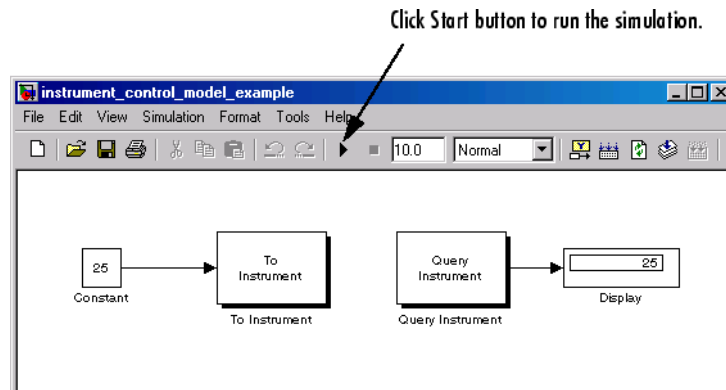
While the simulation is running, the status bar at the bottom of the model window updates the progress of the simulation.

Functions — By Category

Instrument Object Creation

Interface Object

gpib	Create GPIB object
serial	Create serial port object
tcpip	Create TCPIP object
udp	Create UDP object
visa	Create VISA object

Device Object

icdevice	Create device object

State Change

Interface Object

`fclose`	Disconnect interface object from instrument
`fopen`	Connect interface object to instrument
`record`	Record data and event information to file

Device Object

`connect`	Connect device object to instrument
`disconnect`	Disconnect device object from instrument

Property Display and Configuration

`get`	Instrument object properties
`inspect`	Open Property Inspector
`set`	Configure or display instrument object properties

Reading Data

`binblockread`	Read binblock data from instrument
`fgetl`	Read line of text from instrument and discard terminator
`fgets`	Read line of text from instrument and include terminator

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flushinput	Remove data from input buffer
fread	Read binary data from instrument
fscanf	Read data from instrument, and format as text
query	Write text to instrument, and read data from instrument
readasync	Read data asynchronously from instrument
scanstr	Read data from instrument, format as text, and parse
stopasync	Stop asynchronous read and write operations

Writing Data

binblockwrite	Write binblock data to instrument
flushoutput	Remove data from output buffer
fprintf	Write text to instrument
fwrite	Write binary data to instrument
query	Write text to instrument, and read data from instrument
stopasync	Stop asynchronous read and write operations

Information and Help

instrhelp	Help for instrument object type, function, or property
instrhwinfo	Information about available hardware
propinfo	Instrument object property information

Graphical Tools

Interface Object (p. 17-5)	Graphical tools for interface objects
Device Object (p. 17-5)	Graphical tools for device objects

Interface Object

instrcomm	Open graphical tool for communicating with instruments
instrcreate	Open graphical tool for creating and configuring instrument object
tmtool	Open Test & Measurement Tool

Device Object

midedit	Open graphical tool for creating and editing MATLAB instrument driver
midtest	Open graphical tool for testing MATLAB instrument driver
tmtool	Open Test & Measurement Tool

General Purpose

clear	Remove instrument objects from MATLAB workspace
delete	Remove instrument objects from memory
disp	Display instrument object summary information
instrcallback	Display event information when event occurs
instrfind	Read instrument objects from memory to MATLAB workspace
instrfindall	Find visible and hidden instrument objects
instrid	Define and retrieve commands that identify instruments
instrnotify	Define notification for instrument events
instrreset	Disconnect and delete all instrument objects
isvalid	Determine whether instrument objects are valid
length	Length of instrument object array
load	Load instrument objects and variables into MATLAB workspace
methods	Class method names and descriptions
obj2mfile	Convert instrument object to MATLAB code
save	Save instrument objects and variables to MAT-file
size	Size of instrument object array

Interface Objects

GPIB

clrdevice	Clear instrument buffer
gpib	Create GPIB object
spoll	Perform serial poll
trigger	Send trigger message to instrument

Serial Port

serial	Create serial port object
serialbreak	Send break to instrument

TCP/IP

echotcpip	Start or stop TCP/IP echo server
resolvehost	Network name or network address
tcpip	Create TCPIP object

UDP

echoudp	Start or stop UDP echo server
resolvehost	Network name or network address
udp	Create UDP object

VISA-GPIB

clrdevice	Clear instrument buffer
trigger	Send trigger message to instrument
visa	Create VISA object

VISA-GPIB-VXI

clrdevice	Clear instrument buffer
memmap	Map memory for low-level memory read and write operations
mempeek	Low-level memory read from VXI register

mempoke	Low-level memory write to VXI register
memread	High-level memory read from VXI register
memunmap	Unmap memory for low-level memory read and write operations
memwrite	High-level memory write to VXI register
visa	Create VISA object

VISA-Serial

visa	Create VISA object

VISA-VXI

clrdevice	Clear instrument buffer
memmap	Map memory for low-level memory read and write operations
mempeek	Low-level memory read from VXI register
mempoke	Low-level memory write to VXI register
memread	High-level memory read from VXI register
memunmap	Unmap memory for low-level memory read and write operations
memwrite	High-level memory write to VXI register
trigger	Send trigger message to instrument
visa	Create VISA object

Device Objects

devicereset	Reset instrument
geterror	Check and return error message from instrument
invoke	Execute driver-specific function on device object
makemid	Convert driver to MATLAB instrument driver format
selftest	Run instrument self-test

IVI Configuration Store Objects

add	Add entry to IVI configuration store object
commit	Save IVI configuration store object to data file
iviconfigurationstore	Create IVI configuration store object
remove	Remove entry from IVI configuration store object
update	Update entry of IVI configuration store object

Functions — Alphabetical List

add

Purpose	Add entry to IVI configuration store object

Syntax
```
add(obj, 'type', 'name', ...)
add(obj, 'Driversession', 'name', 'ModuleName',
    'HardwareAssetName', 'P1', V1)
add(obj, 'HardwareAsset', 'name', 'IOResourceDescriptor',
    'P1', V1)
add(obj, 'LogicalName', 'name', 'SessionName', 'P1', V1)
add(obj, struct)
```

Arguments

obj	IVI configuration store object
'**DriverSession**' '**HardwareAsset**' '**LogicalName**'	Type of entry being added
'name'	Name of the DriverSession, HardwareAsset, or LogicalName being added
'IOResourceDescriptor'	Tells the driver exactly how to locate the device this asset represents
'ModuleName'	IVI instrument driver or software module
'HardwareAssetName'	Unique identifier for hardware asset
'SessionName'	Unique identifier for asset driver session
'P1'	First optional parameter for added entry. Other parameter-value pairs may follow.
V1	Value for first parameter
struct	Structure defining entry to be added; field names are the entry parameter names

Description   add(obj, 'type', 'name', ...) adds a new entry of type to the IVI configuration store object, obj, with name, name. If an entry of type, type, with name, name, already exists an error will occur. Based on

type, additional arguments are required. *type* can be HardwareAsset, DriverSession, or LogicalName.

add(obj, '**Driversession**', 'name', 'ModuleName', 'HardwareAssetName', '*P1*', V1) adds a new driver session entry to the IVI configuration store object, obj, with name, name, using the specified software module name, ModuleName and hardware asset name, HardwareAssetName. Optional parameter-value pairs may be included.

Valid parameters for DriverSession are listed below. The default value for on/off parameters is off.

Parameter	Value	Description
Description	Any string	Description of driver session
VirtualNames	structure	A struct array containing virtual name mappings
Cache	on/off	Enable caching if the driver supports it.
DriverSetup	Any string	This value is software module dependent
InterchangeCheck	on/off	Enable driver interchangeability checking, if supported
QueryInstrStatus	on/off	Enable instrument status querying by the driver
RangeCheck	on/off	Enable extended range checking by the driver, if supported
RecordCoercions	on/off	Enable recording of coercions by the driver, if supported
Simulate	on/off	Enable simulation by the driver

add(obj, '**HardwareAsset**', 'name', 'IOResourceDescriptor', '*P1*', V1) adds a new hardware asset entry to the IVI configuration store object, obj, with name, name, and resource descriptor,

IOResourceDescriptor. Optional parameter-value pairs may be included.

Valid parameters for `HardwareAsset` are

Parameter	Value	Description
Description	Any string	Description of hardware asset

add(obj, '**LogicalName**', 'name', 'SessionName', '*P1*', V1) adds a new logical name entry to the IVI configuration store object, obj, with name, name, and driver session name, SessionName. Optional parameter-value pairs may be included.

Valid parameters for `LogicalName` are

Parameter	Value	Description
Description	Any string	Description of logical name

add(obj, struct), where struct is a structure whose field names are the entry parameter names, adds an entry to the IVI configuration store object, obj, of the specified type with the values contained in the structure.

Additions made to the configuration store object, obj, can be saved to the configuration store data file with the commit function.

Examples Construct IVI configuration store object, c.

```
c = iviconfigurationstore;
```

Add a hardware asset with name gpib1, and resource description GPIBO::1::INSTR.

```
add(c, 'HardwareAsset', 'gpib1', 'GPIBO::1::INSTR');
```

Add a driver session with name S1, that uses the TekScope software module and the hardware asset with name gpib1.

```
add(c, 'DriverSession', 'S1', 'TekScope', 'gpib1');
```

Add a logical name to configuration store object c, with name MyScope,
driver session name S1, and description A logical name.

```
add(c, 'LogicalName', 'MyScope', 'S1', ...
'Description', 'A logical name');
```

Add a hardware asset with the name gpib3, and resource description
GPIB0::3::ISNTR.

```
s.Type = 'HardwareAsset';
s.Name = 'gpib3';
s.IOResourceDescriptor = 'GPIB0::3::INSTR';
add(c, s);
```

Save the changes to the IVI configuration store data file.

```
commit(c);
```

See Also   **Functions**

iviconfigurationstore, iviconfigurationstore/commit,
iviconfigurationstore/remove, iviconfigurationstore/update

binblockread

Purpose	Read binblock data from instrument

Syntax

```
A = binblockread(obj)
A = binblockread(obj,'precision')
[A,count] = binblockread(...)
[A,count,msg] = binblockread(...)
```

Arguments

obj	An interface object.
'*precision*'	The number of bits read for each value, and the interpretation of the bits as character, integer, or floating-point values.
A	Binblock data returned from the instrument.
count	The number of values read.
msg	A message indicating if the read operation was unsuccessful.

Description A = binblockread(obj) reads binary-block (binblock) data from the instrument connected to obj and returns the values to A. The binblock format is described in the binblockwrite reference pages.

A = binblockread(obj,'*precision*') reads binblock data translating MATLAB values to the precision specified by *precision*. By default the uchar precision is used and numeric values are returned in double-precision arrays. Refer to the fread function for a list of supported precisions.

[A,count] = binblockread(...) returns the number of values read to count.

[A,count,msg] = binblockread(...) returns a warning message to msg if the read operation did not complete successfully.

Remarks Before you can read data from the instrument, it must be connected to obj with the fopen function. A connected interface object has a Status

property value of open. An error is returned if you attempt to perform a read operation while obj is not connected to the instrument.

binblockread blocks the MATLAB command line until one of the following occurs:

- The data is completely read.
- The time specified by the Timeout property passes.

If msg is not included as an output argument and the read operation was not successful, then a warning message is returned to the command line.

Each time binblockread is issued, the ValuesReceived property value is increased by the number of values read.

Some instruments may send a terminating character after the binblock. binblockread will not read the terminating character. You can read the terminating character with the fread function. Additionally, if obj is a GPIB, VISA-GPIB, VISA-VXI, VISA-USB, or VISA-RSIB object, you can use the clrdevice function to remove the terminating character.

Examples   Create the GPIB object g associated with a National Instruments GPIB controller with board index 0, and a Tektronix TDS 210 oscilloscope with primary address 2.

```
g = gpib('ni',0,2);
g.InputBufferSize = 3000;
```

Connect g to the instrument, and write string commands that configure the scope to transfer binary waveform data from memory location A.

```
fopen(g)
fprintf(g,'DATA:DESTINATION REFA');
fprintf(g,'DATA:ENCDG SRPbinary');
fprintf(g,'DATA:WIDTH 1');
fprintf(g,'DATA:START 1');
```

Write the CURVE? command, which prepares the scope to transfer data, and read the data using the binblock format.

binblockread

```
fprintf(g,'CURVE?')
data = binblockread(g);
```

See Also   **Functions**

binblockwrite, fopen, fread, instrhelp

Properties

BytesAvailable, InputBufferSize, Status, ValuesReceived

Purpose   Write binblock data to instrument

Syntax   binblockwrite(obj,A)
binblockwrite(obj,A,'*precision*')
binblockwrite(obj,A,'header')
binblockwrite(obj,A,'*precision*','header')
binblockwrite(obj,A,'*precision*','header','*headerformat*')

Arguments

obj	An interface object.
A	The data to be written using the binblock format.
'*precision*'	The number of bits written for each value, and the interpretation of the bits as character, integer, or floating-point values.
'header'	The ASCII header text to be prefixed to the data.
'*headerformat*'	C language conversion specification format for the header text.

Description binblockwrite(obj,A) writes the data specified by A to the instrument connected to obj as a binary-block (binblock). The binblock format is defined as #<N><D><A>, where

- N specifies the number of digits in D that follow.

- D specifies the number of data bytes in A that follow.

- A is the data written to the instrument.

For example, if A is given by [0 5 5 0 5 5 0], the binblock would be defined as [double('#') 1 7 0 5 5 0 5 5 0].

binblockwrite(obj,A,'*precision*') writes binblock data translating MATLAB values to the precision specified by *precision*. By default the uchar precision is used. Refer to the fwrite function for a list of supported precisions.

binblockwrite

binblockwrite(obj,A,'header') writes a binblock using the data, A, and the ASCII header, header, to the instrument connected to interface object, obj. The data written is constructed using the formula

    <header>#<N><D><A>

binblockwrite(obj,A,'*precision*','header') writes binary data, A, translating MATLAB values to the specified precision, *precision*. The ASCII header, header, is prefixed to the binblock.

binblockwrite(obj,A,'*precision*','header','*headerformat*') writes binary data, A, translating MATLAB values to the specified precision, *precision*. The ASCII header, header, is prefixed to the binblock using the format specified by *headerformat*.

headerformat is a string containing C language conversion specifications. Conversion specifications are composed of the character % and the conversion characters d, i, o, u, x, X, f, e, E, g, G, c, and s. Type instrhelp fprintf for more information on valid values for *headerformat*. By default, *headerformat* is %s.

Remarks

Before you can write data to the instrument, it must be connected to obj with the fopen function. A connected interface object has a Status property value of open. An error is returned if you attempt to perform a write operation while obj is not connected to the instrument.

The ValuesSent property value is increased by the number of values written each time binblockwrite is issued.

An error occurs if the output buffer cannot hold all the data to be written. You can specify the size of the output buffer with the OutputBufferSize property.

Examples

```
s = visa('ni', 'ASRL2::INSTR');
fopen(s);

% Write the command: [double('#14') 0 5 0 5] to the instrument.
binblockwrite(s, [0 5 0 5]);
```

```
% Write the command: [double('Curve #14') O 5 O 5] to the
% instrument.
binblockwrite(s, [O 5 O 5], 'Curve ')
fclose(s);
```

See Also

Functions

binblockread, fopen, fwrite, instrhelp

Properties

OutputBufferSize, OutputEmptyFcn, Status, Timeout,
TransferStatus, ValuesSent

clear

Purpose	Remove instrument objects from MATLAB workspace
Syntax	`clear obj`
Arguments	`obj` An instrument object or an array of instrument objects.
Description	`clear obj` removes `obj` from the MATLAB workspace.

Remarks   If `obj` is connected to the instrument and it is cleared from the workspace, then `obj` remains connected to the instrument. You can restore `obj` to the workspace with the `instrfind` function. An object connected to the instrument has a `Status` property value of `open`.

To disconnect `obj` from the instrument, use the `fclose` function. To remove `obj` from memory, use the `delete` function. You should remove invalid instrument objects from the workspace with `clear`.

Examples   This example creates the GPIB object g, copies g to a new variable gcopy, and clears g from the MATLAB workspace. g is then restored to the workspace with `instrfind` and is shown to be identical to gcopy.

```
g = gpib('ni',0,1);
gcopy = g;
clear g
g = instrfind;
isequal(gcopy,g)
ans =
     1
```

See Also   **Functions**

delete, fclose, instrfind, instrhelp, isvalid

Properties

Status

Purpose   Clear instrument buffer

Syntax   clrdevice(obj)

Arguments   obj   A GPIB, VISA-GPIB, VISA-VXI, or VISA-GPIB-VXI object.

Description   clrdevice(obj) clears the hardware buffer of the instrument connected to obj.

Remarks   Before you can clear the hardware buffer, the instrument must be connected to obj with the fopen function. A connected object has a Status property value of open. If you issue clrdevice when obj is disconnected from the instrument, then an error is returned.

You can clear the software input buffer using the flushinput function. You can clear the software output buffer using the flushoutput function.

See Also   **Functions**

flushinput, flushoutput, fopen

Properties

Status

commit

Purpose
Save IVI configuration store object to data file

Syntax
```
commit(obj)
commit(obj, 'file')
```

Arguments

obj	IVI configuration store object
'file'	Configuration store data file

Description
commit(obj) saves the IVI configuration store object, obj, to the configuration store data file. The configuration store data file is defined by obj's ActualLocation property.

commit(obj, 'file') saves the IVI configuration store object, obj, to the configuration store data file, file. No changes are saved to the configuration store data file that is defined by obj's ActualLocation property.

The IVI configuration store object can be modified with the add, update, and remove functions.

See Also

Functions

iviconfigurationstore, iviconfigurationstore/add, iviconfigurationstore/remove, iviconfigurationstore/update

Purpose	Connect device object to instrument

Syntax

```
connect(obj)
connect(obj,'update')
```

Arguments

obj	A device object or an array of device objects.
update	Update the state of the object or the instrument.

Description   connect(obj) connects the device object specified by obj to the instrument. obj can be an array of device objects.

connect(obj,'update') updates the state of the object or the instrument. update can be object or instrument. If update is object, the object is updated to reflect the state of the instrument. If update is instrument, the instrument is updated to reflect the state of the object. In this case, all property values defined by the object are sent to the instrument on open. By default, update is object.

Remarks   If obj is successfully connected to the instrument, its Status property is configured to open. If obj is an array of device objects and one of the objects cannot be connected to the instrument, the remaining objects in the array will be connected and a warning is displayed.

Examples   Create a device object for a Tektronix TDS 210 oscilloscope that is connected to a National Instruments GPIB board.

```
g = gpib('ni',0,2);
d = icdevice('tektronix_tds210',g);
```

Connect to the instrument.

```
connect(d)
```

List the oscilloscope settings that can be configured.

```
props = set(d);
```

Get the current configuration of the oscilloscope.

```
values = get(d);
```

Disconnect from the instrument and clean up.

```
disconnect(d)
delete([d g])
```

See Also   **Functions**

disconnect, delete, instrhelp

Properties

Status

Purpose   Remove instrument objects from memory

Syntax   `delete(obj)`

Arguments   `obj`   An instrument object or an array of instrument objects.

Description   `delete(obj)` removes `obj` from memory.

Remarks   When you delete `obj`, it becomes an *invalid* object. Because you cannot connect an invalid object to the instrument, you should remove it from the workspace with the `clear` command. If multiple references to `obj` exist in the workspace, then deleting one reference invalidates the remaining references.

If `obj` is connected to the instrument, it has a `Status` property value of `open`. If you issue `delete` while `obj` is connected, the connection is automatically broken. You can also disconnect `obj` from the instrument with the `fclose` function.

If `obj` is an interface object that is associated with a device object, the device object is automatically deleted when `obj` is deleted. However, if `obj` is a device object, the interface object is not automatically deleted when `obj` is deleted.

Examples   This example creates the GPIB object g, connects g to the instrument, writes and reads text data, disconnects g, removes g from memory using `delete`, and then removes g from the workspace using `clear`.

```
g = gpib('ni',0,1);
fopen(g)
fprintf(g,'*IDN?')
idn = fscanf(g);
fclose(g)
delete(g)
clear g
```

delete

See Also   **Functions**

clear, fclose, instrhelp, isvalid, stopasync

Properties

Status

devicereset

Purpose   Reset instrument

Syntax   devicereset(obj)

Arguments
obj	A device object.

Description devicereset(obj) resets the instrument associated with the device
object specified by obj.

disconnect

Purpose	Disconnect device object from instrument
Syntax	disconnect(obj)
Arguments	obj A device object or an array of device objects.
Description	disconnect(obj) disconnects the device object specified by obj from the instrument.
Remarks	If obj is disconnected from the instrument, its Status property is configured to closed. You can reconnect to the instrument with the connect function. If obj is an array of device objects and one of the objects cannot be disconnected from the instrument, the remaining objects in the array will be disconnected and a warning is displayed.
Examples	Create a device object for a Tektronix TDS 210 oscilloscope that is connected to a National Instruments GPIB board.

```
g = gpib('ni',0,2);
d = icdevice('tektronix_tds210',g);
```

Connect to the instrument.

```
connect(d)
```

Get the current configuration of the oscilloscope.

```
values = get(d);
```

Disconnect from the instrument and clean up.

```
disconnect(d)
delete([d g])
```

See Also   **Functions**

connect, delete, instrhelp

Properties

Status

disp

Purpose	Display instrument object summary information
Syntax	```obj``` ```disp(obj)```
Arguments	obj An instrument object or an array of instrument objects.
Description	obj or disp(obj) displays summary information for obj.
Remarks	In addition to the syntax shown above, you can display summary information for obj by excluding the semicolon when • Creating an instrument object • Configuring property values using the dot notation You can also display summary information via the Workspace browser by right-clicking an instrument object, and selecting **Display Summary** from the context menu.

Examples	The following commands display summary information for the GPIB object g.
	
	 ```g = gpib('ni',0,1)```
	 ```g.EOSMode = 'read'```
	 ```g```

Purpose   Start or stop TCP/IP echo server

Syntax   echotcpip('*state*',port)
                  echotcpip('*state*')

Arguments | '*state*' | Turn the server on or off. |
                  |-----------|---------------------------|
                  | port | Port number of the server. |

Description   echotcpip('*state*',port) starts a TCP/IP server with port number specified by port. *state* can only be on.

                  echotcpip('*state*') stops the echo server. *state* can only be off.

Examples   Start the echo server and create a TCPIP object.

```
echotcpip('on',4000)
t = tcpip('localhost',4000);
```

Connect the TCPIP object to the host.

```
fopen(t)
```

Write to the host and read from the host.

```
fprintf(t,'echo this string.')
data = fscanf(t);
```

Stop the echo server and disconnect the TCPIP object from the host.

```
echotcpip('off')
fclose(t)
```

See Also   **Functions**

echoudp, tcpip, udp

echoudp

Purpose	Start or stop UDP echo server

Syntax

```
echoudp('state', port)
echoudp('state')
```

Arguments

'*state*'	Turn the server on or off.
port	Port number of the server.

Description echoudp('*state*', port) starts a UDP server with port number specified by port. *state* can only be on.

echoudp('*state*') stops the echo server. *state* can only be off.

Examples Start the echo server and create a UDP object.

```
echoudp('on',4012)
u = udp('127.0.0.1',4012);
```

Connect the UDP object to the host.

```
fopen(u)
```

Write to the host and read from the host.

```
fwrite(u,65:74)
A = fread(u,10);
```

Stop the echo server and disconnect the UDP object from the host.

```
echoudp('off')
fclose(u)
```

See Also **Functions**

echotcpip, tcpip, udp

Purpose   Disconnect interface object from instrument

Syntax   `fclose(obj)`

Arguments   `obj`   An interface object or an array of interface objects.

Description   `fclose(obj)` disconnects `obj` from the instrument.

Remarks   If `obj` was successfully disconnected, then the `Status` property is configured to `closed` and the `RecordStatus` property is configured to `off`. You can reconnect `obj` to the instrument using the `fopen` function.

An error is returned if you issue `fclose` while data is being written asynchronously. In this case, you should abort the write operation with the `stopasync` function, or wait for the write operation to complete.

Examples   This example creates the GPIB object g, connects g to the instrument, writes and reads text data, and then disconnects g from the instrument using `fclose`.

```
g = gpib('ni',0,1);
fopen(g)
fprintf(g,'*IDN?')
idn = fscanf(g);
fclose(g)
```

At this point, you can once again connect an interface object to the instrument. If you no longer need g, you should remove it from memory with the `delete` function, and remove it from the workspace with the `clear` command.

See Also   **Functions**

`clear`, `delete`, `fopen`, `instrhelp`, `record`, `stopasync`

fclose

Properties

RecordStatus, Status

Purpose   Read line of text from instrument and discard terminator

Syntax   ```
tline = fgetl(obj)
[tline,count] = fgetl(obj)
[tline,count,msg] = fgetl(obj)
[tline,count,msg,datagramaddress,datagramport] = fgetl(obj)
```

**Arguments**
| | |
|---|---|
| obj | An interface object. |
| tline | The text read from the instrument, excluding the terminator. |
| count | The number of values read, including the terminator. |
| msg | A message indicating if the read operation was unsuccessful. |
| datagramaddress | The datagram address. |
| datagramport | The datagram port. |

**Description**  tline = fgetl(obj) reads one line of text from the instrument connected to obj, and returns the data to tline. The returned data does not include the terminator with the text line. To include the terminator, use fgets.

[tline,count] = fgetl(obj) returns the number of values read to count.

[tline,count,msg] = fgetl(obj) returns a warning message to msg if the read operation was unsuccessful.

[tline,count,msg,datagramaddress,datagramport] = fgetl(obj) returns the remote address and port from which the datagram originated. These values are returned only if obj is a UDP object.

**Remarks**     Before you can read text from the instrument, it must be connected to obj with the fopen function. A connected interface object has a Status

property value of `open`. An error is returned if you attempt to perform a read operation while `obj` is not connected to the instrument.

If `msg` is not included as an output argument and the read operation was not successful, then a warning message is returned to the command line.

The `ValuesReceived` property value is increased by the number of values read — including the terminator — each time `fgetl` is issued.

### Rules for Completing a Read Operation with fgetl

A read operation with `fgetl` blocks access to the MATLAB command line until

- The terminator is read. For serial port, TCPIP, UDP, and VISA-serial objects, the terminator is given by the `Terminator` property. Note that for UDP objects, `DatagramTerminateMode` must be `off`.

  For all other interface objects except VISA-RSIB, the terminator is given by the `EOSCharCode` property.

- The EOI line is asserted (GPIB and VXI instruments only).

- A datagram has been received (UDP objects only if `DatagramTerminateMode` is `on`).

- The time specified by the `Timeout` property passes.

- The input buffer is filled.

### More About the GPIB and VXI Terminator

The `EOSCharCode` property value is recognized only when the `EOSMode` property is configured to `read` or `read&write`. For example, if `EOSMode` is configured to `read` and `EOSCharCode` is configured to `LF`, then one of the ways that the read operation terminates is when the line feed character is received.

If `EOSMode` is `none` or `write`, then there is no terminator defined for read operations. In this case, `fgetl` will complete execution and return control to the command line when another criterion, such as a timeout, is met.

**Examples**        Create the GPIB object g, connect g to a Tektronix TDS 210 oscilloscope, configure g to complete read operations when the End-Of-String character is read, and write the *IDN? command with the fprintf function. *IDN? instructs the scope to return identification information.

```
g = gpib('ni',0,1);
fopen(g)
g.EOSMode = 'read';
fprintf(g,'*IDN?')
```

Asynchronously read the identification information from the instrument.

```
readasync(g)
g.BytesAvailable
ans =
    56
```

Use fgetl to transfer the data from the input buffer to the MATLAB workspace, and discard the terminator.

```
idn = fgetl(g)
idn =
TEKTRONIX,TDS 210,0,CF:91.1CT FV:v1.16 TDS2CM:CMV:v1.04

length(idn)
ans =
    55
```

Disconnect g from the scope, and remove g from memory and the workspace.

```
fclose(g)
delete(g)
clear g
```

See Also   **Functions**

fgets, fopen, instrhelp

Properties

BytesAvailable, EOSCharCode, EOSMode, InputBufferSize, Status, Terminator, Timeout, ValuesReceived

Purpose   Read line of text from instrument and include terminator

Syntax
```
tline = fgets(obj)
[tline,count] = fgets(obj)
[tline,count,msg] = fgets(obj)
[tline,count,msg,datagramaddress,datagramport] = fgets(obj)
```

Arguments

obj	An interface object.
tline	The text read from the instrument, including the terminator.
count	The number of values read.
msg	A message indicating that the read operation did not complete successfully.
datagramaddress	The datagram address.
datagramport	The datagram port.

Description   `tline = fgets(obj)` reads one line of text from the instrument connected to obj, and returns the data to tline. The returned data includes the terminator with the text line. To exclude the terminator, use fgetl.

`[tline,count] = fgets(obj)` returns the number of values read to count.

`[tline,count,msg] = fgets(obj)` returns a warning message to msg if the read operation was unsuccessful.

`[tline,count,msg,datagramaddress,datagramport] = fgets(obj)` returns the remote address and port from which the datagram originated. These values are returned only if obj is a UDP object.

Remarks   Before you can read text from the instrument, it must be connected to obj with the fopen function. A connected interface object has a Status

property value of `open`. An error is returned if you attempt to perform a read operation while `obj` is not connected to the instrument.

If `msg` is not included as an output argument and the read operation was not successful, then a warning message is returned to the command line.

The `ValuesReceived` property value is increased by the number of values read — including the terminator — each time `fgets` is issued.

Rules for Completing a Read Operation with fgets

A read operation with `fgets` blocks access to the MATLAB command line until

- The terminator is read. For serial port, TCPIP, UDP, and VISA-serial objects, the terminator is given by the `Terminator` property. Note that for UDP objects, `DatagramTerminateMode` must be `off`.

  For all other interface objects except VISA-RSIB, the terminator is given by the `EOSCharCode` property.

- The EOI line is asserted (GPIB and VXI instruments only).

- A datagram has been received (UDP objects only if `DatagramTerminateMode` is `on`).

- The time specified by the `Timeout` property passes.

- The input buffer is filled.

More About the GPIB and VXI Terminator

The `EOSCharCode` property value is recognized only when the `EOSMode` property is configured to `read` or `read&write`. For example, if `EOSMode` is configured to `read` and `EOSCharCode` is configured to `LF`, then one of the ways that the read operation terminates is when the line feed character is received.

If `EOSMode` is `none` or `write`, then there is no terminator defined for read operations. In this case, `fgets` will complete execution and return control to the command line when another criterion, such as a timeout, is met.

Examples   Create the GPIB object g, connect g to a Tektronix TDS 210 oscilloscope, configure g to complete read operations when the End-Of-String character is read, and write the *IDN? command with the fprintf function. *IDN? instructs the scope to return identification information.

```
g = gpib('ni',0,1);
fopen(g)
g.EOSMode = 'read';
fprintf(g,'*IDN?')
```

Asynchronously read the identification information from the instrument.

```
readasync(g)
g.BytesAvailable
ans =
    56
```

Use fgets to transfer the data from the input buffer to the MATLAB workspace, and include the terminator.

```
idn = fgets(g)
idn =
TEKTRONIX,TDS 210,0,CF:91.1CT FV:v1.16 TDS2CM:CMV:v1.04
length(idn)
ans =
    56
```

Disconnect g from the scope, and remove g from memory and the workspace.

```
fclose(g)
delete(g)
clear g
```

See Also   **Functions**

fgetl, fopen, instrhelp, query

Properties

BytesAvailable, EOSCharCode, EOSMode, InputBufferSize, Status, Terminator, Timeout, ValuesReceived

Purpose   Remove data from input buffer

Syntax   `flushinput(obj)`

Arguments   `obj`   An interface object or an array of interface objects.

Description   `flushinput(obj)` removes data from the input buffer associated with
                   `obj`.

Remarks   After the input buffer is flushed, the `BytesAvailable` property is
                   automatically configured to `0`.

                   If `flushinput` is called during an asynchronous (nonblocking) read
                   operation, the data currently stored in the input buffer is flushed and
                   the read operation continues. You can read data asynchronously from
                   the instrument using the `readasync` function.

                   The input buffer is automatically flushed when you connect an object to
                   the instrument with the `fopen` function.

                   You can clear the output buffer with the `flushoutput` function. You
                   can clear the hardware buffer for GPIB and VXI instruments with the
                   `clrdevice` function.

See Also   **Functions**

                   `clrdevice`, `flushoutput`, `fopen`, `readasync`

                   Properties

                   `BytesAvailable`

flushoutput

Purpose   Remove data from output buffer

Syntax   flushoutput(obj)

Arguments   obj   An interface object or an array of interface objects.

Description flushoutput(obj) removes data from the output buffer associated
                 with obj.

Remarks   After the output buffer is flushed, the BytesToOutput property is
                 automatically configured to 0.

                 If flushoutput is called during an asynchronous (nonblocking) write
                 operation, the data currently stored in the output buffer is flushed and
                 the write operation is aborted. Additionally, the M-file callback function
                 specified for the OutputEmptyFcn property is executed. You can write
                 data asynchronously to the instrument using the fprintf or fwrite
                 functions.

                 The output buffer is automatically flushed when you connect an object
                 to the instrument with the fopen function.

                 You can clear the input buffer with the flushinput function. You can
                 clear the hardware buffer for GPIB and VXI instruments with the
                 clrdevice function.

See Also   **Functions**

                 clrdevice, flushinput, fopen, fprintf, fwrite

                 Properties

                 BytesToOutput, OutputEmptyFcn

Purpose   Connect interface object to instrument

Syntax   fopen(obj)

Arguments   obj   An interface object or an array of interface objects.

Description   fopen(obj) connects obj to the instrument.

Remarks   Before you can perform a read or write operation, obj must be connected to the instrument with the fopen function. When obj is connected to the instrument

- Data remaining in the input buffer or the output buffer is flushed.

- The Status property is set to open.

- The BytesAvailable, ValuesReceived, ValuesSent, and BytesToOutput properties are set to 0.

An error is returned if you attempt to perform a read or write operation while obj is not connected to the instrument. You can connect only one interface object to a given instrument. For example, you can connect only one serial port object to an instrument associated with the COM1 port. Similarly, you can connect only one GPIB object to an instrument with a given board index, primary address, and secondary address.

Some properties are read-only while the interface object is connected, and must be configured before using fopen. Examples include InputBufferSize and OutputBufferSize. Refer to the property reference pages or use the propinfo function to determine which properties have this constraint.

The values for some properties are verified only after obj is connected to the instrument. If any of these properties are incorrectly configured, an error is returned when fopen is issued and obj is not connected to the instrument. Properties of this type include BaudRate and SecondaryAddress, and are associated with instrument settings.

fopen

Examples   This example creates the GPIB object g, connects g to the instrument using fopen, writes and reads text data, and then disconnects g from the instrument.

```
g = gpib('ni',0,1);
fopen(g)
fprintf(g,'*IDN?')
idn = fscanf(g);
fclose(g)
```

See Also   **Functions**

fclose, instrhelp, propinfo

Properties

BytesAvailable, BytesToOutput, Status, ValuesReceived, ValuesSent

Purpose	Write text to instrument

Syntax
```
fprintf(obj,'cmd')
fprintf(obj,'format','cmd')
fprintf(obj,'cmd','mode')
fprintf(obj,'format','cmd','mode')
```

Arguments

obj	An interface object.
'cmd'	The string written to the instrument.
'format'	C language conversion specification.
'mode'	Specifies whether data is written synchronously or asynchronously.

Description

fprintf(obj,'cmd') writes the string cmd to the instrument connected to obj. The default format is %s\n. The write operation is synchronous and blocks the command line until execution is complete.

fprintf(obj,'format','cmd') writes the string using the format specified by format.

format is a C language conversion specification. Conversion specifications involve the % character and the conversion characters d, i, o, u, x, X, f, e, E, g, G, c, and s. Refer to the sprintf file I/O format specifications or a C manual for more information.

fprintf(obj,'cmd','mode') writes the string with command-line access specified by mode. If mode is sync, cmd is written synchronously and the command line is blocked. If mode is async, cmd is written asynchronously and the command line is not blocked. If mode is not specified, the write operation is synchronous.

fprintf(obj,'format','cmd','mode') writes the string using the specified format. If mode is sync, cmd is written synchronously. If mode is async, cmd is written asynchronously.

fprintf

Remarks

Before you can write text to the instrument, it must be connected to `obj` with the `fopen` function. A connected interface object has a `Status` property value of `open`. An error is returned if you attempt to perform a write operation while `obj` is not connected to the instrument.

The `ValuesSent` property value is increased by the number of values written each time `fprintf` is issued.

An error occurs if the output buffer cannot hold all the data to be written. You can specify the size of the output buffer with the `OutputBufferSize` property.

Synchronous Versus Asynchronous Write Operations

By default, text is written to the instrument synchronously and the command line is blocked until the operation completes. You can perform an asynchronous write by configuring the *mode* input argument to be `async`. For asynchronous writes,

- The `BytesToOutput` property value is continuously updated to reflect the number of bytes in the output buffer.

- The M-file callback function specified for the `OutputEmptyFcn` property is executed when the output buffer is empty.

You can determine whether an asynchronous write operation is in progress with the `TransferStatus` property.

Synchronous and asynchronous write operations are discussed in more detail in "Synchronous Versus Asynchronous Write Operations" on page 3-17.

Rules for Completing a Write Operation with fprintf

A write operation using `fprintf` completes when

- The specified data is written.

- The time specified by the `Timeout` property passes.

Rules for Writing the Terminator

For serial port, TCPIP, UDP, and VISA-serial objects, all occurrences of
\n in cmd are replaced with the Terminator property value. Therefore,
when using the default format %s\n, all commands written to the
instrument will end with this property value.

For GPIB, VISA-GPIB, VISA-VXI, and VISA-GPIB-VXI objects, all
occurrences of \n in cmd are replaced with the EOSCharCode property
value if the EOSMode property is set to write or read&write. For
example, if EOSMode is set to write and EOSCharCode is set to LF,
then all occurrences of \n are replaced with a line feed character.
Additionally, for GPIB objects, the End Or Identify (EOI) line is asserted
when the terminator is written out.

Note The terminator required by your instrument will be described in
its documentation.

Examples   Create the serial port object s, connect s to a Tektronix TDS 210
oscilloscope, and write the RS232? command with the fprintf function.
RS232? instructs the scope to return serial port communications
settings.

```
s = serial('COM1');
fopen(s)
fprintf(s,'RS232?')
settings = fscanf(s)
settings =
9600;1;0;NONE;LF
```

Because the default format for fprintf is %s\n, the terminator specified
by the Terminator property was automatically written. However, in
some cases you might want to suppress writing the terminator. To do so,
you must explicitly specify a format for the data that does not include
the terminator, or configure the terminator to empty.

fprintf

```
fprintf(s,'%s','RS232?')
```

See Also   **Functions**

fopen, fwrite, instrhelp, query, sprintf

Properties

BytesToOutput, EOSCharCode, EOSMode, OutputBufferSize,
OutputEmptyFcn, Status, TransferStatus, ValuesSent

fread

Purpose   Read binary data from instrument

Syntax
```
A = fread(obj)
A = fread(obj,size)
A = fread(obj,size,'precision')
[A,count] = fread(...)
[A,count,msg] = fread(...)
[A,count,msg,datagramaddress] = fread(obj,...)
[A,count,msg,datagramaddress,datagramport] = fread(obj,...)
```

Arguments

obj	An interface object.
size	The number of values to read.
'*precision*'	The number of bits read for each value, and the interpretation of the bits as character, integer, or floating-point values.
A	Binary data returned from the instrument.
count	The number of values read.
msg	A message indicating if the read operation was unsuccessful.
datagramaddress	The address of the datagram sender.
datagramport	The port of the datagram sender.

Description   A = fread(obj) and A = fread(obj,size) read binary data from the instrument connected to obj, and returns the data to A. The maximum number of values to read is specified by size. If size is not specified, the maximum number of values to read is determined by the object's InputBufferSize property. Valid options for size are

n	Read at most n values into a column vector.
[m,n]	Read at most m–by–n values filling an m–by–n matrix in column order.

size cannot be `inf`, and an error is returned if the specified number of values cannot be stored in the input buffer. You specify the size, in bytes, of the input buffer with the `InputBufferSize` property. A value is defined as a byte multiplied by the *precision* (see below).

If `obj` is a UDP object and `DatagramTerminateMode` is `off`, the `size` value is honored. If `size` is less than the length of the datagram, only `size` values are read. If `size` is greater than the length of the datagram, a warning is issued stating that a complete datagram was read before `size` values was reached.

`A = fread(obj,size,'`*precision*`')` reads binary data with precision specified by *precision*.

precision controls the number of bits read for each value and the interpretation of those bits as integer, floating-point, or character values. If *precision* is not specified, `uchar` (an 8-bit unsigned character) is used. By default, numeric values are returned in double-precision arrays. The supported values for *precision* are listed below in Remarks.

`[A,count] = fread(...)` returns the number of values read to `count`.

`[A,count,msg] = fread(...)` returns a warning message to `msg` if the read operation was unsuccessful.

`[A,count,msg,datagramaddress] = fread(obj,...)` returns the datagram address to `datagramaddress` if `obj` is a UDP object. If more than one datagram is read, `datagramaddress` is ''.

`[A,count,msg,datagramaddress,datagramport] = fread(obj,...)` returns the datagram port to `datagramport` if `obj` is a UDP object. If more than one datagram is read, `datagramport` is `[]`.

Remarks   Before you can read data from the instrument, it must be connected to `obj` with the `fopen` function. A connected interface object has a `Status` property value of `open`. An error is returned if you attempt to perform a read operation while `obj` is not connected to the instrument.

If `msg` is not included as an output argument and the read operation was not successful, then a warning message is returned to the command line.

The `ValuesReceived` property value is increased by the number of values read, each time `fread` is issued.

Rules for Completing a Binary Read Operation

A read operation with `fread` blocks access to the MATLAB command line until

- The specified number of values is read. For UDP objects, `DatagramTerminateMode` must be `off`.

- The time specified by the `Timeout` property passes.

- A datagram is received (for UDP objects only when `DatagramTerminateMode` is `on`).

- The input buffer is filled.

- The EOI line is asserted (GPIB and VXI instruments only).

- The `EOSCharCode` is received (GPIB and VXI instruments only).

More About the GPIB and VXI Terminator

The `EOSCharCode` property value is recognized only when the `EOSMode` property is configured to `read` or `read&write`. For example, if `EOSMode` is configured to `read` and `EOSCharCode` is configured to `LF`, then one of the ways that the read operation terminates is when the line feed character is received.

If `EOSMode` is `none` or `write`, then there is no terminator defined for read operations. In this case, `fread` will complete execution and return control to the command when another criterion, such as a timeout, is met.

Supported Precisions

The supported values for *precision* are listed below.

Data Type	Precision	Interpretation
Character	uchar	8-bit unsigned character
	schar	8-bit signed character
	char	8-bit signed or unsigned character
Integer	int8	8-bit integer
	int16	16-bit integer
	int32	32-bit integer
	uint8	8-bit unsigned integer
	uint16	16-bit unsigned integer
	uint32	32-bit unsigned integer
	short	16-bit integer
	int	32-bit integer
	long	32- or 64-bit integer
	ushort	16-bit unsigned integer
	uint	32-bit unsigned integer
	ulong	32- or 64-bit unsigned integer
Floating-point	single	32-bit floating point
	float32	32-bit floating point
	float	32-bit floating point
	double	64-bit floating point
	float64	64-bit floating point

See Also   **Functions**

fgetl, fgets, fopen, fscanf, instrhelp

Properties

BytesAvailable, InputBufferSize, Status, ValuesReceived

fscanf

Purpose	Read data from instrument, and format as text

Syntax

```
A = fscanf(obj)
A = fscanf(obj,'format')
A = fscanf(obj,'format',size)
[A,count] = fscanf(...)
[A,count,msg] = fscanf(...)
[A,count,msg,datagramaddress] = fscanf(obj,...)
[A,count,msg,datagramaddress,datagramport] = fscanf(obj,...)
```

Arguments

obj	An interface object.
'*format*'	C language conversion specification.
size	The number of values to read.
A	Data read from the instrument and formatted as text.
count	The number of values read.
msg	A message indicating if the read operation was unsuccessful.
datagramaddress	The address of the datagram sender.
datagramport	The port of the datagram sender.

Description A = fscanf(obj) reads data from the instrument connected to obj, and returns it to A. The data is converted to text using the %c format.

A = fscanf(obj,'*format*') reads data and converts it according to *format*.

format is a C language conversion specification. Conversion specifications involve the % character and the conversion characters d, i, o, u, x, X, f, e, E, g, G, c, and s. Refer to the sscanf file I/O format specifications or a C manual for more information.

A = fscanf(obj,'*format*',size) reads the number of values specified by size. Valid options for size are

n	Read at most n values into a column vector.
[m,n]	Read at most m–by–n values filling an m–by–n matrix in column order.

size cannot be inf, and an error is returned if the specified number of values cannot be stored in the input buffer. If size is not of the form [m,n], and a character conversion is specified, then A is returned as a row vector. You specify the size, in bytes, of the input buffer with the InputBufferSize property. An ASCII value is one byte.

If obj is a UDP object and DatagramTerminateMode is off, the size value is honored. If size is less than the length of the datagram, only size values are read. If size is greater than the length of the datagram, a warning is issued stating that a complete datagram was read before size values was reached.

[A,count] = fscanf(...) returns the number of values read to count.

[A,count,msg] = fscanf(...) returns a warning message to msg if the read operation did not complete successfully.

[A,count,msg,datagramaddress] = fscanf(obj,...) returns the datagram address to datagramaddress if obj is a UDP object. If more than one datagram is read, datagramaddress is ''.

[A,count,msg,datagramaddress,datagramport] = fscanf(obj,...) returns the datagram port to datagramport if obj is a UDP object. If more than one datagram is read, datagramport is [].

Remarks   Before you can read data from the instrument, it must be connected to obj with the fopen function. A connected interface object has a Status property value of open. An error is returned if you attempt to perform a read operation while obj is not connected to the instrument.

If msg is not included as an output argument and the read operation was not successful, then a warning message is returned to the command line.

fscanf

The ValuesReceived property value is increased by the number of values read — including the terminator — each time fscanf is issued.

Rules for Completing a Read Operation with fscanf

A read operation with fscanf blocks access to the MATLAB command line until

- The terminator is read. For serial port, TCPIP, UDP, and VISA-serial objects, the terminator is given by the Terminator property. If Terminator is empty, fscanf will complete execution and return control when another criterion is met. For UDP objects, DatagramTerminateMode must be off.

  For all other interface objects, the terminator is given by the EOSCharCode property.

- The time specified by the Timeout property passes.

- The number of values specified by size is read. For UDP objects, DatagramTerminateMode must be off.

- A datagram is received (for UDP objects only when DatagramTerminateMode is on).

- The input buffer is filled.

- The EOI line is asserted (GPIB and VXI instruments only).

More About the GPIB and VXI Terminator

The EOSCharCode property value is recognized only when the EOSMode property is configured to read or read&write. For example, if EOSMode is configured to read and EOSCharCode is configured to LF, then one of the ways that the read operation terminates is when the line feed character is received.

If EOSMode is none or write, then there is no terminator defined for read operations. In this case, fscanf will complete execution and return control to the command when another criterion, such as a timeout, is met.

Examples   Create the serial port object s and connect s to a Tektronix TDS 210
oscilloscope, which is displaying a sine wave.

```
s = serial('COM1');
fopen(s)
```

Use the fprintf function to configure the scope to measure the
peak-to-peak voltage of the sine wave, return the measurement type,
and return the peak-to-peak voltage.

```
fprintf(s,'MEASUREMENT:IMMED:TYPE PK2PK')
fprintf(s,'MEASUREMENT:IMMED:TYPE?')
fprintf(s,'MEASUREMENT:IMMED:VAL?')
```

Because the default value for the ReadAsyncMode property is
continuous, data associated with the two query commands is
automatically returned to the input buffer.

```
s.BytesAvailable
ans =
    13
```

Use fscanf to read the measurement type. The operation will complete
when the first terminator is read.

```
meas = fscanf(s)
meas =
PK2PK
```

Use fscanf to read the peak-to-peak voltage as a floating-point number,
and exclude the terminator.

```
pk2pk = fscanf(s,'%e',6)
pk2pk =
    2.0200
```

Disconnect s from the scope, and remove s from memory and the workspace.

```
fclose(s)
delete(s)
clear s
```

See Also   **Functions**

fgetl, fgets, fopen, fread, instrhelp, scanstr, sscanf

Properties

BytesAvailable, BytesAvailableFcn, EOSCharCode, EOSMode, InputBufferSize, Status, Terminator, Timeout, TransferStatus

Purpose   Write binary data to instrument

Syntax
```
fwrite(obj,A)
fwrite(obj,A,'precision')
fwrite(obj,A,'mode')
fwrite(obj,A,'precision','mode')
```

Arguments

`obj`	An interface object.
`A`	The binary data written to the instrument.
`'precision'`	The number of bits written for each value, and the interpretation of the bits as character, integer, or floating-point values.
`'mode'`	Specifies whether data is written synchronously or asynchronously.

Description   `fwrite(obj,A)` writes the binary data A to the instrument connected to `obj`.

`fwrite(obj,A,'precision')` writes binary data with precision specified by *precision*.

precision controls the number of bits written for each value and the interpretation of those bits as integer, floating-point, or character values. If *precision* is not specified, uchar (an 8-bit unsigned character) is used. The support values for *precision* are listed in "Supported Precisions" on page 18-45.

`fwrite(obj,A,'mode')` writes binary data with command line access specified by *mode*. If *mode* is sync, A is written synchronously and the command line is blocked. If *mode* is async, A is written asynchronously and the command line is not blocked. If *mode* is not specified, the write operation is synchronous.

`fwrite(obj,A,'precision','mode')` writes binary data with precision specified by *precision* and command-line access specified by *mode*.

fwrite

Remarks   Before you can write data to the instrument, it must be connected to `obj` with the `fopen` function. A connected interface object has a `Status` property value of `open`. An error is returned if you attempt to perform a write operation while `obj` is not connected to the instrument.

The `ValuesSent` property value is increased by the number of values written each time `fwrite` is issued.

An error occurs if the output buffer cannot hold all the data to be written. You can specify the size of the output buffer with the `OutputBufferSize` property.

Synchronous Versus Asynchronous Write Operations

By default, data is written to the instrument synchronously and the command line is blocked until the operation completes. You can perform an asynchronous write by configuring the *mode* input argument to be `async`. For asynchronous writes,

- The `BytesToOutput` property value is continuously updated to reflect the number of bytes in the output buffer.

- The M-file callback function specified for the `OutputEmptyFcn` property is executed when the output buffer is empty.

You can determine whether an asynchronous write operation is in progress with the `TransferStatus` property.

Synchronous and asynchronous write operations are discussed in more detail in "Synchronous Versus Asynchronous Write Operations" on page 3-17.

Rules for Completing a Write Operation with fwrite

A binary write operation using `fwrite` completes when

- The specified data is written.

- The time specified by the `Timeout` property passes.

> **Note** The Terminator and EOSCharCode properties are not used with
> binary write operations.

Supported Precisions

The supported values for *precision* are listed below.

Data Type	Precision	Interpretation
Character	uchar	8-bit unsigned character
	schar	8-bit signed character
	char	8-bit signed or unsigned character
Integer	int8	8-bit integer
	int16	16-bit integer
	int32	32-bit integer
	uint8	8-bit unsigned integer
	uint16	16-bit unsigned integer
	uint32	32-bit unsigned integer
	short	16-bit integer
	int	32-bit integer
	long	32- or 64-bit integer
	ushort	16-bit unsigned integer
	uint	32-bit unsigned integer
	ulong	32- or 64-bit unsigned integer

Data Type	Precision	Interpretation
Floating-point	`single`	32-bit floating point
	`float32`	32-bit floating point
	`float`	32-bit floating point
	`double`	64-bit floating point
	`float64`	64-bit floating point

See Also

Functions

fopen, fprintf, instrhelp

Properties

OutputBufferSize, OutputEmptyFcn, Status, Timeout, TransferStatus, ValuesSent

Purpose	Instrument object properties

Syntax

```
get(obj)
out = get(obj)
out = get(obj,'PropertyName')
```

Arguments

obj	An instrument object or an array of instrument objects.
'*PropertyName*'	A property name or a cell array of property names.
out	A single property value, a structure of property values, or a cell array of property values.

Description

get(obj) returns all property names and their current values to the command line for obj. The properties are divided into two sections. The base properties are listed first and the object-specific properties are listed second.

out = get(obj) returns the structure out where each field name is the name of a property of obj, and each field contains the value of that property.

out = get(obj,'*PropertyName*') returns the value out of the property specified by *PropertyName* for obj. If *PropertyName* is replaced by a 1-by-n or n-by-1 cell array of strings containing property names, then get returns a 1-by-n cell array of values to out. If obj is an array of instrument objects, then out will be an m-by-n cell array of property values where m is equal to the length of obj and n is equal to the number of properties specified.

Remarks

When specifying a property name, you can do so without regard to case, and you can make use of property name completion. For example, if g is a GPIB object, then these commands are all valid.

```
out = get(g,'EOSMode');
```

```
out = get(g,'eosmode');
out = get(g,'EOSM');
```

Examples   This example illustrates some of the ways you can use get to return property values for the GPIB object g.

```
g = gpib('ni',0,1);
out1 = get(g);
out2 = get(g,{'PrimaryAddress','EOSCharCode'});
get(g,'EOIMode')
ans =
on
```

See Also   **Functions**

instrhelp, propinfo, set

Purpose   Check and return error message from instrument

Syntax   msg = geterror(obj)

Arguments
obj	A device object.
msg	The error message returned from the instrument.

Description   msg = geterror(obj) checks the instrument associated with the
device object specified by obj for an error message. If an error message
exists, it is returned to msg. The interpretation of msg will vary based
on the instrument.

gpib

Purpose	Create GPIB object

Syntax
```
obj = gpib('vendor, boardindex, primaryaddress)
obj = gpib('vendor',boardindex,primaryaddress,'PropertyName',
    PropertyValue,...)
```

Arguments

`'vendor'`	The vendor name.
`boardindex`	The GPIB board index.
`primaryaddress`	The instrument primary address.
`'PropertyName'`	A GPIB property name.
`'PropertyValue'`	A property value supported by *PropertyName*.
`obj`	The GPIB object.

Description   obj = gpib('*vendor*, boardindex, primaryaddress) creates the GPIB object obj associated with the board specified by boardindex, and the instrument specified by primaryaddress. The GPIB hardware is supplied by *vendor*. Supported vendors are given below.

Vendor	**Description**
advantech	Advantech Company hardware
agilent	Agilent Technologies hardware
cec	Capital Equipment Corporation hardware
contec	CONTEC hardware
ics	ICS Electronics hardware
iotech	IOTech hardware
keithley	Keithley Instruments hardware

Vendor	Description
mcc	Measurement Computing Corporation hardware
ni	National Instruments hardware

obj = gpib('*vendor*',boardindex,primaryaddress,'*PropertyName*', PropertyValue,...) creates the GPIB object with the specified property names and property values. If an invalid property name or property value is specified, an error is returned and obj is not created.

Remarks   At any time, you can use the instrhelp function to view a complete listing of properties and functions associated with GPIB objects.

    instrhelp gpib

When you create a GPIB object, these property value are automatically configured:

• Type is given by gpib.

• Name is given by concatenating GPIB with the board index and the primary address specified in the gpib function. If the secondary address is specified, then this value is also used in Name.

• BoardIndex and PrimaryAddress are given by the values supplied to the gpib function.

Note You do not use the GPIB board primary address in the GPIB object constructor syntax. You use the board index, and the instrument address.

You can specify the property names and property values using any format supported by the set function. For example, you can use property name/property value cell array pairs. Additionally, you can

specify property names without regard to case, and you can make use of property name completion. For example, these commands are all valid:

```
g = gpib('ni',0,1,'SecondaryAddress',96);
g = gpib('ni',0,1,'secondaryaddress',96);
g = gpib('ni',0,1,'SECOND',96);
```

Before you can communicate with the instrument, it must be connected to obj with the fopen function. A connected GPIB object has a Status property value of open. An error is returned if you attempt to perform a read or write operation while obj is not connected to the instrument.

You cannot connect multiple GPIB objects to the same instrument. A GPIB instrument is uniquely identified by its board index, primary address, and secondary address.

Examples   This example creates the GPIB object g1 associated with a National Instruments board at index 0 with primary address 1, and then connects g1 to the instrument.

```
g1 = gpib('ni',0,1);
fopen(g1)
```

The Type, Name, BoardIndex, and PrimaryAddress properties are automatically configured.

```
get(g1, {'Type','Name','BoardIndex','PrimaryAddress'})
ans =
    'gpib'    'GPIB0-1'    [0]    [1]
```

To specify the secondary address during object creation,

```
g2 = gpib('ni',0,1,'SecondaryAddress',96);
```

See Also   **Functions**

fopen, instrhelp, instrhwinfo

Properties

BoardIndex, Name, PrimaryAddress, SecondaryAddress, Status, Type

icdevice

Purpose	Create device object

Syntax
```
obj = icdevice('driver', hwobj)
obj = icdevice('driver', 'RsrcName')
obj = icdevice('driver')
obj = icdevice('driver', hwobj, 'P1', V1, 'P2', V2,...)
obj = icdevice('driver', 'RsrcName','P1', V1, 'P2', V2,...)
obj = icdevice('driver','P1', V1, 'P2', V2,...)
```

Arguments

driver	A MATLAB instrument driver.
hwobj	An interface object.
RsrcName	VISA resource name.
'P1', 'P2',...	Device-specific property names.
V1, V2,...	Property values supported by corresponding *P1*, *P2*,...
obj	A device object.

Description   obj = icdevice('driver', hwobj) creates the device object obj. The instrument-specific information is defined in the MATLAB interface instrument driver, driver. Communication to the instrument is done through the interface object, hwobj. The interface object can be a serial port, GPIB, VISA, TCPIP, or UDP object. If driver does not exist or if hwobj is invalid, the device object is not created.

Device objects may also be used with VXI*plug&play* and Interchangeable Virtual Instrument (IVI) drivers. To use these drivers, you must first have a MATLAB instrument driver wrapper for the underlying VXI*plug&play* or IVI driver. If the MATLAB instrument driver wrapper does not already exist, it may be created using makemid or midedit. Note that makemid or midedit only needs to be used once to create the MATLAB instrument driver wrapper.

obj = icdevice('driver', 'RsrcName') creates a device object obj, using the MATLAB instrument driver, driver. The specified driver

must be a MATLAB VXI*plug&play* instrument driver or MATLAB IVI instrument driver. Communication to the instrument is done through the resource specified by `rsrcname`. For example, all VXI*plug&play*, and many IVI drivers require VISA resource names for `rsrcname`.

`obj = icdevice('driver')` constructs a device object `obj`, using the MATLAB instrument driver, `driver`. The specified `driver` must be a MATLAB IVI instrument driver, and the underlying IVI driver must be referenced using a logical name.

`obj = icdevice('driver', hwobj, 'P1', V1, 'P2', V2,...)`, `obj = icdevice('driver', 'RsrcName','P1', V1, 'P2', V2,...)`, and `obj = icdevice('driver','P1', V1, 'P2', V2,...)`, construct a device object, `obj`, with the specified property values. If an invalid property name or property value is specified, the object will not be created.

Note that the parameter-value pairs can be in any format supported by the `set` function: parameter-value string pairs, structures, and parameter-value cell array pairs.

Additionally, you can specify property names without regard to case, and you can make use of property name completion. For example, these commands are all valid and equivalent:

```
d = icdevice('tektronix_tds210',g,'ObjectVisibility','on');
d = icdevice('tektronix_tds210',g,'objectvisibility','on');
d = icdevice('tektronix_tds210',g,'ObjectVis','on');
```

Remarks At any time, you can use the `instrhelp` function to view a complete listing of properties and functions associated with device objects.

```
instrhelp icdevice
```

When you create a device object, these property values are automatically configured:

- `Interface` specifies the interface used to communicate with the instrument. For device objects created using interface objects, it is that interface object. For VXI*plug&play* and IVI-C, this is the session

handle to the driver session. For IVI-COM and MATLAB instrument drivers, this is the handle to the driver's default COM interface.

- `LogicalName` is an IVI logical name. For non-IVI drivers, it is empty.

- `Name` is given by concatenating the instrument type with the name of the instrument driver.

- `RsrcName` is the full VISA resource name for VXI*plug&play* and IVI drivers. For MATLAB interface drivers, `RsrcName` is an empty string.

- `Type` is the instrument type, if known (for example, `scope` or `multimeter`).

To communicate with the instrument, the device object must be connected to the instrument with the `connect` function. When the device object is constructed, the object's `Status` property is `closed`. Once the device object is connected to the instrument with the `connect` function, the `Status` property is configured to `open`.

Examples   The first example creates a device object for a Tektronix TDS 210 oscilloscope that is connected to a Keithley GPIB board, using a MATLAB interface object and MATLAB interface instrument driver.

```
g = gpib('keithley',0,2);
d = icdevice('tektronix_tds210',g);
```

Connect to the instrument.

```
connect(d);
```

List the oscilloscope settings that can be configured.

```
props = set(d);
```

Get the current configuration of the oscilloscope.

```
values = get(d);
```

Disconnect from the instrument and clean up.

```
disconnect(d);
delete([d g]);
```

The second example creates a device object for a Tektronix TDS 210 oscilloscope using a MATLAB VXI*plug&play* instrument driver.

This example assumes that the 'tktds5k' VXI*plug&play* driver is installed on your system.

This first step is necessary only if a MATLAB VXI*plug&play* instrument driver for the tktds5k does not exist on your system.

```
makemid('tktds5k', 'Tktds5kMATLABDriver');
```

Construct a device object that uses the VXI*plug&play* driver. The instrument is assumed to be located at GPIB primary address 2.

```
d = icdevice('Tktds5kMATLABDriver', 'GPIB0::2::INSTR');
```

Connect to the instrument.

```
connect(d);
```

List the oscilloscope settings that can be configured.

```
props = set(d);
```

Get the current configuration of the oscilloscope.

```
values = get(d);
```

Disconnect from the instrument and clean up.

```
disconnect(d);
delete(d);
```

See Also   **Functions**

icdevice/connect, icdevice/disconnect, instrhelp

icdevice

Properties

Status

Purpose   Open Property Inspector

Syntax   inspect(obj)

Arguments   obj   An instrument object or an array of instrument objects.

Description   inspect(obj) opens the Property Inspector and allows you to inspect and set properties for instrument object obj.

Remarks   You can also open the Property Inspector via the Workspace browser by right-clicking an instrument object and selecting **Call Property Inspector** from the context menu, or by double-clicking the object.

Below is a Property Inspector for a device object that communicates with a Tektronix TDS 210 oscilloscope.

Purpose	Display event information when event occurs

Syntax　　　　instrcallback(obj, event)

Arguments

obj	An instrument object.
event	The event that caused the callback to execute.

Description　　instrcallback(obj, event) displays a message that contains the event type, the time the event occurred, and the name of the instrument object that caused the event to occur.

For error events, the error message is also displayed. For pin status events, the pin that changed value and its value are also displayed. For trigger events, the trigger line is also displayed. For datagram received events, the number of bytes received and the datagram address and port are also displayed.

Remarks　　　You should use instrcallback as a template from which you create callback functions that suit your specific application needs.

Examples　　　The following example creates the serial port objects s, and configures s to execute instrcallback when an output-empty event occurs. The event occurs after the *IDN? command is written to the instrument.

```
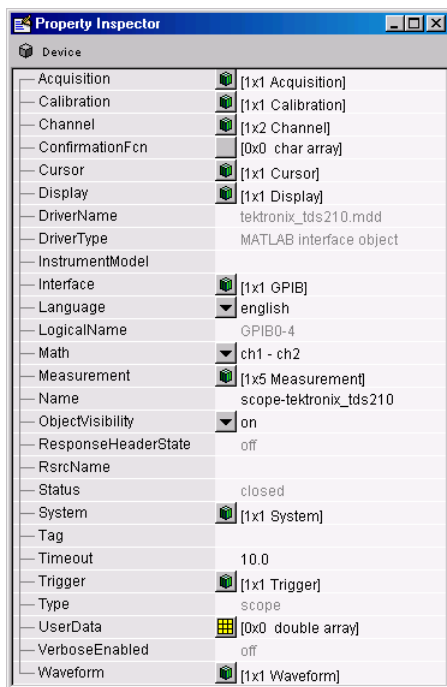s = serial('COM1');
set(s,'OutputEmptyFcn',@instrcallback)
fopen(s)
fprintf(s,'*IDN?','async')
```

The resulting display from instrcallback is shown below.

```
OutputEmpty event occurred at 08:37:49 for the object: Serial-COM1
```

Read the identification information from the input buffer and end the serial port session.

```
idn = fscanf(s);
fclose(s)
delete(s)
clear s
```

Purpose   Open graphical tool for communicating with instruments

Syntax   instrcomm
                instrcomm(obj)

Arguments   obj   An instrument object.

Description instrcomm opens the Instrument Control Communication Tool, which
                 is an interactive tool for communicating with instruments. With this
                 tool you can

- Display all existing instrument objects

- Create new instrument objects

- Configure instrument object properties

- Connect or disconnect instrument objects from the instrument

- Read or write binary or ASCII data to and from the instrument

- Export instrument data to the MATLAB workspace, a MAT-file,
  MATLAB array editor, or directly to a plot

- Convert the communication session to an equivalent M-file

- Flush the input buffer

instrcomm(obj) opens the Instrument Control Communication Tool
targeting the instrument object, obj.

Creating Instrument Interface Objects

You must create an instrument interface object (GPIB, VISA, TCPIP,
UDP, or serial port) to communicate with instruments using the
Instrument Control Communication Tool. There are three ways to
create a new object:

- Select **Create New Object** from the **File** menu. This displays the **New Object Creation** dialog box, which enables you to define the interface object you want to use.

- Use the Instrument Control Creation Tool (`instrcreate`) to create and configure the interface object.

- Call the object constructor on the command line. See "Creating Instrument Objects" on page 2-3 for more information.

Configuring Instrument Interface Objects

You can use the Property Inspector to access all interface object properties. To display the Property Inspector, right-click on any interface object in the **Instrument Object Browser** and select **Edit Properties**.

Generating Session M-Code

You can record (and later recreate) your communication session by generating M-Code from your current session. Select the **File > Save Session Log** menu item and provide a name for the M-file in the dialog box displayed. See "Recording the Session in M-Code" on page 18-77 for a sample of the code generated.

Exporting Data

The Instrument Control Communication Tool provides options for exporting data as well as instrument objects. The **File > Export** menu item provides two choices:

- **Instrument Response(s)** – export the data read from the instrument as variables in the MATLAB workspace, as a plot in a figure window, as variables in an MAT-File, or to the MATLAB Array Editor.

- **Instrument Object** – export the instrument object to the MATLAB workspace, as the equivalent M-File, or in a MAT-File.

Examples   This example uses the Instrument Control Communication Tool to communicate with a Tektronix TDS 210 oscilloscope. The read and write operations are based on "Example: Writing and Reading Text Data" on page 4-20.

The first step is to create the GPIB interface object. This example creates the object by calling the gpib constructor on the command line.

```
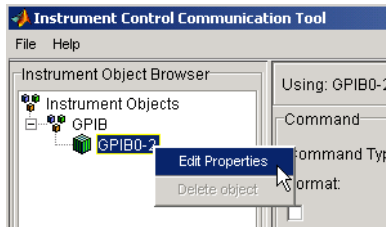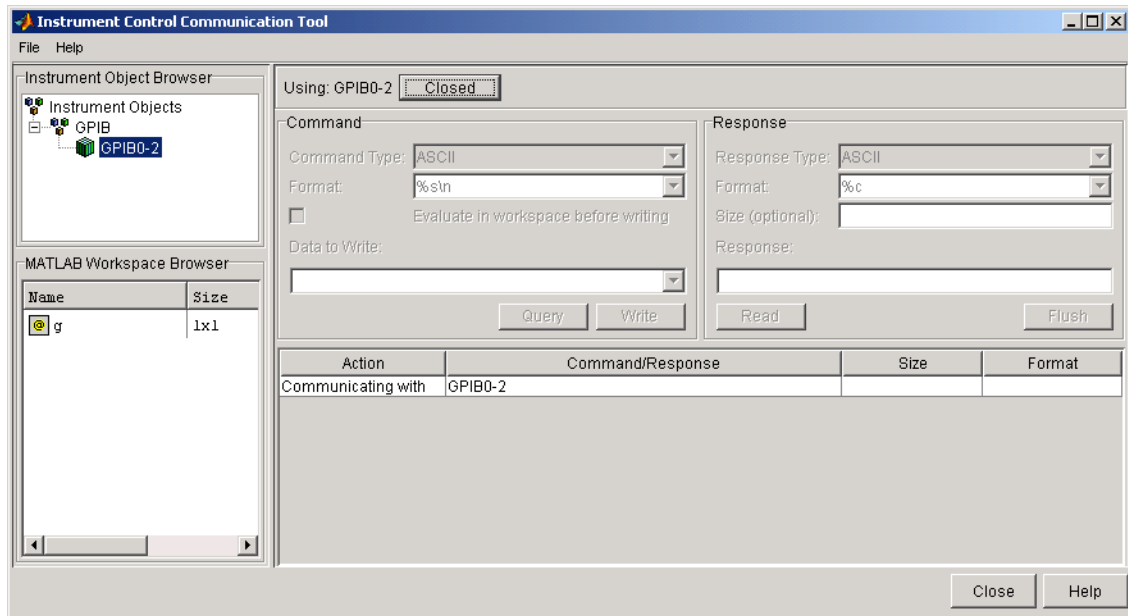g = gpib('keithley',0,2);
```

Now open the Instrument Control Communication Tool using the GPIB object g.

```
instrcomm(g)
```

The instrcomm window is shown below. Note that the newly create GPIB object is displayed in the **Instrument Object Browser**.

The communication session follows these steps:

1 At the top of the pane, a button label indicates that the connection to object GPIB0-2 is **Closed**. Clicking this button connects the object to the instrument and changes the button label to **Open**.

2 In the **Command** pane, enter the instrument commands one at a time, and click the **Write**, **Read**, or **Query** button as needed for each command.

You can specify the command and data format using the **Command Type** and **Format** options, respectively.

The complete communication session is shown below.

Instrument Control Communication Tool

File   Help

Instrument Object Browser

- Instrument Objects
  - GPIB
    - GPIB0-2

Using: GPIB0-2   Open

Command

Command Type: ASCII

Format: %s\n

☐ Evaluate in workspace before writing

Data to Write:

MEASUREMENT:MEAS1:VALUE?

Query   Write

Response

Response Type: ASCII

Format: %c

Size (optional):

Response:

1.8799999952E0

Read   Flush

MATLAB Workspace Browser

Name	Size
g	1x1

Action	Command/Response	Size	Format
Communicating with	GPIB0-2		
Connecting to	GPIB0-2		
Write (Query)	*IDN?	1x5	%s\n
Read (Query)	TEKTRONIX,TDS 210,0,CF:91.1CT FV:v1.16 TDS2CM:...	1x56	%c
Write (Query)	MEASUREMENT:IMMED:SOURCE?	1x25	%s\n
Read (Query)	CH1	1x4	%c
Write	MEASUREMENT:MEAS1:TYPE PK2PK	1x28	%s\n
Write (Query)	MEASUREMENT:MEAS1:VALUE?	1x24	%s\n
Read (Query)	1.8799999952E0	1x15	%c

Close   Help

Recording the Session in M-Code

Create a record of this example by generating M-code. To do this, select the **File > Save Session Log** menu item using the name session1.m for the generated M-file. The M-file contains the following code.

```
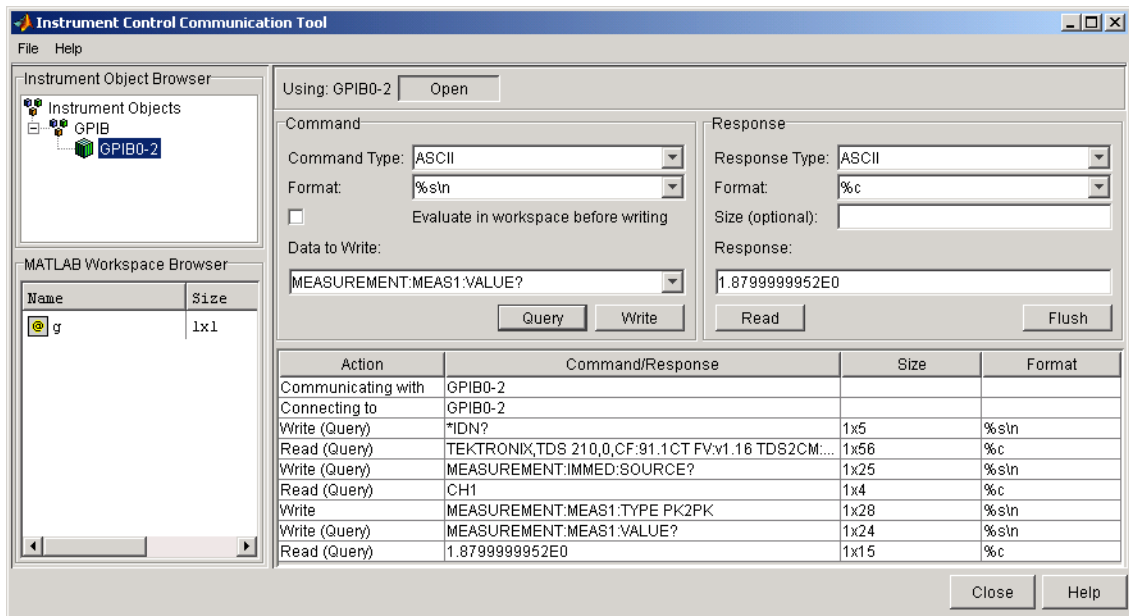%SESSION1 M-Code for communicating with an instrument.
%
% This is the machine generated represenation of an instrument
% control session. The instrument control session comprises all
% the steps you are likely to take when communicating with your
% instrument. These steps are:
%
%     1. Create an instrument object
%     2. Connect to the instrument
%     3. Configure properties
%     4. Write and read data
%     5. Disconnect from the instrument
```

```
%
% To run the instrument control session, type the name of the
% M-file, session1, at the MATLAB command prompt.
%
% The M-file, SESSION1.M must be on your MATLAB PATH. For
% additional information on setting your MATLAB PATH, type
% 'help addpath' at the MATLAB command prompt.
%
% Example:
%     session1;
%
% See also SERIAL, GPIB, TCPIP, UDP, VISA.
%

% Creation time: 12-Jan-2004 15:52:29

% Create a GPIB object.
obj1 = instrfind('Type', 'gpib', 'BoardIndex', 0,
'PrimaryAddress', 2, 'Tag', '');

% Create the GPIB object if it does not exist
% otherwise use the object that was found.
if isempty(obj1)
    obj1 = gpib('Keithley', 0, 2);
else
    fclose(obj1);
    obj1 = obj1(1)
end

% Connect to instrument object, obj1.
fopen(obj1);

% Communicating with instrument object, obj1.
data1 = query(obj1, '*IDN?');
data2 = query(obj1, 'MEASUREMENT:IMMED:SOURCE?');
fprintf(obj1, 'MEASUREMENT:MEAS1:TYPE PK2PK');
data3 = query(obj1, 'MEASUREMENT:MEAS1:VALUE?');
```

```
% Disconnect all objects.
fclose(obj1);

% Clean up all objects.
delete(obj1);
```

See Also   **Functions**

instrcreate

instrcreate

Purpose　　　Open graphical tool for creating and configuring instrument object

Syntax　　　`instrcreate`

Description　`instrcreate` open the Instrument Control Creation Tool. Using this tool, you can

- Create instrument objects.
- Configure new and existing instrument objects, regardless of how the objects were created.
- Identify the instrument connected to the object.
- See a list of all existing instrument objects.

You can use the instrument object in conjunction with the Instrument Control Communication Tool, `instrcomm`, to communicate with instruments.

If you want to access the object from the command line, click the **Export** button and save the instrument object as a workspace variable, a MAT-file, or convert it to the equivalent M-code.

Examples　　This example uses `instrcreate` to create a GPIB object that communicates with a Tektronix TDS 210 oscilloscope. The configuration steps are taken from "Example: Reading Binary Data" on page 4-22.

The first step is to open the Instrument Control Creation Tool:

```
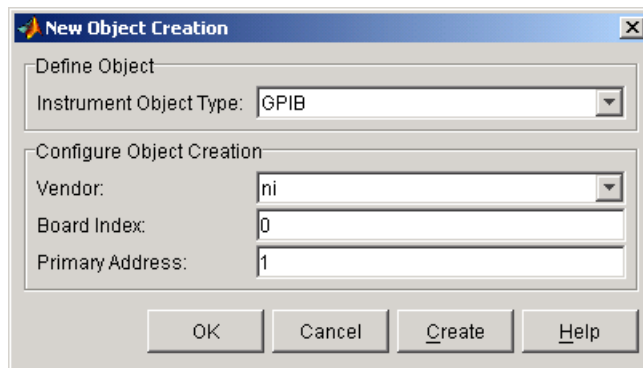instrcreate
```

The initial `instrcreate` window is shown below.

This example uses a GPIB object created for a National Instruments GPIB controller with board index 0, and an oscilloscope with primary address 1.

Create the Object

Click the **New Object** button to display the **New Object Creation** dialog box.

Specify the object as follows:

- **Instrument Object Type** set to GPIB

- **Vendor** set to ni

- **Board Index** set to 0

- **Primary Address** set to 1

Click **OK** to create the object and dismiss the dialog box.

Configure the Object

Return to the Instrument Control Creation Tool. The **Instrument Object Browser** shows the object under the GPIB node.

Select the **Configure** tab and set the following properties:

- **InputBufferSize** set to 50000.

- **Timeout** is to 120.

- **BytesAvailableFcn** set to @instrcallback

- **BytesAvailableFcnMode** is set to byte

- **BytesAvailableFcnCount** is set to 5000.

These parameters are configured so that the M-file callback function instrcallback executes every time 5,000 bytes are stored in the input buffer.

Identifying the Object

You can identify the instrument connected to an instrument object from the **Identify** tab. This pane enables you to send the instrument's identify command and see the response returned.

Type the instrument's identify command in the **Command used to identify instrument** text field, click on the **Identify** button, and see the response in the **Instrument Identification** field.

Exporting the Object

This example saves the GPIB object to the MATLAB workspace as the variable g and as the equivalent M-code in an M-file named myGPIB1.m. To do this, click the **Export** button to display the **Object Exporter**.

First, export the object as a variable.

- Set the **Object destination** to MATLAB Workspace.

- Enter the name of the variable under the **Variable Name** column.

• Click the **Export** button on the **Object Exporter**.

Next, export the object to an M-file.

• Set the **Object destination** to M-File.

• Click the **Export** button on the **Object Exporter**.

• Enter the file name (myGPIB1.m) in the **File name** text field of the **Export to M-File** dialog box. Then click **Save**.

After creating and configuring the GPIB object, you can use it to communicate with your instrument via the command line or via the Instrument Control Communication Tool, instrcomm. Note that instrcomm does not support asynchronous read and write operations. Therefore, the bytes-available events will not be generated.

See Also   **Functions**

instrcomm

Purpose   Read instrument objects from memory to MATLAB workspace

Syntax

```
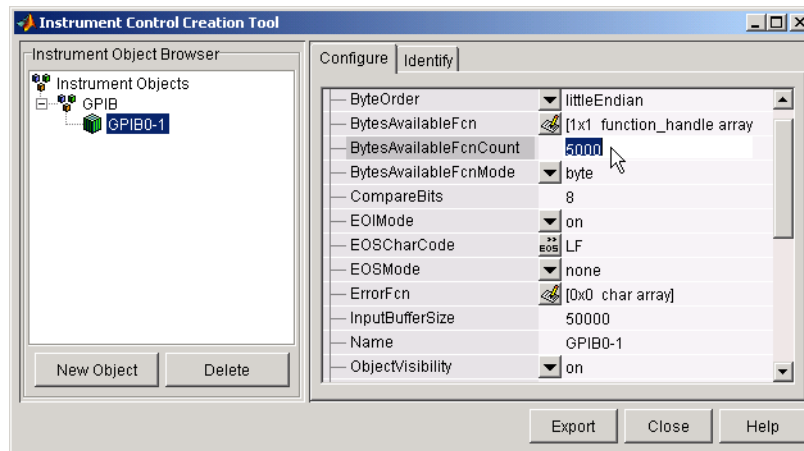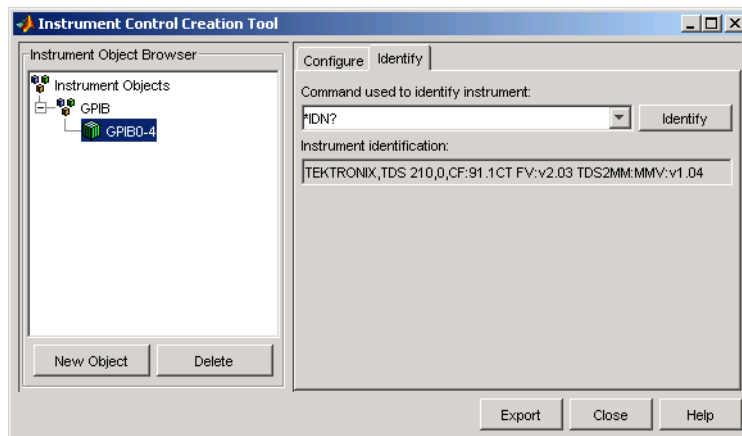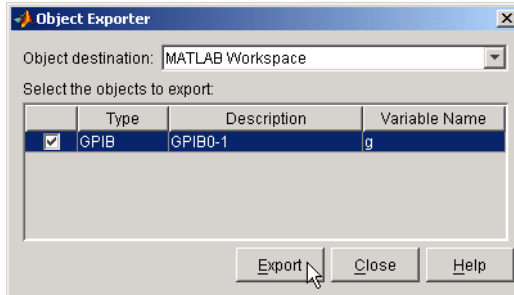out = instrfind
out = instrfind('PropertyName',PropertyValue,...)
out = instrfind(S)
out = instrfind(obj,'PropertyName',PropertyValue,...)
```

Arguments

`'PropertyName'`	A property name for `obj`.
`PropertyValue`	A property value supported by *PropertyName*.
`S`	A structure of property names and property values.
`obj`	An instrument object, or an array of instrument objects.
`out`	An array of instrument objects.

Description   `out = instrfind` returns all valid instrument objects as an array to `out`.

`out = instrfind('PropertyName',PropertyValue,...)` returns an array of instrument objects whose property names and property values match those specified.

`out = instrfind(S)` returns an array of instrument objects whose property names and property values match those defined in the structure `S`. The field names of `S` are the property names, while the field values are the associated property values.

`out = instrfind(obj,'PropertyName',PropertyValue,...)` restricts the search for matching property name/property value pairs to the instrument objects listed in `obj`.

Remarks   `instrfind` will not return an instrument object if its `ObjectVisibility` property is configured to `off`.

You must specify property values using the same format as the `get` function returns. For example, if `get` returns the `Name` property value as

instrfind

MyObject, instrfind will not find an object with a Name property value of myobject. However, this is not the case for properties that have a finite set of string values. For example, instrfind will find an object with a Parity property value of Even or even. You can use the propinfo function to determine if a property has a finite set of string values.

You can use property name/property value string pairs, structures, and cell array pairs in the same call to instrfind.

Examples   Suppose you create the following two GPIB objects.

```
g1 = gpib('ni',0,1);
g2 = gpib('ni',0,2);
g2.EOSCharCode = 'CR';
fopen([g1 g2])
```

You can use instrfind to return instrument objects based on property values.

```
out1 = instrfind('Type','gpib');
out2 = instrfind({'Type','EOSCharCode'},{'gpib','CR'});
```

You can also use instrfind to return cleared instrument objects to the MATLAB workspace.

```
clear g1 g2
newobjs = instrfind

Instrument Object Array
   Index:   Type:           Status:      Name:
   1        gpib            open         GPIB0-1
   2        gpib            open         GPIB0-2
```

Assign the instrument objects their original names.

```
g1 = newobjs(1);
g2 = newobjs(2);
```

Close both g1 and g2.

```
fclose(newobjs)
```

See Also

Functions

clear, get, instrfindall, propinfo

Properties

ObjectVisibility

instrfindall

Purpose   Find visible and hidden instrument objects

Syntax
```
out = instrfindall
out = instrfindall('P1',V1,...)
out = instrfindall(s)
out = instrfindall(objs,'P1',V1,...)
```

Arguments

`'P1'`	Name of an instrument object property or device group object property
`V1`	Value allowed for corresponding *P1*.
`s`	A structure of property names and property values.
`objs`	An array of instrument objects or device group objects.
`out`	An array of returned instrument objects or device group objects.

Description   `out = instrfindall` finds all instrument objects and device group objects, regardless of the value of the objects' `ObjectVisibility` property. The object or objects are returned to `out`.

`out = instrfindall('P1',V1,...)` returns an array, `out`, of instrument objects and device group objects whose property names and corresponding property values match those specified as arguments.

`out = instrfindall(s)` returns an array, `out`, of instrument objects whose property names and corresponding property values match those specified in the structure `s`, where the field names correspond to property names and the field values correspond to the current value of the respective property.

`out = instrfindall(objs,'P1',V1,...)` restricts the search for objects with matching property name/value pairs to the instrument objects and device group objects listed in `objs`.

Note that you can use string property name/property value pairs, structures, and cell array property name/property value pairs in the same call to `instrfindall`.

Remarks `instrfindall` differs from `instrfind` in that it finds objects whose `ObjectVisibility` property is set to `off`.

Property values are case sensitive. You must specify property values using the same format as that returned by the `get` function. For example, if `get` returns the `Name` property value as `MyObject`, `instrfindall` will not find an object with a `Name` property value of `myobject`. However, this is not the case for properties that have a finite set of string values.

For example, `instrfindall` will find an object with a `Parity` property value of `Even` or `even`. You can use the `propinfo` function to determine if a property has a finite set of string values.

Examples Suppose you create the following instrument objects.

```
s1 = serial('COM1');
s2 = serial('COM2');
g1 = gpib('keithley',0,2);
set(g1,'ObjectVisibility','off')
```

Because object `g1` has its `ObjectVisibility` set to off, it is not visible to commands like `instrfind`:

```
instrfind

 Instrument Object Array
 Index:  Type:          Status:      Name:
 1       serial         closed       Serial-COM1
 2       serial         closed       Serial-COM2
```

However, `instrfindall` finds all objects regardless of the value of ObjectVisibility:

```
instrfindall

 Instrument Object Array
 Index:   Type:          Status:       Name:
 1        serial         closed        Serial-COM1
 2        serial         closed        Serial-COM2
 3        gpib           closed        GPIB0-2
```

The following statements use `instrfindall` to return objects with specific property settings, which are passed as cell arrays:

```
props = {'PrimaryAddress','SecondaryAddress'};
vals = {2,0};
obj = instrfindall(props,vals);
```

You can use `instrfindall` as an argument when you want to apply the command to all objects, visible and invisible. For example, the following statement makes all objects visible:

```
set(instrfindall,'ObjectVisibility','on')
```

See Also   **Functions**

`instrfind`, `propinfo`

Properties

`ObjectVisibility`

Purpose	Help for instrument object type, function, or property

Syntax

```
instrhelp
instrhelp('name')
out = instrhelp('name')
instrhelp(obj)
instrhelp(obj,'name')
out = instrhelp(obj,'name')
```

Arguments

`'name'`	A function name, property name, or instrument object type.
obj	An instrument object.
out	The help text.

Description instrhelp returns a complete listing of toolbox functions, with a brief description of each.

instrhelp('*name*') returns help for the function, property, or instrument object type specified by *name*.

You can return specific instrument object information by specifying *name* in the form object/function or object.property. For example, to return the help for a serial port object's fprintf function, *name* would be serial/fprintf. To return the help for a serial port object's Parity property, *name* would be serial.parity.

out = instrhelp('*name*') returns the help text to out.

instrhelp(obj) returns a complete listing of functions and properties for obj, with a brief description of each. Help for the constructor is also returned.

instrhelp(obj,'*name*') returns help for the function or property specified by *name* associated with obj.

out = instrhelp(obj,'*name*') returns the help text to out.

instrhelp

Remarks When returning property help, the names in the See Also section that contain all uppercase letters are function names. The names that contain a mixture of upper and lowercase letters are property names. When returning function help, the See Also section contains only function names.

You can also display help via the Workspace browser by right-clicking an instrument object, and selecting **Instrument Help** from the context menu.

Examples The following commands illustrate some of the ways you can get function and property help without creating an instrument object.

```
instrhelp gpib
out = instrhelp('gpib.m');
instrhelp set
instrhelp('gpib/set')
instrhelp EOSCharCode
instrhelp('gpib.eoscharcode')
```

The following commands illustrate some of the ways you can get function and property help for an existing instrument object.

```
g = gpib('ni',0,1);
instrhelp(g)
instrhelp(g,'EOSMode');
out = instrhelp(g,'trigger');
```

See Also **Functions**

propinfo

Purpose   Information about available hardware

Syntax
```
out = instrhwinfo
out = instrhwinfo('interface')
out = instrhwinfo('drivertype')
out = instrhwinfo('interface','adaptor')
out = instrhwinfo('drivertype','drivername')
out = instrhwinfo('ivi','LogicalName')
out = instrhwinfo('interface','adaptor','type')
out = instrhwinfo(obj)
out = instrhwinfo(obj,'FieldName')
```

Arguments

'*interface*'	A supported instrument interface.
'*drivertype*'	Instrument driver type, may be matlab or vxipnp.
'*adaptor*'	A supported GPIB or VISA adaptor.
'drivername'	Name of VXI*plug&play* or MATLAB instrument driver.
'LogicalName'	IVI logical name value.
'*type*'	Type of VISA interface.
obj	An instrument object or array of instrument objects.
'FieldName'	A field name or cell array of field names associated with obj.
out	A structure or array containing hardware information.

Description   out = instrhwinfo returns hardware information to the structure out. This information includes the toolbox version, MATLAB version, and supported interfaces.

out = instrhwinfo('*interface*') returns information related to the interface specified by *interface*. *interface* can be serial, gpib,

tcpip, udp, or visa. For the GPIB and VISA interfaces, the information includes the installed adaptors. For the serial port interface, the information includes the available ports and the object constructor name. For the TCP/IP and UDP interfaces, the information includes the local host address.

out = instrhwinfo('*drivertype*') returns a structure, out, which contains information related to the specified driver type, *drivertype*. *drivertype* can be matlab, vxipnp, or ivi. If *drivertype* is matlab, this information includes the MATLAB instrument drivers found on the MATLAB path. If *drivertype* is vxipnp, this information includes the found VXI*plug&play* drivers. If *drivertype* is ivi, this information includes the available logical names and information on the IVI configuration store.

out = instrhwinfo('*interface*','*adaptor*') returns information related to the adaptor specified by *adaptor*, and for the interface specified by *interface*. *interface* can be gpib or visa. The returned information includes the adaptor version and available hardware. The GPIB adaptors are advantech, agilent, cec, contec, ics, iotech, keithley, mcc, and ni. The VISA adaptors are agilent, ni, and tek.

out = instrhwinfo('*drivertype*','drivername') returns a structure, out, which contains information related to the specified driver, drivername, for the specified *drivertype*. *drivertype* can be set to matlab, or vxipnp. The available drivername values are returned by out = instrhwinfo('*drivertype*').

out = instrhwinfo('**ivi**','LogicalName') returns a structure, out, which contains information related to the specified logical name, LogicalName. The available logical name values are returned by instrhwinfo('ivi').

out = instrhwinfo('*interface*','*adaptor*','*type*') returns a structure, out, which contains information on the specified type, *type*. *interface* can only be visa. *adaptor* can be agilent, ni, or tek. *type* can be gpib, vxi, gpib-vxi, serial, or rsib.

out = instrhwinfo(obj) returns information on the adaptor and vendor-supplied DLL associated with the VISA or GPIB object obj. If

obj is a serial port, TCPIP, or UDP object, then JAR file information is returned. If obj is an array of instrument objects, then out is a 1-by-n cell array of structures where n is the length of obj.

out = instrhwinfo(obj,'FieldName') returns hardware information for the field name specified by FieldName. FieldName can be a single string or a cell array of strings. out is an m-by-n cell array where m is the length of obj and n is the length of FieldName. You can return the supported values for FieldName using the instrhwinfo(obj) syntax.

Remarks   You can also display hardware information via the Workspace browser by right-clicking an instrument object, and selecting **Display Hardware Info** from the context menu.

Examples   The following commands illustrate some of the ways you can get hardware-related information without creating an instrument object.

```
out1 = instrhwinfo;
out2 = instrhwinfo('serial');
out3 = instrhwinfo('gpib','ni');
out4 = instrhwinfo('visa','agilent');
```

The following commands illustrate some of the ways you can get hardware-related information for an existing instrument object.

```
vs = visa('agilent','ASRL1::INSTR');
out5 = instrhwinfo(vs)
out5 =
              AdaptorDllName: [1x67 char]
           AdaptorDllVersion: 'Version 1.2 (R13)'
                 AdaptorName: 'AGILENT'
     VendorDriverDescription: 'Agilent Technologies VISA Driver'
         VendorDriverVersion: '1.1000'

vsdll = instrhwinfo(vs,'AdaptorDllName')
vsdll = D:\V6\toolbox\instrument\instrumentadaptors\win32\
mwagilentvisa.dll
```

instrid

Purpose	Define and retrieve commands that identify instruments

Syntax

```
instrid
instrid('cmd')
out = instrid(...)
```

Arguments

cmd	The instrument identification command.
out	The list of commands used to locate and identify instruments.

Description

instrid returns the currently defined instrument identification commands.

instrid('cmd') defines the instruments identification commands to be the string cmd. Note that you can also specify a cell array of commands.

out = instrid(...) returns the instrument identification commands to out.

Remarks

The Instrument Control Toolbox instrhwinfo and tmtool functions use the instrument identification commands as defined by instrid when locating and identifying instruments.

By default, the Instrument Control Toolbox uses the command *IDN?, which identifies most instruments. However, some instruments respond to different identification commands such as *ID? or *IDEN?.

If instrhwinfo or tmtool does not identify a known instrument, use instrid to specify the identification commands the instrument will respond to. If instrid returns no commands, an instrument cannot be found.

Examples

Set the identification command to *ID?.

```
instrid('*ID?')
```

Specify three new identification commands using a cell array.

```
instrid({'*IDN?','*ID?','IDEN?'})
```

Assign a list of current identification commands to an output variable.

```
id_commands = instrid;
```

See Also   instrhwinfo, tmtool

instrnotify

Purpose	Define notification for instrument events

Syntax

```
instrnotify('Type', callback)
instrnotify({'P1', 'P2', ...}, 'Type', callback)
instrnotify(obj, 'Type', callback)
instrnotify(obj, {'P1', 'P2', ...}, 'Type', callback)
instrnotify('Type', callback, '-remove')
instrnotify(obj, 'Type', callback, '-remove')
```

Arguments

`'Type'`	The type of event: `ObjectCreated`, `ObjectDeleted`, or `PropertyChangedPostSet`
`callback`	Function handle, string, or cell array to evaluate.
`'P1', P2', ...`	Any number of object property names.
`obj`	Instrument object or device group object.
`'-remove'`	Argument to remove specified callback.

Description instrnotify('*Type*', callback) evaluates the MATLAB expression, callback, in the MATLAB workspace when an event of type *Type* is generated. *Type* can be ObjectCreated, ObjectDeleted, or PropertyChangedPostSet.

If *Type* is ObjectCreated, callback is evaluated each time an instrument object or a device group object is created. If *Type* is ObjectDeleted, callback is evaluated each time an instrument object or a device group object is deleted. If *Type* is PropertyChangedPostSet, callback is evaluated each time an instrument object or device group object property is configured with set.

callback can be

- A function handle

- A string to be evaluated

- A cell array containing the function to evaluate in the first cell (function handle or name of function) and extra arguments to pass to the function in subsequent cells

The callback function is invoked with

```
function(obj, event, [arg1, arg2,...])
```

where obj is the instrument object or device group object generating the event. event is a structure containing information on the event generated. If *Type* is ObjectCreated or ObjectDeleted, event contains the type of event. If *Type* is PropertyChangedPostSet, event contains the type of event, the property being configured, and the new property value.

instrnotify({'*P1*', '*P2*', ...}, '*Type*', callback) evaluates the MATLAB expression, callback, in the MATLAB workspace when any of the specified properties, *P1*, *P2*, ... are configured. *Type* can be only PropertyChangedPostSet.

instrnotify(obj, '*Type*', callback) evaluates the MATLAB expression, callback, in the MATLAB workspace when an event of type *Type* for object obj, is generated. obj can be an array of instrument objects or device group objects.

instrnotify(obj, {'*P1*', '*P2*', ...}, '*Type*', callback) evaluates the MATLAB expression, callback, in the MATLAB workspace when any of the specified properties, *P1*, *P2*, are configured on object obj.

instrnotify('*Type*', callback, '**-remove**') removes the specified callback of type *Type*.

instrnotify(obj, '*Type*', callback, '**-remove**') removes the specified callback of type *Type* for object obj.

Remarks   PropertyChangedPostSet events are generated only when the property is configured to a different value than what the property is currently configured to. For example, if a GPIB object's Tag property is configured to 'myobject', a PropertyChangedPostSet event will not

be generated if the object's `Tag` property is currently set to `'myobject'`. A `PropertyChangedPostSet` event will be generated if the object's `Tag` property is set to `'myGPIBObject'`.

If `obj` is specified and the callback *Type* is `ObjectCreated`, the callback will not be generated because `obj` has already been created.

If *Type* is `ObjectDeleted`, the invalid object `obj` is not passed as the first input argument to the `callback` function. Instead, an empty matrix is passed as the first input argument.

Examples

```
instrnotify('PropertyChangedPostSet', @instrcallback);
g = gpib('keithley', O, 5);
set(g, 'Name', 'mygpib');
fopen(g);
fclose(g);
instrnotify('PropertyChangedPostSet',@instrcallback,'-remove');
```

instrreset

Purpose	Disconnect and delete all instrument objects
Syntax	`instrreset`
Description	`instrreset` disconnects and deletes all instrument objects.
Remarks	If data is being written or read asynchronously, the asynchronous operation is stopped.
	`instrreset` is equivalent to issuing the `stopasync` (if needed), `fclose`, and `delete` functions for all instrument objects.
	When you delete an instrument object, it becomes *invalid*. Because you cannot connect an invalid object to the instrument, you should remove it from the workspace with the `clear` command.

See Also

Functions

`clear`, `delete`, `fclose`, `isvalid`, `stopasync`

invoke

Purpose	Execute driver-specific function on device object
Syntax	`out = invoke(obj,'name')` `out = invoke(obj,'name',arg1,arg2,...)`

Arguments

`obj`	A device object.
`name`	The function to execute.
`arg1,arg2,...`	Arguments passed to `name`.
`out`	The function output.

Description `out = invoke(obj,'name')` executes the function specified by `name` on the device object specified by `obj`. The function's output is returned to `out`.

`out = invoke(obj,'name',arg1,arg2,...)` passes the arguments `arg1,arg2,...` to the function specified by `name`.

Remarks To list the driver-specific functions supported by `obj`, type

```
methods(obj)
```

To display help for a specific function, type

```
instrhelp(obj,'name')
```

Examples Create a device object for a Tektronix TDS 210 oscilloscope that is connected to a National Instruments GPIB board.

```
g = gpib('ni',0,2);
d = icdevice('tektronix_tds210',g);
```

Perform a self-calibration for the oscilloscope by invoking the `calibrate` function.

```
out = invoke(d,'calibrate')
```

```
out =
    '0'
```

0 indicates that the self-calibration completed without any errors.

See Also

Functions

instrhelp, methods

Properties

Status

isvalid

Purpose	Determine whether instrument objects are valid
Syntax	`out = isvalid(obj)`

Arguments

`obj`	An instrument object or array of instrument objects.
`out`	A logical array.

Description `out = isvalid(obj)` returns the logical array `out`, which contains a 0 where the elements of `obj` are invalid instrument objects and a 1 where the elements of `obj` are valid instrument objects.

Remarks `obj` becomes invalid after it is removed from memory with the `delete` function. Because you cannot connect an invalid object to the instrument, you should remove it from the workspace with the `clear` command.

Examples Suppose you create the following two GPIB objects:

```
g1 = gpib('ni',0,1);
g2 = gpib('ni',0,2);
```

g2 becomes invalid after it is deleted.

```
delete(g2)
```

isvalid verifies that g1 is valid and g2 is invalid.

```
garray = [g1 g2];
isvalid(garray)
ans =
     1     0
```

See Also **Functions**

`clear`, `delete`

Purpose   Create IVI configuration store object

Syntax   obj = iviconfigurationstore
                obj = iviconfigurationstore('file')

Arguments   obj   IVI configuration store object

                'file'   Configuration store data file

Description   obj = iviconfigurationstore creates an IVI configuration store
                object and establishes a connection to the IVI Configuration Server. The
                data in the master configuration store is used.

                obj = iviconfigurationstore('file') creates an IVI configuration
                store object and establishes a connection to the IVI Configuration
                Server. The data in the configuration store, file, is used. If file
                cannot be found or is not a valid configuration store, an error occurs.

See Also   **Functions**

                iviconfigurationstore/add, iviconfigurationstore/commit,
                iviconfigurationstore/remove, iviconfigurationstore/update

length

Purpose	Length of instrument object array
Syntax	length(obj)
Arguments	obj An instrument object or an array of instrument objects.
Description	length(obj) returns the length of obj. It is equivalent to the command max(size(obj)).
See Also	**Functions** instrhelp, size

Purpose   Load instrument objects and variables into MATLAB workspace

Syntax
```
load filename
load filename obj1 obj2 ...
out = load('filename','obj1','obj2',...)
```

Arguments

filename	The MAT-file name.
obj1 obj2 ...	Instrument objects or arrays of instrument objects.
out	A structure containing the specified instrument objects.

Description   load filename returns all variables from the MAT-file specified by filename into the MATLAB workspace.

load filename obj1 obj2 ... returns the instrument objects specified by obj1 obj2... from the MAT-file filename into the MATLAB workspace.

out = load('filename','obj1','obj2',...) returns the specified instrument objects from the MAT-file filename as a structure to out instead of directly loading them into the workspace. The field names in out match the names of the loaded instrument objects.

Remarks   Values for read-only properties are restored to their default values upon loading. For example, the Status property is restored to closed. To determine if a property is read-only, examine its reference pages or use the propinfo function.

Examples   Suppose you create the GPIB objects g1 and g2, configure a few properties for g1, and connect both objects to their associated instruments.

```
g1 = gpib('ni',0,1);
g2 = gpib('ni',0,2);
```

load

```
set(g1,'EOSMode','read','EOSCharCode','CR')
fopen([g1 g2])
```

The read-only Status property is automatically configured to open.

```
get([g1 g2],'Status')
ans =
    'open'
    'open'
```

Save g1 and g2 to the file MyObject.mat, and then load the objects into the MATLAB workspace.

```
save MyObject g1 g2
load MyObject g1 g2
```

Values for read-only properties are restored to their default values upon loading, while all other property values are honored.

```
get([g1 g2],{'EOSMode','EOSCharCode','Status'})
ans =
    'read'      'CR'      'closed'
    'none'      'LF'      'closed'
```

See Also   Functions

instrhelp, propinfo, save

Purpose   Convert driver to MATLAB instrument driver format

Syntax
```
makemid('driver')
makemid('driver', 'filename')
makemid('driver', 'type')
makemid('driver', 'filename', 'type')
makemid('driver', 'type', 'interface')
makemid('driver', 'filename', 'type', 'interface')
```

Arguments

`'driver'`	Name of driver being converted.
`'filename'`	Name of file that the converted driver is saved to. You may specify a full pathname. If an extension is not specified, the `.mdd` extension is used.
`'type'`	The type of driver the function looks for. By default, the function searches among all types.
`'interface'`	The IVI-COM interface to be used.

Description   `makemid('driver')` searches through known driver types for `driver` and creates a MATLAB instrument driver representation of the driver. Known driver types include VXI*plug&play*, IVI-C, and IVI-COM. For `driver` you can use a `Module` (for IVI-C), a `ProgramID` (for IVI-COM), a `LogicalName` (for either IVI-C or IVI-COM), or the original VXI*plug&play* instrument driver name. The MATLAB instrument driver will be saved in the current working directory as `driver.mdd`

The MATLAB instrument driver can then be modified using `midedit` to customize the driver behavior, and may be used to instantiate a device object using `icdevice`.

`makemid('driver', 'filename')` creates and saves the MATLAB instrument driver using the name and path specified by `filename`.

`makemid('driver', 'type')` and `makemid('driver', 'filename', 'type')` override the default search order and look only for drivers whose type is `type`. Valid types are `vxiplug&play`, `ivi-c`, and `ivi-com`.

makemid

makemid('driver', '*type*', 'interface') and makemid('driver', 'filename', '*type*', 'interface') specify the IVI-COM driver interface to be used for the object. *type* must be ivi-com.

The function searches for the specified driver root interface. For example, if the driver supports the IIviScope interface, an interface value of IIviScope results in a device object that only contains the IVIScope class-compliant properties and methods.

Examples   To convert the driver hp34401 into the MATLAB instrument driver hp34401.mdd in the current working directory,

```
makemid('hp34401');
```

To convert the driver tktds5k into the MATLAB instrument driver with a specific name and location,

```
makemid('tktds5k', 'C:\MyDrivers\tektronix_5k.mdd');
```

To convert the IVI-C driver tktds5k into the MATLAB instrument driver tktds5k.mdd in the current working directory. This example causes the function to look for the driver only among the IVI-C drivers.

```
makemid('tktds5k', 'ivi-c');
```

To create the MATLAB instrument driver MyIviLogicalName.mdd from the IVI logical name MyIviLogicalName,

```
makemid('MyIviLogicalName');
```

See Also   **Functions**

icdevice, midedit

memmap

Purpose	Map memory for low-level memory read and write operations

Syntax

```
memmap(obj,'adrspace',offset,size)
```

Arguments

obj	A VISA-VXI or VISA-GPIB-VXI object.
'*adrspace*'	The memory address space.
offset	Offset for the memory address space.
size	Number of bytes to map.

Description memmap(obj,'*adrspace*',offset,size) maps the amount of memory specified by size in address space, *adrspace* with an offset, offset. You can configure *adrspace* to A16 (A16 address space), A24 (A24 address space), or A32 (A32 address space).

Remarks Before you can map memory, obj must be connected to the instrument with the fopen function. A connected interface object has a Status property value of open. An error is returned if you attempt to map memory while obj is not connected to the instrument.

To unmap the memory, use the memunmap function. If memory is mapped and fclose is called, the memory is unmapped before the object is disconnected from the instrument.

The MappedMemorySize property returns the size of the memory space mapped. You must map the memory space before using the mempoke or mempeek function.

Examples Create the VISA-VXI object vv associated with a VXI chassis with index 0, and an Agilent E1432A digitizer with logical address 130.

```
vv = visa('agilent','VXI0::130::INSTR');
fopen(vv)
```

memmap

Use memmap to map 16 bytes in the A16 address space.

```
memmap(vv,'A16',0,16)
```

Read the first and second instrument registers.

```
reg1 = mempeek(vv,0,'uint16');
reg2 = mempeek(vv,2,'uint16');
```

Unmap the memory and disconnect vv from the instrument.

```
memunmap(vv)
fclose(vv)
```

See Also

Functions

fopen, fclose, mempeek, mempoke, memunmap

Properties

MappedMemorySize, Status

Purpose

Low-level memory read from VXI register

Syntax

```
out = mempeek(obj,offset)
out = mempeek(obj,offset,'precision')
```

Arguments

obj	A VISA-VXI or VISA-GPIB-VXI object.
offset	The offset in the mapped memory space from which the data is read.
'precision'	The number of bits to read from the memory address.
out	An array containing the returned value.

Description

out = mempeek(obj,offset) reads a uint8 value from the mapped memory space specified by offset for the object obj. The value is returned to out.

out = mempeek(obj,offset,'precision') reads the number of bits specified by precision, from the mapped memory space specified by offset. precision can be uint8, uint16, or uint32, which instructs mempeek to read 8-, 16-, or 32-bit values, respectively. precision can also be single, which instructs mempeek to read single precision values.

Remarks

Before you can read from the VXI register, obj must be connected to the instrument with the fopen function. A connected interface object has a Status property value of open. An error is returned if you attempt a read operation while obj is not connected to the instrument.

You must map the memory space using the memmap function before using mempeek. The MappedMemorySize property returns the size of the memory space mapped.

offset indicates the offset in the mapped memory space from which the data is read. For example, if the mapped memory space begins at 200H, the offset is 2, and the precision is uint8, then the data is read

mempeek

from memory location 202H. If the precision is `uint16`, the data is read from 202H and 203H.

To increase speed, `mempeek` does not return error messages from the instrument.

Examples
Create the VISA-VXI object `vv` associated with a VXI chassis with index 0, and an Agilent E1432A digitizer with logical address 130.

```
vv = visa('agilent','VXI0::130::INSTR');
fopen(vv)
```

Use `memmap` to map 16 bytes in the A16 address space.

```
memmap(vv,'A16',0,16)
```

Perform a low-level read of the first and second instrument registers.

```
reg1 = mempeek(vv,0,'uint16')
reg1 =
      53247
reg2 = mempeek(vv,2,'uint16')
reg2 =
      20993
```

Unmap the memory and disconnect `vv` from the instrument.

```
memunmap(vv)
fclose(vv)
```

Refer to "Example: Using High-Level Memory Functions" on page 5-16 for a description of the first four registers of the E1432A digitizer.

See Also   **Functions**

fopen, memmap, mempoke, memunmap

Properties

MappedMemorySize, MemoryIncrement, Status

Purpose   Low-level memory write to VXI register

Syntax   mempoke(obj,data,offset)
                     mempoke(obj,data,offset,'precision')

Arguments
obj	A VISA-VXI or VISA-GPIB-VXI object.
data	The data written to the memory address.
offset	The offset in the mapped memory space to which the data is written.
'*precision*'	The number of bits to write to the memory address.

Description   mempoke(obj,data,offset) writes the uint8 value specified by data
                     to the mapped memory address specified by offset for the object obj.

                     mempoke(obj,data,offset,'precision') writes data using the
                     number of bits specified by *precision. precision* can be uint8,
                     uint16, or uint32, which instructs mempoke to write data as 8-, 16-,
                     or 32-bit values, respectively. *precision* can also be single, which
                     instructs mempoke to write data as single-precision values.

Remarks   Before you can write to the VXI register, obj must be connected to the
                     instrument with the fopen function. A connected interface object has a
                     Status property value of open. An error is returned if you attempt a
                     write operation while obj is not connected to the instrument.

                     You must map the memory space using the memmap function before
                     using mempoke. The MappedMemorySize property returns the size of
                     the memory space mapped.

                     offset indicates the offset in the mapped memory space to which the
                     data is written. For example, if the mapped memory space begins at
                     200H, the offset is 2, and the precision is uint8, then the data is written
                     to memory location 202H. If the precision is uint16, the data is written
                     to 202H and 203H.

mempoke

To increase speed, mempoke does not return error messages from the instrument.

Examples
Create the VISA-VXI object vv associated with a VXI chassis with index 0, and an Agilent E1432A digitizer with logical address 130.

```
vv = visa('agilent','VXI0::130::INSTR');
fopen(vv)
```

Use memmap to map 16 bytes in the A16 address space.

```
memmap(vv,'A16',0,16)
```

Perform a low-level write to the fourth instrument register, which has an offset of 6.

```
mempoke(vv,45056,6,'uint16')
```

Unmap the memory and disconnect vv from the instrument.

```
memunmap(vv)
fclose(vv)
```

Refer to "Example: Using High-Level Memory Functions" on page 5-16 for a description of the first four registers of the E1432A digitizer.

See Also **Functions**

fopen, memmap, mempeek

Properties

MappedMemorySize, MemoryIncrement, Status

Purpose   High-level memory read from VXI register

Syntax
```
out = memread(obj)
out = memread(obj,offset)
out = memread(obj,offset,'precision')
out = memread(obj,offset,'precision','adrspace')
out = memread(obj,offset,'precision','adrspace',size)
```

Arguments

obj	A VISA-VXI or VISA-GPIB-VXI object.
offset	Offset for the memory address space.
'*precision*'	The number of bits to read from the memory address.
'*adrspace*'	The memory address space.
offset	Offset for the memory address space.
size	The size of the data block to read.
out	An array containing the returned value.

Description   out = memread(obj) reads a uint8 value from the A16 address space with an offset of 0 for the object obj.

out = memread(obj,offset) reads a uint8 value from the A16 address space with an offset specified by offset. You must specify offset as a decimal value.

out = memread(obj,offset,'*precision*') reads the number of bits specified by *precision* from the A16 address space. *precision* can be uint8, uint16, or uint32, which instructs memread to read 8-, 16-, or 32-bit values, respectively. *precision* can also be single, which instructs memread to read single-precision values.

out = memread(obj,offset,'*precision*','*adrspace*') reads the specified number of bits from the address space specified by *adrspace*. *adrspace* can be A16, A24, or A32. The MemorySpace property indicates which VXI address spaces are used by the instrument.

out = memread(obj,offset,'*precision*','*adrspace*',size) reads a block of data with a size specified by size.

Remarks   Before you can read data from the VXI register, obj must be connected to the instrument with the fopen function. A connected interface object has a Status property value of open. An error is returned if you attempt to read memory while obj is not connected to the instrument.

Examples   Create the VISA-VXI object vv associated with a VXI chassis with index 0, and an Agilent E1432A digitizer with logical address 130.

```
vv = visa('agilent','VXI0::130::INSTR');
fopen(vv)
```

Perform a high-level read of the first instrument register.

```
reg1 = memread(vv,0,'uint16')
reg1 =
      53247
```

Perform a high-level read of the next three instrument registers.

```
reg24 = memread(vv,2,'uint16','A16',3)
reg24 =
      20993
      50012
      40960
```

Disconnect vv from the instrument.

```
fclose(vv)
```

Refer to "Example: Using High-Level Memory Functions" on page 5-16 for a description of the first four registers of the E1432A digitizer.

See Also   **Functions**

fopen, mempeek, memwrite

Properties

`MemoryIncrement, MemorySpace, Status`

memunmap

Purpose	Unmap memory for low-level memory read and write operations

Syntax

```
memunmap(obj)
```

Arguments

obj	A VISA-VXI or VISA-GPIB-VXI object.

Description

memunmap(obj) unmaps memory space previously mapped by the memmap function.

Remarks

When the memory space is unmapped, the MappedMemorySize property is set to 0 and the MappedMemoryBase property is set to 0H.

Examples

Create the VISA-VXI object vv associated with a VXI chassis with index 0, and an Agilent E1432A digitizer with logical address 130.

```
vv = visa('agilent','VXI0::130::INSTR');
fopen(vv)
```

Map 16 bytes in the A16 address space.

```
memmap(vv,'A16',0,16)
```

Read the first and second instrument registers.

```
reg1 = mempeek(vv,0,'uint16');
reg2 = mempeek(vv,2,'uint16');
```

Use memunmap to unmap the memory, and disconnect vv from the instrument.

```
memunmap(vv)
fclose(vv)
```

See Also

Functions

memmap, mempeek, mempoke

Properties

`MappedMemoryBase, MappedMemorySize`

memwrite

Purpose	High-level memory write to VXI register

Syntax

```
memwrite(obj,data)
memwrite(obj,data,offset)
memwrite(obj,data,offset,'precision')
memwrite(obj,data,offset,'precision','adrspace')
```

Arguments

obj	A VISA-VXI or VISA-GPIB-VXI object.
data	The data written to the memory address.
offset	Offset for the memory address space.
'*precision*'	The number of bits to write to the memory address.
'*adrspace*'	The memory address space.

Description memwrite(obj,data) writes the uint8 value specified by data to the A16 address space with an offset of 0 for the object obj. data can be an array of uint8 values.

memwrite(obj,data,offset) writes data to the A16 address space with an offset specified by offset. offset is specified as a decimal value.

memwrite(obj,data,offset,'*precision*') writes data with precision specified by *precision*. *precision* can be uint8, uint16, or uint32, which instructs memwrite to write data as 8-, 16-, or 32-bit values, respectively. *precision* can also be single, which instructs memwrite to write data as single-precision values.

memwrite(obj,data,offset,'*precision*','*adrspace*') writes data to the address space specified by *adrspace*. *adrspace* can be A16, A24, or A32. The MemorySpace property indicates which VXI address spaces are used by the instrument.

Remarks Before you can write to the VXI register, obj must be connected to the instrument with the fopen function. A connected interface object has a

Status property value of open. An error is returned if you attempt a write operation while obj is not connected to the instrument.

Examples Create the VISA-VXI object vv associated with a VXI chassis with index 0, and an Agilent E1432A digitizer with logical address 130.

```
vv = visa('agilent','VXI0::130::INSTR');
fopen(vv)
```

Perform a high-level write to the fourth instrument register, which has an offset of 6.

```
memwrite(vv,45056,6,'uint16','A16')
```

Disconnect vv from the instrument.

```
fclose(vv)
```

Refer to "Example: Using High-Level Memory Functions" on page 5-16 for a description of the first four registers of the E1432A digitizer.

See Also **Functions**

fopen, memread, mempoke

Properties

MemoryIncrement, MemorySpace, Status

methods

Purpose	Class method names and descriptions

Syntax

```
m = methods('classname')
m = methods(object)
m = methods(...,'-full')
```

Arguments

m	Cell array of strings
'classname'	Class whose methods are returned
object	An instrument object or device group object
'-full'	Request to return full descriptions of methods

Description

m = methods('classname') returns, in a cell array of strings, the names of all methods for the class with the name classname.

m = methods(object) returns the names of all methods for the class of which object is an instance.

m = methods(...,'-full') returns full descriptions of the methods in the class, including inheritance information and, for Java methods, also attributes and signatures. Duplicate method names with different signatures are not removed. If classname represents a MATLAB class, then inheritance information is returned only if that class has been instantiated.

Remarks

methods differs from what in that the methods from all method directories are reported together, and methods removes all duplicate method names from the result list. methods will also return the methods for a Java class.

See Also

Functions

methodsview, what, which, help

Purpose   Open graphical tool for creating and editing MATLAB instrument driver

Syntax   ```
midedit
midedit('driver')
```

Arguments   `'driver'`   The name of a MATLAB instrument driver.

Description   `midedit` opens the MATLAB Instrument Driver Editor, which is a graphical tool for creating and editing instrument drivers.

`midedit('driver')` opens the MATLAB Instrument Driver Editor for the specified instrument driver. The default extension for driver is .mdd. Note that driver can include a relative partial pathname.

The editor consists of two main parts: the navigation pane and the detail pane. The navigation pane lists the driver-specific properties and functions in a tree view, while the detail pane allows you to configure and document the properties and functions.

`midedit` may also be used to import VXI*plug&play* or IVI drivers. With `midedit` open, select **Import** from the **File** menu. The import process creates a new MATLAB Instrument Driver based on the VXI*plug&play* or IVI driver. This allows you to customize the behavior of device objects that use the VXI*plug&play* or IVI driver.

For details and examples on the MATLAB Instrument Driver Editor, see Chapter 14, "The Instrument Driver Editor".

See Also   `icdevice`, `makemid`, `midtest`, `tmtool`

midtest

Purpose	Open graphical tool for testing MATLAB instrument driver
Syntax	midtest midtest('file')
Arguments	'file' File containing the test to be used by the MATLAB Instrument Driver Testing Tool

Description   midtest opens the MATLAB Instrument Driver Testing Tool. The MATLAB Instrument Driver Testing Tool provides a graphical environment for creating a test to verify the functionality of a MATLAB instrument driver.

The MATLAB Instrument Driver Testing Tool provides a way to

- Verify property behavior
- Verify function behavior
- Save the test as MATLAB code
- Export the test results to MATLAB workspace, figure window, MAT-file, or the MATLAB array editor
- Save test results as an HTML page

midtest('file') opens the MATLAB Instrument Driver Testing Tool with the test loaded from file.

For a full description of the tool with examples, see Chapter 15, "The Instrument Driver Testing Tool".

Examples   midtest('test.xml')

opens the MATLAB Instrument Driver Testing Tool with the test test.xml loaded.

See Also   icdevice, makemid, midedit, tmtool

obj2mfile

Purpose Convert instrument object to MATLAB code

Syntax
```
obj2mfile(obj,'filename')
obj2mfile(obj,'filename','syntax')
obj2mfile(obj,'filename','mode')
obj2mfile(obj,'filename','syntax','mode')
obj2mfile(obj,'filename','reuse')
obj2mfile(obj,'filename','syntax','mode','reuse')
```

Arguments

obj	An instrument object or an array of instrument objects.
'filename'	The name of the file that the MATLAB code is written to. You can specify the full pathname. If an extension is not specified, the .m extension is used.
'syntax'	Syntax of the converted MATLAB code. By default, the set syntax is used. If dot is specified, then the dot notation is used.
'mode'	Specifies whether all properties are converted to code, or only modified properties are converted to code.
'reuse'	Specifies whether existing object is reused or new object is created.

Description obj2mfile(obj,'filename') converts obj to the equivalent MATLAB code using the set syntax and saves the code to filename. Only those properties not set to their default value are saved.

obj2mfile(obj,'filename','syntax') converts obj to the equivalent MATLAB code using the syntax specified by syntax. You can specify syntax to be set or dot. set uses the set syntax, while dot uses the dot notation.

obj2mfile(obj,'filename','mode') converts the properties specified by mode. You can specify mode to be all or modified. If mode is all,

then all properties are converted to code. If *mode* is modified, then only those properties not set to their default value are converted to code.

`obj2mfile(obj,'filename','`*`syntax`*`','`*`mode`*`')` converts the specified properties to code using the specified syntax.

`obj2mfile(obj,'filename','`*`reuse`*`')`

`obj2mfile(obj,'filename','`*`syntax`*`','`*`mode`*`','`*`reuse`*`')` check for an existing instrument object, obj, before creating obj. If *reuse* is reuse, the object is used if it exists, otherwise the object is created. If *reuse* is create, the object is always created. By default, *reuse* is reuse.

An object will be reused if the existing object has the same constructor arguments as the object about to be created, and if their Type and Tag property values are the same.

Remarks   You can recreate a saved instrument object by typing the name of the M-file at the MATLAB command line.

If the UserData property is not empty or if any of the callback properties are set to a cell array of values or a function handle, then the data stored in those properties is written to a MAT-file when the instrument object is converted and saved. The MAT-file has the same name as the M-file containing the instrument object code (see the example below).

Read-only properties are restored with their default values. For example, suppose an instrument object is saved with a Status property value of open. When the object is recreated, Status is set to its default value of closed.

Examples   Suppose you create the GPIB object g, and configure several property values.

```
g = gpib('ni',0,1);
set(g,'Tag','MyGPIB object','EOSMode','read','EOSCharCode','CR')
set(g,'UserData',{'test',2,magic(10)})
```

The following command writes MATLAB code to the files `MyGPIB.m` and `MyGPIB.mat`.

```
obj2mfile(g,'MyGPIB.m','dot')
```

`MyGPIB.m` contains code that recreates the commands shown above using the dot notation for all properties that have their default values changed. Because `UserData` is set to a cell array of values, this property appears in `MyGPIB.m` as

```
obj1.UserData = userdata1;
```

It is saved in `MyGPIB.mat` as

```
userdata = {'test', 2, magic(10)};
```

To recreate `g` in the MATLAB workspace using a new variable, `gnew`,

```
gnew = MyGPIB;
```

The associated MAT-file, `MyGPIB.mat`, is automatically run and `UserData` is assigned the appropriate values.

```
gnew.UserData
ans =
    'test'    [2]    [10x10 double]
```

See Also   **Functions**

propinfo

propinfo

Purpose	Instrument object property information

Syntax

```
out = propinfo(obj)
out = propinfo(obj,'PropertyName')
```

Arguments

obj	An instrument object.
'*PropertyName*'	A property name or cell array of property names.
out	A structure containing property information.

Description

out = propinfo(obj) returns the structure out with field names given by the property names for obj. Each property name in out contains the fields shown below.

Field Name	Description
Type	The property data type. Possible values are any, ASCII value, callback, instrument range value, double, string, and struct.
Constraint	The type of constraint on the property value. Possible values are ASCII value, bounded, callback, instrument range value, enum, and none.
ConstraintValue	Property value constraint. The constraint can be a range of valid values or a list of valid string values.
DefaultValue	The property default value.
ReadOnly	The condition under which a property is read-only. Possible values are always, never, whileOpen, and whileRecording.
Interface Specific	If the property is interface-specific, a 1 is returned. If a 0 is returned, the property is supported for all interfaces.

out = propinfo(obj,'*PropertyName*') returns the structure out for the property specified by *PropertyName*. The field names of out are given in the table shown above. If *PropertyName* is a cell array of property names, a cell array of structures is returned for each property.

Remarks   You can get help for instrument object properties with the instrhelp function.

You can display all instrument object property names and their current values using the get function. You can display all configurable properties and their possible values using the set function.

When specifying property names, you can do so without regard to case, and you can make use of property name completion. For example, if g is a GPIB object, then the following commands are all valid.

```
out = propinfo(g,'EOSMode');
out = propinfo(g,'eosmode');
out = propinfo(g,'EOSM');
```

Examples   To return all property information for the GPIB object g,

```
g = gpib('ni',0,1);
out = propinfo(g);
```

To display all the property information for the InputBufferSize property,

```
out.InputBufferSize
ans =
                Type: 'double'
          Constraint: 'none'
     ConstraintValue: ''
        DefaultValue: 512
            ReadOnly: 'whileOpen'
   InterfaceSpecific: 0
```

propinfo

To display the default value for the EOSMode property,

```
out.EOSMode.DefaultValue
ans =
none
```

See Also   **Functions**

get, instrhelp, set

Purpose   Write text to instrument, and read data from instrument

Syntax
```
out = query(obj,'cmd')
out = query(obj,'cmd','wformat')
out = query(obj,'cmd','wformat','rformat')
[out,count] = query(...)
[out,count,msg] = query(...)
[out,count,msg,datagramaddress,datagramport] = query(...)
```

Arguments

obj	An interface object.
'cmd'	String that is written to the instrument.
'*wformat*'	Format for written data.
'*rformat*'	Format for read data.
out	Contains data read from the instrument.
count	The number of values read.
msg	A message indicating if the read operation was unsuccessful.
datagramaddress	The datagram address.
datagramport	The datagram port.

Description   out = query(obj,'cmd') writes the string cmd to the instrument connected to obj. The data read from the instrument is returned to out. By default, the %s\n format is used for cmd, and the %c format is used for the returned data.

out = query(obj,'cmd','*wformat*') writes the string cmd using the format specified by *wformat*.

wformat is a C language conversion specification. Conversion specifications involve the % character and the conversion characters d, i, o, u, x, X, f, e, E, g, G, c, and s. Refer to the sprintf file I/O format specifications or a C manual for more information.

query

out = query(obj,'cmd','*wformat*','*rformat*') writes the string cmd using the format specified by *wformat*. The data read from the instrument is returned to out using the format specified by *rformat*.

rformat is a C language conversion specification. The supported conversion specifications are identical to those supported by *wformat*.

[out,count] = query(...) returns the number of values read to count.

[out,count,msg] = query(...) returns a warning message to msg if the read operation did not complete successfully.

[out,count,msg,datagramaddress,datagramport] = query(...) returns the remote address and port from which the datagram originated. These values are returned only when using a UDP object.

Remarks   Before you can write or read data, obj must be connected to the instrument with the fopen function. A connected interface object has a Status property value of open. An error is returned if you attempt to perform a query operation while obj is not connected to the instrument.

query operates only in synchronous mode, and blocks the command line until the write and read operations complete execution.

Using query is equivalent to using the fprintf and fgets functions. The rules for completing a write operation are described in the fprintf reference pages. The rules for completing a read operation are described in the fgets reference pages.

Examples   This example creates the GPIB object g, connects g to a Tektronix TDS 210 oscilloscope, writes and reads text data using query, and then disconnects g from the instrument.

```
g = gpib('ni',0,1);
fopen(g)
idn = query(g,'*IDN?')
idn =
TEKTRONIX,TDS 210,0,CF:91.1CT FV:v1.16 TDS2CM:CMV:v1.04
fclose(g)
```

See Also

Functions

`fopen, fprintf, fgets, sprintf`

Properties

`Status`

readasync

Purpose	Read data asynchronously from instrument

Syntax

```
readasync(obj)
readasync(obj,size)
```

Arguments

obj	An interface object.
size	The number of bytes to read from the instrument.

Description

readasync(obj) initiates an asynchronous read operation.

readasync(obj,size) asynchronously reads, at most, the number of bytes specified by size. If size is greater than the difference between the InputBufferSize property value and the BytesAvailable property value, an error is returned.

Remarks

Before you can read data, you must connect obj to the instrument with the fopen function. A connected interface object has a Status property value of open. An error is returned if you attempt to perform a read operation while obj is not connected to the instrument.

For serial port, TCPIP, UDP, and VISA-serial objects, you should use readasync only when you configure the ReadAsyncMode property to manual. readasync is ignored if used when ReadAsyncMode is continuous.

The TransferStatus property indicates if an asynchronous read or write operation is in progress. For all interface objects, you cannot use readasync while a read operation is in progress. For serial port and VISA-serial objects, you can write data while an asynchronous read is in progress because serial ports have separate read and write pins. You can stop asynchronous read and write operations with the stopasync function.

You can monitor the amount of data stored in the input buffer with the BytesAvailable property. Additionally, you can use the

`BytesAvailableFcn` property to execute an M-file callback function when the terminator or the specified amount of data is read.

Rules for Completing an Asynchronous Read Operation

An asynchronous read operation with `readasync` completes when one of these conditions is met:

- The terminator is read. For serial port, TCPIP, UDP, and VISA-serial objects, the terminator is given by the `Terminator` property. Note that for UDP objects, `DatagramTerminateMode` must be `off`.

  For all other interface objects except VISA-RSIB, the terminator is given by the `EOSCharCode` property.

- The time specified by the `Timeout` property passes.

- The specified number of bytes is read.

- The input buffer is filled.

- A datagram has been received (UDP objects only if `DatagramTerminateMode` is `on`)

- The EOI line is asserted (GPIB and VXI instruments only).

For serial port, TCPIP, UDP, and VISA-serial objects, `readasync` can be slow because it checks for the terminator. To increase speed, you might want to configure `ReadAsyncMode` to `continuous` and continuously return data to the input buffer as soon as it is available from the instrument.

Examples   This example creates the serial port object s, connects s to a Tektronix TDS 210 oscilloscope, configures s to read data asynchronously only if `readasync` is issued, and configures the instrument to return the peak-to-peak value of the signal on channel 1.

```
s = serial('COM1');
fopen(s)
s.ReadAsyncMode = 'manual';
fprintf(s,'Measurement:Meas1:Source CH1')
```

```
fprintf(s,'Measurement:Meas1:Type Pk2Pk')
fprintf(s,'Measurement:Meas1:Value?')
```

Initially, there is no data in the input buffer.

```
s.BytesAvailable
ans =
     0
```

Begin reading data asynchronously from the instrument using readasync. When the read operation is complete, return the data to the MATLAB workspace using fscanf.

```
readasync(s)
s.BytesAvailable
ans =
     15
out = fscanf(s)
out =
2.0399999619E0
fclose(s)
```

See Also   **Functions**

fopen, stopasync

Properties

BytesAvailable, BytesAvailableFcn, ReadAsyncMode, Status, TransferStatus

Purpose	Record data and event information to file
Syntax	record(obj) record(obj,'*switch*')

Arguments

obj	An instrument object.
'*switch*'	Switch recording capabilities on or off.

Description   record(obj) toggles the recording state for obj.

record(obj,'*switch*') initiates or terminates recording for obj. *switch* can be on or off. If *switch* is on, recording is initiated. If *switch* is off, recording is terminated.

Remarks   Before you can record information to disk, obj must be connected to the instrument with the fopen function. A connected instrument object has a Status property value of open. An error is returned if you attempt to record information while obj is not connected to the instrument. Each instrument object must record information to a separate file. Recording is automatically terminated when obj is disconnected from the instrument with fclose.

The RecordName and RecordMode properties are read-only while obj is recording, and must be configured before using record.

For a detailed description of the record file format and the properties associated with recording data and event information to a file, refer to "Debugging: Recording Information to Disk" on page 12-6.

Examples   This example creates the GPIB object g, connects g to the instrument, and configures g to record detailed information to the disk file MyGPIBFile.txt.

```
g = gpib('ni',0,1);
fopen(g)
g.RecordDetail = 'verbose';
```

record

```
    g.RecordName = 'MyGPIBFile.txt';
```

Initiate recording, write the *IDN? command to the instrument, and
read back the identification information.

```
    record(g,'on')
    fprintf(g,'*IDN?')
    out = fscanf(g);
```

Terminate recording and disconnect g from the instrument.

```
    record(g,'off')
    fclose(g)
```

See Also   **Functions**

fclose, fopen, propinfo

Properties

RecordMode, RecordName, RecordStatus, Status

Purpose	Remove entry from IVI configuration store object

Syntax
```
remove(obj, 'type', 'name')
remove(obj, struct)
```

Arguments

obj	IVI configuration store object
'*type*'	Type of entry being removed; *type* can be DriverSession, HardwareAsset, or LogicalName
'name'	Name of the DriverSession, HardwareAsset, or LogicalName to be removed
struct	Structure defining entries to be removed

Description remove(obj, '*type*', 'name') removes an entry of type, *type*, with name, name, from the IVI configuration store object, obj. *type* can be HardwareAsset, DriverSession, or LogicalName. If an entry of type, *type*, with name, name, does not exist, an error will occur.

remove(obj, struct) removes an entry using the fields in struct. If an entry with the *type* and name field in struct does not exist, an error will occur.

The modified configuration store object, obj, can be saved to the configuration store data file with the commit function.

If you attempt to remove an entry that is actively referenced by another entry, an error will occur. For example, you cannot remove a hardware asset that is currently referenced by a driver session.

Examples
```
c = iviconfigurationstore;
remove(c, 'HardwareAsset', 'gpib1');
```

See Also **Functions**

iviconfigurationstore, iviconfigurationstore/add, iviconfigurationstore/commit, iviconfigurationstore/update

resolvehost

Purpose	Network name or network address

Syntax	`name = resolvehost('host')`
	`[name,address] = resolvehost('host')`
	`out = resolvehost('host','`*`returntype`*`')`

Arguments

`'host'`	The network name or network address of host.
`'`*`returntype`*`'`	Return either the name or address of host
`name`	Network name of host
`address`	Network address of host

Description `name = resolvehost('host')` returns the name of the specified host. You can specify `host` as either a network name or a network address. For example, www.mathworks.com is a network name and `144.212.100.10` is a network address.

`[name,address] = resolvehost('host')` returns the name and address of the specified host.

`out = resolvehost('host','`*`returntype`*`')` returns the host name if *returntype* is name and returns the host address if *returntype* is address.

Examples The following commands show how you can return the host name and address.

```
[name,address] = resolvehost('144.212.100.10')
name = resolvehost('144.212.100.10','name')
address = resolvehost('www.mathworks.com','address')
```

See Also **Functions**

tcpip, udp

Purpose   Save instrument objects and variables to MAT-file

Syntax
```
save filename
save filename obj1 obj2 ...
```

Arguments

filename	The MAT-file name.
obj1 obj2 ...	Instrument objects or arrays of instrument objects.

Description   save filename saves all MATLAB variables to the MAT-file filename. If an extension is not specified for filename, then a .mat extension is used.

save filename obj1 obj2 ... saves the instrument objects obj1 obj2 ... to the MAT-file filename.

Remarks   You can use save in the functional form as well as the command form shown above. When using the functional form, you must specify the filename and instrument objects as strings. For example, to save the serial port object s to the file MySerial.mat,

```
s = serial('COM1');
save('MySerial','s')
```

Any data that is associated with the instrument object is not automatically stored in the MAT-file. For example, suppose there is data in the input buffer for obj. To save that data to a MAT-file, you must bring the data into the MATLAB workspace using one of the synchronous read functions, and then save the data to the MAT-file using a separate variable name. You can also save data to a text file with the record function.

You return objects and variables to the MATLAB workspace with the load command. Values for read-only properties are restored to their default values upon loading. For example, the Status property is restored to closed. To determine if a property is read-only, examine its reference pages or use the propinfo function.

Examples   This example illustrates how to use the command form and the functional form of save.

```
s = serial('COM1');
set(s,'BaudRate',2400,'StopBits',1)
save MySerial1 s
set(s,'BytesAvailableFcn',@mycallback)
save('MySerial2','s')
```

See Also   **Functions**

instrhelp, load, propinfo, record

Properties

Status

Purpose   Read data from instrument, format as text, and parse

Syntax
```
A = scanstr(obj)
A = scanstr(obj,'delimiter')
A = scanstr(obj,'delimiter','format')
[A,count] = scanstr(...)
[A,count,msg] = scanstr(...)
```

Arguments

obj	An interface object.
'delimiter'	One or more delimiters used to parse the data.
'format'	C language conversion specification.
A	Data read from the instrument and formatted as text.
count	The number of values read.
msg	A message indicating if the read operation was unsuccessful.

Description   A = scanstr(obj) reads formatted data from the instrument connected to obj, parses the data using both a comma and a semicolon delimiter, and returns the data to the cell array A. Each element of the cell array is determined to be either a double or a string.

A = scanstr(obj,'delimiter') parses the data into separate variables based on the specified delimiter. delimiter can be a single character or a string array. If delimiter is a string array, then each character in the array is used as a delimiter.

A = scanstr(obj,'delimiter','format') converts the data according to the specified format. A can be a matrix or a cell array depending on format. See the textread M-file help for complete details. format is a string containing C language conversion specifications.

Conversion specifications involve the % character and the conversion characters d, i, o, u, x, X, f, e, E, g, G, c, and s. See the sscanf file I/O format specifications or a C manual for complete details.

If *format* is not specified, then the best format (either a double or a string) is chosen.

`[A,count] = scanstr(...)` returns the number of values read to `count`.

`[A,count,msg] = scanstr(...)` returns a warning message to `msg` if the read operation did not complete successfully.

Remarks

Before you can read data from the instrument, it must be connected to `obj` with the `fopen` function. A connected interface object has a `Status` property value of `open`. An error is returned if you attempt to perform a read operation while `obj` is not connected to the instrument.

If `msg` is not included as an output argument and the read operation was not successful, then a warning message is returned to the command line.

The `ValuesReceived` property value is increased by the number of values read — including the terminator — each time `scanstr` is issued.

Examples

Create the GPIB object g associated with a National Instruments board with index 0 and primary address 2, and connect g to a Tektronix TDS 210 oscilloscope.

```
g = gpib('ni',0,2);
fopen(g)
```

Return identification information to separate elements of a cell array using the default delimiters.

```
fprintf(g,'*IDN?');
idn = scanstr(g)
idn =
    'TEKTRONIX'
    'TDS 210'
    [        0]
    'CF:91.1CT FV:v1.16 TDS2CM:CMV:v1.04'
```

See Also   **Functions**

fopen, fscanf, instrhelp, sscanf, textread

Properties

EOSCharCode, EOSMode, Status, Terminator, ValuesReceived

selftest

Purpose	Run instrument self-test

Syntax

```
out = selftest(obj)
```

Arguments

obj	A device object.
out	The result of the self-test.

Description out = selftest(obj) runs the self-test for the instrument associated with the device object specified by obj. The result of the self-test is returned to out. Note that the test result will vary based on the instrument.

Purpose   Create serial port object

Syntax   ```
obj = serial('port')
obj = serial('port','PropertyName',PropertyValue,...)
```

**Arguments**    
| | |
|---|---|
| 'port' | The serial port name. |
| 'PropertyName' | A serial port property name. |
| PropertyValue | A property value supported by PropertyName. |
| obj | The serial port object. |

**Description**  obj = serial('port') creates a serial port object associated with the serial port specified by port. If port does not exist, or if it is in use, you will not be able to connect the serial port object to the instrument with the fopen function.

obj = serial('port','PropertyName',PropertyValue,...) creates a serial port object with the specified property names and property values. If an invalid property name or property value is specified, an error is returned and the serial port object is not created.

**Remarks**      At any time, you can use the instrhelp function to view a complete listing of properties and functions associated with serial port objects.

```
instrhelp serial
```

When you create a serial port object, these property values are automatically configured:

- Type is given by serial.

- Name is given by concatenating Serial with the port specified in the serial function.

- Port is given by the port specified in the serial function.

You can specify the property names and property values using any format supported by the set function. For example, you can use property name/property value cell array pairs. Additionally, you can specify property names without regard to case, and you can make use of property name completion. For example, the following commands are all valid.

```
s = serial('COM1','BaudRate',4800);
s = serial('COM1','baudrate',4800);
s = serial('COM1','BAUD',4800);
```

Before you can communicate with the instrument, it must be connected to obj with the fopen function. A connected serial port object has a Status property value of open. An error is returned if you attempt a read or write operation while obj is not connected to the instrument. You can connect only one serial port object to a given serial port.

Examples   This example creates the serial port object s1 associated with the serial port COM1.

```
s1 = serial('COM1');
```

The Type, Name, and Port properties are automatically configured.

```
get(s1,{'Type','Name','Port'})
ans =
    'serial'    'Serial-COM1'    'COM1'
```

To specify properties during object creation,

```
s2 = serial('COM2','BaudRate',1200,'DataBits',7);
```

See Also   **Functions**

fclose, fopen, propinfo

Properties

Name, Port, Status, Type

Purpose   Send break to instrument

Syntax   serialbreak(obj)
                 serialbreak(obj,time)

Arguments

obj	A serial port object.
time	The duration of the break, in milliseconds.

Description   serialbreak(obj) sends a break of 10 milliseconds to the instrument connected to obj.

serialbreak(obj,time) sends a break to the instrument with a duration, in milliseconds, specified by time. Note that the duration of the break might be inaccurate under some operating systems.

Remarks   For some instruments, the break signal provides a way to clear the hardware buffer.

Before you can send a break to the instrument, it must be connected to obj with the fopen function. A connected serial port object has a Status property value of open. An error is returned if you attempt to send a break while obj is not connected to the instrument.

serialbreak is a synchronous function, and blocks the command line until execution is complete.

If you issue serialbreak while data is being asynchronously written, an error is returned. In this case, you must call the stopasync function or wait for the write operation to complete.

See Also   **Functions**

fopen, stopasync

Properties

Status

set

Purpose	Configure or display instrument object properties
| **Syntax** | ```
set(obj)
props = set(obj)
set(obj,'PropertyName')
props = set(obj,'PropertyName')
set(obj,'PropertyName',PropertyValue,...)
set(obj,PN,PV)
set(obj,S)
``` |

Arguments

obj	An instrument object or an array of instrument objects.
'*PropertyName*'	A property name for obj.
PropertyValue	A property value supported by *PropertyName*.
PN	A cell array of property names.
PV	A cell array of property values.
S	A structure with property names and property values.
props	A structure array whose field names are the property names for obj, or cell array of possible values.

Description set(obj) displays all configurable property values for obj. If a property has a finite list of possible string values, then these values are also displayed.

props = set(obj) returns all configurable properties and their possible values for obj to props. props is a structure whose field names are the property names of obj, and whose values are cell arrays of possible property values. If the property does not have a finite set of possible values, then the cell array is empty.

set(obj,'*PropertyName*') displays the valid values for *PropertyName* if it possesses a finite list of string values.

props = set(obj,'*PropertyName*') returns the valid values for *PropertyName* to props. props is a cell array of possible string values or an empty cell array if *PropertyName* does not have a finite list of possible values.

set(obj,'*PropertyName*',PropertyValue,...) configures multiple property values with a single command.

set(obj,PN,PV) configures the properties specified in the cell array of strings PN to the corresponding values in the cell array PV. PN must be a vector. PV can be m-by-n where m is equal to the number of instrument objects in obj and n is equal to the length of PN.

set(obj,S) configures the named properties to the specified values for obj. S is a structure whose field names are instrument object properties, and whose field values are the values of the corresponding properties.

Remarks   You can use any combination of property name/property value pairs, structure arrays, and cell arrays in one call to set. Additionally, you can specify a property name without regard to case, and you can make use of property name completion. For example, if g is a GPIB object, then the following commands are all valid.

```
set(g,'EOSMode')
set(g,'eosmode')
set(g,'EOSM')
```

Examples   This example illustrates some of the ways you can use set to configure or return property values for the GPIB object g.

```
g = gpib('ni',0,1);
set(g,'EOSMode','read','OutputBufferSize',50000)
set(g,{'EOSCharCode','RecordName'},{13,'sydney.txt'})
set(g,'EOIMode')
[ {on} | off ]
```

set

See Also   **Functions**

get, instrhelp, propinfo

Purpose   Size of instrument object array

Syntax
```
d = size(obj)
[m,n] = size(obj)
[m1,m2,m3,...,mn] = size(obj)
m = size(obj,dim)
```

Arguments

obj	An instrument object or an array of instrument objects.
dim	The dimension of obj.
d	The number of rows and columns in obj.
m	The number of rows in obj, or the length of the dimension specified by dim.
n	The number of columns in obj.
m1,m2,...,mn	The length of the first N dimensions of obj.

Description   d = size(obj) returns the two-element row vector d containing the number of rows and columns in obj.

[m,n] = size(obj) returns the number of rows and columns in separate output variables.

[m1,m2,m3,...,mn] = size(obj) returns the length of the first n dimensions of obj.

m = size(obj,dim) returns the length of the dimension specified by the scalar dim. For example, size(obj,1) returns the number of rows.

See Also   **Functions**

instrhelp, length

spoll

Purpose	Perform serial poll

Syntax

```
out = spoll(obj)
out = spoll(obj,val)
```

Arguments

obj	A GPIB object or an array of GPIB objects.
val	A numeric array containing the indices of the objects in obj, that must be ready for servicing before control is returned to MATLAB.
out	The GPIB objects ready for servicing.

Description

out = spoll(obj) performs a serial poll on the instruments associated with obj. out contains the GPIB objects that are ready for servicing. If no objects are ready for servicing, then out is empty.

out = spoll(obj,val) performs a serial poll and waits until the instruments specified by val are ready for servicing. An error is returned if a value specified in val does not match an index value in obj.

Using this syntax, spoll blocks access to the MATLAB command line until the objects specified by val are ready for servicing, or a timeout occurs for each object specified by val. The timeout period is specified by the Timeout property.

Remarks

Serial polling is a method of obtaining specific information from GPIB objects when they request service. When you perform a serial poll, out contains the GPIB object that has asserted its service request (SRQ) line.

If obj is an array of GPIB objects

- Each element of obj must have the same BoardIndex property value.

- Each element of obj is polled to determine if the instrument is ready for servicing.

Examples   If `obj` is a four-element array and `val` is set to `[1 3]`, then `spoll` will block access to the MATLAB command line until the instruments connected to the first and third GPIB objects have both asserted their SRQ line, or a timeout occurs.

See Also   **Functions**

`gpib, length`

Properties

`BoardIndex, Timeout`

stopasync

Purpose   Stop asynchronous read and write operations

Syntax   stopasync(obj)

Arguments   obj   An interface object or an array of interface objects.

Description stopasync(obj) stops any asynchronous read or write operation that is in progress for obj.

Remarks   You can write data asynchronously using the fprintf or fwrite functions. You can read data asynchronously using the readasync function, or by configuring the ReadAsyncMode property to continuous (serial port, TCPIP, UDP, and VISA-serial objects). In-progress asynchronous operations are indicated by the TransferStatus property.

If obj is an array of interface objects and one of the objects cannot be stopped, the remaining objects in the array are stopped and a warning is returned. After an object stops,

- Its TransferStatus property is configured to idle.

- Its ReadAsyncMode property is configured to manual (serial port, TCPIP, UDP, and VISA-serial objects).

- The data in its output buffer is flushed.

Data in the input buffer is not flushed. You can return this data to the MATLAB workspace using any of the synchronous read functions. If you execute the readasync function, or configure the ReadAsyncMode property to continuous, then the new data is appended to the existing data in the input buffer.

See Also   **Functions**

fprintf, fwrite, readasync

Properties

ReadAsyncMode, TransferStatus

tcpip

Purpose	Create TCPIP object

Syntax

```
obj = tcpip('rhost')
obj = tcpip('rhost',rport)
obj = tcpip(...,'PropertyName',PropertyValue,...)
```

Arguments

'rhost'	The remote host.
rport	The remote port.
'*PropertyName*'	A TCPIP property name.
PropertyValue	A property value supported by *PropertyName*.
obj	The TCPIP object.

Description

obj = tcpip('rhost') creates a TCPIP object, obj, associated with remote host rhost and the default remote port value of 80.

obj = tcpip('rhost',rport) creates a TCPIP object with remote port value rport.

obj = tcpip(...,'*PropertyName*',PropertyValue,...) creates a TCPIP object with the specified property name/property value pairs. If an invalid property name or property value is specified, the object is not created.

Remarks

At any time, you can use the instrhelp function to view a complete listing of properties and functions associated with TCPIP objects.

```
instrhelp tcpip
```

When you create a TCPIP object, these property values are automatically configured:

- Type is given by tcpip.

- Name is given by concatenating TCPIP with the remote host name specified in the tcpip function.

- `RemoteHost` and `RemotePort` are given by the values specified in the `tcpip` function.

You can specify the property names and property values using any format supported by the `set` function. For example, you can use property name/property value cell array pairs. Additionally, you can specify property names without regard to case, and you can make use of property name completion. For example, the following commands are all valid.

```
t = tcpip('144.212.113.252','InputBufferSize',1024);
t = tcpip('144.212.113.252','inputbuffersize',1024);
t = tcpip('144.212.113.252','INPUT',1024);
```

When the TCPIP object is constructed, the `Status` property value is `closed`. Once the object is connected to the host with the `fopen` function, the `Status` property is configured to `open`.

The default local host in multihome hosts is the system's default. The `LocalPort` property defaults to a value of `[]` and it causes any free local port to be used. `LocalPort` is updated when `fopen` is issued.

Examples   Start a TCP/IP echo server and create a TCPIP object.

```
echotcpip('on',4012)
t = tcpip('localhost',4012);
```

Connect the TCPIP object to the host.

```
fopen(t)
```

Write to the host and read from the host.

```
fwrite(t,65:74)
A = fread(t, 10);
```

Disconnect the TCPIP object from the host and stop the echo server.

```
fclose(t)
echotcpip('off')
```

See Also   **Functions**

fopen, sendmail, udp, urlread, urlwrite

Properties

LocalHost, LocalPort, LocalPortMode, Name, RemoteHost,
RemotePort, Status, Type

Purpose   Open Test & Measurement Tool

Syntax   `tmtool`

Description   `tmtool` starts the Test & Measurement Tool. The Test & Measurement Tool displays the resources (hardware, drivers, interfaces, etc.) accessible to the toolboxes that support the tool, and enables you to configure and communicate with those resources.

You use the Test & Measurement Tool to manage your instrument control session. This tool enables you to

- Search for available hardware and drivers

- Create instrument objects

- Connect to an instrument

- Configure instrument settings

- Write data to an instrument

- Read data from an instrument

- Save a log of your session as an M-file

For a full description of the Test & Measurement Tool with examples, see Chapter 13, "The Test & Measurement Tool".

See Also   `instrcreate`, `instrcomm`, `midedit`, `midtest`

trigger

Purpose	Send trigger message to instrument
Syntax	`trigger(obj)`
Arguments	`obj` A GPIB, VISA-GPIB, or VISA-VXI object.
Description	`trigger(obj)` sends a trigger message to the instrument connected to `obj`.

Remarks

Before you can use `trigger`, `obj` must be connected to the instrument with the `fopen` function. A connected interface object has a `Status` property value of `open`. An error is returned if you attempt to use `trigger` while `obj` is not connected to the instrument.

For GPIB and VISA-GPIB objects, the Group Execute Trigger (GET) message is sent to the instrument.

For VISA-VXI objects, if the `TriggerType` property is configured to `software`, the Word Serial Trigger command is sent to the instrument. If `TriggerType` is configured to `hardware`, a hardware trigger is sent on the line specified by the `TriggerLine` property.

See Also

Functions

`fopen`

Properties

`Status, TriggerLine, TriggerType`

Purpose   Create UDP object

Syntax   obj = udp('')
                  obj = udp('rhost')
                  obj = udp('rhost',rport)
                  obj = udp(...,'*PropertyName*',PropertyValue,...)

Arguments

'rhost'	The remote host.
rport	The remote port.
'*PropertyName*'	A UDP property name.
PropertyValue	A property value supported by *PropertyName*.
obj	The UDP object.

Description   obj = udp('') creates a UDP object, obj, not associated with a remote host. obj = udp('rhost') creates a UDP object associated with remote host rhost.

obj = udp('rhost',rport) creates a UDP object with remote port value, rport. The default remote port is 9090.

obj = udp(...,'*PropertyName*',PropertyValue,...) creates a UDP object with the specified property name/property value pairs. If an invalid property name or property value is specified, the object is not created.

Remarks   At any time, you can use the instrhelp function to view a complete listing of properties and functions associated with UDP objects.

          instrhelp udp

When you create a UDP object, these properties are automatically configured:

• Type is given by udp.

- `Name` is given by concatenating UDP with the remote host name specified in the udp function.

- `RemoteHost` and `RemotePort` are given by the values specified in the udp function.

You can specify the property names and property values using any format supported by the set function. For example, you can use property name/property value cell array pairs. Additionally, you can specify property names without regard to case, and you can make use of property name completion. For example, the following commands are all valid.

```
u = udp('144.212.113.252','InputBufferSize',1024);
u = udp('144.212.113.252','inputbuffersize',1024);
u = udp('144.212.113.252','INPUT',1024);
```

The UDP object must be bound to the local socket with the fopen function. The default remote port is 9090. The default local host in multihome hosts is the system's default. The `LocalPort` property defaults to a value of `[]` and it causes any free local port to be used. `LocalPort` is updated when fopen is issued. When the UDP object is constructed, the Status property value is closed. Once the object is bound to the local socket with fopen, Status is configured to open.

The maximum packet size for reading is 8192 bytes. The input buffer can hold as many packets as defined by the `InputBufferSize` property value. You can write any data size to the output buffer. The data will be sent in packets of at most 4096 bytes.

Examples   Start the echo server and create a UDP object.

```
echoudp('on',4012)
u = udp('127.0.0.1',4012);
```

Connect the UDP object to the host.

```
fopen(u)
```

Write to the host and read from the host.

```
fwrite(u,65:74)
A = fread(u,10);
```

Stop the echo server and disconnect the UDP object from the host.

```
echoudp('off')
fclose(u)
```

See Also   **Functions**

fopen

Properties

LocalHost, LocalPort, LocalPortMode, Name, RemoteHost,
RemotePort, Status, Type

update

Purpose	Update entry of IVI configuration store object
Syntax	update(obj, '*type*', 'name', '*P1*', V1, ...) update(obj, struct)

Arguments

obj	IVI configuration store object.
'*type*'	Type of entry; *type* can be HardwareAsset, DriverSession, or LogicalName.
'name'	Name of the DriverSession, HardwareAsset, or LogicalName to be updated.
'*P1*'	First parameter for updated entry; other parameter-value pairs may follow.
V1	Value for first parameter.
struct	Structure defining entry fields to be updated.

Description

update(obj, '*type*', 'name', '*P1*', V1, ...) updates an entry of type, *type*, with name, name, in IVI configuration store object, obj, using the specified parameter-value pairs. *type* can be HardwareAsset, DriverSession, or LogicalName.

If an entry of type, *type* with name, name does not exist, an error will occur.

Valid parameters for a DriverSession are listed below. The default value for on/off parameters is off.

Parameter	Value	Description
Name	string	A unique name for the driver session.
SoftwareModule	string	The name of a software module entry in the configuration store.

Parameter	Value	Description
HardwareAsset	string	The name of a hardware asset entry in the configuration store.
Description	Any string	Description of driver session
VirtualNames	structure	A struct array containing virtual name mappings
Cache	on/off	Enable caching if the driver supports it.
DriverSetup	Any string	This value is software module dependent
InterchangeCheck	on/off	Enable driver interchangeability checking, if supported
QueryInstrStatus	on/off	Enable instrument status querying by the driver
RangeCheck	on/off	Enable extended range checking by the driver, if supported
RecordCoercions	on/off	Enable recording of coercions by the driver, if supported
Simulate	on/off	Enable simulation by the driver

Valid fields for HardwareAsset are

Parameter	Value	Description
Name	string	A unique name for the hardware asset
Description	Any string	Description of hardware asset
IOResourceDescriptor	string	The I/O address of the hardware asset

update

Valid fields for `LogicalName` are

Parameter	Value	Description
Name	string	A unique name for the logical name
Description	Any string	Description of hardware asset
Session	string	The name of a driver session entry in the configuration store

`update(obj, struct)` updates the entry using the fields in `struct`. If an entry with the type and name field in `struct` does not exist, an error will occur. Note that the `name` field cannot be updated using this syntax.

Examples   Update the `Description` parameter of the driver session named `ScopeSession` in the IVI configuration store object named c.

```
c = iviconfigurationstore;
update(c, 'DriverSession', 'ScopeSession', 'Description', ...
'A session.');
```

See Also   **Functions**

iviconfigurationstore, iviconfigurationstore/add, iviconfigurationstore/commit, iviconfigurationstore/remove

Purpose   Create VISA object

Syntax   obj = visa('*vendor*','rsrcname')
              obj = visa('*vendor*','rsrcname','*PropertyName*',PropertyValue,
              ...)

Arguments

'*vendor*'	A supported VISA vendor.
'rsrcname'	The resource name of the VISA instrument.
'*PropertyName*'	A VISA property name.
PropertyValue	A property value supported by *PropertyName*.
obj	The VISA object.

Description   obj = visa('*vendor*','rsrcname') creates the VISA object obj with a
resource name given by rsrcname for the vendor specified by *vendor*.
If an invalid vendor or resource name is specified, an error is returned
and the VISA object is not created. The supported values for *vendor*
are given below.

Vendor	Description
agilent	Agilent Technologies VISA
ni	National Instruments VISA
tek	Tektronix VISA

The format for rsrcname is given below for the supported VISA
interfaces. The values indicated by brackets are optional. You can use
the instrument's VISA Alias for rsrcname.

Interface	Resource Name
GPIB	GPIB[board]::primary_address[::secondary_address]::INSTR
GPIB-VXI	GPIB-VXI[chassis]::VXI_logical_address::INSTR

Interface	Resource Name
RSIB	RSIB::remote_host::INSTR (provided by NI VISA only)
Serial	ASRL[port_number]::INSTR
TCPIP	TCPIP[board]::remote_host[::lan_device_name]::INSTR
USB	USB[board]::manid::model_code::serial_No[::interface_No]::INSTR
VXI	VXI[chassis]::VXI_logical_address::INSTR

The rsrcname parameters are described below.

Parameter	Description
board	Board index (optional — defaults to 0)
chassis	VXI chassis index (optional — defaults to 0)
interface_No	USB interface
lan_device_name	Local Area Network (LAN) device name (optional — defaults to inst0)
manid	Manufacturer ID of the USB instrument
model_code	Model code for the USB instrument
port_number	Serial port number (optional — defaults to 1)
primary_address	Primary address of the GPIB instrument
remote_host	Host name or IP address of the instrument
secondary_address	Secondary address of the GPIB instrument (optional — defaults to 0)
serial_No	Index of the instrument on the USB hub
VXI_logical_address	Logical address of the VXI instrument

```
obj =
visa('vendor','rsrcname','PropertyName',PropertyValue,...)
```
creates the VISA object with the specified property names and property

values. If an invalid property name or property value is specified, an error is returned and the VISA object is not created.

Remarks   At any time, you can use the `instrhelp` function to view a complete listing of properties and functions associated with VISA objects.

```
instrhelp visa
```

You can specify the property names and property values using any format supported by the `set` function. For example, you can use property name/property value cell array pairs. Additionally, you can specify property names without regard to case, and you can make use of property name completion. For example, the following commands are all valid.

```
v = visa('ni','GPIB0::1::INSTR','SecondaryAddress', 96);
v = visa('ni','GPIB0::1::INSTR','secondaryaddress', 96);
v = visa('ni','GPIB0::1::INSTR','SECOND', 96);
```

Before you can communicate with the instrument, it must be connected to `obj` with the `fopen` function. A connected VISA object has a `Status` property value of `open`. An error is returned if you attempt a read or write operation while `obj` is not connected to the instrument. You cannot connect multiple VISA objects to the same instrument.

Creating a VISA-GPIB Object

When you create a VISA-GPIB object, these properties are automatically configured:

- `Type` is given by `visa-gpib`.

- `Name` is given by concatenating VISA-GPIB with the board index, the primary address, and the secondary address.

- `BoardIndex`, `PrimaryAddress`, `SecondaryAddress`, and `RsrcName` are given by the values specified during object creation.

Creating a VISA-GPIB-VXI Object

When you create a VISA-GPIB-VXI object, these properties are automatically configured:

- `Type` is given by `visa-gpib-vxi`.
- `Name` is given by concatenating `VISA-GPIB-VXI` with the chassis index and the logical address specified in the `visa` function.
- `ChassisIndex`, `LogicalAddress`, and `RsrcName` are given by the values specified during object creation.
- `BoardIndex`, `PrimaryAddress`, and `SecondaryAddress` are given by the `visa` driver after the object is connected to the instrument with `fopen`.

Creating a VISA-RSIB Object

When you create a VISA-RSIB object, these properties are automatically configured:

- `Type` is given by `visa-rsib`.
- `Name` is given by concatenating `VISA-RSIB` with the remote host specified in the `visa` function.
- `RemoteHost` and `RsrcName` are given by the values specified during object creation.

Creating a VISA-Serial Object

When you create a VISA-serial object, these properties are automatically configured:

- `Type` is given by `visa-serial`.
- `Name` is given by concatenating `VISA-Serial` with the port specified in the `visa` function.
- `Port` and `RsrcName` are given by the values specified during object creation.

Creating a VISA-TCPIP Object

When you create a VISA-TCPIP object, these properties are automatically configured:

- `Type` is given by `visa-tcpip`.
- `Name` is given by concatenating `VISA-TCPIP` with the board index, remote host, and LAN device name specified in the `visa` function.
- `BoardIndex`, `RemoteHost`, `LANNAme`, and `RsrcName` are given by the values specified during object creation.

Creating a VISA-USB Object

When you create a VISA-USB object, these properties are automatically configured:

- `Type` is given by `visa-usb`.
- `Name` is given by concatenating `VISA-USB` with the board index, manufacturer ID, model code, serial number, and interface number specified in the `visa` function.
- `BoardIndex`, `ManufacturerID`, `ModelCode`, `SerialNumber`, `InterfaceIndex`, and `RsrcName` are given by the values specified during object creation.

Creating a VISA-VXI Object

When you create a VISA-VXI object, these properties are automatically configured:

- `Type` is given by `visa-vxi`.
- `Name` is given by concatenating `VISA-VXI` with the chassis index and the logical address specified in the `visa` function.
- `ChassisIndex`, `LogicalAddress`, and `RsrcName` are given by the values specified during object creation.

Examples   Create a VISA-serial object connected to serial port COM1 using National Instruments VISA interface.

```
vs = visa('ni','ASRL1::INSTR');
```

Create a VISA-GPIB object connected to board 0 with primary address 1 and secondary address 30 using Agilent Technologies VISA interface.

```
vg = visa('agilent','GPIB0::1::30::INSTR');
```

Create a VISA-VXI object connected to a VXI instrument located at logical address 8 in the first VXI chassis.

```
vv = visa('agilent','VXI0::8::INSTR');
```

Create a VISA-GPIB-VXI object connected to a GPIB-VXI instrument located at logical address 72 in the second VXI chassis.

```
vgv = visa('agilent','GPIB-VXI1::72::INSTR');
```

Create a VISA-RSIB object connected to an instrument configured with IP address 192.168.1.33.

```
vr = visa('ni', 'RSIB::192.168.1.33::INSTR')
```

Create a VISA-TCPIP object connected to an instrument configured with IP address 216.148.60.170.

```
vt = visa('tek', 'TCPIP::216.148.60.170::INSTR')
```

Create a VISA-USB object connected to a USB instrument with manufacturer ID 0x1234, model code 125, and serial number A22-5.

```
vu = visa('agilent', 'USB::0x1234::125::A22-5::INSTR')
```

See Also   **Functions**

fclose, fopen, instrhelp, instrhwinfo

Properties

```
BoardIndex, ChassisIndex, InterfaceIndex, LANName,
LogicalAddress, ManufacturerID, ModelCode, Name, Port,
PrimaryAddress, RsrcName, SecondaryAddress, SerialNumber,
Status, Type
```

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Properties — By Category

Interface Object Base Properties

Writing Data

BytesToOutput	Number of bytes currently in output buffer
OutputBufferSize	Specify size of output buffer in bytes
Timeout	Specify waiting time to complete read or write operation
TransferStatus	Status of whether asynchronous read or write operation is in progress
ValuesSent	Total number of values written to instrument

Reading Data

BytesAvailable	Number of bytes available in input buffer
InputBufferSize	Specify size of input buffer in bytes
Timeout	Specify waiting time to complete read or write operation

`TransferStatus`	Status of whether asynchronous read or write operation is in progress
`ValuesReceived`	Total number of values read from instrument

Recording Data

`RecordDetail`	Specify amount of information saved to record file
`RecordMode`	Specify whether data and event information are saved to one or to multiple record files
`RecordName`	Specify name of record file
`RecordStatus`	Status of whether data and event information are saved to record file

Callbacks

`BytesAvailableFcn`	Specify M-file callback function to execute when specified number of bytes are available in input buffer, or terminator is read
`BytesAvailableFcnCount`	Specify number of bytes that must be available in input buffer to generate bytes-available event
`BytesAvailableFcnMode`	Specify whether bytes-available event is generated after specified number of bytes are available in input buffer, or after terminator is read
`ErrorFcn`	Specify M-file callback function to execute when error event occurs

`OutputEmptyFcn`	Specify M-file callback function to execute when output buffer is empty
`TimerFcn`	Specify M-file callback function to execute when predefined period passes
`TimerPeriod`	Specify period between timer events

General Purpose

`ByteOrder`	Specify byte order of instrument
`Name`	Specify descriptive name for instrument object
`ObjectVisibility`	Control access to instrument object
`Status`	Status of whether object is connected to instrument
`Tag`	Specify label to associate with instrument object
`Type`	Instrument object type
`UserData`	Specify data to associate with instrument object

Interface-Specific Properties

GPIB

`BoardIndex`	Specify index number of interface board
`BusManagementStatus`	State of GPIB bus management lines

CompareBits	Specify number of bits that must match EOS character to complete read operation, or to assert EOI line
EOIMode	Specify if EOI line is asserted at end of write operation
EOSCharCode	Specify EOS character
EOSMode	Specify when EOS character is written or read
HandshakeStatus	State of GPIB handshake lines
PrimaryAddress	Specify primary address of GPIB instrument
SecondaryAddress	Specify secondary address of GPIB instrument

Serial Port

BaudRate	Specify bit transmit rate
BreakInterruptFcn	Specify M-file callback function to execute when break-interrupt event occurs
DataBits	Specify number of data bits to transmit
DataTerminalReady	Specify state of DTR pin
FlowControl	Specify data flow control method to use
Parity	Specify type of parity checking
PinStatus	State of CD, CTS, DSR, and RI pins
PinStatusFcn	Specify M-file callback function to execute when CD, CTS, DSR, or RI pin changes state
Port	Specify platform-specific serial port name

`ReadAsyncMode`	Specify whether asynchronous read operation is continuous or manual
`RequestToSend`	Specify state of RTS pin
`StopBits`	Specify number of bits used to indicate end of byte
`Terminator`	Specify terminator character

TCPIP

`LocalHost`	Specify local host
`LocalPort`	Specify local host port for connection
`LocalPortMode`	Specify local host port selection mode
`ReadAsyncMode`	Specify whether asynchronous read operation is continuous or manual
`RemoteHost`	Specify remote host
`RemotePort`	Specify remote host port for connection
`Terminator`	Specify terminator character
`TransferDelay`	Specify use of TCP segment transfer algorithm

UDP

`DatagramAddress`	IP dotted decimal address of received datagram sender
`DatagramPort`	Port number of datagram sender
`DatagramReceivedFcn`	Specify M-file callback function to execute when datagram is received
`DatagramTerminateMode`	Configure terminate read mode when reading datagrams
`LocalHost`	Specify local host

`LocalPort`	Specify local host port for connection
`LocalPortMode`	Specify local host port selection mode
`ReadAsyncMode`	Specify whether asynchronous read operation is continuous or manual
`RemoteHost`	Specify remote host
`RemotePort`	Specify remote host port for connection
`Terminator`	Specify terminator character

VISA-GPIB

`BoardIndex`	Specify index number of interface board
`EOIMode`	Specify if EOI line is asserted at end of write operation
`EOSCharCode`	Specify EOS character
`EOSMode`	Specify when EOS character is written or read
`PrimaryAddress`	Specify primary address of GPIB instrument
`RsrcName`	Resource name for VISA instrument
`SecondaryAddress`	Specify secondary address of GPIB instrument

VISA-GPIB-VXI

`BoardIndex`	Specify index number of interface board
`ChassisIndex`	Specify index number of VXI chassis
`EOIMode`	Specify if EOI line is asserted at end of write operation

`EOSCharCode`	Specify EOS character
`EOSMode`	Specify when EOS character is written or read
`LogicalAddress`	Specify logical address of VXI instrument
`MappedMemoryBase`	Base memory address of mapped memory
`MappedMemorySize`	Size of mapped memory for low-level read and write operations
`MemoryBase`	Base address of A24 or A32 space
`MemoryIncrement`	Specify whether VXI register offset increments after data is transferred
`MemorySize`	Size of memory requested in A24 or A32 address space
`MemorySpace`	Address space used by instrument
`PrimaryAddress`	Specify primary address of GPIB instrument
`RsrcName`	Resource name for VISA instrument
`SecondaryAddress`	Specify secondary address of GPIB instrument
`Slot`	Slot location of VXI instrument

VISA-RSIB

`EOIMode`	Specify if EOI line is asserted at end of write operation
`RemoteHost`	Specify remote host

VISA-Serial

`BaudRate`	Specify bit transmit rate
`DataBits`	Specify number of data bits to transmit
`DataTerminalReady`	Specify state of DTR pin
`FlowControl`	Specify data flow control method to use
`Parity`	Specify type of parity checking
`PinStatus`	State of CD, CTS, DSR, and RI pins
`Port`	Specify platform-specific serial port name
`ReadAsyncMode`	Specify whether asynchronous read operation is continuous or manual
`RequestToSend`	Specify state of RTS pin
`RsrcName`	Resource name for VISA instrument
`StopBits`	Specify number of bits used to indicate end of byte
`Terminator`	Specify terminator character

VISA-TCPIP

`BoardIndex`	Specify index number of interface board
`EOIMode`	Specify if EOI line is asserted at end of write operation
`EOSCharCode`	Specify EOS character
`EOSMode`	Specify when EOS character is written or read
`LANName`	Specify LAN device name
`RemoteHost`	Specify remote host

VISA-USB

`BoardIndex`	Specify index number of interface board
`EOIMode`	Specify if EOI line is asserted at end of write operation
`EOSCharCode`	Specify EOS character
`EOSMode`	Specify when EOS character is written or read
`InterfaceIndex`	Specify USB interface number
`ManufacturerID`	Specify manufacturer ID of USB instrument
`ModelCode`	Specify model code of USB instrument
`SerialNumber`	Specify index of USB instrument on USB hub

VISA-VXI

`ChassisIndex`	Specify index number of VXI chassis
`EOIMode`	Specify if EOI line is asserted at end of write operation
`EOSCharCode`	Specify EOS character
`EOSMode`	Specify when EOS character is written or read
`InterruptFcn`	Specify M-file callback function to execute when interrupt event occurs
`LogicalAddress`	Specify logical address of VXI instrument
`MappedMemoryBase`	Base memory address of mapped memory

MappedMemorySize	Size of mapped memory for low-level read and write operations
MemoryBase	Base address of A24 or A32 space
MemoryIncrement	Specify whether VXI register offset increments after data is transferred
MemorySize	Size of memory requested in A24 or A32 address space
MemorySpace	Address space used by instrument
RsrcName	Resource name for VISA instrument
Slot	Slot location of VXI instrument
TriggerFcn	Specify M-file callback function to execute when trigger event occurs
TriggerLine	Specify trigger line on VXI instrument
TriggerType	Specify trigger type

Device Object Base Properties

ConfirmationFcn	Specify M-file callback function to execute when confirmation event occurs
DriverType	Specify type of driver used to communicate with instrument
InstrumentModel	Instrument model that object connects to
Interface	Interface object that communicates with instrument
LogicalName	Specify description of interface used to communicate with instrument
Name	Specify descriptive name for instrument object
ObjectVisibility	Control access to instrument object
Status	Status of whether object is connected to instrument
Tag	Specify label to associate with instrument object
Timeout	Specify waiting time to complete read or write operation
Type	Instrument object type
UserData	Specify data to associate with instrument object

IVI Configuration Store Object Properties

ActualLocation	Configuration store file used by IVI configuration store object
DriverSessions	Array of driver sessions contained in IVI configuration store
HardwareAssets	Array of hardware assets contained in IVI configuration store
LogicalNames	Array of logical names contained in IVI configuration store
MasterLocation	Full pathname of master configuration store file
Name (iviconfigurationstore)	Name of IVI configuration server
ProcessLocation	Configuration store file for process to use if master configuration store is not used
PublishedAPIs	Array of published APIs in IVI configuration store
Revision	IVI configuration store version
ServerDescription	IVI configuration store server description
Sessions	Array of driver sessions in IVI configuration store
SoftwareModules	Array of software modules in IVI configuration store
SpecificationVersion	IVI configuration server specification version that this server revision complies with
Vendor	IVI configuration server vendor

Properties — Alphabetical List

ActualLocation

Purpose   Configuration store file used by IVI configuration store object

Description   `ActualLocation` reflects the location of the IVI configuration store actually being used. It is either the master configuration store, or the `ProcessLocation` if an alternative to the master store was specified when the IVI configuration store object was created.

Characteristics

Usage	IVI configuration store object
Read only	Always
Data type	String

Values   The default value is the master configuration store.

See Also   **Functions**

commit

Properties

MasterLocation, ProcessLocation

Purpose   Alias of resource name for VISA instrument

Description   Alias indicates the alias for the resource name for a VISA instrument. When you create a VISA object, you can specify either the resource name for a VISA instrument or an alias for the resource name. If an alias is specified, Alias is automatically assigned the value specified in the VISA function. If a resource name is specified and the resource name has an alias, Alias is updated with the alias value. If the resource name does not have an alias, Alias is an empty string.

Characteristics

Usage	VISA object
Read only	Always
Data type	String

Values   The default value is an empty string.

Remarks   You set the alias for a resource name using vender-supplied tools. You do not set an alias in MATLAB. When you create the VISA object in MATLAB, the Alias property of the object takes on the value of the resource name alias. You do not directly set the value of this property.

National Instruments' Measurement & Automation Explorer (MAX) is one example of a graphical interface tool for setting a VISA alias in NI-VISA. In this tool, select **Tools > NI-VISA > Alias Editor** to edit, add, or clear aliases. When you have your aliases defined, you can use them in MATLAB to access your resources.

See Also   **Functions**

visa

Properties

RsrcName

BaudRate

Purpose
Specify bit transmit rate

Description
You configure BaudRate as bits per second. The transferred bits include the start bit, the data bits, the parity bit (if used), and the stop bits. However, only the data bits are stored.

The baud rate is the rate at which information is transferred in a communication channel. In the serial port context, "9600 baud" means that the serial port is capable of transferring a maximum of 9600 bits per second. If the information unit is one baud (one bit), then the bit rate and the baud rate are identical. If one baud is given as 10 bits, (for example, eight data bits plus two framing bits), the bit rate is still 9600 but the baud rate is 9600/10, or 960. You always configure BaudRate as bits per second. Therefore, in the above example, set BaudRate to 9600.

Note Both the computer and the instrument must be configured to the same baud rate before you can successfully read or write data.

Standard baud rates include 110, 300, 600, 1200, 2400, 4800, 9600, 14400, 19200, 38400, 57600, 115200, 128000, and 256000 bits per second. However, your serial port might support baud rates that differ from these values.

Characteristics

Usage	Serial port, VISA-serial
Read only	Never
Data type	Double

Values
The default value is 9600.

See Also

Properties

DataBits, Parity, StopBits

Purpose   Specify index number of interface board

Description   You configure BoardIndex to be the index number of the GPIB board,
USB board, or TCP/IP board associated with your instrument. When
you create a GPIB, VISA-GPIB, VISA-GPIB-VXI, VISA-TCPIP, or
VISA-USB object, BoardIndex is automatically assigned the value
specified in the gpib or visa function.

For GPIB objects, the Name property is automatically updated to
reflect the BoardIndex value. For VISA-GPIB, VISA-GPIB-VXI,
VISA-TCPIP, or VISA-USB objects, the Name and RsrcName properties
are automatically updated to reflect the BoardIndex value.

You can configure BoardIndex only when the object is disconnected
from the instrument. You disconnect a connected object with the fclose
function. A disconnected object has a Status property value of closed.

Characteristics

Usage	GPIB, VISA-GPIB, VISA-GPIB-VXI, VISA-TCPIP, VISA-USB
Read only	While open (GPIB, VISA-GPIB), always (VISA-GPIB-VXI, VISA-TCPIP, VISA-USB)
Data type	Double

Values   The value is defined after the instrument object is created.

Examples   Suppose you create a VISA-GPIB object associated with board 4,
primary address 1, and secondary address 8.

```
vg = visa('agilent','GPIB4::1::8::INSTR');
```

The BoardIndex, Name, and RsrcName properties reflect the GPIB board
index number.

```
get(vg,{'BoardIndex','Name','RsrcName'})
ans =
    [4]    'VISA-GPIB4-1-8'    'GPIB4::1::8::INSTR'
```

BoardIndex

See Also   **Functions**

fclose, gpib, visa

Properties

Name, RsrcName, Status

Purpose Specify M-file callback function to execute when break-interrupt event occurs

Description You configure `BreakInterruptFcn` to execute an M-file callback function when a break-interrupt event occurs. A break-interrupt event is generated by the serial port when the received data is in an off (space) state longer than the transmission time for one byte.

Note A break-interrupt event can be generated at any time during the instrument control session.

If the `RecordStatus` property value is `on`, and a break-interrupt event occurs, the record file records this information:

- The event type as `BreakInterrupt`
- The time the event occurred using the format day-month-year hour:minute:second:millisecond

To learn how to create a callback function, refer to "Creating and Executing Callback Functions" on page 4-32.

Characteristics

Usage	Serial port
Read only	Never
Data type	Callback function

Values The default value is an empty string.

See Also **Functions**

record

BreakInterruptFcn

Properties

RecordStatus

Purpose   State of GPIB bus management lines

Description   BusManagementStatus is a structure array that contains the fields
                   Attention, InterfaceClear, RemoteEnable, ServiceRequest, and
                   EndOrIdentify. These fields indicate the state of the Attention (ATN),
                   Interface Clear (IFC), Remote Enable (REN), Service Request (SRQ)
                   and End Or Identify (EOI) GPIB lines.

                   BusManagementStatus can be on or off for any of these fields. If
                   BusManagementStatus is on, the associated line is asserted. If
                   BusManagementStatus is off, the associated line is unasserted.

Characteristics

Usage	GPIB
Read only	Always
Data type	Structure

Values

off	The GPIB line is unasserted
on	The GPIB line is asserted

The default value is instrument dependent.

Examples   Create the GPIB object g associated with a National Instruments board,
                 and connect g to a Tektronix TDS 210 oscilloscope.

```
g = gpib('ni',0,0);
fopen(g)
```

Write the *STB? command, which queries the instrument's status byte
register, and then return the state of the bus management lines with
the BusManagementStatus property.

```
fprintf(g,'*STB?')
g.BusManagementStatus
```

```
ans =
        Attention: 'off'
   InterfaceClear: 'off'
     RemoteEnable: 'on'
    ServiceRequest: 'off'
     EndOrIdentify: 'on'
```

REN is asserted because the system controller placed the scope in the remote enable mode, while EOI is asserted to mark the end of the command.

Now read the result of the `*STB?` command, and return the state of the bus management lines.

```
out = fscanf(g)
out =
O
g.busmanagementstatus
ans =
        Attention: 'on'
   InterfaceClear: 'off'
     RemoteEnable: 'on'
    ServiceRequest: 'off'
     EndOrIdentify: 'off'
```

ATN is asserted because a multiline response was read from the scope.

```
fclose(g)
delete(g)
clear g
```

Purpose   Specify byte order of instrument

Description   You configure ByteOrder to be littleEndian or bigEndian. If ByteOrder is littleEndian, then the instrument stores the first byte in the first memory address. If ByteOrder is bigEndian, then the instrument stores the last byte in the first memory address.

For example, suppose the hexadecimal value 4F52 is to be stored in instrument memory. Because this value consists of two bytes, 4F and 52, two memory locations are used. Using big-endian format, 4F is stored first in the lower storage address. Using little-endian format, 52 is stored first in the lower storage address.

Note You should configure ByteOrder to the appropriate value for your instrument before performing a read or write operation. Refer to your instrument documentation for information about the order in which it stores bytes.

Characteristics

Usage	Any instrument object
Read only	Never
Data type	String

Values

{littleEndian}	The byte order of the instrument is little-endian.
bigEndian	The byte order of the instrument is big-endian.

See Also   **Properties**

Status

BytesAvailable

Purpose

Number of bytes available in input buffer

Description

BytesAvailable indicates the number of bytes currently available to be read from the input buffer. The property value is continuously updated as the input buffer is filled, and is set to 0 after the fopen function is issued.

You can make use of BytesAvailable only when reading data asynchronously. This is because when reading data synchronously, control is returned to the MATLAB command line only after the input buffer is empty. Therefore, the BytesAvailable value is always 0. To learn how to read data asynchronously, refer to "Synchronous Versus Asynchronous Read Operations" on page 3-22.

The BytesAvailable value can range from zero to the size of the input buffer. Use the InputBufferSize property to specify the size of the input buffer. Use the ValuesReceived property to return the total number of values read.

Characteristics

Usage	Any instrument object
Read only	Always
Data type	Double

Values

The value can range from zero to the size of the input buffer. The default value is 0.

See Also

Functions

fopen

Properties

InputBufferSize, TransferStatus, ValuesReceived

Purpose   Specify M-file callback function to execute when specified number of bytes are available in input buffer, or terminator is read

Description   You configure `BytesAvailableFcn` to execute an M-file callback function when a bytes-available event occurs. A bytes-available event occurs when the number of bytes specified by the `BytesAvailableFcnCount` property is available in the input buffer, or after a terminator is read, as determined by the `BytesAvailableFcnMode` property.

Note A bytes-available event can be generated only for asynchronous read operations.

If the `RecordStatus` property value is `on`, and a bytes-available event occurs, the record file records this information:

- The event type as `BytesAvailable`
- The time the event occurred using the format day-month-year hour:minute:second:millisecond

To learn how to create a callback function, refer to "Creating and Executing Callback Functions" on page 4-32.

Characteristics

Usage	Any instrument object
Read only	Never
Data type	Callback function

Values   The default value is an empty string.

Examples   Create the serial port object s for a Tektronix TDS 210 two-channel oscilloscope connected to the serial port COM1.

```
s = serial('COM1');
```

Configure s to execute the M-file callback function `instrcallback` when 40 bytes are available in the input buffer.

```
s.BytesAvailableFcnCount = 40;
s.BytesAvailableFcnMode = 'byte';
s.BytesAvailableFcn = @instrcallback;
```

Connect s to the oscilloscope.

```
fopen(s)
```

Write the `*IDN?` command, which instructs the scope to return identification information. Because the default value for the `ReadAsyncMode` property is `continuous`, data is read as soon as it is available from the instrument.

```
fprintf(s,'*IDN?')
```

The resulting output from `instrcallback` is shown below.

```
BytesAvailable event occurred at 18:33:35 for the object:
Serial-COM1.
```

56 bytes are read and `instrcallback` is called once. The resulting display is shown above.

```
s.BytesAvailable
ans =
    56
```

Suppose you remove 25 bytes from the input buffer and issue the `MEASUREMENT?` command, which instructs the scope to return its measurement settings.

```
out = fscanf(s,'%c',25);
fprintf(s,'MEASUREMENT?')
```

The resulting output from `instrcallback` is shown below.

```
BytesAvailable event occurred at 18:33:48 for the object:
```

```
Serial-COM1.

BytesAvailable event occurred at 18:33:48 for the object:
Serial-COM1.
```

There are now 102 bytes in the input buffer, 31 of which are left over from the *IDN? command. instrcallback is called twice; once when 40 bytes are available and once when 80 bytes are available.

```
s.BytesAvailable
ans =
    102
```

See Also   **Functions**

record

Properties

BytesAvailableFcnCount, BytesAvailableFcnMode, EOSCharCode, RecordStatus, Terminator, TransferStatus

BytesAvailableFcnCount

Purpose	Specify number of bytes that must be available in input buffer to generate bytes-available event
Description	You configure `BytesAvailableFcnCount` to the number of bytes that must be available in the input buffer before a bytes-available event is generated.
	Use the `BytesAvailableFcnMode` property to specify whether the bytes-available event occurs after a certain number of bytes are available or after a terminator is read.
	The bytes-available event executes the M-file callback function specified for the `BytesAvailableFcn` property.
	You can configure `BytesAvailableFcnCount` only when the object is disconnected from the instrument. You disconnect an object with the `fclose` function. A disconnected object has a `Status` property value of `closed`.

Characteristics

Usage	Any instrument object
Read only	While open
Data type	Double

Values   The default value is 48.

See Also   **Functions**

fclose

Properties

BytesAvailableFcn, BytesAvailableFcnMode, EOSCharCode, Status, Terminator

Purpose

Specify whether bytes-available event is generated after specified number of bytes are available in input buffer, or after terminator is read

Description

For serial port, TCPIP, UDP, or VISA-serial objects, you can configure BytesAvailableFcnMode to be terminator or byte. For all other instrument objects, you can configure BytesAvailableFcnMode to be eosCharCode or byte.

If BytesAvailableFcnMode is terminator, a bytes-available event occurs when the terminator specified by the Terminator property is read. If BytesAvailableFcnMode is eosCharCode, a bytes-available event occurs when the End-Of-String character specified by the EOSCharCode property is read. If BytesAvailableFcnMode is byte, a bytes-available event occurs when the number of bytes specified by the BytesAvailableFcnCount property is available.

The bytes-available event executes the M-file callback function specified for the BytesAvailableFcn property.

You can configure BytesAvailableFcnMode only when the object is disconnected from the instrument. You disconnect an object with the fclose function. A disconnected object has a Status property value of closed.

Characteristics

Usage	Any instrument object
Read only	While open
Data type	String

Values

Serial, TCPIP, UDP, and VISA-Serial

{terminator}	A bytes-available event is generated when the terminator is reached.
byte	A bytes-available event is generated when the specified number of bytes available.

BytesAvailableFcnMode

GPIB, VISA-GPIB, VISA-VXI, and VISA-GPIB-VXI

{eosCharCode}	A bytes-available event is generated when the EOS (End-Of-String) character is reached.
byte	A bytes-available event is generated when the specified number of bytes is available.

See Also

Functions

fclose

Properties

BytesAvailableFcn, BytesAvailableFcnCount, EOSCharCode, Status, Terminator

Purpose   Number of bytes currently in output buffer

Description   BytesToOutput indicates the number of bytes currently in the output buffer waiting to be written to the instrument. The property value is continuously updated as the output buffer is filled and emptied, and is set to 0 after the fopen function is issued.

You can make use of BytesToOutput only when writing data asynchronously. This is because when writing data synchronously, control is returned to the MATLAB command line only after the output buffer is empty. Therefore, the BytesToOutput value is always 0. To learn how to write data asynchronously, Refer to "Synchronous Versus Asynchronous Write Operations" on page 3-17.

Use the ValuesSent property to return the total number of values written to the instrument.

Note If you attempt to write out more data than can fit in the output buffer, then an error is returned and BytesToOutput is 0. You specify the size of the output buffer with the OutputBufferSize property.

Characteristics

Usage	Any instrument object
Read only	Always
Data type	Double

Values   The default value is 0.

See Also   **Functions**

fopen

Properties

OutputBufferSize, TransferStatus, ValuesSent

ChassisIndex

Purpose   Specify index number of VXI chassis

Description   You configure ChassisIndex to be the index number of the VXI chassis associated with your instrument.

When you create a VISA-VXI or VISA-GPIB-VXI object, ChassisIndex is automatically assigned the value specified in the visa function. For both object types, the Name and RsrcName properties are automatically updated to reflect the ChassisIndex value.

You can configure ChassisIndex only when the object is disconnected from the instrument. You disconnect a connected object with the fclose function. A disconnected object has a Status property value of closed.

Characteristics

Usage	VISA-VXI, VISA-GPIB-VXI
Read only	While open
Data type	double

Values   The value is defined after the instrument object is created.

Examples   Suppose you create a VISA-GPIB-VXI object associated with chassis 0 and logical address 32.

```
v = visa('agilent','GPIB-VXI0::32::INSTR');
```

The ChassisIndex, Name, and RsrcName properties reflect the VXI chassis index number.

```
get(v,{'ChassisIndex','Name','RsrcName'})
ans =
    [0]     'VISA-GPIB-VXI0-32'     'GPIB-VXI0::32::INSTR'
```

See Also   **Functions**

fclose, visa

Properties

Name, RsrcName, Status

CompareBits

Purpose Specify number of bits that must match EOS character to complete read operation, or to assert EOI line

Description You can configure CompareBits to be 7 or 8. If CompareBits is 7, the read operation completes when a byte that matches the low seven bits of the End-Of-String (EOS) character is received. The End Or Identify (EOI) line is asserted when a byte that matches the low seven bits of the EOS character is written. If CompareBits is 8, the read operation completes when a byte that matches all eight bits of the EOS character is received. The EOI line is asserted when a byte that matches all eight bits of the EOS character is written.

You can specify the EOS character with the EOSCharCode property. You can specify when the EOS character is used (read operation, write operation, or both) with the EOSMode property.

Characteristics

Usage	GPIB
Read only	Never
Data type	Double

Values

{8}	Compare all eight EOS bits.
7	Compare the lower seven EOS bits.

See Also **Properties**

EOSCharCode, EOSMode

Purpose   Specify M-file callback function to execute when confirmation event occurs

Description   You configure ConfirmationFcn to execute an M-file callback function when a confirmation event occurs.

A confirmation event is generated when the command written to the instrument results in the instrument being configured to a different value than it was sent.

Note A confirmation event can be generated only when the object is connected to the instrument with connect.

Characteristics   Usage   Device
Read only   Never
Data type   Callback

Values   The default value is an empty string.

See Also   **Functions**

connect

DataBits

Purpose   Specify number of data bits to transmit

Description   You can configure `DataBits` to be 5, 6, 7, or 8. Data is transmitted as a series of five, six, seven, or eight bits with the least significant bit sent first. At least seven data bits are required to transmit ASCII characters. Eight bits are required to transmit binary data. Five and six bit data formats are used for specialized communication equipment.

> **Note** Both the computer and the instrument must be configured to transmit the same number of data bits.

In addition to the data bits, the serial data format consists of a start bit, one or two stop bits, and possibly a parity bit. You specify the number of stop bits with the `StopBits` property, and the type of parity checking with the `Parity` property.

Characteristics

Usage	Serial port, VISA-serial
Read only	Never
Data type	Double

Values   `DataBits` can be 5, 6, 7, or 8. The default value is 8.

See Also   **Properties**

`Parity`, `StopBits`

Purpose   IP dotted decimal address of received datagram sender

Description   DatagramAddress is the datagram sender IP address of the next datagram to be read from the input buffer. An example of an IP dotted decimal address string is 144.212.100.10.

When you read a datagram from the input buffer, DatagramAddress is updated.

Characteristics

Usage	UDP
Read only	Always
Data type	String

Values   The default value is `''`.

See Also   **Functions**

udp

Properties

DatagramPort, RemotePort

DatagramPort

Purpose	Port number of datagram sender	

Description   DatagramPort is the port number of the next datagram to be read from the input buffer. When you read a datagram from the input buffer, DatagramPort is updated.

Characteristics

Usage	UDP
Read only	Never
Data type	Double

Values   The default value is [].

See Also   **Functions**

udp

Properties

DatagramAddress

Purpose

Specify M-file callback function to execute when datagram is received

Description

You configure `DatagramReceivedFcn` to execute an M-file callback function when a datagram has been received. The callback executes when a complete datagram is received in the input buffer.

Note A datagram-received event can be generated at any time during the instrument control session.

If the `RecordStatus` property value is `on`, and a datagram-received event occurs, the record file records this information:

- The event type as `DatagramReceived`
- The time the event occurred using the format day-month-year hour:minute:second:millisecond

To learn how to create a callback function, refer to "Creating and Executing Callback Functions" on page 4-32

Characteristics

Usage	UDP
Read only	Never
Data type	Callback

Values

The default value is `''`.

See Also

Functions

readasync, udp

Properties

DatagramAddress, DatagramPort, ReadAsyncMode

DatagramTerminateMode

Purpose   Configure terminate read mode when reading datagrams

Description   `DatagramTerminateMode` defines how `fread` and `fscanf` read operations terminate. You can configure `DatagramTerminateMode` to be on or `off`.

If `DatagramTerminateMode` is on, the read operation terminates when a datagram is read. When `DatagramTerminateMode` is `off`, `fread` and `fscanf` read across datagram boundaries.

Characteristics

Usage	UDP
Read only	Never
Data type	String

Values

{on}	The read operation terminates when a datagram is read.
off	The read operation spans datagram boundaries.

See Also   **Functions**

`fread`, `fscanf`, `udp`

Purpose   Specify state of DTR pin

Description   You can configure `DataTerminalReady` to be on or off. If
`DataTerminalReady` is on, the Data Terminal Ready (DTR) pin is
asserted. If `DataTerminalReady` is off, the DTR pin is unasserted.

In normal usage, the DTR and Data Set Ready (DSR) pins work
together, and are used to signal if instruments are connected and
powered. However, there is nothing in the RS-232 standard that states
the DTR pin must be used in any specific way. For example, DTR
and DSR might be used for handshaking. You should refer to your
instrument documentation to determine its specific pin behavior.

You can return the value of the DSR pin with the `PinStatus` property.
Handshaking is described in "The Control Pins" on page 6-7.

Characteristics

Usage	Serial port, VISA-serial
Read only	Never
Data type	String

Values

{on}	The DTR pin is asserted.
off	The DTR pin is unasserted.

See Also   **Properties**

`FlowControl`, `PinStatus`

DriverName

Purpose   Specify name of driver used to communicate with instrument

Description   For device objects with a `DriverType` property value of `MATLAB Instrument Driver`, the `DriverName` property specifies the name of the MATLAB instrument driver that contains the supported instrument commands.

For device objects with a `DriverType` property value of `VXIplug&play`, `IVI-C`, or `IVI-COM`, the `DriverName` is the name of the VXI*plug&play*, IVI-C, or IVI-COM driver, respectively.

Characteristics

Usage	Device
Read only	Always
Data type	String

Values   `DriverName` is defined at device object creation.

See Also   **Properties**

`DriverType`

Purpose   Array of driver sessions contained in IVI configuration store

Description   `DriverSessions` identifies all the driver sessions in the IVI configuration store. Each driver session maps a software module to a hardware asset and its `IOResourceDescriptor`. A driver session also determines default settings and behavior for its software module.

Characteristics

Usage	IVI configuration store object
Read only	Always
Data type	Array of Structs

See Also   **Properties**

HardwareAssets, SoftwareModules

DriverType

Purpose   Specify type of driver used to communicate with instrument

Description   DriverType can be MATLAB interface object, MATLAB VXIplug&play,
or MATLAB IVI. If DriverType is MATLAB interface object, an
interface object is used to communicate with the instrument. If
DriverType is MATLAB VXIplug&play, a VXI*plug&play* driver is used to
communicate with the instrument. If DriverType is MATLAB IVI, an
IVI driver is used to communicate with the instrument.

Characteristics   Usage   Device

Read only   Always

Data type   String

Values   The DriverType value is defined at the device object creation.
DriverType can be MATLAB interface object, MATLAB VXIplug&play,
or MATLAB IVI.

See Also   **Properties**

DriverName

Purpose   Specify if EOI line is asserted at end of write operation

Description   You can configure EOIMode to be on or off. If EOIMode is on, the End
                     Or Identify (EOI) line is asserted at the end of a write operation. If
                     EOIMode is off, the EOI line is not asserted at the end of a write
                     operation. EOIMode applies to both binary and text write operations.

Characteristics
Usage	GPIB, VISA-GPIB, VISA-VXI, VISA-GPIB-VXI
Read only	Never
Data type	String

Values
{on}	The EOI line is asserted at the end of a write operation.
off	The EOI line is not asserted at the end of a write operation.

See Also   **Properties**

                     BusManagementStatus

EOSCharCode

Purpose   Specify EOS character

Description   You can configure EOSCharCode to an integer value ranging from 0 to
                   255, or to the equivalent ASCII character. For example, to configure
                   EOSCharCode to a carriage return, you specify the value to be CR or 13.

                   EOSCharCode replaces \n wherever it appears in the ASCII command
                   sent to the instrument. Note that %s\n is the default format for the
                   fprintf function.

                   For many practical applications, you will configure both EOSCharCode
                   and the EOSMode property. EOSMode specifies when the EOS character is
                   used. If EOSMode is write or read&write (writing is enabled), the EOI
                   line is asserted every time the EOSCharCode value is written to the
                   instrument. If EOSMode is read or read&write (reading is enabled),
                   then the read operation might terminate when the EOSCharCode value
                   is detected. For GPIB objects, the CompareBits property specifies the
                   number of bits that must match the EOS character to complete a read
                   or write operation.

                   To see how EOSCharCode and EOSMode work together, refer to the
                   example given in the EOSMode property description.

Characteristics | Usage | GPIB, VISA-GPIB, VISA-VXI, VISA-GPIB-VXI |
                     |-----------|--|
                     | Read only | Never |
                     | Data type | ASCII value |

Values   An integer value ranging from 0 to 255 or the equivalent ASCII
                   character. The default value is LF, which corresponds to a line feed.

See Also   **Functions**

                   fprintf

                   Properties

                   CompareBits, EOSMode

Purpose   Specify when EOS character is written or read

Description   For GPIB, VISA-GPIB, VISA-VXI, and VISA-GPIB-VXI objects, you can configure EOSMode to be none, read, write, or read&write.

If EOSMode is none, the End-Of-String (EOS) character is ignored. If EOSMode is read, the EOS character is used to terminate a read operation. If EOSMode is write, the EOS character is appended to the ASCII command being written whenever \n is encountered. When the EOS character is written to the instrument, the End Or Identify (EOI) line is asserted. If EOSMode is read&write, the EOS character is used in both read and write operations.

The EOS character is specified by the EOSCharCode property. For GPIB objects, the CompareBits property specifies the number of bits that must match the EOS character to complete a read operation, or to assert the EOI line.

Rules for Completing a Read Operation

For any EOSMode value, the read operation completes when

- The EOI line is asserted.
- Specified number of values is read.
- A timeout occurs.

Additionally, if EOSMode is read or read&write (reading is enabled), then the read operation can complete when the EOSCharCode property value is detected.

Rules for Completing a Write Operation

Regardless of the EOSMode value, a write operation completes when

- The specified number of values is written.
- A timeout occurs.

EOSMode

Additionally, if EOSMode is write or read&write, the EOI line is asserted each time the EOSCharCode property value is written to the instrument.

Characteristics

Usage	GPIB, VISA-GPIB, VISA-VXI, VISA-GPIB-VXI
Read only	Never
Data type	String

Values

{none}	The EOS character is ignored.
read	The EOS character is used for each read operation.
write	The EOS character is used for each write operation.
read&write	The EOS character is used for each read and write operation.

Examples

Suppose you input a nominal voltage signal of 2.0 volts into a function generator, and read back the voltage value using fscanf.

```
g = gpib('ni',0,1);
fopen(g)
fprintf(g,'Volt?')
out = fscanf(g)
out =
+2.00000E+00
```

The EOSMode and EOSCharCode properties are configured to terminate the read operation when an E character is encountered.

```
set(g,'EOSMode','read')
set(g,'EOSCharCode','E')
fprintf(g,'Volt?')
out = fscanf(g)
out =
+2.00000
```

See Also   **Properties**

CompareBits, EOIMode, EOSCharCode

ErrorFcn

Purpose   Specify M-file callback function to execute when error event occurs

Description   You configure ErrorFcn to execute an M-file callback function when an error event occurs.

> **Note** An error event is generated only for asynchronous read and write operations.

An error event is generated when a timeout occurs. A timeout occurs if a read or write operation does not successfully complete within the time specified by the Timeout property. An error event is not generated for configuration errors such as setting an invalid property value.

If the RecordStatus property value is on, and an error event occurs, the record file records this information:

- The event type as Error
- The error message
- The time the event occurred using the format day-month-year hour:minute:second:millisecond

To learn how to create a callback function, refer to "Creating and Executing Callback Functions" on page 4-32.

Characteristics

Usage	Any instrument object
Read only	Never
Data type	Callback function

Values   The default value is an empty string.

See Also

Functions

record

Properties

RecordStatus, Timeout

FlowControl

Purpose   Specify data flow control method to use

Description   You can configure FlowControl to be none, hardware, or software.
If FlowControl is none, then data flow control (handshaking) is not
used. If FlowControl is hardware, then hardware handshaking is
used to control data flow. If FlowControl is software, then software
handshaking is used to control data flow.

Hardware handshaking typically utilizes the Request to Send (RTS) and
Clear to Send (CTS) pins to control data flow. Software handshaking
uses control characters (Xon and Xoff) to control data flow. To learn
more about hardware and software handshaking, refer to "Using
Control Pins" on page 6-28.

You can return the value of the CTS pin with the PinStatus property.
You can specify the value of the RTS pin with the RequestToSend
property. However, if FlowControl is hardware, and you specify a value
for RequestToSend, then that value might not be honored.

Note Although you might be able to configure your instrument for both
hardware handshaking and software handshaking at the same time,
the toolbox does not support this behavior.

Characteristics

Usage	Serial port, VISA-serial
Read only	Never
Data type	String

Values

{none}	No flow control is used.
hardware	Hardware flow control is used.
software	Software flow control is used.

See Also   **Properties**

PinStatus, RequestToSend

HandshakeStatus

Purpose   State of GPIB handshake lines

Description   HandshakeStatus is a structure array that contains the fields DataValid, NotDataAccepted, and NotReadyForData. These fields indicate the state of the Data Valid (DAV), Not Data Accepted (NDAC) and Not Ready For Data (NRFD) GPIB lines, respectively.

HandshakeStatus can be on or off for any of these fields. A value of on indicates the associated line is asserted. A value of off indicates the associated line is unasserted.

Characteristics

Usage	GPIB
Read only	Never
Data type	Structure

Values

on	The associated handshake line is asserted
off	The associated handshake line is unasserted

The default value is instrument dependent.

Purpose   Array of hardware assets contained in IVI configuration store

Description   `HardwareAssets` specifies all hardware assets in the IVI configuration store, each hardware asset referencing an `IOResourceDescriptor`.

Characteristics

Usage	IVI configuration store object
Read only	Always
Data type	Array of Structs

Values   The default value is empty.

See Also   **Properties**

`DriverSessions, SoftwareModules`

HwIndex

Purpose   Hardware index of device group object

Description   Every device group object contained by a device object has an associated hardware index that is used to reference that device group object. For example, to configure property values for an individual device group object, you must reference the group object through its property name and the appropriate HwIndex value.

HwIndex provides a convenient way to programmatically access device group objects.

Characteristics

Usage	Device Group
Read only	Always
Data type	Double

Values   The default value is defined at the device group object creation.

See Also   **Properties**

HwName

Purpose   Hardware name of device group object

Description   Every device group object contained by a device object has an associated hardware name that can be used to reference that device group object.

HwName provides a convenient way to programmatically access device group objects.

Characteristics Usage   Device Group

Read only   Always

Data type   String

Values   The default value is defined at the device group object creation.

See Also   **Properties**

HwIndex

InputBufferSize

Purpose   Specify size of input buffer in bytes

Description   You configure `InputBufferSize` as the total number of bytes that can be stored in the software input buffer during a read operation.

A read operation is terminated if the amount of data stored in the input buffer equals the `InputBufferSize` value. You can read text data with the `fgetl`, `fgets`, or `fscanf` functions. You can read binary data with the `fread` function.

You can configure `InputBufferSize` only when the instrument object is disconnected from the instrument. You disconnect an object with the `fclose` function. A disconnected object has a `Status` property value of `closed`.

If you configure `InputBufferSize` while there is data in the input buffer, then that data is flushed.

Characteristics

Usage	Any instrument object
Read only	While open
Data type	Double

Values   The default value is `512`.

See Also   **Functions**

`fclose`, `fgetl`, `fgets`, `fopen`, `fread`, `fscanf`

Properties

`Status`

Purpose   Instrument model that object connects to

Description   InstrumentModel returns the information returned by the instrument identification command, e.g., *IDN?, *ID?. The instrument identification command is defined by the instrument driver.

Characteristics

Usage	Device
Read only	Always
Data type	String

Values   InstrumentModel will be an empty string until the object is connected to the instrument with the connect function and the property value is queried with the get function.

See Also   **Functions**

connect, get

Interface

Purpose   Interface object that communicates with instrument

Description   If `DriverType` is `MATLAB Instrument Driver`, then `Interface` is
                     the interface object used to communicate with the instrument. If
                     `DriverType` is `VXIplug&play` or `IVI-C`, then `Interface` is the handle
                     to the VISA session that is used to communicate with the instrument.
                     If `DriverType` is `IVI-COM`, `Interface` is the handle to the IVI driver's
                     default interface.

Characteristics Usage   Device

                     Read only   Always

                     Data type   String

Values   `Interface` is defined at device object creation.

See Also   **Properties**

                     `DriverType`, `LogicalName`, `RsrcName`

Purpose   Specify USB interface number

Description   You configure `InterfaceIndex` to be the USB interface number.

The `Name` and `RsrcName` properties are automatically updated to reflect the `InterfaceIndex` value.

You can configure `InterfaceIndex` only when the object is disconnected from the instrument. You disconnect a connected object with the `fclose` function. A disconnected object has a `Status` property value of `closed`.

Characteristics

Usage	VISA-USB
Read only	While open
Data type	Double

See Also   **Functions**

`fclose`

Properties

`Name, RsrcName`

InterruptFcn

Purpose   Specify M-file callback function to execute when interrupt event occurs

Description   You configure InterruptFcn to execute an M-file callback function
when an interrupt event occurs. An interrupt event is generated when a
VXI bus signal or a VXI bus interrupt is received from the instrument.

Note An interrupt event can be generated at any time during the
instrument control session.

If the RecordStatus property value is on, and an interrupt event occurs,
the record file records

- The event type as Interrupt
- The time the event occurred using the format day-month-year
  hour:minute:second:millisecond

Characteristics

Usage	VISA-VXI
Read only	Never
Data type	String

Values   The default value is an empty string.

See Also   **Functions**

record

Properties

RecordStatus

Purpose   Specify LAN device name

Description   You configure LANName to be the LAN (Local Area Network) device name.

The Name and RsrcName properties are automatically updated to reflect the LANName value.

You can configure LANName only when the object is disconnected from the instrument. You disconnect a connected object with the fclose function. A disconnected object has a Status property value of closed.

Characteristics

Usage	VISA-TCPIP
Read only	While open
Data type	String

See Also   **Functions**

fclose

Properties

Name, RsrcName

LocalHost

Purpose   Specify local host

Description   `LocalHost` specifies the local host name or the IP dotted decimal address. An example dotted decimal address is 144.212.100.10. If you have only one address or you do not specify this property, the object uses the default IP address when you connect to the hardware with the `fopen` function.

You can configure `LocalHost` only when the object is disconnected from the hardware. You disconnect a connected object with the `fclose` function. A disconnected object has a `Status` property value of `closed`.

Characteristics

Usage	TCPIP, UDP
Read only	While open
Data type	String

Values   The default value is an empty string.

See Also   **Functions**

`fclose`, `fopen`, `tcpip`, `udp`

Properties

`LocalPort`, `RemoteHost`, `Status`

Purpose   Specify local host port for connection

Description   You configure `LocalPort` to be the port value of the local host. The default value is `[]`.

If `LocalPortMode` is set to `auto` or if `LocalPort` is `[]`, the property is assigned any free port when you connect the object to the hardware with the `fopen` function. If `LocalPortMode` is set to `manual`, the specified `LocalPort` value is used when you issue `fopen`. If you explicitly configure `LocalPort`, `LocalPortMode` is automatically set to `manual`.

You can configure `LocalPort` only when the object is disconnected from the hardware. You disconnect a connected object with the `fclose` function. A disconnected object has a `Status` property value of `closed`.

Characteristics

Usage	TCPIP, UDP
Read only	While open
Data type	Double

Values   The default value is `[]`.

See Also   **Functions**

`fclose`, `fopen`, `tcpip`, `udp`

Properties

`LocalHost`, `LocalPortMode`, `Status`

LocalPortMode

Purpose   Specify local host port selection mode

Description   `LocalPortMode` specifies the selection mode for the `LocalPort` property when you connect a TCPIP or UDP object.

If `LocalPortMode` is set to `auto`, MATLAB uses any free local port. If `LocalPortMode` is set to `manual`, the specified `LocalPort` value is used when you issue the `fopen` function. If you explicitly specify a value for `LocalPort`, `LocalPortMode` is automatically set to `manual`.

Characteristics

Usage	TCPIP, UDP
Read only	While open
Data type	String

Values

{auto}	Use any free local port.
manual	Use the specified local port value.

See Also   **Functions**

`fclose`, `fopen`, `tcpip`, `udp`

Properties

`LocalHost`, `LocalPort`, `Status`

Purpose   Specify logical address of VXI instrument

Description   For VISA-VXI and VISA-GPIB-VXI objects, you configure `LogicalAddress` to be the logical address of the VXI instrument. You must include the logical address as part of the resource name during object creation using the `visa` function.

The `Name` and `RsrcName` properties are automatically updated to reflect the `LogicalAddress` value.

You can configure `LogicalAddress` only when the object is disconnected from the instrument. You disconnect a connected object with the `fclose` function. A disconnected object has a `Status` property value of `closed`.

Characteristics

Usage	VISA-VXI, VISA-GPIB-VXI
Read only	While open
Data type	Double

Values   The value is defined when the instrument object is created.

Examples   This example creates a VISA-VXI object associated with chassis 4 and logical address 1, and then returns the logical address.

```
vv = visa('agilent','VXI4::1::INSTR');
vv.LogicalAddress
ans =
     1
```

See Also   **Functions**

`fclose`, `visa`

Properties

`Name`, `RsrcName`, `Status`

LogicalName

Purpose	Specify description of interface used to communicate with instrument
Description	For device objects with a `DriverType` property value of `MATLAB Instrument Driver`, the `LogicalName` property specifies the type of interface used to communicate with the instrument. For example, a `LogicalName` of `GPIB0-2` indicates that communication is through a GPIB board at index 0 with an instrument at primary address 2.
	For device objects with a `DriverType` property value of `VXIplug&play`, the `LogicalName` is the resource name used to communicate with the instrument.
	For device objects with a `DriverType` property value of `IVI-C` or `IVI-COM`, the `LogicalName` is the `LogicalName` associated with the IVI-C or IVI-COM driver.

Characteristics

Usage	Device
Read only	Always
Data type	String

Values   `LogicalName` is defined at device object creation.

See Also   **Properties**

`DriverType`, `Interface`, `RsrcName`

Purpose   Array of logical names contained in IVI configuration store

Description   Each entry in `LogicalNames` identifies a logical name in the IVI
                  configuration store. Each logical name references a driver session in
                  the configuration store, and is used in creating device objects with the
                  `icdevice` function.

Characteristics

Usage	IVI configuration store object
Read only	Always
Data type	Array of Structs

See Also   **Functions**

                  icdevice

                  Properties

                  DriverSessions

ManufacturerID

Purpose   Specify manufacturer ID of USB instrument

Description   You configure `ManufacturerID` to be the manufacturer ID of the USB instrument.

The `Name` and `RsrcName` properties are automatically updated to reflect the `ManufacturerID` value.

You can configure `ManufacturerID` only when the object is disconnected from the instrument. You disconnect a connected object with the `fclose` function. A disconnected object has a `Status` property value of `closed`.

Characteristics

Usage	VISA-USB
Read only	While open
Data type	String

See Also   **Functions**

`fclose`

Properties

`Name, RsrcName`

Purpose　　　Base memory address of mapped memory

Description　　`MappedMemoryBase` is the base address of the mapped memory used for low level read and write operations.

The memory address is returned as a string representing a hexadecimal value. For example, if the mapped memory base is 200000, then `MappedMemoryBase` returns 200000H. If no memory is mapped, `MappedMemoryBase` is 0H.

Use the `memmap` function to map the specified amount of memory in the specified address space (A16, A24, or A32) with the specified offset. Use the `memunmap` function to unmap the memory space.

Characteristics

Usage	VISA-VXI, VISA-GPIB-VXI
Read only	Always
Data type	String

Values　　　The default value is 0H.

Examples　　Create the VISA-VXI object vv associated with a VXI chassis with index 0, and an Agilent E1432A digitizer with logical address 130.

```
vv = visa('agilent','VXI0::130::INSTR');
fopen(vv)
```

Map 16 bytes in the A16 address space with no offset, and then return the base address of the mapped memory.

```
memmap(vv,'A16',0,16)
vv.MappedMemoryBase
ans =
    16737610H
```

MappedMemoryBase

See Also   **Functions**

`memmap, memunmap`

Properties

`MappedMemorySize`

Purpose   Size of mapped memory for low-level read and write operations

Description   MappedMemorySize indicates the amount of memory mapped for low-level read and write operations.

Use the memmap function to map the specified amount of memory in the specified address space (A16, A24, or A32) with the specified offset. Use the memunmap function to unmap the memory space.

Characteristics

Usage	VISA-VXI, VISA-GPIB-VXI
Read only	Always
Data type	Double

Values   The default value is 0.

Examples   Create the VISA-VXI object vv associated with a VXI chassis with index 0, and an Agilent E1432A digitizer with logical address 130.

```
vv = visa('agilent','VXI0::130::INSTR');
fopen(vv)
```

Map 16 bytes in the A16 address space with no offset, and then return the size of the mapped memory.

```
memmap(vv,'A16',0,16)
vv.MappedMemorySize
ans =
     16
```

See Also   **Functions**

memmap, memunmap

Properties

MappedMemoryBase

MasterLocation

Purpose   Full pathname of master configuration store file

Description   `MasterLocation` identifies the master (default) configuration store location.

Characteristics

Usage	IVI configuration store object
Read only	Always
Data type	String

Values   The default value is set at IVI installation.

See Also   **Properties**

`ActualLocation`, `ProcessLocation`

Purpose   Base address of A24 or A32 space

Description   MemoryBase indicates the base address of the A24 or A32 space. The value is returned as a string representing a hexadecimal value.

All VXI instruments have an A16 address space that is 16 bits wide. There are also 24- and 32-bit wide address spaces known as A24 and A32. Some instruments require the additional memory associated with the A24 or A32 address space when the 64 bytes of A16 space are insufficient for performing necessary functions. A bit in the A16 address space is set allowing the instrument to recognize commands to its A24 or A32 space.

An instrument cannot use both the A24 and A32 address space. The address space is given by the MemorySpace property. If MemorySpace is A16, then MemoryBase is 0H.

Characteristics

Usage	VISA-VXI, VISA-GPIB-VXI
Read only	Always
Data type	String

Values   The default value is 0H.

Examples   Create the VISA-VXI object vv associated with a VXI chassis with index 0, and an Agilent E1432A digitizer with logical address 130.

```
vv = visa('agilent','VXI0::130::INSTR');
fopen(vv)
```

The MemorySpace property indicates that the A24 memory space is supported.

```
vv.MemorySpace
ans =
A16/A24
```

MemoryBase

The base address of the A24 space is

```
vv.MemoryBase
ans =
'200000H'
```

See Also   **Properties**

MemorySpace

Purpose   Specify whether VXI register offset increments after data is transferred

Description   You can configure MemoryIncrement to be block or FIFO. If MemoryIncrement is block, the memread and memwrite functions increment the offset after every read and write operation, and data is transferred from or to consecutive memory elements. If MemoryIncrement is FIFO, the memread and memwrite functions do not increment the VXI register offset, and data is always read from or written to the same memory element.

Characteristics

Usage	VISA-VXI, VISA-GPIB-VXI
Read only	Never
Data type	String

Values

{block}	Increment the VXI register offset.
FIFO	Do not increment the VXI register offset.

Examples   Create the VISA-VXI object v associated with a VXI chassis with index 0, and an instrument with logical address 8.

```
v = visa('ni','VXI0::8::INSTR');
fopen(v)
```

Configure the hardware for a FIFO read and write operation.

```
set(v,'MemoryIncrement','FIFO')
```

Write two values to the VXI register starting at offset 16. Because MemoryIncrement is FIFO, the VXI register offset does not change and both values are written to offset 16.

```
memwrite(v,[1984 2000],16,'uint32','A16')
```

Read the value at offset 16. The value returned is the second value written with the `memwrite` function.

```
memread(v,16,'uint32')
ans =
2000
```

Read two values starting at offset 16. Note that both values are read at offset 16.

```
memread(v,16,'uint32','A16',2);
ans =
2000
2000
```

Configure the hardware for a block read and write operation.

```
set(v,'MemoryIncrement','block')
```

Write two values to the VXI register starting at offset 16. The first value is written to offset 16 and the second value is written to offset 20 because a `uint32` value consists of four bytes.

```
memwrite(v,[1984 2000],16,'uint32','A16')
```

Read the value at offset 16. The value returned is the first value written with the `memwrite` function.

```
memread(v,16,'uint32')
ans =
1984
```

Read two values starting at offset 16. The first value is read at offset 16 and the second value is read at offset 20.

```
memread(v,16,'uint32','A16',2);
ans =
1984
2000
```

See Also   **Functions**

`mempeek, mempoke, memread, memwrite`

MemorySize

Purpose	Size of memory requested in A24 or A32 address space

Description   `MemorySize` indicates the size of the memory requested by the instrument in the A24 or A32 address space.

Some instruments use the A24 or A32 address space when the 64 bytes of A16 space are not enough for performing necessary functions. An instrument cannot use both the A24 and A32 address space. The address space is given by the `MemorySpace` property. If `MemorySpace` is A16, then `MemorySize` is 0.

Characteristics

Usage	VISA-VXI, VISA-GPIB-VXI
Read only	Always
Data type	Double

Values   The default value is 0.

Examples   Create the VISA-VXI object vv associated with a VXI chassis with index 0, and an Agilent E1432A digitizer with logical address 130.

```
vv = visa('agilent','VXI0::130::INSTR');
fopen(vv)
```

The `MemorySpace` property indicates that the A24 memory space is supported.

```
vv.MemorySpace
ans =
A16/A24
```

The size of the A24 space is

```
vv.MemorySize
ans =
262144
```

See Also **Properties**

MemorySpace

MemorySpace

Purpose   Address space used by instrument

Description   MemorySpace indicates the address space requested by the instrument. MemorySpace can be A16, A16/A24, or A16/A32. If MemorySpace is A16, the instrument uses only the A16 address space. If MemorySpace is A16/A24, the instrument uses the A16 and A24 address space. If MemorySpace is A16/A32, the instrument uses the A16 and A32 address space.

All VXI instruments have an A16 address space that is 16 bits wide. There are also 24- and 32-bit wide address spaces known as A24 and A32, respectively. Some instruments use this memory when the 64 bytes of A16 space are not enough for performing necessary functions. An instrument cannot use both the A24 and A32 address space.

The size of the memory is given by the MemorySize property. The base address of the memory is given by the MemoryBase property.

Characteristics

Usage	VISA-VXI, VISA-GPIB-VXI
Read only	Always
Data type	String

Values

{A16}	The instrument uses the A16 address space.
A16/A24	The instrument uses the A16 and A24 address space.
A16/A32	The instrument uses the A16 and A32 address space.

Examples   Create the VISA-VXI object vv associated with a VXI chassis with index 0, and an Agilent E1432A digitizer with logical address 130.

```
vv = visa('agilent','VXI0::130::INSTR');
fopen(vv)
```

Return the memory space supported by the instrument.

```
vv.MemorySpace
ans =
A16/A24
```

This value indicates that the instrument supports A24 memory space in addition to the A16 memory space.

See Also   **Properties**

MemoryBase, MemorySize

ModelCode

Purpose　　　Specify model code of USB instrument

Description　　You configure ModelCode to be the model code of the USB instrument.

The Name and RsrcName properties are automatically updated to reflect the ModelCode value.

You can configure ModelCode only when the object is disconnected from the instrument. You disconnect a connected object with the fclose function. A disconnected object has a Status property value of closed.

Characteristics

Usage	VISA-USB
Read only	While open
Data type	String

See Also　　**Functions**

fclose

Properties

Name, RsrcName

Purpose   Specify descriptive name for instrument object

Description   You configure Name to be a descriptive name for an instrument object.

When you create an instrument object, a descriptive name is automatically generated and stored in Name. However, you can change this value at any time. As shown below, the components of Name reflect the instrument object type and the input arguments you supply to the creation function.

Instrument Object	Default Value of Name
GPIB	GPIB and BoardIndex-PrimaryAddress-SecondaryAddress
serial port	Serial and Port
TCPIP	TCPIP and RemoteHost
UDP	UDP and RemoteHost
VISA-serial	VISA-Serial and Port
VISA-GPIB	VISA-GPIB and BoardIndex-PrimaryAddress-SecondaryAddress
VISA-VXI	VISA-VXI and ChassisIndex-LogicalAddress
VISA-GPIB-VXI	VISA-GPIB-VXI and ChassisIndex-LogicalAddress
VISA-TCPIP	VISA-TCPIP and BoardIndex-RemoteHost-LANName
VISA-RSIB	VISA-RSIB and RemoteHost
VISA-USB	VISA-USB and BoardIndex-ManufacturerID-ModelCode-SerialNumber-InterfaceIndex

If the secondary address is not specified when a GPIB or VISA-GPIB object is created, then Name does not include this component.

Name

If you change the value of any property that is a component of `Name` (for example, `Port` or `PrimaryAddress`), then `Name` is automatically updated to reflect those changes.

Characteristics

Usage	Any instrument object
Read-only	Never
Data type	String

Values `Name` is automatically defined at object creation time. The value of `Name` depends on the specific instrument object you create.

Purpose   Name of IVI configuration server

Description   Name identifies the name of the IVI configuration store server. This is
                   not user-configurable.

Characteristics Usage   IVI configuration store object

                     Read only   Always

                     Data type   String

ObjectVisibility

Purpose	Control access to instrument object
Description	The ObjectVisibility property provides a way for application developers to prevent end-user access to the instrument objects created by their application. When an object's ObjectVisibility property is set to off, instrfind and instrreset do not return or delete those objects.

Objects that are not visible are still valid. If you have access to the object (for example, from within the M-file that creates it), then you can set and get its properties and pass it to any function that operates on instrument objects. |

Characteristics

Usage	Any instrument object
Read only	Never
Data type	String

Values   The default value is on.

{on}	Object is visible to instrfind and instrreset
off	Object is not visible from the command line (except by instrfindall)

Examples   The following statement creates an instrument object with its ObjectVisibility property set to off:

```
g = gpib('keithley',0,2,'ObjectVisibility','off');
instrfind
ans =
     []
```

However, since the object is in the workspace (g), you can access it.

```
get(g,'ObjectVisibility')
ans =
```

```
off
```

See Also   **Functions**

instrfind, instrfindall, instrreset

OutputBufferSize

Purpose	Specify size of output buffer in bytes
Description	You configure OutputBufferSize as the total number of bytes that can be stored in the software output buffer during a write operation.
	An error occurs if the output buffer cannot hold all the data to be written. You write text data with the fprintf function. You write binary data with the fwrite function.
	You can configure OutputBufferSize only when the instrument object is disconnected from the instrument. You disconnect an object with the fclose function. A disconnected object has a Status property value of closed.

Characteristics

Usage	Any instrument object
Read only	While open
Data type	Double

Values

The default value is 512.

See Also

Functions

fprintf, fwrite

Properties

Status

Purpose   Specify M-file callback function to execute when output buffer is empty

Description   You configure OutputEmptyFcn to execute an M-file callback function when an output-empty event occurs. An output-empty event is generated when the last byte is sent from the output buffer to the instrument.

Note An output-empty event can be generated only for asynchronous write operations.

If the RecordStatus property value is on, and an output-empty event occurs, the record file records this information:

- The event type as OutputEmpty

- The time the event occurred using the format day-month-year hour:minute:second:millisecond

To learn how to create a callback function, refer to "Creating and Executing Callback Functions" on page 4-32.

Characteristics

Usage	Any instrument object
Read only	Never
Data type	Callback function

Values   The default value is an empty string.

See Also   **Functions**

record

OutputEmptyFcn

Properties

`RecordStatus`

Purpose   Parent (device object) of device group object

Description   The parent of a device group object is defined as the device object that contains the device group object.

You can create a copy of the device object containing a particular device group object by returning the value of Parent. This copy can be treated like any other device object. For example, you can configure property values, connect to the instrument, and so on.

Characteristics

Usage	Device group
Read only	Always
Data type	Device object

Values   Parent is defined at device object creation.

Parity

Purpose   Specify type of parity checking

Description You can configure Parity to be none, odd, even, mark, or space. If Parity is none, parity checking is not performed and the parity bit is not transmitted. If Parity is odd, the number of mark bits (1s) in the data is counted, and the parity bit is asserted or unasserted to obtain an odd number of mark bits. If Parity is even, the number of mark bits in the data is counted, and the parity bit is asserted or unasserted to obtain an even number of mark bits. If Parity is mark, the parity bit is asserted. If Parity is space, the parity bit is unasserted.

Parity checking can detect errors of one bit only. An error in two bits might cause the data to have a seemingly valid parity, when in fact it is incorrect. To learn more about parity checking, refer to "The Parity Bit" on page 6-11.

In addition to the parity bit, the serial data format consists of a start bit, between five and eight data bits, and one or two stop bits. You specify the number of data bits with the DataBits property, and the number of stop bits with the StopBits property.

Characteristics

Usage	Serial port, VISA-serial
Read only	Never
Data type	String

Values

{none}	No parity checking
odd	Odd parity checking
even	Even parity checking
mark	Mark parity checking
space	Space parity checking

See Also   **Properties**

DataBits, StopBits

PinStatus

Purpose
State of CD, CTS, DSR, and RI pins

Description
PinStatus is a structure array that contains the fields CarrierDetect, ClearToSend, DataSetReady and RingIndicator. These fields indicate the state of the Carrier Detect (CD), Clear to Send (CTS), Data Set Ready (DSR) and Ring Indicator (RI) pins, respectively. Refer to "The Control Pins" on page 6-7 to learn more about these pins.

PinStatus can be on or off for any of these fields. A value of on indicates the associated pin is asserted. A value of off indicates the associated pin is unasserted. For serial port objects, a pin status event occurs when any of these pins changes its state. A pin status event executes the M-file specified by PinStatusFcn.

In normal usage, the Data Terminal Ready (DTR) and DSR pins work together, while the Request To Send (RTS) and CTS pins work together. You can specify the state of the DTR pin with the DataTerminalReady property. You can specify the state of the RTS pin with the RequestToSend property.

Refer to "Example: Connecting Two Modems" on page 6-28 for an example that uses PinStatus.

Characteristics

Usage	Serial port, VISA-serial
Read only	Always
Data type	Structure

Values

off	The associated pin is asserted
on	The associated pin is asserted

The default value is instrument dependent.

See Also   **Properties**

DataTerminalReady, PinStatusFcn, RequestToSend

PinStatusFcn

Purpose   Specify M-file callback function to execute when CD, CTS, DSR, or RI
pin changes state

Description   You configure `PinStatusFcn` to execute an M-file callback function
when a pin status event occurs. A pin status event occurs when the
Carrier Detect (CD), Clear to Send (CTS), Data Set Ready (DSR) or
Ring Indicator (RI) pin changes state. A serial port pin changes state
when it is asserted or unasserted. Information about the state of these
pins is recorded in the `PinStatus` property.

Note A pin status event can be generated at any time during the
instrument control session.

If the `RecordStatus` property value is `on`, and a pin status event occurs,
the record file records this information:

- The event type as `PinStatus`

- The pin that changed its state, and pin state as either `on` or `off`

- The time the event occurred using the format day-month-year
hour:minute:second:millisecond

To learn how to create a callback function, refer to "Creating and
Executing Callback Functions" on page 4-32.

Characteristics

Usage	Serial port
Read only	Never
Data type	Callback function

Values   The default value is an empty string.

See Also   **Functions**

record

Properties

PinStatus, RecordStatus

Port

Purpose	Specify platform-specific serial port name
Description	You configure Port to be the name of a serial port on your platform. Port specifies the physical port associated with the object and the instrument.

When you create a serial port or VISA-serial object, Port is automatically assigned the port name specified for the serial or visa function.

You can configure Port only when the object is disconnected from the instrument. You disconnect an object with the fclose function. A disconnected object has a Status property value of closed.

Characteristics

Usage	Serial port, VISA-serial
Read only	While open
Data type	String

Values The value is determined when the instrument object is created.

Examples Suppose you create a serial port and VISA-serial object associated with serial port COM1.

```
s = serial('COM1')
vs = visa('ni','ASRL1::INSTR')
```

The Port property values are given below.

```
get([s vs],'Port')
ans =
    'COM1'
    'ASRL1'
```

See Also **Functions**

fclose, serial, visa

Properties

Name, RsrcName, Status

PrimaryAddress

Purpose   Specify primary address of GPIB instrument

Description   For GPIB and VISA-GPIB objects, you configure `PrimaryAddress` to be the GPIB primary address associated with your instrument. The primary address can range from 0 to 30, and you must specify it during object creation using the `gpib` or `visa` function. For VISA-GPIB-VXI objects, `PrimaryAddress` is read-only, and the value is returned automatically by the VISA interface after the object is connected to the instrument with the `fopen` function.

For GPIB and VISA-GPIB objects, the `Name` property is automatically updated to reflect the `PrimaryAddress` value. For VISA-GPIB objects, the `RsrcName` property is automatically updated to reflect the `PrimaryAddress` value.

You can configure `PrimaryAddress` only when the GPIB or VISA-GPIB object is disconnected from the instrument. You disconnect a connected object with the `fclose` function. A disconnected object has a `Status` property value of `closed`.

Characteristics

Usage	GPIB, VISA-GPIB, VISA-GPIB-VXI
Read only	While open (GPIB, VISA-GPIB), always (VISA-GPIB-VXI)
Data type	Double

Values   `PrimaryAddress` can range from 0 to 30. The value is determined when the instrument object is created.

Examples   This example creates a VISA-GPIB object associated with board 0, primary address 1, and secondary address 8, and then returns the primary address.

```
vg = visa('agilent','GPIB0::1::8::INSTR');
vg.PrimaryAddress
ans =
     1
```

See Also   **Functions**

fclose, gpib, visa

Properties

Name, RsrcName, Status

ProcessLocation

Purpose	Configuration store file for process to use if master configuration store is not used
Description	ProcessLocation identifies an IVI configuration store being used as an alternative to the master configuration store. The use of an alternative is particular to each iviconfigurationstore object, and is specified when the object is created.

Characteristics

Usage	IVI configuration store object
Read only	Always
Data type	String

Values   The default value is an empty string.

See Also   **Functions**

iviconfigurationstore

Properties

ActualLocation, MasterLocation

Purpose   Array of published APIs in IVI configuration store

Description PublishedAPIs identifies the published APIs in the IVI configuration
store server. This is not user-configurable.

Characteristics

Usage	IVI configuration store object
Read only	Always
Data type	Array of Structs

ReadAsyncMode

Purpose　　Specify whether asynchronous read operation is continuous or manual

Description　You can configure ReadAsyncMode to be continuous or manual. If ReadAsyncMode is continuous, the object continuously queries the instrument to determine if data is available to be read. If data is available, it is automatically read and stored in the input buffer. If issued, the readasync function is ignored.

If ReadAsyncMode is manual, the object will not query the instrument to determine if data is available to be read. Instead, you must manually issue the readasync function to perform an asynchronous read operation. Because readasync checks for the terminator, this function can be slow. To increase speed, you should configure ReadAsyncMode to continuous.

Note If the instrument is ready to transmit data, then it will do so regardless of the ReadAsyncMode value. Therefore, if ReadAsyncMode is manual and a read operation is not in progress, then data can be lost. To guarantee that all transmitted data is stored in the input buffer, you should configure ReadAsyncMode to continuous.

You can determine the amount of data available in the input buffer with the BytesAvailable property. For either ReadAsyncMode value, you can bring data into the MATLAB workspace with one of the synchronous read functions such as fscanf, fgetl, fgets, or fread.

Characteristics

Usage	Serial port, TCPIP, UDP, VISA-serial
Read only	Never
Data type	String

| **Values** | {continuous} | Continuously query the instrument to determine if data is available to be read. |
| | manual | Manually read data from the instrument using the readasync function. |

See Also

Functions

fgetl, fgets, fread, fscanf, readasync

Properties

BytesAvailable, InputBufferSize

RecordDetail

Purpose   Specify amount of information saved to record file

Description   You can configure RecordDetail to be compact or verbose. If
                   RecordDetail is compact, the number of values written to the
                   instrument, the number of values read from the instrument, the data
                   type of the values, and event information are saved to the record file.
                   If RecordDetail is verbose, the data transferred to and from the
                   instrument is also saved to the record file.

                   The verbose record file structure is shown in "Example: Recording
                   Information to Disk" on page 12-10.

Characteristics

Usage	Any instrument object
Read only	Never
Data type	String

Values

{compact}	The number of values written to the instrument, the number of values read from the instrument, the data type of the values, and event information are saved to the record file.
verbose	The data written to the instrument, and the data read from the instrument are also saved to the record file.

See Also   **Functions**

                   record

                   Properties

                   RecordMode, RecordName, RecordStatus

Purpose   Specify whether data and event information are saved to one or to multiple record files

Description   You can configure RecordMode to be overwrite, append, or index. If RecordMode is overwrite, then the record file is overwritten each time recording is initiated. If RecordMode is append, then data is appended to the record file each time recording is initiated. If RecordMode is index, a different record file is created each time recording is initiated, each with an indexed filename.

You can configure RecordMode only when the object is not recording. You terminate recording with the record function. A object that is not recording has a RecordStatus property value of off.

You specify the record filename with the RecordName property. The indexed filename follows a prescribed set of rules. Refer to "Specifying a Filename" on page 12-7 for a description of these rules.

Characteristics

Usage	Any instrument object
Read only	While recording
Data type	String

Values

{overwrite}	The record file is overwritten.
append	Data is appended to the record file.
index	Multiple record files are written, each with an indexed filename.

Examples   Suppose you create the serial port object s associated with the serial port COM1.

```
s = serial('COM1');
fopen(s)
```

RecordMode

Specify the record filename with the `RecordName` property, configure `RecordMode` to `index`, and initiate recording.

```
s.RecordName = 'myrecord.txt';
s.RecordMode = 'index';
record(s)
```

The record filename is automatically updated with an indexed filename after recording is turned off.

```
record(s,'off')
s.RecordName
ans =
myrecord01.txt
```

Disconnect s from the instrument, and remove s from memory and from the MATLAB workspace.

```
fclose(s)
delete(s)
clear s
```

See Also   **Functions**

record

Properties

RecordDetail, RecordName, RecordStatus

Purpose   Specify name of record file

Description   You configure `RecordName` to be the name of the record file. You can specify any value for `RecordName` — including a directory path — provided the filename is supported by your operating system.

MATLAB supports any filename supported by your operating system. However, if you access the file through MATLAB, you might need to specify the filename using single quotes. For example, suppose you name the record file `my record.txt`. To type this file at the MATLAB command line, you must include the name in quotes.

```
type('my record.txt')
```

You can specify whether data and event information are saved to one disk file or to multiple disk files with the `RecordMode` property. If `RecordMode` is `index`, then the filename follows a prescribed set of rules. Refer to "Specifying a Filename" on page 12-7 for a description of these rules.

You can configure `RecordName` only when the object is not recording. You terminate recording with the `record` function. An object that is not recording has a `RecordStatus` property value of `off`.

Characteristics

Usage	Any instrument object
Read only	While recording
Data type	String

Values   The default record file name is `record.txt`.

See Also   **Functions**

`record`

Properties

`RecordDetail`, `RecordMode`, `RecordStatus`

RecordStatus

Purpose   Status of whether data and event information are saved to record file

Description   You can configure RecordStatus to be off or on with the record
                   function. If RecordStatus is off, then data and event information are
                   not saved to a record file. If RecordStatus is on, then data and event
                   information are saved to the record file specified by RecordName.

                   Use the record function to initiate or complete recording. RecordStatus
                   is automatically configured to reflect the recording state.

Characteristics

Usage	Any instrument object
Read only	Always
Data type	String

Values

{off}	Data and event information are not written to a record file
on	Data and event information are written to a record file

See Also   **Functions**

                   record

                   Properties

                   RecordDetail, RecordMode, RecordName

Purpose   Specify remote host

Description   RemoteHost specifies the remote host name or IP dotted decimal address. An example dotted decimal address is 144.212.100.10.

For TCPIP objects, you can configure RemoteHost only when the object is disconnected from the hardware. You disconnect a connected object with the fclose function. A disconnected object has a Status property value of closed.

For UDP objects, you can configure RemoteHost at any time. If the object is open, a warning is issued if the remote address is invalid.

Characteristics

Usage	TCPIP, UDP
Read only	While open (TCPIP), never (UDP)
Data type	String

Values   The value is defined when you create the TCPIP or UDP object.

See Also   **Functions**

fclose, fopen, tcpip, udp

Properties

LocalHost, RemotePort, Status

RemotePort

Purpose	Specify remote host port for connection
Description	You can configure RemotePort to be any port number between 1 and 65535. The default value is 80 for TCPIP objects and 9090 for UDP objects.

For TCPIP objects, you can configure RemotePort only when the object is disconnected from the hardware. You disconnect a connected object with the fclose function. A disconnected object has a Status property value of closed.

For UDP objects, you can configure RemotePort at any time.

Characteristics

Usage	TCPIP, UDP
Read only	While open (TCPIP), never (UDP)
Data type	Double

Values   Any port number between 1 and 65535. The default value is 80 for TCPIP objects and 9090 for UDP objects.

See Also   **Functions**

fclose, fopen, tcpip, udp

Properties

RemoteHost, LocalPort, Status

Purpose   Specify state of RTS pin

Description   You can configure RequestToSend to be on or off. If RequestToSend
                     is on, the Request to Send (RTS) pin is asserted. If RequestToSend is
                     off, the RTS pin is unasserted.

                     In normal usage, the RTS and Clear to Send (CTS) pins work together,
                     and are used as standard handshaking pins for data transfer. In this
                     case, RTS and CTS are automatically managed by the DTE and DCE.
                     However, there is nothing in the RS-232 standard that states the RTS
                     pin must to be used in any specific way. Therefore, if you manually
                     configure the RequestToSend value, it is probably for nonstandard
                     operations.

                     If your instrument does not use hardware handshaking in the standard
                     way, and you need to manually configure RequestToSend, then you
                     should configure the FlowControl property to none. Otherwise, the
                     RequestToSend value that you specify might not be honored. Refer to
                     your instrument documentation to determine its specific pin behavior.

                     You can return the value of the CTS pin with the PinStatus property.
                     Handshaking is described in "The Control Pins" on page 6-7.

Characteristics Usage   Serial port, VISA-serial

                     Read only   Never

                     Data type   String

Values   {on}   The RTS pin is asserted.

                     off   The RTS pin is unasserted.

See Also   **Properties**

                     FlowControl, PinStatus

Revision

Purpose   IVI configuration store version

Description   `Revision` identifies the version of the IVI configuration store. This is not user-configurable.

Characteristics

Usage	IVI configuration store object
Read only	Always
Data type	String

Purpose　　Resource name for VISA instrument

Description　　RsrcName indicates the resource name for a VISA instrument. When you create a VISA object, RsrcName is automatically assigned the value specified in the visa function.

The resource name is a symbolic name for the instrument. The resource name you supply to visa depends on the interface and has the format shown below. The components in brackets are optional and have a default value of 0, except port_number, which has a default value of 1.

Interface	Resource Name
VXI	VXI[chassis]::VXI_logical_address::INSTR
GPIB-VXI	GPIB-VXI[chassis]::VXI_logical_address::INSTR
GPIB	GPIB[board]::primary_address[::secondary_address]::INSTR
TCPIP	TCPIP[board]::remote_host[::lan_device_name]::INSTR
RSIB	RSIB::remote_host::INSTR
Serial	ASRL[port_number]::INSTR
USB	USB[board]::manid::model_code::serial_No[::interface_No]::INSTR

If you change the BoardIndex, ChassisIndex, InterfaceIndex, LANName, LogicalAddress, ManufacturerID, ModelCode, Port, PrimaryAddress, RemoteHost, SecondaryAddress, or SerialNumber property value, RsrcName is automatically updated to reflect the change.

Characteristics

Usage	VISA-GPIB, VISA-VXI, VISA-GPIB-VXI, VISA-serial
Read only	Always
Data type	String

Values　　The value is defined when the instrument object is created.

RsrcName

Examples   To create a VISA-GPIB object associated with a GPIB controller with
                 board index 0 and an instrument with primary address 1, you supply
                 the following resource name to the visa function.

```
vg = visa('ni','GPIB0::1::INSTR');
```

To create a VISA-VXI object associated with a VXI chassis with index 0
and an instrument with logical address 130, you supply the following
resource name to the visa function.

```
vv = visa('agilent','VXI0::130::INSTR');
```

To create a VISA-GPIB-VXI object associated with a VXI chassis with
index 0 and an instrument with logical address 80, you supply the
following resource name to the visa function.

```
vgv = visa('agilent','GPIB-VXI0::80::INSTR');
```

To create a VISA-serial object associated with the COM1 serial port, you
supply the following resource name to the visa function.

```
vs = visa('ni','ASRL1::INSTR');
```

See Also   **Functions**

visa

Properties

BoardIndex, ChassisIndex, InterfaceIndex, LANName,
LogicalAddress, ManufacturerID, ModelCode, Port, PrimaryAddress,
RemoteHost, SecondaryAddress, SerialNumber

Purpose   Specify secondary address of GPIB instrument

Description   For GPIB and VISA-GPIB objects, you configure SecondaryAddress
to be the GPIB secondary address associated with your instrument.
You can initially specify the secondary address during object creation
using the gpib or visa function. For VISA-GPIB-VXI objects,
SecondaryAddress is read-only, and the value is returned automatically
by the VISA interface after the object is connected to the instrument
with the fopen function.

For GPIB objects, SecondaryAddress can range from 96 to 126, or it
can be 0 indicating that no secondary address is used. For VISA-GPIB
objects, SecondaryAddress can range from 0 to 30. If your instrument
does not have a secondary address, then SecondaryAddress is 0.

For GPIB and VISA-GPIB objects, the Name property is automatically
updated to reflect the SecondaryAddress value. For VISA-GPIB
objects, the RsrcName property is automatically updated to reflect the
SecondaryAddress value.

You can configure SecondaryAddress only when the GPIB or
VISA-GPIB object is disconnected from the instrument. You disconnect
a connected object with the fclose function. A disconnected object has
a Status property value of closed.

Characteristics

Usage	GPIB, VISA-GPIB, VISA-GPIB-VXI
Read only	While open (GPIB, VISA-GPIB), always (VISA-GPIB-VXI)
Data type	Double

Values   For GPIB objects, SecondaryAddress can range from 96 to 126, or it can
be 0. For VISA-GPIB objects, SecondaryAddress can range from 0 to
30. The default value is 0.

SecondaryAddress

Examples

This example creates a VISA-GPIB object associated with board 0, primary address 1, and secondary address 8, and then returns the secondary address.

```
vg = visa('agilent','GPIB0::1::8::INSTR');
vg.SecondaryAddress
ans =
     8
```

See Also

Functions

fclose, gpib, visa

Properties

Name, RsrcName, Status

SerialNumber

Purpose   Specify index of USB instrument on USB hub

Description   You configure SerialNumber to be the index of the USB instrument
on the USB hub.

The Name and RsrcName properties are automatically updated to reflect
the SerialNumber value.

You can configure SerialNumber only when the object is disconnected
from the instrument. You disconnect a connected object with the fclose
function. A disconnected object has a Status property value of closed.

Characteristics

Usage	VISA-USB
Read only	While open
Data type	String

See Also   **Functions**

fclose

Properties

Name, RsrcName

ServerDescription

Purpose   IVI configuration store server description

Description   `ServerDescription` contains the description of the IVI configuration store server. This is not user-configurable.

Characteristics

Usage	IVI configuration store object
Read only	Always
Data type	String

Purpose   Array of driver sessions in IVI configuration store

Description   Sessions identifies the sessions in the IVI configuration store, including the driver sessions.

Characteristics

Usage	IVI configuration store object
Read only	Always
Data type	Array of Structs

See Also   **Properties**

DriverSessions

Slot

Purpose Slot location of VXI instrument

Description Slot indicates the physical slot of the VXI instrument. Slot can be any value between 0 and 12.

Characteristics

Usage	VISA-VXI, VISA-GPIB-VXI
Read only	Always
Data type	Double

Values The property value is defined when the instrument object is connected.

Purpose   Array of software modules in IVI configuration store

Description   SoftwareModules identifies the software modules in the IVI configuration store. These are installed by the user, but are not configurable. They include instrument drivers.

Characteristics

Usage	IVI configuration store object
Read only	Always
Data type	Array of Structs

Values   The default value is empty when no software modules are installed.

See Also   **Properties**

DriverSessions, HardwareAssets

SpecificationVersion

Purpose　　　IVI configuration server specification version that this server revision complies with

Description　　`SpecificationVersion` identifies the specification version of the IVI configuration store server. This is not user-configurable.

Characteristics　Usage　　　IVI configuration store object

Read only　　Always

Data type　　String

Purpose　Status of whether object is connected to instrument

Description　Status can be open or closed. If Status is closed, the object is not connected to the instrument. If Status is open, the object is connected to the instrument.

Before you can write or read data, you must connect the object to the instrument with the fopen function. You use the fclose function to disconnect an object from the instrument.

Characteristics

Usage	Any instrument object
Read only	Always
Data type	String

Values

{closed}	The object is not connected to the instrument.
open	The object is connected to the instrument.

See Also　**Functions**

fclose, fopen

StopBits

Purpose　　　Specify number of bits used to indicate end of byte

Description　　You can configure StopBits to be 1, 1.5, or 2 for serial port objects, or 1 or 2 for VISA-serial objects If StopBits is 1, one stop bit is used to indicate the end of data transmission. If StopBits is 2, two stop bits are used to indicate the end of data transmission. If StopBits is 1.5, the stop bit is transferred for 150% of the normal time used to transfer one bit.

Note Both the computer and the instrument must be configured to transmit the same number of stop bits.

In addition to the stop bits, the serial data format consists of a start bit, between five and eight data bits, and possibly a parity bit. You specify the number of data bits with the DataBits property, and the type of parity checking with the Parity property.

Characteristics

Usage	Serial port, VISA-serial
Read only	Never
Data type	double

Values　　　　**Serial Port**

{1}	One stop bit is transmitted to indicate the end of a byte.
1.5	The stop bit is transferred for 150% of the normal time used to transfer one bit.
2	Two stop bits are transmitted to indicate the end of a byte.

VISA-Serial

{1}	One stop bit is transmitted to indicate the end of a byte.
2	Two stop bits are transmitted to indicate the end of a byte

See Also

Properties

DataBits, Parity

Tag

Purpose   Specify label to associate with instrument object

Description   You configure Tag to be a string value that uniquely identifies an instrument object.

Tag is particularly useful when constructing programs that would otherwise need to define the instrument object as a global variable, or pass the object as an argument between callback routines.

You can return the instrument object with the instrfind function by specifying the Tag property value.

Characteristics

Usage	Any instrument object
Read only	Never
Data type	String

Values   The default value is an empty string.

Examples   Suppose you create a serial port object associated with the serial port COM1.

```
s = serial('COM1');
fopen(s);
```

You can assign s a unique label using Tag.

```
set(s,'Tag','MySerialObj')
```

You can access s in the MATLAB workspace or in an M-file using the instrfind function and the Tag property value.

```
s1 = instrfind('Tag','MySerialObj');
```

See Also   **Functions**

instrfind

Purpose   Specify terminator character

Description   For serial, TCPIP, UDP, and VISA-serial objects, you can configure
Terminator to an integer value ranging from 0 to 127, to the equivalent
ASCII character, or to empty ("). For example, to configure Terminator
to a carriage return, you specify the value to be CR or 13. To configure
Terminator to a line feed, you specify the value to be LF or 10. For
serial port objects, you can also set Terminator to CR/LF or LF/CR. If
Terminator is CR/LF, the terminator is a carriage return followed by a
line feed. If Terminator is LF/CR, the terminator is a line feed followed
by a carriage return. Note that there are no integer equivalents for
these two values.

Additionally, you can set Terminator to a 1-by-2 cell array. The first
element of the cell is the read terminator and the second element of the
cell array is the write terminator.

When performing a write operation using the fprintf function, all
occurrences of \n are replaced with the Terminator value. Note that
%s\n is the default format for fprintf. A read operation with fgetl,
fgets, or fscanf completes when the Terminator value is read. The
terminator is ignored for binary operations.

You can also use the terminator to generate a bytes-available event
when the BytesAvailableFcnMode is set to terminator.

Characteristics

Usage	Serial, TCPIP, UDP, VISA-serial
Read only	Never
Data type	ASCII value

Values   An integer value ranging from 0 to 127, the equivalent ASCII character,
or empty ("). For serial port objects, CR/LF and LF/CR are also accepted
values. You specify different read and write terminators as a 1-by-2
cell array.

Terminator

See Also **Functions**

fgetl, fgets, fprintf, fscanf

Properties

BytesAvailableFcnMode

Purpose   Specify waiting time to complete read or write operation

Description You configure Timeout to be the maximum time (in seconds) to wait to complete a read or write operation.

If a timeout occurs, then the read or write operation aborts. Additionally, if a timeout occurs during an asynchronous read or write operation, then

- An error event is generated.

- The M-file callback function specified for ErrorFcn is executed.

Characteristics Usage   Any instrument object

Read only   Never

Data type   Double

Values   The default value is 10 seconds.

See Also   **Properties**

ErrorFcn

TimerFcn

Purpose Specify M-file callback function to execute when predefined period passes

Description You configure `TimerFcn` to execute an M-file callback function when a timer event occurs. A timer event occurs when the time specified by the `TimerPeriod` property passes. Time is measured relative to when the object is connected to the instrument with `fopen`.

Note A timer event can be generated at any time during the instrument control session.

If the `RecordStatus` property value is `on`, and a timer event occurs, the record file records this information:

- The event type as `Timer`
- The time the event occurred using the format day-month-year hour:minute:second:millisecond

Some timer events might not be processed if your system is significantly slowed or if the `TimerPeriod` value is too small.

To learn how to create a callback function, refer to "Creating and Executing Callback Functions" on page 4-32.

Characteristics

Usage	Any instrument object
Read only	Never
Data type	Callback function

Values The default value is an empty string.

See Also

Functions

`fopen, record`

Properties

`RecordStatus, TimerPeriod`

TimerPeriod

Purpose	Specify period between timer events

Description TimerPeriod specifies the time, in seconds, that must pass before the callback function specified for TimerFcn is called. Time is measured relative to when the object is connected to the instrument with fopen.

Some timer events might not be processed if your system is significantly slowed or if the TimerPeriod value is too small.

Characteristics

Usage	Any instrument object
Read only	Never
Data type	Callback function

Values The default value is 1 second. The minimum value is 0.01 second.

See Also **Functions**

fopen

Properties

TimerFcn

Purpose   Specify use of TCP segment transfer algorithm

Description   You can configure TransferDelay to on or off. If TransferDelay is on, small segments of outstanding data are collected and sent in a single packet when acknowledgment (ACK) arrives from the server. If TransferDelay is off, data is sent immediately to the network.

If a network is slow, you can improve its performance by configuring TransferDelay to on. However, on a fast network acknowledgments arrive quickly and there is negligible difference between configuring TransferDelay to on or off.

Note that the segment transfer algorithm used by TransferDelay is Nagle's algorithm.

Characteristics

Usage	TCPIP
Read only	Never
Data type	String

Values

{on}	Use the TCP segment transfer algorithm.
off	Do not use the TCP segment transfer algorithm.

See Also   **Functions**

tcpip

TransferStatus

Purpose   Status of whether asynchronous read or write operation is in progress

Description   TransferStatus can be `idle`, `read`, `write`, or `read&write`. If TransferStatus is `idle`, then no asynchronous read or write operations are in progress. If TransferStatus is `read`, then an asynchronous read operation is in progress. If TransferStatus is `write`, then an asynchronous write operation is in progress. If TransferStatus is `read&write`, then both an asynchronous read and an asynchronous write operation are in progress.

You can write data asynchronously using the `fprintf` or `fwrite` functions. You can read data asynchronously using the `readasync` function, or by configuring ReadAsyncMode to `continuous` (serial, TCPIP, UDP, and VISA-serial objects only). For detailed information about asynchronous read and write operations, refer to "Communicating with Your Instrument" on page 2-8.

While `readasync` is executing for any instrument object, TransferStatus might indicate that data is being read even though data is not filling the input buffer. However, if ReadAsyncMode is `continuous`, TransferStatus indicates that data is being read only when data is actually filling the input buffer.

Characteristics

Usage	Any instrument object
Read only	Always
Data type	String

Values

{idle}	No asynchronous operations are in progress.
read	An asynchronous read operation is in progress.
write	An asynchronous write operation is in progress.
read&write	Asynchronous read and write operations are in progress.

See Also

Functions

`fprintf`, `fwrite`, `readasync`

Properties

`ReadAsyncMode`

TriggerFcn

Purpose   Specify M-file callback function to execute when trigger event occurs

Description   You configure `TriggerFcn` to execute an M-file callback function when a trigger event occurs. A trigger event is generated when a trigger occurs in software, or on one of the VXI hardware trigger lines. You configure the trigger type with the `TriggerType` property.

> **Note** A trigger event can be generated at any time during the instrument control session.

If the `RecordStatus` property value is on, and a trigger event occurs, the record file records

- The event type as `Trigger`
- The time the event occurred using the format day-month-year hour:minute:second:millisecond

Characteristics

Usage	VISA-VXI
Read only	Never
Data type	String

Values   The default value is an empty string.

See Also   **Functions**

`record`

Properties

`RecordStatus, TriggerLine, TriggerType`

Purpose   Specify trigger line on VXI instrument

Description   You can configure `TriggerLine` to be `TTL0` through `TTL7`, `ECL0`, or `ECL1`. You can use only one trigger line at a time.

You can specify the trigger type with the `TriggerType` property. When `TriggerType` is `hardware`, the line triggered is given by the `TriggerLine` value. When the `TriggerType` is `software`, the `TriggerLine` value is ignored.

You execute a trigger for a VISA-VXI object with the `trigger` function.

Characteristics

Usage	VISA-VXI
Read only	Never
Data type	String

Values   `TriggerLine` can be `TTL0` through `TTL7`, `ECL0`, or `ECL1`. The default value is `TTL0`.

See Also   **Functions**

`trigger`

Properties

`TriggerType`

TriggerType

Purpose   Specify trigger type

Description   You can configure `TriggerType` to be `software` or `hardware`. If `TriggerType` is `software`, then a software trigger is used. If `TriggerType` is `hardware`, then the trigger line specified by the `TriggerLine` property is used.

You execute a trigger for a VISA-VXI object with the `trigger` function.

Characteristics

Usage	VISA-VXI
Read only	Never
Data type	String

Values

{hardware}	A hardware trigger is used.
software	A software trigger is used.

See Also   **Functions**

`trigger`

Properties

`TriggerLine`

Purpose   Instrument object type

Description   Type indicates the type of the object. Type is automatically defined after the instrument object is created with the serial, gpib, or visa function.

Using the instrfind function and the Type value, you can quickly identify instrument objects of a given type.

Characteristics

Usage	Any instrument object
Read only	Always
Data type	String

Values

gpib	The object type is GPIB.
serial	The object type is serial port.
tcpip	The object type is TCPIP.
udp	The object type is UDP.
visa-gpib	The object type is VISA-GPIB.
visa-vxi	The object type is VISA-VXI.
visa-gpib-vxi	The object type is VISA-GPIB-VXI.
visa-serial	The object type is VISA-serial.

The value is automatically determined when the instrument object is created.

Type

Examples   Create a serial port object associated with the serial port COM1. The value of the Type property is serial, which is the object class.

```
s = serial('COM1');
s.Type
ans =
serial
```

See Also   **Functions**

instrfind, gpib, serial, tcpip, udp, visa

Purpose   Specify data to associate with instrument object

Description You configure UserData to store data that you want to associate with an instrument object. The object does not use this data directly, but you can access it using the get function or the dot notation.

Characteristics

Usage	Any instrument object
Read only	Never
Data type	Any type

Values   The default value is an empty vector.

Examples   Suppose you create the serial port object associated with the serial port COM1.

```
s = serial('COM1');
```

You can associate data with s by storing it in UserData.

```
coeff.a = 1.0;
coeff.b = -1.25;
s.UserData = coeff
```

ValuesReceived

Purpose   Total number of values read from instrument

Description   `ValuesReceived` indicates the total number of values read from the instrument. The value is updated after each successful read operation, and is set to `0` after the `fopen` function is issued. If the terminator is read from the instrument, then this value is reflected by `ValuesReceived`.

If you are reading data asynchronously, use the `BytesAvailable` property to return the number of bytes currently available in the input buffer.

When performing a read operation, the received data is represented by values rather than bytes. A value consists of one or more bytes. For example, one `uint32` value consists of four bytes. Refer to "The Output Buffer and Data Flow" on page 3-13 for more information about bytes and values.

Characteristics

Usage	Any instrument object
Read only	Always
Data type	Double

Values   The default value is `0`.

Examples   Suppose you create a serial port object associated with the serial port COM1.

```
s = serial('COM1');
fopen(s)
```

If you write the RS232? command, and then read back the response using fscanf, ValuesReceived is 17 because the instrument is configured to send the LF terminator.

```
fprintf(s,'RS232?')
out = fscanf(s)
out =
9600;0;0;NONE;LF
s.ValuesReceived
ans =
    17
```

See Also

Functions

fopen

Properties

BytesAvailable

ValuesSent

Purpose   Total number of values written to instrument

Description   `ValuesSent` indicates the total number of values written to the
                     instrument. The value is updated after each successful write operation,
                     and is set to `0` after the `fopen` function is issued. If you are writing the
                     terminator, then `ValuesSent` reflects this value.

                     If you are writing data asynchronously, use the `BytesToOutput` property
                     to return the number of bytes currently in the output buffer.

                     When performing a write operation, the transmitted data is represented
                     by values rather than bytes. A value consists of one or more bytes. For
                     example, one `uint32` value consists of four bytes. Refer to "The Output
                     Buffer and Data Flow" on page 3-13 for more information about bytes
                     and values.

Characteristics

Usage	Any instrument object
Read only	Always
Data type	Double

Values   The default value is `0`.

Examples   Suppose you create a serial port object associated with the serial port
                     COM1.

```
s = serial('COM1');
fopen(s)
```

If you write the *IDN? command using the fprintf function, then ValuesSent is 6 because the default data format is %s\n, and the terminator was written.

```
fprintf(s,'*IDN?')
s.ValuesSent
ans =
    6
```

See Also   **Functions**

fopen

Properties

BytesToOutput

Vendor

Purpose　　　IVI configuration server vendor

Description　　Vendor identifies the vendor of the IVI configuration server. This is not user-configurable.

Characteristics

Usage	IVI configuration store object
Read only	Always
Data type	String

Blocks — Alphabetical List

Query Instrument

Purpose   Query or read instrument data

Library   Instrument Control Toolbox

Description   The Query Instrument block configures and opens an interface to an
instrument, initializes the instrument, and queries the instrument for
data. The configuration and initialization happen at the start of the
model execution. The block queries the instrument for data during
model run-time.

The block as no input ports. The block has one output port corresponding
to the data received from the instrument.

Dialog Box

Block sample time
The Block sample time is the only parameter setting outside of
the dialog tabs. The default value of -1 sets the block to inherit
timing. A positive value is used as the sample period.

The other parameters of the Query Instrument block are divided among
three tabs:

- Hardware Configuration

- Instrument Initialization

- Query

Following is an illustration of each tab, and descriptions of the
parameters that it controls.

Hardware Configuration

The **Hardware Configuration** tab is where you define the settings
for communications with your instrument. You have two choices about
establishing an interface:

- Specify new hardware configuration

- Use interface object from MATLAB workspace

The following figure shows the **Hardware Configuration** tab set to specify a new hardware configuration using a serial port interface.

Because some of these parameters apply to more than one interface type, they appear here in alphabetical order.

Baudrate

   The rate at which bits are transmitted for the serial or VISA serial interface.

Board index

   The index of the board used for GPIB, VISA GPIB, VISA TCPIP, or VISA USB interface to the instrument.

Query Instrument

Board vendor

The vendor of the GPIB board used for the interface to the instrument. Your choices are Advantech, Agilent, Capital Equipment, Contec, ICS, IOTech, Keithley, Measurement Computing, and National Instruments.

Chassis index

The index number of the VXI chassis. Used for VISA VXI and VISA VXI-GPIB interface types.

Input buffer size

The total number of bytes that can be stored in the software input buffer during a read operation.

Interface

Select the type of hardware interface to the instrument. Your options are those interfaces supported by the Instrument Control Toolbox. The previous figure shows a configuration for a serial port interface.

Logical address

The logical address of the VXI instrument. Used for VISA VXI and VISA VXI-GPIB interface types.

Manufacturer ID

The manufacturer ID of the VISA USB instrument.

Model code

The model code of the VISA USB instrument.

Port

The port for the serial interface: COM1, COM2, etc.

Primary address

The primary address of the instrument on the GPIB.

Remote host

The hostname or IP address of the instrument. Used for UDP, TCPIP, or VISA TCPIP interface types.

Remote port

> The port on the instrument or remote host used for communication. Used for UDP, TCPIP, or VISA TCPIP interface types.

Secondary address

> The secondary address of the instrument on the GPIB.

Serial number

> The serial number of the VISA USB instrument.

Timeout

> Time allowed to complete the query operation.

VISA vendor

> The vendor of the VISA used for any of the VISA interface types. Your choices are Agilent, National Instruments, and Tektronix.

Instrument Initialization

The **Instrument Initialization** tab is where you define what happens when you first open your connection to the instrument.

Query Instrument

None

    The default initialization option is none.

Send string

    A string sent to the instrument as an instrument command to initialize the instrument or set it up in a known state.

Execute function

    Any function that has as its only argument the interface object representing the instrument. You can write this function to include several instrument commands and initialization data.

Query

The **Query** tab is where you define the optional query command, set the format for the response, and define what the block does after the initial instrument response.

Query command

> This is the query command that is sent to the instrument. It is usually a request for instrument status or data. *This command is optional*—If you are retrieving information or data from the instrument and no query command is necessary to do that, you can leave this field blank.

Query Instrument

Data format

Your options are ASCII, Binary, or Binblock.

ASCII format string

Available only when the format is ASCII, this defines the format string for the data. For a list of formats, see the `fscanf` function.

Precision

Used for binary or binblock format. Your options are 8-bit, 16-bit, or 32-bit integer; 8-bit, 16-bit, or 32-bit unsigned integer; or 32-bit or 64-bit float.

Byte order

When using binary or binblock format with more than 8 bits, this specifies the instrument's byte order for the data. Your options are Big Endian or Little Endian.

Binary values to read

Used for binary format. Specify the number of binary values to read from the instrument.

After initial response

This defines the action to take after the first response from the instrument. Your options are Repeat query for new data, Recycle original data, Hold final value, Output zero, or Stop simulation.

Enable frame output

A frame is a sequence of samples combined into a single vector. In frame-based processing all the samples in a frame are processed simultaneously. In sample-based processing, samples are processed one at a time. The advantage of frame-based processing is that it can greatly increase the speed of a simulation. For example, you might use frames if you are reading a waveform from your instrument rather than a single-point measurement.

Frame size

Frame size determines the number of samples in a frame.

Note Hardware information shown in the dialog box is determined
and cached when the dialog box is first opened. To refresh the display
with new values, restart MATLAB.

See Also   To Instrument

To Instrument

Purpose   Send simulation data to instrument

Library   Instrument Control Toolbox

Description The To Instrument block configures and opens an interface to
an instrument, initializes the instrument, and sends data to the
instrument. The configuration and initialization happen at the start
of the model execution. The block sends data to the instrument during
model run-time.

The block as no output ports. The block has one input port corresponding
to the data sent to the instrument.

Dialog   **Block sample time**
Box   The Block sample time is the only parameter setting outside of
       the dialog tabs. The default value of -1 sets the block to inherit
       timing. A positive value is used as the sample period.

The other parameters of the To Instrument block are divided among
three tabs:

- Hardware Configuration

- Instrument Initialization

- Send

Following is an illustration of each tab, and descriptions of the
parameters that it controls.

Hardware Configuration

The **Hardware Configuration** tab is where you define the settings
for communications with your instrument. You have two choices about
establishing an interface:

- Specify new hardware configuration

- Use interface object from MATLAB workspace

The following figure shows the **Hardware Configuration** tab set to specify a new hardware configuration using a serial port interface.

Because some of these parameters apply to more than one interface type, they appear here in alphabetical order.

Baudrate

The rate at which bits are transmitted for the serial or VISA serial interface.

Board index

The index of the board used for GPIB, VISA GPIB, VISA TCPIP, or VISA USB interface to the instrument.

Board vendor

The vendor of the GPIB board used for the interface to the instrument. Your choices are Advantech, Agilent, Capital Equipment, Contec, ICS, IOTech, Keithley, Measurement Computing, and National Instruments.

To Instrument

Chassis index

The index number of the VXI chassis. Used for VISA VXI and VISA VXI-GPIB interface types.

Input buffer size

The total number of bytes that can be stored in the software input buffer during a read operation.

Interface

Select the type of hardware interface to the instrument. Your options are those interfaces supported by the Instrument Control Toolbox. The previous figure shows a configuration for a serial port interface.

Logical address

The logical address of the VXI instrument. Used for VISA VXI and VISA VXI-GPIB interface types.

Manufacturer ID

The manufacturer ID of the VISA USB instrument.

Model code

The model code of the VISA USB instrument.

Port

The port for the serial interface: COM1, COM2, etc.

Primary address

The primary address of the instrument on the GPIB.

Remote host

The hostname or IP address of the instrument. Used for UDP, TCPIP, or VISA TCPIP interface types.

Remote port

The port on the instrument or remote host used for communication. Used for UDP, TCPIP, or VISA TCPIP interface types.

Secondary address

The secondary address of the instrument on the GPIB.

Serial number

> The serial number of the VISA USB instrument.

Timeout

> Time allowed to complete the query operation.

VISA vendor

> The vendor of the VISA used for any of the VISA interface types. Your choices are Agilent, National Instruments, and Tektronix.

Instrument Initialization

The **Instrument Initialization** tab is where you define what happens when you first open your connection to the instrument.

None

> The default initialization option is none.

Send string

>   A string sent to the instrument as an instrument command to
>   initialize the instrument or set it up in a known state.

Execute function

>   Any function that has as its only argument the interface object
>   representing the instrument. You can write this function to
>   include several instrument commands and initialization data.

Send

The **Send** tab is where you define the optional command sent to the
instrument and the format of the sent data.

Command

>   This is the command that is sent to the instrument with the
>   Simulink data. *This command is optional*—If you leave this field

blank, the Simulink data is sent to the instrument without any prefix or additional formatting.

Output format

Your options are ASCII, Binary, or Binblock.

ASCII format string

Available only when the format is ASCII, this defines the format string for the data. For a list of formats, see the `fprintf` function.

Precision

Used for binary or binblock format. Your options are 8-bit, 16-bit, or 32-bit integer; 8-bit, 16-bit, or 32-bit unsigned integer; or 32-bit or 64-bit float.

Byte order

When using binary or binblock format with more than 8 bits, this specifies the instrument's byte order for the data. Your options are Big Endian or Little Endian.

Note Hardware information shown in the dialog box is determined and cached when the dialog box is first opened. To refresh the display with new values, restart MATLAB.

See Also   Query Instrument

Vendor Driver Requirements and Limitations

This appendix describes the requirements and limitations for the vendor GPIB and VISA drivers supported by the Instrument Control Toolbox.

Note The limitations described in this appendix are restricted to the limitations directly associated with using the Instrument Control Toolbox.

Driver Requirements

You can use the Instrument Control Toolbox with the GPIB and VISA drivers listed below.

Interface	Vendor	Minimum Driver Requirements
GPIB	Advantech	Advantech version 1.0
	Agilent	SICL version H.012.02.00
	Capital Equipment Corporation	CEC-488 version 5.08
	CONTEC	API-GPLV version 1.33
	ICS Electronics	ICS 488.2 version 2.0.3.15
	IOTech	IOTech version 1.0
	Keithley	Keithley-488 version 5.08
	Measurement Computing Corporation	GPIB-32 version 2.12
	National Instruments	NI-488 version 1.6
VISA	Agilent	Agilent IO Libraries version M.01.01.04
	National Instruments	NI-VISA version 3.0
	Tektronix	Tektronix VISA version 2.0

See the following sections for a description of

- "GPIB Driver Limitations" on page A-3
- "VISA Driver Limitations" on page A-7

GPIB Driver Limitations

This section lists the GPIB driver limitations categorized by vendor:

Advantech

The Advantech GPIB driver has these limitations:

- Asynchronous read and write operations are not supported. Therefore, Advantech GPIB objects do not support the following toolbox functionality:
  - The `readasync` function
  - The `async` flag for the `fprintf` and `fwrite` functions
  - `BytesAvailableAction` and `OutputEmptyAction` properties

Agilent Technologies

The Agilent GPIB driver has these limitations:

- Asynchronous read and write operations are not supported. Therefore, Agilent GPIB objects do not support the following toolbox functionality:
  - The `readasync` function
  - The `async` flag for the `fprintf` and `fwrite` functions
  - `BytesAvailableAction` and `OutputEmptyAction` properties
- The End Or Identify (EOI) line is not asserted when the End-Of-String (EOS) character is written to the hardware. Therefore, when the `EOSMode` property is configured to `write` and the `EOIMode` property is configured to

on, the EOI line is not asserted when the `EOSCharCode` property value is written to the hardware.

- All eight bits are used for the EOS comparison. Therefore, the only value supported by the `CompareBits` property is 8.

- A board index value of 0 is not supported.

- An error is not reported for an invalid primary address. Instead, the read and write operations will time out.

Capital Equipment Corporation

The Capital Equipment Corporation (CEC) GPIB driver has these limitations:

- Asynchronous read operations are not supported. Therefore, CEC GPIB objects do not support the following toolbox functionality:

  - The `readasync` function

  - The `async` flag for the `fprintf` and `fwrite` functions

  - The `BytesAvailableAction` and `OutputEmptyAction` properties

- The Handshake and Bus Management line values are not provided. The `BusManagementStatus` and `HandshakeStatus` properties always return the line values as on.

- The EOI line is not asserted when the EOS character is written to the hardware. Therefore, when the `EOSMode` property is configured to `write` and the `EOIMode` property is configured to `on`, the EOI line is not asserted when the `EOSCharCode` property value is written to the hardware.

- All eight bits are used for the EOS comparison. Therefore, the only value supported by the `CompareBits` property is 8.

- You should not simultaneously use a GPIB controller address of 0 and an instrument primary address of 0.

ICS Electronics

The ICS Electronics GPIB adaptor only works with their USB GPIB controller. However, you can still use their other controllers (PCI/PCMCIA) by using the `mcc` adaptor. See Solution 1-1BFZ2 on the MathWorks support Web site.

IOTech

The IOTech GPIB driver has these limitations:

- Asynchronous read and write operations are not supported. Therefore, IOTech GPIB objects do not support the following toolbox functionality:
  - The `readasync` function
  - The `async` flag for the `fprintf` and `fwrite` functions
  - The `BytesAvailableAction` and `OutputEmptyAction` properties.
- Incorrect values are returned for the REN and IFC bus management lines. The `BusManagementStatus` property always returns a value of `on` for the `RemoteEnable` and the `InterfaceClear` fields.
- The EOI line is not asserted when the EOS character is written to the hardware. Therefore, when the `EOSMode` property is configured to `write` and the `EOIMode` property is configured to `on`, the EOI line will not be asserted when the `EOSCharCode` property value is written to the hardware.

Keithley

The Keithley GPIB driver has these limitations:

- Asynchronous read and write operations are not supported. Therefore, Keithley GPIB objects do not support the following toolbox functionality:
  - The `readasync` function
  - The `async` flag for the `fprintf` and `fwrite` functions
  - The `BytesAvailableAction` and `OutputEmptyAction` properties
- The Handshake and Bus Management line values are not provided. The `BusManagementStatus` and `HandshakeStatus` properties always return the line value as `on`.
- The EOI line is not asserted when the EOS character is written to the hardware. Therefore, when the `EOSMode` property is configured to `write` and the `EOIMode` property is configured to `on`, the EOI line will not be asserted when the `EOSCharCode` property value is written to the hardware.
- All eight bits are used for the EOS comparison. Therefore, the only value supported by the `CompareBits` property is `8`.

- You should not simultaneously use a GPIB controller address of 0 and an instrument primary address of 0.

Measurement Computing Corporation

The Measurement Computing Corporation GPIB driver does not support asynchronous notification for the completion of read and write operations. Therefore, Measurement Computing Corporation GPIB objects do not support the following toolbox functionality:

- The `readasync` function
- The `async` flag for the `fprintf` and `fwrite` functions
- The `BytesAvailableAction` and `OutputEmptyAction` properties

VISA Driver Limitations

This section lists the VISA driver limitations categorized by vendor:

Agilent Technologies

The Agilent VISA driver has these known limitations:

- Asynchronous read and write operations for GPIB, GPIB-VXI and VXI VISA objects are not supported. Therefore, the following toolbox functionality is not supported for these objects:

  - The `readasync` function

  - The `BytesAvailableAction` and `OutputEmptyAction` properties

- All eight bits are used for the EOS comparison. Therefore, the only value supported by the `CompareBits` property is `8`.

National Instruments

The National Instruments VISA driver uses all eight bits for the EOS comparison. Therefore, the only value that the `CompareBits` property supports is `8.x`

B

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