# Instrument Control Toolbox

For Use with MATLAB®

Computation

Visualization

Programming

User's Guide

*Version 1*

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*Instrument Control Toolbox User's Guide*

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# Preface

This chapter provides a brief overview of the Instrument Control Toolbox, as well as information about this documentation set. 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, the TCP/IP or UDP protocols, and the serial port interface (RS-232, RS-422, and RS-485). Note that the toolbox extends the basic serial port features included with MATLAB.
- Functions for transferring data between MATLAB and your instrument:
  - The data can be binary (numerical) or text.
  - Text data can be any command used by your instrument such as a command given by the Standard Commands for Programmable Instruments (SCPI) language.
  - The transfer can be synchronous and block the MATLAB command line, or asynchronous and not block 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

## Exploring the 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.

# Related Products

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 either

- The online documentation for that product if it is installed or if you are reading the documentation from the CD
- The MathWorks Web site, at `http://www.mathworks.com`; see the "products" section

The toolboxes listed below all include functions that extend the capabilities of MATLAB.

| Product | Description |
|---|---|
| Data Acquisition Toolbox | Acquire and send out data from plug-in data acquisition boards |
| Database Toolbox | Exchange data with relational databases |
| MATLAB Report Generator | Automatically generate documentation for MATLAB applications and data |
| Signal Processing Toolbox | Perform signal processing, analysis, and algorithm development |
| Statistics Toolbox | Apply statistical algorithms and probability models |
| System Identification Toolbox | Create linear dynamic models from measured input-output data |
| Wavelet Toolbox | Analyze, compress, and denoise signals and images using wavelet techniques |

# Using This Guide

## Expected Background

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

- The basic features of MATLAB
- The commands used to communicate with your instrument; these commands might use the SCPI language or some other vendor-specific language
- The features of the interface associated with your instrument

## Learning the Instrument Control Toolbox

Start with Chapter 1, "Getting Started with the Instrument Control Toolbox," 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. These chapters are described in the next section.

If you want detailed information about a specific function, refer to Chapter 8, "Function Reference." If you want detailed information about a specific property, refer to Chapter 9, "Property Reference."

### Using the Documentation Examples with Your Instrument

The examples in this guide use specific peripheral 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.

If your instrument accepts different string commands, or if your hardware is configured to use different address information, then you should modify the examples accordingly.

## How This Guide Is Organized

The organization of this guide is described below.

| Chapter | Description |
|---|---|
| Getting Started | Describes how to get started with the Instrument Control Toolbox. Topics include examining your hardware resources and communicating with your instrument. |
| The Instrument Control Session | Describes all the steps you are likely to take when communicating with your instrument. |
| Controlling GPIB Instruments | Shows you how to use the toolbox to communicate with instruments that support the GPIB interface. |
| Controlling Instruments Using the VISA Standard | Shows you how to use the toolbox to communicate with instruments that support the VISA standard. |
| Controlling Serial Port Instruments | Shows you how to use the toolbox to communicate with instruments that support the serial port interface. |
| Saving and Loading the Session | Shows you how to save your work to an M-file, a MAT-file, or a text file. |
| Function Reference | Presents a complete description of all toolbox functions. |
| Property Reference | Presents a complete description of all toolbox properties. |
| Selected Bibliography | Presents a list of references for exploring instrumentation standards and hardware. |

# Installation Information

To communicate with your instrument from the MATLAB environment, you must install these components:

- MATLAB 6.5 (Release 13)
- The Instrument Control Toolbox

Additionally, you might need to install hardware such as a GPIB controller and software such as drivers, support libraries, and so on. For a complete listing of all supported vendors, refer to "The Interface Driver Adaptor" on page 1-4.

## 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 *MATLAB Installation Guide* for your platform. If you experience installation difficulties and have Web access, 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 the Instrument Control Toolbox Release Notes.

---

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

---

# Typographical Conventions

This manual uses some or all of these conventions.

| Item | Convention | Example |
|---|---|---|
| Example code | `Monospace` font | To assign the value 5 to `A`, enter<br>`A = 5` |
| Function names, syntax, filenames, directory/folder names, and user input | `Monospace` font | The `cos` function finds the cosine of each array element.<br>Syntax line example is<br>`MLGetVar ML_var_name` |
| Buttons and keys | **Boldface** with book title caps | Press the **Enter** key. |
| Literal strings (in syntax descriptions in reference chapters) | **`Monospace bold`** for literals | `f = freqspace(n,'whole')` |
| Mathematical expressions | *Italics* for variables<br>Standard text font for functions, operators, and constants | This vector represents the polynomial $p = x^2 + 2x + 3$. |
| MATLAB output | `Monospace` font | MATLAB responds with<br>`A =`<br>`5` |
| Menu and dialog box titles | **Boldface** with book title caps | Choose the **File Options** menu. |
| New terms and for emphasis | *Italics* | An *array* is an ordered collection of information. |
| Omitted input arguments | (...) ellipsis denotes all of the input/output arguments from preceding syntaxes. | `[c,ia,ib] = union(...)` |
| String variables (from a finite list) | *`Monospace italics`* | `sysc = d2c(sysd,'method')` |

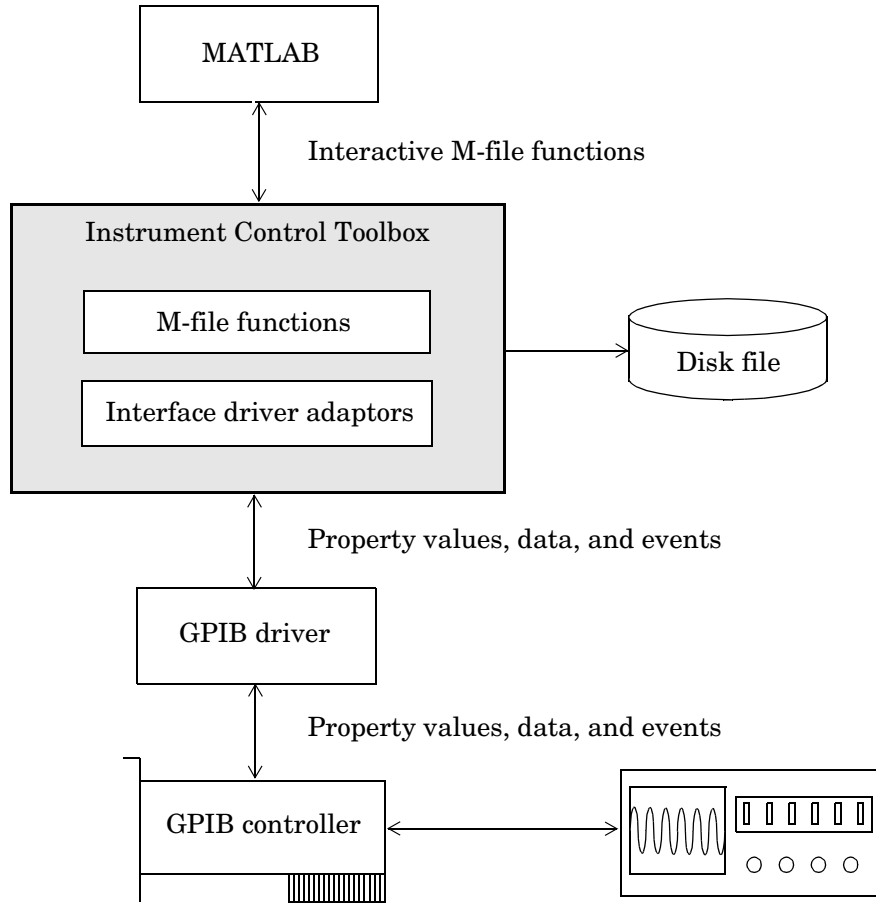
1

# Getting Started with the Instrument Control Toolbox

This chapter provides the information you need to get started with the Instrument Control Toolbox. The sections are as follows.

# 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. For example, 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
- Evaluate your application status and examine your hardware resources

For a listing of all Instrument Control Toolbox functions, refer to Chapter 8, "Function Reference." You can also display all 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.

**Table 1-1: Supported Interfaces and Adaptor Names**

| Interface | Adaptor Name |
|---|---|
| GPIB | `agilent`, `cec`, `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 1-13, you can list the supported interfaces and adaptor names with the `instrhwinfo` function. For a list of vendor driver requirements and limitations, refer to the Instrument Control Toolbox Release Notes.

# Communicating with Your Instrument

Perhaps the most effective way to get started with the Instrument Control Toolbox is to communicate with your instrument. This section provides simple examples that show you how to communicate with a

- GPIB instrument
- GPIB-VXI instrument
- Serial port instrument

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 8, "Function Reference." If you want detailed information about any properties that are used, refer to Chapter 9, "Property Reference."

## 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 outputting 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 3, "Controlling GPIB Instruments."

1 **Create an instrument 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 6 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 the VISA standard, refer to Chapter 4, "Controlling Instruments Using the VISA Standard."

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
```

## 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 5, "Controlling Serial Port Instruments."

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
```

# 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:

- The `Contents` M-file
- Documentation examples
- Demos

## The Contents M-File

The `Contents` M-file lists the toolbox functions and demos. You can display this information by typing

```
help instrument
```

## 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, then you should modify the examples accordingly.

## Demos

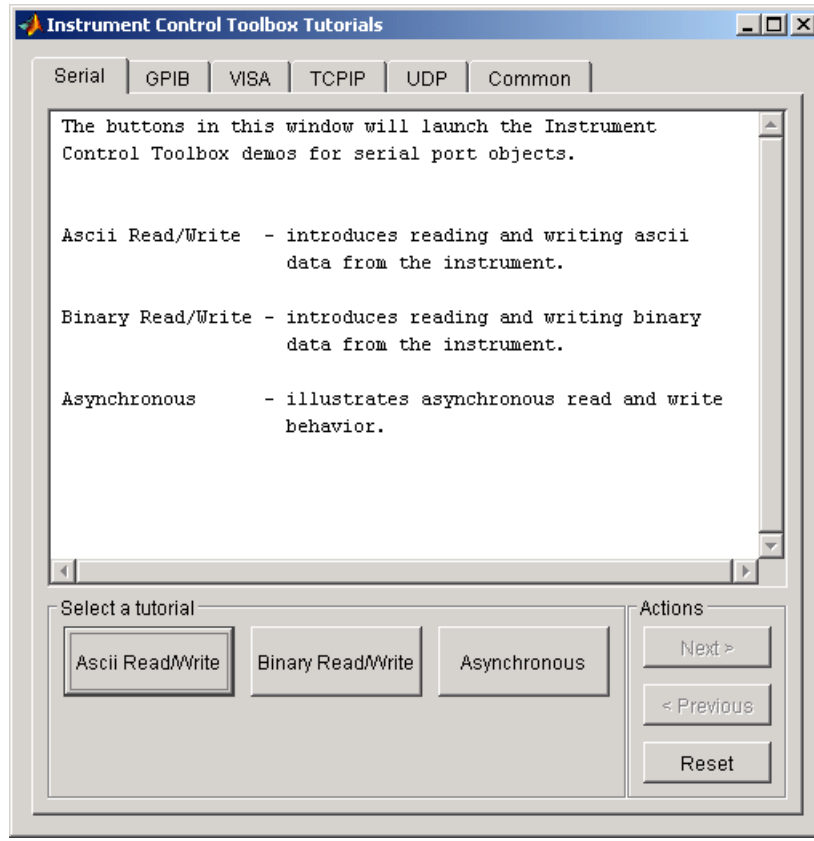
The toolbox includes a large collection of demos, which are divided into two main groups: command line tutorials and graphical applications. You can access all demos through the Help browser's Demos pane. Use the following command to open the Help browser to the toolbox demos.

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

For your convenience, the command line tutorials are collected together using a graphical user interface (GUI). To open this GUI directly from the command line, type

```
instrschool
```

The `instrschool` GUI is shown below.




---

**Note** `instrschool` uses prerecorded data. Therefore, you do not need an instrument connected to your computer to use these demos.

---

All demos have associated M-files, which are listed below. To run a particular demo, type the M-file name at the command line.

### Common Demos

The common demos illustrate features that are common to all supported instrument objects. These demos are listed below.

| Demo Name | Description |
|---|---|
| `democ_callback` | How to use callback properties and functions |
| `democ_intro` | How to get started with the toolbox |
| `democ_record` | How to record data and event information to disk fil |
| `democ_save` | How to save or load an instrument control session |
| `instrcomm` | Graphical tool for communicating with an instrument using text data |
| `instrcreate` | Graphical tool for creating an instrument object |

### GPIB Demos

The GPIB demos are listed below.

| Demo Name | Description |
|---|---|
| `demog_ascii` | How to read and write ASCII (text) data |
| `demog_async` | How to read and write data asynchronously |
| `demog_binary` | How to read and write binary (numerical) data |

### Serial Port Demos

The serial port demos are listed below.

| Demo Name | Description |
|---|---|
| `demos_ascii` | How to read and write ASCII (text) data |
| `demos_async` | How to read and write data asynchronously |
| `demos_binary` | How to read and write binary (numerical) data |

### TCP/IP Demos

The TCP/IP demos are listed below.

| Demo Name | Description |
|---|---|
| `demot_ascii` | How to read and write ASCII (text) data |
| `demot_async` | How to read and write data asynchronously |
| `demot_binary` | How to read and write binary (numerical) data |

### UDP Demos

The UDP demos are listed below.

| Demo Name | Description |
|---|---|
| `demou_ascii` | How to read and write ASCII (text) data |
| `demou_async` | How to read and write data asynchronously |
| `demou_binary` | How to read and write binary (numerical) data |

### VISA Demos

The VISA demos are listed below.

| Demo Name | Description |
|---|---|
| `demov_ascii` | How to read and write ASCII (text) data |
| `demov_async` | How to read and write data asynchronously |
| `demov_binary` | How to read and write binary (numerical) data |
| `demov_intro` | Describes the VISA standard and the supported communication interfaces |
| `demov_register` | How to use register-based functionality to communicate with VXI instruments |

# Examining Your Hardware Resources

You can examine the hardware-related resources visible to the toolbox with the `instrhwinfo` function. The returned information includes the installed adaptors and the syntax for creating instrument objects. For instruments associated with the VISA standard, `instrhwinfo` also returns address information such as the GPIB board index, the VXI logical address, the VXI chassis, and so on.

The specific information returned by `instrhwinfo` depends on the supplied arguments, and is divided into these four categories:

- General toolbox information
- Interface information
- Adaptor information
- Instrument object information

## General Toolbox Information

To display general information about the Instrument Control Toolbox:

```
out = instrhwinfo

           MATLABVersion: '6.5 (R13)'
    SupportedInterfaces: {'gpib'  'serial'  'visa'  'tcpip'  'udp'}
             ToolboxName: 'Instrument Control Toolbox'
          ToolboxVersion: '1.2 (R13)'
```

The `SupportedInterfaces` field lists the interfaces supported by the toolbox, but not necessarily the interfaces installed on your computer.

## Interface Information

To display information about a specific interface, you must supply the interface name as an argument to `instrhwinfo`. The interface name can be `gpib`, `serial`, `tcpip`, `udp`, or `visa`. For the serial port interface, the returned information includes the available serial ports. For the GPIB and VISA interfaces, the returned information includes the installed adaptors. 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 1.2 (R13)'
```

The `InstalledAdaptors` field indicates that the Measurement Computing Corporation and National Instruments drivers are installed. This means that it is possible to communicate with instruments using GPIB controllers from these vendors.

## Adaptor Information

To display information about a specific installed adaptor, you must 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` | `agilent`, `cec`, `iotech`, `keithley`, `mcc`, `ni` |
| `visa` | `agilent`, `ni`, `tek` |

The returned information describes the adaptor, the vendor driver, and the object constructor(s). For example, to display information for the National Instruments GPIB adaptor:

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

ghwinfo =

            AdaptorDllName: [1x81 char]
         AdaptorDllVersion: 'Version 1.2 (R13)'
               AdaptorName: 'ni'
     ObjectConstructorName: 'gpib('ni', <BID>, <PR>)'
             VendorDllName: 'gpib-32.dll'
   VendorDriverDescription: 'NI-488'
```

The `ObjectConstructorName` field describes how you can create a GPIB object for the National Instruments adaptor. For example, to create the GPIB object `g` associated with a GPIB controller with board index `0` and an instrument with primary address `1`:

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

To display information for the Agilent Technologies VISA adaptor:

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

            AdaptorDllName: [1x62 char]
         AdaptorDllVersion: 'Version 1.2 (R13)'
               AdaptorName: 'AGILENT'
          AvailableChassis: 0
       AvailableSerialPorts: ''
          InstalledBoardIds: 0
       ObjectConstructorName: {7x1 cell}
                 SerialPorts: ''
              VendorDllName: 'hpvisa32.dll'
    VendorDriverDescription: 'Agilent Technologies VISA Driver'
        VendorDriverVersion: 1.1000
```

The available VISA object constructor names are shown below.

```
vhwinfo.ObjectConstructorName
ans =
    'visa('agilent', 'GPIB0::9::0::INSTR');'
    'visa('agilent', 'GPIB0::9::10::INSTR');'
    'visa('agilent', 'VXI0::0::INSTR');'
    'visa('agilent', 'VXI0::130::INSTR');'
    'visa('agilent', 'VXI0::32::INSTR');'
    'visa('agilent', 'GPIB-VXI0::0::INSTR');'
    'visa('agilent', 'GPIB-VXI0::80::INSTR');
```

The `ObjectConstructorName` field describes how you can create a VISA instrument object for instruments associated with the GPIB, VXI, and GPIB-VXI interfaces. For example, to create the VISA-VXI object `vv` associated with a VXI chassis with index `0` and an instrument with logical address `130`:

```
vv = visa('agilent','VXI0::130::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:

```
ghwinfo = instrhwinfo(g)
ghwinfo =

            AdaptorDllName: [1x56 char]
         AdaptorDllVersion: 'Version 1.2 (R13)'
               AdaptorName: 'NI'
             VendorDllName: 'gpib-32.dll'
    VendorDriverDescription: 'NI-488'
```

To display information for the VISA-VXI object created in the preceding section:

```
vvhwinfo = instrhwinfo(vv)
vvhwinfo =

            AdaptorDllName: [1x61 char]
         AdaptorDllVersion: 'Version 1.2 (R13)'
               AdaptorName: 'AGILENT'
             VendorDllName: 'hpvisa32.dll'
    VendorDriverDescription: 'Agilent Technologies VISA Driver'
        VendorDriverVersion: 1.1000
```

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

# Getting Help

The Instrument Control Toolbox provides you with these help resources:

- The HTML and PDF versions of this guide, which are available through the Help browser
- M-file function help, which you can display with the `help` command (because many toolbox functions are overloaded, you might need to specify the appropriate pathname as well)
- The `instrhelp` function
- The `propinfo` function

## 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 need not 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 **Explore -> 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 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. |

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

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

2

# The Instrument Control Session

The instrument control session consists of all the steps you are likely to take when communicating with your instrument. These steps are described in the following sections.

| | |
|---|---|
| Creating an Instrument Object (p. 2-2) | Create a MATLAB object that represents the instrument. |
| Connecting to the Instrument (p. 2-5) | Establish a connection between the object and the instrument. |
| Configuring and Returning Properties (p. 2-6) | Define the instrument object behavior by assigning values to properties. |
| Writing and Reading Data (p. 2-12) | Write data to the instrument and read data from the instrument. |
| Disconnecting and Cleaning Up (p. 2-25) | Disconnect the object from the instrument, and remove the object from memory and from the workspace. |

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

# Creating an Instrument Object

*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 instrument control application. Each instrument object is associated with a specific interface standard, one instrument, and possibly additional hardware such as a GPIB or VXI controller.

To create an instrument 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 "MATLAB Classes and Objects" in the Help browser. The supported instrument objects are listed below.

**Table 2-1: Instrument Object Creation Functions**

| Constructor | Description |
|---|---|
| `gpib` | Create a GPIB object. |
| `serial` | Create a serial port object. |
| `tcpip` | Create a TCP/IP 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 instrument 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', <BID>, <PR>)
```

The constructor syntax tells you that you must supply the GPIB controller's board index and the instrument's primary address to the `gpib` function. For example, to create a GPIB object with board index 0 and primary address 1:

```
g = 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 2-6, 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. However, if you specify a value that is not supported by your instrument, the object will be created but you will not be informed of the invalid value until you connect the object to the instrument with the `fopen` function. For example, suppose you configure the `BaudRate` property to `2`. Although this is a valid value for the property, it is an invalid value for the instrument.

For more information about configuring properties, refer to "Configuring and Returning Properties" on page 2-6. For detailed property descriptions, refer to Chapter 9, "Property Reference."

## Creating an Array of Instrument Objects

In MATLAB, you can create an array from existing variables by concatenating those variables together. 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 8, "Function Reference," 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 instrument object to the instrument with the `fopen` function.

```
fopen(g)
```

Some properties are read-only while the instrument 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 9, "Property Reference."

---

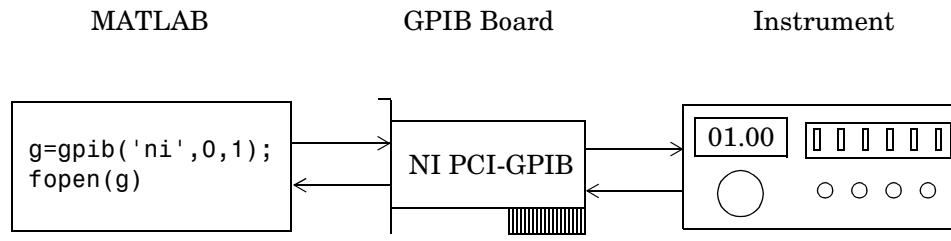
**Note** You can create any number of instrument objects. However, at any time, you can connect only one instrument object to an instrument with a given address or port.

---

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.

Instrument objects possess two types of properties: *base properties* and *object-specific properties*. Base properties are supported for all instrument objects (serial port, GPIB, VISA-VXI, and so on). For example, the `Timeout` property is supported for all instrument objects. Object-specific properties are supported only for instrument objects of a given 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 9, “Property Reference,” 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 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 9, "Property Reference" to find the default value for any property.

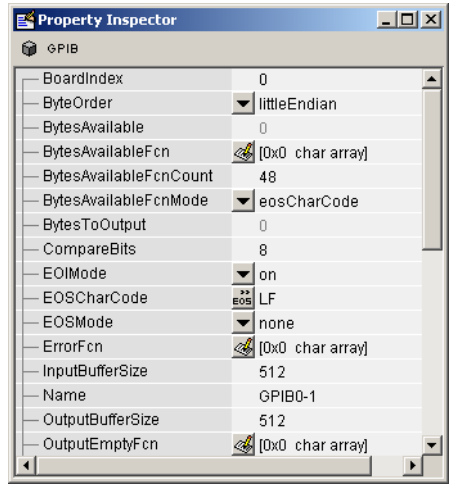
## The Property Inspector

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, or via the Workspace browser by right-clicking an instrument object and selecting **Explore -> Call Property Inspector** from the context menu.

The Property Inspector for the GPIB object g is shown below.



# 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 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.

**Table 2-2: 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.

**Table 2-3: 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]
```

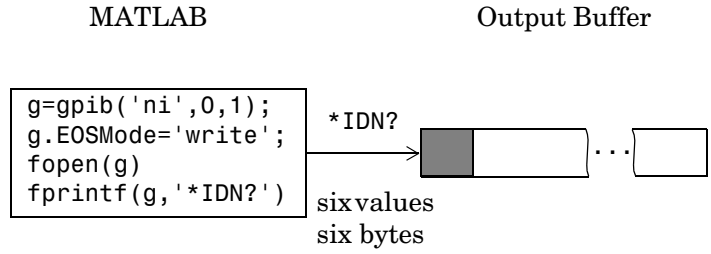
If you attempt to write more data than can fit in the output buffer, an error is returned and no data is written.

---

**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.

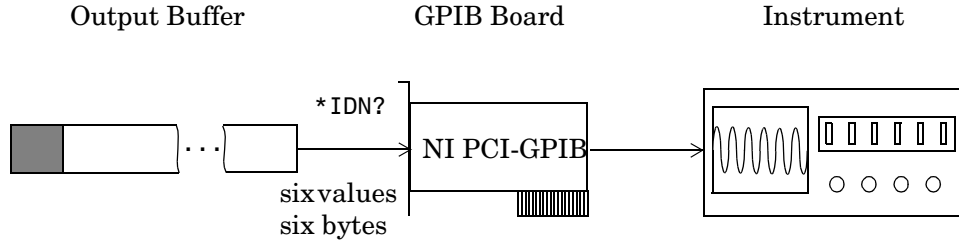



Bytes used during write

Bytes unused during write

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.




Bytes used during write

Bytes unused during write

### 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 `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 must supply the `async` input argument to the `fprintf` or `fwrite` functions.

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.

**Table 2-4: 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.

**Table 2-5: 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, TCP/IP, UDP, and VISA-serial objects only). |
| `Timeout` | Specify the waiting time to complete a read or write operation. |

**Table 2-5: 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:

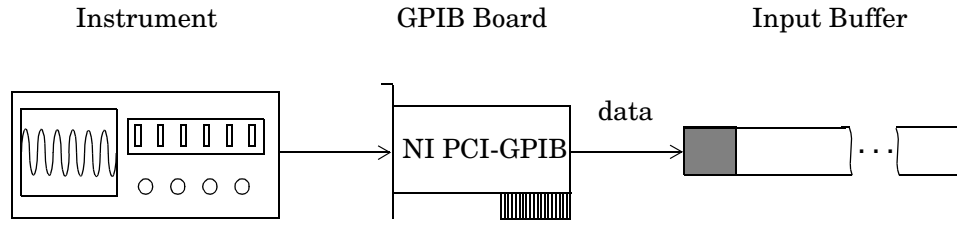
1. The data read from the instrument is stored in the input buffer.
2. The data in the input buffer is returned to the MATLAB variable specified by the read function.

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',0,1);
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.

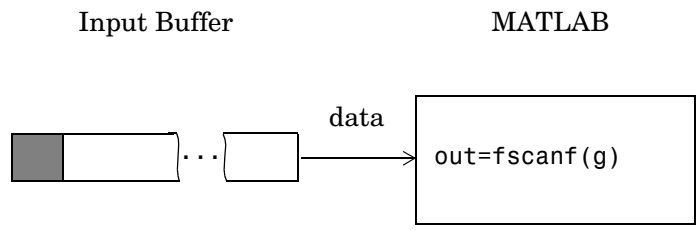



Bytes used during read

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`.




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 must 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 must use one of the synchronous read functions.

---

**Note** For serial port, TCP/IP, 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)
```

Before using `delete`, you must disconnect the object from the instrument with the `fclose` function.

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.

3

# Controlling GPIB Instruments

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

| | |
|---|---|
| GPIB Overview (p. 3-2) | Basic features of the General Purpose Interface Bus (GPIB). |
| Creating a GPIB Object (p. 3-18) | The GPIB object establishes a connection between MATLAB and the instrument via its GPIB interface. |
| Configuring the GPIB Address (p. 3-20) | The GPIB address consists of the board index of the GPIB controller, and the primary address and (optionally) the secondary address of the instrument. |
| Writing and Reading Data (p. 3-21) | Interface-specific issues related to writing and reading data with a GPIB object. |
| Events and Callbacks (p. 3-30) | Enhance your instrument control application using events and callbacks. |
| Triggers (p. 3-37) | 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. 3-39) | Execute a serial poll where the Controller asks (polls) all addressed Listeners 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?
- Important GPIB Features
- GPIB Lines
- Status and Event Reporting
- Using Vendor Tools to Identify and Test Your Resources

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 3-18. 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, refer to the appropriate references in Appendix A, "Selected Bibliography."

### The 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.

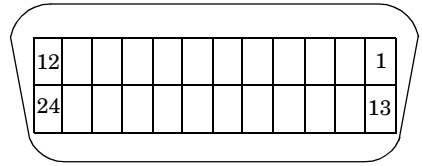
Data transfer consists of one byte (8 bits) sent in parallel.The data transfer rate across the interface is limited to 1 megabyte per second. However, this data rate is usually not achieved in practice, and is limited by the slowest device on the bus.

## 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.

**Table 3-1: 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 |
| 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.

**Table 3-2: 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. |
| 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.

**Table 3-3: 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 holds the NRFD line high and the NDAC line low indicating it is 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.

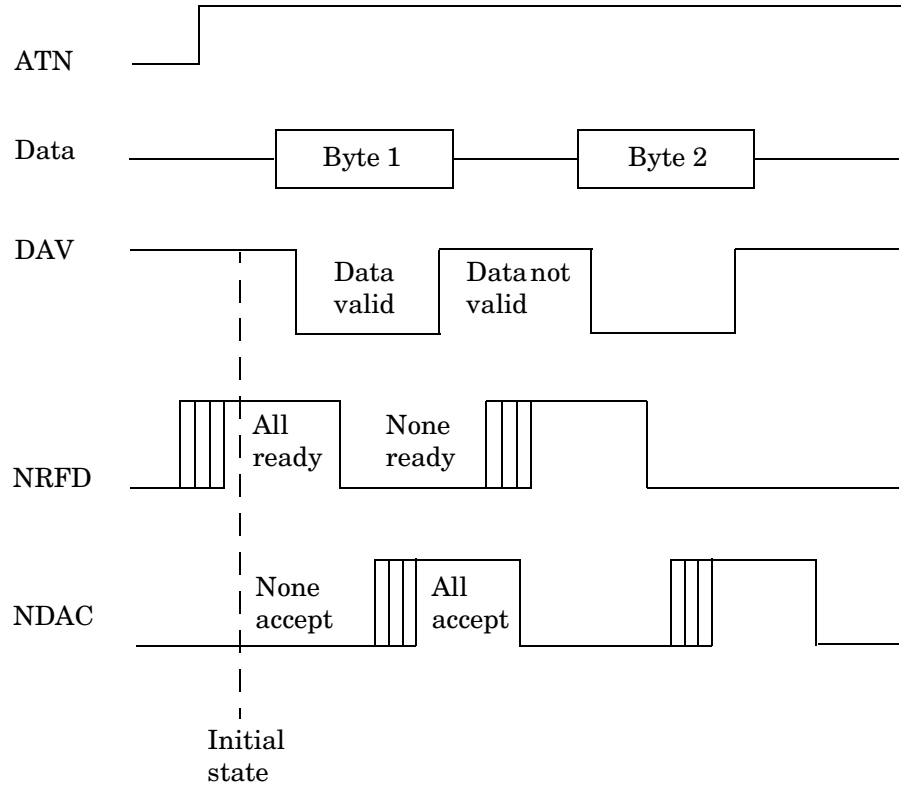
6 The Listeners hold the NRFD line high indicating they are ready to receive data again, and the NDAC line is held low indicating no data is accepted.

---

**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.



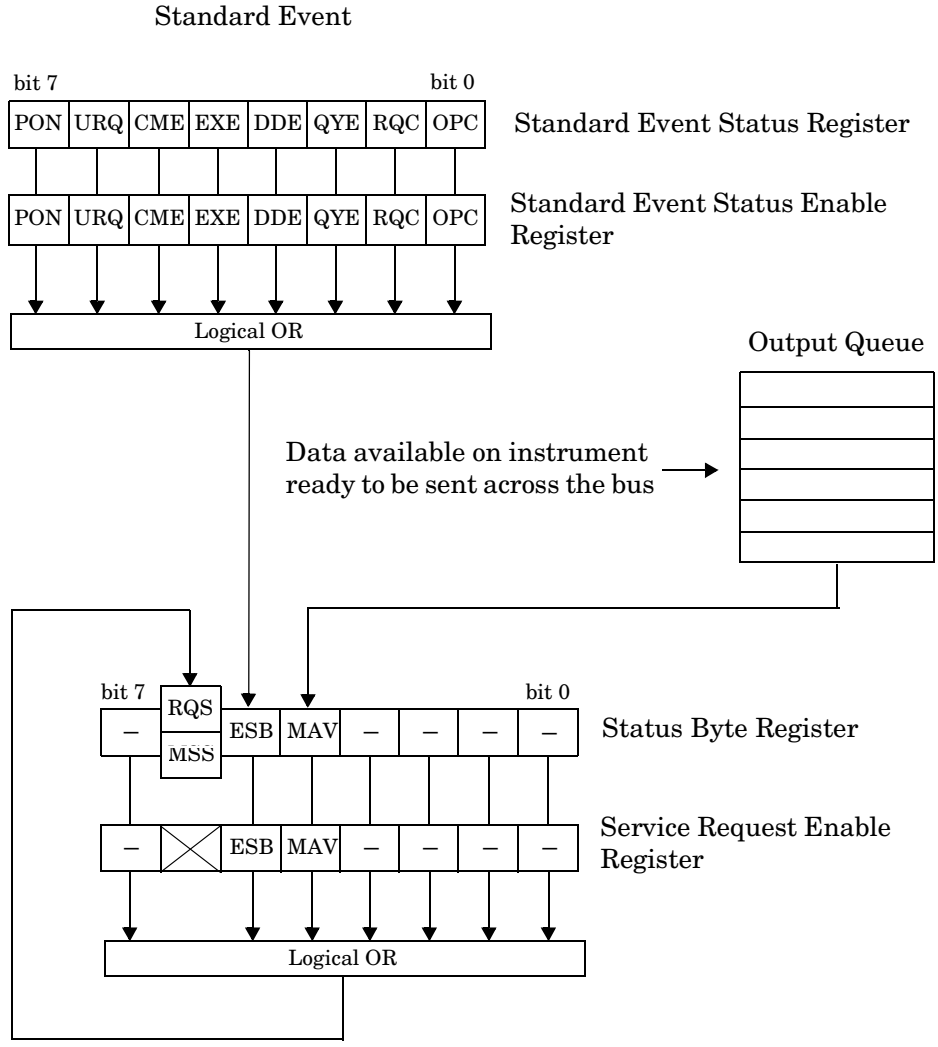
You can examine the state of the handshake lines with the `HandshakeStatus` property.

## 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.



### The 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.

**Table 3-4: 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 the following section) so that the error event of interest is reported by the ESB bit of the SBR.

### The 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.

**Table 3-5: 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 the preceding section) 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.

**Table 3-6: 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`.

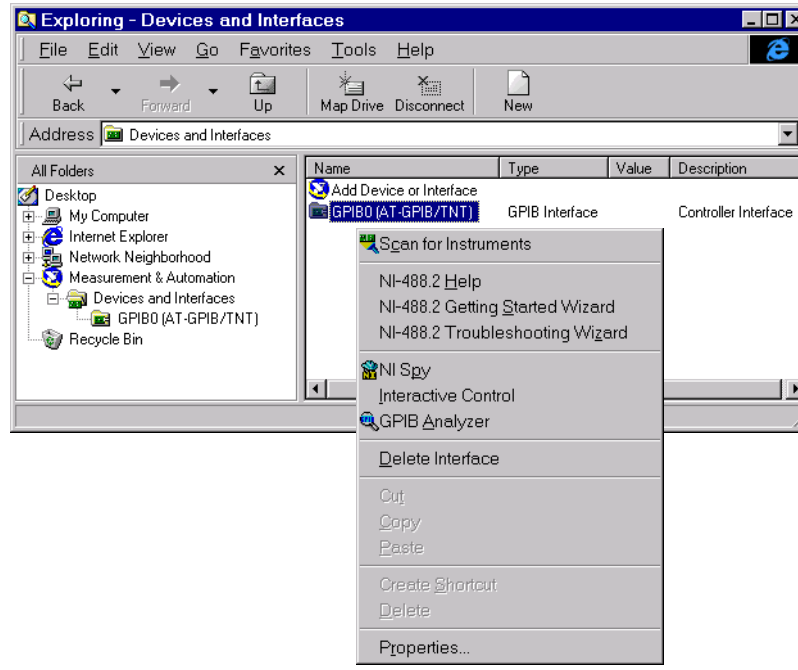
To see how to use many of these commands in the context of an instrument control session, refer to “Example: Executing a Serial Poll” on page 3-39.

## Using Vendor Tools to Identify and Test Your Resources

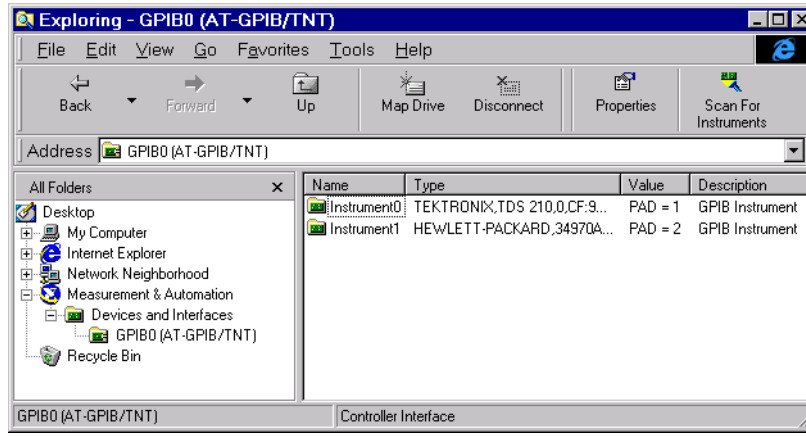
The supported GPIB vendors provide tools that allow you to identify, configure, and test the GPIB resources in your system. These tools are usually installed in conjunction with the GPIB drivers. You should use these tools to

- Determine the GPIB board index, which is used to create a GPIB object. Some tools also determine address information for connected and powered instruments (see below).
- Test the GPIB interface.

For example, National Instruments' Measurement & Automation tool is shown below. The display indicates that a GPIB controller with board index 0 is available on the system. By selecting the name of the controller and right-clicking, you can perform several helpful tasks via the drop-down menu. For example, you can scan for instruments, use the NI-488.2 Getting Started Wizard to verify the GPIB driver and controller installation, or use the NI-488.2 Troubleshooting Wizard to test the GPIB interface.



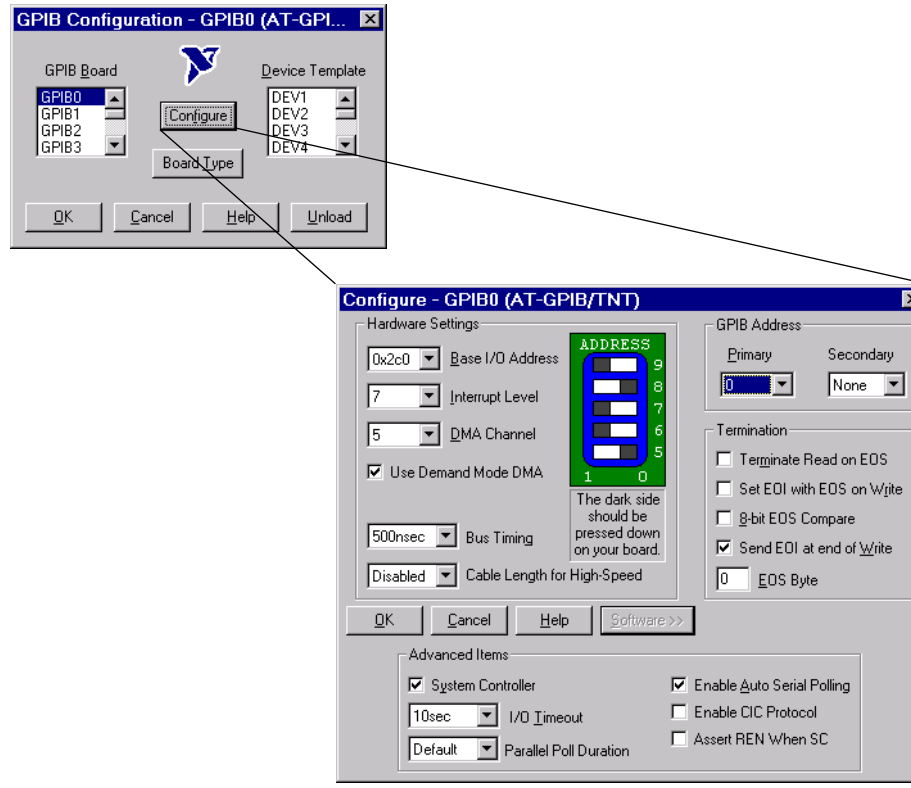
By selecting **Scan for Instruments** in the drop-down menu, you can display all instruments that are powered on and connected to the GPIB board. As shown below, a Tektronix TDS 210 oscilloscope with primary address 1 and a Hewlett-Packard 34970A data acquisition/switch unit with primary address 2 are connected and powered.




By selecting **NI-488.2 Getting Started Wizard** in the drop-down menu, you can configure the GPIB interface, verify the hardware and software installation, and communicate with the instrument.

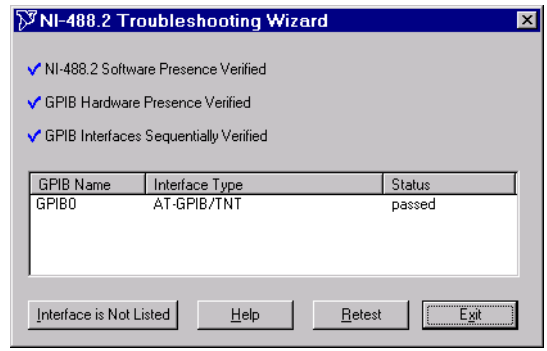
The GPIB Configuration component of the Getting Started Wizard is shown below. After selecting the appropriate GPIB board, you can select the **Configure** button to configure computer hardware settings such as the

interrupt line and the base I/O address. You can also configure GPIB software settings such as the address and termination parameters.




**Note** The GPIB software settings given by the GPIB Configuration interface are overridden by your MATLAB code, and will have no effect on your GPIB application.

By selecting **NI-488.2 Troubleshooting Wizard** in the drop-down menu, you can test the GPIB interface and display the results. The Troubleshooting Wizard is shown below.



# 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 "Configuring Properties During Object Creation" on page 2-3, you can also configure property values during object creation. For a list of supported adaptors, refer to "The Interface Driver Adaptor" on page 1-4.

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);
```

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.

**Table 3-7: 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 **Explore -> 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.

As described in "Using Vendor Tools to Identify and Test Your Resources" on page 3-14, you can find the GPIB board index number by invoking the appropriate vendor tool. Note that some vendors place limits on the allowed board index values. Refer to the Instrument Control Toolbox Release Notes 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 it can be 0 indicating that no secondary address is used.

The properties associated with the GPIB address are given below.

**Table 3-8: 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 3-18 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

- The rules for completing write and read operations
- Examples that illustrate writing and reading text data and binary data

For a general overview about writing and reading data, as well as a list of all associated functions and properties, refer to "Writing and Reading Data" on page 2-12.

## 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
```

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.

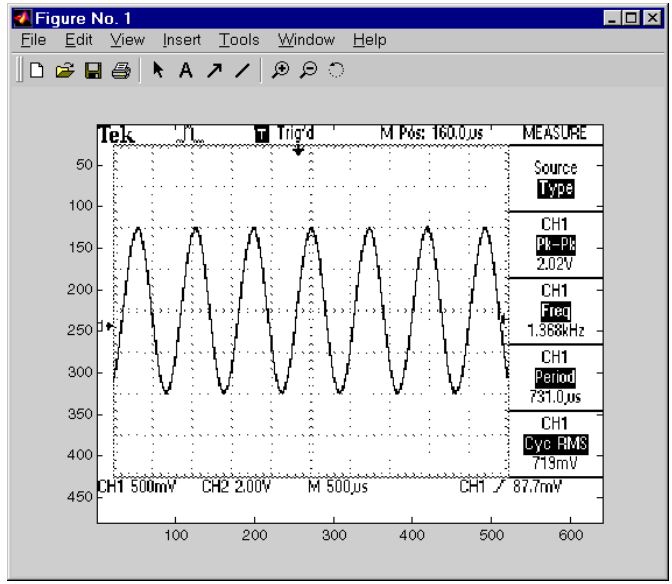
Note that the MATLAB file I/O versions of the `fopen`, `fwrite`, and `fclose` functions are used.

```
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',0,1);
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: GPIB0-1.
```

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.

**Table 3-9: 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 3-33, 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 7-5 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.

**Table 3-10: 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 |

**Table 3-10: GPIB Event Information (Continued)**

| Event Type | Field | Field Value |
|---|---|---|
| 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 pages. 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 Table 3-10, GPIB Event Information, on page 3-32. 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 3-24 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');
```

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')
   ```

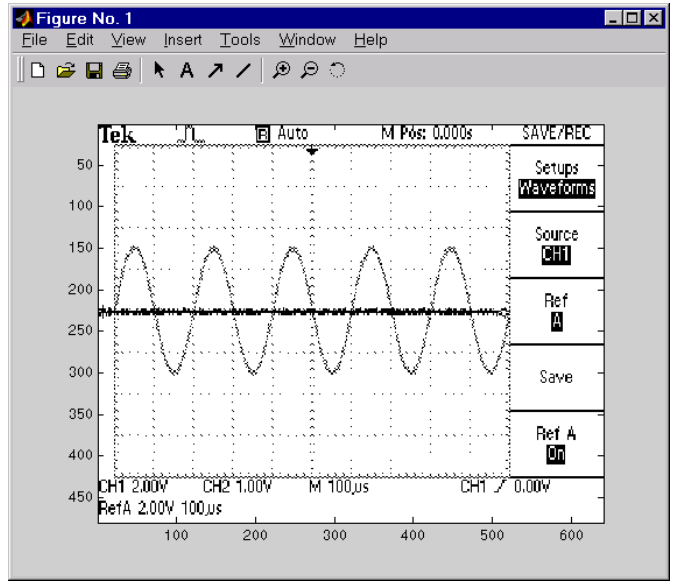
   Trigger the instrument.

   ```
   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 3-9 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 a 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 "The Standard Event Status Register" on page 3-12.

1. **Create instrument objects —** Create a GPIB object associated with a 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
```

4

# Controlling Instruments Using the VISA Standard

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.

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**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.

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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 4-5
- "The VXI Interface" on page 4-9
- "The GPIB-VXI Interface" on page 4-21
- "The Serial Port Interface" on page 4-26

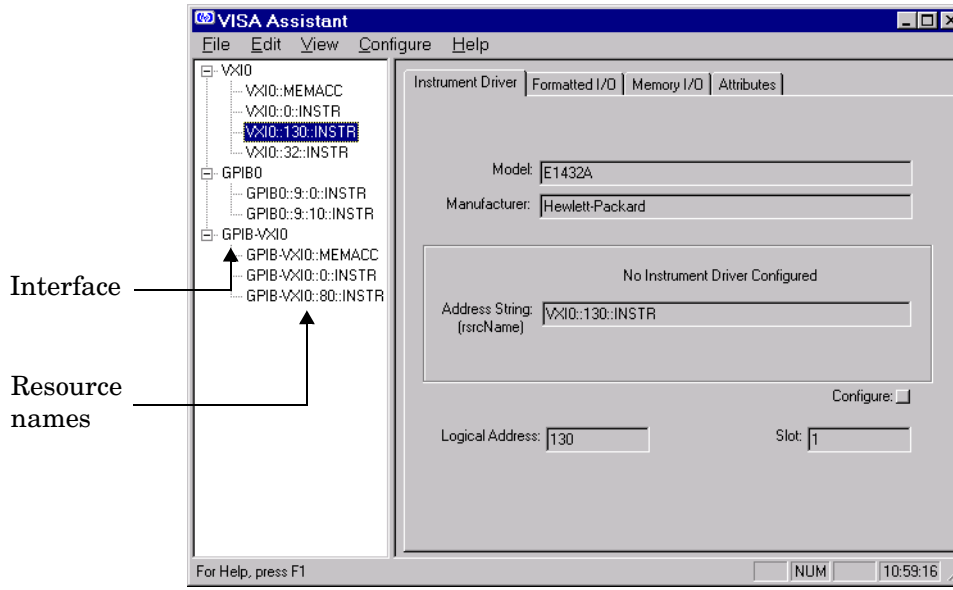

If you want a high-level description of all the steps you are likely to take when communicating with your instrument, refer to Chapter 2, "The Instrument Control Session."

## Using Vendor Tools to Identify and Test Your Resources

Both National Instruments and Agilent Technologies provide tools that allow you to identify, configure, and test the VISA resources in your system. These tools are usually installed in conjunction with the VXIplug&play driver. You should use these tools to

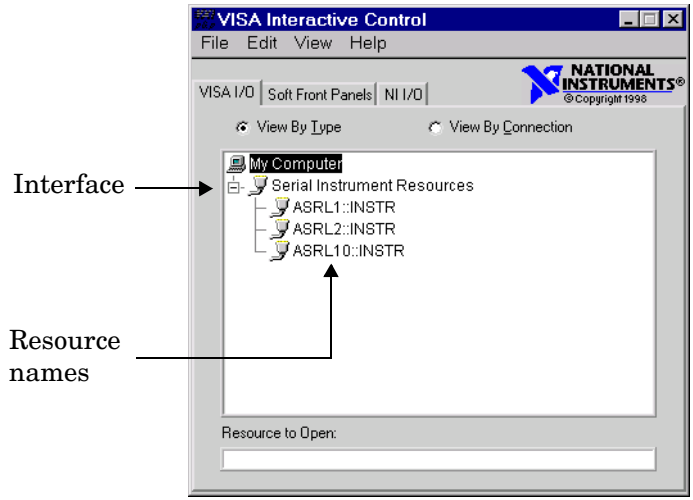
- Determine the device resource name, which is used to create a VISA instrument object. As described in "Adaptor Information" on page 1-14, you can also return the resource name with the `instrhwinfo` function.
- Determine if your hardware configuration is correct.

Agilent's VISA Assistant tool is shown below. The display indicates that VXI, GPIB, and GPIB-VXI interface resources are available on the system.




The `VXI0::MEMACC` and `GPIB-VXI0::MEMACC` resource names are associated with register-based communication. The Instrument Control Toolbox does not directly support these resource names. Instead, register-based communication is supported for VXI instruments with the `memread`, `memwrite`, `mempoke`, and `mempeek` functions, which are described in "Register-Based Communication" on page 4-13.

National Instruments' VISA Interactive Control tool is shown below. The display indicates that serial port interface resources are available on the system.



# 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
- The VISA-GPIB address

Refer to Chapter 3, "Controlling GPIB Instruments" to learn about the GPIB interface, writing and reading text and binary data, using events and callbacks, using triggers, and so on.

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

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## 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. As described in "Configuring Properties During Object Creation" on page 2-3, 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            636  visa object

Grand total is 14 elements using 636 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.

**Table 4-1: 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 **Explore -> 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.

**Table 4-2: 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. |

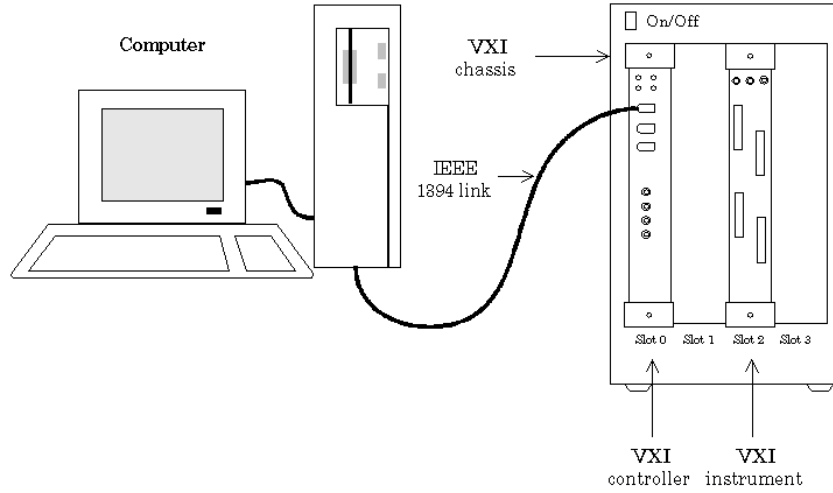
The `BoardIndex`, `PrimaryAddress`, and `SecondaryAddress` properties are automatically updated with the specified resource name values when you create the VISA-GPIB object.

You can display the address property values for the VISA-GPIB object `vg` created in “Creating a VISA-GPIB Object” on page 4-5 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
- The VISA-VXI address
- Register-based communication

Refer to Chapter 3, "Controlling GPIB Instruments" 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. As described in "Configuring Properties During Object Creation" on page 2-3, 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            634  visa object

Grand total is 13 elements using 634 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.

**Table 4-3: VISA-VXI Descriptive Properties**

| Property Name | Description |
|---|---|
| `Name` | Specify a descriptive name for the VISA-VXI object. |

**Table 4-3: VISA-VXI Descriptive Properties (Continued)**

| Property Name | Description |
|---|---|
| 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-VXIO-32'    'VXIO::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-VXIO-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.

**Table 4-4: 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 4-10 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 "Writing and Reading Data" on page 2-12.

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 4-16 for more information. The main advantage of the low-level functions is speed. Refer to "Example: Using Low-Level Memory Functions" on page 4-18 for more information.

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

**Table 4-5: 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.

**Table 4-6: 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.

**Table 4-7: 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 4-16.

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]
```

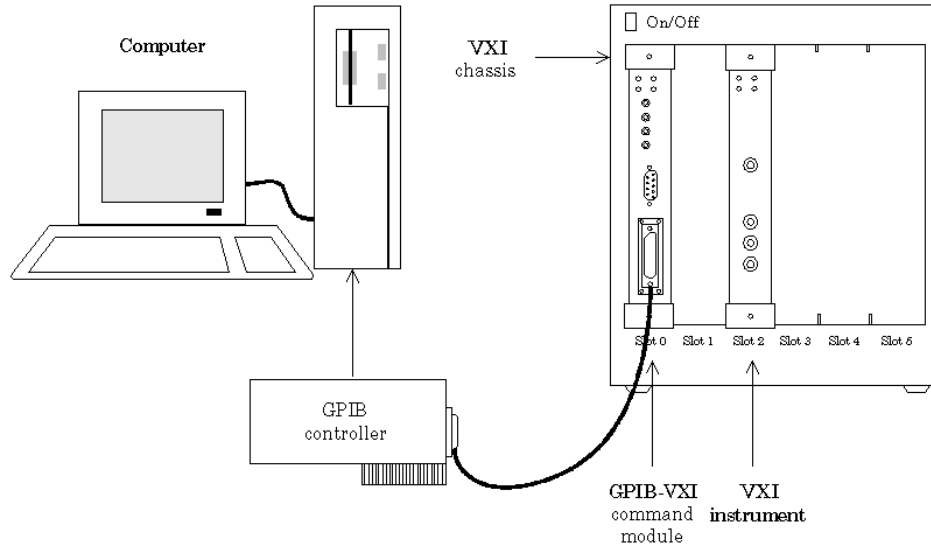
If memory is still mapped when the object is disconnected from the instrument, the memory is automatically unmapped for you.

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
- The VISA-GPIB-VXI address

Refer to Chapter 3, "Controlling GPIB Instruments" 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 4-13 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. As described in "Configuring Properties During Object Creation" on page 2-3, 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            644  visa object

Grand total is 18 elements using 644 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.

**Table 4-8: 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.

**Table 4-9: 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 4-22 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
- Configuring communication settings

Refer to Chapter 5, "Controlling Serial Port Instruments," 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. As described in "Configuring Properties During Object Creation" on page 2-3, 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            640  visa object

Grand total is 16 elements using 640 byte
```

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.

**Table 4-10: 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. These properties are given below.

**Table 4-11: 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 4-26 with the `get` function.

```
get(vs,{'BaudRate','DataBits','Parity','StopBits','Terminator'})
ans =
    [9600]    [8]    'none'    [1]    'LF'
```

5

# Controlling Serial Port Instruments

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

# Serial Port Overview

This section provides an overview of the serial port. Topics include

- What is Serial Communication?
- The Serial Port Interface Standard
- Connecting Two Devices with a Serial Cable
- Serial Port Signals and Pin Assignments
- Serial Data Format
- Finding Serial Port Information for Your Platform

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 5-16. 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-232" 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.

---

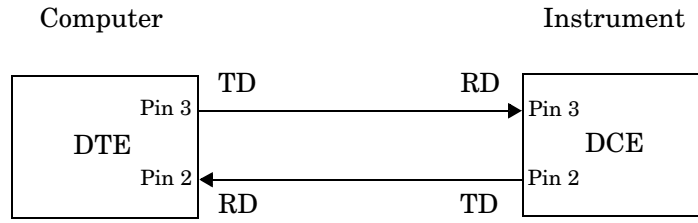
## Connecting Two Devices with a Serial Cable

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.

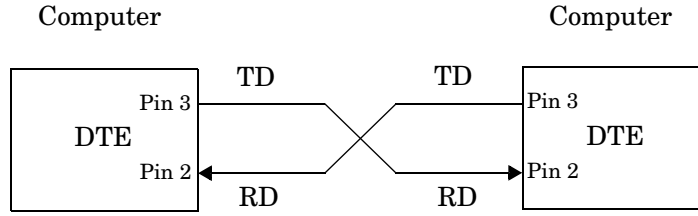
Throughout this guide, your computer is considered a DTE, while peripheral devices such as modems and printers are considered DCEs. Note that many scientific instruments function as DTEs.

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 5-5 for more information about serial port pins.




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.

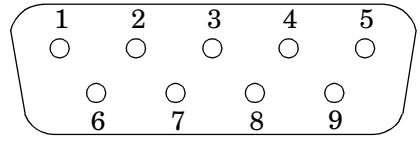



**Note** You can connect multiple RS-422 or RS-485 devices to a serial port. If you have an RS-232/RS-485 adaptor, then you can use the serial port object with these devices.

## 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 PC's 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.

**Table 5-1: 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.

---

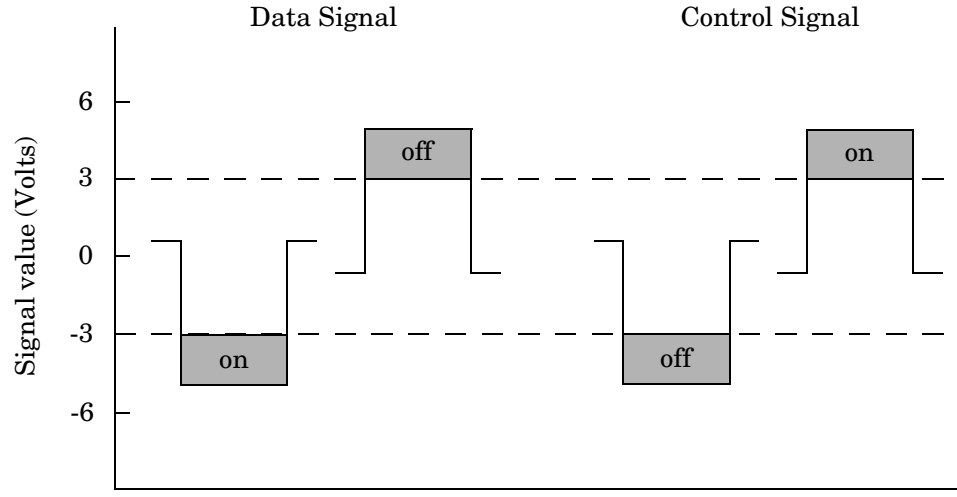
## Signal States

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 5-32.

**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.

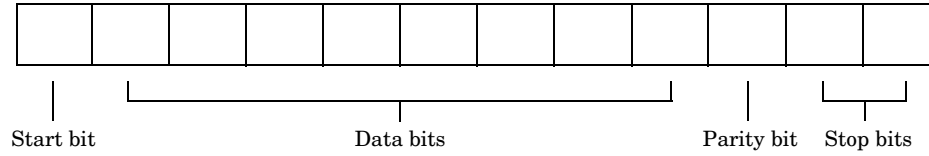
**The CD and RI Pins.** The CD and RI pins are typically used to indicate the presence of certain signals during modem-modem connections.

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 comprise 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 5-19.

### 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 5-10, 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.

**Table 5-2: Parity Types**

| Parity Type | Description |
|---|---|
| Even | The data bits plus the parity bit produce an even number of 1’s. |
| Mark | The parity bit is always 1. |
| Odd | The data bits plus the parity bit produce an odd number of 1’s. |
| 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.

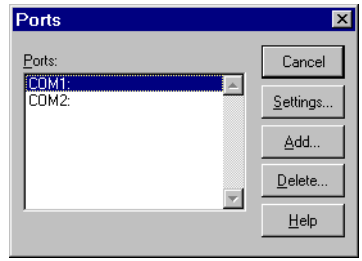
---

You can also use the `instrhwinfo` function to return the available serial ports programmatically.

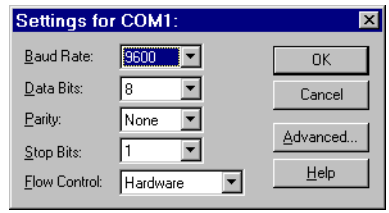
## Windows Platform

You can easily access serial port information through the Windows Control Panel. You can invoke the Control Panel with the **Start** button (**Start** -> **Settings** -> **Control Panel**).

For Windows NT, you access the serial ports by selecting the Ports icon within the Control Panel. The resulting **Ports** dialog box is shown below.




To obtain information on the possible settings for COM1, select this port under the **Ports** list box and then select **Settings**.




You can access serial port information for the Windows 98 and Windows 2000 operating systems with the **System Properties** dialog box, which is available through the Control Panel.

### 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 Property Values" on page 2-9, 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.

**Table 5-3: 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'
```

## 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 **Explore -> 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. These properties are given below.

**Table 5-4: 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, then 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 5-16 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 "Writing and Reading Data" on page 2-12.

## 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 5-24 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 2-17. The process of reading data asynchronously is described in the next section.

### 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 3-30.

## Event Types and Callback Properties

The event types and associated callback properties supported by serial port objects are listed below.

**Table 5-5: 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 3-31.

**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 5-5 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 3-33, 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 7-5 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.

**Table 5-6: 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 |

**Table 5-6: Serial Port 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 |
| 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 5-5 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 5-5, 9-pin serial ports include six control pins. These control pins allow you to

- Signal the presence of connected devices
- Control the flow of data

The properties associated with the serial port control pins are given below.

**Table 5-7: 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

DTE's and DCE's 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 the `PinStatus` 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
- Software handshaking

---

**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 5-8.

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.

**Table 5-8: 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)
```

6

# Controlling Instruments Using TCP/IP and UDP

This chapter describes specific issues 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 TCP/IP Object

You create a TCP/IP 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 Property Values" on page 2-9, you can also configure property values during object creation.

Each TCP/IP object is associated with one instrument. For example, to create a TCP/IP 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 TCP/IP 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 TCP/IP object is created, the properties listed below are automatically assigned values. These general purpose properties provide descriptive information about the TCP/IP object based on the object type, the remote host, and the remote port.

**Table 6-1: TCP/IP Descriptive Properties**

| Property Name | Description |
|---|---|
| `Name` | Specify a descriptive name for the TCP/IP 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 TCP/IP Object Display

The TCP/IP 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 TCP/IP object variable name at the command line.
- Exclude the semicolon when creating a TCP/IP 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 **Explore -> Display Summary** from the context menu.

The display summary for the TCP/IP object `t` is given below.

```
TCP/IP Object : TCP/IP-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: Server Drops the Connection

This example shows what happens when a TCP/IP 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 TCP/IP 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 TCP/IP 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 Property Values" on page 2-9, 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.

**Table 6-2: 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 **Explore -> 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 hosts. Your platform is considered the local host with name `doejohn.dhcp`, while the other platform is considered the remote host with address `192.168.1.12`. To run this example on your platform, you can use the name of your machine as the local host.

1 **Create an instrument object** — Create a UDP object for the local host.

```
u1 = udp('','LocalPort',4114);
```

A UDP object is also created for the remote host. Note that the remote host must specify the local host name and port number.

```
u2 = udp('doejohn.dhcp',4114);
```

2 **Connect to the host** — Connect `u1` to the remote host. The warning occurs because you created `u1` as a listener with no knowledge of `u2`'s address.

```
fopen(u1)
Warning: Unknown RemoteHost: ' '.
```

Connect `u2` to the host associated with `u1`.

```
fopen(u2)
```

3 **Write and read data** — Communicate with `u1` by writing a message.

```
fprintf(u2,'Is anybody home?')
```

Before reading data with `u1`, you must configure its datagram address and datagram port. This information is available to `u1` after communication is established by `u2`.

```
get(u1,{'DatagramAddress','DatagramPort'})
ans =
    '192.168.1.12'    [2194]
u1.RemoteHost = u1.DatagramAddress;
u1.RemotePort = u1.DatagramPort;
```

You can now read the message.

```
fscanf(u1)
ans =
Is anybody home?
```

You can also write a message to u2.

```
fprintf(u2,'I''m here!')
```

4 **Disconnect and clean up —** When you no longer need u1, you should disconnect it from the host, and remove it from memory and from the MATLAB workspace.

```
fclose(u1)
delete(u1)
clear u1
```

# Writing and Reading Data

This section describes interface-specific issues related to writing and reading data with TCP/IP and UDP objects. Topics include

- The rules for completing write and read operations
- Examples that illustrate writing and reading text data and binary data

For a general overview about writing and reading data, as well as a list of all associated functions and properties, refer to "Writing and Reading Data" on page 2-12.

## 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 TCP/IP 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 TCP/IP Object

This example illustrates how to use text and binary read and write operations with a TCP/IP 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 TCP/IP 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 TCP/IP 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 3-30.

## Event Types and Callback Properties

The event types and associated callback properties supported by TCP/IP and UDP objects are listed below.

**Table 6-3: TCP/IP 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 3-31.

**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 3-33, 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 7-5 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.

**Table 6-4: TCP/IP 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 |
| 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.

## Example: Using Events and Callbacks

This example extends "Example: Communicating Between Two Hosts" on page 6-10 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 `u1`.

```
u1.DatagramReceivedFcn = @instrcallback;
```

When a datagram is received, the following message is displayed.

```
DatagramReceived event occurred at 10:26:20 for the object:
UDP-192.168.1.12.
17 bytes were received from address 192.168.1.12, port 2194.
```

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# 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. 7-2) | 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. 7-5) | 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 7-5.

## 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 the preceding section 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.

**Table 7-1: 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',0,1);
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 the next section.

## 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 significand 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 left most 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 =
00010000000000000000000
```

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 3-24 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.
```

# 8

# Function Reference

This chapter describes the toolbox M-file functions that you use directly. A number of other M-file helper functions are provided with this toolbox to support the functions listed below. These helper functions are not documented because they are not intended for direct use.

# Functions – By Category

This section contains brief descriptions of all toolbox functions. The functions are divided into these two groups:

- Base functions
- Object-specific functions

## Base Functions

Base functions apply to all supported instrument objects (GPIB, VISA-VXI, and so on). For example, the `fscanf` function is supported for all instrument objects. The base functions are organized into the following categories.

### Creating Instrument Objects

| | |
|---|---|
| `gpib` | Create a GPIB object |
| `serial` | Create a serial port object |
| `tcpip` | Create a TCP/IP object |
| `udp` | Create a UDP object |
| `visa` | Create a VISA object |

### State Change

| | |
|---|---|
| `fclose` | Disconnect an instrument object from the instrument |
| `fopen` | Connect an instrument object to the instrument |
| `record` | Record data and event information to a file |

### Reading and Writing Data

| | |
|---|---|
| `binblockread` | Read binblock data from the instrument |
| `binblockwrite` | Write binblock data to 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 |
| `fprintf` | Write text to the instrument |
| `fread` | Read binary data from the instrument |
| `fscanf` | Read data from the instrument, and format as text |
| `fwrite` | Write binary data to the instrument |
| `query` | Write text to the instrument, and read data from the instrument |
| `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 |

### Getting and Setting Properties

| | |
|---|---|
| `get` | Return instrument object properties |
| `inspect` | Open Property Inspector |
| `set` | Configure or display instrument object properties |

### Getting Information and Help

| | |
|---|---|
| `instrhelp` | Return instrument object function and property help |
| `instrhwinfo` | Return information about available hardware |
| `instrschool` | Interface for displaying toolbox tutorials |
| `propinfo` | Return instrument object property information |

### Graphical Tools

| | |
|---|---|
| `instrcomm` | Graphical tool for communicating with an instrument using text data |
| `instrcreate` | Graphical tool for creating and configuring an instrument object |

### General Purpose Functions

| | |
|---|---|
| `clear` | Remove instrument objects from the MATLAB workspace |
| `delete` | Remove instrument objects from memory |
| `disp` | Display instrument object summary information |
| `flushinput` | Remove data from the input buffer |
| `flushoutput` | Remove data from the output buffer |
| `instrcallback` | Display event information when an event occurs |
| `instrfind` | Return instrument objects from memory to the MATLAB workspace |
| `instrreset` | Disconnect and delete all instrument objects |
| `isvalid` | Determine if instrument objects are valid |
| `length` | Length of instrument object array |
| `load` | Load instrument objects and variables into the MATLAB workspace |
| `obj2mfile` | Convert instrument object to MATLAB code |
| `save` | Save instrument objects and variables to a MAT-file |
| `size` | Size of instrument object array |

## Object-Specific Functions

Object-specific functions apply only to instrument objects of a given type (GPIB, VISA-VXI, and so on). For example, the `serialbreak` function is supported only for serial port objects. The object-specific functions are organized into the following categories based on instrument object type.

### GPIB Functions

| | |
|---|---|
| `clrdevice` | Clear instrument buffer |
| `gpib` | Create a GPIB object |
| `spoll` | Perform a serial poll |
| `trigger` | Send a trigger message to the instrument |

### Serial Port Functions

| | |
|---|---|
| `freeserial` | Release MATLAB's hold on a serial port |
| `serial` | Create a serial port object |
| `serialbreak` | Send a break to the instrument |

### TCP/IP Functions

| | |
|---|---|
| `echotcpip` | Start or stop a TCP/IP echo server |
| `tcpip` | Create a TCP/IP object |
| `resolvehost` | Return network name or network address |

### UDP Functions

| | |
|---|---|
| `echoudp` | Start or stop a UDP echo server |
| `udp` | Create a UDP object |

### VISA-GPIB Functions

| | |
|---|---|
| `clrdevice` | Clear instrument buffer |
| `trigger` | Send a trigger message to the instrument |
| `visa` | Create a VISA object |

### VISA-VXI Functions

| | |
|---|---|
| `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 a trigger message to the instrument |
| `visa` | Create a VISA object |

### VISA-GPIB-VXI Functions

| | |
|---|---|
| `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 a VISA object |

### VISA-Serial Functions

| | |
|---|---|
| `visa` | Create a VISA object |

# Functions – Alphabetical List

This section contains detailed descriptions of all toolbox functions. Each function reference page contains some or all of this information:

- The function name
- The function purpose
- The function syntax

  All valid input argument and output argument combinations are shown. In some cases, an ellipsis (. . .) is used for the input arguments. This means that all preceding input argument combinations are valid for the specified output argument(s).
- A description of each argument
- A description of each function syntax
- Additional remarks about usage
- An example of usage
- Related functions and properties

# binblockread

## Purpose

Read binblock data from the instrument

## Syntax

```
A = binblockread(obj)
A = binblockread(obj,'precision')
[A,count] = binblockread(...)
[A,count,msg] = binblockread(...)
```

## Arguments

| | |
|---|---|
| `obj` | An instrument 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 instrument 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.

The ValuesReceived property value is increased by the number of values read, each time binblockread is issued.

## Example

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.

```
fprintf(g,'CURVE?')
data = binblockread(g);
```

## See Also

### Functions

binblockwrite, fopen, fread, instrhelp

### Properties

BytesAvailable, InputBufferSize, Status, ValuesReceived

# binblockwrite

## Purpose

Write binblock data to the instrument

## Syntax

```
binblockwrite(obj,A)
binblockwrite(obj,A,'precision')
```

## Arguments

| | |
|---|---|
| `obj` | An instrument 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. |

## 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 `D` that follow.
- `D` specifies the number of data bytes `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.

## Remarks

Before you can write data to the instrument, it must be connected to `obj` with the `fopen` function. A connected instrument 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.

## Example

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.OutputBufferSize = 3000;
```

Connect g to the instrument, and write string commands that configure the scope to transfer binary waveform data to 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');
```

Create the waveform data.

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

Write the binblock data to the scope.

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

## See Also

### Functions

`binblockread`, `fopen`, `fwrite`, `instrhelp`

### Properties

`OutputBufferSize`, `OutputEmptyFcn`, `Status`, `Timeout`, `TransferStatus`, `ValuesSent`

# clear

## Purpose

Remove instrument objects from the 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`.

## Example

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`

# delete

## 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, then the connection is automatically broken. You can also disconnect `obj` from the instrument with the `fclose` function.

## Example

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
```

## See Also

### Functions

`clear`, `fclose`, `instrhelp`, `isvalid`, `stopasync`

### Properties

`Status`

## Purpose

Display instrument object summary information

## Syntax

```
obj
disp(obj)
```

## Arguments

`obj` An instrument object or an array of instrument objects.

## Description

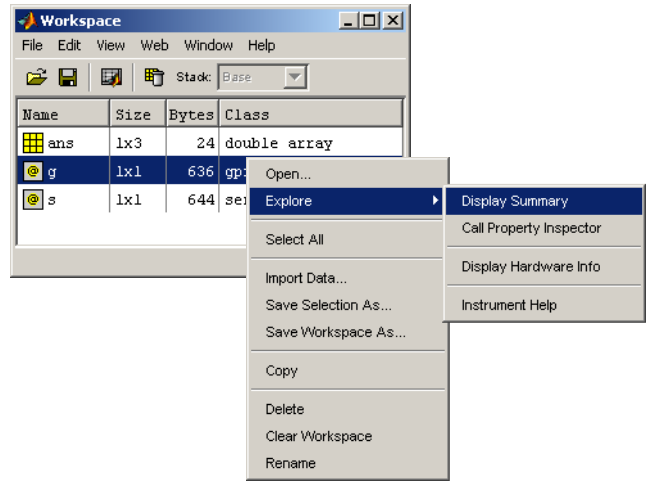
`obj` or `disp(obj)` displays summary information for `obj`.

## 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

As shown below, you can also display summary information via the Workspace browser by right-clicking an instrument object, and selecting **Explore -> Display Summary** from the context menu.




Access context (pop-up) menus by right-clicking an instrument object.

## Example

The following commands display summary information for the GPIB object `g`.

```
g = gpib('ni',0,1)
g.EOSMode = 'read'
g
```

# echotcpip

## Purpose

Start or stop a 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`.

## Example

Start the echo server and create a TCP/IP object.

```
echotcpip('on',4000)
t = tcpip('localhost',4000);
```

Connect the TCP/IP 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 TCP/IP object from the host.

```
echotcpip('off')
fclose(t)
```

## See Also

### Functions

`echoudp`, `tcpip`, `udp`

## Purpose

Start or stop a 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`.

## Example

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`

# fclose

## Purpose

Disconnect an instrument object from the instrument

## Syntax

```
fclose(obj)
```

## Arguments

| | |
|---|---|
| `obj` | An instrument object or an array of instrument 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.

## Example

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 instrument 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`

### Properties

`RecordStatus`, `Status`

## Purpose

Read one line of text from the instrument and discard the terminator

## Syntax

```
tline = fgetl(obj)
[tline,count] = fgetl(obj)
[tline,count,msg] = fgetl(obj)
```

## Arguments

| | |
|---|---|
| `obj` | An instrument 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. |

## 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.

## Remarks

Before you can read text from the instrument, it must be connected to `obj` with the `fopen` function. A connected instrument 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, TCP/IP, 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 instrument 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.

## Example

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`

# fgets

## Purpose

Read one line of text from the instrument and include the terminator

## Syntax

```
tline = fgets(obj)
[tline,count] = fgets(obj)
[tline,count,msg] = fgets(obj)
```

## Arguments

| | |
|---|---|
| `obj` | An instrument 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. |

## 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.

## Remarks

Before you can read text from the instrument, it must be connected to `obj` with the `fopen` function. A connected instrument 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, TCP/IP, 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 instrument 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.

## Example

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 the input buffer

## Syntax

```
flushinput(obj)
```

## Arguments

| | |
|---|---|
| `obj` | An instrument object or an array of instrument 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 the output buffer

## Syntax

```
flushoutput(obj)
```

## Arguments

| | |
|---|---|
| `obj` | An instrument object or an array of instrument 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 an instrument object to the instrument

## Syntax

```
fopen(obj)
```

## Arguments

| | |
|---|---|
| `obj` | An instrument object or an array of instrument 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 instrument object to the same 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 instrument object is open (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, then 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.

## Example

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 the instrument

## Syntax

```
fprintf(obj,'cmd')
fprintf(obj,'format','cmd')
fprintf(obj,'cmd','mode')
fprintf(obj,'format','cmd','mode')
```

## Arguments

| | |
|---|---|
| `obj` | An instrument 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.

## Remarks

Before you can write text to the instrument, it must be connected to `obj` with the `fopen` function. A connected instrument 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 2-17.

### 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, TCP/IP, 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.

---

## Example

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(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 the instrument

## Syntax

```
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 instrument 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,size)` reads 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`. 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 instrument 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 |

| Data Type | Precision | Interpretation |
|---|---|---|
| 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`

# freeserial

## Purpose

Release the hold on a serial port

## Syntax

```
freeserial
freeserial('port')
freeserial(obj)
```

## Arguments

| | |
|---|---|
| `'port'` | A serial port name, or a cell array of serial port names |
| `obj` | A serial port object, or an array of serial port objects. |

## Description

`freeserial` releases the hold MATLAB has on all serial ports.

`freeserial('port')` releases the hold MATLAB has on the serial port specified by `port`. `port` can be a cell array of strings.

`freeserial(obj)` releases the hold MATLAB has on the serial port associated with the object specified by `obj`. `obj` can be an array of serial port objects.

## Remarks

An error is returned if a serial port object is connected to the port that is being freed. Use the `fclose` function to disconnect the serial port object from the serial port.

`freeserial` is necessary only on Windows platforms. You should use `freeserial` if you need to connect to the serial port from another application after a serial port object has been connected to that port, and you do not want to exit MATLAB.

## See Also

### Functions

`fclose`

## Purpose

Read data from the 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 instrument 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 instrument 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 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, TCP/IP, 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 instrument 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.

## Example

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 the instrument

## Syntax

```
fwrite(obj,A)
fwrite(obj,A,'precision')
fwrite(obj,A, mode')
fwrite(obj,A,'precision', mode')
```

## Arguments

| | |
|---|---|
| `obj` | An instrument 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 supported values for *`precision`* are listed below in Remarks.

`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`*.

## Remarks

Before you can write data to the instrument, it must be connected to `obj` with the `fopen` function. A connected instrument 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 2-17.

### 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 |
| 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

Return 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 a 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 you specify 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');
```

## Example

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

Create a 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 |
|---|---|
| `agilent` | Agilent Technologies hardware |
| `cec` | Capital Equipment Corporation hardware |
| `iotech` | IOTech hardware |
| `keithley` | Keithley hardware |
| `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:

- The `Type` property is given by `gpib`.
- The `Name` property 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`.
- The `BoardIndex` and `PrimaryAddress` property values are given by the values supplied to `gpib`.

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 instrument 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.

## Example

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

# inspect

## Purpose

Open Property Inspector

## Syntax

```
inspect(obj)
```

## Arguments

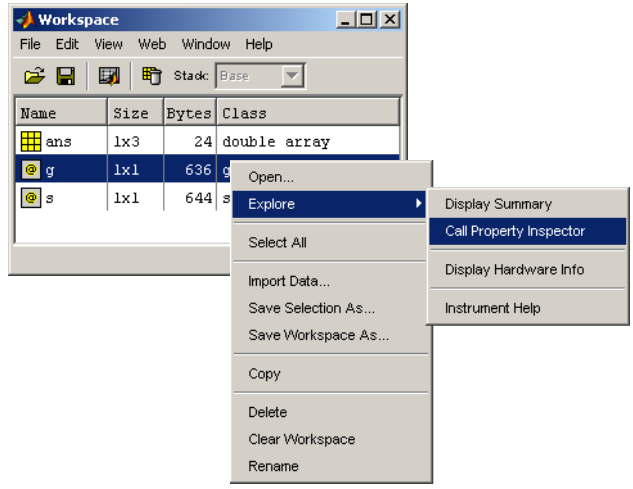
| | |
|---|---|
| `obj` | An instrument object or an array of instrument objects. |

## 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 **Explore -> Call Property Inspector** from the context menu.




Access context (pop-up) menus by right-clicking an instrument object.

## Purpose

Display event information when an 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.

## Example

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
```

# instrcomm

## Purpose

Graphical tool for communicating with an instrument using text data

## Syntax

```
instrcomm(obj)
instrcomm
```

## Arguments

| | |
|---|---|
| `obj` | An instrument object |

## Description

`instrcomm(obj)` launches the Instrument Control ASCII Communication Tool for the instrument object `obj`. `instrcomm` provides you with these features and capabilities:

- Connect `obj` to the instrument, and disconnect `obj` from the instrument.
- Initiate and terminate recording.
- Perform synchronous read, write, and query operations for text commands. A history of transferred data is also provided.
- Flush the input buffer.
- Monitor the values sent and values received.

`instrcomm` launches the Instrument Control Configuration Tool, `instrcreate`. After you create an instrument object, it is automatically passed to the Instrument Control ASCII Communication Tool.

## Example

This example uses `instrcomm` to communicate with a Tektronix TDS 210 oscilloscope, and saves the data to a record file. The read and write operations are taken from “Example: Writing and Reading Text Data” on page 3-22.

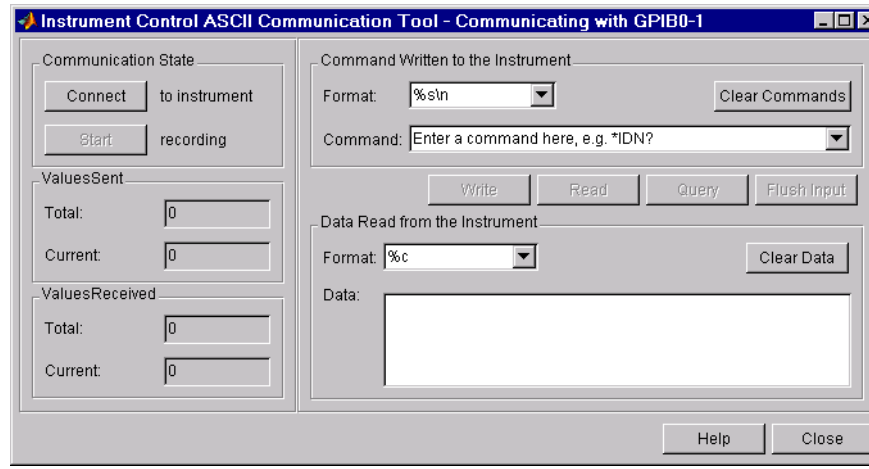
First, create the GPIB object `g` at the command line. Note that you can also create this object using `instrcreate`.

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

Launch the Instrument Control ASCII Communication Tool for `g`.

```
instrcomm(g)
```

The initial `instrcomm` window is shown below. Note that the object name is displayed in the figure title.

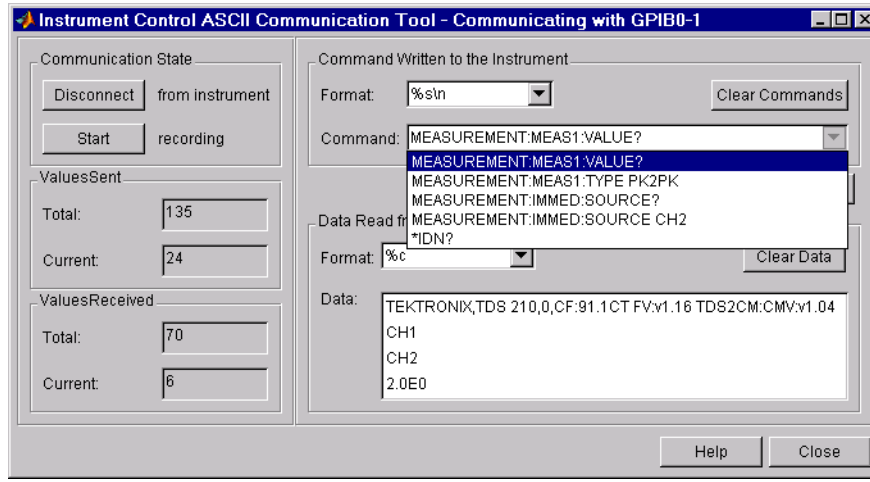



The communication session follows these steps:

1. In the **Communication State** panel, select the **Connect** button to connect g to the instrument, and select the **Start** button to initiate recording.
2. Input the instrument commands one at a time, and select the **Write**, **Read**, or **Query** button as needed for each command.

   You can specify the command and data format using the **Format** parameters, and you can clear the commands and data from the interface tool using the **Clear Commands** and **Clear Data** buttons, respectively.

The complete communication session is shown below. The most recent command written to the instrument is at the top of the **Command** list, while the most recent command response read from the instrument is at the bottom of the **Data** list.




## See Also

### Functions

`instrcreate`

## Purpose

Graphical tool for creating and configuring an instrument object

## Syntax

```
instrcreate
obj = instrcreate
```

## Arguments

`obj` An instrument object.

## Description

`instrcreate` launches the Instrument Control Configuration Tool. Using this tool, you can create and configure an instrument object. You can then save the instrument object to the MATLAB workspace, convert it to the equivalent M-code, or save it to a MAT-file. Using this syntax, you have access to the MATLAB command line.

After the object is created, you can use it from the command line, or use it in conjunction with the Instrument Control ASCII Communication Tool, `instrcomm`. `instrcreate` is automatically launched if you call `instrcomm` without an input argument.

`obj = instrcreate` saves the configured instrument object to `obj` if the **The MATLAB workspace** check box is selected (see example below). Otherwise, `obj` is empty. Using this syntax, you do not have access to the MATLAB command line until you save the instrument object to the workspace, convert it to the equivalent M-Code, save it to a MAT-file, or select the **Close** button.

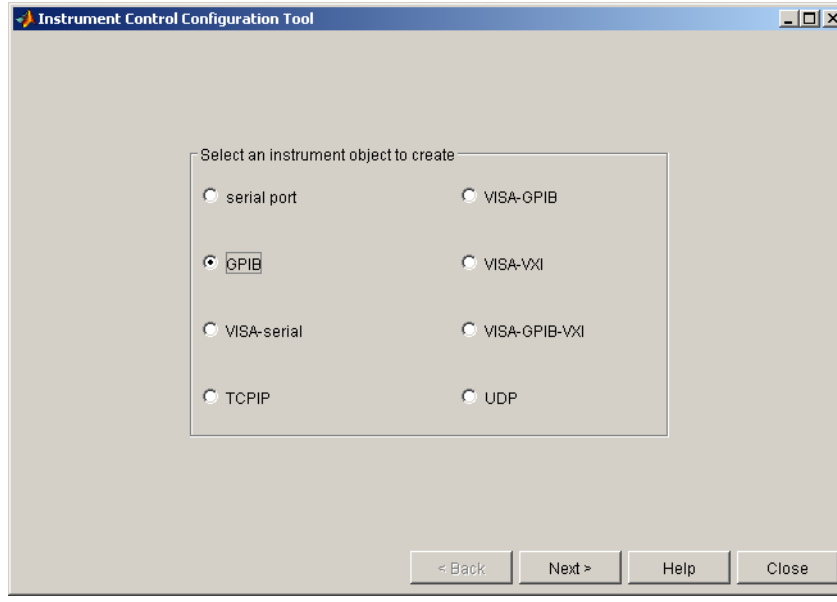
## Example

This example uses `instrcreate` to create a GPIB object that will communicate with a Tektronix TDS 210 oscilloscope. The configuration steps are taken from “Example: Reading Binary Data” on page 3-24.

The first step is to launch the Instrument Control Configuration Tool:

```
instrcreate
```

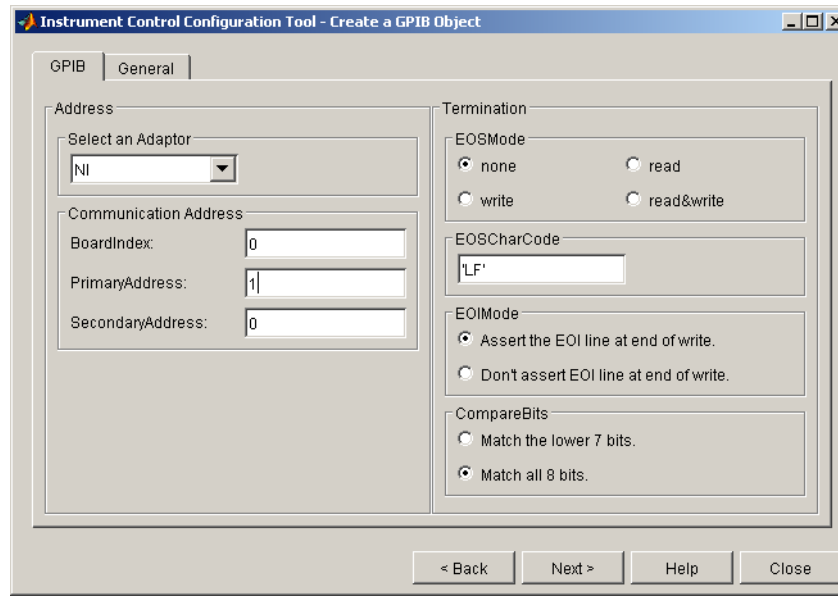
The initial `instrcreate` window is shown below. Select The **GPIB** radio button to configure and create a GPIB object.




Select the **Next** button to display the property configuration window. This window consists of two parts, which are accessible with the **GPIB** and **General** tabs. Each tabbed window contains dialog box parameters that are directly associated with instrument object properties. By selecting the **GPIB** tab, you can select an adaptor, configure the communication address, and configure the conditions under which a read or write operation completes.

For this example, the GPIB object is created for a National Instruments GPIB controller with board index 0, and an oscilloscope with primary address 1.

The **GPIB** property configuration window is shown below.

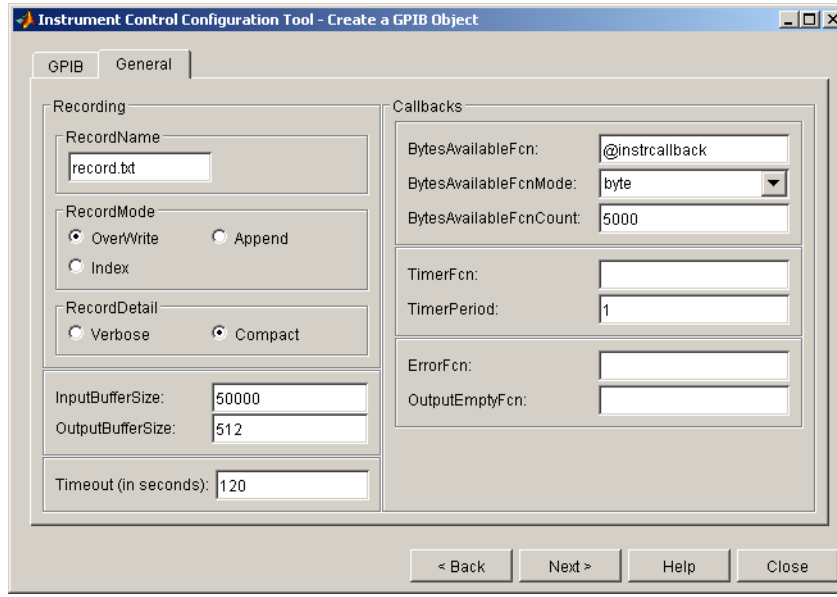



Select the **General** tab to display the parameters associated with recording, buffering, the timeout, and callbacks. For this example, the GPIB object is configured in this way:

- The **InputBufferSize** parameter is configured to `50000`.
- The **Timeout** parameter is configured to `120`.
- The **BytesAvailableFcn** parameter is configured to `@instrcallback`, the **BytesAvailableFcnMode** parameter is configured to `byte`, and the **BytesAvailableFcnCount** parameter is configured 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.

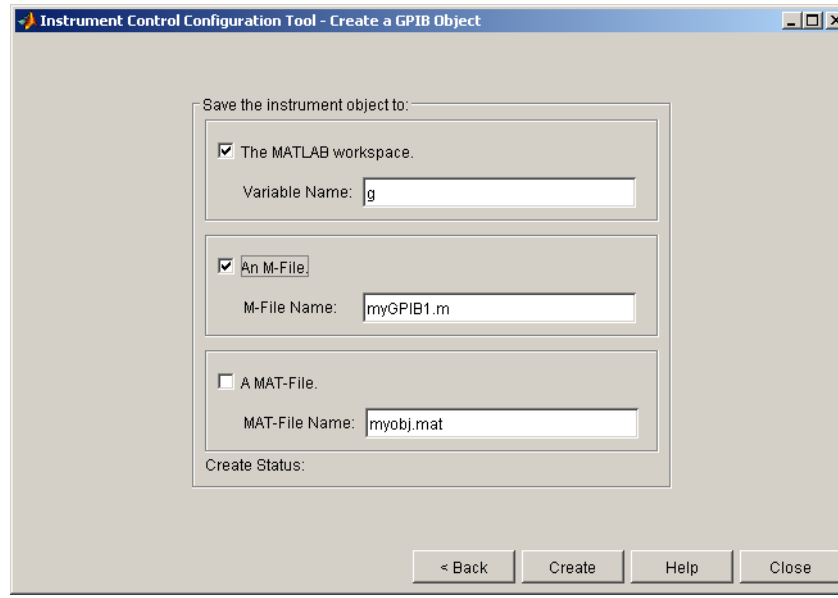
The **General** property configuration window is shown below.




Select the **Next** button to display the object creation window. This window allows you to save the GPIB object to the MATLAB workspace, convert it to the equivalent M-code, and save it to a MAT-file. For this example, the GPIB object is saved to the workspace using the variable `g`, and saved as M-code to the file `myGPIB1.m`.

The instrument object and M-file are created when you select the **Create** button. Note that you can select the **Back** button and modify parameters for `g`, or create a new instrument object.

The object creation window is shown below.




After the GPIB object is configured and created, you can use it to communicate with your instrument via the command line or via the Instrument Control ASCII 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`

# instrfind

## Purpose

Return instrument objects from memory to the 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

You must specify property values using the same format as the `get` function returns. For example, if `get` returns the `Name` property value as `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`.

## Example

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`, `propinfo`

# instrhelp

## Purpose

Return instrument object function and property help

## Syntax

```
instrhelp
instrhelp('name')
out = instrhelp('name')
instrhelp(obj)
instrhelp(obj,'name')
out = instrhelp(obj,'name')
```

## Arguments

| | |
|---|---|
| `'name'` | A function name, property name, or interface type. |
| `obj` | An instrument object. |
| `out` | Contains the text string. |

## Description

`instrhelp` returns a complete listing of instrument object functions, with a brief description of each.

`instrhelp('name')` returns help for the function, property, or interface 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.

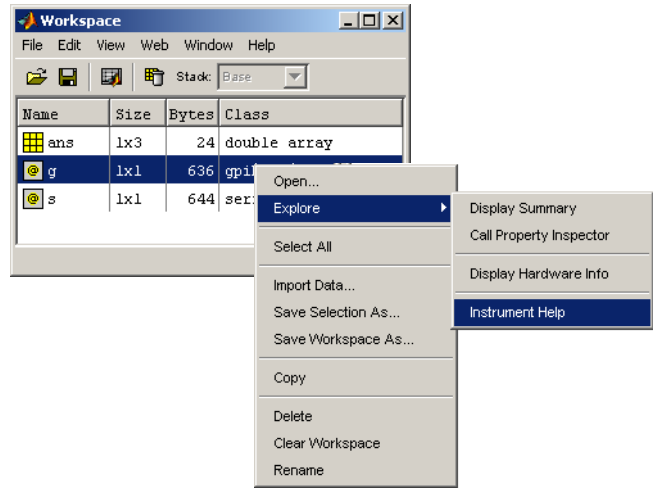
`instrhelp(obj,'name')` returns help for the function or property specified by *`name`* associated with `obj`.

`out = instrhelp(obj,'name')` returns the help text to `out`.

## 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.

As shown below, you can also display help via the Workspace browser by right-clicking an instrument object, and selecting **Explore -> Instrument Help** from the context menu.




Access context (pop-up) menus by right-clicking an instrument object.

## Example

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

Return information about available hardware

## Syntax

```
out = instrhwinfo
out = instrhwinfo('interface')
out = instrhwinfo('interface','adaptor')
out = instrhwinfo('interface','adaptor','type')
out = instrhwinfo(obj)
out = instrhwinfo(obj,'FieldName')
```

## Arguments

| | |
|---|---|
| `'interface'` | A supported instrument interface. |
| `'adaptor'` | A supported GPIB or VISA adaptor. |
| `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('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 `agilent`, `cec`, `iotech`, `keithley`, `mcc`, and `ni`. The VISA adaptors are `agilent`, `ni`, and `tek`.

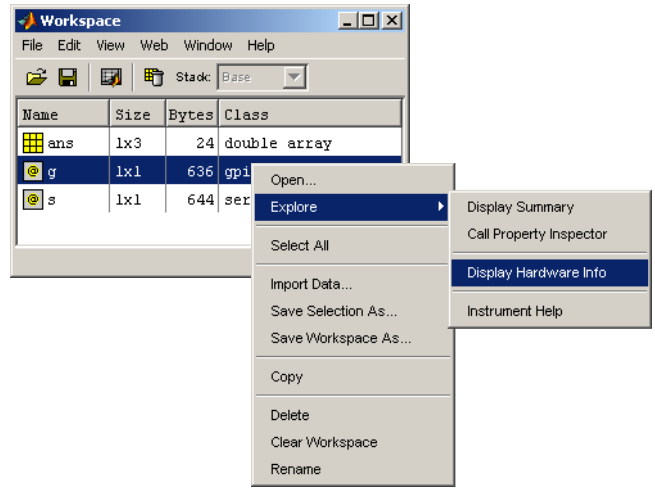
`out = instrhwinfo('interface','adaptor','type')` returns a structure, `out`, which contains information on the specified type, `type`. `interface` can only be `visa`. `adaptor` can be `agilent`, `ni`, or `tek`. `type` can be `gpib`, `vxi`, `gpib-vxi`, `serial`, or `rsib`.

`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, TCP/IP, 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 a 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

As shown below, you can also display hardware information via the Workspace browser by right-clicking an instrument object, and selecting **Explore -> Display Hardware Info** from the context menu.




Access context (pop-up) menus by right-clicking an instrument object.

## Example

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
```

# 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`

## Purpose

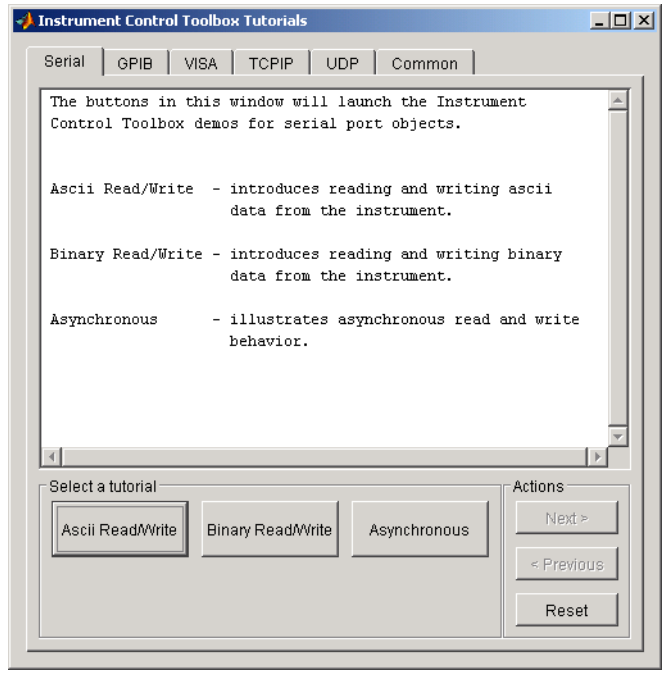
Interface for displaying toolbox tutorials

## Syntax

```
instrschool
```

## Description

`instrschool` launches the Instrument Control Toolbox Tutorials interface, which is shown below.




Refer to “Demos” on page 1-9 for a list of demos included with `instrschool`.

# isvalid

## Purpose

Determine if 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.

## Example

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

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`

# load

## Purpose

Load instrument objects and variables into the 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.

## Example

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);
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`

# 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 instrument 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.

## Example

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)
```

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`

# mempeek

## 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 instrument 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 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.

## Example

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 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 4-16 for a description of the first four registers of the E1432A digitizer.

## See Also

### Functions

fopen, memmap, mempoke, memunmap

### Properties

MappedMemorySize, MemoryIncrement, Status

# mempoke

## 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 instrument 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.

To increase speed, `mempoke` does not return error messages from the instrument.

## Example

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 4-16 for a description of the first four registers of the E1432A digitizer.

## See Also

### Functions

fopen, memmap, mempeek

### Properties

MappedMemorySize, MemoryIncrement, Status

# memread

## 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 instrument 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.

## Example

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 4-16 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`.

## Example

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`

## 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 instrument 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.

## Example

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 4-16 for a description of the first four registers of the E1432A digitizer.

## See Also

### Functions

fopen, memread, mempoke

### Properties

MemoryIncrement, MemorySpace, Status

## Purpose

Convert instrument object to MATLAB code

## Syntax

```
obj2mfile(obj,'filename')
obj2mfile(obj,'filename','syntax')
obj2mfile(obj,'filename','mode')
obj2mfile(obj,'filename','syntax','mode')
```

## 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. |

## 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.

## 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.

## Example

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

## Purpose

Return 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`, `double`, `string`, and `struct`. |
| `Constraint` | The type of constraint on the property value. Possible values are `ASCII value`, `bounded`, `callback`, `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 you specify 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');
```

## Example

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
```

To display the default value for the `EOSMode` property:

```
out.EOSMode.DefaultValue
ans =
none
```

## See Also

### Functions

`get`, `instrhelp`, `set`

## Purpose

Write text to the instrument, and read data from the instrument

## Syntax

```
out = query(obj,'cmd')
out = query(obj,'cmd','wformat')
out = query(obj,'cmd','wformat','rformat')
[out,count] = query(...)
[out,count,msg] = query(...)
```

## Arguments

| | |
|---|---|
| `obj` | An instrument 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. |

## 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.

`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`*.

`[A,count] = query(...)` returns the number of values read to `count`.

`[A,count,msg] = query(...)` returns a warning message to `msg` if the read operation did not complete successfully.

## Remarks

Before you can write or read data, `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 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.

## Example

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`

## Purpose

Read data asynchronously from the instrument

## Syntax

```
readasync(obj)
readasync(obj,size)
```

## Arguments

| | |
|---|---|
| `obj` | An instrument 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 instrument 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, TCP/IP, 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 instrument 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, TCP/IP, 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 instrument 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, TCP/IP, 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.

## Example

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`

# record

## Purpose

Record data and event information to a 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 7-5.

## Example

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';
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`

# resolvehost

## Purpose

Return 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`.

## Example

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 a 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.

## Example

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 the 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 instrument 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 instrument 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.

## Example

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`

## Purpose

Create a 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:

- The `Type` property is given by `serial`.
- The `Name` property is given by concatenating `Serial` with the port specified in the `serial` function.
- The `Port` property 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.

## Example

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 a break to the 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 properties 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 ]
```

## See Also

### Functions

`get`, `instrhelp`, `propinfo`

# size

## Purpose

Size of instrument object array

## Syntax

```
d = size(obj)
[m,n] = size(obj)
[m1,m2,...,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`

## Purpose

Perform a 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 instrument 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.

## Example

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

## Purpose

Stop asynchronous read and write operations

## Syntax

```
stopasync(obj)
```

## Arguments

| | |
|---|---|
| `obj` | An instrument object or an array of instrument 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, TCP/IP, UDP, and VISA-serial objects). In-progress asynchronous operations are indicated by the `TransferStatus` property.

If `obj` is an array of instrument 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, TCP/IP, 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 a TCP/IP object

## Syntax

```
obj = tcpip('rhost')
obj = tcpip('rhost',rport)
obj = tcpip(...,'PropertyName',PropertyValue,...)
```

## Arguments

| | |
|---|---|
| `'rhost'` | The remote host. |
| `rport` | The remote port. |
| `'PropertyName'` | A TCP/IP property name. |
| `PropertyValue` | A property value supported by *`PropertyName`*. |
| `obj` | The TCP/IP object. |

## Description

`obj = tcpip('rhost')` creates a TCP/IP object, `obj`, associated with remote host, `rhost`, and the default remote port value of 80.

`obj = tcpip('rhost',rport)` creates a TCP/IP object with remote port value, `rport`.

`obj = tcpip(...,'PropertyName',PropertyValue,...)` creates a TCP/IP 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 TCP/IP objects.

```
instrhelp tcpip
```

When you create a TCP/IP object, these property values are automatically configured:

- The `Type` property is given by `tcpip`.
- The `Name` property is given by concatenating `TCP/IP` with the remote host name specified in the `tcpip` function.
- The `RemoteHost` and `RemotePort` properties 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 TCP/IP 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.

## Example

Start a TCP/IP echo server and create a TCP/IP object.

```
echotcpip('on',4012)
t = tcpip('localhost',4012);
```

Connect the TCP/IP 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 TCP/IP 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`

# trigger

## Purpose

Send a trigger message to the 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 instrument 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 a 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:

- The `Type` property is given by `udp`.
- The `Name` property is given by concatenating `UDP` with the remote host name specified in the `udp` function.
- The `RemoteHost` and `RemotePort` properties 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.

## Example

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`

## Purpose

Create a 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.

| Interface | Resource Name |
|---|---|
| GPIB | GPIB[board]::primary_address::[secondary_address]::INSTR |
| VXI | VXI[chassis]::VXI_logical_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 |

The `rsrcname` parameters are described below.

| Parameter | Description |
|---|---|
| board | Board index (optional – defaults to 0) |
| chassis | VXI chassis index (optional – defaults to 0) |
| 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) |
| 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 instrument 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.
- The `BoardIndex`, `PrimaryAddress`, `SecondaryAddress`, and `RsrcName` values 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.
- The `ChassisIndex`, `LogicalAddress`, and `RsrcName` values 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.
- The `ChassisIndex`, `LogicalAddress`, and `RsrcName` values are given by the values specified during object creation.

- The BoardIndex, PrimaryAddress, and SecondaryAddress values are given by the visa driver after the object is connected to the instrument with fopen.

### 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.
- The Port and RsrcName values are given by the values specified during object creation.

## Example

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');
```

## See Also

### Functions

fclose, fopen, instrhelp, instrhwinfo

### Properties

BoardIndex, ChassisIndex, LogicalAddress, Name, Port, PrimaryAddress, RsrcName, SecondaryAddress, Status, Type

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# Property Reference

This section describes the instrument object properties in detail.

# Properties – By Category

This section contains brief descriptions of all toolbox properties. The properties are divided into these two groups:

- Base properties
- Object-specific properties

## Base Properties

Base properties apply to all supported instrument objects (GPIB, VISA-VXI, and so on). For example, the `Timeout` property is supported for all instrument objects. The base properties are organized into the following categories.

### Write Properties

| | |
|---|---|
| `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 |

### Read Properties

| | |
|---|---|
| `BytesAvailable` | Indicate the number of bytes available in the input buffer |
| `InputBufferSize` | Specify the size of the input 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 |
| `ValuesReceived` | Indicate the total number of values read from the instrument |

## Callback Properties

| | |
|---|---|
| `BytesAvailableFcn` | Specify the M-file callback function to execute when a specified number of bytes are available in the input buffer, or a terminator is read |
| `BytesAvailableFcnCount` | Specify the number of bytes that must be available in the input buffer to generate a bytes-available event |
| `BytesAvailableFcnMode` | Specify if the bytes-available event is generated after a specified number of bytes are available in the input buffer, or after a terminator is read |
| `ErrorFcn` | Specify the M-file callback function to execute when an error event occurs |
| `OutputEmptyFcn` | Specify the M-file callback function to execute when the output buffer is empty |
| `TimerFcn` | Specify the M-file callback function to execute when a predefined period of time passes |
| `TimerPeriod` | Specify the period of time between timer events |

## Recording Properties

| | |
|---|---|
| `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 |

### General Purpose Properties

| | |
|---|---|
| `ByteOrder` | Specify the order in which the instrument stores bytes |
| `Name` | Specify a descriptive name for the instrument object |
| `Status` | Indicate if the instrument object is connected to the instrument |
| `Tag` | Specify a label to associate with a instrument object |
| `Type` | Indicate the object type |
| `UserData` | Specify data that you want to associate with a instrument object |

## Object-Specific Properties

Object-specific properties apply only to instrument objects of a given type (GPIB, VISA-VXI, and so on). For example, the `BreakInterruptFcn` property is supported only for serial port objects. The object-specific properties are organized into the following categories based on instrument object type.

### GPIB Properties

| | |
|---|---|
| `BoardIndex` | Specify the index number of the GPIB board |
| `BusManagementStatus` | Indicate the state of the GPIB bus management lines |
| `CompareBits` | Specify the number of bits that must match the EOS character to complete a read operation, or to assert the EOI line |
| `EOIMode` | Specify if the EOI line is asserted at the end of a write operation |
| `EOSCharCode` | Specify the EOS character |
| `EOSMode` | Specify when the EOS character is written or read |
| `HandshakeStatus` | Indicate the state of the GPIB handshake lines |
| `PrimaryAddress` | Specify the primary address of the GPIB instrument |
| `SecondaryAddress` | Specify the secondary address of the GPIB instrument |

### Serial Port Properties

| | |
|---|---|
| `BaudRate` | Specify the rate at which bits are transmitted |
| `BreakInterruptFcn` | Specify the M-file callback function to execute when a break-interrupt event occurs |
| `DataBits` | Specify the number of data bits to transmit |
| `DataTerminalReady` | Specify the state of the DTR pin |
| `FlowControl` | Specify the data flow control method to use |
| `Parity` | Specify the type of parity checking |
| `PinStatus` | Indicate the state of the CD, CTS, DSR, and RI pins |
| `PinStatusFcn` | Specify the M-file callback function to execute when the CD, CTS, DSR, or RI pins change state |
| `Port` | Specify the platform-specific serial port name |
| `ReadAsyncMode` | Specify whether an asynchronous read operation is continuous or manual |
| `RequestToSend` | Indicate the state of the RTS pin |
| `StopBits` | Specify the number of bits used to indicate the end of a byte |
| `Terminator` | Specify the terminator character |

### TCP/IP Properties

| | |
|---|---|
| `LocalHost` | Specify the local host |
| `LocalPort` | Specify the local host port for the connection |
| `LocalPortMode` | Specify the local host port selection mode |
| `ReadAsyncMode` | Specify whether an asynchronous read operation is continuous or manual |
| `RemoteHost` | Specify the remote host |
| `RemotePort` | Specify the remote host port for the connection |

| | |
|---|---|
| `Terminator` | Specify the terminator character |
| `TransferDelay` | Specify the use of the TCP segment transfer algorithm |

### UDP Properties

| | |
|---|---|
| `DatagramAddress` | Indicate the IP dotted decimal address of the received datagram sender |
| `DatagramPort` | Indicate the port number of the datagram sender |
| `DatagramReceivedFcn` | Specify the M-file callback function to execute whenever a datagram has been received |
| `DatagramTerminateMode` | Configure the terminate read mode when reading datagrams |
| `LocalHost` | Specify the local host |
| `LocalPort` | Specify the local host port for the connection |
| `LocalPortMode` | Specify the local port selection mode |
| `ReadAsyncMode` | Specify whether an asynchronous read operation is continuous or manual |
| `RemoteHost` | Specify the remote host |
| `RemotePort` | Specify the remote host port for the connection |
| `Terminator` | Specify the terminator character |

### VISA-GPIB Properties

| | |
|---|---|
| `BoardIndex` | Specify the index number of the GPIB board |
| `EOIMode` | Specify if the EOI line is asserted at the end of a write operation |
| `EOSCharCode` | Specify the EOS character |
| `EOSMode` | Specify when the EOS character is written or read |
| `PrimaryAddress` | Specify the primary address of the GPIB instrument |
| `RsrcName` | Indicate the resource name for a VISA instrument |
| `SecondaryAddress` | Specify the secondary address of the GPIB instrument |

### VISA-VXI Properties

| | |
|---|---|
| `ChassisIndex` | Indicate the index number of the VXI chassis |
| `EOIMode` | Specify if the EOI line is asserted at the end of a write operation |
| `EOSCharCode` | Specify the EOS character |
| `EOSMode` | Specify when the EOS character is written or read |
| `InterruptFcn` | Specify the M-file callback function to execute when an interrupt event occurs |
| `LogicalAddress` | Specify the logical address of the VXI instrument |
| `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 |
| `RsrcName` | Indicate the resource name for a VISA instrument |
| `Slot` | Indicate the slot location of the VXI instrument |
| `TriggerFcn` | Specify the M-file callback function to execute when a trigger event occurs |
| `TriggerLine` | Specify the trigger line on the VXI instrument |
| `TriggerType` | Specify the trigger type |

### VISA-GPIB-VXI Properties

| | |
|---|---|
| `BoardIndex` | Specify the index number of the GPIB board |
| `ChassisIndex` | Indicate the index number of the VXI chassis |
| `EOIMode` | Specify if the EOI line is asserted at the end of a write operation |
| `EOSCharCode` | Specify the EOS character |
| `EOSMode` | Specify when the EOS character is written or read |
| `LogicalAddress` | Specify the logical address of the VXI instrument |
| `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 |
| `PrimaryAddress` | Specify the primary address of the GPIB instrument |
| `RsrcName` | Indicate the resource name for a VISA instrument |
| `SecondaryAddress` | Specify the secondary address of the GPIB instrument |
| `Slot` | Indicate the slot location of the VXI instrument |

### VISA-Serial Properties

| | |
|---|---|
| `BaudRate` | Specify the rate at which bits are transmitted |
| `DataBits` | Specify the number of data bits to transmit |
| `DataTerminalReady` | Specify the state of the DTR pin |
| `FlowControl` | Specify the data flow control method to use |
| `Parity` | Specify the type of parity checking |
| `PinStatus` | Indicate the state of the CD, CTS, DSR, and RI pins |
| `Port` | Specify the platform-specific serial port name |
| `ReadAsyncMode` | Specify whether an asynchronous read operation is continuous or manual |
| `RequestToSend` | Indicate the state of the RTS pin |
| `RsrcName` | Indicate the resource name for a VISA instrument |
| `StopBits` | Specify the number of bits used to indicate the end of a byte |
| `Terminator` | Specify the terminator character |

# Properties – Alphabetical List

This section contains detailed descriptions of all toolbox properties. Each property reference page contains some or all of this information:

- The property name
- A description of the property
- The property characteristics, including:
  - Usage — the instrument object(s) the property is associated with
  - Read only — the condition under which the property is read-only

    A property can be read-only always, never, while the instrument object is open, or while the instrument object is recording. You can configure a property value using the `set` command or dot notation. You can return the current property value using the `get` command or dot notation.
  - Data type — the property data type

    This is the data type you use when specifying a property value
- Valid property values including the default value

  When property values are given by a predefined list, the default value is usually indicated by `{}` (curly braces).
- An example using the property
- Related properties and functions

## Purpose

Specify the rate at which bits are transmitted

## 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`

# BoardIndex

## Purpose

Specify the index number of the GPIB board

## Description

You configure `BoardIndex` to be the index number of the GPIB board associated with your instrument. When you create a GPIB or VISA-GPIB 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 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 |
| Read only | While open (GPIB, VISA-GPIB), always (VISA-GPIB-VXI) |
| Data type | double |

## Values

The value is defined after the instrument object is created.

## Example

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'
```

## See Also

### Functions

`fclose`, `gpib`, `visa`

### Properties

`Name`, `RsrcName`, `Status`

## Purpose

Specify the M-file callback function to execute when a 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 3-33.

## Characteristics

| | |
|---|---|
| Usage | Serial port |
| Read only | Never |
| Data type | Callback function |

## Values

The default value is an empty string.

## See Also

### Functions

`record`

### Properties

`RecordStatus`

# BusManagementStatus

## Purpose

Indicate the state of the 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.

## Example

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 =
0
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
```

# ByteOrder

## Purpose

Specify the byte order of the 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`

## Purpose

Indicate the number of bytes available in the 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 2-23.

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`

# BytesAvailableFcn

## Purpose

Specify the M-file callback function to execute when a specified number of bytes are available in the input buffer, or a 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 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 3-33.

## Characteristics

| | |
|---|---|
| Usage | Any instrument object |
| Read only | Never |
| Data type | Callback function |

## Values

The default value is an empty string.

## Example

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`

## Purpose

Specify the number of bytes that must be available in the input buffer to generate a 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`

# BytesAvailableFcnMode

## Purpose

Specify if the bytes-available event is generated after a specified number of bytes are available in the input buffer, or after a terminator is read

## Description

For serial port, TCP/IP, 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, TCP/IP, 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. |

### 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 available. |

## See Also

### Functions

`fclose`

### Properties

`BytesAvailableFcn`, `BytesAvailableFcnCount`, `EOSCharCode`, `Status`, `Terminator`

# BytesToOutput

## Purpose

Indicate the number of bytes currently in the 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 2-17.

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`

## Purpose

Specify the index number of the 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.

## Example

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 the number of bits that must match the EOS character to complete a read operation, or to assert the 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 the 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`

# DatagramAddress

## Purpose

Indicate the IP dotted decimal address of the 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`

## Purpose

Indicate the port number of the datagram sender

## Description

`DatagramPort` is the port number of the datagram to be read next 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`

# DatagramReceivedFcn

## Purpose

Specify the M-file callback function to execute whenever a datagram has been 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 3-33

## Characteristics

| | |
|---|---|
| Usage | UDP |
| Read only | Never |
| Data type | Callback |

## Values

The default value is `''`.

## See Also

### Functions

`readasync`, `udp`

### Properties

`DatagramAddress`, `DatagramPort`, `ReadAsyncMode`

## Purpose

Configure the 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`

# DataTerminalReady

## Purpose

Specify the state of the 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 5-8.

## 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`

## Purpose

Specify if the EOI line is asserted at the end of a 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 the 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 the 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.

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. |

## Example

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`

## Purpose

Specify the M-file callback function to execute when an 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 3-33.

## 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 the 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 5-29.

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`

## Purpose

Indicate the state of the 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.

# InputBufferSize

## Purpose

Specify the size of the 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

Specify the M-file callback function to execute when an 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`

# LocalHost

## Purpose

Specify the 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 | TCP/IP, UDP |
| Read only | While open |
| Data type | String |

## Values

The default value is `''`.

## See Also

### Functions

`fclose`, `fopen`, `tcpip`, `udp`

### Properties

`LocalPort`, `RemoteHost`, `Status`

## Purpose

Specify the local host port for the 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 | TCP/IP, 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 the local host port selection mode

## Description

`LocalPortMode` specifies the selection mode for the `LocalPort` property when you connect a TCP/IP 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 | TCP/IP, 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 the logical address of the 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.

## Example

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`

# MappedMemoryBase

## Purpose

Indicate the base memory address of the 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`.

## Example

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
```

## See Also

### Functions

`memmap`, `memunmap`

### Properties

`MappedMemorySize`

## Purpose

Indicate the size of the 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`.

## Example

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`

# MemoryBase

## Purpose

Indicate the base address of the 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`.

## Example

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 base address of the A24 space is

```
vv.MemoryBase
ans =
'200000H'
```

## See Also

### Properties

`MemorySpace`

# MemoryIncrement

## Purpose

Specify if the 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. |

## Example

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

Indicate the size of the memory requested in the 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`.

## Example

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`

## Purpose

Indicate the address space used by the 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. |

## Example

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`

## Purpose

Specify a descriptive name for the 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` |
| TCP/IP | `TCP/IP` 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` |

If the secondary address is not specified when a GPIB or VISA-GPIB object is created, then `Name` will not include this component.

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.

# Name

## 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

Specify the size of the 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`

# OutputEmptyFcn

## Purpose

Specify the M-file callback function to execute when the 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 3-33.

## 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`

## Purpose

Specify the 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 (1's) 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 5-12.

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

Indicate the state of the 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 5-8 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 5-29 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`

## Purpose

Specify the M-file callback function to execute when the 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 3-33.

## 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 the 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.

## Example

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`

## Purpose

Specify the primary address of the 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.

## Example

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`

# ReadAsyncMode

## Purpose

Specify whether an 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, TCP/IP, 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 the amount of information saved to a 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 7-9.

## 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 record file 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 7-6 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. |

## Example

Suppose you create the serial port object `s` associated with the serial port COM1.

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

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 the name of the 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 7-6 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

Indicate if data and event information are saved to a 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 the 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 TCP/IP 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 | TCP/IP, UDP |
| Read only | While open (TCP/IP), Never (UDP) |
| Data type | String |

## Values

The value is defined when you create the TCP/IP or UDP object.

## See Also

### Functions

`fclose`, `fopen`, `tcpip`, `udp`

### Properties

`LocalHost`, `RemotePort`, `Status`

# RemotePort

## Purpose

Specify the remote host port for the connection

## Description

You can configure `RemotePort` to be any port number between `1` and `65535`. The default value is `80` for TCP/IP objects and `9090` for UDP objects.

For TCP/IP 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 | TCP/IP, UDP |
| Read only | While open (TCP/IP), Never (UDP) |
| Data type | Double |

## Values

Any port number between `1` and `65535`. The default value is `80` for TCP/IP objects and `9090` for UDP objects.

## See Also

### Functions

`fclose`, `fopen`, `tcpip`, `udp`

### Properties

`RemoteHost`, `LocalPort`, `Status`

## Purpose

Specify the state of the 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 5-8.

## 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`

# RsrcName

## Purpose

Indicate the resource name for a 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 |
|---|---|
| GPIB | GPIB[board]::primary_address::[secondary_address]::INSTR |
| VXI | VXI[chassis]::VXI_logical_address::INSTR |
| GPIB-VXI | GPIB-VXI[chassis]::VXI_logical_address::INSTR |
| Serial | ASRL[port_number]::INSTR |

If you change the `BoardIndex`, `PrimaryAddress`, `SecondaryAddress`, `ChassisIndex`, `LogicalAddress`, or `Port` property values, `RsrcName` is automatically updated to reflect these changes.

## 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.

## Example

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`, `LogicalAddress`, `Port`, `PrimaryAddress`, `SecondaryAddress`

# SecondaryAddress

## Purpose

Specify the secondary address of the 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`.

## Example

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`

# Slot

## Purpose

Indicate the slot location of the 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

Indicate if the object is connected to the 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 the number of bits used to indicate the end of a 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 the 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`

## Purpose

Specify a label to associate with an 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.

## Example

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`

# Terminator

## Purpose

Specify the terminator character

## Description

For serial port., TCP/IP, 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 port, TCP/IP, 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.

## See Also

### Functions

`fgetl`, `fgets`, `fprintf`, `fscanf`

### Properties

`BytesAvailableFcnMode`

## Purpose

Specify the waiting time to complete a 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 the M-file callback function to execute when a predefined period of time 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 3-33.

## 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`

## Purpose

Specify the period of time 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`

# TransferDelay

## Purpose

Specify the use of the 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 | TCP/IP |
| Read only | Never |
| Data type | String |

## Values

| | |
|---|---|
| `{on}` | Use the TCP segment transfer algorithm. |
| `off` | Do no use the TCP segment transfer algorithm. |

## See Also

### Functions

`tcpip`

## Purpose

Indicate if an 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, TCP/IP, UDP, and VISA-serial objects only). For detailed information about asynchronous read and write operations, refer to "Writing and Reading Data" on page 2-12.

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 the M-file callback function to execute when a 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 the trigger line on the 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 the 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

Indicate the 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 TCP/IP. |
| `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.

## Example

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`

# UserData

## Purpose

Specify data that you want to associate with an 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.

## Example

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
```

## Purpose

Indicate the total number of values read from the 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 2-14 for more information about bytes and values.

## Characteristics

| | |
|---|---|
| Usage | Any instrument object |
| Read only | Always |
| Data type | Double |

## Values

The default value is `0`.

## Example

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`

## Purpose

Indicate the total number of values written to the 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 2-14 for more information about bytes and values.

## Characteristics

| | |
|---|---|
| Usage | Any instrument object |
| Read only | Always |
| Data type | Double |

## Values

The default value is `0`.

## Example

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`

# ValuesSent

A

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