VISA

NI-VISA™ User Manual

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About This Manual

This manual describes how to use NI-VISA, the National Instruments implementation of the VISA I/O standard, in any environment using LabWindows/CVI, any ANSI C compiler, or Microsoft Visual Basic. It is intended to increase ease of use for end users through open, multivendor systems, specifically through VISA I/O software. The assumption is made that a user of VISA software and this manual is familiar with programming I/O software for VXI, GPIB, Serial, PXI, and Ethernet technology on one or more of the following operating systems:

- Windows 2000/NT/XP/Me/9*x*
- LabVIEW RT
- Solaris 2.*x*
- Mac OS 8/9/X
- Linux *x*86
- VxWorks *x*86

How to Use This Document Set

Use the documentation that came with your GPIB and/or VXI hardware and software for Windows to install and configure your system.

Refer to the Read Me First document for information on installing the NI-VISA distribution media.

Use the *NI-VISA User Manual* for detailed information on how to program using VISA.

Use the NI-VISA online help or the *NI-VISA Programmer Reference Manual* for specific information about the attributes, events, and operations, such as format, syntax, parameters, and possible errors.

♦ **Windows users**—The *NI-VISA Programmer Reference Manual* is not included in Windows kits. Windows users can access this information through the `NI-visa.hlp` file at **Start»Programs»National Instruments»VISA»VISA Help**.

Conventions

The following conventions appear in this manual:

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

♦ The ♦ symbol indicates that the following text applies only to a specific product, a specific operating system, or a specific software version.

 This icon denotes a tip, which alerts you to advisory information.

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

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

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

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

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

Related Documentation

The following documents contain information that you may find helpful as you read this manual:

- ANSI/IEEE Standard 488.1-1987, *IEEE Standard Digital Interface for Programmable Instrumentation*
- ANSI/IEEE Standard 488.2-1992, *IEEE Standard Codes, Formats, Protocols, and Common Commands*

- ANSI/IEEE Standard 1014-1987, *IEEE Standard for a Versatile Backplane Bus: VMEbus*
- ANSI/IEEE Standard 1155-1992, *VMEbus Extensions for Instrumentation: VXIbus*
- ANSI/ISO Standard 9899-1990, *Programming Language C*
- *NI-488.2 Function Reference Manual for DOS/Windows*, National Instruments Corporation
- *NI-488.2 User Manual for Windows*, National Instruments Corporation
- *NI-VXI Programmer Reference Manual*, National Instruments Corporation
- *NI-VXI User Manual*, National Instruments Corporation
- VPP-1, *Charter Document*
- VPP-2, *System Frameworks Specification*
- VPP-3.1, *Instrument Drivers Architecture and Design Specification*
- VPP-3.2, *Instrument Driver Functional Body Specification*
- VPP-3.3, *Instrument Driver Interactive Developer Interface Specification*
- VPP-3.4, *Instrument Driver Programmatic Developer Interface Specification*
- VPP-4.3, *The VISA Library*
- VPP-4.3.2, *VISA Implementation Specification for Textual Languages*
- VPP-4.3.3, *VISA Implementation Specification for the G Language*
- VPP-5, *VXI Component Knowledge Base Specification*
- VPP-6, *Installation and Packaging Specification*
- VPP-7, *Soft Front Panel Specification*
- VPP-8, *VXI Module/Mainframe to Receiver Interconnection*
- VPP-9, *Instrument Vendor Abbreviations*

1

Introduction

This chapter discusses how to use this manual, lists what you need to get started, and contains a brief description of the VISA Library. The National Instruments implementation of VISA is known as *NI-VISA*.

How to Use This Manual

This manual provides a sequential introduction to setting up a system to use VISA and then using and programming the environment. Please gather all the components described in the next section, *What You Need to Get Started*. The Read Me First document included with your kit explains how to install and set up your system.

Once you have set up your system, you can use Chapter 2, *Introductory Programming Examples*, to guide yourself through some simple examples. Chapters 3 through 8 contain more in-depth information about the different elements that make up the VISA system.

For GPIB users or those familiar with NI-488, suggested reading is Chapter 2, *Introductory Programming Examples*, Chapter 5, *Message-Based Communication*, and the *GPIB* section in Chapter 9, *Interface Specific Information*. For VXI users or those familiar with NI-VXI, suggested reading is Chapter 2, *Introductory Programming Examples*, Chapter 6, *Register-Based Communication*, and the *VXI* section in Chapter 9, *Interface Specific Information*.

What You Need to Get Started

- ❑ Appropriate hardware, in the form of a National Instruments GPIB, GPIB-VXI, MXI/VXI or serial interface board. For other hardware interfaces, the computer's standard ports should be sufficient for most applications.
- ❑ For GPIB applications, install NI-488. For VXI applications, install NI-VXI. For other hardware interfaces, NI-VISA uses the system's standard drivers.

- NI-VISA distribution media
- If you have a GPIB-VXI command module from another vendor, you need that vendor's GPIB-VXI VISA component. It will be installed into the <*VXIPNPPATH*>\<*Framework*>\bin directory. For example, the Hewlett-Packard component for the HPE1406 would be:

  `C:\VXIpnp\Win95\bin\HPGPVX32.dll`

Introduction to VISA

The main objective of the VXI*plug&play* Systems Alliance is to increase ease of use for end users through open, multi-vendor systems. The alliance members share a common vision for multi-vendor systems architecture, encompassing both hardware and software. This common vision enables the members to work together to define and implement standards for system-level issues.

As a step toward industry-wide software compatibility, the alliance developed one specification for I/O software—the Virtual Instrument System Architecture, or VISA. The VISA specification defines a next-generation I/O software standard not only for VXI, but also for GPIB, Serial, and other interfaces. With the VISA standard endorsed by over 35 of the largest instrumentation companies in the industry including Tektronix, Hewlett-Packard, and National Instruments, VISA unifies the industry to make software interoperable, reusable, and able to stand the test of time. The alliance also grouped the most popular operating systems, application development environments, and programming languages into distinct frameworks and defined in-depth specifications to guarantee interoperability of components within each framework.

This manual describes how to use NI-VISA, the National Instruments implementation of the VISA I/O standard, in any environment using LabWindows/CVI, any ANSI C compiler, or Microsoft Visual Basic. NI-VISA currently supports the frameworks and programming languages shown in Table 1-1. For information on programming VISA from LabVIEW, refer to the VISA documentation included with your LabVIEW software.

Table 1-1. NI-VISA Support

Operating System	Programming Language/Environment	VXI*plug&play* Framework
Windows Me/98/95	LabWindows/CVI, ANSI C, Visual Basic	WIN95
Windows Me/98/95	LabVIEW	GWIN95
Windows 2000/NT/XP	LabWindows/CVI, ANSI C, Visual Basic	WINNT
Windows 2000/NT/XP	LabVIEW	GWINNT
LabVIEW RT	LabVIEW	*
Solaris 2.*x*	LabWindows/CVI, ANSI C	SUN
Solaris 2.*x*	LabVIEW	GSUN
Mac OS 8/9/X	ANSI C, LabVIEW	*
Linux *x*86	ANSI C, LabVIEW	*
VxWorks *x*86	ANSI C	*

* This framework is supported by NI-VISA even though it is not defined by the VXI*plug&play* Systems Alliance.

You may find that programming with NI-VISA is not significantly different from programming with other I/O software products. However, the programming concepts, model, and paradigm that NI-VISA uses create a solid foundation for taking advantage of VISA's more powerful features in the future.

2

Introductory Programming Examples

This chapter introduces some examples of common communication with instruments. To help you become comfortable with VISA, the examples avoid VISA terminology. Chapter 3, *VISA Overview*, looks at these examples again but using VISA terminology and focusing more on how they explain the VISA model.

Note The examples in this chapter show C source code. You can find the same examples in Visual Basic syntax in Appendix A, *Visual Basic Examples*.

Example of Message-Based Communication

Serial, GPIB, and VXI systems all have a definition of message-based communication. In GPIB and serial, the messages are inherent in the design of the bus itself. For VXI, the messages actually are sent via a protocol known as *word serial*, which is based on register communication. In either case, the end result is sending or receiving strings.

Example 2-1 shows the basic steps in any VISA program.

Example 2-1

```
#include "visa.h"

#define MAX_CNT 200

int main(void)
{
       ViStatus    status;               /* For checking errors          */
       ViSession   defaultRM, instr;     /* Communication channels       */
       ViUInt32    retCount;             /* Return count from string I/O */
       ViChar      buffer[MAX_CNT];      /* Buffer for string I/O        */


       /* Begin by initializing the system*/
       status = viOpenDefaultRM(&defaultRM);
       if (status < VI_SUCCESS) {
          /* Error Initializing VISA...exiting*/
          return -1;
       }

       /* Open communication with GPIB Device at Primary Addr 1*/
       /* NOTE: For simplicity, we will not show error checking*/
       status = viOpen(defaultRM, "GPIB0::1::INSTR", VI_NULL, VI_NULL,
          &instr);

       /* Set the timeout for message-based communication*/
       status = viSetAttribute(instr, VI_ATTR_TMO_VALUE, 5000);

       /* Ask the device for identification */
       status = viWrite(instr, "*IDN?\n", 6, &retCount);
       status = viRead(instr, buffer, MAX_CNT, &retCount);

       /* Your code should process the data */

       /* Close down the system                                          */
       status = viClose(instr);
       status = viClose(defaultRM);
       return 0;
}
```

Example 2-1 Discussion

We can break down Example 2-1 into the following steps.

1. Begin by initializing the VISA system. For this task you use `viOpenDefaultRM()`, which opens a communication channel with VISA itself. This channel has a purpose similar to a telephone line. The function call is analogous to picking up the phone and dialing the operator. From this point on, the phone line, or the value output from `viOpenDefaultRM()`, is what connects you to the VISA driver. Any communication on the line is between you and the VISA driver only. Chapter 3, *VISA Overview*, has more details about `viOpenDefaultRM()`, but for now it is sufficient for you to understand that the function initializes VISA and must be the first VISA function called in your program.
2. Now you must open a communication channel to the device itself using `viOpen()`. Notice that this function uses the handle returned by `viOpenDefaultRM()`, which is the variable `defaultRM` in the example, to identify the VISA driver. You then specify the address of the device you want to talk to. Continuing with the phone analogy, this is like asking the operator to dial a number for you. In this case, you want to address a GPIB device at primary address 1 on the GPIB0 bus. The value for *x* in the GPIB*x* token (GPIB0 in this example) indicates the GPIB board to which your device is attached. This means that you can have multiple GPIB boards installed in the computer, each controlling independent buses. For more information on address strings, `viOpen()`, and `viOpenDefaultRM()`, see Chapter 4, *Initializing Your VISA Application*.

   The two `VI_NULL` values following the address string are not important at this time. They specify that the session should be initialized using VISA defaults. Finally, `viOpen()` returns the communication channel to the device in the parameter `instr`. From now on, whenever you want to talk to this device, you use the `instr` variable to identify it. Notice that you do not use the `defaultRM` handle again. The main use of `defaultRM` is to tell the VISA driver to open communication channels to devices. You do not use this handle again until you are ready to end the program.
3. At this point, set a timeout value for message-based communication. A timeout value is important in message-based communication to determine what should happen when the device stops communicating for a certain period of time. VISA has a common function to set values such as these: `viSetAttribute()`. This function sets values such as timeout and the termination character for the communication channel. In this example, notice that the function call to `viSetAttribute()`

sets the timeout to be 5 s (5000 ms) for both reading and writing strings.

4. Now that you have the communication channel set up, you can perform string I/O using the `viWrite()` and `viRead()` functions. Notice that this is the section of the programming code that is unique for message-based communication. Opening communication channels, as described in steps 1 and 2, and closing the channels, as described in step 5, are the same for all VISA programs. The parameters that these calls use are relatively straightforward.
   a. First you identify which device you are talking to with `instr`.
   b. Next you give the string to send, or what buffer to put the response in.
   c. Finally, specify the number of characters you are interested in transferring.

   For more information on these functions, see Chapter 5, *Message-Based Communication*. Also refer to the NI-VISA online help or the *NI-VISA Programmer Reference Manual*.
5. When you are finished with your device I/O, you can close the communication channel to the device with the `viClose()` function.

   Notice that the program shows a second call to `viClose()`. When you are ready to shut down the program, or at least close down the VISA driver, you use `viClose()` to close the communication channel that was opened using `viOpenDefaultRM()`.

Example of Register-Based Communication

Note You can skip over this section if you are exclusively using GPIB or serial communication. Register-based programming applies only to VXI, GPIB-VXI, or PXI.

VISA has two standard methods for accessing registers. The first method uses *High-Level Access* functions. You can use these functions to specify the address to access; the functions then take care of the necessary details to perform the access, from mapping an I/O window to checking for failures. The drawback to using these functions is the amount of software overhead associated with them.

To reduce the overhead, VISA also has *Low-Level Access* functions. These functions break down the tasks done by the High-Level Access functions and let the program perform each task itself. The advantage is that you can optimize the sequence of calls based on the style of register I/O you are

about to perform. However, you must be more knowledgeable about how register accesses work. In addition, you cannot check for errors easily. The following example shows how to perform register I/O using the High-Level Access functions, which is the method we recommend for new users. If you are an experienced user or understand register I/O concepts, you can use the *Low-Level Access Operations* section in Chapter 6, *Register-Based Communication*.

Note Examples 2-2 through 2-4 use **bold** text to distinguish lines of code that are different from the other examples in this chapter.

Example 2-2

```
#include "visa.h"

int main(void)
{
       ViStatus    status;               /* For checking errors          */
       ViSession   defaultRM, instr;     /* Communication channels       */
       ViUInt16    deviceID;             /* To store the value           */

       /* Begin by initializing the system*/
       status = viOpenDefaultRM(&defaultRM);
       if (status < VI_SUCCESS) {
          /* Error Initializing VISA...exiting*/
          return -1;
       }

       /* Open communication with VXI Device at Logical Addr 16 */
       /* NOTE: For simplicity, we will not show error checking */
       status = viOpen(defaultRM, "VXI0::16::INSTR", VI_NULL, VI_NULL,
          &instr);

       /* Read the Device ID, and write to memory in A24 space */
       status = viIn16(instr, VI_A16_SPACE, 0, &deviceID);
       status = viOut16(instr, VI_A24_SPACE, 0, 0x1234);

       /* Close down the system */
       status = viClose(instr);
       status = viClose(defaultRM);
       return 0;
}
```

Example 2-2 Discussion

The general structure of this example is very similar to that of Example 2-1. For this reason, we merely point out the basic differences as denoted in **bold** text:

- A different address string is used for the VXI device.
- The string functions from Example 2-1 are replaced with register functions.

The address string is still the same format as the address string in Example 2-1, but it has replaced the GPIB with VXI. Again, remember that the difference in the address string name is the extent to which the specific interface bus will be important. Indeed, since this is a simple string, it is possible to have the program read in the string from a user input or a configuration file. Thus, the program can be compiled and is still portable to different platforms, such as from a GPIB-VXI to a MXIbus board.

As you can see from the programming code, you use different functions to perform I/O with a register-based device. The functions `viIn16()` and `viOut16()` read and write 16-bit values to registers in either the A16, A24, or A32 space of VXI. As with the message-based functions, you start by specifying which device you want to talk to by supplying the `instr` variable. You then identify the address space you are targeting, such as `VI_A16_SPACE`.

The next parameter warrants close examination. Notice that we want to read in the value of the Device ID register for the device at logical address 16. Logical addresses start at offset 0xC000 in A16 space, and each logical address gets 0x40 bytes of address space. Because the Device ID register is the first address within that 0x40 bytes, the absolute address of the Device ID register for logical address 16 is calculated as follows:

```
0xC000 + (0x40 * 16) = 0xC400
```

However, notice that the offset we supplied was 0. The reason for this is that the `instr` parameter identifies which device you are talking to, and therefore the VISA driver is able to perform the address calculation itself. The 0 indicates the first register in the 0x40 bytes of address space, or the Device ID register. The same holds true for the `viOut16()` call. Even in A24 or A32 space, although it is possible that you are talking to a device whose memory starts at 0x0, it is more likely that the VXI Resource Manager has provided some other offset, such as 0x200000 for the memory. However, because `instr` identifies the device, and the Resource Manager has told the driver the offset address of the device's memory, you do not need to know the details of the absolute address. Just provide the

offset within the memory space, and VISA does the rest. For more detailed information about other defined VXI registers, refer to the *NI-VXI User Manual*.

Again, when you are done with the register I/O, use `viClose()` to shut down the system.

Example of Handling Events

When dealing with instrument communication, it is very common for the instrument to require service from the controller when the controller is not actually looking at the device. A device can notify the controller via a service request (SRQ), interrupt, or a signal. Each of these is an asynchronous event, or simply an event. In VISA, you can handle these and other events through either callbacks or a software queue.

Callbacks

Using callbacks, you can have sections of code that are never explicitly called by the program, but instead are called by the VISA driver whenever an event occurs. Due to their asynchronous nature, callbacks can be difficult to incorporate into a traditional, sequential flow program. Therefore, we recommend the queuing method of handling events for new users. If you are an experienced user or understand callback concepts, look at the *Callbacks* section in Chapter 7, *VISA Events*.

Queuing

When using a software queue, the VISA driver detects the asynchronous event but does not alert the program to the occurrence. Instead, the driver maintains a list of events that have occurred so that the program can retrieve the information later. With this technique, the program can periodically poll the driver for event information or halt the program until the event has occurred. Example 2-3 programs an oscilloscope to capture a waveform. When the waveform is complete, the instrument generates a VXI interrupt, so the program must wait for the interrupt before trying to read the data.

Example 2-3

```
#include "visa.h"

int main(void)
{
       ViStatus    status;               /* For checking errors          */
       ViSession   defaultRM, instr;     /* Communication channels       */
       ViEvent     eventData;            /* To hold event info           */
       ViUInt16    statID;               /* Interrupt Status ID          */

       /* Begin by initializing the system */
       status = viOpenDefaultRM(&defaultRM);
       if (status < VI_SUCCESS) {
          /* Error Initializing VISA...exiting */
          return -1;
       }

       /* Open communication with VXI Device at Logical Address 16*/
       /* NOTE: For simplicity, we will not show error checking */
       status = viOpen(defaultRM, "VXI0::16::INSTR", VI_NULL, VI_NULL,
          &instr);

       /* Enable the driver to detect the interrupts */
       status = viEnableEvent(instr, VI_EVENT_VXI_SIGP, VI_QUEUE, VI_NULL);

       /* Send the commands to the oscilloscope to capture the */
       /* waveform and interrupt when done */

       status = viWaitOnEvent(instr, VI_EVENT_VXI_SIGP, 5000, VI_NULL,
          &eventData);
       if (status < VI_SUCCESS) {
          /* No interrupts received after 5000 ms timeout */
          viClose(defaultRM);
          return -1;
       }

       /* Obtain the information about the event and then destroy the*/
       /* event. In this case, we want the status ID from the interrupt.*/
       status = viGetAttribute(eventData, VI_ATTR_SIGP_STATUS_ID, &statID);
       status = viClose(eventData);

       /* Your code should read data from the instrument and process it.*/
```

```
        /* Stop listening to events */
        status = viDisableEvent(instr, VI_EVENT_VXI_SIGP, VI_QUEUE);

        /* Close down the system */
        status = viClose(instr);
        status = viClose(defaultRM);
        return 0;
}
```

Example 2-3 Discussion

Programming with events presents some new functions to use. The first two functions you notice are `viEnableEvent()` and `viDisableEvent()`. These functions tell the VISA driver which events to listen for—in this case `VI_EVENT_VXI_SIGP`, which covers both VXI interrupts and VXI signals. In addition, these functions tell the driver how to handle events when they occur. In this example, the driver is instructed to queue (`VI_QUEUE`) the events until asked for them. Notice that `instr` is also supplied to the functions, since VISA performs event handling on a per-communication-channel basis.

Once the driver is ready to handle events, you are free to write code that will result in an event being generated. In the example above, this is shown as a comment block because the exact code depends on the device. After you have set the device up to interrupt, the program must wait for the interrupt. This is accomplished by the `viWaitOnEvent()` function. Here you specify what events you are waiting for and how long you want to wait. The program then blocks, and that thread performs no other functions, until the event occurs. Therefore, after the `viWaitOnEvent()` call returns, either it has timed out (5 s in the above example) or it has caught the interrupt. After some error checking to determine whether it was successful, you can obtain information from the event through `viGetAttribute()`. When you are finished with the event data structure (`eventData`), destroy it by calling `viClose()` on it. You can now continue with the program and retrieve the data. The rest of the program is the same as the previous examples.

Notice the difference in the way you can shut down the program if a timeout has occurred. You do not need to close the communication channel with the device, but only with the VISA driver. You can do this because when a driver channel (`defaultRM`) is closed, the VISA driver closes all I/O channels opened with it. So when you need to shut down a program quickly, as in the case of an error, you can simply close the channel to the driver and VISA handles the rest for you. However, VISA does not clean up anything

not associated with VISA, such as memory you have allocated. You are still responsible for those items.

Example of Locking

Occasionally you may need to prevent other applications from using the same resource that you are using. VISA has a service called *locking* that you can use to gain exclusive access to a resource. VISA also has another locking option in which you can have multiple sessions share a lock. Because lock sharing is an advanced topic that may involve inter-process communication, see the *Lock Sharing* section in Chapter 8, *VISA Locks*, for more information. Example 2-4 uses the simpler form, the exclusive lock, to prevent other VISA applications from modifying the state of the specified serial port.

Example 2-4

```
#include "visa.h"

#define MAX_CNT 200

int main(void)
{
       ViStatus    status;               /* For checking errors          */
       ViSession   defaultRM, instr;     /* Communication channels       */
       ViUInt32    retCount;             /* Return count from string I/O */
       ViChar      buffer[MAX_CNT];      /* Buffer for string I/O        */


       /* Begin by initializing the system*/
       status = viOpenDefaultRM(&defaultRM);
       if (status < VI_SUCCESS) {
          /* Error Initializing VISA...exiting*/
          return -1;
       }

       /* Open communication with Serial Port 1*/
       /* NOTE: For simplicity, we will not show error checking*/
       status = viOpen(defaultRM, "ASRL1::INSTR", VI_NULL, VI_NULL, &instr);

       /* Set the timeout for message-based communication*/
       status = viSetAttribute(instr, VI_ATTR_TMO_VALUE, 5000);
```

```
        /* Lock the serial port so that nothing else can use it*/
        status = viLock(instr, VI_EXCLUSIVE_LOCK, 5000, VI_NULL, VI_NULL);

        /* Set serial port settings as needed*/
        /* Defaults = 9600 Baud, no parity, 8 data bits, 1 stop bit*/
        status = viSetAttribute(instr, VI_ATTR_ASRL_BAUD, 2400);
        status = viSetAttribute(instr, VI_ATTR_ASRL_DATA_BITS, 7);

        /* Set this attribute for binary transfers, skip it for this text example */
        /* status = viSetAttribute(instr, VI_ATTR_ASRL_END_IN, 0); */

        /* Ask the device for identification */
        status = viWrite(instr, "*IDN?\n", 6, &retCount);
        status = viRead(instr, buffer, MAX_CNT, &retCount);

        /* Unlock the serial port before ending the program*/
        status = viUnlock(instr);

        /* Your code should process the data*/

        /* Close down the system */
        status = viClose(instr);
        status = viClose(defaultRM);
        return 0;
}
```

Example 2-4 Discussion

As you can see, the program does not differ with respect to controlling the instrument. The ability to lock and unlock the resource simply involves inserting the `viLock()` and `viUnlock()` operations around the code that you want to ensure is protected, as far as the instrument is concerned.

To lock a resource, you use the `viLock()` operation on the session to the resource. Notice that the second parameter is `VI_EXCLUSIVE_LOCK`. This parameter tells VISA that you want this session to be the only session that can access the device. The next parameter, `5000`, is the time in milliseconds you are willing to wait for the lock. For example, another program may have locked its session to the resource before you. Using this timeout feature, you can tell your program to wait until either the other program has unlocked the session, or 5 s have passed, whichever comes first.

The final two parameters are used in the lock sharing feature of `viLock()` and are discussed further in Chapter 8, *VISA Locks*. For most applications, however, these parameters are set to `VI_NULL`. Notice that if the `viLock()` call succeeds, you then have exclusive access to the device. Other programs do not have access to the device at all. Therefore, you should hold a lock only for the time you need to program the device, especially if you are designing an instrument driver. Failure to do so may cause other applications to block or terminate with a failure.

When using a VISA lock over the Ethernet, the lock applies to any machine using the given resource. For example, calling `viLock()` when using a National Instruments ENET Serial controller prevents other machines from performing I/O on the given serial port.

To end the example, the application calls `viUnlock()` when it has acquired the data from the instrument. At this point, the resource is accessible from any other session in any application.

3

VISA Overview

This chapter contains an overview of the VISA Library.

Background

The history of instrumentation reached a milestone with the ability to communicate with an instrument from a computer. Controlling instruments programmably brought a great deal of power and flexibility with the capability to control devices faster and more accurately without the need for human supervision. Over time, application development environments such as LabVIEW and LabWindows/CVI eased the task of programming and increased productivity, but instrumentation system developers were still faced with the details of programming the instrument or the device interface bus.

Instrument programmers require a software architecture that exports the capabilities of the *devices*, not just the interface bus. In addition, the architecture needs to be consistent across the devices and interface buses. The VISA library realizes these goals. It results in a simpler model to understand, reduces the number of functions the user needs to learn, and significantly reduces the time and effort involved in programming different interfaces. Instead of using a different Application Programming Interface (API) devoted to each interface bus, you can use the VISA API whether your system uses an Ethernet, GPIB, GPIB-VXI, VXI, PXI, or Serial controller.

Finally, most instruments export a specific set of commands to which they will respond. These commands are often primitive functions of the device and require several commands to group them together so that the device can perform common tasks. As a result, communicating directly with the device may require much overhead in the form of multiple commands to *do task* A, *do task* B, and so on. By driving the formation of the VXI*plug&play* Systems Alliance and the IVI Foundation, National Instruments has spearheaded standards for higher-level instrument drivers that use VISA. This makes it easier for the vendors of instruments to create the instrument drivers themselves, so that instrumentation system developers do not have to learn the primitive command sets of each device.

Interactive Control of VISA

NI-VISA comes with a utility called VISA Interactive Control (VISAIC) on all platforms that support VISA, with the exception of Macintosh and VxWorks. This utility gives you access to all of VISA's functionality interactively, in an easy-to-use graphical environment. It is a convenient starting point for program development and learning about VISA.

When VISAIC runs, it automatically finds all of the available resources in the system and lists the instrument descriptors for each of these resources under the appropriate resource type. This information is displayed on the **VISA I/O** tab.

The following figure shows the VISAIC opening window.

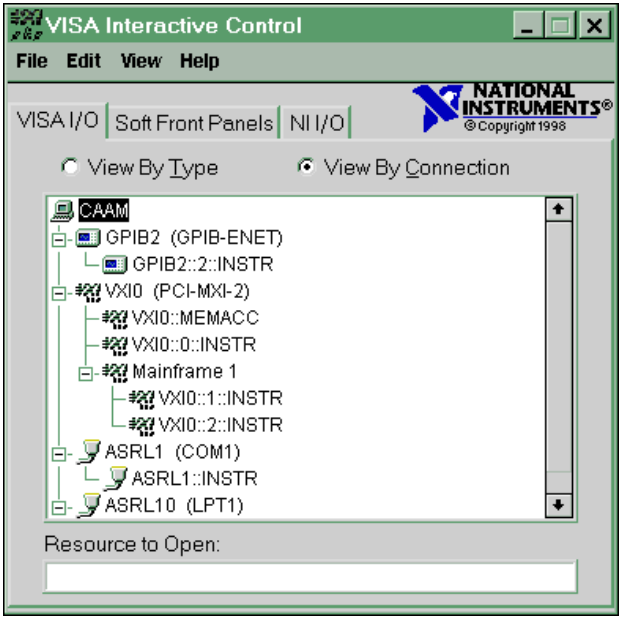


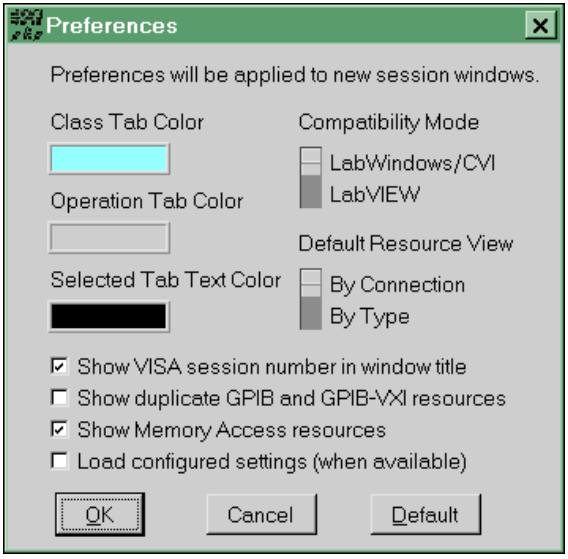
Figure 3-1. VISAIC Opening Window

The **Soft Front Panels** tab of the main VISAIC panel gives you the option to launch the soft front panels of any VXI*plug&play* instrument drivers that have been installed on the system.

The **NI I/O** tab gives you the option to launch the NI-VXI interactive utility or the NI-488 interactive utility. This gives you convenient links into the

interactive utilities for the drivers VISA calls in case you would like to try debugging at this level.

Double-clicking on any of the instrument descriptors shown in the VISAIC window opens a session to that instrument. Opening a session to the instrument produces a window with a series of tabs for interactively running VISA commands. The exact appearance of these tabs depends on which compatibility mode VISAIC is in. To access the compatibility mode and other VISAIC preferences select **Edit»Preferences…** to bring up the following window.

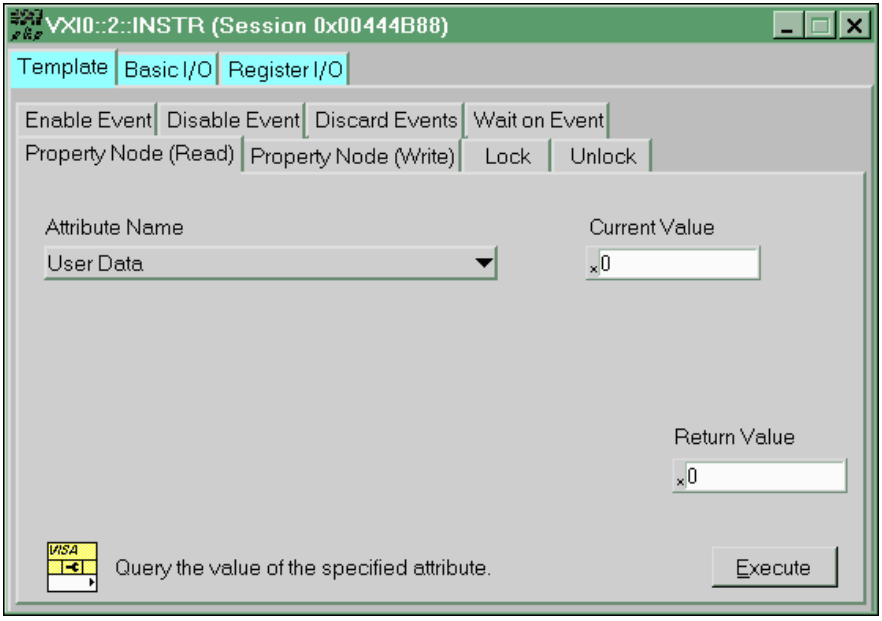


The VISA implementations are slightly different in LabVIEW and LabWindows/CVI. These differences are reflected in the operation tabs that are shown when you open a session to a resource.

- **Windows users**—VISAIC detects whether you have LabVIEW and/or LabWindows/CVI installed on your system and sets the compatibility mode accordingly.

  If you change the preferences, the new preferences take effect for any subsequent session you open.

  When a session to a resource is opened interactively, a window similar to the following appears. This window uses the LabVIEW compatibility mode.



Three main tabs appear in the window. The initial tab is the **Template** tab, which contains all of the operations dealing with events, properties, and locks. Notice that there is a separate tab for each of these operations under the main tab. The other main tabs are **Basic I/O** and **Register I/O**. The **Basic I/O** tab contains the operations for message-based instruments, while the **Register I/O** tab contains the operations for register-based instruments. The **Register I/O** tab does not appear for either GPIB or Serial instruments.

VISA Terminology

Chapter 2, *Introductory Programming Examples*, introduced some examples of how to write code for the VISA driver. However, the chapter deliberately avoided using VISA terminology to show that writing programs under VISA can be very straightforward and similar to software drivers you have used in the past. This section looks at these examples again, but this time from the perspective of the underlying architecture.

Beginning Terminology

Typical device capabilities include sending and receiving messages, responding to register accesses, requesting service, being reset, and so on. One of the underlying premises of VISA, as defined in the previous section,

is to export the capabilities of the devices—independent of the interface bus—to the user. VISA encapsulates each of these abilities into a *resource*.

A resource is simply a complete description of a particular set of capabilities of a device. For example, to be able to write to a device, you need a function you can use to send messages—`viWrite()`. In addition, there are certain details you need to consider, such as how long the function should try to communicate before timing out. Those of you familiar with this methodology might recognize this approach as object-oriented (OO) design. Indeed, VISA is based on OO design. In keeping with the terminology of OO, we call the functions of these resources *operations* and the details, such as the timeout, *attributes*.

An important VISA resource is the *INSTR* Resource. This resource encapsulates all of the basic device functions together so that you can communicate with the device through a single resource. The INSTR Resource exports the most commonly used features of these resources and is sufficient for most instrument drivers.

Other resource classes currently supported include MEMACC, INTFC, BACKPLANE, SERVANT, and SOCKET. Most of these are specific to a given hardware interface type, and are intended for advanced programmers. You can read more about these classes in *VISA Resource Types* in *NI-VISA Programmer Reference Manual*.

Returning to Example 2-1 in Chapter 2, *Introductory Programming Examples*, look at the point where the program has opened a communication channel with a message-based device. Because of interface independence, it does not matter whether the device is GPIB or VXI or of any other interface type. You want to send the identification query, "`*IDN?\n`", to the device. Because of the possibility that the device or interface could fail, you want to ensure that the computer will not hang in the event that the device does not receive the string. Therefore, the first step is to tell the resource to time out after 5 s (5000 ms):

```
status = viSetAttribute(instr, VI_ATTR_TMO_VALUE, 5000);
```

This sets an attribute (`VI_ATTR_TMO_VALUE`) of the resource. From this point on, all communication to this resource through this communication channel (`instr`) will have a timeout of 5 s. As you become more experienced with VISA, you will see more of the benefits of this OO approach. But for now, you can see that you can set the timeout with an operation (function) in a manner similar to that used with other drivers. In addition, the operation you need to remember, `viSetAttribute()`, is the

same operation you use to set any feature of any resource. Now you send the string to the device and read the result:

```
status = viWrite(instr, "*IDN?\n", 6, &retCount);
status = viRead(instr, buffer, MAX_CNT, &retCount);
```

This is a familiar approach to programming. You use a write operation to send a string to a device, and read the response with a read operation.

See Chapter 5, *Message-Based Communication*, for more information.

Communication Channels: Sessions

The examples from Chapter 2, *Introductory Programming Examples*, used an operation called `viOpen()` to open communication channels with the instruments. In VISA terminology, this channel is known as a *session*. A session connects you to the resource you addressed in the `viOpen()` operation and keeps your communication and attribute settings unique from other sessions to the same resource. In VISA, a resource can have multiple sessions to it from the same program and for interfaces other than Serial, even from other programs simultaneously. Therefore you must consider some things about the resource to be *local*, that is, unique to the session, and other things to be *global*, that is, common for all sessions to the resource.

If you look at the descriptions of the various attributes supported by the VISA resources, you will see that some are marked *global* (such as `VI_ATTR_INTF_TYPE`) and others are marked *local* (such as `VI_ATTR_TMO_VALUE`). For example, the interface bus that the resource is using to communicate with the device (`VI_ATTR_INTF_TYPE`) is the same for everyone using that resource and is therefore a *global attribute*. However, different programs may have different timeout requirements, so the communication timeout value (`VI_ATTR_TMO_VALUE`) is a *local attribute*.

Again, look at Example 2-1. To open communication with the instrument, that is, to create a session to the INSTR Resource, you use the `viOpen()` operation as shown below:

```
status = viOpen(defaultRM, "GPIB0::1::INSTR", VI_NULL, VI_NULL,
    &instr);
```

In this case, the interface to which the instrument is connected is important, but only as a means to uniquely identify the instrument. The code above references a GPIB device on bus number 0 with primary address 1. The access mode and timeout values for `viOpen()` are both `VI_NULL`. Other

values are defined, but VI_NULL is recommended for new users and all instrument drivers.

However, notice the statement has two sessions in the parameter list for viOpen(), defaultRM and instr. Why do you need two sessions? As you will see in a moment, viOpen() is an operation on the Resource Manager, so you must have a communication channel to this resource. However, what you want is a session to the *instrument*; this is what is returned in instr.

For the entire duration that you communicate with this GPIB instrument, you use the session returned in instr as the communication channel. When you are finished with the communication, you need to close the channel. This is accomplished through the viClose() operation as shown below:

```
status = viClose(instr);
```

At this point, the communication channel is closed but you are still free to open it again or open a session to another device. Notice that you do *not* need to close a session to open another session. You can have as many sessions to different devices as you want.

The Resource Manager

The previous section briefly mentioned the VISA Resource known as the Resource Manager. What exactly is a Resource Manager? If you have worked with VXI, you are familiar with the VXI Resource Manager. Its job is to search the VXI chassis for instruments, configure them, and then return its findings to the user. The VISA Resource Manager has a similar function. It scans the system to find all the devices connected to it through the various interface buses and then controls the access to them. Notice that the Resource Manager simply keeps track of the resources and creates sessions to them as requested. You do not go through the Resource Manager with every operation defined on a resource.

Again referring to Example 2-1, notice that the first line of code is a function call to get a session to the Default Resource Manager:

```
status = viOpenDefaultRM(&defaultRM);
```

The viOpenDefaultRM() function returns a unique session to the Default Resource Manager, but does not require some other session to operate. Therefore this function is not a part of any resource—not even the Resource Manager Resource. It is provided by the VISA driver itself and is the means by which the driver is initialized.

Now that you have a communication channel (session) to the Resource Manager, you can ask it to create sessions to instruments for you. In addition to this, VISA also defines operations that can be invoked to query the Resource Manager about other resources it knows about. You can use the `viFindRsrc()` operation to give the Resource Manager a search string, known as a regular expression, for instruments in the system. See Chapter 4, *Initializing Your VISA Application*, for more information about `viFindRsrc()`.

Examples of Interface Independence

Now that you are more familiar with the architecture of the VISA driver, we will cover two examples of how VISA provides interface independence.

First, many devices available today have both a Serial port and a GPIB port. If you do not use VISA, then you must learn and use two APIs to communicate with this device, depending on how you have it connected. With VISA, however, you can use a single API to communicate with this device regardless of the connection. Only the initialization code differs—for example, the resource string is different, and you may have to set the serial communication port parameters if they are different from the specified defaults. But all communication after the initialization should be identical for either bus type. Many VISA-based instrument drivers exist for these types of devices.

The existence of multi-interface devices is a trend that will continue and likely increase with the proliferation of new computer buses. This trend is also true of non-GPIB devices. Several VXI device manufacturers, for example, have repackaged their boards as PXI devices, with a similarly minimal impact on their VISA-based instrument drivers.

A second example of interface independence is the GPIB-VXI controller. This lets you communicate with VXI devices, but through a GPIB cable. In other words, you use a GPIB interface with GPIB software to send messages to VXI devices, the same way you program stand-alone GPIB instruments. But how do you perform register accesses to the VXI devices? Prior to VISA, you were required to send messages to the GPIB-VXI itself and ask it to perform the register access. For example, when talking to the National Instruments GPIB-VXI/C with NI-488.2, the register access looks like the following when using NI-488 function calls:

```
dev = ibdev(boardID, PrimAddr, SecAddr, TMO, EOT, EOS);
status = ibwrt(dev, "A24 #h200000, #h1234", cnt);
```

If you had ever planned to move your code to a MXI or embedded VXI controller solution, you would spend a great deal of time changing your GPIB calls to VXI calls, especially when considering register accesses. VISA has been designed to eliminate problems such as this limitation. If you are talking to a VXI instrument, you can perform register I/O regardless of whether you are connected via GPIB, MXI, or an embedded VXI computer. In addition, the code is exactly the same for all three cases. Therefore the code for writing to the A24 register through a GPIB-VXI is:

```
status = viOut16(instr, VI_A24_SPACE, 0x0, 0x1234);
```

These examples show how VISA removes the bus details from instrument communication. The VISA library takes care of those details and allows you to program your instrument based on its capabilities.

4

Initializing Your VISA Application

This chapter describes the steps required to prepare your application for communication with your device.

Introduction

A powerful feature of VISA is the concept of a single interface for finding and accessing devices on various platforms. The VISA Resource Manager does this by exporting services for controlling and managing resources. These services include, but are not limited to, assigning unique resource addresses and unique resource IDs, locating resources, and creating sessions.

Each session contains all the information necessary to configure the communication channel with a device, as well as information about the device itself. This information is encapsulated inside a generic structure called an *attribute*. You can use the attributes to configure a session or to find a particular resource.

Opening a Session

When trying to access any of the VISA resources, the first step is to get a reference to the default Resource Manager by calling `viOpenDefaultRM()`. Your application can then use the session returned from this call to open sessions to resources controlled by that Resource Manager, as shown in the following example.

Note The examples in this chapter show C source code. You can find the same examples in Visual Basic syntax in Appendix A, *Visual Basic Examples*.

Example 4-1

```
#include "visa.h"

int main(void)
{
       ViStatus    status;
       ViSession   defaultRM, instr;

       /* Open Default RM */
       status = viOpenDefaultRM(&defaultRM);
       if (status < VI_SUCCESS) {
          /* Error Initializing VISA...exiting */
          return -1;
       }

       /* Access other resources */
       status = viOpen(defaultRM, "GPIB::1::INSTR", VI_NULL, VI_NULL,
          &instr);

       /* Use device and eventually close it. */
       viClose(instr);
       viClose(defaultRM);
       return 0;
}
```

As shown in this example, you use the `viOpen()` call to open new sessions. In this call, you specify which resource to access by using a string that describes the resource. The following table shows the format for this string. Square brackets indicate optional string segments.

Interface	Syntax
VXI INSTR	`VXI[`*board*`]::`*VXI logical address*`[::INSTR]`
VXI MEMACC	`VXI[`*board*`]::MEMACC`
VXI BACKPLANE	`VXI[`*board*`][::`*mainframe logical address*`]::BACKPLANE`
VXI SERVANT	`VXI[`*board*`]::SERVANT`
GPIB-VXI INSTR	`GPIB-VXI[`*board*`]::`*VXI logical address*`[::INSTR]`

Interface	Syntax
GPIB-VXI MEMACC	`GPIB-VXI[board]::MEMACC`
GPIB-VXI BACKPLANE	`GPIB-VXI[board][::mainframe logical address]::BACKPLANE`
GPIB INSTR	`GPIB[board]::primary address[::secondary address][::INSTR]`
GPIB INTFC	`GPIB[board]::INTFC`
GPIB SERVANT	`GPIB[board]::SERVANT`
PXI INSTR	`PXI[board]::device[::function][::INSTR]`
Serial INSTR	`ASRL[board][::INSTR]`
TCPIP INSTR	`TCPIP[board]::host address[::LAN device name][::INSTR]`
TCPIP SOCKET	`TCPIP[board]::host address::port::SOCKET`

Use the VXI keyword for VXI instruments via either embedded or MXIbus controllers. Use the GPIB-VXI keyword for a GPIB-VXI controller. Use the GPIB keyword to establish communication with a GPIB device. Use the ASRL keyword to establish communication with an asynchronous serial (such as RS-232) device.

Refer to Chapter 10, *NI-VISA Platform-Specific and Portability Issues*, for help in determining exactly which resource you may be accessing. In some cases, such as serial (ASRL) resources, the naming conventions with other serial naming conventions may be confusing. In the Windows platform, COM1 corresponds to ASRL1, unlike in LabVIEW where COM1 is accessible using port number 0.

The default values for optional string segments are as follows.

Optional String Segments	Default Value
board	0
secondary address	none
LAN device name	inst0

The following table shows examples of address strings.

Address String	Description
VXI0::1::INSTR	A VXI device at logical address 1 in VXI interface VXI0.
GPIB-VXI::9::INSTR	A VXI device at logical address 9 in a GPIB-VXI controlled system.
GPIB::1::0::INSTR	A GPIB device at primary address 1 and secondary address 0 in GPIB interface 0.
ASRL1::INSTR	A serial device attached to interface ASRL1.
VXI::MEMACC	Board-level register access to the VXI interface.
GPIB-VXI1::MEMACC	Board-level register access to GPIB-VXI interface number 1.
GPIB2::INTFC	Interface or raw resource for GPIB interface 2.
VXI::1::BACKPLANE	Mainframe resource for chassis 1 on the default VXI system, which is interface 0.
GPIB-VXI2::BACKPLANE	Mainframe resource for default chassis on GPIB-VXI interface 2.
GPIB1::SERVANT	Servant/device-side resource for GPIB interface 1.
VXI0::SERVANT	Servant/device-side resource for VXI interface 0.
PXI::15::INSTR	PXI device number 15 on bus 0.
TCPIP0::1.2.3.4::999 ::SOCKET	Raw TCP/IP access to port 999 at the specified IP address.
TCPIP::dev@company.com ::INSTR	A TCP/IP device using VXI-11 located at the specified address. This uses the default LAN Device Name of inst0.

The previous tables show the canonical resource name formats. NI-VISA also supports the use of aliases to make opening devices easier. On Windows, run the Measurement & Automation Explorer (MAX) and choose the menu option **Tools»NI-VISA»Alias Editor** to manage all your aliases. On UNIX, run `visaconf` and double-click any resource to bring up a dialog box for managing the alias for that resource. NI-VISA supports alias names that include letters, numbers, and underscores. To use an alias in your program, just call `viOpen()` with the alias name instead of the canonical resource name.

Finding Resources

As shown in the previous section, you can create a session to a resource using the `viOpen()` call. However, before you use this call you need to know the exact location (address) of the resource you want to open. To find out what resources are currently available at a given point in time, you can use the search services provided by the `viFindRsrc()` operation, as shown in the following example.

Example 4-2

```
#include "visa.h"

#define MANF_ID    0xFF6 /* 12-bit VXI manufacturer ID of device */
#define MODEL_CODE 0x0FE /* 12-bit or 16-bit model code of device */

/* Find the first matching device and return a session to it */
ViStatus autoConnect(ViPSession instrSesn)
{
       ViStatus   status;
       ViSession  defaultRM, instr;
       ViFindList fList;
       ViChar     desc[VI_FIND_BUFLEN];
       ViUInt32   numInstrs;
       ViUInt16   iManf, iModel;

       status = viOpenDefaultRM(&defaultRM);
       if (status < VI_SUCCESS) {
          /* Error initializing VISA ... exiting */
          return status;
       }
       /* Find all VXI instruments in the system */
```

```
    status = viFindRsrc(defaultRM, "?*VXI?*INSTR", &fList, &numInstrs,
        desc);
    if (status < VI_SUCCESS) {
        /* Error finding resources ... exiting */
        viClose(defaultRM);
        return status;
    }

    /* Open a session to each and determine if it matches */
    while (numInstrs--) {
        status = viOpen(defaultRM, desc, VI_NULL, VI_NULL, &instr);
        if (status < VI_SUCCESS) {
            viFindNext(fList, desc);
            continue;
        }
        status = viGetAttribute(instr, VI_ATTR_MANF_ID, &iManf);
        if ((status < VI_SUCCESS) || (iManf != MANF_ID)) {
            viClose(instr);
            viFindNext(fList, desc);
            continue;
        }
        status = viGetAttribute(instr, VI_ATTR_MODEL_CODE, &iModel);
        if ((status < VI_SUCCESS) || (iModel != MODEL_CODE)) {
            viClose(instr);
            viFindNext(fList, desc);
            continue;
        }

        /* We have a match, return the session without closing it */
        *instrSesn = instr;
        viClose(fList);
        /* Do not close defaultRM, as that would close instr too */
        return VI_SUCCESS;
    }

    /* No match was found, return an error */
    viClose(fList);
    viClose(defaultRM);
    return VI_ERROR_RSRC_NFOUND;
}
```

As this example shows, you can use `viFindRsrc()` to get a list of matching resource names, which you can then further examine one at a time using `viFindNext()`. Remember to free the space allocated by the system by invoking `viClose()` on the list reference `fList`.

Notice that while this sample function returns a session, it does not return the reference to the resource manager session that was also opened within the same function. In other words, there is only one output parameter, the session to the instrument itself, `instrSesn`. When your program is done using this session, it also needs to close that corresponding resource manager session. Therefore, if you use this style of initialization routine, you should later get the reference to the resource manager session by querying the attribute `VI_ATTR_RM_SESSION` just before closing the INSTR session. You can then close the resource manager session with `viClose()`.

Finding VISA Resources Using Regular Expressions

Using `viFindRsrc()` to locate a resource in a VISA system requires a way for you to identify which resources you are interested in. The VISA Resource Manager accomplishes this through the use of regular expressions, which specify a match for certain resources in the system. Regular expressions are strings consisting of ordinary characters as well as certain characters with special meanings that you can use to search for patterns instead of specific text. Regular expressions are based on the idea of matching, where a given string is tested to see if it *matches* the regular expression; that is, to determine if it fits the pattern of the regular expression. You can apply this same concept to a list of strings to return a subset of the list that matches the expression.

The following table defines the special characters and syntax rules used in VISA regular expressions.

Special Characters and Operators	Meaning
`?`	Matches any one character.
`\`	Makes the character that follows it an ordinary character instead of special character. For example, when a question mark follows a backslash (`\?`), it matches the `?` character instead of any one character.
`[list]`	Matches any one character from the enclosed `list`. You can use a hyphen to match a range of characters.
`[^list]`	Matches any character not in the enclosed `list`. You can use a hyphen to match a range of characters.
`*`	Matches 0 or more occurrences of the preceding character or expression.
`+`	Matches 1 or more occurrences of the preceding character or expression.
`exp|exp`	Matches either the preceding or following expression. The OR operator `|` matches the entire expression that precedes or follows it and not just the character that precedes or follows it. For example, `VXI|GPIB` means `(VXI)|(GPIB)`, not `VX(I|G)PIB`.
`(exp)`	Grouping characters or expressions.

The priority, or *precedence* of the operators in regular expressions is as follows:

- The grouping operator `()` in a regular expression has the highest precedence.
- The `+` and `*` operators have the next highest precedence.
- The OR operator `|` has the lowest precedence.

Notice that in VISA, the string `"GPIB?*INSTR"` applies to both GPIB and GPIB-VXI instruments.

The following table lists some examples of valid regular expressions that you can use with `viFindRsrc()`.

Regular Expression	Sample Matches
`?*INSTR`	Matches all INSTR (device) resources.
`GPIB?*INSTR`	Matches `GPIB0::2::INSTR`, `GPIB1::1::1::INSTR`, and `GPIB-VXI1::8::INSTR`.
`GPIB[0-9]*::?*INSTR`	Matches `GPIB0::2::INSTR` and `GPIB1::1::1::INSTR` but not `GPIB-VXI1::8::INSTR`.
`GPIB[^0]::?*INSTR`	Matches `GPIB1::1::1::INSTR` but not `GPIB0::2::INSTR` or `GPIB12::8::INSTR`.
`VXI?*INSTR`	Matches `VXI0::1::INSTR` but not `GPIB-VXI0::1::INSTR`.
`GPIB-VXI?*INSTR`	Matches `GPIB-VXI0::1::INSTR` but not `VXI0::1::INSTR`.
`?*VXI[0-9]*::?*INSTR`	Matches `VXI0::1::INSTR` and `GPIB-VXI0::1::INSTR`.
`ASRL[0-9]*::?*INSTR`	Matches `ASRL1::INSTR` but not `VXI0::5::INSTR`.
`ASRL1+::INSTR`	Matches `ASRL1::INSTR` and `ASRL11::INSTR` but not `ASRL2::INSTR`.
`(GPIB|VXI)?*INSTR`	Matches `GPIB1::5::INSTR` and `VXI0::3::INSTR` but not `ASRL2::INSTR`.
`(GPIB0|VXI0)::1::INSTR`	Matches `GPIB0::1::INSTR` and `VXI0::1::INSTR`.
`?*VXI[0-9]*::?*MEMACC`	Matches `VXI0::MEMACC` and `GPIB-VXI1::MEMACC`.
`VXI0::?*`	Matches `VXI0::1::INSTR`, `VXI0::2::INSTR`, and `VXI0::MEMACC`.
`?*`	Matches all resources.

Notice that in VISA, the regular expressions used for resource matching are not case sensitive. For example, calling `viFindRsrc()` with `"VXI?*INSTR"` would return the same resources as invoking it with `"vxi?*instr"`.

Attribute-Based Resource Matching

VISA can also search for a resource based on the values of the resource's attributes. The `viFindRsrc()` search expression is handled in two parts: the regular expression for the resource string and the (optional) logical

expression for the attributes. Assuming that a given resource matches the given regular expression, VISA checks the attribute expression for a match. The resource matches the overall string if it matches both parts.

Attribute matching works by using familiar constructs of logical operations such as AND (`&&`), OR (`||`), and NOT (`!`). Equal (`==`) and unequal (`!=`) apply to all types of attributes, and you can additionally compare numerical attributes using other common comparators (`>`, `<`, `>=`, and `<=`).

You are free to make attribute matching expressions as complex as you like, using multiple ANDs, ORs, and NOTs. Precedence applies as follows:

- The grouping operator `()` in an attribute matching expression has the highest precedence.
- The NOT `!` operator has the next highest precedence.
- The AND `&&` operator has the next highest precedence.
- The OR operator `||` has the lowest precedence.

The following table shows three examples of matching based on attributes.

Expression	Meaning
`GPIB[0-9]*::?*::?*::INSTR {VI_ATTR_GPIB_SECONDARY_ADDR > 0 && VI_ATTR_GPIB_SECONDARY_ADDR < 10}`	Find all GPIB devices that have secondary addresses from 1 to 9.
`ASRL?*INSTR{VI_ATTR_ASRL_BAUD == 9600}`	Find all serial ports configured at 9600 baud.
`?*VXI?INSTR{VI_ATTR_MANF_ID == 0xFF6 && !(VI_ATTR_VXI_LA ==0 || VI_ATTR_SLOT <= 0)}`	Find all VXI instrument resources with manufacturer ID of FF6 and which are not logical address 0, slot 0, or external controllers.

Notice that only *global* VISA attributes are permitted in the attribute matching expression.

The following example is similar to Example 4-2, except that it uses a regular expression with attribute matching. Notice that because only the first match is needed, `VI_NULL` is passed for both the **retCount** and **findList** parameters. This tells VISA to automatically close the find list rather than return it to the application.

Example 4-3

```
#include <stdio.h>
#include "visa.h"

#define MANF_ID    0xFF6 /* 12-bit VXI manufacturer ID of device */
#define MODEL_CODE 0x0FE /* 12-bit or 16-bit model code of device */

/* Find the first matching device and return a session to it */
ViStatus autoConnect2(ViPSession instrSesn)
{
       ViStatus   status;
       ViSession  defaultRM, instr;
       ViChar     desc[VI_FIND_BUFLEN], regExToUse[VI_FIND_BUFLEN];

       status = viOpenDefaultRM(&defaultRM);
       if (status < VI_SUCCESS) {
          /* Error initializing VISA ... exiting */
          return status;
       }

       /* Find the first matching VXI instrument */
       sprintf(regExToUse,
       "?*VXI?*INSTR{VI_ATTR_MANF_ID==0x%x && VI_ATTR_MODEL_CODE==0x%x}",
             MANF_ID, MODEL_CODE);
       status = viFindRsrc(defaultRM, regExToUse, VI_NULL, VI_NULL, desc);
       if (status < VI_SUCCESS) {
          /* Error finding resources ... exiting */
          viClose(defaultRM);
          return status;
       }

       status = viOpen(defaultRM, desc, VI_NULL, VI_NULL, &instr);
       if (status < VI_SUCCESS) {
          viClose(defaultRM);
          return status;
       }

       *instrSesn = instr;
       /* Do not close defaultRM, as that would close instr too */
       return VI_SUCCESS;
}
```

Configuring a Session

After the Resource Manager opens a session, communication with the device can usually begin using the default session settings. However, in some cases such as ASRL (serial) resources, you need to set some other parameters such as baud rate, parity, and flow control before proper communication can begin. GPIB and VXI sessions may have still other configuration parameters to set, such as timeouts and end-of-transmission modes, although in general the default settings should suffice.

Accessing Attributes

VISA uses two operations for obtaining and setting parameters—`viGetAttribute()` and `viSetAttribute()`. Attributes not only describe the state of the device, but also the method of communication with the device.

For example, you could use the following code to obtain the logical address of a VXI address:

```
status = viGetAttribute(instr, VI_ATTR_VXI_LA, &Laddr);
```

and the variable **Laddr** would contain the device's address. If you want to set an attribute, such as the baud rate of an ASRL session, you could use:

```
status = viSetAttribute(instr, VI_ATTR_ASRL_BAUD, 9600);
```

Notice that some attributes are read-only, such as logical address, while others are read/write attributes, such as the baud rate. Also, some attributes apply only to certain types of sessions; `VI_ATTR_VXI_LA` would not exist for an ASRL session. If you attempted to use it, the status parameter would return with the code `VI_ERROR_NSUP_ATTR`. Finally, the data types of some attribute values are different from each other. Using the above examples, the logical address is a 16-bit value, whereas the baud rate is a 32-bit value. It is particularly important to use variables of the correct data type in `viGetAttribute()`.

Refer to the online help or to the *NI-VISA Programmer Reference Manual* for a list of all available attributes you can use for each supported interface.

Common Considerations for Using Attributes

As you set up your sessions, there are some common attributes you can use that will affect how the sessions handle various situations. For currently supported session types, all support the setting of timeout values and termination methods:

- `VI_ATTR_TMO_VALUE` denotes how long (in milliseconds) to wait for accesses to the device. Defaults to two seconds (2000 ms).
- `VI_ATTR_TERMCHAR_EN` sets whether a termination character specified by `VI_ATTR_TERMCHAR` will be used on read operations. The termchar defaults to linefeed (`\n` or `LF`) but the termchar enable attribute defaults to `VI_FALSE`. Serial users should also see Chapter 9, *Interface Specific Information*.
- `VI_ATTR_SEND_END_EN` determines whether to use an END bit on your write operations. Defaults to `VI_TRUE`.

Various interfaces have other types of attributes that may affect channel communication. See Chapter 9, *Interface Specific Information*, for attribute information relevant to each support hardware interface type.

5

Message-Based Communication

This chapter shows how to use the VISA library in message-based communication.

Introduction

Whether you are using RS-232, GPIB, Ethernet, or VXI, message-based communication is a standard protocol for controlling and receiving data from instruments. Because most message-based devices have similar capabilities, it is natural that the driver interface should be consistent. Under VISA, controlling message-based devices is the same regardless of what hardware interface(s) those devices support or how those devices are connected to your computer.

VISA message-based communication includes the Basic I/O Services and the Formatted I/O Services from within the VISA Instrument Control Resource (INSTR). All sessions to a VISA Instrument Control Resource (INSTR) opened using `viOpen()` have full message-based communication capabilities. Of course, if the device is a register-based VXI device, the message-based operations return an error code (`VI_ERROR_NSUP_OPER`) to indicate that this *device* does not support the operations, although the *session* still provides access to them. This chapter discusses the uses of the Basic I/O Services and the Formatted I/O Services provided by the INSTR Resource in a VISA application.

Basic I/O Services

The VISA Instrument Control Resource lets a controller interact with the device that it is associated with by providing the controller with services to do the following:

- Send blocks of data to the device
- Request blocks of data from the device
- Send the device clear command to the device
- Trigger the device
- Find information about the status of the device

Note For the ASRL INSTR and TCPIP SOCKET resources, the I/O protocol attribute must be set to `VI_PROT_4882_STRS` to use `viReadSTB()` and `viAssertTrigger()`.

The following sections describe the operations provided by the VISA Instrument Control Resource for the Basic I/O Services.

Synchronous Read/Write Services

The most straightforward of the operations are `viRead()` and `viWrite()`, which perform the actual receiving and sending of strings. Notice that these operations look upon the data as a string and do not interpret the contents. For this reason, the data could be messages, commands, or binary encoded data, depending on how the device has been programmed. For example, the IEEE 488.2 command **IDN?* is a message that is sent in ASCII format. However, an oscilloscope returning a digitized waveform may take each 16-bit data point and put it end to end as a series of 8-bit characters. The following code segment shows a program requesting the waveform that the device has captured.

```
status = viWrite(instr, "READ:WAVFM:CH1", 14, &retCount);
status = viRead(instr, buffer, 1024, &retCount);
```

Now the character array `buffer` contains the data for the waveform, but you still do not know how the data is formatted. For example, if the data points were *1, 2, 3,* ...the buffer might be formatted as “1,2,3,...”. However, if the data were binary encoded 8-bit values, the first byte of `buffer` would be 1—not the ASCII character 1, but the actual value 1. The next byte would be neither a comma nor the ASCII character 2, but the actual value 2, and so on. Refer to the documentation that came with the device for information on how to program the device and interpret the responses.

The various ways that a string can be sent is the next issue to consider in message-based communication. For example, the actual mechanism for sending a byte differs drastically between GPIB and VXI; however, both have similar mechanisms to indicate when the last byte has been transferred. Under both systems, a device can specify an actual character, such as linefeed, to indicate that no more data will be sent. This is known as the End Of String (EOS) character and is common in older GPIB devices. The obvious drawback to this mechanism is that you must send an extra character to terminate the communication, and you cannot use this character in your messages. However, both GPIB and VXI can specify that the current byte is the last byte. GPIB uses the EOI line on the bus, and VXI uses the END bit in the Word Serial command that encapsulates the byte.

You need to determine how to inform the VISA driver which mechanism to use. As was discussed in Chapter 3, *VISA Overview*, VISA uses a technique known as *attributes* to hold this information. For example, to tell the driver to use the EOI line or END bit, you set the `VI_ATTR_SEND_END_EN` attribute to true.

```
status = viSetAttribute(instr, VI_ATTR_SEND_END_EN, VI_TRUE);
```

You can terminate reads on a carriage return by using the following code.

```
status = viSetAttribute(instr, VI_ATTR_TERMCHAR, 0x0D);
status = viSetAttribute(instr, VI_ATTR_TERMCHAR_EN, VI_TRUE);
```

Refer to the *Common Considerations for Using Attributes* section in Chapter 4, *Initializing Your VISA Application*, for the default values of these attributes. Refer to the NI-VISA online help or the *NI-VISA Programmer Reference Manual* for a complete list and description of the available attributes.

Asynchronous Read/Write Services

In addition to the synchronous read and write services, VISA has operations for asynchronous I/O. The functionality of these operations is identical to that of the synchronous ones; therefore, the topics covered in the previous section apply to asynchronous read and write operations as well. The main difference is that a job ID is returned from the asynchronous I/O operations instead of the transfer status and return count. You then wait for an I/O completion event, from which you can get that information.

Note You must enable the session for the I/O completion event before beginning an asynchronous transfer.

One other difference is the timeout attribute, `VI_ATTR_TMO_VALUE`. This attribute may or may not apply to asynchronous operations, depending on the implementation. If you want to ensure that asynchronous operations never time out, even on implementations that *do* use the timeout attribute, set the attribute value to `VI_TMO_INFINITE`. If you want to ensure that asynchronous operations do not last beyond a certain period of time, even on implementations that *do not* use the timeout attribute, you should abort the I/O using the `viTerminate()` operation if it does not complete within the expected time, as shown in the following code.

```
status = viEnableEvent(instr, VI_EVENT_IO_COMPLETION,
   VI_QUEUE, VI_NULL);
status = viWriteAsync(instr, "READ:WAVFM:CH1" ,14, &jobID);
```

```
status = viWaitOnEvent(instr, VI_EVENT_IO_COMPLETION, 10000,
    &etype, &event);
if (status < VI_SUCCESS) {
        status = viTerminate(instr, VI_NULL, jobID);
        /* now the I/O completion event should exist in the queue*/
        status = viWaitOnEvent(instr, VI_EVENT_IO_COMPLETION,0,
                    &etype, &event);
}
```

As long as an asynchronous operation is successfully posted (if the return value from the asynchronous operation is greater than or equal to `VI_SUCCESS`), there will always be exactly one I/O completion event resulting from the transfer. However, if the asynchronous operation (`viReadAsync()` or `viWriteAsync()`) returns an error code, there will *not* be an I/O completion event. In the above example, if the I/O has not completed in 10 seconds, the call to `viTerminate()` aborts the I/O and results in the I/O completion event being generated.

The I/O completion event has attributes containing information about the transfer status, return count, and more. For a more complete description of the I/O completion event and its attributes, refer to the *NI-VISA Programmer Reference Manual* or to the NI-VISA online help. For a more detailed example using asynchronous I/O, see Example 7-1 in Chapter 7, *VISA Events*.

Note The asynchronous I/O services are not available when programming with Visual Basic.

Clear Service

When communicating with a message-based device, particularly when you are first developing your program, you may need to tell the device to clear its I/O buffers so that you can start again. In addition, if a device has more information than you need, you may want to read until you have everything you need and then tell the device to throw the rest away. The `viClear()` operation performs these tasks.

More specifically, the clear operation lets a controller send the device clear command to the device it is associated with, as specified by the interface specification and the type of device. The action that the device takes depends on the interface to which it is connected.

- For a GPIB device, the controller sends the IEEE 488.1 SDC (04h) command.

- For a VXI or MXI device, the controller sends the Word Serial Clear (FFFFh) command.
- For the ASRL INSTR or TCPIP SOCKET resource, the controller sends the string "`*CLS\n`". The I/O protocol must be set to `VI_PROT_4882_STRS` for this service to be available to these resources.

For more details on these clear commands, refer to your device documentation, the IEEE 488.1 standard, or the VXIbus specification.

Trigger Service

Most instruments can be instructed to wait until they receive a trigger before they start performing operations such as generating a waveform, reading a voltage, and so on. Under GPIB, this trigger is a software command sent to the device. Under VXI, this could either be a software trigger or a hardware trigger on one of the multiple TTL/ECL trigger lines on the VXIbus backplane.

VISA uses the same operation—`viAssertTrigger()`—to perform these actions. Which trigger method (software or hardware) you use is dependent on a combination of an attribute (`VI_ATTR_TRIG_ID`) and a parameter to the operation. For example, to send a software trigger by default under either interface, you use the following code.

```
status = viSetAttribute(instr, VI_ATTR_TRIG_ID, VI_TRIG_SW);
status = viAssertTrigger(instr, VI_TRIG_PROT_DEFAULT);
```

Of course, you need to set the attribute only once at the beginning of the program, not every time you assert the trigger. If you want to assert a VXI hardware trigger, such as a SYNC pulse, you can use the following code.

```
status = viSetAttribute(instr, VI_ATTR_TRIG_ID, VI_TRIG_TTL3);
status = viAssertTrigger(instr, VI_TRIG_PROT_SYNC);
```

Keep in mind that VISA currently uses *device triggering*. That is, each call to `viAssertTrigger()` is associated with a specific device through the session used in the call. However, the VXI hardware triggers by definition have *interface-level triggering*. In other words, you cannot prevent two devices from receiving a SYNC pulse of TTL3 if both devices are listening to the line. Therefore, if you need to trigger multiple devices off a single VXI trigger line, you can do this by sending the trigger to any one of the devices on the line.

Status/Service Request Service

It is fairly common for a device to need to communicate with a controller at a time when the controller is not planning to talk with the device. For example, if the device detects a failure or has completed a data acquisition sequence, it may need to get the attention of the controller. In both GPIB and VXI, this is accomplished through a Service Request (SRQ). Although the actual technique for delivering this service request to the controller differs between the two interfaces, the end result is that an event (`VI_EVENT_SERVICE_REQ`) is received by the VISA driver. You can find more details on event notification and handling in Chapter 2, *Introductory Programming Examples*, and Chapter 7, *VISA Events*. At this time, just assume that the program has received the event and has a handle to the data through the `eventContext` parameter.

Under VISA, the `VI_EVENT_SERVICE_REQ` event contains no additional information other than the type of event. Therefore, by using `viGetAttribute()` on the `eventContext` parameter, as shown in the following code, the program can identify the event as a service request.

```
status = viGetAttribute(eventContext,VI_ATTR_EVENT_TYPE, &eventType);
```

You can retrieve the status byte of the device by issuing a `viReadSTB()` operation. This is especially important because on some interfaces, such as GPIB, it is not always possible to know which device has asserted the service request until a `viReadSTB()` is performed. This means that all sessions to devices on the bus with the service request may receive a service request event. Therefore, you should always check the status byte to ensure that your device was the one that requested service. Even if you have only one device asserting a service request, you should still call `viReadSTB()` to guarantee delivery of future service request events. For example, the following code checks the type of event, performs a `viReadSTB()`, and then checks the result.

```
status = viGetAttribute(eventContext,VI_ATTR_EVENT_TYPE, &eventType);
if (eventType == VI_EVENT_SERVICE_REQ) {
    status = viReadSTB(instr, &statusByte);
    if ((status >= VI_SUCCESS) && (statusByte & 0x40)) {
        /* Perform action based on Service Request*/
    }

    /* Otherwise ignore the Service Request */

} /* End IF SRQ*/
```

Example VISA Message-Based Application

The following is an example VISA application using message-based communication.

Note This example shows C source code. You can find the same example in Visual Basic syntax in Appendix A, *Visual Basic Examples*.

Example 5-1

```
#include "visa.h"

int main(void)
{
       ViSession   defaultRM, instr;
       ViUInt32    retCount;
       ViChar      idnResult[72];
       ViChar      resultBuffer[256];
       ViStatus    status;

       /* Open Default Resource Manager */
       status = viOpenDefaultRM(&defaultRM);
       if (status < VI_SUCCESS) {
          /* Error Initializing VISA...exiting */
          return -1;
       }

       /* Open communication with GPIB Device at Primary Addr 1 */
       /* NOTE: For simplicity, we will not show error checking */
       viOpen(defaultRM, "GPIB::1::INSTR", VI_NULL, VI_NULL, &instr);
       /* Initialize the timeout attribute to 10 s */
       viSetAttribute(instr, VI_ATTR_TMO_VALUE, 10000);
       /* Set termination character to carriage return (\r=0x0D) */
       viSetAttribute(instr, VI_ATTR_TERMCHAR, 0x0D);
       viSetAttribute(instr, VI_ATTR_TERMCHAR_EN, VI_TRUE);
       /* Don't assert END on the last byte */
       viSetAttribute(instr, VI_ATTR_SEND_END_EN, VI_FALSE);
       /* Clear the device */
       viClear(instr);
       /* Request the IEEE 488.2 identification information */
       viWrite(instr, "*IDN?\n", 6, &retCount);
       viRead(instr, idnResult, 72, &retCount);

       /* Use idnResult and retCount to parse device info */
```

```
        /* Trigger the device for an instrument reading */
        viAssertTrigger(instr, VI_TRIG_PROT_DEFAULT);
        /* Receive results */
        viRead(instr, resultBuffer, 256, &retCount);
        /* Close sessions */
        viClose(instr);
        viClose(defaultRM);
        return 0;
}
```

Formatted I/O Services

The Formatted I/O Services perform formatted and buffered I/O for devices. A formatted write operation writes to a buffer inside the VISA driver, while a formatted read operation reads from a buffer inside the driver. Buffering improves system performance by having the driver perform the I/O with the device only at certain times, such as when the buffer is full. The driver is then able to send larger blocks of information to the device at a time, improving overall throughput.

The buffer operations also provide control over the low-level serial driver buffers. See the *Controlling the Serial I/O Buffers* section in Chapter 9, *Message-Based Communication*, for more information on that topic.

Formatted I/O Operations

The main two operations under the formatted I/O services are `viPrintf()` and `viScanf()`. Although this section discusses these two operations only, this material also applies to other formatted I/O routines such as `viVPrintf()` and `viVScanf()`. These operations derive their names from the standard C string I/O functions. Like `printf()` and `scanf()`, these operations let you use special format strings to dynamically create or parse the string. For example, a common command for instruments is the `"Fx"` command for function *X*. This could be `"F1"` for volt measurement, `"F2"` for ohm measurement, and so on. With formatted I/O, you can select the type of measurement and use only a single operation to send the string. Consider the following code segment.

```
/* Retrieve user's selections. Assume the variable */
/* X holds the choice from the following menu: */
/*   1) VDC, (2) Ohms, (3) Amps */
status = viPrintf(instr, "F%d", X);
```

Here, the variable *X* corresponds to the type of measurement denoted by a number matching the function number for the instrument. Without formatted I/O, the result would have been either:

```
sprintf(buffer, "F%d", X);
viWrite(instr, buffer, strlen(buffer), &retCount);
```

or

```
switch(X) {
    case 1:
        viWrite(instr, "F1", 2, &retCount);
        break;
    case 2:
        viWrite(instr, "F2", 2, &retCount);
        break;
    .
    .
}
```

In addition, there is an operation `viQueryf()` that combines the functionality of a `viPrintf()` followed by a `viScanf()` operation. `viQueryf()` is used to query the device for information:

```
status = viQueryf(instr,"*IDN?\n","%s",buf);
```

I/O Buffer Operations

Another method for communicating with your instruments using formatted I/O functions is using the formatted I/O buffer functions: `viSPrintf()`. `viSScanf()`, `viBufRead()`, and `viBufWrite()`. You can use these functions to manipulate a buffer that you will send or receive from an instrument.

For example, you may want to bring information from a device into a buffer and then manipulate it yourself. To do this, first call `viBufRead()`, which reads the string from the instrument into a user-specified buffer. Then use `viSScanf()` to extract information from the buffer. Similarly, you can format a buffer with `viSPrintf()` and then use `viBufWrite()` to send it to an instrument.

As you can see, the formatted I/O approach is the simplest way to get the job done. Because of the variety of modifiers you can use in the format string, this section does not go into any more detail on these operations. Please refer either to the NI-VISA online help or to Chapter 5, *Operations,* in the *NI-VISA Programmer Reference Manual* for more information.

Variable List Operations

You can also use another form of the standard formatted I/O operations known as *Variable List* operations: `viVPrintf()`, `viVSPrintf()`, `viVScanf()`, `viVSScanf()`, and `viVQueryf()`. These functions are identical in their operation to the ANSI C versions of variable list operations. Please see your C reference guide for more information.

Manually Flushing the Formatted I/O Buffers

This section describes flushing issues that are related to formatted I/O buffers. The descriptions apply to all buffered read and buffered write operations. For example, the `viPrintf()` description applies equally to other buffered write operations (`viVPrintf()` and `viBufWrite()`). Similarly, the `viScanf()` description applies to other buffered read operations (`viVScanf()` and `viBufRead()`).

Flushing a write buffer immediately sends any queued data to the device. Flushing a read buffer discards the data in the read buffer. An empty read buffer guarantees that the next call to `viScanf()`, `viBufRead()`, or a related operation reads data directly from the device rather than from queued data residing in the read buffer.

The easiest way to flush the buffers is with an explicit call to `viFlush()`. This operation can actually flush the buffers in two ways. The simpler way uses discard flags. These flags tell the driver to discard the contents of the buffers *without* performing any I/O to the device. For example,

```
status = viFlush(instr, VI_READ_BUF_DISCARD);
```

However, the flush operation can also complete the current I/O before flushing the buffer. For a write buffer, this simply means to send the rest of the buffer to the device. However, for a read buffer, the process is more involved. Because you could be in the middle of a read from the device (that is, the device still has information to send), it is possible to have the driver check the buffer for an EOS or END bit/EOI signal. If such a value exists in the buffer, the contents of the buffer are discarded. However, if the driver can find no such value, it begins reading from the device until it detects the end of the communication and then discards the data. This process keeps the program and device in synchronization with each other. See the description of the `viFlush()` operation in the NI-VISA online help or in the *NI-VISA Programmer Reference Manual* for more information.

Automatically Flushing the Formatted I/O Buffers

Although you can explicitly flush the buffers by making a call to `viFlush()`, the buffers are flushed implicitly under some conditions. These conditions vary for the `viPrintf()` and `viScanf()` operations. In addition, you can modify the conditions through attributes.

The write buffer is maintained by the `viPrintf()`, `viVPrintf()`, `viBufWrite()`, and `viVQueryf()` (write side) operations. To explicitly flush the write buffer, you can make a call to the `viFlush()` operation with a write flag set.

The standard conditions for automatically flushing the buffer are as follows.

- Whenever the END indicator is sent. The indicator could be either the EOS character or the END bit/EOI line, depending on the current state of the attributes which select these modes.
- When the write buffer is full.
- In response to a call to `viSetBuf()` with the `VI_WRITE_BUF` flag set.

In addition to these rules, the `VI_ATTR_WR_BUF_OPER_MODE` attribute can modify the flushing of the buffer. The default setting for this attribute is `VI_FLUSH_WHEN_FULL`, which means that the preceding three rules apply. However, if the attribute is set to `VI_FLUSH_ON_ACCESS`, the buffer is flushed with every call to `viPrintf()` and `viVPrintf()`, essentially disabling the buffering mode.

The read buffer is maintained by the `viScanf()`, `viVScanf()`, `viBufRead()`, and `viVQueryf()` (read side) operations. To explicitly flush the read buffer, you can make a call to the `viFlush()` operation with a read flag set. The only rule for automatically flushing the read buffer is in response to the `viSetBuf()` operation. However, as with the write buffer, you can use an attribute to control how to flush the buffer: `VI_ATTR_RD_BUF_OPER_MODE`. If the attribute is set to `VI_FLUSH_DISABLE`, the buffer is flushed only when an explicit call to `viFlush()` is made. If this attribute is set to `VI_FLUSH_ON_ACCESS`, the buffer is flushed at the end of every call to `viScanf()`.

In addition to the preceding rules and attributes, the formatted I/O buffers of a session to a given device are reset whenever that device is cleared through the `viClear()` operation. At such a time, the read and write buffer must be flushed and any ongoing operation through the read/write port must be aborted.

Resizing the Formatted I/O Buffers

The read and write buffers, as mentioned previously, can be dynamically resized using the `viSetBuf()` operation. Remember that this operation automatically flushes the buffers, so it is best to set the size of the buffers before beginning the actual I/O calls. You specify which buffer you want to modify and then the size of the buffer you require. It is important to check the return code of this operation because you may be requesting a buffer beyond the size that the system can allocate at the time. If this occurs, the buffer size is not changed.

For example, to set both the read and write buffers to 8 KB, use the following code.

```
status = viSetBuf(instr, VI_READ_BUF | VI_WRITE_BUF, 8192);
```

Formatted I/O Instrument Driver Examples

This section shows examples of VISA formatted I/O usage found in existing instrument drivers. It shows how to perform various I/O tasks using the formatted I/O services in VISA. This section assumes a basic knowledge of string formatting and ANSI-C format specifiers. For more information on VISA format specifiers, refer to the NI-VISA Programmer Reference Manual.

The VISA formatting capabilities include those specified by ANSI-C with extensions for common protocols used by instrumentation systems. To perform I/O, use the `viPrintf()`, `viScanf()`, and `viQueryf()` service routines with the appropriate format strings.

This section includes four different categories of formatted I/O: Integers, Floating point numbers, Strings, and Data blocks. For each category, we give a description and a list of short examples. The focus is on the VISA I/O supported format specifiers that are most frequently used in driver development, with an explanation of how different modifiers work with the format codes. To eliminate redundancy and make the examples easier to understand, we have omitted error-checking routines on I/O operations from all of the following examples.

Integers

Integer formatting is often found in driver development. Besides transferring the numeric values that the instrument reads, it may also represent the status codes (Boolean values) or error codes returned by the instrument. When writing integer values to or reading them from the

instrument, you can use `%d` format code with length modifiers (`h` and `l`) and the array modifier (`,`).

Short Integer—"%hd"

Use this modifier for short (16 bit) integers. These are typically used for holding test results and status codes.

Examples

This example shows how to scan a self test result (a 16 bit integer) returned from an instrument into a short integer.

```
/* Self Test */
ViInt16 testResult;
viPrintf (io, "*TST?\n");
viScanf (io, "%hd", testResult);
/* read test result into short integer */
```

This example shows how to query the instrument to determine whether it has encountered an error. The error status is returned as a short integer (16 bits).

```
/* Check Error Status */
ViInt16 esr;
viQueryf (io, "*ESR?\n", "%hd", &esr);
/* read status into short integer */
```

Long Integer—"%ld", "%d"

Use this modifier for long (32 bit) integers. These are typically used for data value transfers and error code queries.

Examples

This example shows how to scan an error code (a 32 bit integer) returned from an instrument into a 32 bit integer

```
/* Error query */
ViInt32 errCode;
viPrintf (io, ":STAT:ERR?\n");
viScanf (io, "%d", &errCode);
/* read error code into integer */
```

This example shows how to format the sample count (a 32 bit integer) into the command string sent to an instrument.

```
/* Send Sample Count */
ViInt32 value = 5000;
viPrintf (io, ":SAMP:COUN %d;", value);
```

Floating Point Values

When writing floating point values to or reading them from the instrument, you can use `%f` or `%e` format codes with length modifiers (`l` and `L`) and the array modifier (`,`). Floating point values are important when programming a numeric value transfer.

Note `%f` does not fully represent a floating point value in the extreme cases. Use `%e` for a floating point value in such cases.

Double Float—"%le"

Use this modifier for double (64 bit) floats. These are typically used for data value transfers.

Examples

This example shows how to scan the vertical range (a 64 bit floating point number).

```
/* Query Vertical Range */
ViReal64 value;
viPrintf (io, ":CH1:SCA?\n");
viScanf (io, "%le", &value);
```

This example shows how to format a trigger delay of 50.0 (specified as a 64 bit floating point number) into the command string sent to an instrument.

```
/* Send Trigger Delay */
ViReal64 value = 50.0;
viPrintf (io, ":TRIG:DEL %le;", value);
```

Precision Specifier—"."

Use the precision specifier to specify the number of precision digits when doing a numeric transfer. This modifier sets the accuracy of the values.

Example

This example shows how to set the voltage resolution. The resolution is represented in a double floating point (64 bits). The precision modifier `.9` specifies that there are nine digits after the decimal point. In this case, 0.000000005 is sent to the instrument.

```
/* Set Resolution */
ViReal64 value = 0.0000000051;
viPrintf (io, "VOLT:RES %.9le", value);
```

Array of Floating Point Values Specifier—","

Use this modifier when transferring an array of floating point values to or from an instrument. The count of the number of elements can be represented by a constant, asterisk (*) sign, or number (#) sign. The asterisk (*) sign indicates the count is the first argument on `viPrintf()`. The number (#) sign indicates that the count is the first argument on `viScanf()`, and the count is passed by address. You can use the constant with both `viPrintf()` and `viScanf()`.

Examples

This example shows how to send an array of double numbers to the instrument. The comma (,) indicates the parameter is an array and the asterisk (*) specifies the array size to be passed in from the argument.

```
/* Create User Defined Mask */
ViInt32 maskSize = 100;
ViReal64 interleaved[100];
/* define points in the specified mask and store them in the array */
viPrintf (io, ":MASK:MASK1:POINTS %*,le", maskSize, interleaved);
```

This example shows how to take multiple readings from an instrument. The comma (,) indicates the parameter is an array and the number (#) sign specifies the actual number of readings returns from the instrument.

```
/* Read Multi-Point */
ViInt32 readingCnt = 50;
ViReal64 readingArray[50];
viQueryf (io, "READ?\n", "%,#le", &readingCnt, readingArray);
```

This example shows how to fetch multiple readings from an instrument. The comma (,) indicates the parameter is an array while the constant 1000 specifies the number of readings.

```
/* Fetch Multi-Point */
ViReal64 readingArray[1000];
viScanf (io, "%,1000le", readingArray);
```

Strings

When transferring string values to or from the instrument, you can use `%s`, `%t`, `%T` and `%[]` format codes with a field width modifier. Because this is a message-based communication system, string formatting is the most common routine. With string formatting, you can configure instrument settings and query instrument information.

White Space Termination—"%s"

Characters are read from an instrument into the string until a white space character is read.

Example

This example queries the trigger source. This instrument returns a string. The maximum length of the string is specified in the format string with the number (#) sign. The argument `rdBufferSize` contains the maximum length on input, and it contains the actual number of bytes read on output.

```
/* Trigger Source Query */
ViChar rdBuffer[BUFFER_SIZE];
ViInt32 rdBufferSize = sizeof(rdBuffer);
viPrintf (io, ":TRIG:SOUR?\n");
viScanf (io, "%#s", &rdBufferSize, rdBuffer);
```

END Termination—"%t"

Characters are read from an instrument into the string until the first END indicator is received. This will often be accompanied by the linefeed character (\n) but that is not always the case. Use `%T` to parse up to a linefeed instead of an END.

Example

This example queries the instrument model on a Tektronix instrument. The model number, a 32-bit integer, is the part of the string between the first two characters "," returned from the instrument. The format string `%t` specifies that the string reads from the device until the END indicator is received. For instance, if the instrument returns `TEKTRONIX,TDS 210,0,CF:91.1CT FV:v1.16 TDS2CM:CMV:v1.04\n`, then the model number is 210, and the module string is `0,CF:91.1CT FV:v1.16 TDS2CM:CMV:v1.04\n`.

```
/* Instrument Model Information */
ViChar moduleStr[BUFFER_SIZE];
ViInt32 modelNumber;
viPrintf (io, "*IDN?\n");
viScanf (io, "TEKTRONIX,TDS %d,%t", &modelNumber, moduleStr);
```

Other Terminators—"%[^]", "%*[^]"

Without the asterisk, characters are read from an instrument into the string until the character specified after ^ is read. With the asterisk, characters are discarded until the character specified after ^ is read.

Examples

This is an example of how to perform a self-test. In this case, the format string `%256[^\n]` specifies the maximum field width of the string as 256 and terminates with a line feed (`LF`) character.

```
/* Self Test */
ViChar testMessage[256];
viPrintf (io, "TST\n");
viScanf (io, "%256[^\n]", testMessage);
```

This example shows how to query for an error. The instrument returns an integer (32 bits) as the error code and a message that terminates with a double-quote ("). The message is in quotes.

```
/* Error Query */
ViInt32 errCode;
ViChar errMessage[MAX_SIZE];
viPrintf (io, ":STAT:ERR?\n");
viScanf (io, "%d,\"%[^\"]\"", &errCode, errMessage);
```

This example shows how to query for the instrument manufacturer. The manufacturer name is the first part of the string, up to the character `","`, returned from the instrument. For instance, if the instrument returns `ROHDE&SCHWARZ,NRVD,835430/066,V1.52 V1.40\n`, then the manufacturer name is ROHDE&SCHWARZ. The rest of the response is discarded.

```
/* Instrument Manufacturer */
ViChar rdBuffer[256];
viQueryf (io, "*IDN?\n", "%256[^,]%*T", rdBuffer);
```

This example shows how to query for the instrument model. The model name is the part of the string between the first two characters "," returned from the instrument. For instance, if the instrument returns `ROHDE&SCHWARZ,NRVD, 835430/066,V1.52 V1.40\n`, then the model name is NRVD. The format string `%*[^,]` discards the input up to character `","`. The final part of the response is also discarded.

```
/* Instrument Model Information */
ViChar rdBuffer[256];
viQueryf (io, "*IDN?\n", "%*[^,],%256[^,]%*T", rdBuffer);
```

This example queries the instrument firmware revision. The firmware revision information is everything up to the carriage return (CR) character.

```
/* Instrument Firmware Revision */
ViChar rdBuffer[256];
viQueryf (io, "ROM?", "%256[^\r]", rdBuffer);
```

Data Blocks

Both raw data and binary data can be transferred between the driver and the instrument. Data block transfer is a simple yet powerful formatting technique for transferring waveform data between drivers and instruments.

IEEE-488.2 Binary Data—"%b"

When writing binary data to or reading it from the instrument, you can use %b, %B format codes with length modifiers (h, l, z, and Z). ASCII data is represented by signed integer values. The range of values depends on the byte width specified. One-byte-wide data ranges from –128 to +127. Two-byte-wide data ranges from –32768 to +32767. An example of an ASCII waveform data string follows:

```
CURVE -109, -110, -109, -107, -109, -107, -105, -103, -100, -97, -90, -84, -80
```

Examples

This example queries a waveform. The data is in IEEE 488.2 <ARBITRARY BLOCK PROGRAM DATA> format. The number (#) sign specifies the data size. In the absence of length modifiers, the data is assumed to be of byte-size elements.

```
/* Waveform Query */
ViInt32 totalPoints = MAX_DATA_PTS;
ViInt8 rdBuffer[MAX_DATA_PTS];
viQueryf (io, ":CURV?\n", "%#b", &totalPoints, rdBuffer);
```

This example shows how to scan the preamble of waveform data returned from a scope, how to determine the number of data points in the waveform, and how to scan the array of raw binary data returned.

```
/* Waveform Preamble */
ViByte data[MAX_WAVEFORM_SIZE];
ViInt32 i, tmpCount, acqType;
ViReal64 xInc, xOrg, xRef, yInc, yOrg, yRef;

viQueryf (io, "WAV:PRE?\n",
    "%*[^,], %ld, %ld, %*[^,], %Lf, %Lf, %Lf, %Lf, %Lf, %Lf",
    &acqType, &tmpCount, &xInc, &xOrg, &xRef, &yInc, &yOrg, &yRef);
tmpCount = (acqType == 3) ? 2*tmpCount : tmpCount;
viQueryf (io, "WAV:DAT?\n", "%#b", &tmpCount, data));
```

Raw Binary Data—"%y"

When transferring raw binary data to or from an instrument, use the %y format code with length modifiers (h and l) and byte ordering modifiers (!ob and !ol). Raw binary data can be represented by signed integer values or positive integer values. The range of the values depends on the specified byte width:

Byte Width	Signed Integer Range	Positive Integer Range
1	–128 to +127	0 to 255
2	–32768 to +32767	0 to 65535

Examples

This example shows how to send a block of unsigned short integer (16 bits) in binary form to the instrument. In this case, the binary data is an arbitrary waveform. The asterisk (`*`) specifies the block size to be passed in from the argument. Also, `!ob` specifies data is sent in standard (big endian) format. Use `!ol` to send data in little endian format.

```
/* Create Arbitrary Waveform */
ViInt32 wfmSize = WFM_SIZE;
ViUInt16 dataBuffer[WFM_SIZE]; /* contains waveform data */
dataBuffer[WFM_SIZE-1] |= 0x1000;
/* Add the end of waveform indicator */
viPrintf (io, "STARTBIN 0 %d;%*!obhy", wfmSize, wfmSize, dataBuffer);
```

This example shows how to send a block of signed integers (32 bits) in binary form to the instrument. The asterisk (*) specifies the block size to be passed in from the argument. Without the presence of a byte order modifier, data is sent in standard (big endian) format.

```
/* Create FM Modulation Waveform */
ViInt32 dataBuffer[WFM_SIZE];
/*contains waveform data */
viPrintf (io, "%*ly", wfmSize, dataBuffer);
```

6

Register-Based Communication

This chapter shows how to use the VISA library in register-based communication.

Note You can skip this chapter if you are using GPIB, Serial, or Ethernet exclusively. Register-based programming applies only to PXI, VXI, and GPIB-VXI.

Introduction

Register-based devices (RBDs) are a class of devices that are simple and relatively inexpensive to manufacture. Communication with such devices is usually accomplished via reads and writes to registers. VISA has the ability to read from and write to individual device registers, as well as a block of registers, through the Memory I/O Services.

In addition to accessing RBDs, VISA also provides support for memory management of the memory exported by a device. For example, both local controllers and remote devices can have general-purpose memory in A24/A32 space. With VISA, although the user must know how each remote device accesses its own memory, the memory management aspects of local controllers are handled through the *Shared Memory* operations—`viMemAlloc()` and `viMemFree()`. For more information on this topic, refer to the *Shared Memory Operations* section in this chapter.

With the Memory I/O Services, you access the device registers based on the session to the device. In other words, if a session communicates with a device at VXI logical address 16, you cannot use Memory I/O Services on that session to access registers on a device at any other logical address. The range of address locations you can access with Memory I/O Services on a session is the range of address locations assigned to that device. This is true for both High-Level and Low-Level Access operations.

To facilitate access to the device registers for multiple VXI devices, VISA allows you to open a VXI MEMACC (memory access) session. A session to a VXI MEMACC Resource allows an application to access the entire VXI memory range for a specified address space. The MEMACC Resource supports the same high-level and low-level operations as the INSTR

Resource. Programmatically, the main difference between a VXI INSTR session and a VXI MEMACC session is the value of the offset parameter you pass to the register based operations. When using an INSTR Resource, all address parameters are relative to the device's assigned memory base in the given address space; knowing a device's base address is neither required by nor relevant to the user. When using a MEMACC Resource, all address parameters are absolute within the given address space; knowing a device's base address is both required by and relevant to the user.

Note A session to a MEMACC Resource supports only the high-level, low-level, and resource template operations. A MEMACC session does not support the other INSTR operations.

In VISA, you can choose between two styles for accessing registers—High-Level Access or Low-Level Access. Both styles have operations to read the value of a device register and write to a device register, as shown in the following table. In addition, there are high-level operations designed to read or write a block of data. The block-move operations do not have a low-level counterpart.

	High-Level Access	High-Level Block	Low-Level Access

Read	`viIn8()`
	`viIn16()`
	`viIn32()`
		`viMoveIn8()`
		`viMoveIn16()`
		`viMoveIn32()`
			`viPeek8()`
			`viPeek16()`
			`viPeek32()`

Write	`viOut8()`
	`viOut16()`
	`viOut32()`
		`viMoveOut8()`
		`viMoveOut16()`
		`viMoveOut32()`
			`viPoke8()`
			`viPoke16()`
			`viPoke32()`

Note The remainder of this chapter uses *XX* in the names of some operations to denote that the information applies to 8-bit, 16-bit, and 32-bit reads and writes. For example, `viInXX()` refers to `viIn8()`, `viIn16()`, and `viIn32()`.

The following sections show the benefits of each style so you can make an informed choice of which is more appropriate for your programming requirements.

High-Level Access Operations

The High-Level Access (HLA) operations `viIn`*`XX`*`()` and `viOut`*`XX`*`()` have a simple and easy-to-use interface for performing register-based communication. The HLA operations in VISA are wholly self-contained, in that all the information necessary to carry out the operation is contained in the parameters of the operation. The HLA operations also perform all the necessary hardware setup as well as the error detection and handling. There is no need to call other operations to do any other activity related to the register access. For this reason, you should use HLA operations if you are just becoming familiar with the system.

To use `viIn`*`XX`*`()` or `viOut`*`XX`*`()` operations to access a register on a device, you need to have the following information about the register:

- The address space where the register is located. In a VXI interface bus, for example, the address space can be A16, A24, or A32. In the PXI bus, the device's address space can be the PXI configuration registers or one of the BAR spaces (BAR0-BAR5).
- The offset of the register relative to the device for the specified address space. You do not need to know the actual base address of the device, just the offset.

Note When using the VXI MEMACC Resource, you need to provide the absolute VXI address (base + offset) for the register.

The following sample code reads the Device Type register of a VXI device located at offset 0 from the base address in A16 space, and writes a value to the A24 shared memory space at offset 0x20 (this offset has no special significance).

```
status = viIn16(instr, VI_A16_SPACE, 0, &retValue);
status = viOut16(instr, VI_A24_SPACE, 0x20, 0x1234);
```

With this information, the HLA operations perform the necessary hardware setup, perform the actual register I/O, check for error conditions, and restore the hardware state. To learn how to perform these steps individually, see the Low-Level Access operations.

The HLA operations can detect and handle a wide range of possible errors. HLA operations perform boundary checks and return an error code (`VI_ERROR_INV_OFFSET`) to disallow accesses outside the valid range of addresses that the device supports. The HLA operations also trap and

handle any bus errors appropriately and then report the bus error as VI_ERROR_BERR.

That is all that is really necessary to perform register I/O. For more examples of HLA register I/O, please see Example 2-2 in Chapter 2, *Introductory Programming Examples*.

High-Level Block Operations

The high-level block operations viMoveIn*XX*() and viMoveOut*XX*() have a simple and easy-to-use interface for reading and writing blocks of data residing at either the same or consecutive (incrementing) register addresses. Like the high-level access operations, the high-level block operations can detect and handle many errors and do not require calls to the low-level mapping operations. Unlike the high-level access operations, the high-level block operations do not have a direct low-level counterpart. To perform block operations using the low-level access operations, you must map the desired region of memory and then perform multiple viPeek*XX*() or viPoke*XX*() operation invocations, instead of a single call to viMoveIn*XX*() or viMoveOut*XX*().

To use the block operations to access a device, you need to have the following information about the registers:

- The address space where the registers are located. In a VXI interface, for example, the address space can be A16, A24, or A32. In the PXI bus, the device's address space can be the PXI configuration registers or one of the BAR spaces (BAR0-BAR5).
- The beginning offset of the registers relative to the device for the specified address space.

Note With an INSTR Resource you do not need to know the actual base address of the device, just the offset.

- The number of registers or register values to access.

The default behavior of the block operations is to access consecutive register addresses. However, you can change this behavior using the attributes VI_ATTR_SRC_INCREMENT (for viMoveIn*XX*()) and VI_ATTR_DEST_INCREMENT (for viMoveOut*XX*()). If the value is changed from 1 (the default value, indicating consecutive addresses) to 0 (indicating that registers are to be treated as FIFOs), then the block operations performs the specified number of accesses to the same register address.

Note The range value of 0 for the `VI_ATTR_SRC_INCREMENT` and `VI_ATTR_DEST_INCREMENT` attributes may not be supported on all VISA implementations. In this case, you may need to perform a manual FIFO block move using individual calls to the high-level or low-level access operations.

If you are using the block operations in the default mode (consecutive addresses), the number of elements that you want to access may not go beyond the end of the device's memory in the specified address space.

In other words, the following code sample reads the VXI device's entire register set in A16 space:

```
status = viMoveIn16(instr, VI_A16_SPACE, 0, 0x20, regBuffer16);
```

Notice that although the device has 0x40 bytes of registers in A16 space, the fourth parameter is 0x20. Why is this? Since the operation accesses 16-bit registers, the actual range of registers read is 0x20 accesses times 2 B, or all 0x40 bytes. Similarly, the following code sample reads a PXI device's entire register set in configuration space:

```
status = viMoveIn32 (instr, VI_PXI_CFG_SPACE, 0, 64, regBuffer32);
```

When using the block operations to access FIFO registers, the number of elements to read or write is not restricted, because all accesses are to the same register and never go beyond the end of the device's memory region. The following sample code writes 4 KB of data to a device's FIFO register in A16 space at offset 0x10 (this offset has no special significance):

```
status = viSetAttribute(instr, VI_ATTR_DEST_INCREMENT, 0);
status = viMoveOut32(instr, VI_A16_SPACE, 0x10, 1024, regBuffer32);
```

Low-Level Access Operations

Low-Level Access (LLA) operations provide a very efficient way to perform register-based communication. LLA operations incur much less overhead than HLA operations for certain types of accesses. LLA operations perform the same steps that the HLA operations do, except that each individual task performed by an HLA operation is an individual operation under LLA.

Overview of Register Accesses from Computers

Before learning about the LLA operations, first consider how a computer can perform a register access to an external device. There are two possible ways to perform this access. The first and more obvious, although

primitive, is to have some hardware on the computer that communicates with the external device.

You would have to follow these steps:

1. Write the address you want.
2. Specify the data to send.
3. Send the command to perform the access.

As you can see, this method involves a great deal of communication with the local hardware.

The National Instruments MXI plug-in cards and embedded VXI computers use a second, much more efficient method. This method involves taking a section of the computer's address space and *mapping* this space to another space, such as the VXI A16 space. Most PXI devices also have registers that are memory mapped into your computer.

To understand how mapping works, you must first remember that memory and address space are two different things. For example, most 32-bit CPUs have 4 GB of *address space*, but have *memory* measured in megabytes. This means that the CPU can put out over 2^{32} possible addresses onto the local bus, but only a small portion of that corresponds to memory. In most cases, the memory chips in the computer will respond to these addresses. However, because there is less memory in the computer than address space, National Instruments can add hardware that responds to other addresses. This hardware can then modify the address, according to the *mapping* that it has, to a VXI address and perform the access on the VXIbus automatically. The result is that the computer acts as if it is performing a local access, but in reality the access has been mapped out of the computer and to the VXIbus.

You may wonder what the difference is between the efficient method and the primitive method. They seem to be telling the hardware the same information. However, there are two important differences. In the primitive method, the communication described must take place for *each* access. However, the efficient method requires only occasional communication with the hardware. Only when you want a different address space or an address outside of the window do you need to reprogram the hardware. In addition, when you have set up your hardware, you can use standard memory access methods, such as pointer dereferences in C, to access the registers.

Using VISA to Perform Low-Level Register Accesses

The first LLA operation you need to call to access a device register is the `viMapAddress()` operation, which sets up the hardware window and obtains the appropriate pointer to access the specified address space. The `viMapAddress()` operation first programs the hardware to map local CPU addresses to hardware addresses as described in the previous section. In addition, it returns a pointer that you can use to access the registers.

The following code is an example of programming the VXI hardware to access A16 space.

```
status = viMapAddress(instr, VI_A16_SPACE, 0, 0x40, VI_FALSE,
    VI_NULL, &address);
```

This sample code sets up the hardware to map A16 space, starting at offset 0 for 0x40 bytes, and returns the pointer to the window in `address`. Remember that the offset is relative to the base address of the device we are talking to through the `instr` session, not from the base of A16 space itself. Therefore, offset 0 does not mean address 0 in A16 space, but rather the starting point of the device's A16 memory. You can ignore the `VI_FALSE` and `VI_NULL` parameters for the most part because they are reserved for definition by a future version of VISA.

If you call `viMap Address()` on an INSTR session with an address space the device does not support, or an offset or size greater than the device's memory range, then the VISA driver will not map the memory and will return an error.

Note To access the device registers through a VXI MEMACC session, you need to provide the absolute VXIbus addresses (base address for device + register offset in device address space).

If you need more than a single map for a device, you must open a second session to the device, because VISA currently supports only a single map per session. There is very low overhead in having two sessions because sessions themselves do not take much memory. However, you need to keep track of two session handles. Notice that this is different from the maximum number of windows you can have on a system. The hardware for the controller you are using may have a limit on the number of unique windows it can support.

When you are finished with the window or need to change the mapping to another address or address space, you must first unmap the window using

the viUnmapAddress() operation. All you need to specify is which session you used to perform the map.

```
status = viUnmapAddress(instr);
```

Operations versus Pointer Dereference

After the viMapAddress() operation returns the pointer, you can use it to read or write registers. VISA provides the viPeek*XX*() and viPoke*XX*() operations to perform the accesses. On many systems, the viMapAddress() operation returns a pointer that you can also dereference directly, rather than calling the LLA operations. The performance gain achievable by using pointer dereferences over operation invocations is extremely system dependent. To determine whether you can use a pointer dereference to perform register accesses on a given mapped session, examine the value of the VI_ATTR_WIN_ACCESS attribute. If the value is VI_DEREF_ADDR, it is safe to perform a pointer dereference.

To make your code portable across different platforms, we recommend that you always use the accessor operations—viPeek*XX*() and viPoke*XX*()—as a backup method to perform register I/O. In this way, not only is your source code portable, but your executable can also have binary compatibility across different hardware platforms, even on systems that do not support direct pointer dereferences:

```
viGetAttribute(instr, VI_ATTR_WIN_ACCESS, &access);
if (access == VI_DEREF_ADDR)
    *address = 0x1234;
else
    viPoke16(instr, address, 0x1234);
```

Manipulating the Pointer

Every time you call viMapAddress(), the pointer you get back is valid for accessing a region of addresses. Therefore, if you call viMapAddress() with mapBase set to address 0 and mapSize to 0x40 (the configuration register space for a VXI device), you can access not only the register located at address 0, but also registers in the same vicinity by manipulating the pointer returned by viMapAddress(). For example, if you want to access another register at address 0x2, you can add 2 to the pointer. You can add up to and including 0x3F to the pointer to access these registers in this example because we have specified 0x40 as the map size. However, notice that you cannot subtract any value from the address variable because the mapping starts at that location and cannot go backwards. Example 6-1 shows how you can access other registers from address.

Note The examples in this chapter show C source code. You can find the same examples in Visual Basic syntax in Appendix A, *Visual Basic Examples*.

Example 6-1

```
#include "visa.h"

#define ADD_OFFSET(addr, offs)  (((ViPByte)addr) + (offs))

int main(void)
{
       ViStatus    status;               /* For checking errors          */
       ViSession   defaultRM, instr;     /* Communication channels       */
       ViAddr      address;              /* User pointer                 */
       ViUInt16    value;                /* To store register value      */

       /* Begin by initializing the system */
       status = viOpenDefaultRM(&defaultRM);
       if (status < VI_SUCCESS) {
          /* Error Initializing VISA...exiting */
          return -1;
       }

       /* Open communication with VXI Device at Logical Address 16 */
       /* NOTE: For simplicity, we will not show error checking */
       status = viOpen(defaultRM, "VXI0::16::INSTR", VI_NULL, VI_NULL,
          &instr);

       status = viMapAddress(instr, VI_A16_SPACE, 0, 0x40, VI_FALSE, VI_NULL,
          &address);

       viPeek16(instr, address, &value);
       /* Access a different register by manipulating the pointer.*/
       viPeek16(instr, ADD_OFFSET(address, 2), &value);

       status = viUnmapAddress(instr);

       /* Close down the system*/
       status = viClose(instr);
       status = viClose(defaultRM);
       return 0;
}
```

Bus Errors

The LLA operations do not report bus errors. In fact, `viPeek`*`XX`*`()` and `viPoke`*`XX`*`()` do not report any error conditions. However, the HLA operations do report bus errors. When using the LLA operations, you must ensure that the addresses you are accessing are valid.

Comparison of High-Level and Low-Level Access

Speed

In terms of the speed of developing your application, the HLA operations are much faster to implement and debug because of the simpler interface and the status information received after each access. For example, HLA operations encapsulate the mapping and unmapping of hardware windows, which means that you do not need to call `viMapAddress()` and `viUnmapAddress()` separately.

For speed of execution, the LLA operations perform faster when used for several random register I/O accesses in a single window. If you *know* that the next several accesses are within a single window, you can perform the mapping just once and then each of the accesses has minimal overhead.

The HLA operations will be slower because they must perform a map, access, and unmap within each call. Even if the window is correctly mapped for the access, the HLA call at the very least needs to perform some sort of check to determine if it needs to remap. Furthermore, because HLA operations encapsulate many status-checking capabilities not included in LLA operations, HLA operations have higher software overhead. For these reasons, HLA is slower than LLA in many cases.

Note For block transfers, the high-level **`viMoveXX()`** operations perform the fastest.

Ease of Use

HLA operations are easier to use because they encapsulate many status checking capabilities not included in LLA operations, which explains the higher software overhead and lower execution speed of HLA operations. HLA operations also encapsulate the mapping and unmapping of hardware windows, which means that you do not need to call `viMapAddress()` and `viUnmapAddress()` separately.

Accessing Multiple Address Spaces

You can use LLA operations to access only the address space currently mapped. To access a different address space, you need to perform a remapping, which involves calling `viUnmapAddress()` and `viMapAddress()`. Therefore, LLA programming becomes more complex, without much of a performance increase, for accessing several address spaces concurrently. In these cases, the HLA operations are superior.

In addition, if you have several sessions to the same or different devices all performing register I/O, they must compete for the finite number of windows available. When using LLA operations, you must allocate the windows and always ensure that the program does not ask for more windows than are available. The HLA operations avoid this problem by restoring the window to the previous setting when they are done. Even if all windows are currently in use by LLA operations, you can still use HLA functions because they will save the state of the window, remap, access, and then restore the window. As a result, you can have an unlimited number of HLA windows.

Shared Memory Operations

Note There are two distinct cases for using shared memory operations. In the first case, the local VXI controller exports general-purpose memory to the A24/A32 space. In the second case, remote VXI devices export memory into A24/A32 space. Unlike the first case, the memory exported to A24/A32 space may not be general purpose, so the VISA Shared Memory services do not control memory on remote VXI devices.

A common configuration in a VXI system is to export memory to either the A24 or A32 space. The local controller usually can export such memory. This memory can then be used to buffer the data going to or from the instruments in the system. However, a common problem is preventing multiple devices from using the same memory. In other words, a memory manager is needed on this memory to prevent corruption of the data.

The VISA Shared Memory operations—`viMemAlloc()` and `viMemFree()`—provide the memory management for a specific device, namely, the local controller. Since these operations are part of the INSTR resource, they are associated with a single VXI device. In addition, because a VXI device can export memory in either A24 or A32 space (but not both), the memory pool available to these operations is defined at startup. You can

determine whether the memory resides in A24 or A32 space by querying the attribute VI_ATTR_MEM_SPACE.

Shared Memory Sample Code

The following example shows how these shared memory operations work by incorporating them into Example 6-1. Their main purpose is to allocate a block of memory from the pool that can then be accessed through the standard register-based access operations (high level or low level). The INSTR resource for this device ensures that no two sessions requesting memory receive overlapping blocks.

Note *Example 6-2* uses **bold text** to distinguish lines of code that are different from those in *Example 6-1*.

Example 6-2

```
#include "visa.h"

#define ADD_OFFSET (addr, offs)  (((ViPByte)addr) + (offs))

int main(void)
{
       ViStatus      status;             /* For checking errors          */
       ViSession     defaultRM, self;    /* Communication channels       */
       ViAddr        address;            /* User pointer                 */
       ViBusAddress  offset;             /* Shared memory offset         */
       ViUInt16      addrSpace;          /* Shared memory space          */
       ViUInt16      value;              /* To store register value      */

       /* Begin by initializing the system */
       status = viOpenDefaultRM(&defaultRM);
       if (status < VI_SUCCESS) {
          /* Error Initializing VISA...exiting */
          return -1;
       }

       /* Open communication with VXI Device at Logical Address 0 */
       /* NOTE: For simplicity, we will not show error checking */
       status = viOpen(defaultRM, "VXI0::0::INSTR", VI_NULL, VI_NULL,
          &self);

       /* Allocate a portion of the device's memory */
       status = viMemAlloc(self, 0x100, &offset);
```

```
        /* Determine where the shared memory resides */
        status = viGetAttribute(self, VI_ATTR_MEM_SPACE, &addrSpace);

        status = viMapAddress(self, addrSpace, offset, 0x100, VI_FALSE,
            VI_NULL, &address);

        viPeek16(self, address, &value);
        /* Access a different register by manipulating the pointer. */
        viPeek16(self, ADD_OFFSET(address, 2), &value);

        status = viUnmapAddress(self);
        status = viMemFree(self, offset);

        /* Close down the system */
        status = viClose(self);
        status = viClose(defaultRM);
        return 0;
}
```

7

VISA Events

This chapter describes the VISA event model and how to use it. The following sections discuss the various events VISA supports and the event handling paradigm.

Introduction

VISA defines a common mechanism to notify an application when certain conditions occur. These conditions or occurrences are referred to as *events*. An event is a means of communication between a VISA resource and its applications. Typically, events occur because of a condition requiring the attention of applications.

The VISA event model provides the following two different ways for an application to receive event notification:

- The first method uses a queuing mechanism. You can use this method to place all of the occurrences of a specified event in a queue. The queuing mechanism is generally useful for noncritical events that do not need immediate servicing. The *Queuing* section in this chapter describes this mechanism in detail.
- The other method is to have VISA invoke a function that the program specifies prior to enabling the event. This is known as a *callback handler* and is invoked on every occurrence of the specified event. The callback mechanism is useful when your application requires an immediate response. The *Callbacks* section in this chapter describes this mechanism in detail.

The queuing and callback mechanisms are suitable for different programming styles. However, because these mechanisms work independently of each other, you can have them both enabled at the same time.

Supported Events

VISA defines the following generic and INSTR-specific event types.

Table 7-1. Generic and INSTR-specific Event Types

Event Type	Description	Resource Class(es), Other Notes
VI_EVENT_IO_COMPLETION	Notification that an asynchronous I/O operation has completed.	The I/O Completion event applies to all asynchronous operations, which for INSTR includes viReadAsync(), viWriteAsync(), and viMoveAsync(). For resource classes that do not support asynchronous operations, this event type is not applicable.
VI_EVENT_EXCEPTION	Notification that an error condition (exception) has occurred during an operation invocation.	The exception event supports only the callback model. Refer to the *Exception Handling* section at the end of this chapter for more information about this event type.
VI_EVENT_SERVICE_REQ	Notification of a service request (SRQ) from the device.	Supported for message based INSTR classes, including GPIB, VXI, GPIB-VXI, and TCPIP.
VI_EVENT_VXI_SIGP	Notification of a VXIbus signal or VXIbus interrupt from the device.	Supported for VXI INSTR only.
VI_EVENT_VXI_VME_INTR	Notification of a VXIbus interrupt from the device.	Supported for VXI INSTR only. This applies to both VXI and VME devices.
VI_EVENT_TRIG	Notification of a VXIbus trigger.	Supported for VXI INSTR and VXI BACKPLANE only.
VI_EVENT_PXI_INTR	Notification of a PCI/PXI interrupt from the device.	Supported for PXI INSTR only. Not supported on all platforms.
VI_EVENT_ASRL_BREAK	Notification that a break signal was received.	Supported for Serial INSTR only. Not supported on all platforms.

Table 7-1. Generic and INSTR-specific Event Types (Continued)

Event Type	Description	Resource Class(es), Other Notes
VI_EVENT_ASRL_CTS	Notification that the Clear To Send (CTS) line changed state.	Supported for Serial INSTR only. Not supported on all platforms. If the CTS line changes state quickly several times in succession, not all line state changes will necessarily result in event notifications.
VI_EVENT_ASRL_DCD	Notification that the Data Carrier Detect (DCD) line changed state.	Supported for Serial INSTR only. Not supported on all platforms. If the DCD line changes state quickly several times in succession, not all line state changes will necessarily result in event notifications.
VI_EVENT_ASRL_DSR	Notification that the Data Set Ready (DSR) line changed state.	Supported for Serial INSTR only. Not supported on all platforms. If the DSR line changes state quickly several times in succession, not all line state changes will necessarily result in event notifications.
VI_EVENT_ASRL_RI	Notification that the Ring Indicator (RI) input signal was asserted.	Supported for Serial INSTR only. Not supported on all platforms.
VI_EVENT_ASRL_CHAR	Notification that at least one data byte has been received.	Supported for Serial INSTR only. Not supported on all platforms. Each data character will not necessarily result in an event notification.
VI_EVENT_ASRL_TERMCHAR	Notification that the termination character has been received.	Supported for Serial INSTR only. Not supported on all platforms. The actual termination character is specified by setting VI_ATTR_TERMCHAR prior to enabling this event. For this event, the setting of VI_ATTR_TERMCHAR_EN is ignored.

To learn about other event types defined for other resource classes, refer to Chapter *9, Interface Specific Information,* or the *NI-VISA Programmer Reference Manual*.

VISA events use a list of attributes to maintain information associated with the event. You can access the event attributes using the `viGetAttribute()` operation, just as for the session and resource attributes. Remember to use the `eventContext` as the first parameter, rather than the I/O session.

All VISA events support the generic event attribute `VI_ATTR_EVENT_TYPE`. This attribute returns the identifier of the event type. In addition to this attribute, individual events may define attributes to hold additional event information. The events listed below define the accompanying additional attributes; the other event types do not define any additional attributes.

- `VI_EVENT_IO_COMPLETION` defines, among other attributes, `VI_ATTR_STATUS` and `VI_ATTR_RET_COUNT`, which provide information about how the asynchronous I/O operation completed.
- `VI_EVENT_VXI_SIGP` defines `VI_ATTR_SIGP_STATUS_ID`, which contains the 16-bit Status/ID value retrieved during the interrupt or from the Signal register.
- `VI_EVENT_VXI_VME_INTR` defines `VI_ATTR_RECV_INTR_LEVEL` and `VI_ATTR_INTR_STATUS_ID`, which provide the interrupt level and 32-bit interrupt Status/ID value, respectively.
- `VI_EVENT_TRIG` defines `VI_ATTR_RECV_TRIG_ID`, which provides the trigger line on which the trigger was received.
- `VI_EVENT_EXCEPTION` defines `VI_ATTR_STATUS` and `VI_ATTR_OPER_NAME`, which provide information about what error was generated and which operation generated it, respectively.

All the attributes VISA events support are read-only attributes; a user application cannot modify their values. Refer to the *NI-VISA Programmer Reference Manual* for detailed information on the specific events.

Enabling and Disabling Events

Before a session can use either the VISA callback or queuing mechanism, you need to enable the session to sense events. You use the `viEnableEvent()` operation to enable an event type using either of the mechanisms. For example, to enable the `VI_EVENT_SERVICE_REQ` event for queuing, use the following code:

```
status = viEnableEvent(instr,VI_EVENT_SERVICE_REQ,VI_QUEUE,VI_NULL);
```

Note VISA currently allows both queuing and callbacks to be enabled for the same event type on the same session. You can do this in one call by bitwise ORing the mechanisms together (`VI_QUEUE|VI_HNDLR`), or you can do this in two separate calls to `viEnableEvent()`. The two mechanisms operate independently of each other. However, using both mechanisms for the same event type on the same session is usually unnecessary and is difficult to debug. Therefore, this is highly discouraged.

Use `viDisableEvent()` to stop a session from receiving events of a specified type. You can specify the mechanism for which you are disabling, although it is more convenient to use `VI_ALL_MECH` to disable the event type for all mechanisms. For example, to disable the `VI_EVENT_SERVICE_REQ` event regardless of the mechanism for which it was enabled, use the following code:

```
status = viDisableEvent(instr,VI_EVENT_SERVICE_REQ,VI_ALL_MECH);
```

The `viEnableEvent()` operation also automatically enables the hardware, if necessary for detecting the event. The hardware is enabled when the first call to `viEnableEvent()` for the event is made from any of the sessions currently active. Similarly, `viDisableEvent()` disables the hardware when the last enabled session disables itself for the event.

Queuing

The queuing mechanism in VISA gives an application the flexibility to receive events only when it requests them. An application uses the `viWaitOnEvent()` operation to retrieve the event information. However, in addition to retrieving events from the queue, you can also use `viWaitOnEvent()` in your application to halt the current execution and wait for the event to arrive. Both of these cases are discussed in this section.

The event queuing process requires that you first enable the session to sense the particular event type. When enabled, the session can automatically queue the event occurrences as they happen. A session can later dequeue these events using the `viWaitOnEvent()` operation. You can set the timeout to `VI_TMO_IMMEDIATE` if you want your application to check if any event of the specified event type exists in the queue.

Note Each session has a queue for each of the possible events that can occur. This means that each queue is per session and per event type.

An application can also use `viWaitOnEvent()` to wait for events if none currently exists in the queue. When you select a non-zero timeout value (something other than `VI_TMO_IMMEDIATE`), the operation retrieves the

specified event if it exists in the queue and returns immediately. Otherwise, the application waits until the specified event occurs or until the timeout expires, whichever occurs first. When an event arrives and causes `viWaitOnEvent()` to return, the event is not queued for the session on which the wait operation was invoked. However, if any other session is currently enabled for queuing, the event is placed on the queue for that session.

You can use `viDisableEvent()` to disable event queuing on a session, as discussed in the previous section. After calling `viDisableEvent()`, no further event occurrences are queued on that session, but event occurrences that were already in the event queue are retained. Your application can use `viWaitOnEvent()` to dequeue these retained events in the same manner as previously described. The wait operation does not need to have events enabled to work; however, the session must be enabled to detect new events. An application can explicitly clear (flush) the event queue with the `viDiscardEvents()` operation.

The event queues in VISA do not dynamically grow as new events arrive. The default queue length is 50, but you can change the size of a queue by using the `VI_ATTR_MAX_QUEUE_LENGTH` template attribute. This attribute specifies the maximum number of events that can be placed in a queue.

Note If the event queue is full and a new event arrives, the new event is discarded.

VISA does not let you dynamically configure queue lengths. That is, you can only modify the queue length on a given session before the first invocation of the `viEnableEvent()` operation, as shown in the following code segment.

```
status = viSetAttribute(instr, VI_ATTR_MAX_QUEUE_LENGTH, 10);
status = viEnableEvent(instr, VI_EVENT_SERVICE_REQ, VI_QUEUE,
    VI_NULL);
```

See Example 2-3 in Chapter 2, *Introductory Programming Examples*, for an example of handling events via the queue mechanism.

Callbacks

The VISA event model also allows applications to install functions that can be called back when a particular event type is received. You need to install a handler before enabling a session to sense events through the callback

mechanism. Refer to *The userHandle Parameter* section in this chapter for more information. The procedure works as follows:

1. Use the `viInstallHandler()` operation to install handlers to receive events.
2. Use the `viEnableEvent()` operation to enable the session for the callback mechanism as described earlier in the *Enabling and Disabling Events* section.
3. The VISA driver invokes the handler on every occurrence of the specified event.
4. VISA provides the event object in the **`eventContext`** parameter of `viEventHandler()`. The *event context* is like a data structure, and contains information about the specific occurrence of the event. Refer to *The Life of the Event Context* section in this chapter for more information on event context.

You can now have multiple handlers per session in the current revision of VISA. If you have multiple handlers installed for the same event type on the same session, each handler is invoked on every occurrence of that event type. The handlers are invoked in reverse order of installation; that is, in Last In First Out (LIFO) order. For a given handler to prevent other handlers on the same session from being executed, it should return the value `VI_SUCCESS_NCHAIN` rather than `VI_SUCCESS`. This does *not* affect the invocation of event handlers on other sessions or in other processes.

Callback Modes

VISA gives you the choice of two different modes for using the callback mechanism. You can use either direct callbacks or suspended callbacks. You can have only one of these callback modes enabled at any one time.

To use the direct callback mode, specify `VI_HNDLR` in the **mechanism** parameter. In this mode, VISA invokes the callback routine at the time the event occurs.

To use the suspended callback mode, specify `VI_SUSPEND_HNDLR` in the **mechanism** parameter. In this mode, VISA does not invoke the callback routine at the time of event occurrence; instead, the events are placed on a suspended handler queue. This queue is similar to the queue used by the queuing mechanism except that you cannot access it directly. You can obtain the events on the queue only by re-enabling the session for callbacks. You can flush the queue with `viDiscardEvents()`.

For example, the following code segment shows how you can halt the arrival of events while you perform some critical operations that would conflict with code in the callback handler. Notice that no events are lost while this code executes, because they are stored on a queue.

```
status = viEnableEvent(instr, VI_EVENT_SERVICE_REQ,VI_HNDLR,
    VI_NULL);
.
.
.
status = viEnableEvent(instr, VI_EVENT_SERVICE_REQ,
    VI_SUSPEND_HNDLR, VI_NULL);

/*Perform code that must not be interrupted by a callback. */

status = viEnableEvent(instr, VI_EVENT_SERVICE_REQ, VI_HNDLR,
    VI_NULL);
```

When you switch the event mechanism from `VI_HNDLR` to `VI_SUSPEND_HNDLR`, the VISA driver can still detect the events. For example, VXI interrupts still generate a local interrupt on the controller and VISA handles these interrupts. However, the event VISA generates for the VXI interrupt is now placed on the handler queue rather than passed to the application. When the critical section completes, switching the mechanism from `VI_SUSPEND_HNDLR` back to `VI_HNDLR` causes VISA to call the application's callback functions whenever it detects a new event *as well as* for every event waiting on the handler queue.

Independent Queues

As stated previously, the callback and the queuing mechanisms operate totally independently of each other, so VISA keeps the information for event occurrences separately for both mechanisms. Therefore, VISA maintains the suspended handler queue separately from the event queue used for the queuing mechanism. The `VI_ATTR_MAX_QUEUE_LENGTH` attribute mentioned earlier in the *Queuing* section of this chapter applies to the suspended handler queue as well as to the queue for the queuing mechanism. However, because these queues are separate, if one of the queues reaches the predefined limit for storing event occurrences, it does not directly affect the other mechanism.

The userHandle Parameter

When using `viInstallHandler()` to install handlers for the callback mechanism, your application can use the **userHandle** parameter to supply a reference to any application-defined value. This reference is passed back to the application as the **userHandle** parameter to the callback routine during handler invocation. By supplying different values for this parameter, applications can install the same handler with different application-defined contexts.

For example, applications often need information that was received in the callback to be available for the main program. In the past, this has been done through global variables. In VISA, **userHandle** gives the application more modularity than is possible with global variables. In this case, the application can allocate a data structure to hold information locally. When it installs the callback handler, it can pass the reference to this data structure to the callback handler via the **userHandle**. This means that the handler can store the information in the local data structure rather than a global data structure.

For another example, consider an application that installs a handler with a fixed value of 0x1 for the **userHandle** parameter. It can install the same handler with a different value, say 0x2, for the same event type on another session. However, installations of the same handler are different from one another. Both handlers are invoked when the event of the given type occurs but in one invocation the value passed to **userHandle** is 0x1 and in the other it is 0x2. As a result, you can uniquely identify VISA event handlers by a combination of the handler address and user context pair.

This structure also is important when the application attempts to remove the handler. The operation `viUninstallHandler()` requires not only the handler's address but also the **userHandle** value to correctly identify which handler to remove.

Queuing and Callback Mechanism Sample Code

Example 7-1 demonstrates the use of both the queuing and callback mechanisms in event handling. In the program, a message is sent to a GPIB device telling it to read some data. When the data collection is complete, the device asserts SRQ, informing the program that it can now read data. After reading the device's status byte, the handler begins to read asynchronously using a buffer of information that the main program passes to it.

Note This example shows C source code. You can find the same example in Visual Basic syntax in Appendix A, *Visual Basic Examples*.

Example 7-1

```
#include "visa.h"
#include <stdlib.h>

#define MAX_CNT 1024

/* This function is to be called when an SRQ event occurs */
/* Here, an SRQ event indicates the device has data ready */
ViStatus _VI_FUNCH myCallback(ViSession vi, ViEventType etype,
       ViEvent eventContext, ViAddr userHandle)
{
       ViJobId     jobID;
       ViStatus    status;
       ViUInt16    stb;

       status = viReadSTB(vi, &stb);
       status = viReadAsync(vi,(ViBuf)userHandle,MAX_CNT,&jobID);
       return VI_SUCCESS;
}

int main(void)
{
       ViStatus    status;
       ViSession   defaultRM, gpibSesn;
       ViBuf       bufferHandle;
       ViUInt32    retCount;
       ViEventType etype;
       ViEvent     eventContext;

       /* Begin by initializing the system */

       status = viOpenDefaultRM(&defaultRM);
       if (status < VI_SUCCESS) {
          /* Error initializing VISA...exiting */
          return -1;
       }
       /* Open communication with GPIB device at primary address 2 */
       status = viOpen(defaultRM, "GPIB0::2::INSTR", VI_NULL, VI_NULL,
          &gpibSesn);

       /* Allocate memory for buffer */
```

```
        /* In addition, allocate space for the ASCII NULL character */
           bufferHandle = (ViBuf)malloc(MAX_CNT+1);

        /* Tell the driver what function to call on an event */
        status = viInstallHandler(gpibSesn, VI_EVENT_SERVICE_REQ, myCallback,
           bufferHandle);

        /* Enable the driver to detect events */
        status = viEnableEvent(gpibSesn, VI_EVENT_SERVICE_REQ, VI_HNDLR,
           VI_NULL);
        status = viEnableEvent(gpibSesn, VI_EVENT_IO_COMPLETION, VI_QUEUE,
           VI_NULL);


        /* Tell the device to begin acquiring a waveform */
        status = viWrite(gpibSesn, "E0x51; W1", 9, &retCount);

        /* The device asserts SRQ when the waveform is ready */
        /* The callback begins reading the data */
        /* After the data is read, an I/O completion event occurs */

        status = viWaitOnEvent(gpibSesn, VI_EVENT_IO_COMPLETION, 20000,
           &etype, &eventContext);
        if (status < VI_SUCCESS) {
           /* Waveform not received...exiting */
           free(bufferHandle);
           viClose(defaultRM);
           return -1;
        }
        /* Your code should process the waveform data */

        /* Close the event context */
        viClose(eventContext);
        /* Stop listening for events */
        status = viDisableEvent(gpibSesn, VI_ALL_ENABLED_EVENTS,
           VI_ALL_MECH);
        status = viUninstallHandler(gpibSesn, VI_EVENT_SERVICE_REQ,
           myCallback,bufferHandle);
        /* Close down the system */
        free(bufferHandle);
        status = viClose(gpibSesn);
        status = viClose(defaultRM);
        return 0;
}
```

The Life of the Event Context

The event context that the VISA driver generates when an event occurs is a data object that contains the information about the event. Because it is more than just a simple variable, memory allocation and deallocation becomes important.

Event Context with the Queuing Mechanism

When you use the queuing mechanism, the event context is returned when you call `viWaitOnEvent()`. The VISA driver has created this data structure, but it cannot destroy it until you tell it to. For this reason, in VISA you call `viClose()` on the event context so the driver can free the memory for you. Always remember to call `viClose()` when you are done with the event.

If you know the type of event you are receiving, and the event does not provide any useful information to your application other than whether it actually occurred, you can pass `VI_NULL` as the **outEventType** and **eventContext** parameters as shown in the following example:

```
status = viWaitOnEvent(gpibSesn, VI_EVENT_SERVICE_REQ, 5000,
   VI_NULL, VI_NULL);
```

In this case, VISA automatically closes the event data structure rather than returning it to you. Calling `viClose()` on the event context is therefore both unnecessary and incorrect because VISA would not have returned the event context to you.

Event Context with the Callback Mechanism

In the case of callbacks, the event is passed to you in a function, so the VISA driver has a chance to destroy it when the function ends. This has two important repercussions. First, you do not need to call `viClose()` on the event inside the callback function. Indeed, calling this operation on the event could lead to serious problems because VISA will access the event (to close it) when your callback returns. Secondly, the event itself has a life only as long as the callback function is executing. Therefore, if you want to keep any information about the event after the callback function, you should use `viGetAttribute()` to retrieve the information for storage. Any references to the event itself becomes invalid when the callback function ends.

Exception Handling

By using the VISA event VI_EVENT_EXCEPTION, you can have one point in your code that traps all errors and handles them appropriately. This means that after you install and enable your VISA exception handler, you do not have to check the return status from each operation, which makes the code easier to read and maintain. How an application handles error codes is specific to both the device and the application. For one application, an error could mean different things from different devices, and might even be ignored under certain circumstances; for another, any error could always be fatal.

For an application that needs to treat all errors as fatal, one possible use for this event type would be to print out a debug message and then exit the application. Because the method of installing the handler and then enabling the event has already been covered, the following code segment shows only the handler itself:

```
ViStatus _VI_FUNCH myEventHandler (ViSession vi, ViEventType etype,
       ViEvent eventContext, ViAddr uHandle)
{
       ViChar rsrcName[256], operName[256];
       ViStatus stat;
       ViSession rm;

       if (etype == VI_EVENT_EXCEPTION) {
           viGetAttribute(vi,VI_ATTR_RSRC_NAME,rsrcName);
           viGetAttribute(eventContext,VI_ATTR_OPER_NAME,operName);
           viGetAttribute(eventContext,VI_ATTR_STATUS,&stat);
           printf(
           "Session 0x%08lX to resource %s caused error 0x%08lX in operation %s.\n",
           vi,rsrcName,stat,operName);

           /* Use this code only if you will not return control to VISA */
           viGetAttribute(vi,VI_ATTR_RM_SESSION,&rm);
           viClose(eventContext);
           viClose(vi);
           viClose(rm);
           exit(-1);   /* exit the application immediately */
       }
       /* code for other event types */
       return VI_SUCCESS;
}
```

If you wanted just to print out a message, you would leave out the code that closes the objects and exits. Notice that in this code segment, the event object is closed inside of the callback, even though we just recommended in the previous section that you not do this! The reason that we do it here is that the code will never return control to VISA—calling `exit()` will return control to the operation system instead. This is the only case where you should ever invoke `viClose()` within a callback.

Another (more advanced) use of this event type is for throwing C++ exceptions. Because VISA exception event handlers are invoked in the context of the same thread in which the error condition occurs, you can safely throw a C++ exception from the VISA handler. Like the example above, you would invoke `viClose()` on the exception event (but you would probably not close the actual session or its resource manager session). You would also need to include the information about the VISA exception (for example, the status code) in your own exception class (of the type that you throw), since this will not be available once the VISA event is closed.

Throwing C++ exceptions introduces several issues to consider. First, if you have mixed C and C++ code in your application, this could introduce memory leaks in cases where C functions allocate local memory on the heap rather than the stack. Second, if you use asynchronous operations, an exception is thrown only if the error occurs before the operation is posted (for example, if the error generated is `VI_ERROR_QUEUE_ERROR`). If the error occurs during the operation itself, the status is returned as part of the `VI_EVENT_IO_COMPLETION` event. This is important because that event may occur in a separate thread, due to the nature of asynchronous I/O. Therefore, you should not use asynchronous operations if you wish to throw C++ exceptions from your handler.

8

VISA Locks

This chapter describes how to use locks in VISA.

Introduction

VISA introduces locks for access control of resources. In VISA, applications can open multiple sessions to a resource simultaneously and can access the resource through these different sessions concurrently. In some cases, applications accessing a resource must restrict other sessions from accessing that resource. For example, an application may need to execute a write and a read operation as a single step so that no other operations intervene between the write and read operations. The application can lock the resource before invoking the write operation and unlock it after the read operation, to execute them as a single step. VISA defines a locking mechanism to restrict accesses to resources for such special circumstances.

The VISA locking mechanism enforces arbitration of accesses to resources on an individual basis. If a session locks a resource, operations invoked by other sessions are serviced or returned with a locking error, depending on the operation and the type of lock used.

Lock Types

VISA defines two different types, or modes, of locks: *exclusive* and *shared* locks, which are denoted by `VI_EXCLUSIVE_LOCK` and `VI_SHARED_LOCK`, respectively. `viLock()` is used to acquire a lock on a resource, and `viUnlock()` is used to release the lock.

If a session has an exclusive lock, other sessions cannot modify global attributes or invoke operations, but can still get attributes and set local attributes. If the session has a shared lock, other sessions that have shared locks can also modify global attributes and invoke operations.

Regardless of which type of lock a session has, if the session is closed without first being unlocked, VISA automatically performs a `viUnlock()` on that session.

Lock Sharing

The locking mechanism in VISA is session based, not thread based. Therefore, if multiple threads share the same session, they have the same privileges for accessing the resource. VISA locks will not provide mutual exclusion in this scenario. However, some applications might have separate sessions to a resource for these multiple threads, and might require that all the sessions in the application have the same privileges as the session that locked the resource. In other cases, there might be a need to share locks among sessions in different applications. Essentially, sessions that have a lock to a resource may share the lock with certain sessions, and exclude access from other sessions.

This section discusses the mechanism that makes it possible to share locks. VISA defines a lock type—`VI_SHARED_LOCK`—that gives exclusive access privileges to a session, along with the capability to share these exclusive privileges at the discretion of the original session. When locking sessions with a shared lock, the locking session gains an access key. The session can then share this lock with any other session by passing the access key. VISA allows user applications to specify an access key to be used for lock sharing, or VISA can generate the access key for an application.

If the application chooses to specify the **accessKey**, other sessions that want access to the resource must choose the same unique **accessKey** for locking the resource. Otherwise, when VISA generates the **accessKey**, the session that gained the shared lock should make the **accessKey** available to other sessions for sharing access to the locked resource. Before the other sessions can access the locked resource, they must acquire the lock using the same access key in the **accessKey** parameter of the `viLock()` operation. Invoking `viLock()` with the same access key will register the new session with the same access privileges as the original session. All sessions that share a resource should synchronize their accesses to maintain a consistent state of the resource. The following code is an example of obtaining a shared lock with a requested name:

```
status = viLock(instr, VI_SHARED_LOCK, 15000, "MyLockName", accessKey);
```

This example attempts to acquire a shared lock with `"MyLockName"` as the `requestedKey` and a timeout of 15 s. If the call is successful, **accessKey** will contain `"MyLockName"`. If you want to have VISA generate a key, simply pass `VI_NULL` in place of `"MyLockName"` and VISA will return a unique key in **accessKey** that other sessions can use for locking the resource.

Acquiring an Exclusive Lock While Owning a Shared Lock

When multiple sessions have acquired a shared lock, VISA allows one of the sessions to acquire an exclusive lock as well as the shared lock it is holding. That is, a session holding a shared lock can also acquire an exclusive lock using the `viLock()` operation. The session holding both the exclusive and shared lock has the same access privileges it had when it was holding only the shared lock. However, the exclusive lock precludes other sessions holding the shared lock from accessing the locked resource. When the session holding the exclusive lock unlocks the resource using the `viUnlock()` operation, all the sessions (including the one that acquired the exclusive lock) again have all the access privileges associated with the shared lock. This circumstance is useful when you need to synchronize multiple sessions holding a shared lock. A session holding an exclusive and shared lock can also be useful when one of the sessions needs to execute in a critical section.

Nested Locks

VISA supports nested locking. That is, a session can lock the same resource multiple times (for the same lock type). Unlocking the resource requires an equal number of invocations of the `viUnlock()` operation. Each session maintains a separate lock count for each type of locks. Repeated invocations of the `viLock()` operation for the same session increase the appropriate lock count, depending on the type of lock requested. In the case of shared locks, nesting `viLock()` calls return with the same **accessKey** every time. In the case of exclusive locks, `viLock()` does not return an **accessKey**, regardless of whether it is nested. For each invocation of `viUnlock()`, the lock count is decremented. VISA unlocks a resource only when the lock count equals 0.

Locking Sample Code

Example 8-1 uses a shared lock because two sessions are opened for performing trigger operations. The first session receives triggers and the second session sources triggers. A shared lock is needed because an exclusive lock would prohibit the other session from accessing the same resource. If `viWaitOnEvent()` fails, this example performs a `viClose()` on the resource manager without unlocking or closing the sessions. When the resource manager session closes, all sessions that were opened using it automatically close as well. Likewise, remember that closing a session that has any lock results in automatically releasing its lock(s).

Note This example shows C source code. You can find the same example in Visual Basic syntax in Appendix A, *Visual Basic Examples*.

Example 8-1

```
#include "visa.h"

#define MAX_COUNT 128

int main(void)
{
       ViStatus      status;                 /* For checking errors     */
       ViSession     defaultRM;              /* Communication channels  */
       ViSession     instrIN, instrOUT;      /* Communication channels  */
       ViChar        accKey[VI_FIND_BUFLEN]; /* Access key for lock     */
       ViByte        buf[MAX_COUNT];         /* To store device data    */
       ViEventType   etype;                  /* To identify event       */
       ViEvent       event;                  /* To hold event info      */
       ViUInt32      retCount;               /* To hold byte count      */

       /* Begin by initializing the system                              */
       status = viOpenDefaultRM(&defaultRM);
       if (status < VI_SUCCESS) {
          /* Error Initializing VISA...exiting                          */
          return -1;
       }
       /* Open communications with VXI Device at Logical Addr 16        */
       status = viOpen(defaultRM, "VXI0::16::INSTR", VI_NULL, VI_NULL,
                       &instrIN);
       status = viOpen(defaultRM, "VXI0::16::INSTR", VI_NULL, VI_NULL,
                       &instrOUT);

       /* We open two sessions to the same device                       */
       /* One session is used to assert triggers on TTL channel 4       */
       /* The second is used to receive triggers on TTL channel 5       */

       /* Lock first session as shared, have VISA generate the key      */
       /* Then lock the second session with the same access key         */

       status = viLock(instrIN, VI_SHARED_LOCK, 5000, VI_NULL, accKey);
       status = viLock(instrOUT, VI_SHARED_LOCK, VI_TMO_IMMEDIATE, accKey,
                       accKey);
```

```
    /* Set trigger channel for sessions                                  */
    status = viSetAttribute(instrIN, VI_ATTR_TRIG_ID,VI_TRIG_TTL5);
    status = viSetAttribute(instrOUT,VI_ATTR_TRIG_ID,VI_TRIG_TTL4);

    /* Enable input session for trigger events                           */
    status = viEnableEvent(instrIN, VI_EVENT_TRIG, VI_QUEUE, VI_NULL);

    /* Assert trigger to tell device to start sampling                   */
    status = viAssertTrigger(instrOUT, VI_TRIG_PROT_DEFAULT);

    /* Device will respond with a trigger when data is ready             */
    if ((status = viWaitOnEvent(instrIN, VI_EVENT_TRIG, 20000, &etype,
                                &event)) < VI_SUCCESS) {
       viClose(defaultRM);
       return -1;
    }

    /* Close the event                                                   */
    status = viClose(event);

    /* Read data from the device                                         */
    status = viRead(instrIN, buf, MAX_COUNT, &retCount);

    /* Your code should process the data                                 */

    /* Unlock the sessions                                               */
    status = viUnlock(instrIN);
    status = viUnlock(instrOUT);

    /* Close down the system                                             */
    status = viClose(instrIN);
    status = viClose(instrOUT);
    status = viClose(defaultRM);
    return 0;
}
```

9

Interface Specific Information

Although one of the benefits of VISA is an interface-independent API, there are times when you must understand the details of the specific interface with which you are working. This chapter provides additional information about each of the hardware interface types that NI-VISA currently supports.

GPIB

VISA supports programming IEEE-488.1 and IEEE-488.2 devices, and includes complete device-level and board-level functionality.

Introduction to Programming GPIB Devices in VISA

For novice GPIB users, the VISA API presents a simple interface for device communication. Most GPIB devices allow you to set a primary address via either a DIP switch or via front panel selectors. This primary address is the same one used in the VISA resource string to `viOpen()`. The simplest and most common GPIB resource string is "`GPIB::<primary address>::INSTR`". Recall that the "`INSTR`" resource class informs VISA that you are doing instrument (device) communication. Most GPIB programs perform simple message-based transfers (write command, read response). For more information about VISA message-based functionality, see Chapter 5, *Message-Based Communication*.

There are several VISA attributes specific to the GPIB INSTR resource. The `VI_ATTR_GPIB_PRIMARY_ADDR` and `VI_ATTR_GPIB_SECONDARY_ADDR` attributes are read-only, and these return the same values that were used in the resource string passed to `viOpen()`. If the specified device does not have a secondary address, that attribute query will succeed and return a value of –1. The attribute `VI_ATTR_GPIB_READDR_EN` controls whether each message to or from the same device will cause the driver to readdress the device. This attribute is true (enabled) by default, and disabling this attribute (setting it to false) may provide a slight performance increase by removing unnecessary bus-level readdressing to the same device. The attribute `VI_ATTR_GPIB_UNADDR_EN` controls whether the driver will follow each message to or from the specified device with untalk (UNT) and unlisten

(UNL) commands. This attribute is false (disabled) by default, which is the most optimal setting. Changing the values of these attributes may be necessary for certain older non-IEEE-488.2-compliant devices.

More complex GPIB systems often include multiple GPIB controllers (or boards) and devices with both primary and secondary addresses. The canonical form of a complex GPIB instrument resource string is "GPIB<controller>::<primary address>::<secondary address>::INSTR". The controller number is the same as used in the GPIB configuration utility (MAX on Windows, the GPIB Control Panel applet on Macintosh, or ibconf on UNIX). If not specified, the controller number defaults to 0.

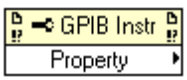
Comparison Between NI-VISA and NI-488 APIs

For GPIB users who are familiar with NI-488, the following table shows several common, but not all, NI-488 device-level function calls and the corresponding VISA operations. As you can see, the APIs are almost identical. The difference is that VISA is extensible to additional hardware interfaces. Therefore, if you are programming multiple devices that communicate over more than one bus type, it might be easier to use VISA for your entire system.

Table 9-1. NI-VISA and NI-488 Functions and Operations

C NI-488 Device Function	C VISA INSTR Operation	LabVIEW NI-488 Device Function	LabVIEW VISA INSTR Operation
ibdev	viOpen	<no equivalent>	 VISA Open
ibonl	viClose	<no equivalent>	 VISA Close
ibwrt	viWrite	 GPIB Write	 VISA Write
ibrd	viRead	 GPIB Read	 VISA Read

Table 9-1. NI-VISA and NI-488 Functions and Operations (Continued)

C NI-488 Device Function	C VISA INSTR Operation	LabVIEW NI-488 Device Function	LabVIEW VISA INSTR Operation
ibclr	viClear	 GPIB Clear	 VISA Clear
ibtrg	viAssertTrigger	 GPIB Trigger	 VISA Assert Trigger
ibrsp	viReadSTB	 GPIB Serial Poll	 VISA Read STB
ibwait	viWaitOnEvent	 Wait for GPIB RQS	 Wait for RQS
ibconfig	viSetAttribute	 GPIB Initialization	 VISA Property Node

One difference in the event mechanism between NI-488 and VISA is worth noting. In VISA, you must always call `viEnableEvent()` prior to being allowed to receive events. While this was not the case with NI-488, this is required in VISA to avoid the race condition of trying to wait on events for which the hardware may not be enabled. Thus, you should enable the session for events not just immediately before calling `viWaitOnEvent()`, but before the device has even been triggered or configured to generate a service request event.

Board-Level Programming

Advanced users occasionally need to control multiple devices simultaneously or need to have multiple controllers connected together in a single system. Power GPIB programmers use interface-level (bus-level) commands to do this. The corresponding VISA resource for this is the GPIB INTFC resource, and the form of the resource string is "`GPIB<controller>::INTFC`". This allows raw message transfers in which the driver does not perform automatic device addressing, as it does with INSTR. Also, with the INTFC resource, the controller can directly

query and manipulate specific lines on the bus such as SRQ or NDAC, and also pass control to other devices that have controller capability.

For users who are familiar with NI-488, the following table shows several common, but not all, NI-488 board-level function calls and the corresponding VISA operations. As in the previous table, you can see that the APIs are almost identical.

Table 9-2. Board-Level Programming Functions and Operations

NI-488 board function	VISA INTFC Operation
ibfind	`viOpen`
ibonl	`viClose`
ibwrt	`viWrite`
ibrd	`viRead`
ibwait	`viWaitOnEvent`
ibconfig	`viSetAttribute`
ibask, ibwait	`viGetAttribute`
ibcmd	`viGpibCommand`
ibsre	`viGpibControlREN`
ibgts, ibcac	`viGpibControlATN`
ibsic	`viGpibSendIFC`

For users who need to write an application that will run inside a device, such as firmware, the INTFC resource provides the necessary functionality. The device status byte attribute is useful for reflecting application status.

GPIB Summary

Since both of these APIs are very similar and both provide the same GPIB functionality, which should you choose? If you are already familiar with NI-488 and are programming only GPIB devices, then there is not a strong reason for you to change to VISA. NI-488 is supported in all major application development environments, including LabVIEW and Measurement Studio. However, if you have instruments with more than one type of port or connection available to them, then using VISA might be advantageous because you can use the same API regardless of the connection medium.

Finally, many modern instrument drivers rely on VISA for their I/O needs, so if you are using instrument drivers, then you need to at least install NI-VISA for them to be able to execute.

GPIB-VXI

VISA supports programming VXI devices connected through a GPIB-VXI controller. The functionality is a subset of the VISA API for VXI devices connected through a native VXI controller.

Introduction to Programming GPIB-VXI Devices in VISA

For new GPIB-VXI users, this controller makes VXI message-based devices appear as though they are GPIB devices with secondary addresses. This initially provided an easy transition into VXI for customers with existing GPIB systems, because they could use the same NI-488 API to control both types of instruments. However, this proved problematic for VXI register-based devices, because their addresses are not mapped directly into the GPIB system.

For controlling message-based VXI devices through a GPIB-VXI, the biggest difference between a program using NI-488 and one using VISA is in the calls made at the beginning and the end. For register-based devices, the differences are more significant. This section first discusses the basic changes common to both types of devices, then discusses some of the changes required for register-based programming.

For message-based programming, an NI-488 program would typically call `ibdev()` with the VXI device's primary and secondary GPIB addresses to get a handle to the specific device. In VISA, a program calls `viOpen()` with the VXI device's logical address (which is a more natural address because the device is VXI) to get a handle to it. The simplest and most common GPIB-VXI resource string is "`GPIB-VXI::<logical address>::INSTR`". Once you have a session to the VXI device, the NI-488 and VISA calls to communicate with the device are very similar, as covered above in the Comparison between NI-VISA and NI-488 APIs section.

Register-based Programming with the GPIB-VXI

Register-based programming does not have a straightforward mapping. Because register accesses using the GPIB-VXI involve sending requests to the controller itself (using the local command set), NI-488 programs would use `ibdev()` with the GPIB-VXI *controller's* primary and secondary

GPIB addresses. In VISA, you call `viOpen()` with the VXI *device's* logical address, the same method for both message-based and register-based devices, and VISA handles sending the necessary messages to the controller. For programming the device, the following NI-488 messages and VISA operations are roughly equivalent:

Table 9-3. Register-based Programming Messages and Operations

NI-488 Message	VISA Operation
"Laddrs?" or "DLAD?"	`viFindRsrc()`
"RMentry?" or "DINF?"	`viGetAttribute()`
"Cmdr?"	`viGetAttribute()` with `VI_ATTR_CMDR_LA`
"LaSaddr?"	`viGetAttribute()` with `VI_ATTR_GPIB_SECONDARY_ADDR`
"Primary?"	`viGetAttribute()` with `VI_ATTR_GPIB_PRIMARY_ADDR`
"WREG" or "A16"	`viOut16()` with `VI_A16_SPACE`
"RREG?" or "A16?"	`viIn16()` with `VI_A16_SPACE`
"A24"	`viOut16()` with `VI_A24_SPACE`
"A24?"	`viIn16()` with `VI_A24_SPACE`
"SrcTrig"	`viAssertTrigger()`

Notice that with the INSTR register access operations `viOut16()` and `viIn16()`, you pass a device-relative offset in the specified address space. This is different from the GPIB-VXI/C local command set, which accepts absolute addresses. If your application currently uses absolute addressing and you do not want to convert to device-relative offsets, you may consider the MEMACC resource, which accepts absolute addressing. The form of the resource string for that class is `"GPIB-VXI<system>::MEMACC"`. You can also use the operations `viOut8()` and `viIn8()` to perform 8-bit accesses, which is not a feature supported by the local command set. VISA also defines 32-bit operations and accesses to A32 space, but because these are not implemented by the GPIB-VXI/C itself, they return errors.

If you have used the DMAmove code instrument in the past, you can instead use the viMoveInxx() and viMoveOutxx() operations instead. They make use of the GPIB-VXI's DMA functionality, but require only a single operation call, instead of the multiple calls required to send the command and data blocks and then poll waiting for the operation to complete. Using VISA to move blocks of data also means that you no longer need to load the DMAmove code instrument, as NI-VISA automatically downloads a separate code instrument to handle these and other operations.

Additional Programming Issues

For advanced users, the GPIB-VXI Mainframe Backplane resource encapsulates the operations and properties of each mainframe (or chassis) in a VXIbus system. This resource type lets a controller query and manipulate specific lines on a specific mainframe in a given VXI system. The form of the resource string for this class is "GPIB-VXI<system>::BACKPLANE". Services in this resource class allow the user to map, unmap, and assert hardware triggers, and also to assert various utility signals.

Although the VISA API is almost identical for VXI and GPIB-VXI, the GPIB-VXI implements only a subset of this functionality. As mentioned above, the GPIB-VXI does not support 32-bit register accesses, nor does it support A32 space. The attributes VI_ATTR_SRC_ACCESS_PRIV, VI_ATTR_DEST_ACCESS_PRIV, and VI_ATTR_WIN_ACCESS_PRIV can only be set to the value VI_DATA_PRIV; other address modifiers are not supported. The attributes VI_ATTR_SRC_BYTE_ORDER, VI_ATTR_DEST_BYTE_ORDER, and VI_ATTR_WIN_BYTE_ORDER can only be set to the value VI_BIG_ENDIAN; little endian transfers are not supported. Also, while the GPIB-VXI does support service request events, it does not support receiving the following events: miscellaneous VXI signals or interrupts, triggers, SYSFAIL, or SYSRESET.

If you have more than one GPIB-VXI controller in your system, or if you change the primary address of a GPIB-VXI controller from its default (1 for the National Instruments GPIB-VXI/C), or if you have a GPIB-VXI controller from another vendor, then you need to configure NI-VISA to find such a controller. Use the NI-VISA configuration utility (MAX on Windows, visaconf on UNIX) and explicitly add a GPIB-VXI controller. You will be prompted for the GPIB controller number to which the GPIB-VXI is connected (usually 0), a unique GPIB-VXI controller number (which you are free to assign), and the primary and secondary addresses to which you have configured this GPIB-VXI controller.

GPIB-VXI Summary

In summary, using VISA to program VXI devices controlled by a GPIB-VXI is no different than if they are controlled with a native VXI controller such as the PCI-MXI-2 or a VXIpc. Although porting the code from NI-488 to VISA is not simple in the case of register-based programming, it will be code that is compatible with native VXI controllers.

VXI

This topic introduces you to the concepts of VXI (VME eXtensions for Instrumentation), VME, MXI (Multisystem eXtension Interface), and how you can control these buses using VISA.

Introduction to Programming VXI Devices in VISA

A VXI device has a unique *logical address*, which serves as a means of referencing the device in the VXI system. This logical address is analogous to a GPIB primary address. VXI uses an 8-bit logical address, allowing for up to 256 VXI devices in a VXI system. VISA addresses a specific VXI device with a resource string identifying the VXI system that the device is in and the logical address of this particular device: "VXI<system>::<logical address>::INSTR".

Each VXI device has a specific set of registers, called *configuration registers*. See the NI-VXI on-line help for a diagram. These registers are located in the upper 16KB of the 64KB A16 address space. The logical address of a VXI device determines the location of the device's configuration registers in the 16KB area reserved by VXI. The rest of A16 space is available for VME devices. The 16MB A24 address space and the 4GB A32 address space are available for VXI and VME devices. Each VXI system has a Resource Manager which is responsible for allocating each device's requests in the appropriate address space. When you open a VXI/VME INSTR resource in VISA, you have access to registers in the spaces that have been allocated by the Resource Manager for the device corresponding to that INSTR resource. Devices which provide only this minimal level of capability are called *register-based* devices, and support VISA operations such as `viInX/viOutX` (read/write a single register), `viMoveInX/viMoveOutX` (perform a block move to read or write a block of registers), `viMapAddress` (map a region of VXI memory into your application for low-level access), and others. These operations are discussed in more detail in Chapter 6, *Register-Based Communication*.

In addition to register-based devices, the VXIbus specification also defines *message-based devices*, which are required to have *communication registers* in addition to configuration registers. All message-based VXIbus devices, regardless of the manufacturer, can communicate using the VXI-specified *Word Serial Protocol*. In addition, you can establish higher-performance communication channels, such as the shared-memory channels in Fast Data Channel (FDC), to take advantage of the VXIbus bandwidth capabilities (a diagram of these protocols is shown in the NI-VXI on-line help).

The VXIbus Word Serial Protocol is a standardized message-passing protocol. This protocol is functionally very similar to the IEEE 488 protocol, which transfers data messages to and from devices one byte at a time. Thus, VXI message-based devices communicate in a fashion very similar to GPIB instruments. In general, message-based devices typically contain a higher level of local intelligence that uses or requires a higher level of communication. In addition, the Word Serial Protocol has special messages for configuring message-based devices. All VXI message-based devices are required to support the Word Serial Protocol and support a basic level of standard communication. There are even higher level message based protocols, such as Standard Commands for Programmable Instrumentation (SCPI); these are not required protocols, and not all VXI message-based devices support them. Message-based VXI devices support VISA operations such as `viRead/viWrite` (Word Serial read/write buffer), `viClear` (Word Serial clear), `viPrintf/viScanf` (formatted I/O), `viAssertTrigger` (Word Serial trigger), `viVxiCommandQuery` (Word Serial command and/or response), and others. These operations are discussed in more detail in Chapter 5, *Message-Based Communication*.

VXI/ VME Interrupts and Asynchronous Events in VISA

VXI/VME devices can communicate asynchronous status and events through VXI/VME interrupt events (`VI_EVENT_VXI_VME_INTR`) or by using specific messages called signals (`VI_EVENT_VXI_SIGP`). Since VXI interrupts can be treated just like signals, a VISA application for VXI devices will typically just use `VI_EVENT_VXI_SIGP` to handle both interrupts and signals, regardless of which is actually sent in hardware. The main difference is that the status/ID returned as an attribute of the event is 16-bit for `VI_EVENT_VXI_SIGP` and 32-bit for `VI_EVENT_VXI_VME_INTR`.

The VXI specification also makes use of triggering (`VI_EVENT_TRIG`) to synchronize events between VXI devices. VXI devices support these events in the INSTR resource through the standard VISA operations such as

viEnableEvent, as discussed in Chapter 7, *VISA Events*. Since devices can both send and receive triggers, the attribute VI_ATTR_TRIG_ID specifies the line used for either. You cannot use the same session to both assert and receive triggers; for this, you need multiple sessions.

Performing Arbitrary Access to VXI Memory with VISA

VISA provides the VXI MEMACC resource class to allow access to arbitrary locations in VXI address spaces. When you open a VXI INSTR resource, VISA automatically performs all register I/O in the address spaces used by that device relative to that device's memory region, and will prevent accidental access outside of the region allocated for your device. If you need to access a memory region not associated with a particular device, or use a low-level scheme for performing your register I/O that uses absolute addresses, you should use the MEMACC resource which provides this capability. When using a MEMACC resource, all address parameters are absolute within the given address space; knowing a device's base address is both required by and relevant to the user. The VISA resource string format for this is "VXI<system>::MEMACC". You can still use the same VISA operations for performing register I/O enumerated above, such as viInX/viOutX, viMoveInX/viMoveOutX, and viMapAddress.

Other VXI Resource Classes and VISA

For certain applications, such as asserting interrupts or triggers, it may be necessary to access the VXI mainframe or chassis ("backplane") directly. VISA provides the BACKPLANE resource for this purpose, where each VXI mainframe can is accessed using the VISA resource string "VXI<system>::<mainframe number>::BACKPLANE". The BACKPLANE resource encapsulates the operations and properties of each mainframe (or chassis) in the VXI system, and lets a controller query and manipulate specific lines on a specific mainframe in a given VXI system. The operations viMapTrigger, viUnmapTrigger, viAssertTrigger, and the event VI_EVENT_TRIG supported on this resource allow the user to map, unmap, assert, and receive hardware triggers. You can also use viAssertUtilSignal, viAssertIntrSignal, VI_EVENT_VXI_VME_SYSFAIL, and VI_EVENT_VXI_VME_SYSRESET to assert and receive various utility and interrupt signals. This includes advanced functionality that might not be available in all implementations or on all controllers.

It is possible to configure your VXI controller to be a Word Serial servant in your VXI system, with another controller as its commander. For such situations, VISA provides another class of asynchronous events associated

with the Word Serial protocol: the Word Serial Servant protocol. Using the VISA SERVANT resource, your device can act as a servant, which means that it can use `VI_EVENT_IO_COMPLETION` to respond to requests from a Word Serial commander. This resource is accessed using "`VXI<system>::SERVANT`" and encapsulates the operations and properties of the capabilities of a *device* and a device's view of the system in which it exists. The SERVANT resource exposes the device-side functionality of the device associated with the given resource. This functionality is somewhat unusual for a VXI controller and in most cases you will never need to use the SERVANT resource. The SERVANT resource provides the complementary functions for the message-based operations discussed above, and therefore implements the servant side `viRead`, `viWrite`, etc. for buffer reads and writes, `viPrintf`, `viScanf`, etc. for formatted I/O, and asynchronous message-based notification events. The resource also provides the ability to assert and receive interrupt and utility signals.

Comparison Between NI-VISA and NI-VXI APIs

As a VXI programmer you may be familiar with the NI-VXI API, but National Instruments recommends that all new VXI applications be developed in NI-VISA, which provides additional flexibility, features, and performance. Fortunately, translating NI-VXI API code to VISA is made fairly simple by the close correlation between the two APIs. For users who are familiar with the NI-VXI API, the following table shows several common, but not all, NI-VXI API function calls and the corresponding VISA operations. You can see that the APIs are almost identical. The difference is that VISA is extensible to additional hardware interfaces. Therefore, if you are programming multiple devices that communicate over more than one bus type, it might be easier to use VISA for your entire system.

Table 9-4. NI-VISA and NI-VXI Functions and Operations

C NI-VXI Function	C VISA INSTR Operation	LabVIEW NI-VXI Function	LabVIEW VISA INSTR Operation
InitVXIlibrary	viOpenDefaultRM viOpen	 InitVXIlibrary	 VISA Open
CloseVXIlibrary	viClose	 CloseVXIlibrary	 VISA Close

Table 9-4. NI-VISA and NI-VXI Functions and Operations (Continued)

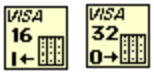
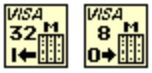
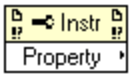
C NI-VXI Function	C VISA INSTR Operation	LabVIEW NI-VXI Function	LabVIEW VISA INSTR Operation
WSwrt	viWrite	 WSwrt	 VISA Write
WSrd	viRead	 WSrd	 VISA Read
WSclr	viClear	 WSclr	 VISA Clear
WStrg, SrcTrig	viAssertTrigger	 WStrg, SrcTrig	 VISA Assert Trigger
VXIin, VXIout	viInX, OutX	 VXIin, VXIout	 VISA InX, VISAOutX
VXImove	viMoveInX, viMoveOutX	 VXImove	 VISA Move InX, VISA Move OutX
MapVXIAddress	viMapAddress	 MapVXIAddress	 VISA Map Address
AssertVXIint	viAssertIntrSignal	 AssertVXIint	 VISA Assert Interrupt
EnableVXItoSignalInt	viEnableEvent	 EnableVXItoSignalInt	 VISA Enable Event

Table 9-4. NI-VISA and NI-VXI Functions and Operations (Continued)

C NI-VXI Function	C VISA INSTR Operation	LabVIEW NI-VXI Function	LabVIEW VISA INSTR Operation
WaitForSignal	viWaitOnEvent	 WaitForSignal	 VISA Wait on Event
GetDevInfo	viGetAttribute	 GetDevInfoLong	 VISA Property Node

An important difference between the NI-VXI API and VISA is the scope of the effect of certain function calls. In the NI-VXI API, many functions (notably, enabling for events) acted on the VXI controller directly and therefore applied to the entire VXI system. Since VISA is generally device-oriented rather than controller-oriented, the corresponding VISA INSTR operations act on a specific VXI device, not the entire system.

Summary of VXI in VISA

Since the VISA API is very similar to the NI-VXI API and both provide almost the same VXI functionality, which should you choose? National Instruments recommends using the VISA API because it allows you to control multiple VXI systems (controllers) from a single computer, provides a more flexible API that allows you to move to other interfaces if the application demands it, and usually provides equal or better performance. However, if your application already uses NI-VXI and you are programming only VXI devices, then there is not a strong reason for you to change the application to VISA. For new applications, though, VISA is almost always preferred. Finally, most modern instrument drivers rely on VISA for their I/O needs, so if you are using instrument drivers, then you need to at least install NI-VISA for them to be able to execute.

PXI

NI-VISA supports programming PCI and PXI (PCI eXtensions for Instrumentation) devices plugged into the local PC or PXI chassis, or PXI devices in a remote chassis connected via a remote controller such as MXI-3.

Introduction to Programming PXI Devices in NI-VISA

Users who are writing an application for a PCI or PXI card can use NI-VISA to gain full access to all the device's configuration, I/O, and memory mapped registers. NI-VISA currently supports the PXI interface only on Windows and LabVIEW RT. The supported functionality is identical for PCI and PXI cards. The terms PCI and PXI are used somewhat interchangeably in this section; technically, PXI is a rigorously defined extension of PCI.

To use PXI or PCI devices in your program, make sure you define the macro `"NIVISA_PXI"` before including `"visa.h"`.

A PXI resource is uniquely identified in the system by 3 characteristics: the PCI bus number on which it is located, the PCI device number it is assigned, and the function number of the device. For single-function devices, the function number is always 0 and is optional; for multi-function devices, the function number is device-specific but will be in the range 0–7. The device number is associated with the slot number, but these numbers are usually different. The bus number of a device is consistent from one system boot to the next, unless bridge devices are inserted somewhere between the device and the system's CPU. The canonical resource string that you pass to `viOpen()` for a PCI or PXI device is `"PXI<bus>::<device>::<function>::INSTR"`, but based on the previous explanation, this can be difficult to determine.

A better way to determine the resource string is to query the system with `viFindRsrc()` and use or display the resource(s) returned from that operation. Each PCI device has a vendor code and a model code; this is much the same as VXI does, although the vendor ID's are different. You can create a query to search for devices of a particular attribute value; in this case, you can search for a specific vendor ID and model code. For example, the PCI vendor ID for National Instruments is 0x1093. If NI made a device with the model code 0xBEEF, you could call `viFindRsrc()` with the expression `"PXI?*INSTR{VI_ATTR_MANF_ID==0x1093 && VI_ATTR_MODEL_CODE==0xBEEF}"`. In many cases the returned list has one or only a few devices.

User Level Functionality

An INSTR session to a PCI or PXI device provides the same register level programming functionality as in VXI. NI-VISA supports both high-level and low-level accesses, as discussed in Chapter 6, *Register-Based Communication*. The valid address spaces for a PXI device are the configuration registers (`VI_PXI_CFG_SPACE`) and the 6 Base Address

Registers (VI_PXI_BAR0_SPACE - VI_PXI_BAR5_SPACE). A device may support any or all of the BAR's. This information is device dependent but can be queried through the attributes VI_ATTR_PXI_MEM_TYPE_BAR0 - VI_ATTR_PXI_MEM_TYPE_BAR5. The values for this attribute are none (0), memory mapped (1), or I/O (2). If the value is memory mapped or I/O, you can also query the appropriate attributes for the base and size of each supported region.

In addition to register accesses, NI-VISA supports the event VI_EVENT_PXI_INTR to provide notification to an application that the specified device has generated a PCI interrupt. This event allows a user to write an entire device driver or instrument driver at the user level, without having to write any kernel code.

Configuring NI-VISA to Recognize a PXI Device

Each PCI device must have a kernel level driver associated with it; this is done in Windows via an .inf file. For NI-VISA to recognize your device, you must run the PXI Driver Development Wizard, available via the **Start** menu under **National Instruments»VISA**.

The wizard first prompts you for basic information NI-VISA needs to properly locate your PXI instrument. This includes the following:

- **Instrument Prefix**—The VXI*plug&play* or IVI instrument driver prefix for the device.
- **PXI Manufacturer ID**—This 16-bit value is vendor specific and is unique among PCI-based device providers. The vendor ID number for National Instruments, for example, is 0x1093.
- **PXI Model Code**—The 16-bit device ID value is device specific, defined by the instrument provider, and required for PCI-based devices.
- **Generates interrupts**—Checking this box indicates that you want to use the VISA event-handling model in response to hardware interrupts your PXI instrument generates.

In text boxes where numerical information is required, preceding the number with 0x designates a hexadecimal value. The wizard assumes all other numeric entries are decimal values.

If you need to handle hardware interrupts, check **Generates interrupts** and the wizard guides you through a two-step process. In Step 1, you specify how your device detects a pending interrupt. This is done via one or more register accesses, where each access is a single register read or write of a

specified width to a given offset relative to a given address space. In the wizard, you specify each access as a Read, Write, or Compare.

The Compare operation is essential for determining whether a PCI/PXI device is interrupting. A Compare operation performs a Read, then applies a user-specified mask to the result and compares the masked result with another user-specified value (you specify both of these values in the wizard). In order to determine whether your device is interrupting, the Compare operation has an associated result of True or False. NI-VISA decides that the device is interrupting if and only if the result of all Compare operations is True. Because NI-VISA relies on the result of the Compare operation in making this determination, at least one Compare operation must be present in an interrupt detection sequence for the sequence to be valid.

In addition to the interrupt detection sequence, NI-VISA also needs the sequence of register operations required to acknowledge an interrupt condition for your device; this is Step 2. At interrupt time, if NI-VISA determines that your device is interrupting (as discussed above), this second sequence should do whatever is necessary to squelch the interrupt condition. This sequence is constructed using the same Read, Write, and Compare operations discussed in Step 1, and individual operations are entered in an identical manner. Because this sequence should consist of the minimum operations necessary to turn off an interrupt condition for your device, the result of any Compare operations, while still valid, are irrelevant to interrupt acknowledgment. If your device uses ROAK (Release on Interrupt Acknowledge) interrupts, and the ROAK register was accessed in the sequence specified by Step 1, this sequence can be left blank.

The wizard will also allow you to enter certain Windows Device Manager settings; these are cosmetic and do not affect the ability of NI-VISA to recognize and control your PXI instrument. They are provided as a convenience, allowing you to more fully customize your instrument driver package.

When you are done, the PXI Driver Development Wizard generates a Windows Setup Information (`.inf`) file for each supported operating system. Before a PXI device will be visible to NI-VISA, you must use the `.inf` files to update the Windows system registry. The procedure for using an `.inf` file to update the registry is Windows-version dependent. To manually install an `.inf` file on any machine, including the one on which it was generated, open the appropriate `.inf` file in a text editor and follow the instructions on the first few lines at the top.

Using CVI to Install Your Device .inf Files

To support your PXI application on a target machine, you must include the generated `.inf` files in your PXI application's installer. National Instruments LabWindows/CVI is a convenient development environment for creating an installer package to redistribute VXI*plug&play* or IVI instrument drivers. CVI can also generate a Win32 installation package for your PXI instrument driver using the **Build»Create Distribution Kit** option.

The Create Distribution Kit menu lists several options for customizing an instrument driver installation. For VISA-based PXI instrument drivers, follow these steps to create the distribution:

1. Generate the `.inf` files for your instrument using the PXI Driver Development Wizard, as discussed above. The files will be named <*prefix*><*os*>, where *os* is one of the following: _9x (Windows 95/98/ME), _nt4 (Windows NT 4), _nt5 (Windows 2000/XP), and _rt (LabVIEW Real-Time). Maintaining these exact file names is important when using CVI to generate a distribution kit.
2. From the CVI Create Distribution Kit dialog, choose Add Group to create a new file group for the PXI `.inf` files. You must name this group "PXI Setup Files".
3. The next dialog box will prompt you for the files to add to the PXI Setup Files group. Add all the `.inf` files generated by the PXI Setup Wizard.
4. Verify that the Group Destination for the PXI Setup Files group is the Application Directory. Also verify that the Relative Path is not enabled (unchecked).
5. Choose Build to create the distribution kit.

LabWindows/CVI will generate a set of installation files (including `setup.exe`) for your driver. You should redistribute all the files it creates (including the `*.msi` and `*.cab`). When this installer is run on a target machine, the installation script handles the extra steps necessary to register the PXI device with NI-VISA.

On all Windows operating systems other than NT 4, it may be necessary to remove the device manually from the Windows Device Manager before rebooting the system. Specifically, if a PXI device is installed before the `.inf` file, Windows will mark the device as "Unknown" and will not properly associate the NI-VISA driver with it.

PXI Summary

NI-VISA provides a convenient means of accessing advanced functionality of PCI and PXI devices. The alternative to using NI-VISA for PCI or PXI device communication is writing a kernel driver. By using NI-VISA, you avoid having to learn how to write kernel drivers, you avoid having to learn a different kernel model for each Windows operating system, and you gain platform independence and portability by scaling to other operating systems such as LabVIEW RT now and others in the future.

Serial

VISA supports programming Serial devices connected to either an RS-232 or RS-485 controller.

Introduction to Programming Serial Devices in VISA

Serial users have traditionally faced difficulties when porting code from one platform to another. Each operating system has its own Serial API; each application development environment has its own Serial API; and all of these usually differ. The VISA Serial API is consistent across all supported platforms and all supported ADEs.

The first thing to point out is how to open a given Serial port. The format of the resource string that you pass to `viOpen()` is "`ASRL<port>::INSTR`". The actual binding of a given resource string to a physical port is platform dependent. Refer to the documentation and example in Chapter 10, *NI-VISA Platform-Specific and Portability Issues*. However, `ASRL1::INSTR` and `ASRL2::INSTR` are typically reserved for the native Serial ports (COM1 and COM2) on the local PC, if they exist.

Default vs. Configured Communication Settings

When you open a Serial port, the VISA specification defines the default communication settings to be 9600 baud, 8 data bits, 1 stop bit, no parity, and no flow control. If you have configured the settings to a different value in the NI-VISA configuration utility (MAX on Windows, `visaconf` on UNIX), then you must pass the value `VI_LOAD_CONFIG` (4) as the `AccessMode` parameter to `viOpen()`. This parameter will cause the configured settings to be used; otherwise, if the `AccessMode` is 0 or VI_NULL, the default settings will be used.

Most Serial devices allow you to set the communication settings parameters via either DIP switches or via front panel selectors. If you are not using the

NI-VISA configuration as discussed above, be sure to use `viSetAttribute()` to make these attribute values consistent with your device settings:

- `VI_ATTR_ASRL_BAUD` sets the baud rate. Defaults to 9600. The range depends on the serial port's capabilities and is platform dependent. For example, most but not all systems support 115200 baud.
- `VI_ATTR_ASRL_DATA_BITS` sets the number of data bits. Defaults to 8. The range is from 5–8.
- `VI_ATTR_ASRL_PARITY` sets the parity. Defaults to `VI_ASRL_PAR_NONE (0)`. You can also choose odd, even, mark, or space.
- `VI_ATTR_ASRL_STOP_BITS` sets the number of stop bits. Defaults to `VI_ASRL_STOP_ONE (10)`. Other valid values are `VI_ASRL_STOP_ONE5 (15)` and `VI_ASRL_STOP_TWO (20)`. Note that 1.5 stop bits is not supported on all systems and is also not supported in all combinations with other settings.
- `VI_ATTR_ASRL_FLOW_CNTRL` sets the method for limiting overflow on transfers between the devices. Defaults to `VI_ASRL_FLOW_NONE` (no flow control). You can also choose between XON/XOFF software flow control, RTS/CTS hardware flow control, and on supported systems, DTR/DSR hardware flow control.

Other common (but not all) ASRL INSTR attributes are as follows:

- `VI_ATTR_ASRL_END_IN` defines the method of terminating reads. Defaults to `VI_ASRL_END_TERMCHAR`. This means that the read operation will stop whenever the character specified by `VI_ATTR_TERMCHAR` is encountered, regardless of the state of `VI_ATTR_TERMCHAR_EN`. To perform binary transfers (and to prevent VISA from stopping reads on the termination character) set this attribute to `VI_ASRL_END_NONE`.
- `VI_ATTR_ASRL_END_OUT` defines the method of terminating writes. Defaults to `VI_ASRL_END_NONE`. (This value means that the setting of `VI_ATTR_SEND_EN` is irrelevant.) To have VISA automatically append a termination character to each write operation, set this attribute to `VI_ASRL_END_TERMCHAR`. To have VISA automatically send a break condition after each write operation, set this attribute to `VI_ASRL_END_BREAK`.
- If the serial port is RS-485, then you can query and manipulate the attribute `VI_ATTR_ASRL_WIRE_MODE`, which designates the RS-485 wiring mode. This attribute can have the values `VI_ASRL_WIRE4` (0, uses 4-wire mode), `VI_ASRL_WIRE2_DTR_ECHO` (1, uses 2-wire DTR

mode controlled with echo), VI_ASRL_WIRE2_DTR_CTRL (2, uses 2-wire DTR mode controlled without echo), and VI_ASRL_WIRE2_AUTO (3, uses 2-wire auto mode controlled with TXRDY). This attribute is not supported for RS-232 ports. It is valid only on the platforms on which National Instruments supports RS-485 products.

For lower-level functionality, you can also query the state of each modem line via viGetAttribute(). VISA will return whether the given line state is asserted (1), unasserted (0), or unknown (–1).

Controlling the Serial I/O Buffers

The viFlush() and viSetBuf() operations also provide a control mechanism for the low-level serial driver buffers. The default size of these buffers is 0, which guarantees that all I/O is flushed on every access. To improve performance, you can alter the size of the output or input serial buffers by invoking the viSetBuf() operation with the VI_ASRL_OUT_BUF or VI_ASRL_IN_BUF flag, respectively. When the buffer size is non-zero, I/O to serial devices is not automatically flushed. You can force the output serial buffer to be flushed by invoking the viFlush() operation with VI_ASRL_OUT_BUF. Alternatively, you can call viFlush() with VI_ASRL_OUT_BUF_DISCARD to empty the output serial buffer without sending any remaining data to the device. You can also call viFlush() with either VI_ASRL_IN_BUF or VI_ASRL_IN_BUF_DISCARD to empty the input serial buffer (both flags have the same effect and are provided only for API consistency).

Note Not all VISA implementations may support setting the size of either the serial input or output buffers. In such an implementation, the viSetBuf() operation will return a warning. While this should not affect most programs, you can at least detect this lack of support if a specific buffer size is required for performance reasons. If serial buffer control is not supported in a given implementation, we recommend that you use some form of handshaking (controlled via the VI_ATTR_ASRL_FLOW_CNTRL attribute), if possible, to avoid loss of data.

When using formatted I/O in conjunction with serial devices, calling viFlush() on a formatted I/O buffer has the same effect on the corresponding serial buffer. For example, invoking viFlush() with VI_WRITE_BUF flushes the formatted I/O output buffer first, and then the low-level serial output buffer. Similarly, VI_WRITE_BUF_DISCARD empties the contents of both the formatted I/O and low-level serial output buffers.

National Instruments ENET Serial Controllers

The ENET to RS-232 and ENET to RS-485 products allow you to have the Serial controller box situated at a different location from your workstation. The workstation communicates over TCP/IP to the Serial controller box, which in turn communicates to the devices connected over the Serial bus. On most Windows operating systems, you can map each port on the controller box to a local port on the workstation, such as COM5.

NI-VISA currently natively supports communicating with these Serial controller boxes on Linux *x*86, Solaris 2.*x*, and Windows. Since you cannot map the remote Serial ports to local Serial ports on the UNIX workstations, you must specify the controller's hostname and the remote Serial port number directly in the resource string. This is also valid on Windows but is unnecessary if you have created a local Serial port mapping. The resource string for these products is "`ASRL::<hostname>::<remote Serial port number>::INSTR`". The hostname can be represented as either an IP address (dot-notation) or network machine name.

The communication settings discussion above applies to the ENET Serial controllers as well.

Serial Summary

VISA provides a consistent API across a broad range of Serial port controllers on all supported platforms. As operating systems continue to evolve and other new Serial APIs inevitably emerge, VISA will insulate you against unnecessary changes to your code.

Ethernet

VISA supports programming Ethernet devices over TCP/IP using either raw socket connections or the LAN instrumentation protocol (also known as VXI-11).

Introduction to Programming Ethernet Devices in VISA

For users writing new code to communicate with an Ethernet instrument, the most important consideration in choosing the right API is which protocol(s) the device supports. The LAN instrument protocol was designed to mimic the message-based IEEE-488 style of programming with which instrumentation users have become accustomed; VISA is the best API to program devices using this protocol. For other devices, if the vendor merely documents the TCP/IP port number and the proprietary raw

packet format, VISA or any sockets API may be the best solution. Finally, some devices use other common well-defined protocols over either TCP/IP or UDP or some other layer; in these cases, an existing standard implementation of that protocol may be more appropriate than VISA.

For the LAN instrument protocol, the simplest resource string is "TCPIP::<hostname>::INSTR". The hostname can be represented as either an IP address (dot-notation) or network machine name. If an Ethernet device supports multiple internal device names or functions, then you can access such a device with "TCPIP::<hostname>::<device name>::INSTR". Recall that the "INSTR" resource class informs VISA that you are doing instrument (device) communication. Programming these LAN instruments is similar to programming GPIB instruments, in that most applications perform simple message-based transfers (write command, read response) and receive service request event notifications. For more information about VISA message-based functionality, see Chapter 5, *Message-Based Communication*.

VISA Sockets vs. Other Sockets APIs

For TCP/IP devices that you want to program directly (in the absence of a higher level protocol implementation), VISA provides a platform independent sockets API. VISA sockets are based on the UNIX sockets implementation in the Berkeley Software Distribution. A socket is a bi-directional communication endpoint; an object through which a VISA sockets application sends or receives packets of data across a network.

The VISA socket resource string format is "TCPIP::<hostname>::<port>::SOCKET". The "SOCKET" resource class informs VISA that you are communicating with an Ethernet device that does not support the LAN instrument protocol. By default, only the read and write operations are valid. If the device recognizes 488.2 commands such as "*TRG\n" and "*STB?\n", you can set the attribute VI_ATTR_IO_PROT to VI_PROT_4882_STRS (4) and then use the operations such as viAssertTrigger() and viReadSTB(). However, unlike LAN instruments, there is no way to support the service request event with the SOCKET resource class.

For users familiar with other platform independent sockets APIs, VISA does have some advantages. The VISA sockets API is simpler than the UNIX sockets API because viOpen() includes the functionality of socket(), bind(), and connect(). It is simpler and more portable than the Windows sockets API because it removes the need for calls to WSAStartup() and WSACleanup(). VISA uses platform independent VISA callbacks for asynchronous reads and writes so you don't need the

platform specific knowledge of threading models and asynchronous completion services that other sockets APIs require. Finally, VISA is more powerful than that of many application development environments because it provides additional attributes for modifying the TCP/IP communication parameters.

The attribute `VI_ATTR_TCPIP_KEEPALIVE` defaults to false, but if enabled will use "keep-alive" packets to ensure that the connection has not been lost. The attribute `VI_ATTR_TCPIP_NODELAY` defaults to true, which enforces that VISA write operations get flushed immediately; this ensures consistency with other supported VISA interfaces. The default setting disables the Nagle algorithm, which typically improves network performance by buffering *send* data until a full-size packet can be sent. Disabling this attribute (setting it to false) may improve the performance of multiple back-to-back VISA write operations to a TCP/IP device.

Ethernet Summary

VISA provides a cross-platform API for programming Ethernet instruments. Other APIs provide the same Ethernet functionality and implement additional protocols, so if you are familiar with them, then there is not a strong reason for you to change to VISA. However, if you have instruments with more than one type of port or connection available to them (such as TCP/IP and GPIB on the same instrument), or are using multiple types of instruments with different hardware interface types, then using VISA may be advantageous because you can use the same interface independent API regardless of the connection medium. The only code that changes is the resource string.

Remote NI-VISA

NI-VISA allows you to programmatically access resources on a remote workstation. NI-DAQ users should find this similar to Remote DAQ.

Introduction to Programming Remote Devices in NI-VISA

Many users have devices that they need to use in multiple situations, such as a group of scientists sharing an instrument in the laboratory. The most common way this is done is for each user to physically carry the device next to his PC, connect the device, and then use it. NI-VISA for Windows and Linux *x*86 now supports a more efficient way to do this. With remote NI-VISA on these supported platforms, you can leave the device connected to a single workstation and access it from multiple client workstations.

Remote NI-VISA is not a separate hardware interface type, but it is included in this chapter for completeness.

How to Configure and Use Remote NI-VISA

On the server machine (the one to which the hardware is connected), you must install Remote NI-VISA Server. This installation option may not exist in all NI-VISA distributions. By default, the server is disabled and access from any other computer is disallowed. Use the NI-VISA configuration utility (MAX on Windows, `visaconf` on UNIX) and make sure the server is enabled. You must also specify each address or address range of the computer(s) you wish to allow access. An address can be either in dot notation (x.x.x.x) or the network machine name; an address range can only be in dot notation (x.x.x.*).

On the client machine, no configuration is necessary. The VISA resource string contains the server machine name and the original VISA resource string on the server: "`visa://hostname/VISA resource string`". The hostname can be represented as either an IP address (dot-notation) or network machine name.

If you want to search for all resources on a specific server, you can pass "`visa://hostname/?*`" to `viFindRsrc()`. On Windows, you can use the “Remote Servers” section of MAX to configure NI-VISA to access certain servers by default. In this case, using "`?*`" will cause `viFindRsrc()` to query all configured servers as well as the local machine. If you want to limit the query to the local machine only, regardless of whether it has been configured to access any remote servers, pass "`/?*`" as the expression to `viFindRsrc()`.

Remote NI-VISA supports the complete functionality of all attributes, events, and operations for all supported hardware interface types.

Remote NI-VISA Summary

Using remote NI-VISA is just one way to access hardware on another machine. If you have an existing application written using VISA and you need to use it from a different client, this may be the easiest solution. However, since each VISA operation invocation is a remote procedure call, your application performance may decrease, especially if it is register-intensive or has a significant amount of programming logic based on device responses or register values. The latency over Ethernet is better suited to applications that transfer large blocks of data. A better way to remotely access hardware is to make remote calls at a higher level, such as using Remote VI Server in LabVIEW.

10

NI-VISA Platform-Specific and Portability Issues

This chapter discusses programming information for you to consider when developing applications that use the NI-VISA driver.

After installing the driver software, you can begin to develop your VISA application software. Remember that the NI-VISA driver relies on NI-488.2 and NI-VXI for driver-level I/O accesses.

- **Windows users**—On VXI and MXI systems, use the Measurement & Automation Explorer (MAX) to run the VXI Resource Manager (`resman`), configure your hardware, and assign VME and GPIB-VXI addresses. For GPIB systems, use MAX to configure your GPIB controllers. To control instruments through Serial ports, you can use MAX to change the default settings, or you can perform all the necessary configuration at run time by setting VISA attributes.

- **All other platforms**—On VXI and MXI systems, you must still run the VXI Resource Manager (`resman`), and use the VXI Resource Editor (`vxiedit` or `vxitedit`) for configuration purposes. For GPIB and GPIB-VXI systems, you still use the GPIB Control Panel applet (Macintosh) or ibconf (UNIX) to configure your system. To control instruments through Serial ports, you can do all necessary configuration at run-time by setting VISA attributes. On UNIX, you can also use the VISA Configuration Utility (`visaconf`) to configure VISA aliases and change the default Serial settings.

  The NI-VISA Programmer Reference Manual contains detailed descriptions of the VISA attributes, events, and operations. Windows and Solaris users can access this same information online through `NI-visa.hlp`, which you can find in the `NIvisa` directory.

Programming Considerations

This section contains information for you to consider when developing applications that use the NI-VISA I/O interface software.

NI Spy: Debugging Tool for Windows

NI Spy tracks the calls your application makes to National Instruments test and measurement (T&M) drivers, including NI-VXI, NI-VISA, and NI-488.2.

NI Spy highlights functions that return errors, so you can quickly determine which functions failed during your development. NI Spy can also log your program's calls to these drivers into a file so you can check them for errors at your convenience.

Multiple Applications Using the NI-VISA Driver

Multiple-application support is an important feature in all implementations of the NI-VISA driver. You can have several applications that use NI-VISA running simultaneously. You can even have multiple instances of the same application that uses the NI-VISA driver running simultaneously, if your application is designed for this. The NI-VISA operations perform in the same manner whether you have only one application or several applications (or several instances of an application) all trying to use the NI-VISA driver.

However, you need to be careful when you have multiple applications or sessions using the low-level bus access functions. The memory windows used to access the bus are a limited resource. Call the `viMapAddress()` operation before attempting to perform low-level bus access with `viPeek`*`XX`*`()` or `viPoke`*`XX`*`()`. Immediately after the accesses are completed, always call the `viUnmapAddress()` operation so that you free up the memory window for other applications.

Low-Level Access Functions

The `viMapAddress()` operation returns a pointer for use with low-level access functions. On some systems, such as the VXIpc embedded computers, it is possible to directly dereference this pointer. However, on other systems such as the GPIB-VXI, you *must* use the `viPeek`*`XX`*`()` and `viPoke`*`XX`*`()` operations. To make your source code portable between these and other platforms, and even other implementations of VISA, check the attribute `VI_ATTR_WIN_ACCESS` after calling `viMapAddress()`. If the value of that attribute is `VI_DEREF_ADDR`, you can safely dereference

the address pointer directly. Otherwise, use the `viPeek`*`XX`*`()` and `viPoke`*`XX`*`()` operations to perform register I/O accesses.

National Instruments also provides macros for `viPeek`*`XX`*`()` and `viPoke`*`XX`*`()` on certain platforms. The C language macros automatically dereference the pointer whenever possible without calling the driver, which can substantially improve performance. Although the macros can increase performance only on NI-VISA, your application will be binary compatible with other implementations of VISA (the macros will just call the `viPeek`*`XX`*`()` and `viPoke`*`XX`*`()` operations). However, the macros are not enabled by default. To use the macros, you must define the symbol `NIVISA_PEEKPOKE` before including `visa.h`.

Interrupt Callback Handlers

Application callbacks are available in C/C++ but not in LabVIEW or Visual Basic. Callbacks in C are registered with the `viInstallHandler()` operation and must be declared with the following signature:

```
ViStatus _VI_FUNCH appHandler (ViSession vi, ViEventType
    eventType, ViEvent event, ViAddr userHandle)
```

Notice that the `_VI_FUNCH` modifier expands to `_stdcall` for Windows (32-bit). This is the standard Windows callback definition. On other systems, such as UNIX and Macintosh, VISA defines `_VI_FUNCH` to be nothing (null). Using `_VI_FUNCH` for handlers makes your source code portable to systems that need other modifiers (or none at all).

When using National Instruments Measurement Studio for Visual C++, callbacks are registered with the `InstallEventHandler()` method. See the Measurement Studio for Visual C++ documentation for more information on VISA callbacks. Handlers for this product must be declared with the following signature:

```
ViStatus __cdecl EventHandler (CNiVisaEvent& event)
```

After you install an interrupt handler and enable the appropriate event(s), an event occurrence causes VISA to invoke the callback. When VISA invokes an application callback, it does so in the correct application context. From within any handler, you can call back into the NI-VISA driver. On all platforms other than Macintosh, you can also make system calls. The way VISA invokes callbacks is platform dependent, as shown in Table 10-1.

Table 10-1. How VISA Invokes Callbacks

Platform	Callback Invocation Method
Windows 2000/NT/XP/Me/9*x*	The callback is performed in a separate thread created by NI-VISA. The thread is signaled as soon as the event occurs.
Mac OS 8/9 VxWorks *x*86	For VXI, the callback is performed from within the driver interrupt service routine. For all other interfaces, the callback is performed only when the driver is accessed.
Solaris 2.*x*	For VXI with the PCI-MXI-2, the callback is performed in a separate thread. For all other interfaces, the callback is performed via a UNIX signal.
Linux *x*86	The callback is performed via a UNIX signal.

What this means is that on Macintosh (all interfaces other than VXI) you cannot wait in a tight loop for a callback to occur. For example, the following code does not work:

```
while (!intr_recv)
    ; /* do nothing */
```

For callbacks to be invoked on the Macintosh platform, you must call any VISA operation or give up processor time. Notice that NI-VISA on Windows and all UNIX platforms does not require you to call VISA operations or give up processor time to receive callbacks. However, because occasionally calling VISA operations ensures that callbacks will be invoked correctly on any platform, you should keep these issues in mind when writing code that you want to be portable.

Multiple Interface Support Issues

This section contains information about how to use or configure your NI-VISA software for certain types of interfaces.

VXI and GPIB Platforms

NI-VISA supports all existing National Instruments GPIB, VXI, and Serial controllers for the operating systems on which NI-VISA exists. For VXI, this includes, but is not limited to, MXI-1, MXI-2, VXI-834x, VXI-1394,

GPIB-VXI, and the line of embedded VXIpc computers. For GPIB, this includes, but is not limited to, PCI-GPIB, GPIB-USB-A, AT-GPIB/TNT, PCMCIA-GPIB, and the GPIB-ENET and GPIB-ENET/100 boxes, which you can use to remotely control GPIB devices. With the GPIB-ENET and GPIB-ENET/100 boxes, you can even remotely control VXI devices when using a GPIB-VXI controller.

Serial Port Support

The maximum number of serial ports that NI-VISA currently supports on any platform is 256. The default numbering of serial ports is system dependent, as shown in Table 10-2.

Table 10-2. How Serial Ports Are Numbered

Platform	Method
Windows 2000/NT/XP/Me/9*x*	ASRL1-ASRL4 access COM1-COM4. ASRL10 accesses LPT1. Other COM ports are automatically detected when you call viFindRsrc(). The VISA interface number may not equal the COM port number.
LabVIEW RT	ASRL1-ASRL4 access COM1-COM4. Other COM ports are automatically detected when you call viFindRsrc().
Mac OS 8/9	ASRL1 accesses the modem port. ASRL2 accesses the printer port. Other COM ports are automatically detected when you call viFindRsrc().
Solaris 2.*x*	ASRL1-ASRL6 access /dev/cua/a – /dev/cua/f.
Linux *x*86	ASRL1-ASRL4 access /dev/ttyS0 – /dev/ttyS3.
VxWorks *x*86	ASRL1-ASRL2 access /tyCo/0 – /tyCo/1.

If you need to know programmatically which ASRL INSTR resource maps to which underlying Serial port, the following code will retrieve and display that information.

Example 10-1

```
#include "visa.h"
int main(void)
{
       ViStatus status; /* For checking errors */
       ViSession defaultRM; /* Communication channels */
       ViSession instr; /* Communication channel */
       ViChar rsrcName[VI_FIND_BUFLEN]; /* Serial resource name */
       ViChar intfDesc[VI_FIND_BUFLEN]; /* Port binding description */
       ViUInt32 retCount; /* To hold number of resources */
       ViFindList flist; /* To hold list of resources */

       /* Begin by initializing the system */
       status = viOpenDefaultRM(&defaultRM);
       if (status < VI_SUCCESS) {
          /* Error Initializing VISA...exiting */
          return -1;
       }

       status = viFindRsrc (defaultRM, "ASRL?*INSTR", &flist, &retCount,
          rsrcName);
       while (retCount--) {
          status = viOpen (defaultRM, rsrcName, VI_NULL, VI_NULL, &instr);
          if (status < VI_SUCCESS)
             printf ("Could not open %s, status = 0x%08lX\n",rsrcName,
                status);
          else
             {
             status = viGetAttribute (instr, VI_ATTR_INTF_INST_NAME,
                intfDesc);
             printf ("Resource %s, Description %s\n", rsrcName, intfDesc);
             status = viClose (instr);
             }
          status = viFindNext (flist, rsrcName);
       }
       viClose (flist);
       viClose (defaultRM);
       return 0;
}
```

VME Support

To access VME devices in your system, you must configure NI-VXI to see these devices. Windows users can configure NI-VXI by using the **Create New Wizard** in MAX. Users on other platforms must use the **Non-VXI Device Editor** in VXI Resource Editor (vxiedit or vxitedit). For each address space in which your device has memory, you must create a separate pseudo-device entry with a logical address between 256 and 511. For example, a VME device with memory in both A24 and A32 spaces requires two entries. You can also specify which interrupt levels the device uses. VXI and VME devices cannot share interrupt levels. You can then access the device from NI-VISA just as you would a VXI device, by specifying the address space and the offset from the base at which you have configured it. NI-VISA support for VME devices includes the register access operations (both high-level and low-level) and the block-move operations, as well as the ability to receive interrupts.

A

Visual Basic Examples

This appendix shows the Visual Basic syntax of the ANSI C examples given earlier in this manual. The examples use the same numbering sequence for easy reference.

These examples use the VISA data types where applicable. This feature is available only on Windows. To use this feature, select the VISA library (`visa32.dll`) as a reference from Visual Basic. This makes use of the type library embedded into the DLL.

Example 2-1

```
Private Sub vbMain()
    Const MAX_CNT = 200

    Dim stat     As ViStatus
    Dim dfltRM   As ViSession
    Dim sesn     As ViSession
    Dim retCount As Long
    Dim buffer   As String * MAX_CNT

    Rem Begin by initializing the system
    stat = viOpenDefaultRM(dfltRM)
    If (stat < VI_SUCCESS) Then
        Rem Error initializing VISA...exiting
        Exit Sub
    End If

    Rem Open communication with GPIB Device at Primary Addr 1
    Rem NOTE: For simplicity, we will not show error checking
    stat = viOpen(dfltRM, "GPIB0::1::INSTR", VI_NULL, VI_NULL, sesn)

    Rem Set the timeout for message-based communication
    stat = viSetAttribute(sesn, VI_ATTR_TMO_VALUE, 5000)

    Rem Ask the device for identification
    stat = viWrite(sesn, "*IDN?", 5, retCount)
    stat = viRead(sesn, buffer, MAX_CNT, retCount)

    Rem Your code should process the data

    Rem Close down the system
    stat = viClose (sesn)
```

```
    stat = viClose (dfltRM)
End Sub
```

Example 2-2

```
Private Sub vbMain()
    Dim stat     As ViStatus
    Dim dfltRM   As ViSession
    Dim sesn     As ViSession
    Dim deviceID As Integer

    Rem Begin by initializing the system
    stat = viOpenDefaultRM(dfltRM)
    If (stat < VI_SUCCESS) Then
        Rem Error initializing VISA...exiting
        Exit Sub
    End If

    Rem Open communication with VXI Device at Logical Addr 16
    Rem NOTE: For simplicity, we will not show error checking
    stat = viOpen(dfltRM, "VXI0::16::INSTR", VI_NULL, VI_NULL, sesn)

    Rem Read the Device ID and write to memory in A24 space
    stat = viIn16(sesn, VI_A16_SPACE, 0, deviceID)
    stat = viOut16(sesn, VI_A24_SPACE, 0, &H1234)

    Rem Close down the system
    stat = viClose(sesn)
    stat = viClose(dfltRM)
End Sub
```

Example 2-3

```
Private Sub vbMain()
    Dim stat   As ViStatus
    Dim dfltRM As ViSession
    Dim sesn   As ViSession
    Dim eType  As ViEventType
    Dim eData  As ViEvent
    Dim statID As Integer

    Rem Begin by initializing the system
    stat = viOpenDefaultRM(dfltRM)
    If (stat < VI_SUCCESS) Then
        Rem Error initializing VISA...exiting
        Exit Sub
    End If
```

```
    Rem Open communication with VXI Device at Logical Address 16
    Rem NOTE: For simplicity, we will not show error checking
    stat = viOpen(dfltRM, "VXI0::16::INSTR", VI_NULL, VI_NULL, sesn)

    Rem Enable the driver to detect the interrupts
    stat = viEnableEvent(sesn, VI_EVENT_VXI_SIGP, VI_QUEUE, VI_NULL)

    Rem Send the commands to the oscilloscope to capture the
    Rem waveform and interrupt when done

    stat = viWaitOnEvent(sesn, VI_EVENT_VXI_SIGP, 5000, eType, eData)
    If (stat < VI_SUCCESS) Then
        Rem No interrupts received after 5000 ms timeout
        stat = viClose (dfltRM)
        Exit Sub
    End If

    Rem Obtain the information about the event and then destroy the
    Rem event. In this case, we want the status ID from the interrupt.
    stat = viGetAttribute(eData, VI_ATTR_SIGP_STATUS_ID, statID)
    stat = viClose(eData)

    Rem Your code should read data from the instrument and process it.


    Rem Stop listening to events
    stat = viDisableEvent(sesn, VI_EVENT_VXI_SIGP, VI_QUEUE)

    Rem Close down the system
    stat = viClose(sesn)
    stat = viClose(dfltRM)
End Sub
```

Example 2-4

```
Private Sub vbMain()
    Const MAX_CNT = 200

    Dim stat     As ViStatus
    Dim dfltRM   As ViSession
    Dim sesn     As ViSession
    Dim retCount As Long
    Dim buffer   As String * MAX_CNT

    Rem Begin by initializing the system
    stat = viOpenDefaultRM(dfltRM)
    If (stat < VI_SUCCESS) Then
        Rem Error initializing VISA...exiting
        Exit Sub
    End If
```

```
    Rem Open communication with Serial Port 1
    Rem NOTE: For simplicity, we will not show error checking
    stat = viOpen(dfltRM, "ASRL1::INSTR", VI_NULL, VI_NULL, sesn)

    Rem Set the timeout for message-based communication
    stat = viSetAttribute(sesn, VI_ATTR_TMO_VALUE, 5000)

    Rem Lock the serial port so that nothing else can use it
    stat = viLock(sesn, VI_EXCLUSIVE_LOCK, 5000, "", "")

    Rem Set serial port settings as needed
    Rem Defaults = 9600 Baud, no parity, 8 data bits, 1 stop bit
    stat = viSetAttribute(sesn, VI_ATTR_ASRL_BAUD, 2400)
    stat = viSetAttribute(sesn, VI_ATTR_ASRL_DATA_BITS, 7)

    Rem Ask the device for identification
    stat = viWrite(sesn, "*IDN?", 5, retCount)
    stat = viRead(sesn, buffer, MAX_CNT, retCount)

    Rem Unlock the serial port before ending the program
    stat = viUnlock(sesn)

    Rem Your code should process the data

    Rem Close down the system
    stat = viClose(sesn)
    stat = viClose(dfltRM)
End Sub
```

Example 4-1

```
Private Sub vbMain()
    Dim stat   As ViStatus
    Dim dfltRM As ViSession
    Dim sesn   As ViSession

    Rem Open Default RM
    stat = viOpenDefaultRM(dfltRM)
    If (stat < VI_SUCCESS) Then
        Rem Error initializing VISA...exiting
        Exit Sub
    End If

    Rem Access other resources
    stat = viOpen(dfltRM, "GPIB::1::INSTR", VI_NULL, VI_NULL, sesn)

    Rem Use device and eventually close it.
    stat = viClose (sesn)
    stat = viClose (dfltRM)
End Sub
```

Example 4-2

```
Rem Find the first matching device and return a session to it
Private Function AutoConnect(instrSesn As ViSession) As ViStatus
    Const MANF_ID    = &HFF6 '12-bit VXI manufacturer ID of a device
    Const MODEL_CODE = &H0FE '12-bit or 16-bit model code of a device

    Dim stat    As ViStatus
    Dim dfltRM  As ViSession
    Dim sesn    As ViSession
    Dim fList   As ViFindList
    Dim desc    As String * VI_FIND_BUFLEN
    Dim nList   As Long
    Dim iManf   As Integer
    Dim iModel  As Integer

    stat = viOpenDefaultRM(dfltRM)
    If (stat < VI_SUCCESS) Then
        Rem Error initializing VISA ... exiting
        AutoConnect = stat
        Exit Function
    End If

    Rem Find all VXI instruments in the system
    stat = viFindRsrc(dfltRM, "?*VXI?*INSTR", fList, nList, desc)
    If (stat < VI_SUCCESS) Then
        Rem Error finding resources ... exiting
        viClose (dfltRM)
        AutoConnect = stat
        Exit Function
    End If

    Rem Open a session to each and determine if it matches
    While (nList)
        stat = viOpen(dfltRM, desc, VI_NULL, VI_NULL, sesn)
        If (stat >= VI_SUCCESS) Then
            stat = viGetAttribute(sesn, VI_ATTR_MANF_ID, iManf)
            If ((stat >= VI_SUCCESS) And (iManf = MANF_ID)) Then
                stat = viGetAttribute(sesn, VI_ATTR_MODEL_CODE, iModel)
                If ((stat >= VI_SUCCESS) And (iModel = MODEL_CODE)) Then
                    Rem We have a match, return session without closing
                    instrSesn = sesn
                    stat = viClose (fList)
                    Rem Do not close dfltRM; that would close sesn too
                    AutoConnect = VI_SUCCESS
                    Exit Function
                End If
```

```
            End If
            stat = viClose (sesn)
        End If
        stat = viFindNext(fList, desc)
        nList = nList - 1
    Wend

    Rem No match was found, return an error
    stat = viClose (fList)
    stat = viClose (dfltRM)
    AutoConnect = VI_ERROR_RSRC_NFOUND
End Function
```

Example 4-3

Example 4-3 uses functionality not available in Visual Basic. Refer to Example 4-2 for sample code using `viFindRsrc()`.

Example 5-1

```
Private Sub vbMain()
    Dim stat         As ViStatus
    Dim dfltRM       As ViSession
    Dim sesn         As ViSession
    Dim retCount     As Long
    Dim idnResult    As String * 72
    Dim resultBuffer As String * 256

    Rem Open Default Resource Manager
    stat = viOpenDefaultRM(dfltRM)
    If (stat < VI_SUCCESS) Then
        Rem Error initializing VISA...exiting
        Exit Sub
    End If

    Rem Open communication with GPIB Device at Primary Addr 1
    Rem NOTE: For simplicity, we will not show error checking
    stat = viOpen(dfltRM, "GPIB::1::INSTR", VI_NULL, VI_NULL, sesn)

    Rem Initialize the timeout attribute to 10 s
    stat = viSetAttribute(sesn, VI_ATTR_TMO_VALUE, 10000)

    Rem Set termination character to carriage return (\r=0x0D)
    stat = viSetAttribute(sesn, VI_ATTR_TERMCHAR, &H0D)
    stat = viSetAttribute(sesn, VI_ATTR_TERMCHAR_EN, VI_TRUE)

    Rem Don't assert END on the last byte
    stat = viSetAttribute(sesn, VI_ATTR_SEND_END_EN, VI_FALSE)
```

```
    Rem Clear the device
    stat = viClear(sesn)

    Rem Request the IEEE 488.2 identification information
    stat = viWrite(sesn, "*IDN?", 5, retCount)
    stat = viRead(sesn, idnResult, 72, retCount)

    Rem Your code should use idnResult and retCount to parse device info

    Rem Trigger the device for an instrument reading
    stat = viAssertTrigger(sesn, VI_TRIG_PROT_DEFAULT)

    Rem Receive results
    stat = viRead(sesn, resultBuffer, 256, retCount)

    Rem Close sessions
    stat = viClose (sesn)
    stat = viClose (dfltRM)
End Sub
```

Example 6-1

```
Private Sub vbMain()
    Dim stat   As ViStatus
    Dim dfltRM As ViSession
    Dim sesn   As ViSession
    Dim addr   As ViAddr
    Dim mSpace As Integer
    Dim Value  As Integer

    Rem Open Default Resource Manager
    stat = viOpenDefaultRM(dfltRM)
    If (stat < VI_SUCCESS) Then
        Rem Error initializing VISA...exiting
        Exit Sub
    End If

    Rem Open communication with VXI Device at Logical Address 16
    Rem NOTE: For simplicity, we will not show error checking
    stat = viOpen(dfltRM, "VXI0::16::INSTR", VI_NULL, VI_NULL, sesn)

    mSpace = VI_A16_SPACE

    stat = viMapAddress(sesn, mSpace, 0, &H40, VI_FALSE, VI_NULL, addr)

    viPeek16 sesn, addr, Value
    Rem Access a different register by manipulating the pointer.
    viPeek16 sesn, addr + 2, Value

    stat = viUnmapAddress(sesn)

    Rem Close down the system
```

```
    stat = viClose(sesn)
    stat = viClose(dfltRM)
End Sub
```

Example 6-2

```
Private Sub vbMain()
    Dim stat   As ViStatus
    Dim dfltRM As ViSession
    Dim self   As ViSession
    Dim addr   As ViAddr
    Dim offs   As Long
    Dim mSpace As Integer
    Dim Value  As Integer

    Rem Begin by initializing the system
    stat = viOpenDefaultRM(dfltRM)
    If (stat < VI_SUCCESS) Then
        Rem Error initializing VISA...exiting
        Exit Sub
    End If

    Rem Open communication with VXI Device at Logical Address 0
    Rem NOTE: For simplicity, we will not show error checking
    stat = viOpen(dfltRM, "VXI0::0::INSTR", VI_NULL, VI_NULL, self)

    Rem Allocate a portion of the device's memory
    stat = viMemAlloc(self, &H100, offs)

    Rem Determine where the shared memory resides
    stat = viGetAttribute(self, VI_ATTR_MEM_SPACE, mSpace)
    stat = viMapAddress(self, mSpace, offs, &H100, VI_FALSE, VI_NULL, addr)
    viPeek16 self, addr, Value
    Rem Access a different register by manipulating the pointer.
    viPeek16 self, addr + 2, Value

    stat = viUnmapAddress(self)
    stat = viMemFree(self, offs)

    Rem Close down the system
    stat = viClose(self)
    stat = viClose(dfltRM)
End Sub
```

Example 7-1

Visual Basic does not support callback handlers, so currently the only way to handle events is through `viWaitOnEvent()`. Because Visual Basic does not support asynchronous operations either, this example uses the `viRead()` call instead of the `viReadAsync()` call.

```
Private Sub vbMain()
    Const MAX_CNT = 1024

    Dim stat         As ViStatus
    Dim dfltRM       As ViSession
    Dim sesn         As ViSession
    Dim bufferHandle As String
    Dim retCount     As Long
    Dim etype        As ViEventType
    Dim event        As ViEvent
    Dim stb          As Integer

    Rem Begin by initializing the system
    Rem NOTE: For simplicity, we will not show error checking
    stat = viOpenDefaultRM(dfltRM)
    If (stat < VI_SUCCESS) Then
        Rem Error initializing VISA...exiting
        Exit Sub
    End If

    Rem Open communication with GPIB device at primary address 2
    stat = viOpen(dfltRM, "GPIB0::2::INSTR", VI_NULL, VI_NULL, sesn)

    Rem Allocate memory for buffer
    Rem In addition, allocate space for the ASCII NULL character
    bufferHandler = Space$(MAX_CNT + 1)

    Rem Enable the driver to detect events
    stat = viEnableEvent(sesn, VI_EVENT_SERVICE_REQ, VI_QUEUE, VI_NULL)

    Rem Tell the device to begin acquiring a waveform
    stat = viWrite(sesn, "E0x51; W1", 9, retCount)

    Rem The device asserts SRQ when the waveform is ready
     stat = viWaitOnEvent(sesn, VI_EVENT_SERVICE_REQ, 20000, etype, event)
    If (stat < VI_SUCCESS) Then
        Rem Waveform not received...exiting
        stat = viClose (dfltRM)
        Exit Sub
End If
    stat = viReadSTB (sesn, stb)

    Rem Read the data
    stat = viRead(sesn, bufferHandle, MAX_CNT, retCount)
```

```
    Rem Your code should process the waveform data

    Rem Close the event context
    stat = viClose (event)

    Rem Stop listening for events
    stat = viDisableEvent(sesn, VI_ALL_ENABLED_EVENTS, VI_ALL_MECH)

    Rem Close down the system
    stat = viClose(sesn)
    stat = viClose(dfltRM)
End Sub
```

Example 8-1

```
Private Sub vbMain()
    Const MAX_COUNT = 128

    Dim stat     As ViStatus                'For checking errors
    Dim dfltRM   As ViSession               'Communication channels
    Dim sesnIN   As ViSession               'Communication channels
    Dim sesnOUT  As ViSession               'Communication channels
    Dim aKey     As String * VI_FIND_BUFLEN 'Access key for lock
    Dim buf      As String * MAX_COUNT      'To store device data
    Dim etype    As ViEventType             'To identify event
    Dim event    As ViEvent                 'To hold event info
    Dim retCount As Long                    'To hold byte count

    Rem Begin by initializing the system
    stat = viOpenDefaultRM(dfltRM)
    If (stat < VI_SUCCESS) Then
        Rem Error initializing VISA...exiting
        Exit Sub
    End If

    Rem Open communications with VXI Device at Logical Addr 16
    stat = viOpen(dfltRM, "VXI0::16::INSTR", VI_NULL, VI_NULL, sesnIN)
    stat = viOpen(dfltRM, "VXI0::16::INSTR", VI_NULL, VI_NULL, sesnOUT)

    Rem We open two sessions to the same device
    Rem One session is used to assert triggers on TTL channel 4
    Rem The second is used to receive triggers on TTL channel 5

    Rem Lock first session as shared, have VISA generate the key
    Rem Then lock the second session with the same access key
    stat = viLock(sesnIN, VI_SHARED_LOCK, 5000, "", aKey)
    stat = viLock(sesnOUT, VI_SHARED_LOCK, VI_TMO_IMMEDIATE, aKey, aKey)

    Rem Set trigger channel for sessions
    stat = viSetAttribute(sesnIN,  VI_ATTR_TRIG_ID, VI_TRIG_TTL5)
```

```
    stat = viSetAttribute(sesnOUT, VI_ATTR_TRIG_ID, VI_TRIG_TTL4)

    Rem Enable input session for trigger events
    stat = viEnableEvent(sesnIN, VI_EVENT_TRIG, VI_QUEUE, VI_NULL)

    Rem Assert trigger to tell device to start sampling
    stat = viAssertTrigger(sesnOUT, VI_TRIG_PROT_DEFAULT)

    Rem Device will respond with a trigger when data is ready
    stat = viWaitOnEvent(sesnIN, VI_EVENT_TRIG, 20000, etype, event)
    If (stat < VI_SUCCESS) Then
        stat = viClose (dfltRM)
        Exit Sub
    End If

    Rem Close the event
    stat = viClose(event)

    Rem Read data from the device
    stat = viRead(sesnIN, buf, MAX_COUNT, retCount)

    Rem Your code should process the data

    Rem Unlock the sessions
    stat = viUnlock(sesnIN)
    stat = viUnlock(sesnOUT)

    Rem Close down the system
    stat = viClose(sesnIN)
    stat = viClose(sesnOUT)
    stat = viClose(dfltRM)
End Sub
```

Example 10-1

```
Private Declare Function viGetAttrString Lib "VISA32.DLL" Alias "#133" (ByVal
vi As ViSession, ByVal attrName As ViAttr, ByVal strValue As Any) As ViStatus

Private Sub vbMain()
    Dim stat As ViStatus
    Dim dfltRM As ViSession
    Dim sesn As ViSession
    Dim fList As ViFindList
    Dim rsrcName As String * VI_FIND_BUFLEN
    Dim instrDesc As String * VI_FIND_BUFLEN
    Dim nList As Long
    stat = viOpenDefaultRM(dfltRM)
    If (stat < VI_SUCCESS) Then
        Rem Error initializing VISA ... exiting
        Exit Sub
```

```
    End If
    Rem Find all Serial instruments in the system
    stat = viFindRsrc(dfltRM, "ASRL?*INSTR", fList, nList, rsrcName)
    If (stat < VI_SUCCESS) Then
        Rem Error finding resources ... exiting
        viClose (dfltRM)
        Exit Sub
    End If
    While (nList)
        stat = viOpen(dfltRM, rsrcName, VI_NULL, VI_NULL, sesn)
        If (stat < VI_SUCCESS) Then
            Debug.Print "Could not open resource", rsrcName, "Status", stat
        Else
            stat = viGetAttrString(sesn, VI_ATTR_INTF_INST_NAME, instrDesc)
            Debug.Print "Resource", rsrcName, "Description", instrDesc
            stat = viClose(sesn)
        End If
        stat = viFindNext(fList, rsrcName)
        nList = nList - 1
    Wend
    stat = viClose(fList)
    stat = viClose(dfltRM)
End Sub
```

B

Technical Support Resources

Web Support

National Instruments Web support is your first stop for help in solving installation, configuration, and application problems and questions. Online problem-solving and diagnostic resources include frequently asked questions, knowledge bases, product-specific troubleshooting wizards, manuals, drivers, software updates, and more. Web support is available through the Technical Support section of `ni.com`.

NI Developer Zone

The NI Developer Zone at `ni.com/zone` is the essential resource for building measurement and automation systems. At the NI Developer Zone, you can easily access the latest example programs, system configurators, tutorials, technical news, as well as a community of developers ready to share their own techniques.

Customer Education

National Instruments provides a number of alternatives to satisfy your training needs, from self-paced tutorials, videos, and interactive CDs to instructor-led hands-on courses at locations around the world. Visit the Customer Education section of `ni.com` for online course schedules, syllabi, training centers, and class registration.

System Integration

If you have time constraints, limited in-house technical resources, or other dilemmas, you may prefer to employ consulting or system integration services. You can rely on the expertise available through our worldwide network of Alliance Program members. To find out more about our Alliance system integration solutions, visit the System Integration section of `ni.com`.

Worldwide Support

National Instruments has offices located around the world to help address your support needs. You can access our branch office Web sites from the Worldwide Offices section of `ni.com`. Branch office Web sites provide up-to-date contact information, support phone numbers, e-mail addresses, and current events.

If you have searched the technical support resources on our Web site and still cannot find the answers you need, contact your local office or National Instruments corporate. Phone numbers for our worldwide offices are listed at the front of this manual.

Glossary

Prefix	Meanings	Value
p-	pico	10^{-12}
n-	nano-	10^{-9}
µ-	micro-	10^{-6}
m-	milli-	10^{-3}
k-	kilo-	10^{3}
M-	mega-	10^{6}
G-	giga-	10^{9}
t-	tera-	10^{12}

A

address — A string (or other language construct) that uniquely locates and identifies a resource. VISA defines an ASCII-based grammar that associates strings with particular physical devices and VISA resources.

address location — Refers to the location of a specific register.

address modifier — One of six signals in the VMEbus specifications used by VMEbus masters to indicate the address space and mode (supervisory/nonprivileged, data/program/block) in which a data transfer is to take place.

address space — In VXI/VME systems, a set of 2^n memory locations differentiated from other such sets in VXI/VMEbus systems by six signal lines known as address modifiers, where *n* (either 16, 24, or 32) is the number of address lines required to uniquely specify a byte location in a given space. In PXI systems, the address space corresponds to 1 of 6 possible BAR locations (BAR0 through BAR5). In VME, VXI, and PXI, a given device may have addresses in one or more address spaces.

address string — A string (or other language construct) that uniquely locates and identifies a resource. VISA defines an ASCII-based grammar that associates strings with particular physical devices and VISA resources.

alias	User-defined name for a VISA resource.
ANSI	American National Standards Institute
API	Application Programming Interface. The direct interface that an end user sees when creating an application. In VISA, the API consists of the sum of all of the operations, attributes, and events of each of the VISA Resource Classes.
ASCII	American Standard Code for Information Interchange.
asynchronous	An action or event that occurs at an unpredictable time with respect to the execution of a program.
attribute	A value within an object or resource that reflects a characteristic of its operational state.

B

b	Bit
B	Byte
backplane	In VXI/VME systems, an assembly, typically a PCB, with 96-pin connectors and signal paths that bus the connector pins. A C-size VXIbus system will have two sets of bused connectors called the J1 and J2 backplanes. A D-size VXIbus system will have three sets of bused connectors called the J1, J2, and J3 backplane.
Base Address Register	Each PCI or PXI device has six of these, BAR0 through BAR5. At power-on, each BAR requests a given size of memory or I/O space. Each device can request from 0 to 6 regions of PCI memory or I/O space. After the operating system starts, each BAR contains an assigned base address in PCI address space. A value of 0 in a given BAR indicates that the device is not using that BAR.
bus error	An error that signals failed access to an address. Bus errors occur with low-level accesses to memory and usually involve hardware with bus mapping capabilities. For example, nonexistent memory, a nonexistent register, or an incorrect device access can cause a bus error.

byte order	How bytes are arranged within a word or how words are arranged within a longword. Motorola (Big-Endian) ordering stores the most significant byte (MSB) or word first, followed by the least significant byte (LSB) or word. Intel (Little-Endian) ordering stores the LSB or word first, followed by the MSB or word.

C

callback	Same as *handler.* A software routine that is invoked when an asynchronous event occurs. In VISA, callbacks can be installed on any session that processes events.
CIC	Controller-In-Charge. The device that manages the GPIB by sending interface messages to other devices.
commander	A device that has the ability to control another device. This term can also denote the unique device that has sole control over another device (as with the VXI Commander/Servant hierarchy).
communication channel	The same as *session*. A communication path between a software element and a resource. Every communication channel in VISA is unique.
configuration registers	A set of registers through which the system can identify a module device type, model, manufacturer, address space, and memory requirements. In order to support automatic system and memory configuration, the PXI and VXIbus specifications require that all PXI and VXIbus devices have a set of such registers.
controller	An entity that can control another device(s) or is in the process of performing an operation on another device.
CPU	Central processing unit

D

device	An entity that receives commands from a controller. A device can be an instrument, a computer (acting in a non-controller role), or a peripheral (such as a plotter or printer).
DLL	Dynamic Link Library. Same as a *shared library* or *shared object*. A file containing a collection of functions that can be used by multiple applications. This term is usually used for libraries on Windows platforms.

DMA	Direct memory access. High-speed data transfer between a board and memory that is not handled directly by the CPU. Not available on some systems. *See* programmed I/O.

E

embedded controller	A computer plugged directly into the VXI backplane. An example is the National Instruments VXIpc-850.
event	An asynchronous occurrence that is independent of the normal sequential execution of the process running in a system.
external controller	A desktop computer or workstation connected to the VXI system via a MXI interface board. An example is a standard personal computer with a PCI-MXI-2 installed.

F

Fast Data Channel	*See* FDC.
FIFO	First In-First Out; a method of data storage in which the first element stored is the first one retrieved.
FDC	Fast Data Channel; a protocol that provides a mechanism for transferring data blocks between a VXIbus Commander and its Servants.

G

GPIB	General Purpose Interface Bus is the common name for the communications interface system defined in ANSI/IEEE Standard 488.1-1987 and ANSI/IEEE Standard 488.2-1992.

H

handler	Same as *callback*. A software routine that is invoked when an asynchronous event occurs. In VISA, callbacks can be installed on any session that processes events.
handshaking	A type of protocol that makes it possible for two devices to synchronize operations.

I

I/O	input/output
IEEE	Institute of Electrical and Electronics Engineers
instrument	A device that accepts some form of stimulus to perform a designated task, test, or measurement function. Two common forms of stimuli are message passing and register reads and writes. Other forms include triggering or varying forms of asynchronous control.
instrument driver	A set of routines designed to control a specific instrument or family of instruments, and any necessary related files for LabWindows/CVI or LabVIEW.
interface	A generic term that applies to the connection between devices and controllers. It includes the communication media and the device/controller hardware necessary for cross-communication.
interrupt	A condition that requires attention out of the normal flow of control of a program.
IVI	Interchangeable Virtual Instruments
IVI Driver	A software module that controls a hardware device and that complies with the IVI Foundation specifications.
IVI Foundation, Inc.	Interchangeable Virtual Instruments, Inc., a non-profit Delaware Corporation, composed of end-user test engineers, instrument and software suppliers, and system integrators, chartered to define software standards that promote instrument interchangeability. See `www.ivifoundation.org` for more details.

L

lock	A state that prohibits sessions other than the session(s) owning the lock from accessing a resource.
logical address	An 8-bit number that uniquely identifies the location of each VXIbus device's configuration registers in a system. The A16 register address of a device is C000h + Logical Address * 40h.

M

mapping	An operation that returns a reference to a specified section of an address space and makes the specified range of addresses accessible to the requester. This function is independent of memory allocation.
MAX	Measurement & Automation Explorer. Provides access to all National Instruments DAQ, GPIB, IMAQ, IVI, Motion, VISA, and VXI devices. With MAX, you can configure National Instruments hardware and software, add new channels, interfaces, and virtual instruments, execute system diagnostics, and view the devices and instruments connected to your system. Installs automatically with NI-VISA version 2.5 or higher or NI-VXI version 3.0 or higher. Available only for Win32-based operating systems.
message-based device	In VXI/VME systems, an intelligent device that implements the defined VXIbus registers and communication protocols. These devices are able to use Word Serial Protocol to communicate with one another through communication registers. All GPIB and Serial devices are by definition message-based, as are devices for some other interfaces. Many modern message-based devices support the IEEE 488.2 protocol.
multitasking	The ability of a computer to perform two or more functions simultaneously without interference from one another. In operating system terms, it is the ability of the operating system to execute multiple applications/processes by time-sharing the available CPU resources.

N

NI Spy	A utility that monitors, records, and displays multiple National Instruments APIs, such as NI-488.2 and NI-VISA. Useful for troubleshooting errors in your application and for verifying communication.

O

operation	An action defined by a resource that can be performed on a resource. In general, this term is synonymous with the connotation of the word *method* in object-oriented architectures.

P

process	An operating system element that shares a system's resources. A multi-process system is a computer system that allows multiple programs to execute simultaneously, each in a separate process environment. A single-process system is a computer system that allows only a single program to execute at a given point in time.
programmed I/O	Low-speed data transfer between a board and memory in which the CPU moves each data value according to program instructions. *See* DMA.
protocol	Set of rules or conventions governing the exchange of information between computer systems.
PXI	PCI eXtensions for Instrumentation. PXI leverages the electrical features defined by the Peripheral Component Interconnect (PCI) specification as well as the CompactPCI form factor, which combines the PCI electrical specification with Eurocard (VME) mechanical packaging and high-performance connectors. This combination allows CompactPCI and PXI systems to have up to seven peripheral slots versus four in a desktop PCI system.

R

register	An address location that can be read from or written into or both. It may contain a value that is a function of the state of hardware or can be written into to cause hardware to perform a particular action. In other words, an address location that controls and/or monitors hardware.
register-based device	In VXI/VME systems, a servant-only device that supports only the four basic VXIbus configuration registers. Register-based devices are typically controlled by message-based devices via device-dependent register reads and writes. All PXI devices are by definition register-based, as are devices for some other interfaces.
Resource Class	The definition for how to create a particular resource. In general, this is synonymous with the connotation of the word *class* in object-oriented architectures. For VISA Instrument Control resource classes, this refers to the definition for how to create a resource which controls a particular capability or set of capabilities of a device.

resource or resource instance	In general, this term is synonymous with the connotation of the word *object* in object-oriented architectures. For VISA, *resource* more specifically refers to a particular implementation (or *instance* in object-oriented terms) of a Resource Class.

S

s	second
SCPI	Standard Commands for Programmable Instrumentation; a protocol which defines a standard set of commands to control programmable test and measurement devices in instrumentation systems.
servant	A device controlled by a Commander.
session	The same as *communication channel*. A communication path between a software element and a resource. Every communication channel in VISA is unique.
shared library or shared object	Same as *DLL*. A file containing a collection of functions that can be used by multiple applications. This term is usually used for libraries on UNIX platforms.
shared memory	A block of memory that is accessible to both a client and a server. The memory block operates as a buffer for communication. This is unique to register-based interfaces such as VXI.
socket	A bi-directional communication endpoint; an object through which a VISA sockets application sends or receives packets of data across a network.
SRQ	IEEE 488 Service Request. This is an asynchronous request from a remote device that requires service. A service request is essentially an interrupt from a remote device. For GPIB, this amounts to asserting the SRQ line on the GPIB. For VXI, this amounts to sending the Request for Service True event (REQT).
status byte	A byte of information returned from a remote device that shows the current state and status of the device. If the device follows IEEE 488 conventions, bit 6 of the status byte indicates whether the device is currently requesting service.

status/ID	A value returned during an IACK cycle. In VME, usually an 8-bit value which is either a status/data value or a vector/ID value used by the processor to determine the source. In VXI, a 16-bit value used as a data; the lower 8 bits form the VXI logical address of the interrupting device and the upper 8 bits specify the reason for interrupting.

T

TCP/IP	Transmission Control Protocol/Internet Protocol. The recognized standard for transmitting data over networks, TCP/IP is a multi-layered suite of communication protocols used to connect hosts on LANs, WANs and the Internet. It is very widely supported, even by network operating systems that have their own communication protocols.
thread	An operating system element that consists of a flow of control within a process. In some operating systems, a single process can have multiple threads, each of which can access the same data space within the process. However, each thread has its own stack and all threads can execute concurrently with one another (either on multiple processors, or by time-sharing a single processor).

V

virtual instrument	A name given to the grouping of software modules (in this case, VISA resources with any associated or required hardware) to give the functionality of a traditional stand-alone instrument. Within VISA, a virtual instrument is the logical grouping of any of the VISA resources.
VISA	Virtual Instrument Software Architecture. This is the general name given to this product and its associated architecture. The architecture consists of two main VISA components: the VISA resource manager and the VISA resources.
VISA Instrument Control Resources	This is the name given to the part of VISA that defines all of the device-specific resource classes. VISA Instrument Control resources encompass all defined device capabilities for direct, low-level instrument control.
VISA memory access resources	This is the name given to the part of VISA that defines all of the register- or memory-specific resource classes. The VISA MEMACC resources encompass all high- and low-level services for interface-level accesses to all memory defined in the system.

VISA Resource Manager	This is the name given to the part of VISA that manages resources. This management includes support for finding resources and opening sessions to them.
VISA Resource Template	This is the name given to the part of VISA that defines the basic constraints and interface definition for the creation and use of a VISA resource. All VISA resources must derive their interface from the definition of the VISA Resource Template. This includes services for setting and retrieving attributes, receiving events, locking resources, and closing objects.
visaconf	VISA configuration utility for Solaris and Linux.
VISAIC	VISA Interacvtive Control utility. Interactively controls VXI/VME devices without using a conventional programming language, LabVIEW, or Measurement Studio.
VME	Versa Module Eurocard or IEEE 1014
VXIbus	VMEbus Extensions for Instrumentation or IEEE 1155

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