Getting Started Guide

Your Guide to Getting Started with IVI Drivers

Revision 1.01

Contents

Chapter 1
Introduction

Purpose

Welcome to ***IVI Getting Started Guide***. This guide introduces key concepts about IVI drivers and shows you how to create a short program to perform a measurement. The guide also provides a brief introduction to several advanced topics.

IVI Getting Started Guide is intended for individuals who write and run programs to control test-and-measurement instruments. As you develop test programs, you face decisions about how you communicate with the instruments. Some of your choices include Direct I/O, VXI*plug&play* drivers, or IVI drivers. If you are new to using IVI drivers or just want a quick refresher on how to get started, ***IVI Getting Started Guide*** can help.

IVI Getting Started Guide shows you that IVI drivers can be straightforward, easy-to-use tools. IVI drivers provide a number of advantages that can save time and money during development, while improving performance as well. Whether you are starting a new program or making improvements to an existing one, you should consider the use of IVI drivers to develop your test programs.

So consider this the “hello, instrument” guide for IVI drivers. If you recall, the “hello world” program, which originally appeared in *Programming in C: A Tutorial,* simply prints out “hello, world.” The “hello, instrument” program performs a simple measurement on a simulated instrument and returns the result. We think you’ll find that far more useful.

Why Use an Instrument Driver?

To understand the benefits of IVI drivers, we need to start by defining instrument drivers in general and describing why they are useful. An instrument driver is a set of software routines that controls a programmable instrument. Each routine corresponds to a programmatic operation, such as configuring, writing to, reading from, and triggering the instrument. Instrument drivers simplify instrument control and reduce test program development time by eliminating the need to learn the programming protocol for each instrument.

Starting in the 1970s, programmers used device-dependent commands for computer control of instruments. But lack of standardization meant even two digital multimeters from the same manufacturer might not use the same commands. In the early 1990s a group of instrument manufacturers developed Standard Commands for Programmable Instrumentation (SCPI). This defined set of

commands for controlling instruments uses ASCII characters, providing some basic standardization and consistency to the commands used to control instruments. For example, when you want to measure a DC voltage, the standard SCPI command is "`MEASURE:VOLTAGE:DC?`".

In 1993, the VXI*plug&play* Systems Alliance created specifications for instrument drivers called VXI*plug&play* drivers. Unlike SCPI, VXI*plug&play* drivers do not specify how to control specific instruments; instead, they specify some common aspects of an instrument driver. By using a driver, you can access the instrument by calling a subroutine in your programming language instead of having to format and send an ASCII string as you do with SCPI. With ASCII, you have to create and send the instrument the syntax "`MEASURE:VOLTAGE:DC?`", then read back a string, and build it into a variable. With a driver you can merely call a function called MeasureDCVoltage( ) and pass it a variable to return the measured voltage.

Although you still need to be syntactically correct in your calls to the instrument driver, making calls to a subroutine in your programming language is less error prone. If you have been programming to instruments without a driver, then you are probably all too familiar with hunting around the programming guide to find the right SCPI command and exact syntax. You also have to deal with an I/O library to format and send the strings, and then build the response string into a variable.

Why IVI?

The VXI*plug&play* drivers do not provide a common programming interface. That means programming a Keithley DMM using VXI*plug&play* still differs from programming an Agilent DMM. For example, the instrument driver interface for one may be ke2000_read while another may be hp34401_get or something even farther afield. Without consistency across instruments manufactured by different vendors, many programmers still spent a lot of time learning each individual driver.

To carry VXI*plug&play* drivers a step (or two) further, in 1998 a group of end users, instrument vendors, software vendors, system suppliers, and system integrators joined together to form a consortium called the Interchangeable Virtual Instruments (IVI) Foundation. If you look at the membership, it's clear that many of the foundation members are competitors. But all agreed on the need to promote specifications for programming test instruments that provide better performance, reduce the cost of program development and maintenance, and simplify interchangeability.

For example, for any IVI driver developed for a DMM, the measurement command is *IviDmmMeasurement.Read*, regardless of the vendor. Once you learn how to program the commands specified by IVI for the instrument class, you can use any vendor's instrument and not need to relearn the commands. Also commands that are common to all drivers, such as *Initialize* and *Close*, are identical regardless of the type of instrument. This commonality lets you spend less time hunting around the help files and programming an instrument, leaving more time to get your job done.

That was the motivation behind the development of IVI drivers.The IVI specifications enable drivers with a consistent and high standard of quality, usability, and completeness. The specifications define an open driver architecture, a set of instrument classes, and shared software components. Together these provide consistency and ease of use, as well as the crucial elements needed for the advanced features IVI drivers support: instrument simulation, automatic range checking, state caching, and interchangeability.

The IVI Foundation has created IVI class specifications that define the capabilities for drivers for the following eight instrument classes:

Class	IVI Driver
Digital multimeter (DMM)	IviDmm
Oscilloscope	IviScope
Arbitrary waveform/function generator	IviFgen
DC power supply	IviDCPwr
Switch	IviSwtch
Power meter	IviPwrMeter
Spectrum analyzer	IviSpecAn
RF signal generator	IviRFSigGen

IVI Class Compliant drivers usually also include capability that is not part of the IVI Class. It is common for instruments that are part of a class to have numerous functions that are beyond the scope of the class definition. This may be because the capability is not common to all instruments of the class or because the instrument offers some control that is more refined than what the class defines.

IVI also defines custom drivers. Custom drivers are used for instruments that are not members of a class. For example, there is not a class definition for network analyzers, so a network analyzer driver must be a custom driver. Custom drivers provide the same consistency and benefits described below for an IVI driver, except interchangeability.

IVI drivers conform to and are documented according to the IVI specifications and usually display the standard IVI logo.

***Note**: For more information on the types of IVI drivers, refer to Chapter 11, Advanced Topics.*

Why Use an IVI Driver?

Why choose IVI drivers over other possibilities? Because IVI drivers can increase performance and flexibility for more intricate test applications. Here are a few of the benefits:

Consistency – IVI drivers all follow a common model of how to control the instrument. That saves you time when you need to use a new instrument.

Ease of use – IVI drivers feature enhanced ease of use in popular Application Development Environments (ADEs). The APIs provide fast, intuitive access to functions. IVI drivers use technology that naturally integrates in many different software environments.

Quality – IVI drivers focus on common commands, desirable options, and rigorous testing to ensure driver quality.

Simulation – IVI drivers allow code development and testing even when an instrument is unavailable. That reduces the need for scarce hardware resources and simplifies test of measurement applications. The example programs in this document use this feature.

Range checking – IVI drivers ensure the parameters you use are within appropriate ranges for an instrument.

State caching – IVI drivers keep track of an instrument's status so that I/O is only performed when necessary, preventing redundant configuration commands from being sent. This can significantly improve test system performance.

Interchangeability – IVI drivers enable exchange of instruments with minimal code changes, reducing the time and effort needed to integrate measurement devices into new or existing systems. The IVI class specifications provide syntactic interchangeability but may not provide behavioral interchangeability. In other words, the program may run on two different instruments but the results may not be the same due to differences in the way the instrument itself functions.

Flavors of IVI Drivers

To support all popular programming languages and development environments, IVI drivers provide either an IVI-C or an IVI-COM (Component Object Model) API. Driver developers may provide either or both interfaces, as well as wrapper interfaces optimized for specific development environments.

Although the functionality is the same, IVI-C drivers are optimized for use in ANSI C development environments; IVI-COM drivers are optimized for environments that support the Component Object Model (COM). IVI-C drivers extend the VXI*plug&play* driver specification and their usage is similar. IVI-COM drivers provide easy access to instrument functionality through methods and properties.

All IVI drivers communicate to the instrument through an I/O Library. Our examples use the Virtual Instrument Software Architecture (VISA), a widely used standard library for communicating with instruments from a personal computer.

Shared Components

To make it easier for you to combine drivers and other software from various vendors, the IVI Foundation members have cooperated to provide common software components, called IVI Shared Components. These components provide services to drivers and driver clients that need to be common to all drivers. For instance, the IVI Configuration Server enables administration of system-wide configuration.

Important! You must install the IVI Shared Components before an IVI driver can be installed.

The IVI Shared Components can be downloaded from vendors' web sites as well as from the IVI Foundation Web site.

To download and install shared components from the IVI Foundation Web site:

1. Go to the IVI Foundation Web site at http://www.ivifoundation.org.
2. Locate Shared Components.
3. Choose the IVI Shared Components msi file for the Microsoft Windows Installer package or the IVI Shared Components exe for the executable installer.

Download and Install IVI Drivers

After you've installed Shared Components, you're ready to download and install an IVI driver. For most ADEs, the steps to download and install an IVI driver are identical. For the few that require a different process, the relevant chapter in ***IVI Getting Started Guide*** provides the information you need.

IVI Drivers are available from your hardware or software vendor's web site or by linking to them from the IVI Foundation web site.

To see the list of drivers registered with the IVI Foundation, go to http://www.ivifoundation.org.

Familiarizing Yourself with the Driver

Although the examples in ***IVI Getting Started Guide*** use a DMM driver, you will likely employ a variety of IVI drivers to develop test programs. To jumpstart that task, you'll want to familiarize yourself quickly with drivers you haven't used before. Most ADEs provide a way to explore IVI drivers to learn their functionality. In each chapter, where applicable, we add a note explaining how to view the available functions. In addition, browsing an IVI driver's help file often proves an excellent way to learn its functionality.

Examples

As we noted above, each example chapter in ***IVI Getting Started Guide*** shows you how to use an IVI driver to write and run a program that performs a simple measurement on a simulated instrument and returns the result. The examples demonstrate common steps using IVI drivers. Where practical, every example includes the steps listed below:

- Download and Install the IVI driver– covered in the Download and Install IVI Drivers section above.
- Determine the VISA address string – Examples in ***IVI Getting Started Guide*** use the simulate mode, so we chose the address string **GPIB0::23::INSTR,** often shown as GPIB::23. If you need to determine the VISA address string for your instrument and the ADE does not provide it automatically, use an IO application, such as National Instruments Measurement and Automation Explorer (MAX) or Agilent Connection Expert.
- Reference the driver or load driver files – For the examples in this guide, the driver is the **Agilent 34401A IVI-COM Specific Driver, Version 1.1.0.11, March 2006 (from Agilent Technologies)** or the **Agilent 34401A IVI-C Specific driver, Version 4.1, October 2006 (from National Instruments).**
- Create an instance of the driver in ADEs that use COM – For the examples in this guide, the driver is the **Agilent 34401A (IVI-COM) or HP 34401 (IVI-C)**.
- Write the program:
    - Initialize the instrument – Initialize is required when using any IVI driver. Initialize establishes a communication link with the instrument and must be called before the program can do anything with the instrument. We set reset to **true**, ID query to **false**, and simulate to **true**.

      Setting reset to true tells the driver to initially reset the instrument. Setting the ID query to false prevents the driver from verifying that the connected instrument is the one the driver was written for. Finally, setting simulate to true tells the driver that it should not attempt to connect to a physical instrument, but use a simulation of the instrument.
    - Configure the instrument – We set a range of **1.5 volts** and a resolution of **0.001 volts (1 millivolt)**.
    - Access an instrument property – We set the trigger delay to **0.01 seconds**.

- Set the reading timeout – We set the reading timeout to **1000 milliseconds (1 second).**
- Take a reading
- Close the instrument – This step is required when using any IVI driver, unless the ADE explicitly does not require it. We close the session to free resources.

Important! Close may be the most commonly missed step when using an IVI driver. Failing to do this could mean that system resources are not freed up and your program may behave unexpectedly on subsequent executions.

- Check the driver for any errors.
- Display the reading.

Note: *Examples that use a console application do not show the display.*

Now that you understand the logic behind IVI drivers, let's see how to get started.

Chapter 2
Using IVI with Visual C++

The Environment

Microsoft Visual C++ is a software development environment for the C++ programming language and is available as part of Microsoft Visual Studio. Visual C++ allows you to create, debug, and execute conventional applications as well as applications that target the .NET Framework.

Example Requirements

- Visual C++
- Microsoft Visual Studio 2005
- IVI-COM: Agilent 34401A IVI-COM, Version 1.1.0.11, March 2006 (from Agilent Technologies); or
- IVI-C: Agilent 34401A IVI-C, Version 4.1, October 2006 (from National Instruments)
- Agilent IO Libraries Suite 14.2

Download and Install the Driver

If you have not already installed the driver, go to the vendor Web site and follow the instructions to download and install it.

Since Visual C++ supports both IVI-COM and IVI-C drivers, this example is written two ways, first to show how to use an IVI-COM driver in Visual C++, and second to show how to use an IVI-C driver in Visual C++.

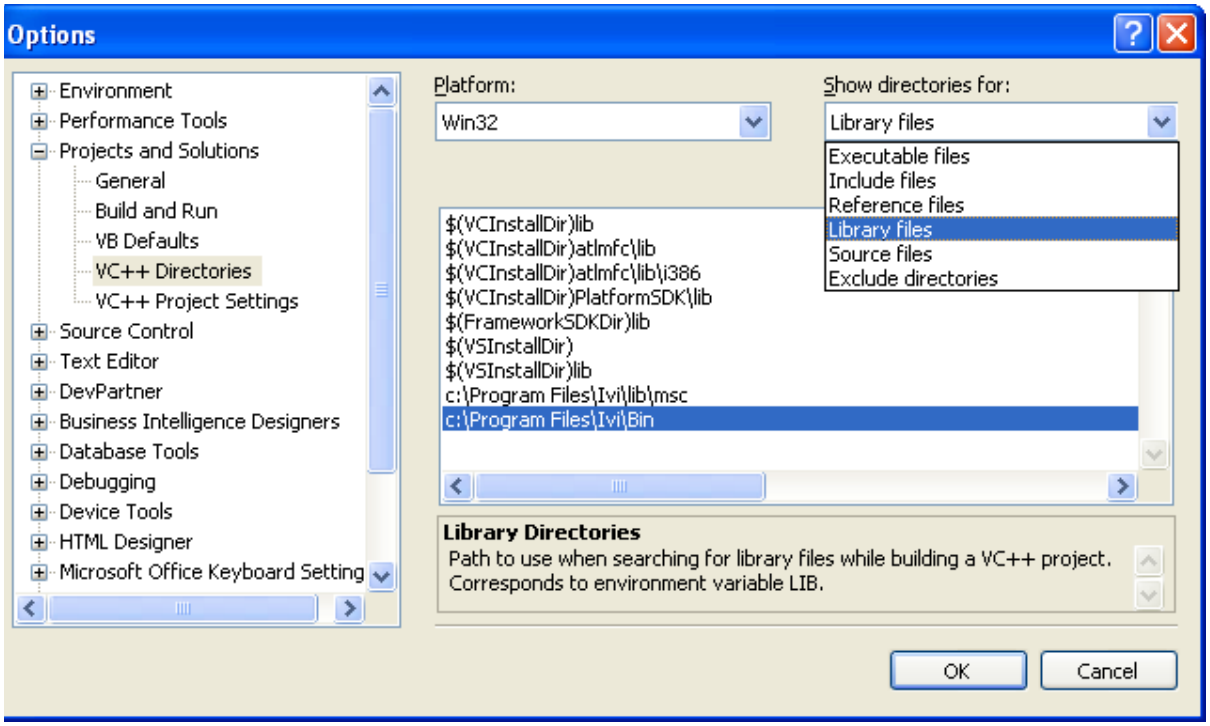
***Note**: If you do not install the appropriate instrument driver, the project will not build because the referenced files are not included in the program. If you need to download and install a driver, you do not need to exit Visual Studio. Install the driver and continue with your program.*

Using IVI-COM in C++

The following sections show how to get started with an IVI-COM driver in Visual C++

Create a New Project and Import the Driver Type Libraries

To use an IVI Driver in a Visual C++ program, you must provide the path to the driver DLL.



1. Launch Visual Studio 2005 and create a Win32 Console Application in C++ with the name IVI demo.

   Note: *The program already includes some required code, including the header file* `#include stdafx.h`.

2. From the Tools menu select Options.
3. Expand “Projects and Solutions”, then click on “VC++ Directories”
4. Click on the “Show directories for” combo box and choose “Library files”
5. Add the following two entries to your path.

   The first entry will point to the default directory for IVI drivers. This is typically:

   `“C:\Program Files\Ivi\Bin”`

   The second entry points to the VISA DLL that many drivers require:

```
"$(VXIPNPPATH)VisaCom"
```

Note: *These steps need only be done once for each computer you use. All subsequent Visual Studio projects will continue to use these settings and will be able to locate your IVI-COM drivers.*

6 Click OK

7 To import the type libraries, type the following statements following the header file reference:

```
#import "IviDriverTypeLib.dll" no_namespace
#import "IviDmmTypeLib.dll" no_namespace
#import "GlobMgr.dll" no_namespace
#import "Agilent34401.dll" no_namespace
```

Note: *The `import` statements access the driver type libraries used by the Agilent 34401 DMM. The no_namespace attribute allows the code to access the interfaces in the typelibraries from the global namespace.*

Initialize COM

1 To initialize the COM library, type the following lines after the { following the int statement:

```
HRESULT hr;
hr = CoInitialize(NULL);
IF(FAILED(hr))
          exit(1);
```

Note*: Including error handling in your programs is good practice. This code checks for errors in your program.*

2 To close the COM library before exiting, type the following line at the end of your code, right before the return line:

```
CoUninitialize();
```

Create an Instance of the Driver

To create an instance of the driver, type

```
IIviDmmPtr dmm(__uuidof(Agilent34401));
```

Note: *This creates a smart pointer that provides easy access to the COM object.*

You are now ready to write the program to control the simulated instrument.

Initialize the Instrument

You can now write the main constructs for your program.

Below the smart pointer statement, type

dmm->Initialize("GPIB::23", false, true, "simulate=true");

***Note**: As soon as you type `->`, Intellisense displays options and helps ensure you use correct syntax and values.*

Configure the Instrument

To set the range to 1.5 volts and resolution to 0.001 volts, type

```
dmm->Configure(IviDmmFunctionDCVolts, 1.5, 0.001);
```

```
int _tmain(int argc, _TCHAR* argv[])
{
    HRESULT hr;
    hr = CoInitialize(NULL);
    if (FAILED(hr))
        exit(1);
    {
        IIviDmmPtr dmm(__uuidof(Agilent34401));
        try{
            dmm->Initialize("GPIB::23", false, true, "simulate=true");
            dmm->Configure(
            dmm->Trigger->Delay = 0.01;
            double reading = dmm->Measurement->Read(1000);
            wprintf(L"Reading: %g\n", reading);
        }
        catch(_com_error e) {
            wprintf(L"Error: %s\n", e.ErrorMessage());
        }
        dmm->Close();
    }
    CoUninitialize();
}
```

Set the Trigger Delay

To set the trigger delay to 0.01 seconds, type

```
dmm->Trigger->Delay = 0.01;
```

Set the Reading Timeout/Display the Reading

Create a variable to represent the reading and make a reading with a timeout of 1 second (1000 milliseconds).

1 Type

```
double reading = dmm->Measurement->Read(1000);
```

2 To display the reading, use `printf`. Type

```
wprintf(L"Reading: %g\n", reading);
```

Error Checking

To catch errors in the code, activate error checking.

1 Surround the preceding statements with a try block. Add the following lines as shown in the illustration above:

```
try {

}
```

2 Process errors in a catch block. Type

```
catch (_com_error e) {
    wprintf(L"Error: %s", e.ErrorMessage());
}
```

Close the Session

To close out the instance of the driver and free resources, type

```
dmm->Close();
```

The final code should look like the following:

```
#include "stdafx.h"
#import "IviDriverTypeLib.dll" no_namespace
#import "IviDmmTypeLib.dll" no_namespace
#import "GlobMgr.dll" no_namespace
#import "Agilent34401.dll" no_namespace
int IVI_Demo()
{
    HRESULT hr;
    hr = CoInitialize(NULL);
    if(FAILED(hr))
```

```
            exit(1);
    {
            IAgilent34401Ptr dmm(__uuidof(Agilent34401));
            try{
dmm->Initialize("GPIB::23",false,true,"simulate=true");
                  dmm->DCVoltage->Configure(1.5, 0.001);
                  dmm->Trigger->Delay = 0.01;
            double reading = dmm->Measurement->Read(1000);
                  wprintf(L"Reading: %g\n", reading);
            }
            catch(_com_error e){
                  wprintf(L"Error: %s\n", e.ErrorMessage);
            }
            dmm->Close();
    }
    CoUninitialize();
    return 0;
}
```

Build and Run the Application

Build your application and run it to verify it works properly.

1. From the Start Menu, select Build, and click Build IVIDemo.
2. From the Start Menu, select Debug, and run the application.

Using IVI-C in Visual C++

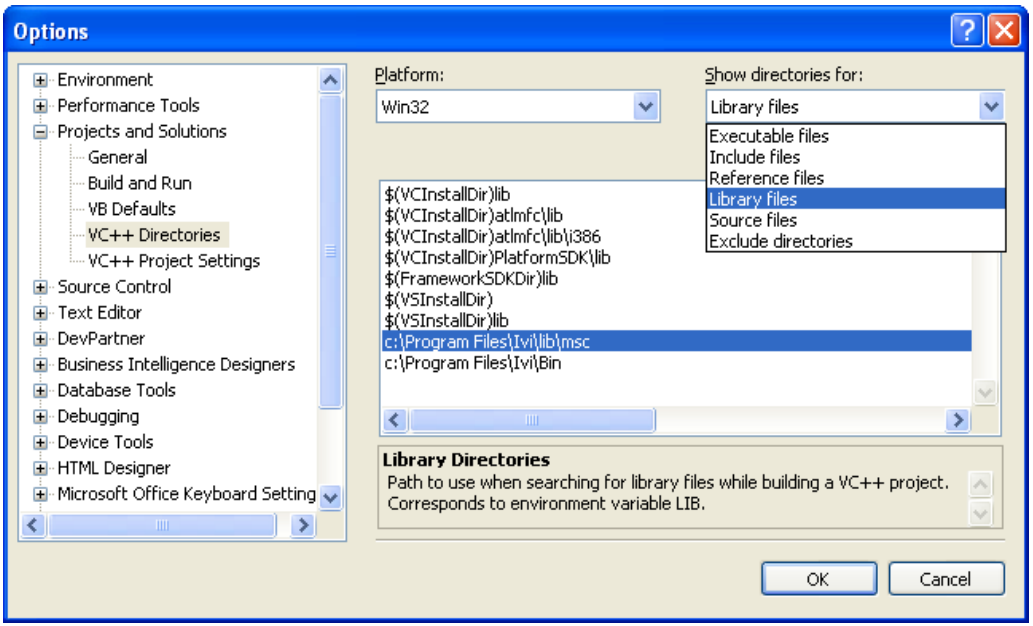
The following sections show to get started with IVI-C in Visual C++.

Create a New Project and Import the Driver Type Libraries

To use an IVI-C Driver in a Visual C++ program, you must provide paths to the header files and libraries it uses.

1. Launch Visual Studio 2005 and create a Win32 Console Application in C++ with the name IVI demo.

   Note: *The program already includes some required code, including the header file* `#include stdafx.h`.



2 From the Tools menu select Options.

3 Expand “Projects and Solutions”, then click on “VC++ Directories”

4 Click on the “Show directories for” combo box and choose “Library files”

5 Add the following entry to your “Library files” path.

This entry points to the default directory for IVI drivers. This is typically:

```
"C:\Program Files\IVI\Lib\msc"
```

6 Click on the “Show directories for” combo box and choose “Include files”

7 Add the following entries to your “Include files” path.

The first entry will point to the default directory for IVI drivers. This is typically:

```
"C:\Program Files\IVI\include"
```

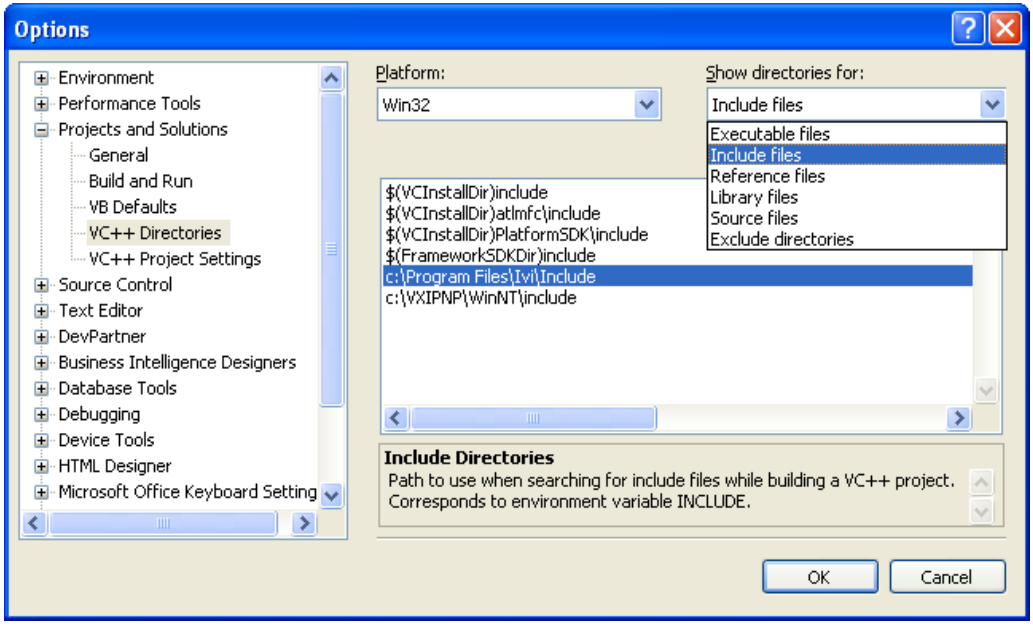
The second entry points to the VISA header files that IVI-C drivers require:

```
"$(VXIPNPPATH)WinNT\include"
```

8 Click OK

Note: *These initial steps need only be done once for each computer you use. All subsequent Visual Studio projects will continue to use these settings and will be able to locate your IVI-COM drivers.*

9 Select Project and click Properties. The IVIDemo.cpp “Property pages” dialog box appears.



10 Expand “Configuration Properties”

11 Expand “Linker”

12 Select Input. In the Additional Dependencies field, type

```
“hp34401a.lib”
```

13 Select OK.

14 To add the hp34401a instrument driver header file to your program, type the following statement following the existing header file reference:

```
#include “hp34401a.h”
```

15 From the Main Menu, select Build and click Build IVIDemo.

Declare Variables

1 You will need to declare some variables that will be used in your program. Type the following lines after the { in the `int main ()` statement:

```
ViSession session;

ViStatus error = VI_SUCCESS;

ViReal64 reading;
```

Define Error Checking

1 Next define error checking for your program. First you will define a macro to catch the errors. It is better to define it once at the beginning of the program that to add the logic to each of your program statements. After the `#include` statements, type the following lines:

```
#ifndef checkErr
#define checkErr(fCall)     \
if (error = (fCall), (error = (error < 0) ? \
error : VI_SUCCESS)) \
{goto Error;}  else error = error
#endif
```

2 Next you will type the following lines at the end of the program to handle any errors that occur:

```
Error:
if (error != VI_SUCCESS)
{
ViChar   errStr[2048];

hp34401a_GetError (session, &error, 2048, errStr);
printf ("Error!", errStr);
}
```

Note: Including error handling in your programs is good practice. This code checks for errors in your program.

Initialize the Instrument

1 To initialize the instrument, add the following Initialize with Options function right after the variable declarations you added in the previous section

```
checkErr( hp34401a_InitWithOptions ("GPIB::23::INSTR",
      VI_FALSE, VI_TRUE, "Simulate = 1", &session));
```

This initializes the instrument with the following parameters:

- GPIB0::23::INSTR as the Resource Name (instrument at GPIB address 23)
- VI_FALSE Does not perform an ID Query
- VI_TRUE Resets the device

- Simulate=1 in the Options parameter sets the driver to simulation mode
- &session assigns the Instrument Handle to the variable “session” defined above

Configure the Instrument

1 To set the range to 1.5 volts and resolution to 0.001 millivolts, type:

```
checkErr( hp34401a_ConfigureMeasurement (session,
      HP34401A_VAL_DC_VOLTS, 1.5, 0.001));
```

Set the Trigger and Trigger Delay

1 To set the trigger source to immediate and the trigger delay to 0.01 seconds, type:

```
checkErr( hp34401a_ConfigureTrigger (session,
      HP34401A_VAL_IMMEDIATE, 0.01));
```

Set the Reading Timeout/Display the Reading

1 To take a reading from the instrument and to set the reading timeout to 1 second (1000 ms) type:

```
checkErr( hp34401a_Read (session, 1000, &reading);
```

Note: The Read function takes a reading from the instrument and assigns the result to the variable “reading” defined above.

2 To display the reading, use a printf statement. Type

```
printf (“Reading = %f”, reading);
```

Close the Session

To close out the instance of the driver and free resources, type

```
If (session)
hp34401a_Close(session);
```

The final code should contain the code below:

```
#include "stdafx.h"
#include <hp34401a.h>

#ifndef checkErr
#define checkErr(fCall) \
if (error = (fCall), (error = (error < 0)?
      error : VI_SUCCESS)) \
{goto Error;}  else error = error
```

```
#endif

int main(int argc, _TCHAR* argv[])
{
ViSession session;
ViStatus  error = VI_SUCCESS;
ViReal64  reading;

checkErr( hp34401a_InitWithOptions ("GPIB::23::INSTR",
      VI_FALSE, VI_TRUE, "Simulate=1", &session));
checkErr( hp34401a_ConfigureMeasurement (session,
      HP34401A_VAL_DC_VOLTS, 1.5, 0.0001));
checkErr( hp34401a_ConfigureTrigger (session,
      HP34401A_VAL_IMMEDIATE, 0.01));
checkErr( hp34401a_Read (session, 1000, &reading));
printf ("Reading = %f", reading);

Error:
if (error != VI_SUCCESS)
{
ViChar   errStr[2048];

hp34401a_GetError (session, &error, 2048, errStr);
printf ("Error!", errStr);
}

if (hp34401a)
hp34401a_close (hp34401a);
}
```

Build and Run the Application

Build your application and run it to verify it works properly.

1. From the Start Menu, select Build, and click Build IVI Demo.
2. From the Start Menu, select Debug, and run the application.

Further Information

Learn more about Visual C++ at http://msdn.microsoft.com/visualc/.

Chapter 3
Using IVI with Visual C# and Visual Basic .NET

The Environment

C# and Visual Basic are object-oriented programming languages developed by Microsoft. They enable programmers to quickly build a wide range of applications for the Microsoft .NET platform. This chapter provides detailed instructions in C# as well as the code for Visual Basic. If you are looking for an example using Visual Basic 6.0, refer to Chapter 9.

Note: *One of the key advantages of using C# and Visual Basic in the Microsoft® Visual Studio® Integrated Development Environment is IntelliSense™. InstelliSense is a form of autocompletion for variable names and functions and a convenient way to access parameter lists and ensure correct syntax. The feature also enhances software development by reducing the amount of keyboard input required.*

Example Requirements

- Visual C#
- Microsoft Visual Studio 2005
- Agilent 34401A IVI-COM, Version 1.1.0.11, March 2006 (from Agilent Technologies)
- Agilent IO Libraries Suite 14.2

Download and Install the Driver

If you have not already installed the driver, go to the vendor Web site and follow the instructions to download and install it. You can also refer to Chapter 1, Download and Install IVI Drivers, for instructions.

This example uses an IVI-COM driver. IVI-COM is the preferred driver for C#, but IVI-C is also supported.

Create a New Project and Reference the Driver

To use an IVI Driver in a Visual C# program, you must first add a reference to it.

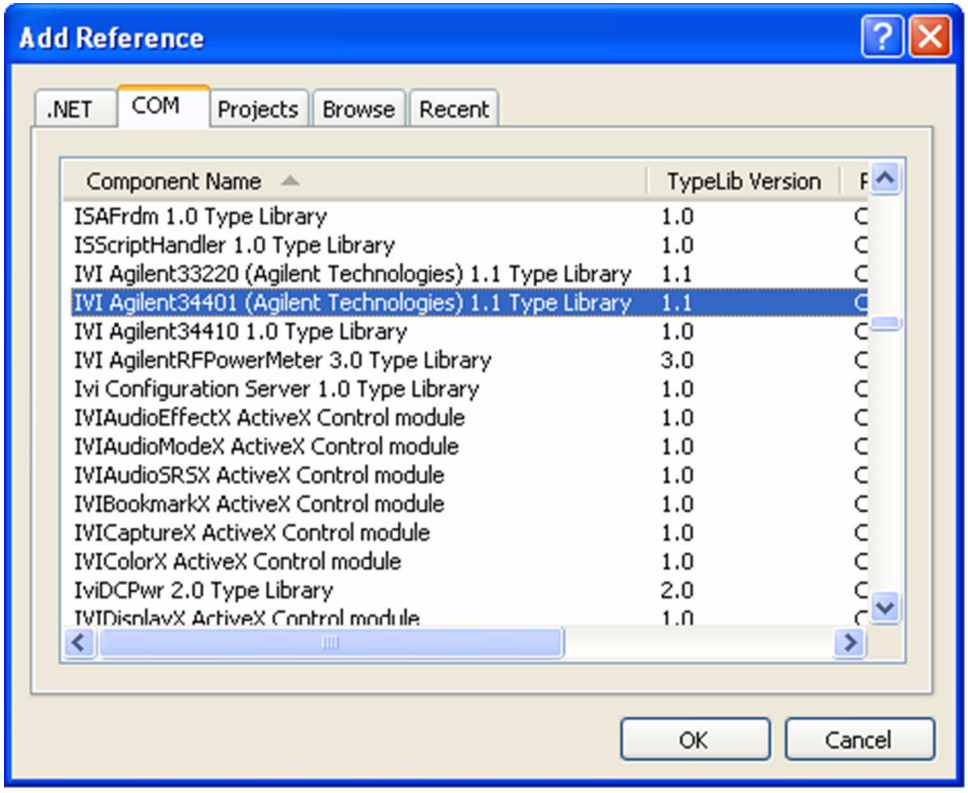
1 Launch Visual Studio and start a new Console Application in Visual C#.

Note: *The program already includes some required code, including using statements. Keep this required code.*

2 Select Project and click Add Reference. The Add Reference dialog appears.

3 Select the COM tab. All IVI drivers begin with IVI. Scroll to the IVI section and select IVI Agilent 34401 (Agilent Technologies) 1.1 Type Library. Click OK.

***Note**: If you have not installed the IVI driver, it will not appear in this list. You must close the Add Reference dialog, install the driver, and select Add Reference again for the driver to appear.*



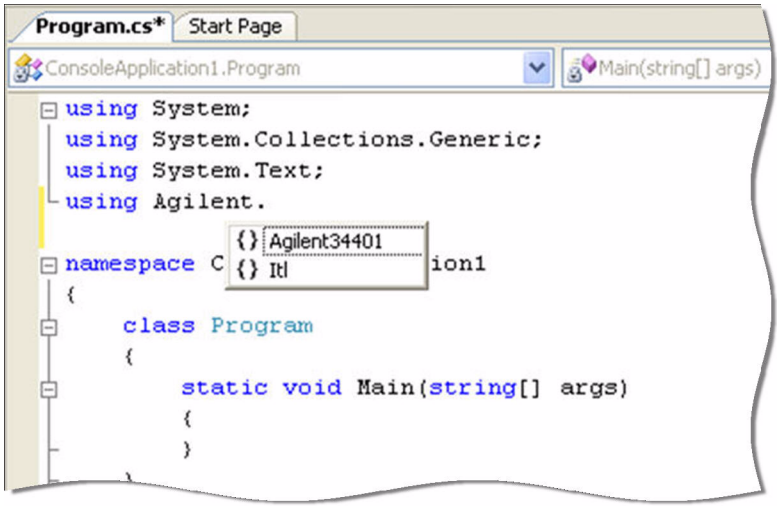
***Note:** The program looks the same as it did before you added the reference, but the driver is now available for use. To see the reference, select View and click Solution Explorer. Solution Explorer appears and lists the reference.*

Create an Instance of the Driver

To allow your program to access the driver without specifying the full path, type the following line immediately below the other `using` statements:

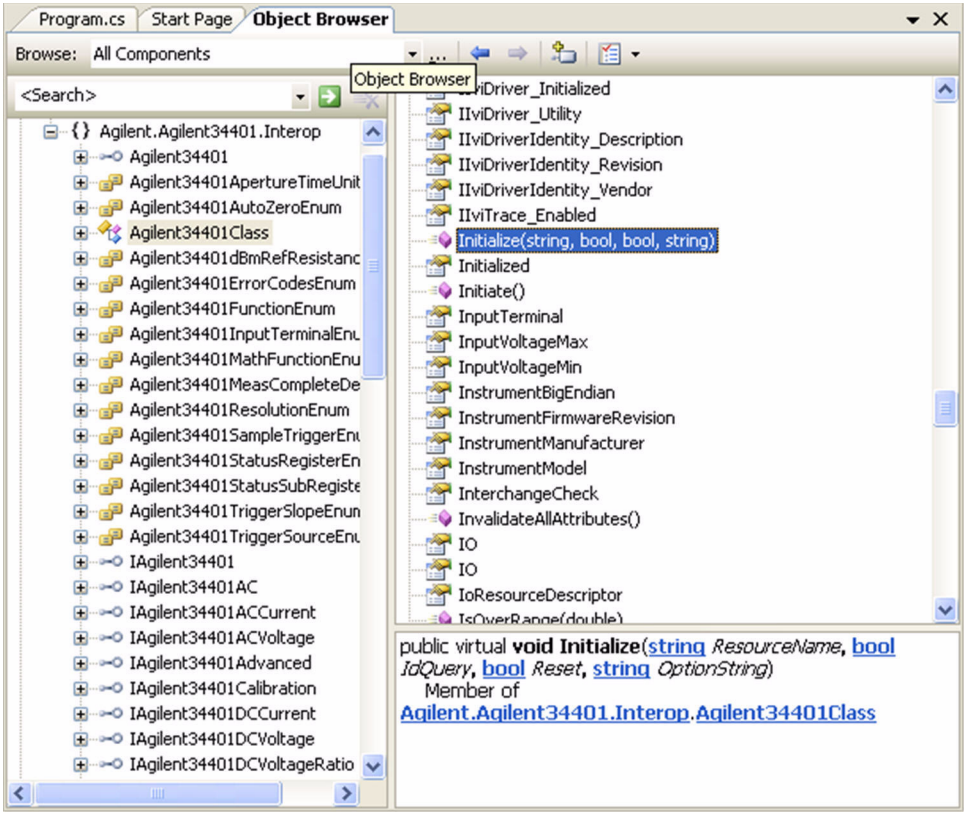
```
using Agilent.Agilent34401.Interop;
```

Note: *As soon as you type the A for Agilent, IntelliSense lists the valid inputs.*



Congratulations! You may now write the program to control the simulated instrument.

Note*: To view the functions and parameters available in the instrument driver, right-click the library in the References folder in Solution Explorer and select View in Object Browser.*



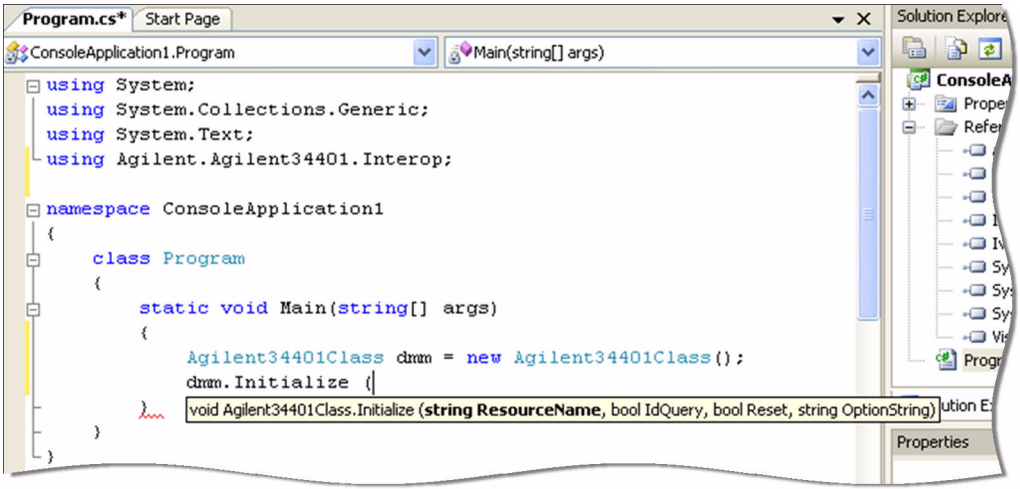
Initialize the Instrument

You can now write the main constructs for your program. Create a variable to represent your instrument and set the Initialization parameters.

1 Type `Agilent34401Class dmm = new Agilent34401Class();`

2 Type `dmm.Initialize ("GPIB::23", false, true, "simulate=true");`

***Note**: IntelliSense helps ensure you use correct syntax and values.*



Configure the Instrument

To set the range to 1.5 volts and the resolution to 1 millivolt, type

```
dmm.DCVoltage.Configure(1.5, 0.001);
```

Set the Trigger Delay

To set the trigger delay to 0.01 seconds, type

```
dmm.Trigger.Delay = 0.01;
```

Set the Reading Timeout/Display the Reading

Create a variable to represent the reading and display the reading:

1. Type `double reading;`
2. To trigger the multimeter and take a reading with a timeout of 1 second, type `reading = dmm.Measurement.Read(1000);`
3. Type `Console.WriteLine("The measurement is {0}", reading);`
4. Type `Console.ReadLine();`

Close the Session

To close out the instance of the driver to free resources, type

```
dmm.Close();
```

Your final program should contain the code below:

```
using System;
using System.Collections.Generic;
using System.Text;
using Agilent.Agilent34401.Interop;

namespace ConsoleApplication1
{
    class Program
    {
        static void Main(string[] args)
        {
            Agilent34401Class dmm = new
Agilent34401Class();
            dmm.Initialize("GPIB::23", false, true, "sim-
ulate=true");
            dmm.DCVoltage.Configure(1.5, 0.001);
            dmm.Trigger.Delay = 0.01;
            double reading;
            reading = dmm.Measurement.Read(1000);
            Console.WriteLine("The measurement is {0}",
reading);
            Console.ReadLine();
            dmm.Close();
        }
    }
}
```

Build and Run the Application

Build your application and run it to verify it works properly.

1. From the Build menu, click the name of your Console Application.
2. From the Debug menu, click Start Debugging.

Tips

The code for a Visual Basic console application in Visual Studio 2005 is almost identical to the C# application:

```
Option Explicit On
```

```
Imports Agilent.Agilent34401.Interop

Module Module1

   Sub Main()

         Dim dmm As New Agilent34401

        dmm.Initialize("GPIB::23", False, True,
"simulate=true")

        dmm.Function =
Agilent34401FunctionEnum.Agilent34401FunctionDCVolts

        dmm.DCVoltage.Configure(1.5, 0.001)

        dmm.Trigger.Delay = 0.01

         Dim reading As New Double

         reading = dmm.Measurement.Read(1000)

         dmm.Close()

     Console.WriteLine("The reading is {0}", reading)

     Console.ReadLine()

   End Sub

End Module
```

The main differences include the following:

- To use Visual Basic, select Visual Basic in Project Types.
- To enforce type checking, insert a line at the start of the code. Type
  `Option Explicit On`
- To call the DCVolts function you need to insert a line of code. Type
  `dmm.Function = Agilent34401FunctionEnum.Agilent34401FunctionDCVolts`
- To dimension a variable for the instrument and reading, use `Dim dmm` and `Dim reading`.

Further Information

- Learn more about Visual C# at http://msdn.microsoft.com/vcsharp/.
- Learn more about Visual Basic at http://msdn.microsoft.com/vbasic/.

Chapter 4
Using IVI with LabVIEW™

The Environment

National Instruments LabVIEW is a graphical development environment for signal acquisition, measurement analysis, and data presentation. LabVIEW provides the flexibility of a programming language with less complexity than traditional development tools.

Example Requirements

- LabVIEW 8.20
- IVI-C: Agilent 34401A IVI-C specific driver, Version 4.1, October 2006 (from National Instruments)
- IVI-COM: Agilent 34401A IVI-COM driver, Version 1.1.0.11, March 2006 (from Agilent Technologies)

Note: *These drivers may require an I/O library to be installed. Check the driver vendor's Web site for details.*

Download and Install the Driver

If you have not already installed the driver, go to the vendor Web site and follow the instructions to download and install it.

Since LabVIEW supports both IVI-C and IVI-COM drivers, this example is written two ways, first to show how to use an IVI-C driver in LabVIEW, and second how to use an IVI-COM driver in LabVIEW.

Using IVI-C

All IVI-C drivers provide a Dynamic Link Library (DLL) interface. While LabVIEW provides the Call Library Function node to call DLLs, many IVI-C drivers also come with a LabVIEW wrapper that provides the familiar VI interface to the driver's functions, making it easier to use in LabVIEW. If your IVI-C driver does not have a LabVIEW wrapper, you can create one using a free tool by clicking on **LabVIEW Instrument Driver Import Wizard at**:

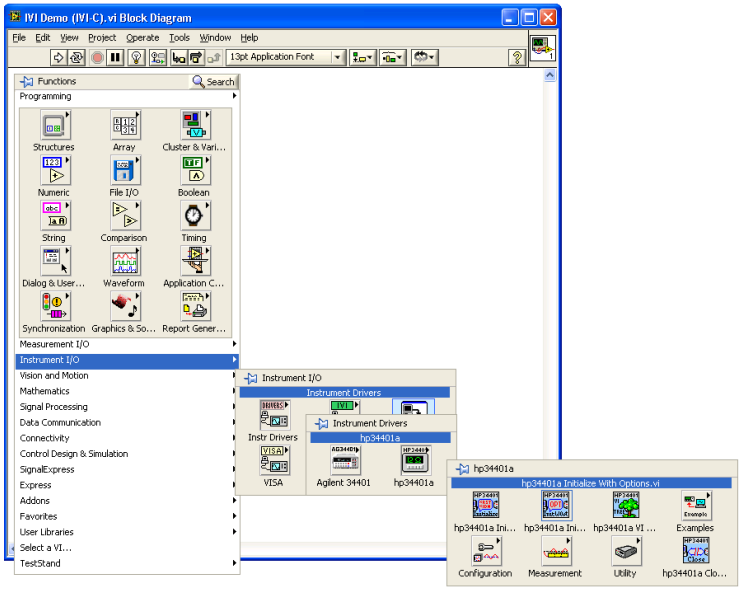
http://www.ni.com/devzone/idnet/development.htm.

Note: *The functionality shown in this section is available in a LabVIEW example supplied with the IVI driver from National Instruments.*

Create a VI and Access the Driver

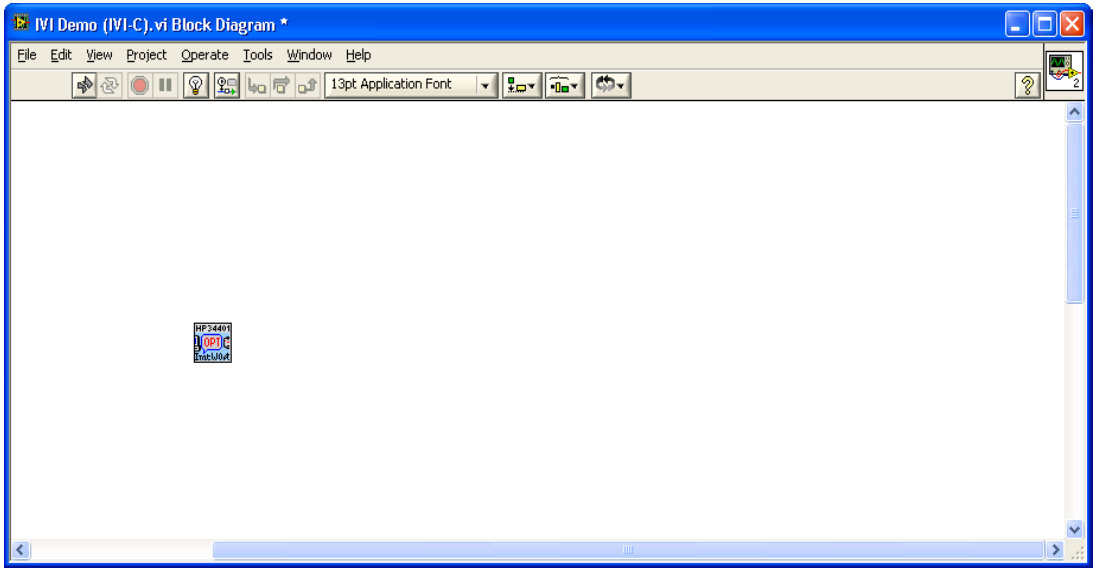
1. Launch LabVIEW.
2. From the File menu, select New VI. The Front Panel and Block Diagram appear.
3. Right-click in the Block Diagram. The Functions palette appears.
4. Select the Instrument I/O subpalette and then the Instrument Drivers subpallete. You can access all instrument driver VIs from this palette.
5. Click Instrument Drivers. Select hp34401a from the palette.
6. Select the hp34401a IVI driver from the palette.

   ***Note**: If the driver you want to use is not listed, download and install the driver, and close and restart LabVIEW. The driver should now appear in the palette. The driver palette allows you to browse the various VIs and functionality supported* by the driver.



Initialize the Instrument

1 Select Initialize With Options VI from the hp34401a palette and place it on the Block Diagram.

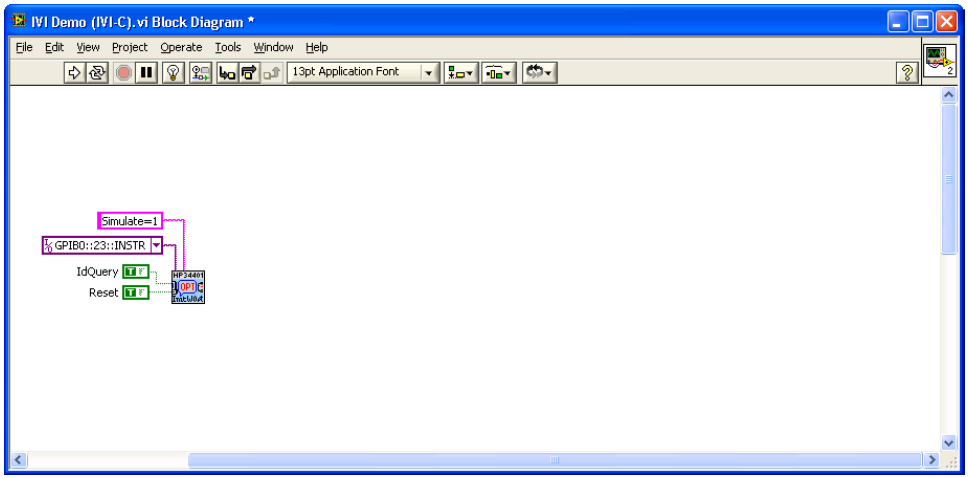


2 Create constants and enter values for instrument resource name, ID Query, Reset, and IVI option string:

- **GPIB0::23::INSTR** in the instrument resource name field
- **False** in the ID Query field
- **True** in the Reset field
- **Simulate=1** in the Options field

Note: *To create a constant, control, or indicator, right-click on the desired input terminal and select Create.*

Configure the Instrument



1. From the Configuration subpalette, select Configure Measurement VI and place it on the Block Diagram.
2. Create constants and enter values to set the resolution to 1 millivolt, the function to DC Voltage, and the range to 1.5 volts:
   - **0.001** in the Resolution field
   - **DC volts** in the Measurement Function field
   - **1.5** in the Range field
3. Connect the instrument handle and error terminals from Initialize With Options VI to Configure Measurement VI.
4. From the Trigger subpalette, select Configure Trigger VI and place it on the Block Diagram.
5. Connect resource name and error information from Configure Measurement VI to Configure Trigger VI.
6. Create a constant and enter a value of **0.01** in the Trigger Delay field.

   Note: *You can also set the Trigger Delay using a Property Node by replacing steps 4 & 5 with a property access as shown in the section "Setting a Property in an IVI-C Driver" below.*

Take the Reading

1. Return to the main hp34401a palette. From the Measurement subpalette, select Read VI and place it on the Block Diagram.
2. Set the value for Timeout to 1 second (1000 ms). Enter **1000** in the Timeout field.

3 Connect resource name and error information from Configure Trigger to Read VI.

Display the Reading

Create an indicator for Reading from the terminal on the Read VI.

Close the Session

1 Return to the main hp 34401a palette. Select Close VI and place it on the Block Diagram.

2 Connect resource name and error information from Read VI to Close VI.

Note: *LabVIEW compiles while developing, which lets you check the program execution at any time.*

Add Error Checking

1 Return to the main functions palette. From the Dialog & User Interface subpalette select Simple Error Handler VI and place it on the Block Diagram.

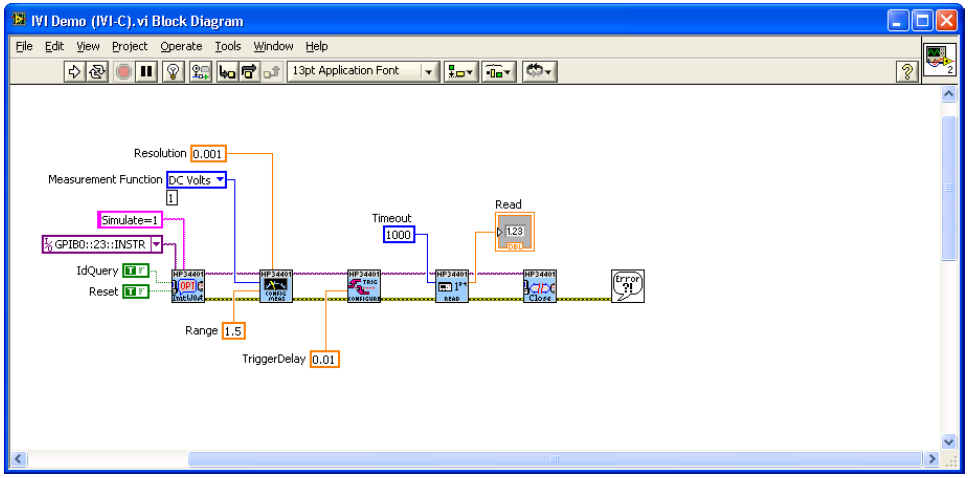
2 Connect the error information from Close VI to Simple Error Handler VI.

Run the Application

Your final VI Block Diagram should contain the elements shown below. To run your VI:

1 Switch to the VI's Front Panel and click on the *Run* arrow to run the application.

2 The *Reading* indicator should display a simulated reading from the instrument.

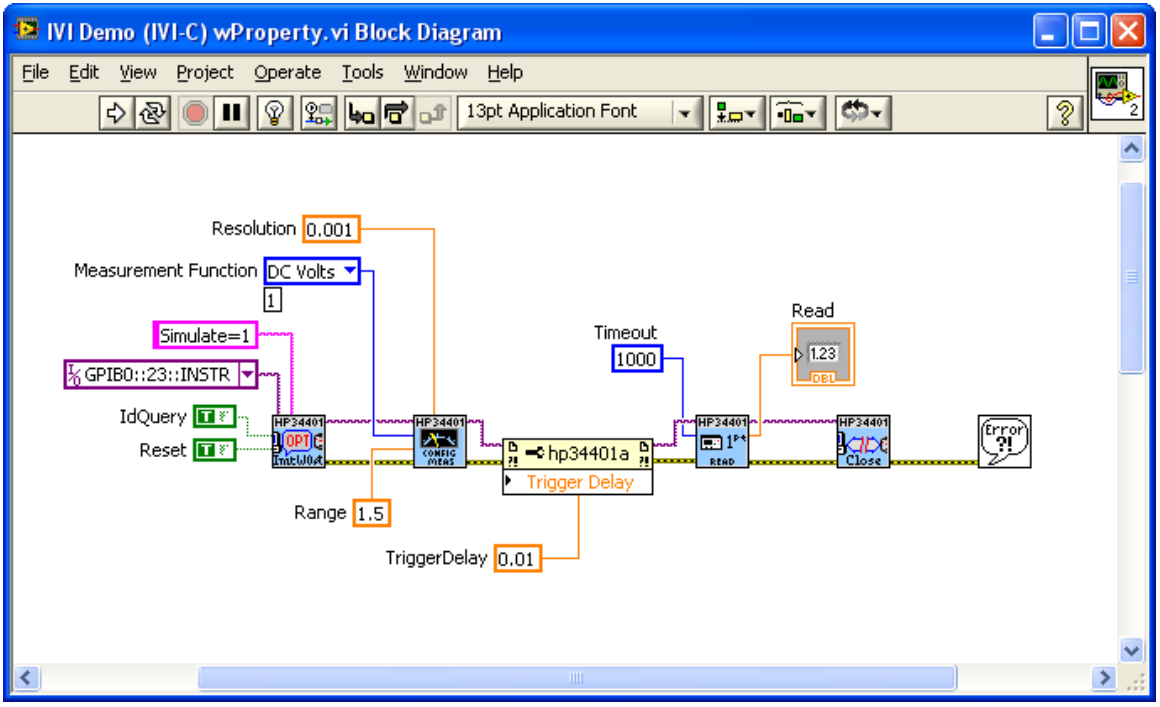


Setting a Property in an IVI-C Driver

Properties such as Trigger Delay can also be set (and read) with a property node. This is important in cases where a configuration function is not provided by the driver.

For example we can replace steps 4 and 5 of the “Configure the Instrument” section with:

1. From the Functions palette select Application Control and drop a Property Node on the Block Diagram.
2. Connect the resource name and error information from Configure Measurement VI to the Property Node.
3. Right-click on the Property Node and select Change All to Write.
4. Click on the Property field and select Trigger >> Trigger Delay.



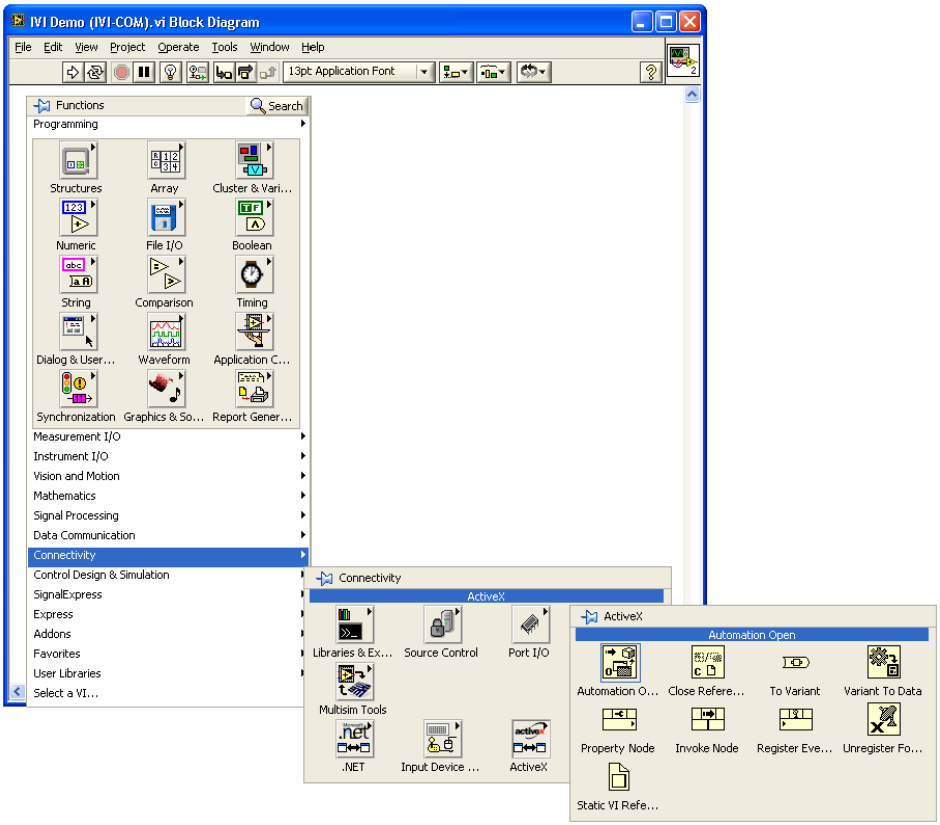
Using IVI-COM

To use IVI-COM drivers in LabVIEW you will use the ActiveX functions and the Class Browser that are built-in to LabVIEW.

Create a VI and Access the Driver

1. Launch LabVIEW

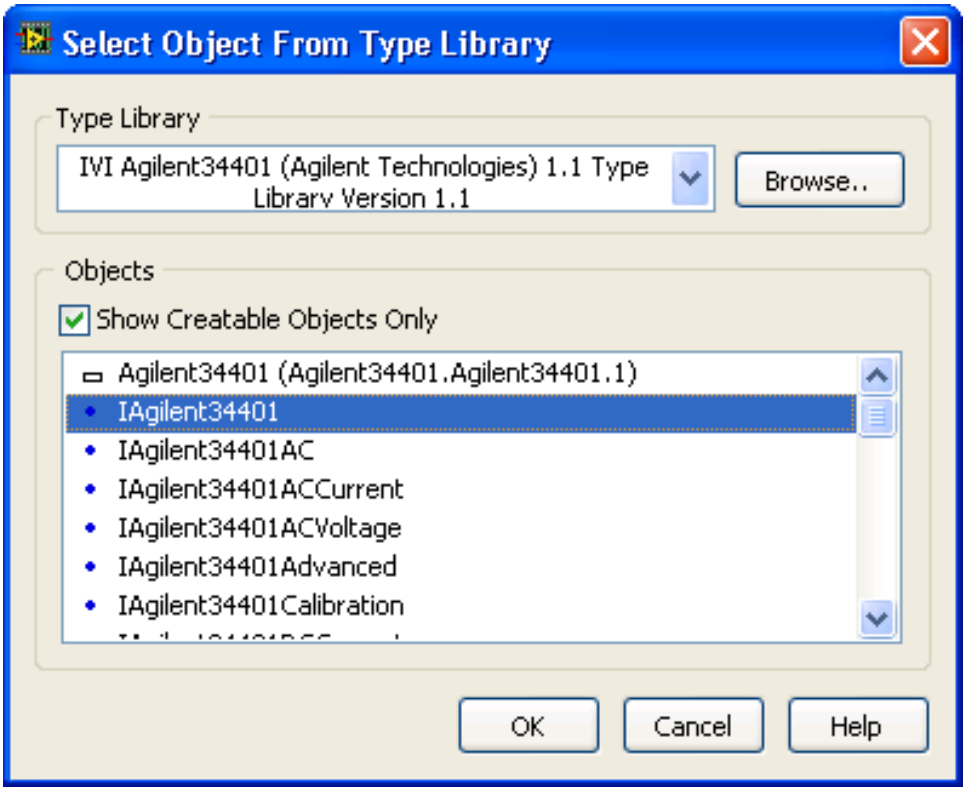
2. From the File menu, select New VI. The Front Panel and Block Diagram appear.
3. Right-click in the Block Diagram. The Functions palette appears.
4. Select the Connectivity subpalette and then the ActiveX subpallete. From this palette, you can access ActiveX and COM objects including all IVI-COM drivers.
5. Select Automation Open from the palette and place it on the block diagram.



6. Right-click on the Automation Refnum terminal, select Select ActiveX Class... and then Browse...

7 From the Type Library drop-down, select the IVI Agilent 34401A (Agilent Technologies) 1.1 Type Library Version 1.1, and then select the IAgilent34401 object. Click OK.

Note: *If the IVI-COM driver you want to use is not listed, download and install the driver and close and restart LabVIEW. The driver should now appear in the type library browser.*



Initialize the Instrument

1 From the View menu, select Class Browser. The Class Browser allows you to invoke methods and set or get properties of the ActiveX/COM object.

2 From the Object library drop-down, select ActiveX and then Select Type Libraries.

3 Scroll down and select the IVI Agilent 34401A (Agilent Technologies) 1.1 Type Library Version 1.1, Click OK.

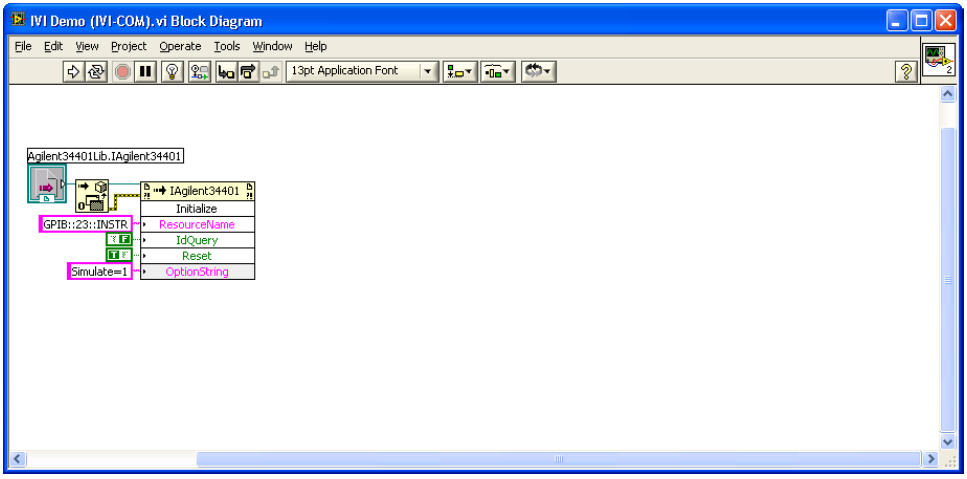
4 Back in the Class Browser, under Properties and Methods, scroll down and select Initialize. Click Create and drag the Invoke Node to the Block Diagram.

5 Create constants and enter values for ResourceName, IDQuery, Reset, and OptionString:

- **GPIB0::23::INSTR** in the instrument ResourceName field
- **False** in the IDQuery field
- **True** in the Reset field
- **Simulate=1** in the OptionString field

6 Connect the automation refnum and error terminals from Automation Open to Initialize Invoke Node.

Note: *Instead of using the Class Browser, you can select an Invoke Node from the ActiveX subpalette and select the Initialize method. To access driver properties, you can select a Property Node from the ActiveX subpalette and select the appropriate property or you can use the Class Browser for both IVI-C and IVI-COM drivers.*



Configure the Instrument

1 Go back to the Class Browser, and under Properties and Methods, double-click the DC Voltage property and select the Configure method. Click Create and drag the Invoke Node to the Block Diagram.

2 Create constants and enter values to set the Resolution to 1 millivolt and the Range to 1.5 volts:

- **0.001** in the Resolution field
- **1.5** in the Range field

3. Connect the automation refnum and error terminals from Initialize Invoke Node to DCVoltage.Configure Invoke Node.
4. In the Class Browser, go back to the top-level object and double-click the Trigger property and select the Delay property. Click Create Write and drag the Property Node to the Block Diagram.
5. Create a constant and enter a value of 0.01 seconds for the Delay field.
6. Connect the automation refnum and error terminals from DCVoltage.Configure Invoke Node to Trigger.Delay Property Node.

Take the Reading

1. Return to the Class Browser, and under Properties and Methods, double-click the Measurement property and select the Read method. Click Create and drag the Invoke Node to the Block Diagram.
2. Set the value for Timeout to 1 second (1000 ms) by entering 1000 in the MaxTimeMilliseconds field.
3. Connect the automation refnum and error terminals from Trigger.Delay Property Node to Measurement.Read Invoke Node.

Display the Reading

Create an indicator for Measurement.Read from the Invoke Node terminal.

Close the Driver and Automation Sessions

1. Return to the Class Browser, and under Properties and Methods, double-click the Close method. Click Create and drag the Invoke Node to the Block Diagram.
2. Close the Class Browser. From the ActiveX subpalette, select Close Reference and place on the Block Diagram.
3. Connect the automation refnum and error terminals from Measurement.Read Invoke Node to Close Invoke Node and then to Close Reference function.

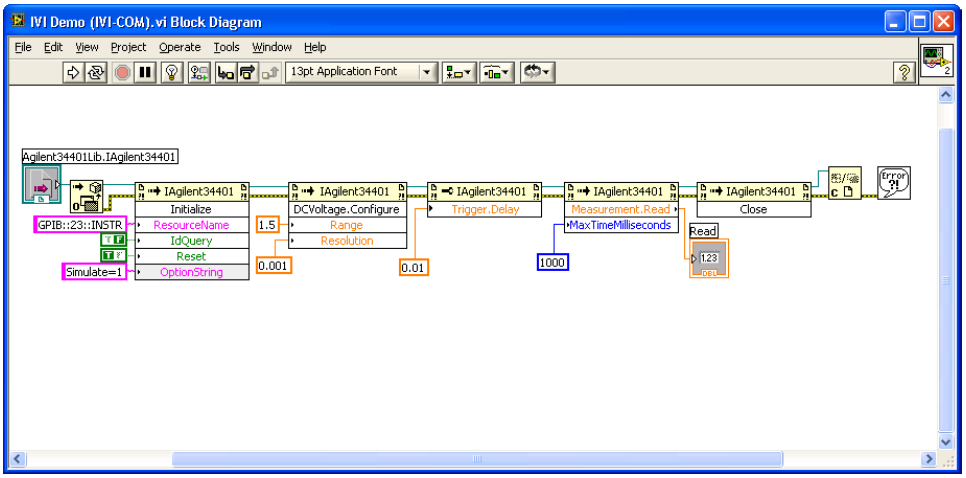
Add Error Checking

1. Return to the main functions palette. From the Dialog & User Interface subpalette select Simple Error Handler VI and place it on the Block Diagram.
2. Connect the error information from Close Reference function to Simple Error Handler VI.

Run the Application

Your final VI Block Diagram should contain the elements shown below. To run your VI:

1. Switch to the VI's Front Panel and click on the Run arrow to run the application.
2. The Reading indicator should display a simulated reading from the instrument.



Further Information

Learn more about using an instrument driver in LabVIEW in this tutorial: http://zone.ni.com/devzone/cda/tut/p/id/2804.

Chapter 5
Using IVI with LabWindows™/CVI™

The Environment

National Instruments LabWindows/CVI is an ANSI-C integrated development environment that provides a comprehensive set of programming tools for creating test and control applications. LabWindows/CVI combines the longevity and reusability of ANSI-C with engineering-specific functionality designed for instrument control, data acquisition, analysis, and user interface development.

Example Requirements

- LabWindows/CVI 8.1
- Agilent 34401A IVI-C specific driver, Version 4.1, October 2006 (from National Instruments)

Note: *This driver requires the IVI Compliance Package to be installed. Check National Instruments' Web site for details*.

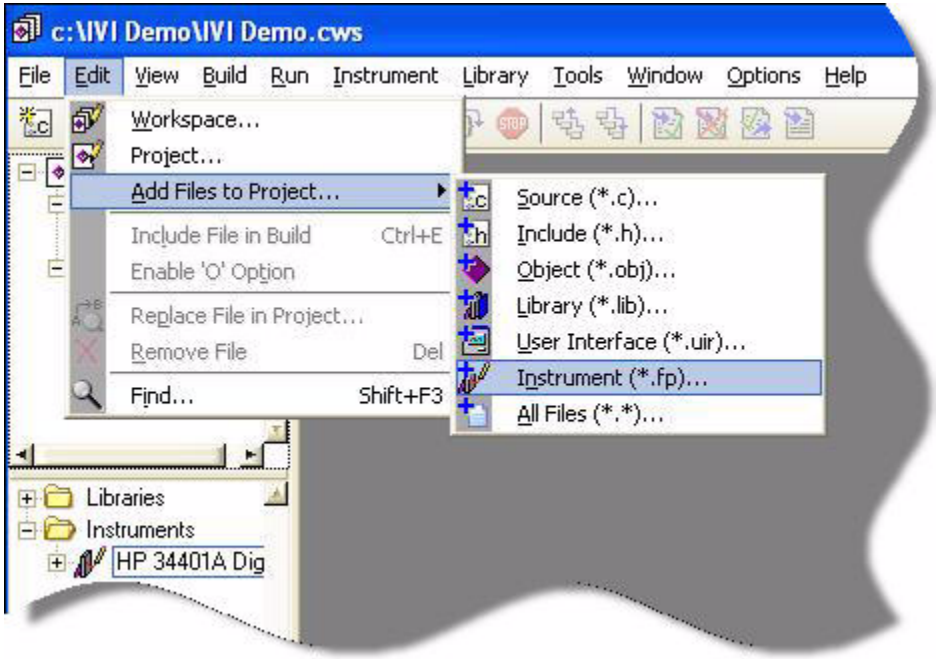
Download and Install the Driver

If you have not already installed the driver, go to the vendor Web site and follow the instructions to download and install it. You can also refer to Chapter 1, Download and Install IVI Drivers, for instructions.

This example uses an IVI-C driver. IVI-C is the preferred driver for LabWindows/CVI.

Create a New Project and Add Instrument Driver Files

1. Launch LabWindows/CVI.
2. Select File, select New, and click Project.
3. To create a new C source file, select New and click Source (*.c). Save the file.
4. Select Edit and click on Add Files to Project to add the C source file to your project.
5. Select Edit and click on Add Files To Project to add one of the following instrument driver files to your project: hp34401a.fp, hp34401a.c, or hp34401a.lib.



***Note**: Any of the three files listed above will work. Adding one of the HP 34401A instrument driver files loads that instrument driver. View the available functions in the library tree in the workspace window.*

6 Add the following line to your program to include the instrument driver header file:

```
#include "hp34401a.h"
```

Initialize the Instrument

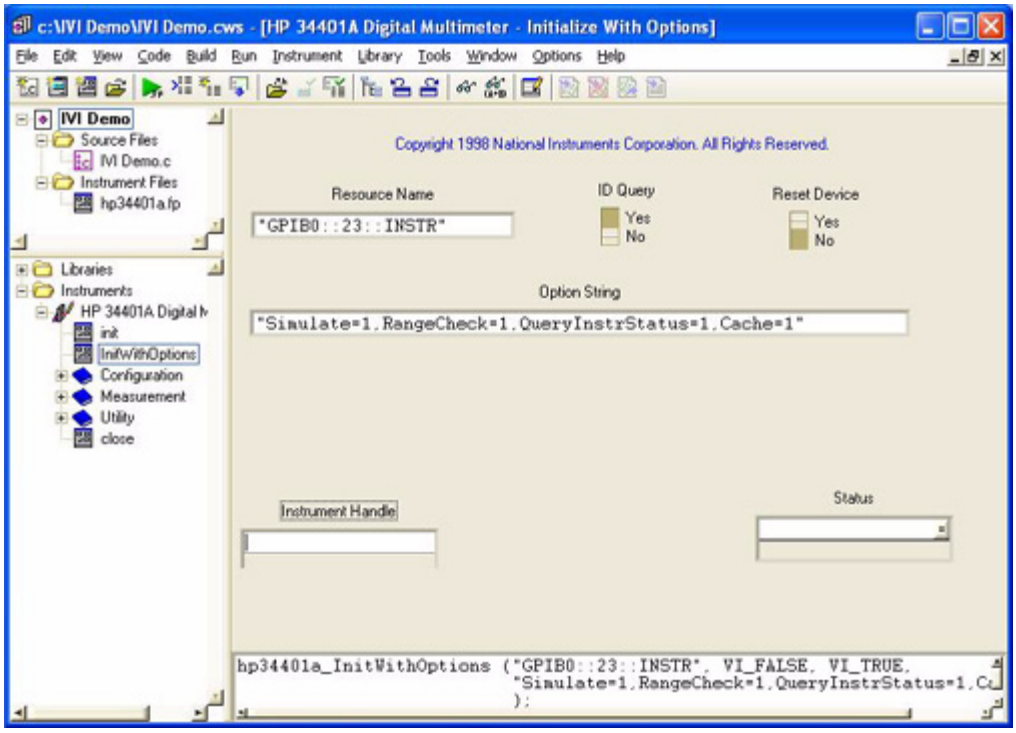
1 From the Edit menu, select Insert Construct, and click Main.

2 Find the hp34401a instrument driver in the instrument driver tree. Select Initialize with Options from the library tree. The Initialize with Options function panel opens.

3 Enter values for Resource Name, ID Query, Reset Device, and Option String:

- **GPIB0::23::INSTR** in the Resource Name field
- **No** for ID Query control
- **Yes** for Reset Device control
- **Simulate=1** in the Options field

***Note:** The RangeCheck, QueryInstrStatus, and Cache options appear automatically. The options are enabled by default.*



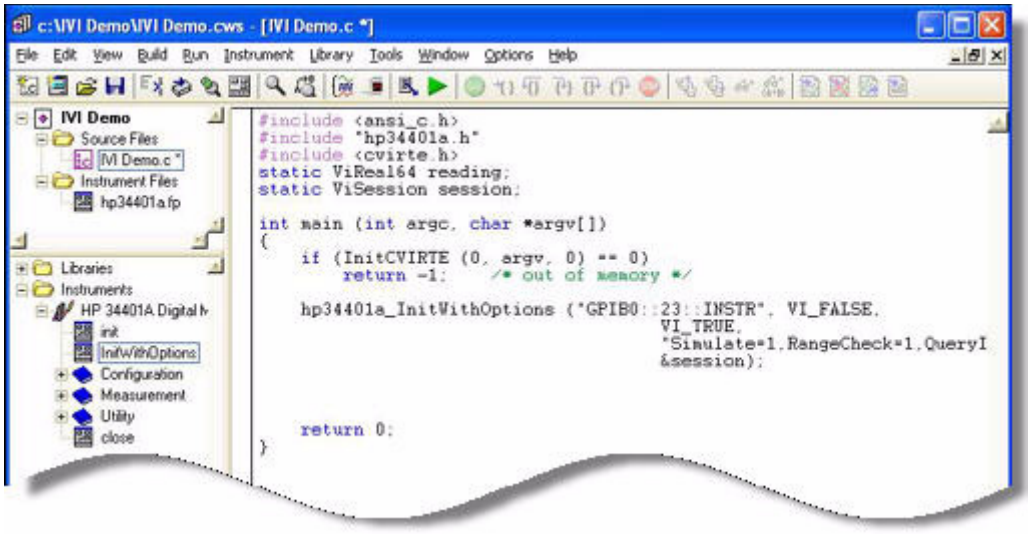
4 Select the Instrument Handle parameter. From the Code Menu, click Declare Variable to set the Instrument Handle parameter.

5 Enter **session** in the Variable Name field.

6 Check the boxes titled Execute declaration in Interactive Window and Add declaration to top of target file “*.c”. Click OK.

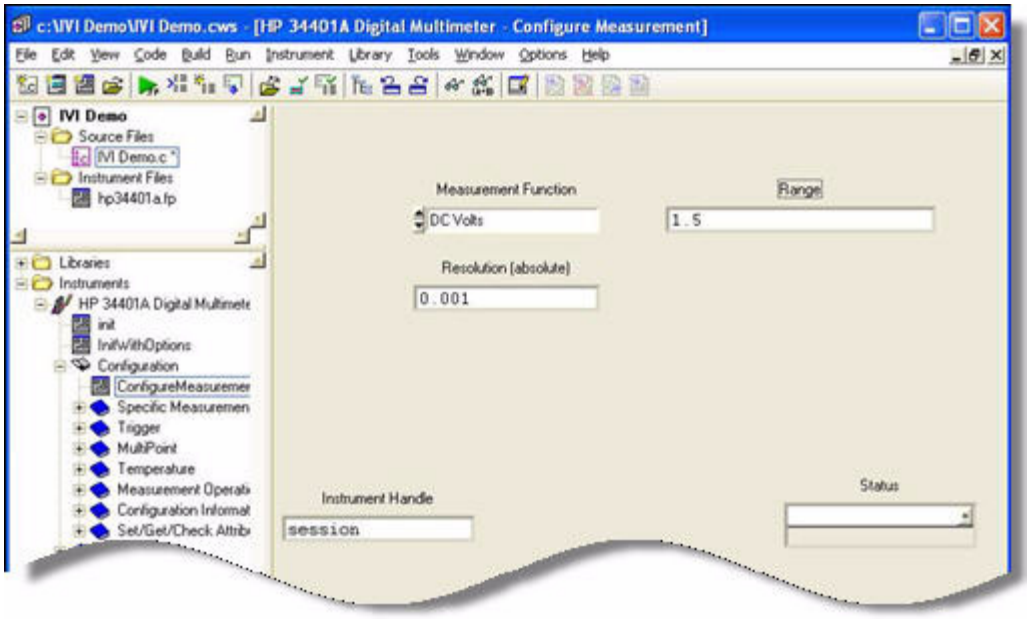
Note: *To test the function with the specified parameter values, select Code and click Run Function Panel or click the run button in the toolbar to operate the function panel interactively.*

7 From the Code Menu, click Insert Function Call to insert the function and values into your program. Close the function panel. The hp34401a_InitWithOptions function appears in your program.



Configure the Instrument

1. From the library tree, select Configuration and click ConfigureMeasurement. The ConfigureMeasurement function panel opens.
2. Set the function to DC Voltage, range to 1.5 volts, resolution to 1 millivolt, and instrument handle to session. Select and enter:
   - **DC Volts** from the drop-down list in the Measurement Function field,
   - **1.5** in the Range field,
   - **0.001** in the Resolution field, and
   - **session** in the Instrument Handle field.



3 Select the Code menu and click Insert Function Call to insert the function and values into your program. Close the function panel. The hp34401a_ConfigureMeasurement function appears in your program.

4 From the library tree, select Configuration, select Trigger, and click ConfigureTrigger. The Configure Trigger function panel opens.

5 Set the trigger source to immediate, the trigger delay to 0.01 seconds, and the instrument handle to session. Select and enter:

- **Immediate** from the drop-down list in the Trigger Source field
- **0.01** in the Trigger Delay field
- **session** in the Instrument Handle field

6 Select Code and click Insert Function Call to insert the function and values into your program. Close the function panel. The hp34401a_ConfigureTrigger function appears in your program.

Set the Reading Timeout

1 From the library tree, select Measurement and click Read. The Read dialog opens.

2 Set the value for Timeout to 1 second (1000 ms), and instrument handle to session. Enter:

- **1000** in the Read field

- **session** in the Instrument Handle field

Display the Reading

1. Select the Reading parameter.
2. Select Code and click Declare Variable. The Declare Variable dialog appears.
3. Enter **reading** in the Variable Name field.
4. Check the boxes titled Execute declaration in Interactive Window and Add declaration to top of target file “*.c”. Click OK.
5. Select Code and click Insert Function Call to insert the function and values into your program. Close the function panel. The hp34401a_Read function appears in your program.

Close the Session

1. From the library tree, select Close. The Close function panel opens.
2. Enter **session** in the Instrument Handle field.
3. Select Code and click Insert Function Call to insert the function and values into your program. Close the function panel. The hp34401a_Close function appears in your program. Your final program should contain the code below:

```
#include <ansi_c.h>
#include "hp34401a.h"
#include <cvirte.h>
static ViReal64 reading;
static ViSession session;

int main (int argc, char *argv[])
{
     if (InitCVIRTE (0, argv, 0) == 0)
         return -1;    /* out of memory */
     hp34401a_InitWithOptions (
           "GPIB0::23::INSTR", VI_FALSE,
           VI_TRUE, "Simulate=1", &session);
     hp34401a_ConfigureMeasurement (session,
           HP34401A_VAL_DC_VOLTS, 1.5, 0.001);
     hp34401a_ConfigureTrigger (session,
           HP34401A_VAL_IMMEDIATE, 0.01);
     hp34401a_Read (session, 1000, &reading);
     printf ("%f", reading);
     hp34401a_close (session);
     return 0;
}
```

Note: *To display the reading, add a printf function. Before the Close function, type:*

```
printf ("%f", reading);
```

Note: *Including error checking in your programs is good practice. Use the CheckErr macro provided in the ivi.h file to handle errors. See the example included with the hp34401 downloaded driver for error handling demonstration code.*

Further Information

Learn more about LabWindows/CVI at http://www.ni.com/lwcvi/.

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Chapter 6
Using IVI with MATLAB®

The Development Environment

MATLAB from The MathWorks is an interactive software environment for data acquisition and analysis, waveform generation, algorithm creation, and test system development. MATLAB also provides a technical computing language that is designed to help you solve technical challenges faster than with traditional software environments.

MATLAB supports IVI instrument drivers using the Instrument Control Toolbox. The toolbox provides additional MATLAB functionality.

Example Requirements

- MATLAB R2007a
- MATLAB Instrument Control Toolbox
- Agilent 34401A IVI-COM, Version 1.1.0.11, March 2006 (from Agilent Technologies)
- Agilent IO Libraries Suite 14.2

Download and Install the Driver

If you have not already installed the driver, go to the vendor Web site and follow the instructions to download and install it.

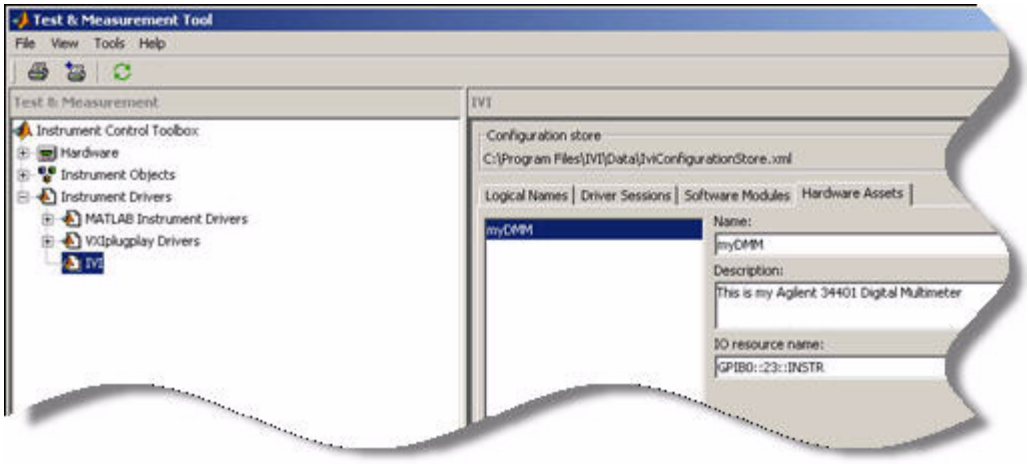
This example uses an IVI-COM driver, MATLAB also supports IVI-C drivers.

Configure the IVI Driver

The Instrument Control Toolbox provides a graphical Test & Measurement Tool that enables you to interact with instrument drivers and instruments without writing MATLAB code. The Test & Measurement Tool lets you configure IVI driver properties in MATLAB and store them in the IVI configuration store.

1. At the MATLAB command line, type `tmtool` to launch the Test & Measurement Tool GUI. Or from the MATLAB Main Menu, select Toolboxes, then Instrument Control Toolbox and click Test & Measurement Tool. The Test & Measurement Tool GUI opens.
2. In the tree at left, click the *IVI* node under the *Instrument Drivers* node.
3. Select the *Hardware Assets* tab. In the Hardware Assets dialog, select Add and enter the following:

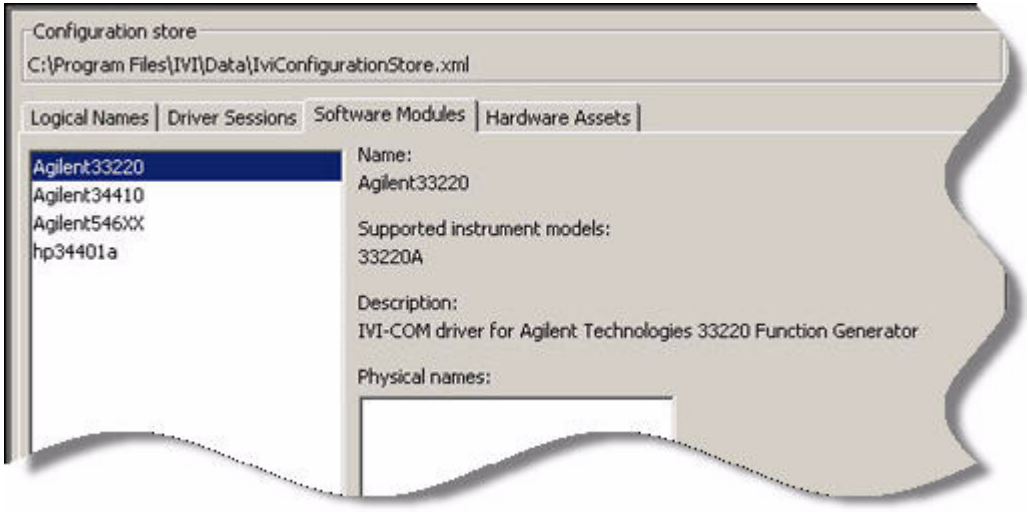
- **myDMM** in the Name field
- **This is my Agilent 34401 Digital Multimeter** in the Description field (optional)
- **GPIB0::23** in the IO Resource name field



4 Select the *Software Modules* tab. The installed IVI drivers appear.

Note: *If you have not installed the IVI driver, it will not appear in this list. You must close MATLAB, install the driver, and restart MATLAB for the driver to appear.*

5 Select Agilent34401 from the drop-down list. The Software Modules dialog lists the module name, supported instrument models, and description.



Next, you must define your Driver Session to link the Software Module with the Hardware Asset and indicate whether you want to use Simulation Mode or other optional parameters when connecting.

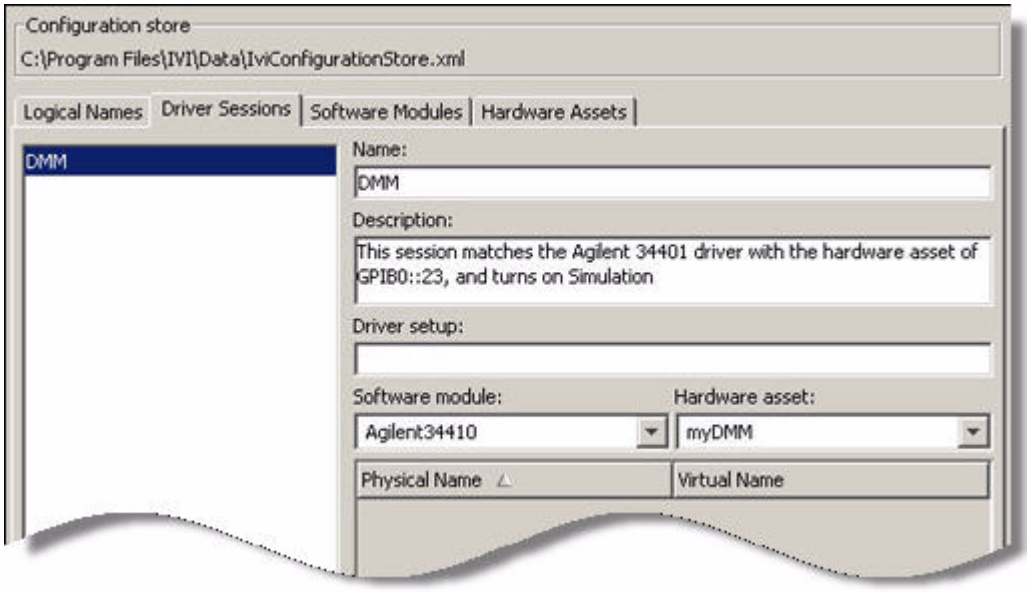
6 Select the *Driver Sessions* tab. In the Driver Sessions dialog, select Add and enter the following:

- **DMM** in the Name field
- **This session matches the Agilent 34401 driver with the hardware asset of GPIB0::23, and turns on Simulation mode of the driver** in the Description field (optional)

7 Select Agilent34401 in the Software module drop-down list.

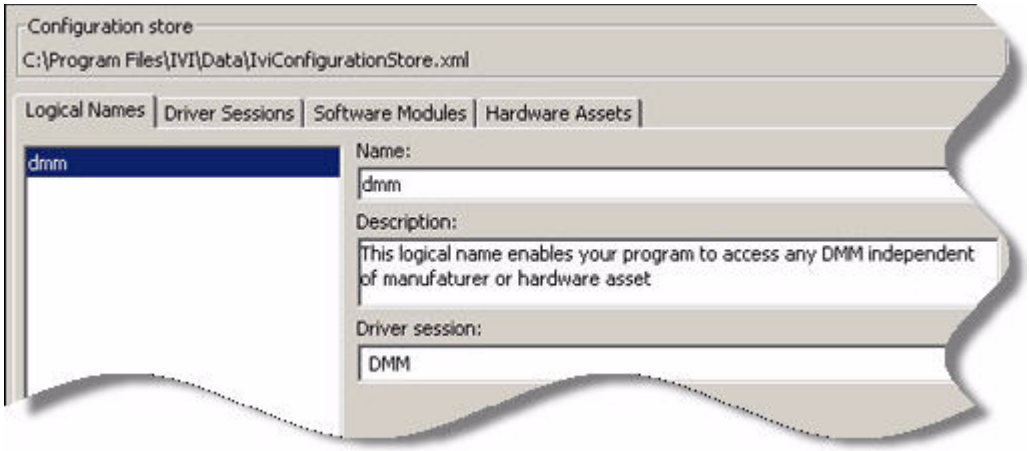
8 Select myDMM in the Hardware asset drop-down list.

9 Check Simulate in the options.



10 Select the *Logical Names* tab. In the Logical Names dialog, select Add and enter the following:

- **dmm** in the Name field
- **This logical name enables your program to access any DMM independent of manufacturer or hardware asset** in the Description field (optional)
- **DMM** in the Driver session field



11 Select *File* and *Save IVI Configuration Store*. Saving to the store may take several moments.

12 Close the Test & Measurement Tool.

Generate an Instrument Wrapper

We will now automatically generate an instrument driver wrapper file (.mdd) so that MATLAB can use the IVI driver.

At the MATLAB command prompt, type

```
makemid('dmm');
```

The file `dmm.mdd` appears in the current directory window. This is the instrument wrapper created by the `makemid` command. You may now use MATLAB to communicate with your instrument through an IVI driver.

Note: *To help you learn the structure of a driver faster, MATLAB provides autocompletion support. As you are typing your commands for a driver, press the Tab key to get a selection of possible completions. You can also use the command "get" to see a list of possible properties and "methods" to get a list of methods on the object. "methodsview" will give you a graphical display of the methods also.*

Configure and Control the Instrument

You can interact with the instrument by using the Test & Measurement Tool or the MATLAB command line. We use the MATLAB command line here.

Note: *All MATLAB methods and properties are available at the command line.*

Create an Instance of the Instrument

To create an instance of the instrument, type

```
myDmm = icdevice('dmm');
```

Connect to the Instrument

Similar to the Initialize command in most ADEs, the Connect command in MATLAB initializes the instrument. The instrument will be initialized with the properties you specified using the Test & Measurement Tool. Type

```
connect(myDmm);
```

Configure the Instrument

To set a range of 1.5 volts and resolution of 0.001 volts, type

```
myDmm.Range = 1.5;
myDmm.Resolution = 0.001;
```

Set the Trigger Delay

To set the trigger delay to 0.01 seconds, type

```
myDmm.Trigger.Delay = 0.01;
```

Set Reading Timeout

To take a reading with a timeout of 1 second, type

```
myDmm.Timeout = 0.01;
```

Display Reading

To display the reading, type

```
data = invoke(myDmm.Measurement,'Read',1000)
```

Disconnect from the Instrument

Similar to the Close() command in most ADEs, the Disconnect command in MATLAB closes the instrument. To disconnect, type

```
disconnect(myDmm);
```

Remove the Driver from Memory

To remove any reference to the driver from memory, type

```
delete(myDmm);
```

Your final application should contain the code below:

```
>> myDmm = icdevice('dmm');
>> connect(myDmm)
>> myDmm.Range = 1.5;
>> myDmm.Resolution = 0.001;
>> myDmm.Trigger.Delay = 0.01;
>> myDmm.Timeout = 0.01;
>> data = invoke(myDmm.Measurement,'Read',1000)

data =

    0.5116

>> disconnect(myDmm);
>> delete(myDmm);
```

Further Information

To learn more about using MATLAB with IVI instrument drivers, visit:
http://www.mathworks.com/ivi

Chapter 7
Using IVI with Measure Foundry®

The Environment

Measure Foundry is a visual software environment for creating test and measurement, control, and analysis applications. The design environment consists of forms and the foundry window. You choose components from the foundry window and drop them onto your form. Clicking on the components accesses property pages where you can set design, configuration, and connectivity. This enables fast application development.

Each application consists of three primary elements:

- a data source supplies data to the application
- a control source determines how and when the data is used
- a data sink receives data to process or display

Example Requirements

- Measure Foundry 5
- Agilent 34401A IVI-COM, Version 1.1.0.11, March 2006 (from Agilent Technologies)
- Agilent IO Libraries Suite 14.2

Download and Install the Driver

If you have not already installed the driver, go to the vendor Web site and follow the instructions to download and install it. You can also refer to Chapter 1, Download and Install IVI Drivers.

This example uses an IVI-COM driver. IVI-COM is the preferred driver for Measure Foundry. IVI-C is not supported.

***Note**: You cannot specify an instrument in Measure Foundry unless you have already installed the appropriate driver. If you need to download and install a driver, you do not need to exit Measure Foundry. Install the driver and it appears in the list of available devices.*

Data Source

The property pages contain all the information necessary to create an instance of the driver, initialize and configure the instrument, set the trigger delay and reading timeout, and close the instrument.

1 Launch Measure Foundry.

2 Select File and Click New. The New Project screen opens.

3 In the Foundry window, select All Components. Enter IVI in the Search field.

4 Select the LXI IVI Dmm component, drag it to the Form, and drop it.

5 Double-click the LXI component. The Properties dialog appears.

***Note**: The Properties dialog lets you access functions based on the purpose of your test.*

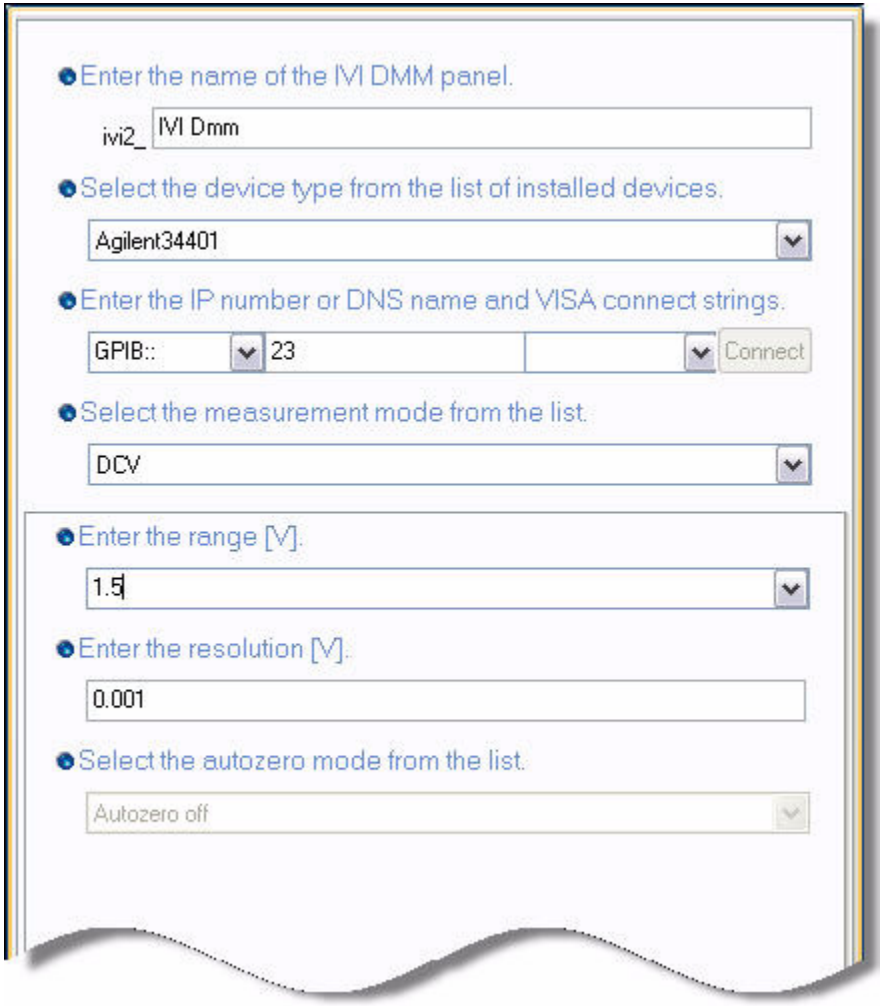
6 Configure the IVI DMM. To initialize the DMM and set the range to 1.5 volts and resolution to 1 millivolt, enter the following In the Properties dialog:

- **IVI Dmm** in the IVI DMM panel field
- **Agilent34401** in the device type field
- **GPIB** and **23** in the VISA connect string field
- **DCV** in the measurement mode field
- **1.5** in the range field

- **0.001** in the resolution field

Note: *Capabilities that are unavailable are grayed out.*

7 Click Next.



8 Configure the operating mode. Select **Auto refresh** and enter **1000** in the update rate field.

9 Click Next.

10 Configure the trigger delay. In the Properties dialog, enter **0.01** in the trigger delay field and **Immediate** in the trigger source field.

11 Click Next.

12 Configure the option string, reset, and reading timeout to 1 second. In the Properties dialog, enter the following:

- **Simulate=true** in the IVI connect option string
- **1000** in the timeout field
- Check the Reset on Connect box

13 Click Next.

Control Source

The property pages contain the information necessary to label the button and specify how it controls the program.

1 In the Foundry window, select Application Control. Drag and drop the Control Button to the form.

2 Double-click the Control Button. The Properties of Control Button dialog appears.

3 Enter **Start/Stop** in the text field.

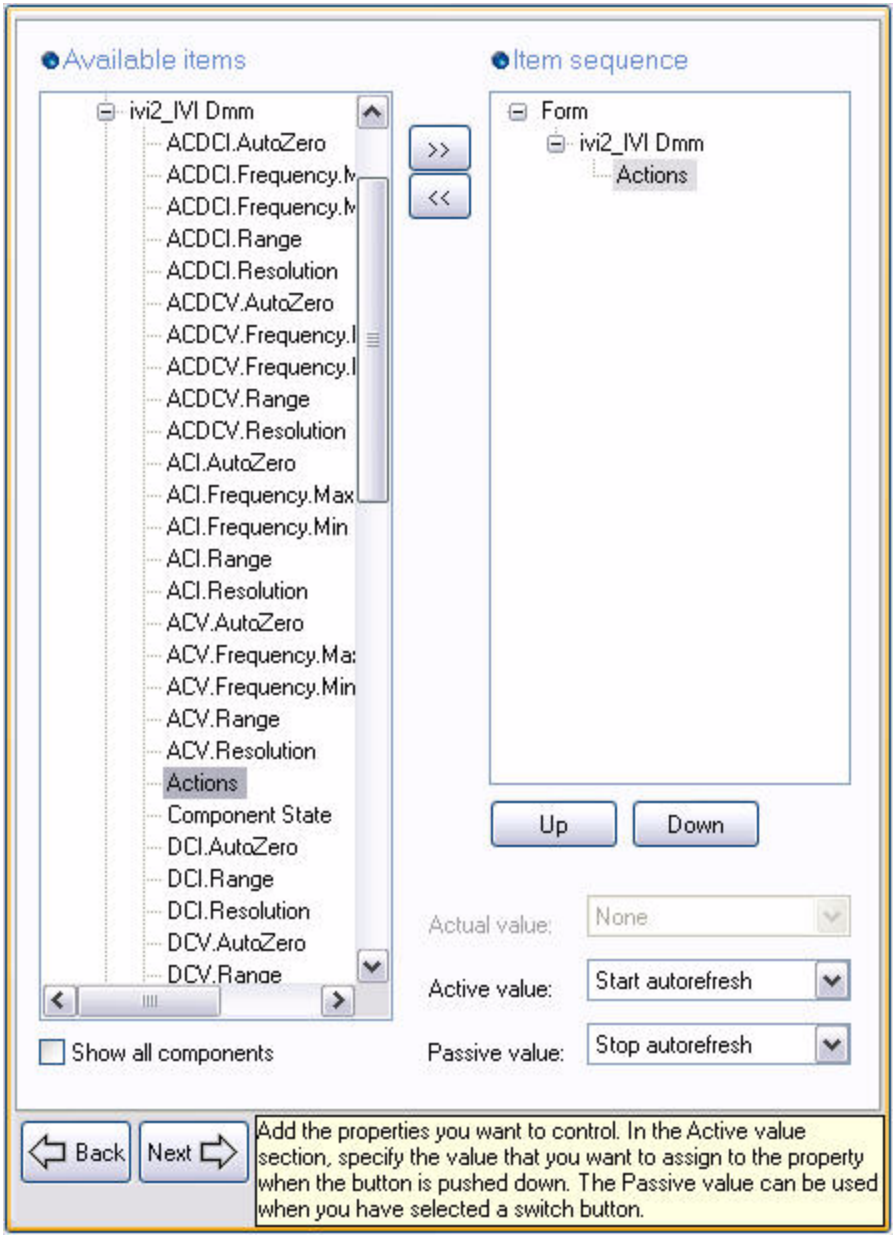
4 Select the switch button type and click Next.

5 Scroll the list of Available items for the IVI Dmm and click Actions.

6 Select Actions and click the double arrow to add to Item sequence.

7 Select Start autorefresh from the drop-down list in Active value.

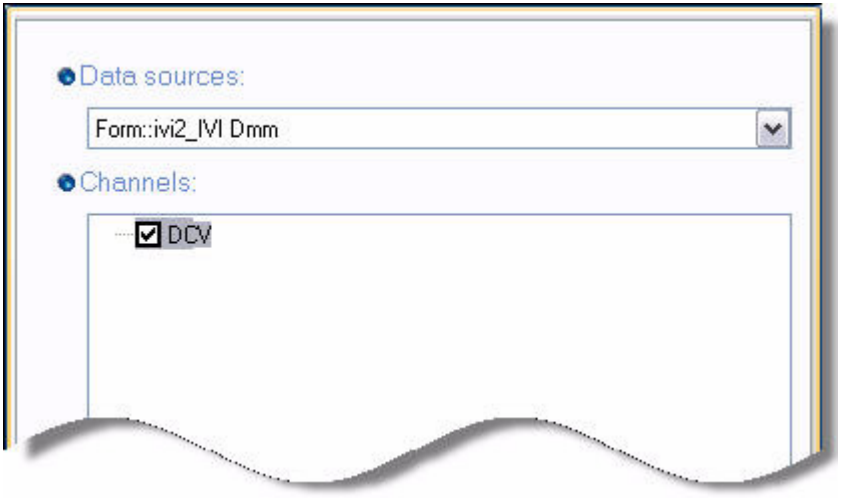
8 Select Stop autorefresh from the drop-down list in Passive value.


Available items
ivi2_IVI Dmm
ACDCI.AutoZero
ACDCI.Frequency.M
ACDCI.Frequency.M
ACDCI.Range
ACDCI.Resolution
ACDCV.AutoZero
ACDCV.Frequency.I
ACDCV.Frequency.I
ACDCV.Range
ACDCV.Resolution
ACI.AutoZero
ACI.Frequency.Max
ACI.Frequency.Min
ACI.Range
ACI.Resolution
ACV.AutoZero
ACV.Frequency.Ma:
ACV.Frequency.Min
ACV.Range
ACV.Resolution
Actions
Component State
DCI.AutoZero
DCI.Range
DCI.Resolution
DCV.AutoZero
DCV.Range
>>
<<
Item sequence
Form
ivi2_IVI Dmm
Actions
Up
Down
Actual value:
None
Active value:
Start autorefresh
Passive value:
Stop autorefresh
Show all components
Back
Next
Add the properties you want to control. In the Active value section, specify the value that you want to assign to the property when the button is pushed down. The Passive value can be used when you have selected a switch button.

Data Sink

The property pages contain all the information necessary to display the output.

1. In the Foundry window, select Display Components. Drag and drop the Single Value Label onto the form.
2. Double-click the Single Value Label. The Properties of Single Value Label dialog appears.
3. Scroll the list of Data sources and click Form:ivi2_IVI Dmm.
4. Check the box by DCV in the Channels field.



Compile and Run

The final program contains the IVC Dmm LXI component (data source), Start/Stop button (control source), and Single Value Label (data sink). From the Start Menu, click Compile and Run to check that your program runs.

Close Session

To close the session and release the driver, either exit the program or program a Control Button to set the Disconnect property to true in the IVI DMM component.

Further Information

Learn more about the Measure Foundry at
http://www.datatranslation.com/products/measurefoundry/.

Chapter 8
Using IVI with PAWS

The Environment

PAWS Developer's Studio gives you the capability to edit, compile, modify, debug, document, execute, and simulate the test procedures developed in Abbreviated Test Language for All Systems (ATLAS) in the Windows NT/2000/XP Platform environment. PAWS supports a full range of the most commonly used ATLAS Language subsets. A PAWS Toolkit can modify the ATLAS Language subset to meet a particular Automatic Test Equipment (ATE) configuration. Its output can be executed on the associated Debugging PAWS/RTS run-time system or can be translated to run on your unique run-time system.

Creation of a PAWS project typically consists of three main steps:

- Prepare the PAWS environment
- Connect to the instrument driver
- Prepare the run-time system environment and run the project

Example Requirements

- TYX PAWS Studio 1.34.6
- Microsoft Visual Studio
- Agilent 34401A IVI-COM, Version 1.1.0.11, March 2006 (from Agilent Technologies)
- Agilent IO Libraries Suite 14.2

Download and Install the Driver

If you have not already installed the driver, go to the vendor Web site and follow the instructions to download and install it. You can also refer to Chapter 1, Download and Install IVI Drivers, for instructions.

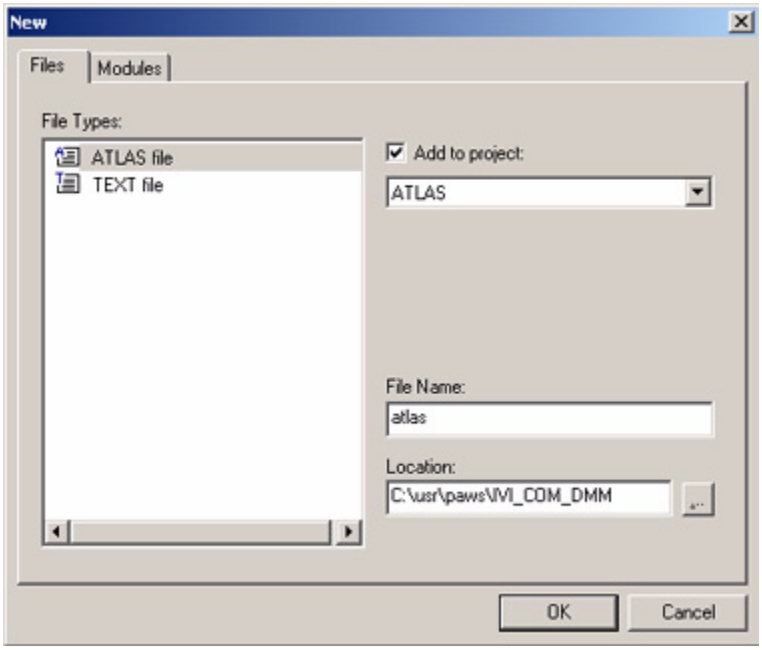
This example uses an IVI-COM driver. PAWS supports both IVI-COM and IVI-C drivers.

***Note**: If you do not install the appropriate instrument driver, the project will not build because the referenced files are not included in the program. If you need to download and install a driver, you do not need to exit PAWS Studio. Install the driver and continue with your program.*

Prepare the PAWS Environment

To use an IVI Driver in PAWS, you must first prepare the PAWS environment.

1. Launch PAWS Studio and create a new project. In the New PAWS Project dialog, enter a project name and directory for the project. Click OK.
2. To add a new file to the ATLAS Project Module, from the Main Menu select File and click New File. The New dialog appears.
3. Select ATLAS file. Check the option to add the file to the project.
4. Enter **atlas** in the File Name field. Click OK. The atlas.atl file appears.



5. Insert the following code in the atlas.atl file and save it:

```
001000 BEGIN, ATLAS PROGRAM 'IVI-COM DMM'                    $
001010 REQUIRE, 'DMM-DC-VOLTS', SENSOR(VOLTAGE), DC SIGNAL,
            CONTROL, VOLTAGE RANGE -300 V TO 300 V,
            MAX-TIME RANGE 1 SEC TO 5 SEC,
           CNX HI LO                                        $
C$
 001110 DECLARE, VARIABLE, 'MEASURED' IS DECIMAL             $
```

```
C$
E02000 OUTPUT, C'\LF\ATLAS PROGRAM STARTS HERE\LF\'          $
C$
 002200 VERIFY, (VOLTAGE INTO 'MEASURED'),
                DC SIGNAL USING 'DMM-DC-VOLTS',
          NOM 0 V UL 0.5 V LL -0.5 V,
          VOLTAGE RANGE -0.5 V TO 0.5 V,
                MAX-TIME 5 SEC,
               CNX HI X20-2 LO X20-3                        $
 002300 OUTPUT, C'DC VOLT MEASUREMENT 1 = ', 'MEASURED', C'
VDC'  $
C$
 999000 OUTPUT, C'\LF\ATLAS PROGRAM ENDS HERE\LF\'           $
C$
 999999 TERMINATE, ATLAS PROGRAM 'IVI-COM DMM'               $
```

6 To add a Device Database Module, from the Main Menu select File and click New Module.

7 Select DEVICEDB and click OK.

8 To add a new file to the DEVICEDB Project Module, from the Main Menu select File and click New File. The New dialog appears.

9 Select DEVICE file. Check the option to add the file to the project.

10 Enter **dmm** in the File Name field. Click OK.

11 In the PAWS Project window, select the file dmm.ddb.

12 Insert the following code in the dmm.dbb file and save it:

```
begin dev DMM;

      cnx hi DMM-Hi, lo DMM-Lo;

   begin FNC = 101; ** DC Voltage Measurement
         sensor(voltage)dc signal;
         control
         {
               voltage range -300 v to 300 v continuous;
```

```
        }
    end; ** DC Voltage Measurement


    end; *end dmm
```

Note: *To understand the file contents, refer to the Paws Studio online help.*

13 To build the project, from the Main Menu select Build and click Rebuild All.

Add the WCEM Interface Functions

The WCEM interface C++ functions are invoked by the ATLAS code. These C++ functions include the IVI-COM calls to control the instrument.

1 From the Main Menu, select File and click New Module. The New dialog appears.

2 Select CEM and enter **WCEM** in the Module Name field. Click OK.

3 From the Main Menu, select View and click CEM Wizard. The CEM Wizard dialog appears.

4 Click on the Advanced tab. The CEM Wizard Advanced Settings dialog appears.

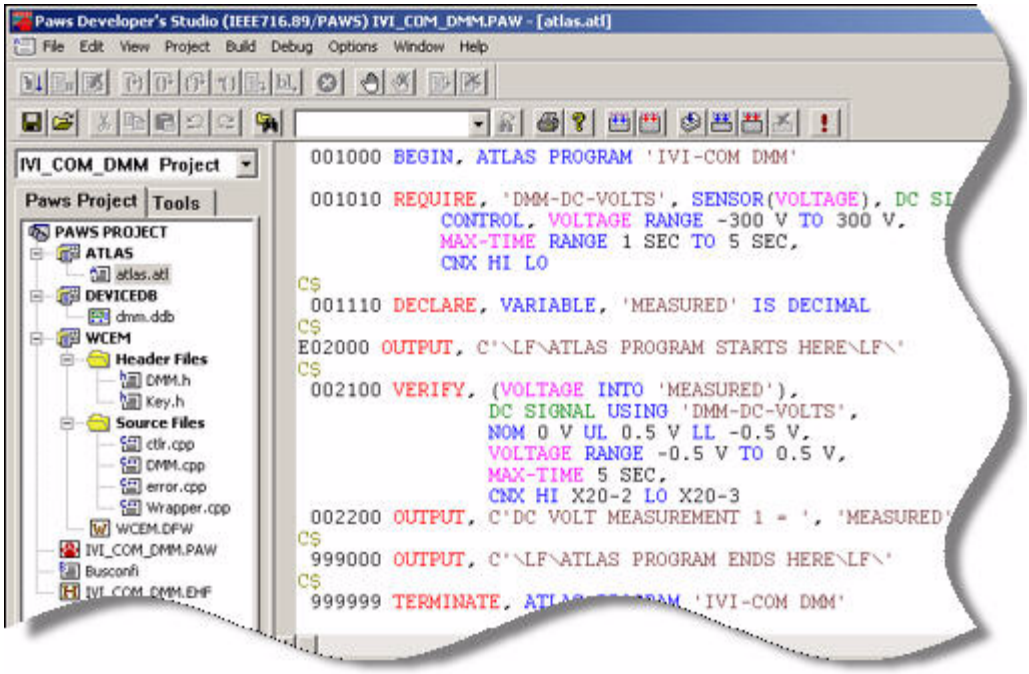
5 Check Open, Unload and Disable CEM Logging. Click OK. The CEM Wizard dialog appears.

6 Right-click on DMM and click on Add Interface Function. The Add Function(s) to Action(s) dialog appears.

7 For Setup, select Setup in the Action(s) dialog and enter **DMM_Setup** in the User Function Name(s) field. Click OK.

8 For Fetch and Init, select the appropriate action in the Action(s) dialog and enter **DMM_Fetch** and **DMM_Init** in the User Function Name(s) field. Click OK.

Note: *This will add several files to your WCEM module: ctrl.cpp, DMM.cpp, Error.cpp, Wrapper.cpp, and Key.h. ctrl.cpp includes the doOpen and doUnload functions. Dmm.cpp includes the three DMM_ functions.*



9 To add a new *.h file called DMM.h to include the code necessary to reference the driver header files and librairies , right-click on the WCEM module.

10 Select Add New File to Module. The New dialog appears.

11 Select CEM header file and check Add to Project.

12 Enter **DMM** in the File Name field. Click OK.

Connect to the IVI-COM Driver

1 From the PAWS Project window, select the DMM.h file. Insert the following code in the DMM.h file:

```
#ifndef __DMM_h__
#define __DMM_h__


#include <atlbase.h>


#include "Visacom_i.c"
#import "IviDriverTypeLib.dll" named_guids,
raw_interfaces_only, raw_native_types no_namespace
```

```
#import "IviDmmTypeLib.dll" named_guids,
raw_interfaces_only, raw_native_types no_namespace

#import "Agilent34401.dll" named_guids, raw_interfaces_only,
raw_native_types no_namespace


#endif
```

Note: *This header file allows access to the COM, IVI-specific, and device environments.*

2 From the PAWS Project window, select the ctrl.cpp file. Insert the following code in the ctrl.cpp file directly below #include "key.h" code:

```
#include "DMM.h"


extern CComPtr<IAgilent34401> driver;

extern CComPtr<IAgilent34401DCVoltage> pDMMDCVolt;

extern CComPtr<IAgilent34401Trigger> pDMMTrig;

extern CComPtr<IAgilent34401Measurement> pDMMData;


extern HRESULT hr;
```

3 From the PAWS Project window, select the DMM.cpp file. Insert the following code in the DMM.cpp file directly below #include "key.h" code:

```
#include "DMM.h"


CComPtr<IAgilent34401> driver;

CComPtr<IAgilent34401DCVoltage> pDMMDCVolt;

CComPtr<IAgilent34401Trigger> pDMMTrig;

CComPtr<IAgilent34401Measurement> pDMMData;


HRESULT hr;
```

4 To create the driver object and open an I/O session to the instrument with the Initialize method, select the ctrl.cpp file from the PAWS Project window.

Note: *To determine the syntax for the commands you want to use in your program, consult the driver help file.*

5 In the doOpen() interface function, insert the following code below the line Please insert your CEM driver code here:

```
hr = driver.CoCreateInstance(CLSID_Agilent34401);
if (FAILED(hr))
{
   Display("\033[30;41m Bad return from
   CoCreateInstance() method\033[m\n");
}

hr = driver->Initialize(CComBSTR("GPIB0::23::INSTR"),
                        VARIANT_FALSE,
                        VARIANT_TRUE,
                        CComBSTR("Simulate=TRUE"));
if (FAILED(hr))
{
   Display("\033[30;41m Bad return from Initialize()
   method\033[m\n");
}
```

Note: *doOpen is called for the first time when the run-time system loads the PAWS project. If you intend to use non-ATLAS modules in your ATLAS code, subsequent calls to doOpen will be made and you will need to execute the code above only once.*

6 To set the function for DC Voltage, the range to 1.5 volts, and the resolution to 1 millivolt, select the DMM.cpp file from the PAWS Project window.

7 In the `DMM_Setup()` interface function, insert the following code below the line Please insert your CEM driver code here：

```
hr = driver->put_Function(Agilent34401FunctionDCVolts);
if (FAILED(hr))
{
   Display("\033[30;41m Bad return from
   put_Function(Agilent34401FunctionDCVolts)method\033[m\n"
   );
}
hr = driver->get_DCVoltage(&pDMMDCVolt);
```

```
if (FAILED(hr))
{
   Display("\033[30;41m Bad return from
   get_DCVoltage(&pDMMDCVolt) method\033[m\n");
}
hr = pDMMDCVolt->Configure(1.5, 0.001);
if (FAILED(hr))
{
   Display("\033[30;41m Bad return from >Configure(1.5,
   0.001) method\033[m\n");
}
```

8 To set the trigger delay to 0.01, select the DMM.cpp file from the PAWS Project window.

9 In the `DMM_Init()` interface function, insert the following code below the line Please insert your CEM driver code here：

```
hr = driver->get_Trigger(&pDMMTrig);
if (FAILED(hr))
{
   Display("\033[30;41m Bad return from
   get_Trigger(&pDMMTrig)  method\033[m\n");
}
hr = pDMMTrig->Configure(Agilent34401TriggerSourceImmediate,
0.01);
if (FAILED(hr))
{
   Display("\033[30;41m Bad return from
   Configure(Agilent34401TriggerSourceImmediate, 0.01)
   method\033[m\n");
}
hr = driver->get_Measurement(&pDMMData);
if (FAILED(hr))
{
   Display("\033[30;41m Bad return from
   get_Measurement(&pDMMData) method\033[m\n");
}
```

```
hr = pDMMData->Initiate();
if (FAILED(hr))
{
   Display("\033[30;41m Bad return from Initiate()
   method\033[m\n");
}
```

10 To set the reading timeout to 1 second, select the DMM.cpp file from the PAWS Project window.

11 In the `DMM_Fetch()` interface function, insert the following code below the line Please insert your CEM driver code here：

```
   double Data = 0;
DATUM *fdat;

hr = pDMMData->Fetch(1000, &Data);
if (FAILED(hr))
{

   Display("\033[30;41m Bad return from Fetch(1000,
   &Data) method\033[m\n");
}

fdat = FthDat();
DECDatVal(fdat, 0) = Data;
FthCnt(1);
```

Note: *The first argument in the* ***Fetch*** *method specifies how long to wait in the* ***Fetch*** *operation since it is possible that no data is available or the trigger event did not occur. The second parameter contains the actual reading or a value indicating that an over-range condition occurred.*

12 To conserve resources, you should close the driver session. From the PAWS Project window, select the ctrl.cpp file.

13 In the doUnload() interface function, insert the following code below the line // Please insert your CEM driver code here:

```
hr = driver->Close();
if (FAILED(hr))
{
   Display("\033[30;41m Bad return from Close()
   method\033[m\n");
```

```
}


driver.Release();
pDMMData.Release();
pDMMTrig.Release();
pDMMDCVolt.Release();
```

Note: *The function doUnload gets called only once, when the Paws project is unloaded from the run-time system.*

Build the Project

1. From the Main Menu, select Options and click on CEM. The WCEM dialog appears.
2. Select the Files tab and enter C:\Program Files\IVI\Include in the Include Path field. Click Apply.

   Note: *The path includes the Visacom_i.c file from the DMM.h header.*
3. From the Main Menu, select Build and click on Rebuild All. The Output area appears with a message that indicates the project was successfully built.

   Note: *Most of the IVI-COM driver methods return HRESULT value, which is used in this example across the entire driver implementation for error handling. Error handling code is recommended as you develop a PAWs application. In our example, the error handling code begins with if (FAILED(hr)) and ends with the } after the Display line for most of the methods.*

Prepare the Run-Time System Environment

1. In the Project Workspace area, double-click on the Busconfi. The DMM name in a Busconfi file corresponds to the name defined in the dmm.ddb file following the `begin dev` statement.
2. Set the Listen Address MLA and Talk Address MTA to the device address of 23.
3. The Bus number must correspond to the Channel number.

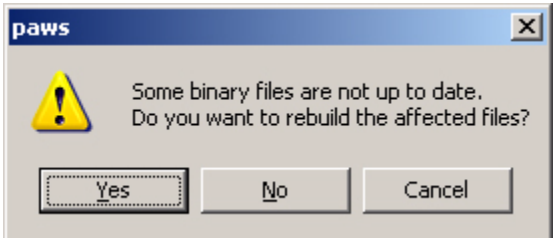
   The Busconfi code should appear as below:

```
;       IEEE-488 Bus Configuration File -


"Channel"        1


DMM BUS 1       MLA 23       MTA 23
```

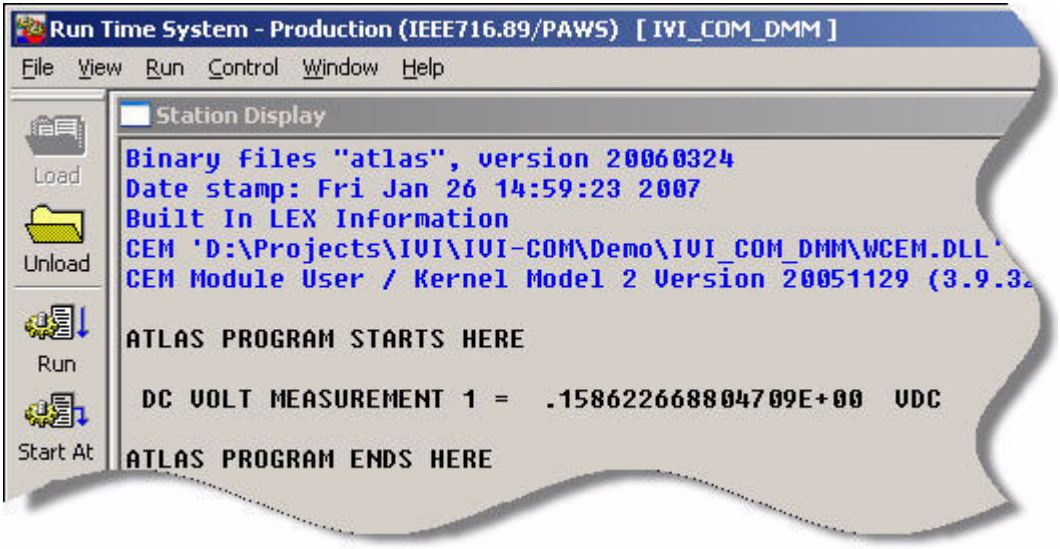
Load and Run the Project

1 From the Main Menu, select Build and click on Execute Wrts.

***Note**: The message below may appear before invoking the Run-Time system interface. This message usually appears when you have changed the code without recompiling it. Click Yes to let the project be rebuilt before execution. If you make changes to the Busconfi file only, you do not need to rebuild the project, because it is used as a reference file at run-time.*



2 From the list at left, select Run. The program runs and returns a DC Voltage measurement.



3 From the Main Menu, select File and click Exit to exit from the Run-Time system.

Further Information

Learn more about PAWS at http://www.tyx.com/pawsdeva.html.

Chapter 9
Using IVI with Visual Basic 6.0

The Environment

Visual Basic 6.0 is a programming environment derived from Basic and developed by Microsoft for the Windows operating system. Software vendors and developers use VB to create applications quickly by writing code to accompany on-screen objects such as buttons, windows, and dialog boxes.

This chapter focuses on VB 6.0, which is not the most current version. If you are new to VB, we recommend you refer to Chapter 3, Using IVI with C# and Visual Basic .NET.

Example Requirements

- Visual Basic 6.0
- Microsoft Visual Studio 6.0
- Agilent 34401A IVI-COM, Version 1.1.0.11, March 2006 (from Agilent Technologies)
- Agilent IO Libraries Suite 14.2

Download and Install the Driver

If you have not already installed the driver, go to the vendor Web site and follow the instructions to download and install it. You can also refer to Chapter 1, Download and Install IVI Drivers, for instructions.

This example uses an IVI-COM driver. IVI-COM is the preferred driver for Visual Basic 6.0, but IVI-C is also supported via the inclusion of .bas files.

Create a New Project and Reference the Driver

To use an IVI Driver in a Visual Basic program, you must first create a project and add a reference to the driver.

1. Launch Visual Basic and create a new project using Standard EXE project.

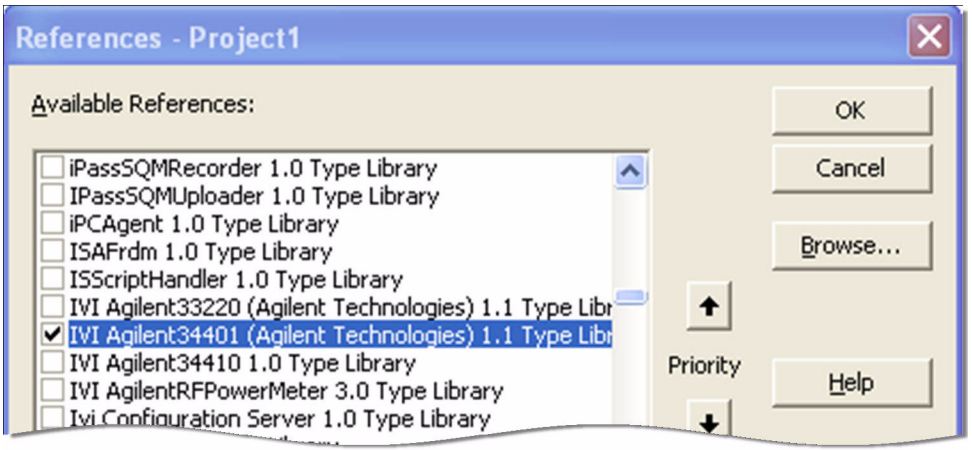
   Note: *This creates a Windows Application program.*

2. From the Start Menu, select Project, and click References. The References dialog appears.

3 Select the IVI Agilent34401 1.1 Type Library from the drop-down list. Place a check in the box next to this driver.

***Note**: If you have not installed the IVI driver, it will not appear in this list. You must close the References dialog, install the driver, and select References again for the driver to appear.*

4 Click OK. The References dialog closes.



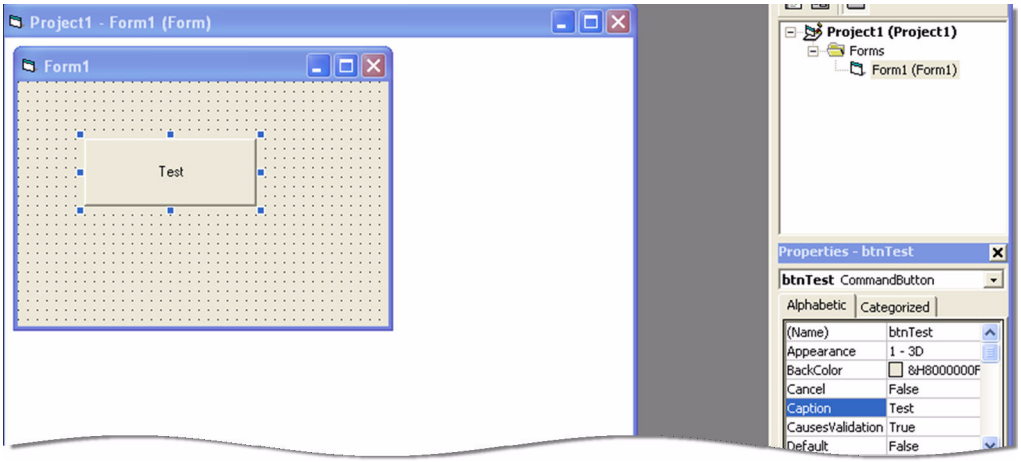
***Note:** You must click OK for Visual Basic to accept the References; however, the software provides no confirmation. You can verify the driver is available for use by opening the Add References dialog and viewing the checked references. All checked references appear near the top of the list.*

Add a Button

1 Click the Command Button in the Toolbox to create a button.

2 Drag the button to the form and drop it.

3 Change the (Name) property to btnTest and the Caption property on the Command1 button to Test in the Properties list at right.



Create an Instance of the Driver

1. Double-click Test. The Project1 – Form1(Code) screen appears. Note that some code has already been added, including `Private Sub btnTest_Click() and End Sub.`
2. To enable strong type checking, at the top of the screen before the `Private Sub` line type
   `Option Explicit`
3. Create a variable for the driver and initialize it with the New statement. On the next line type
   `Dim dmm As New Agilent33401`

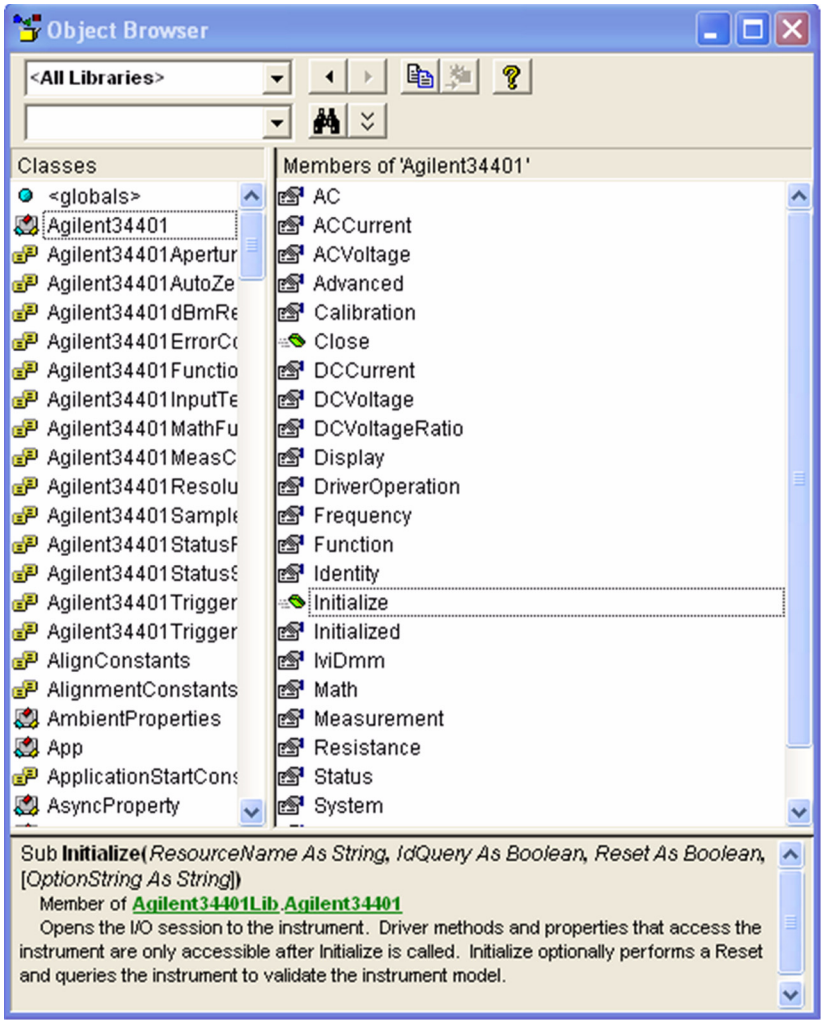
Initialize the Instrument

Now you will enter the code that will execute when you click Test.

On the line after `Private Sub btnTest_Click()`, type `dmm.` Then type `dmm.Initialize "GPIB::23", False, True, "Simulate=True"`

Note: *As soon as you type the period, Intellisense displays the possible methods and properties and helps ensure you use correct syntax and values.*

Note: *From the Start Menu, select View, and click Object Browser to view the functions and parameters available in the instrument driver. Limit the Object Browser to a specific library by selecting it in the top left list box.*



Configure the Instrument

Set the function to DC Voltage, range to 1.5 volts, and resolution to 1 millivolt.

1. Type `dmm.Function = Agilent34401FunctionDCVolts`
2. Type `dmm.DCVoltage.Configure 1.5, 0.001`
3. Select Configure from the drop-down list and press the space bar.

   Note: *The Object Browser shows the parameters and syntax for Configure in the box at bottom, along with a short description.*

4. Type `1.5, 0.001`

Set the Trigger Delay

Set the trigger delay to 0.01 seconds.

```
Type: dmm.Trigger.Delay = 0.01
```

Display the Reading

Set the reading timeout to 1 second and display the reading.

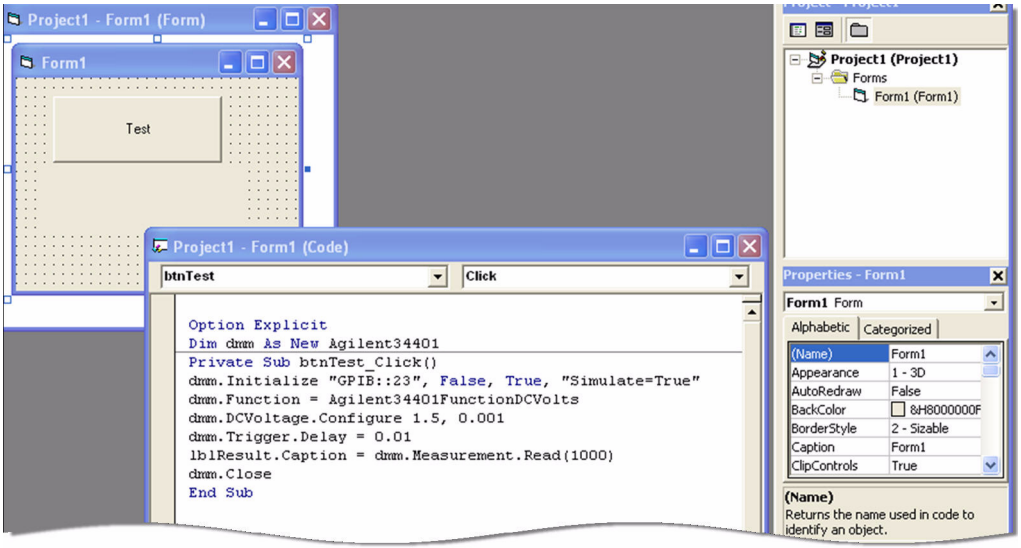
1. Return to the form view and click the Label Button in the Toolbox to create a label.
2. Drag it to the form and drop it.
3. Change the Name to **lblResult** in the Properties list at right.
4. Remove the text under Caption.
5. In the code after the trigger delay command, type
   `lblResult.Caption = dmm.Measurement.Read(1000)`

Close the Session

Type `dmm.Close`

Your final program should contain the code below.

```
Option Explicit

Dim dmm As New Agilent34401

Private Sub btnTest_Click()
dmm.Initialize "GPIB::23", False, True, "Simulate=True"
dmm.Function = Agilent34401FunctionDCVolts
dmm.DCVoltage.Configure 1.5, 0.001
dmm.Trigger.Delay = 0.01
lblResult.Caption = dmm.Measurement.Read(1000)
dmm.Close

End Sub
```



Tips

The Agilent 34401 driver conforms to the IviDmm class, so you can easily write your program to use the class-compliant interfaces instead of the instrument-specific interfaces. You will need to add a Reference to the IviDmm Class Type library for your project to compile. Here is the code:

```
Option Explicit

Dim dmm As New Agilent33401
Dim ividmm As IIviDmm

Private Sub btnTest_Click()

Set ividmm = dmm
ividmm.Initialize "GPIB::23", False, True, "Simu-
late=True"
ividmm.Configure IviDmmFunctionDCVolts, 1.5, 0.001
ividmm.Trigger.Delay = 0.01
lblResult.Caption = ividmm.Measurement.Read(1000)
ividmm.Close

End Sub
```

Further Information

Learn more about Visual Basic at http://msdn.microsoft.com/library/default.asp?url=/library/en-us/dnanchor/html/vb6anchor.asp.

Chapter 10
Using IVI with Agilent VEE Pro

The Development Environment

Agilent Visual Engineering Environment Pro is a graphical programming environment designed to help you quickly create and automate measurements and tests. VEE Pro lets you program by creating an intuitive block diagram. You select and edit objects from pull-down menus and connect them to specify the program flow. VEE Pro also includes Instrument Manager, which facilitates control and management of your devices. Let's see how VEE Pro works with IVI.

Example Requirements

- Agilent VEE Pro 8.0
- Agilent 34401A IVI-COM, Version 1.1.0.11, March 2006 (from Agilent Technologies)
- Agilent IO Libraries Suite 14.2

Download and Install the Driver

If you have not already installed the driver, go to the vendor Web site and follow the instructions to download and install it. You can also refer to Chapter 1, Download and Install IVI Drivers, for instructions.

This example uses the IVI-COM driver. VEE Pro does not support the use of IVI-C drivers through the Instrument Manager.

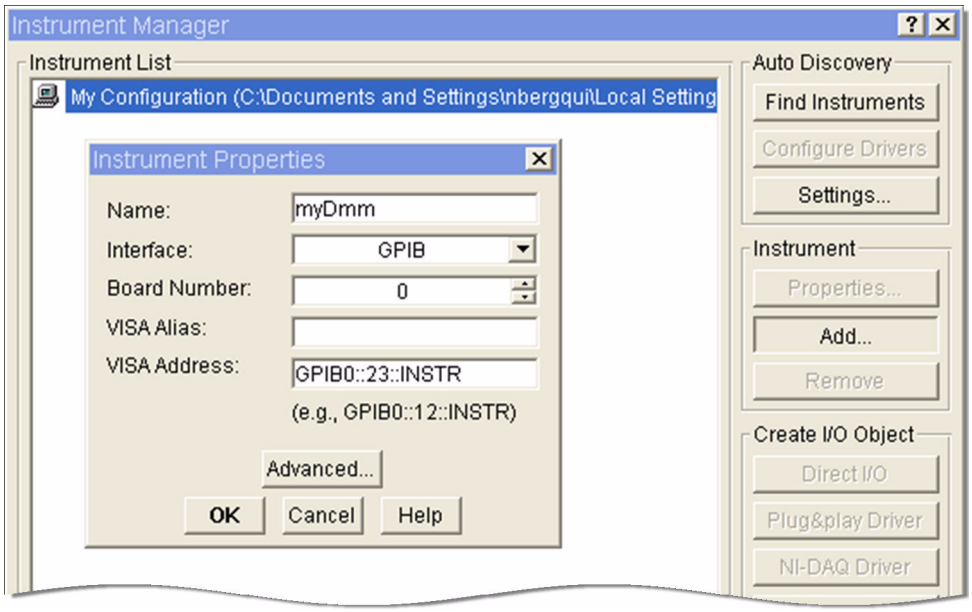
Launch the Instrument Manager and Select the Driver

If you have correctly installed the IVI driver, VEE Pro's Instrument Manager will automatically find it for you.

1. Launch VEE Pro.
2. From the Main Menu, select I/O, and click Instrument Manager.

   ***Note**: If you were connected to a live instrument, you would click the Find Instruments button at the right in this screen and then skip to the next section.*
3. Click Add under instrument in the list at the right to add a simulated instrument. The Instrument Properties dialog box appears.
4. In the Instrument Properties dialog box, enter or select the following:
   - **myDMM** in the Name field
   - **GPIB** in the Interface field
   - **0** in the Board Number field

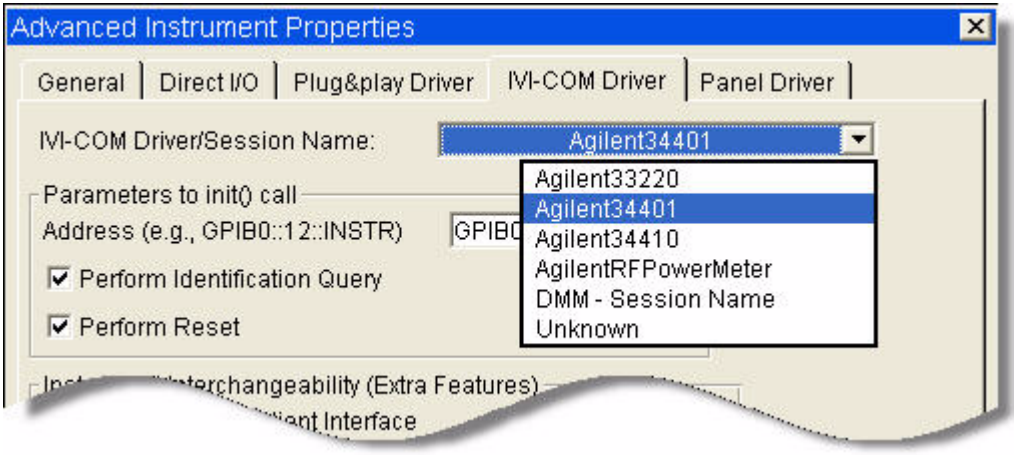
- **GPIB0::23::INSTR** in the VISA Address field



5 Click Advanced. The Advanced Instrument Properties dialog box appears.

6 Click the IVI-COM Driver tab. Select Agilent 34401 from the drop-down list.

***Note**: The VISA address that you entered earlier appears automaticaly in the Address field.*



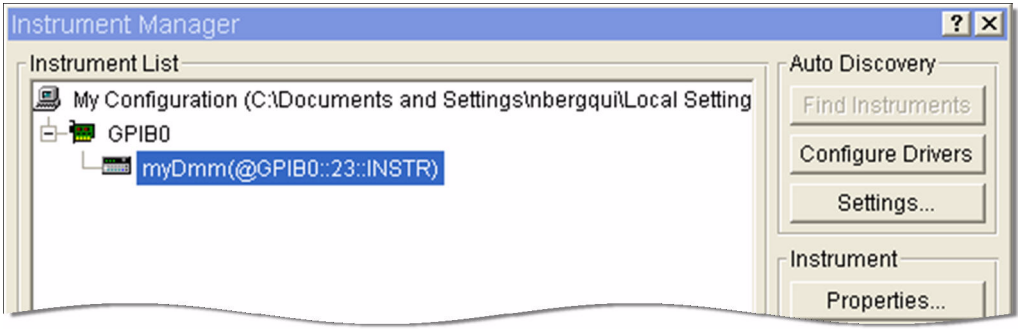
7 Click the IVI-COM Driver tab. Select Agilent 34401 from the drop-down list.

Note: *The VISA address that you entered earlier appears automatically in the Address field.*

8 Click OK. The dialog closes and returns to the Instrument Properties dialog.

9 Click OK. The dialog closes and returns to the Instrument Manager. Congratulations! You can now access the IVI Driver in the Instrument Manager.

Note: *If the driver is correctly installed, the text darkens on the IVI-COM Driver button under Create I/O Object in the list at the right.*



Create an Instance of the Driver

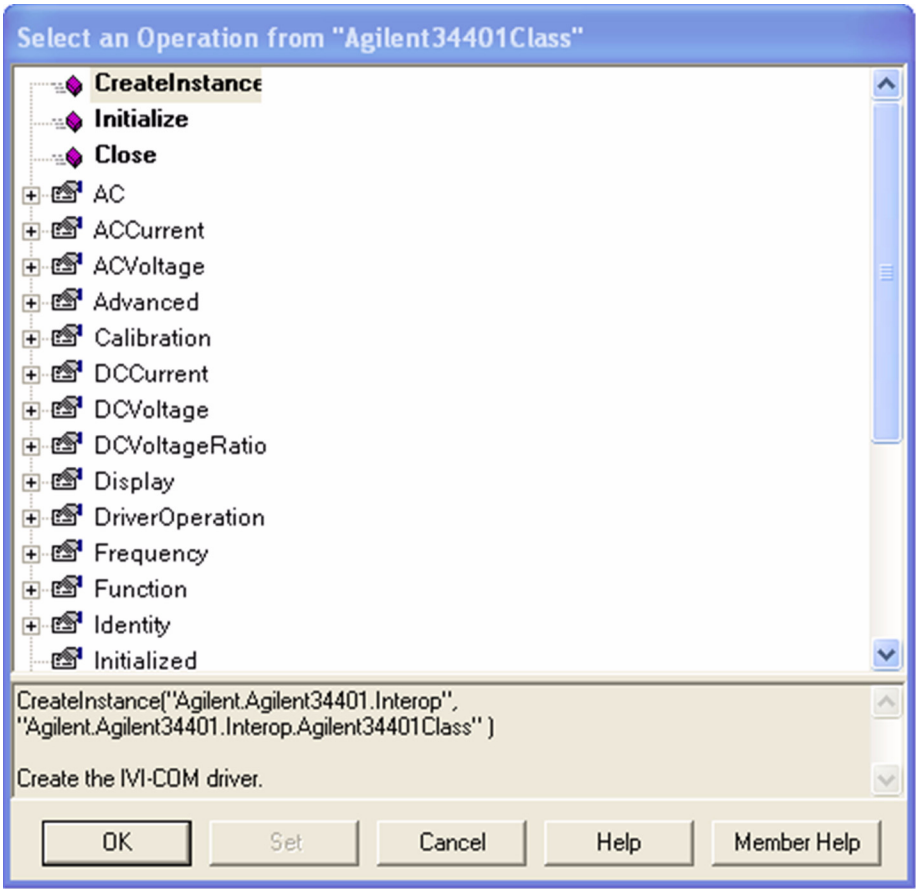
1 Click IVI-COM Driver under Create I/O Object at the right. An outline of the object appears.

2 Move the object onto your workspace.

3 Double-click <Double-Click to Add Operation> in the To/From myDMM object. The Select an Operation dialog box appears.

4 Select CreateInstance to create an instance of the Agilent 34401 driver.

Note: *At the bottom of the dialog box, the code for the operation appears along with an explanation of its function.*



5 Click OK. The Edit CreateInstance dialog box appears.

6 Click OK.

Initialize the Instrument

1 Double-click to add another operation. The Select an Operation dialog box appears.

2 Select Initialize to initialize the simulated Agilent 34401. Click OK. The Edit Initialize dialog box appears.

3 In the Edit Initialize dialog box, **GPIB0::23::INSTR** has already been entered in the ResourceName field. Enter or select the following:

- **False** in the IdQuery field
- **True** in the Reset field
- **simulate=true** in the OptionString field

4 Click OK.

Configure the Instrument

1 Double-click to add another operation. The Select an Operation dialog box appears.

2 Expand the treenode DCVoltage and select Configure. Click OK. The Edit Configure dialog box appears.

3 To set a range of 1.5 volts and resolution of 1 millivolt, enter the following in the Edit Configure dialog box:

- **1.5** in the Range field
- **0.001** in the Resolution field

4 Click OK.

Set the Trigger Delay

1 Double-click to add another operation. The Select an Operation dialog box appears.

2 Expand the treenode Trigger and select Delay. Click Set. The Edit Delay dialog box appears.

3 To set a trigger delay of 0.01 seconds, enter **0.01** in the delay field.

4 Click OK.

Set the Reading Timeout

1 Double-click to add another operation. The Select an Operation dialog box appears.

2 Expand the treenode Measurement and select Read. Click OK. The Edit Read dialog box appears.

3 To take a reading with a timeout of 1 second, enter **1000** in the MaxTimeMilliseconds field.

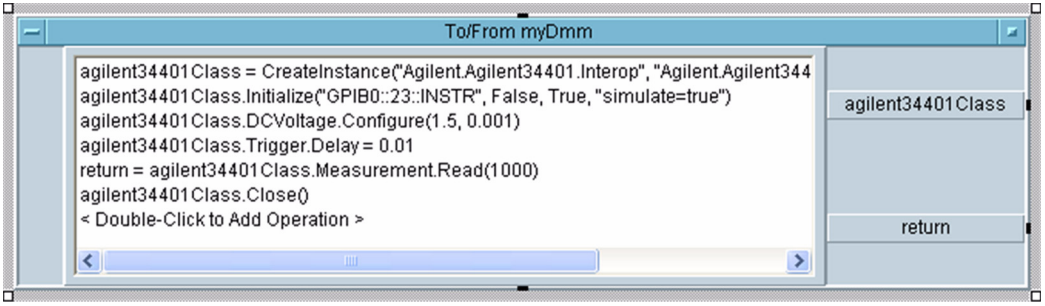
4 Click OK. The To/From myDMM object includes an additional output node labeled return. This will hold the value returned from the Read Measurement operation.

Close the Session

Now that you have completed all of the driver operations, you should close the driver session to free resources.

1 Double-click to add another operation. The Select an Operation dialog box appears.

2 Select Close to release all resources associated with the simulated Agilent 34401. Click OK.



Display the Reading

1 To display the measurement, from the Main Menu select Display, and click AlphaNumeric. Place the AlphaNumeric object on your workspace.

2 Connect a wire from the return output terminal on To/From myDmm to the input terminal of the AlphaNumeric object.

3 Click F5 or the Right Arrow button on the toolbar to run the program. The Display returns a simulated result.

Tips

Another Method to Display the Reading

You can display the measurement in another way as well. From the Main Menu, select select Data, Variable, and click Declare Variable. Declare a global variable named agilent34401Class with a Type Object and Sub Type .NET. Select Edit and in the Specify Object Type dialog, select the following:

- **Agilent.Agilent34401.Interop** in the Assembly field
- **Agilent.Agilent34401.Interop** in the Namespace field
- **Agilent34401Class** in the Type field

Then delete the agilent34401Class output terminal. You can now share this IVI-COM object with other To/From objects or formula objects in VEE. This will let you use multiple objects for the same driver instance without creating all of your driver commands in one object.

Further Information

Learn more about VEE Pro at www.agilent.com/find/vee.

Chapter 11
Advanced Topics

Now that you've seen how to create a short program to perform a measurement in popular programming environments, we want to introduce a few advanced IVI topics: architecture, requirements for interchangeability, Configuration Store, and future developments. These should broaden your view of the capabilities of IVI drivers.

IVI Architecture

Up to this point, we've focused on using either an IVI-COM or IVI-C driver from a specific ADE. The schematic below illustrates the use model for IVI drivers that was deployed in the previous chapters. This use model is the simplest method of using an IVI driver but does not enable interchangeability. This section explains the architecture, including the capabilities of the various driver types and their contribution to interchangeability.

Driver API

To support popular programming languages and development environments, IVI drivers provide either an IVI-COM or an IVI-C API. Driver developers may provide both interfaces, as well as wrapper interfaces that improve usability in specific development environments.

The IVI-COM driver uses a standard Component Object Model (COM) interface that provides access to the functions defined in the class through a hierarchy of methods and properties.

The IVI-C driver appears as a dynamic link library (DLL), such as Windows DLL, composed of standard C functions. The C specifications also define components such as error handling and driver session creation and management, which ensure robustness and interoperability.

The easiest interface to use in a given Application Development Environment is one that is native to the environment. So a C interface works best in C and a COM interface in Visual Basic. Some ADEs support only one type of interface, however, which makes the choice simple.

Driver developers also provide wrapper interfaces optimized for specific development environments. The wrapper functions as an adapter between an ADE and a driver not designed for that ADE. It enables the ADE to use technologies for which no native implementation exists. In Chapter 6, IVI with MATLAB, for example, generating an instrument wrapper is a key step in creating the program.

Driver Types

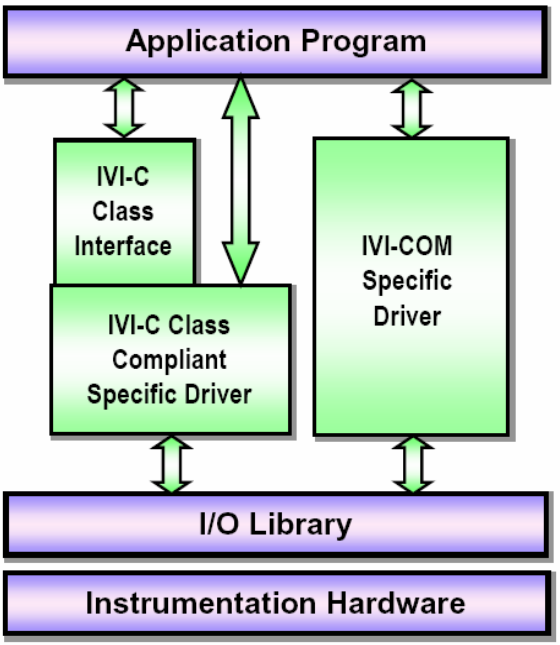
The schematic on the next page shows the three basic types of drivers: Both IVI-COM and IVI-C use Custom and Class Compliant Drivers, but Class Drivers are unique to IVI-C. Usually, you only need to be concerned about the type of driver if you want to enable interchangeability. To understand the differences among them, you first need to understand the various capabilities these drivers support:

Inherent capabilities: capabilities required by the IVI Foundation, such as instrument simulation, state-caching, interchangeability checking, and range checking, as well as commands, such as Initialize, Reset, and Close. Some capabilities are required for all drivers, but others are optional.

Base class capabilities: capabilities identified by an IVI Foundation working group as common among the majority of instruments in a class. In the DMM class, for example, base capabilities include performing a DC voltage or current measurement.

Class extension capabilities*:* capabilities identified by an IVI Foundation working group as less common but still supported by multiple instruments within a class. In the DMM class, for example, class extension capabilities include temperature measurement.

Instrument-specific or vendor-specific capabilities: capabilities not standardized by IVI and unique to a manufacturer's specific instrument. In the DMM class, for example, this might be a measurement that uses a thermocouple to sense the temperature.



Now that we've defined the capabilities, we can look at each driver in terms of those it supports.

Custom Specific Driver: This driver supports only IVI inherent capabilities and instrument-specific capabilities, but not base class or class extension capabilities. This lets instrument manufacturers 1) innovate and provide specialized features, and 2) supply IVI drivers for instruments for which no class specification exists, such as network analyzers and Bluetooth testers.

Class Compliant Specific Driver: This driver must support inherent and base class capabilities. These drivers may also support class extensions and instrument-specific capabilities. For IVI-C and IVI-COM drivers, a Class Compliant Specific Driver enables interchangeability through generic instrument Application Programming Interfaces (APIs) that can be used with a multitude of instruments. See more about APIs below.

Class Driver: This driver is used for IVI-C only. A Class Driver also supports inherent, base class, and all class extension capabilities. A Class Driver enables instrument interchangeability when using IVI-C Class Compliant Specific Drivers.

For IVI-COM drivers, the IVI inherent capabilities, custom capabilities, and the class capabilities may be provided in a single driver. All IVI-COM drivers include the inherent capabilities. If an IVI-COM driver only has custom and inherent

capabilities, it is called an IVI-COM custom driver. If the driver includes the class capabilities, it is called an IVI-COM Class Compliant driver. IVI-COM Class Compliant drivers may or may not include custom capabilities.

Instrument I/O

All IVI drivers communicate to the instrument hardware through an I/O Library. The VISA library is typically used because it provides uniform access to GPIB, RS-232, USB-TMC and LAN instrument. Drivers that communicate with insruments that only use RS-232 or LAN occasionally include their own I/O that does not require VISA.

Shared Components

IVI Foundation members have cooperated to provide common software components, called IVI Shared Components, that ensure compatibility among drivers from various manufacturers. These components provide services to drivers and driver clients that need to be common to all drivers.

IVI Configuration Server: This component is the run-time module responsible for providing configuration data to IVI drivers. The Configuration Server specifically provides system initialization and configuration information.

COM Session Factory: This component can dynamically load an IVI-COM software module without requiring the application program to identify the IVI software module when it is compiled. This allows the test program source code to have all references to a specific instrument removed. This capability is provided in IVI-C using an IVI-C Class driver.

Interchangeability

One aspect of the IVI standard is instrument interchangeability, which allows you to write and compile your program for an instrument from one manufacturer and then swap it out for the same type of instrument from another manufacturer. After making changes to a configuration file on your computer to identify the new instrument (and driver) and the hardware address (if that changes), you can run your program without modifying or recompiling it. That's in an ideal world, of course.

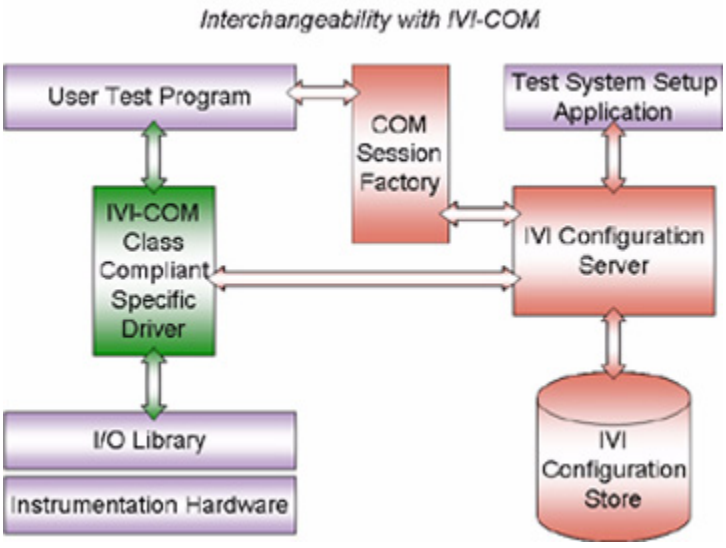
The minimum necessary requirements for interchangeability include the following:

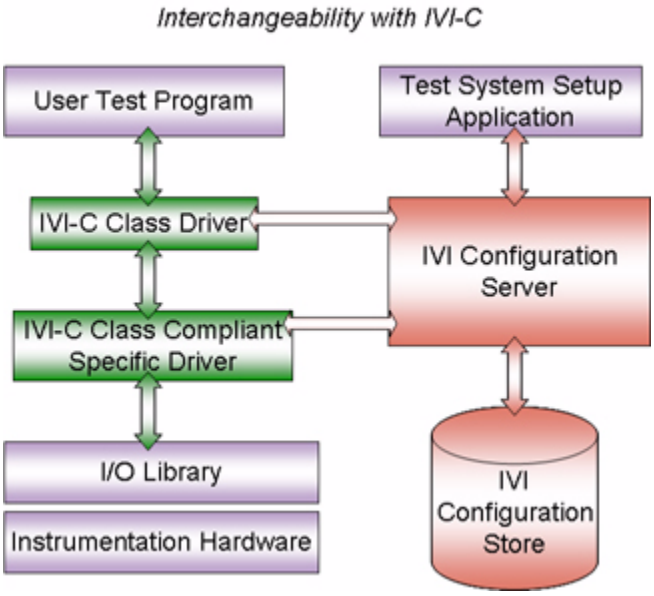
- Drivers for both instruments must be of the same type (IVI-C or IVI-COM);
- Both drivers must implement the same instrument class. For example, both must conform to the requirements for IviDmm or IviScope;
- For IVI-C, your program must use a Class Driver, which in turn instantiates the Class Compliant Specific Driver and calls class compliant functions in it.
- Your program calls only those Class Extension functions supported by both drivers.
- Your program never calls Instrument Specific functions.

- The instruments must provide the same behavior, at least with respect to the calling program.

Meeting these requirements is necessary to achieve “100%” interchangeability. However, if your application does not meet all of these requirements, in some cases you may be able to add additional code to your program to handle the differences between the instruments or drivers you are using and still achieve a certain degree of interchangeability.

The images below depict the functionality of the IVI Configuration Server and Configuration Store and COM Session Factory in their role of enabling interchangeability among IVI-COM and IVI-C drivers.





IVI Configuration Store

The IVI Configuration Store holds information about the IVI drivers installed on your computer and configuration information for your instrument system. By providing a way to flexibly reference and configure IVI drivers and instrument I/O connections outside of your application, the IVI Configuration Store makes interchangeability possible.

Consider an application in which you use a specific driver to communicate with a specific instrument model at a fixed location. Change anything – the driver, the model, the location – and you have to modify the application to accommodate that change.

That's when the Configuration Store comes into play. An IVI Configuration Store offers the capability to work with different instrument drivers, models, or locations, without having to modify your application. You can imagine how useful this can be when using a compiled application that you cannot easily modify.

The IVI Configuration Store contains data that describe: the software modules used to control the instruments, the hardware assets that perform measurement or stimulus functions, the driver session that associates the software and hardware, and the logical name that lets you point to a specific session.

`SoftwareModule`: A `SoftwareModule` provides information about a particular instrument driver software component that is installed and registered on your system. This read-only component is commonly provided by the instrument vendor

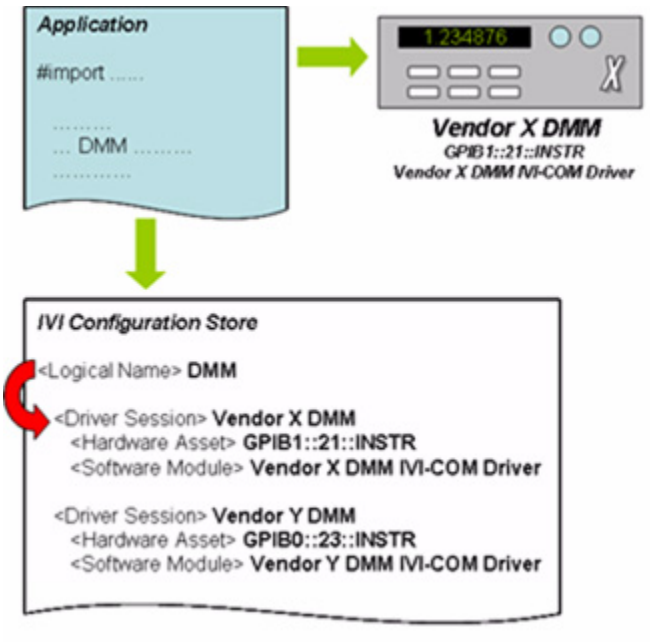
and contains the commands and functions necessary to communicate with the instrument. You can use the software module entry data to locate the component on your system and determine what instrument models and class interfaces (called Published APIs in the configuration server) are supported by the component.

`HardwareAsset`: A `HardwareAsset` describes a specific physical device in your system with which you communicate such as an oscilloscope or power supply. The `HardwareAsset` includes a resource descriptor – a string that specifies the I/O interface and address of a hardware asset, such as GPIB::23::INSTR.

`DriverSession`: A `DriverSession` provides the information needed to use a driver in a particular context. It makes the association between a `SoftwareModule` and a `HardwareAsset`. It defines a set of properties for use by IVI instrument driver software modules, such as initial configurable settings for attributes, virtual name mappings, and simulation settings. You can configure a `DriverSession` for each instrument, for each of its possible I/O resource descriptors, and for each program that uses it.

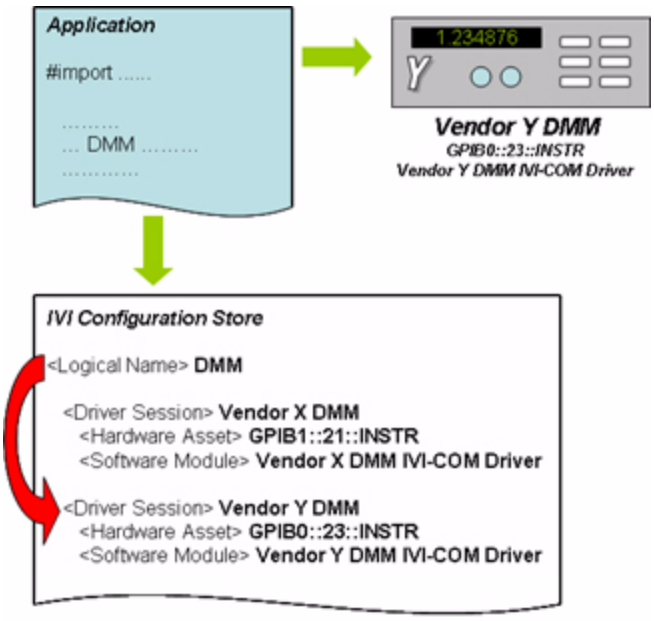
`LogicalName`: A `LogicalName` is a configurable pointer to a particular `DriverSession`. Application programs use logical names to avoid direct references to software modules and hardware assets. In a typical setup, the application communicates with an instrument via a logical name. If the application needs to communicate with a different instrument (for example, the same kind of scope at a different location), only the logical name within the IVI Configuration Store needs to be updated to point to the new driver session. You don't need to rewrite any code in the application, because it uses the same logical name.

The illustration below shows how the IVI Configuration Store enables interchangeability. The application is developed and makes calls via the logical name. In the illustration, this is shown as DMM. The actual DMM is from Vendor X at address GPIB1::21::INSTR and uses the Vendor X DMM IVI-COM driver. In the Configuration Store, the logical name DMM is associated with a Driver Session that is configured to the specific information of the Vendor X DMM.



In the illustration below, we replace the Vendor X DMM with a Vendor Y DMM. All we need to do is change the `LogicalName` so that it points to a different `DriverSession`. In this example, change the `LogicalName` so that it point to the Vendor Y `DriverSession`. We do not need to make any modifications to the application itself. All changes are contained within the Configuration Store.

Below we show examples of using interchangeability using logical names with IVI-COM and IVI-C.



IVI-COM

This C# example shows interchangeability using IIviDriver, which references all of IVI's inherent capabilities.

IIviDriver

1. Create a string variable for logical name.

   ```
   string logicalName = "AgilentDriver";
   ```

2. Add a reference to the Session Factory. Go to Project and Add Reference. Select the IVI Session Factory Type Library under the COM tab.

3. Create an instance of the Session Factory.

   ```
   IIviSessionFactory factory = new IviSessionFactoryClass();
   ```

4. Set the type to match the referenced IVI Instrument Class, for class interchangeability. This example uses IIviDriver, because it is common to all drivers. This uses the Session Factory to create a driver based on the logical name "AgilentDriver."

5. In the Configuration Store, logical name "AgilentDriver" points to a driver session. The driver session points to a software module, which can be any IVI-COM driver. The Session Factory creates an instance of the driver and returns

a reference to the instance of the driver. This line of code then casts the reference returned to type IIviDriver, from which all of IVI's inherent capabilities can be referenced.

```
IIviDriver driver =
(IIviDriver)factory.CreateDriver(logicalName);
```

6 Initialize is required, because the Session Factory does not take care of that function.

```
driver.Initialize(logicalName, true, true);
```

7 Identity is a property of IIviDriver that references the IIviDriverIdentity interface. Identifier is a property of IIviDriverIdentity interface that returns a string that identifies the driver.

```
string identifier = driver.Identity.Identifier;
```

8 Print the string.

```
Console.WriteLine("Identifier: {0}", identifier);
```

IIviDmm

If we want the code to use multiple drivers that all support the DMM class and use the IVI DMM class interfaces, we must modify it as shown below. Note that only IVI-COM drivers that implement the IVI DMM class will work with this program.

1 Create a string variable for logical name.

```
string logicalName = "LineVoltage";
```

2 Create an instance of the Session Factory.

```
IIviSessionFactory factory = new IviSessionFactoryClass();
```

3 Set the type to match the referenced IVI Instrument Class for class interchangeability. This code for IIviDmm uses the factory to create a driver based on the logical name "LineVoltage."

4 In the Configuration Store, logical name "LineVoltage" points to a driver session. The driver session points to a software module, which can be any IVI-COM driver. The Session Factory creates an instance of the driver and returns a reference to the instance of the driver. This line of code then casts the reference returned to type IIviDmm, from which all of IVI DMM's class-compliant features can be referenced.

```
IIviDmm dmm = (IIviDmm)factory.CreateDriver(logicalName);
```

5 Initialize is required, because the session factory does not take care of that function.

```
dmm.Initialize(logicalName, false, false, "simulate=true");
```

The rest of the code follows that used for the examples, but note that it is written to the class-compliant interfaces, not the instrument-specific ones.

```
dmm.Configure(IviDmmFunctionEnum.IviDmmFunctionDCVolts, 1.5,
0.001);

dmm.Trigger.Delay = 0.01;

Console.WriteLine(dmm.Measurement.Read(1000).ToString());

dmm.Close();
```

IVI-C

This C example shows how to use an IVI-C Class Driver to achieve interchangeability. It is very similar to the IVI-C examples in Chapters 2 and 5 except for 3 differences:

1. The function calls are all for the class driver and do not refer to the particular instrument being used, e.g., IviDMM_Read vs. HP34401A_Read
2. The parameters in certain function calls are generic for the instrument class and do not refer to the particular instrument being used, e.g., IVIDMM_VAL_DC_VOLTS vs. HP34401A_VAL_DC_VOLTS
3. The initialize function refers to a logical name instead of the instruments physical address, in this case “SampleDMM” vs. “GPIB0::23::INSTR”

In order to interchange a different DMM for the Agilent 34401A DMM, you would update your configuration store to have the logical name “SampleDMM” point to the new instrument’s Driver Session.

This is what the code for the example used in this guide would look like using and IVI-C class driver.

```
static ViReal64 reading;

static ViSession session;


IviDMM_InitWithOptions ("SampleDMM", VI_FALSE,

VI_TRUE,"Simulate=1", &session);

IviDMM_ConfigureMeasurement (session, IVIDMM_VAL_DC_VOLTS,
1.5, 0.001);
```

```
IviDMM_ConfigureTrigger (session, IVIDMM_VAL_IMMEDIATE,
0.01);

IviDMM_Read (session, 1000, &reading);

printf ("%f", reading);

IviDMM_close (session);
```

Editing the Configuration Store

If you installed the IVI Shared Components in the default location, you will find the Configuration Store information in a file named IviConfigurationStore.xml in C:\Program Files\IVI\Data. Recent versions of Microsoft Internet Explorer can display .xml files. If you double-click on the file, a copy of Internet Explorer should start and you can view the contents of the file.

But we do mean *view*, not *edit*; you should use an IVI configuration utility or the IVI Configuration Store API to make changes to the Configuration Store file. You can usually obtain these utilities with your IVI driver, instrument, or ADE.

Important! Never make changes directly to the Configuration Store file. Instead use an IVI configuration utility or the IVI Configuration Store API.

The configuration server provides much more functionality than it is possible to describe here. For more information, see the IVI Configuration Server specification at http://ivifoundation.org/specifications/default.aspx or contact your IVI provider.

Future Development of IVI

One feature of IVI that gives it an advantage over other instrument drivers is simply that it's still actively evolving. Current IVI work focuses on the following:

- Keeping up-to-date with technology, including 64-bit integers and new Windows operating system compatibility;
- Keeping up-to-date with advances in test and measurement, including LXI technology;
- Developing new class specifications for digitizers, counter timers, and synthetic instruments
- Developing a .NET standard that will optimize IVI drivers for use in .NET.

IVI Drivers in Action

IVI Getting Started Guide contains a single example in many different ADEs. You probably work primarily in a single ADE but would benefit from seeing other examples that use IVI drivers. Examples are available from two primary sources:

1. Vendors who provide IVI drivers frequently show examples of their use in test applications on their Web site. Visit the vendor's site and search for "IVI drivers" to find information on and examples of driver use.

2 Several vendors include examples as part of driver installation. For the Agilent 34401A driver (from Agilent Technologies) we use in some of the examples throughout the guide a folder, located at C:\Program Files\IVI\Drivers\Agilent 34401\Examples, contains examples that show its use in a variety of different environments.

Finally, contact your driver vendor for help. Even if the vendor hasn't published examples online or included them during installation, they may have samples that you can use to build a program.