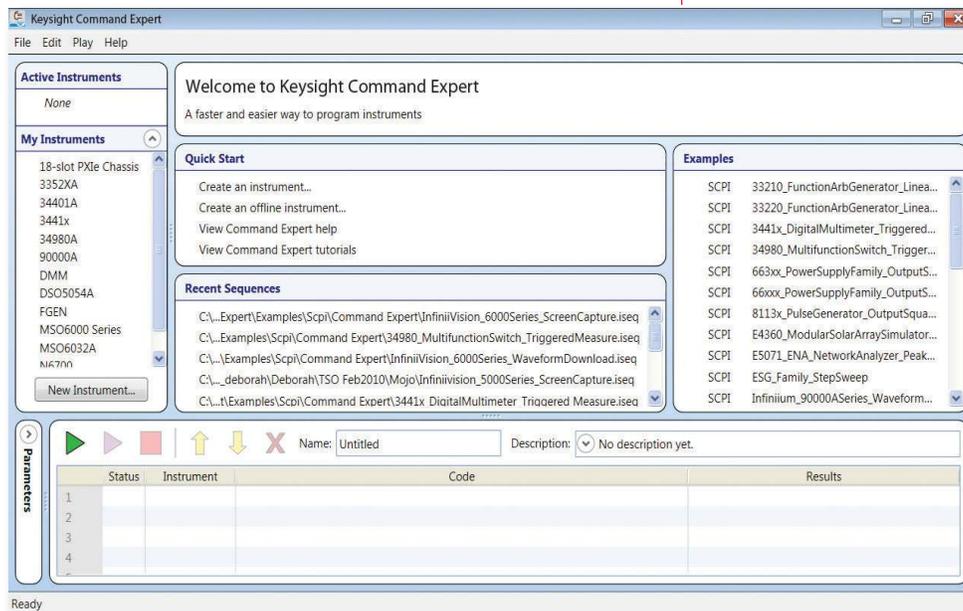


# Keysight Technologies

## Accelerate Program Development using Keysight Command Expert with Microsoft Visual Studio

### Application Note



## Introduction

### Keysight Command Expert for fast and easy instrument control!

Keysight Technologies, Inc. Command Expert is a FREE software application that provides fast and easy instrument control in many PC application environments. Command Expert combines instrument command sets, command sequences, documentation, syntax checking, and command execution in one simple interface. Command Expert helps you to:

- Find instrument commands
- Access command documentation
- Verify command syntax
- Build instrument command sequences
- Execute instrument command sequences
- Integrate sequences into the Visual Studio, Excel, LabVIEW, MATLAB, Keysight VEE, or Keysight SystemVue PC application environment
- Generate code for command sequences in Visual C#, VisualBasic.NET, Visual C/C++, and MATLAB
- Profile command execution time
- Debug command sequences using breakpoints and single-stepping
- Generate SCPI.NET for use in Visual Studio

Instrument command sets are available for instruments that use Standard Commands for Programmable Instrumentation (SCPI) or IVI-COM drivers.

#### **This application note contains two main sections:**

- **Command Expert Basics**  
Introduces you to the Command Expert user interface and shows an example sequence.
- **Command Expert in the Visual Studio Environment**  
Describes how to generate code for use in Visual Studio projects and how to use SCPI.NET drivers in Visual Studio.

## Command Expert Basics

This section describes how to download, install, and start Command Expert, and uses an example sequence to show the features of the Command Expert user interface.



Figure 1. Command Expert and Visual Studio Integration

## Downloading and Installing Command Expert



Figure 2. Command Expert Icon

You can download Command Expert from [www.keysight.com/find/commandexpert](http://www.keysight.com/find/commandexpert).

After downloading, click **Run** in the installer window and follow the instructions on your screen.

### Additional required software

Be sure to install Keysight IO Libraries Suite to find and communicate with instruments. You can download Keysight IO Libraries Suite from [www.keysight.com/find/iosuite](http://www.keysight.com/find/iosuite).

### Visual Studio Versions Supported

Command Expert can be used with Visual Studio 2005, Visual Studio 2008, or Visual Studio 2010.

# Starting Command Expert

Click **Start > All Programs > Keysight Command Expert > Keysight Command Expert**.

The Command Expert opening window (Welcome Window) is shown below.

Command Expert comes with a number of preconfigured examples for popular instruments. The installation software installs an example instrument named *N6700* that provides the commands for the Keysight N6700B Power Supply. We will use this instrument and the *N6700\_PowerSupply\_OutputSetup* example to introduce you to the Command Expert user interface.

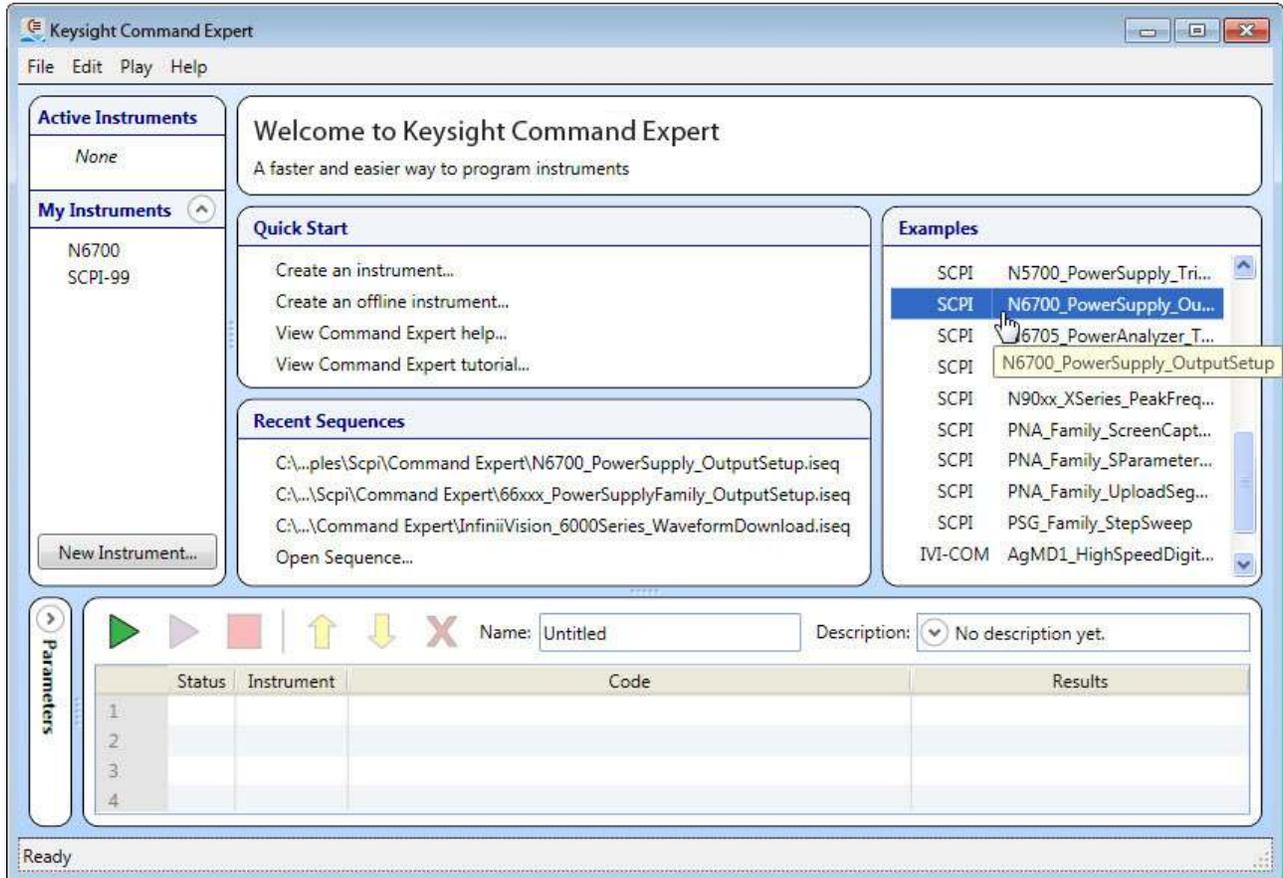


Figure 3. Command Expert Welcome Window

### Internet access and command sets

The N6700 instrument and its SCPI command set are installed by default. For other instrument examples, you will be prompted to install the instrument's command set. After installing Command Expert, you will need Internet access to download SCPI command sets or IVI-COM instrument drivers for your instruments. If you work in a secure environment with limited Internet access, you can still use Command Expert. Simply download the SCPI command sets or IVI-COM instrument drivers using a computer with internet access. You can then transfer the command sets or drivers to the computer with no internet access (using a USB drive, for example).

## The Command Sequence

The command sequence for the *N6700\_PowerSupply\_OutputSetup* example is shown in the Sequence Pane in the graphic below. A Command Expert sequence is a series of steps that are executed in order to connect to an instrument, configure an instrument, set outputs, and perform measurements.

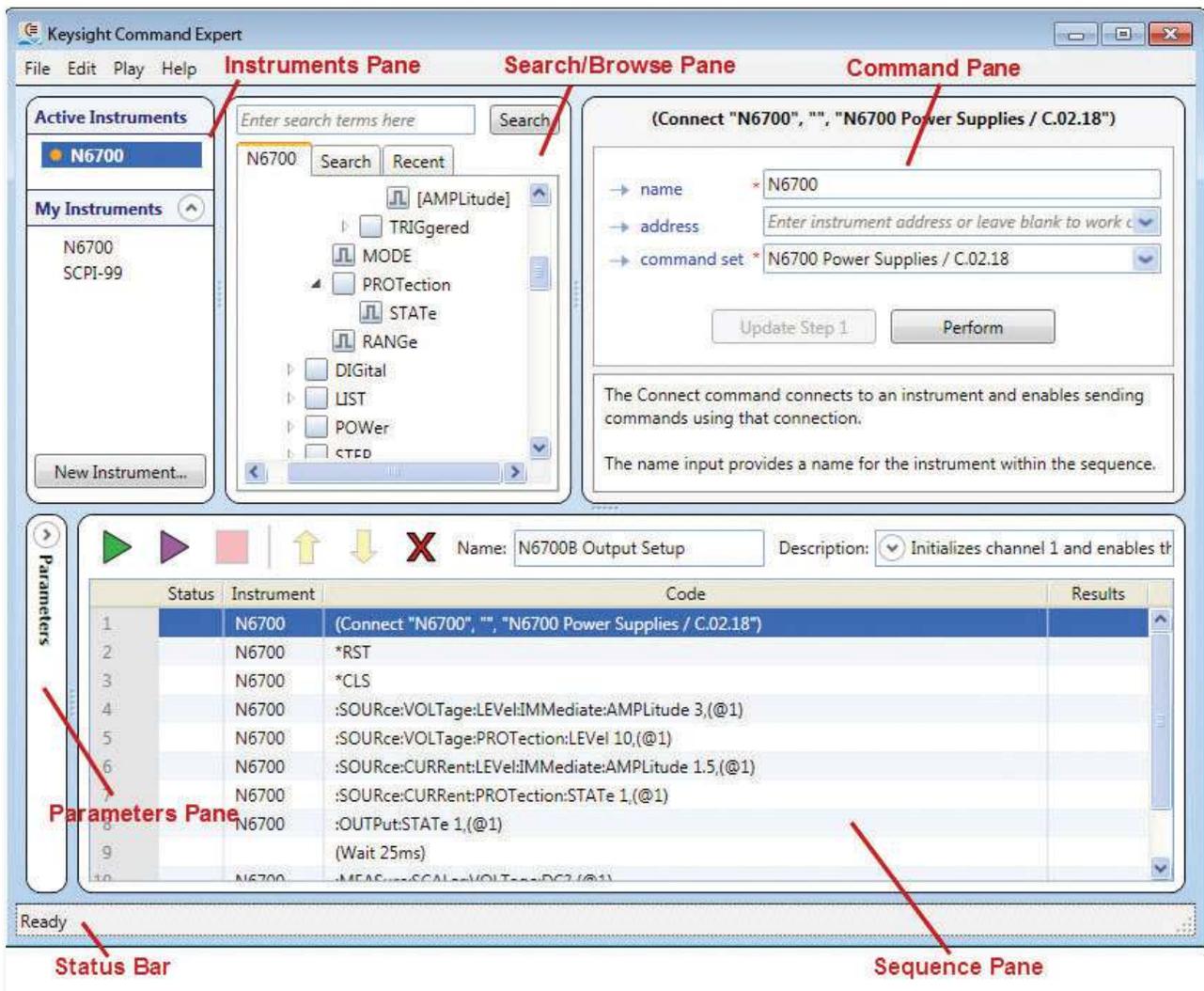


Figure 4. Command Expert User Interface Overview

- The **Instruments Pane** shows your instruments and lets you connect to them.
- The **Search/Browse Pane** shows you the commands for the selected instrument and lets you search for commands.
- The **Command Pane** shows the selected command and its documentation, and lets you execute the command.
- The **Status Bar** shows progress messages as Command Expert performs operations.
- The **Parameters Pane** expands to show sequence parameters and lets you view and edit their names and values.
- The **Sequence Pane** shows the various steps in the Command Expert sequence and lets you edit the sequence and replay commands. The Sequence Pane has the following features:

## The Command Sequence cont'd

The screenshot shows the Sequence Pane interface. At the top, there are several control buttons: 'Run Sequence' (green play), 'Run Selected Step(s)' (purple play), 'Stop Sequence' (red stop), 'Move Step(s) Up' (yellow up arrow), 'Move Step(s) Down' (yellow down arrow), and 'Delete Step(s)' (red X). Below these buttons are fields for 'Name: N6700B Output Setup' and 'Description: Initializes channel 1 and enables the output of an'. The main area is a table with the following data:

| Status | Instrument | Code  | Results    |
|--------|------------|---|------------|
| 1      | ✓          | N6700 (Connect "N6700", "", "N6700 Power Supplies / C.02.18")           |            |
| 2      | ✓          | N6700 *RST  |            |
| 3      | ✓          | N6700 *CLS  |            |
| 4      | ✓          | N6700 :SOURce:VOLTage:LEVel:IMMediate:AMPLitude <voltage2>, <chanlist2> |            |
| 5      | ✓          | N6700 :SOURce:VOLTage:PROTection:LEVel <voltage>, <chanlist>            |            |
| 6      | ✓          | N6700 :SOURce:CURRent:LEVel:IMMediate:AMPLitude 1.5, (@1)               |            |
| 7      | ✓          | N6700 :SOURce:CURRent:PROTection:STATE 1, (@1)                          |            |
| 8      | ✓          | N6700 :OUTPut:STATE 1, (@1)   |            |
| 9      | ✓          | (Wait 60ms)   |            |
| 10     | ✓          | N6700 :MEASure:SCALar:VOLTage:DC? (@1)                                  | [1.501516] |

Red annotations point to the 'Status' column (labeled 'Status of most recent execution of step'), the 'Code' column (labeled 'Steps in this sequence'), and the 'Results' column (labeled 'Result of most recent execution of step').

Figure 5. Sequence Pane Details

### Working offline

The absence of a specific instrument address in step 1 of the sequence shown above indicates that we are working offline. To connect to an actual instrument, select step 1 in the Sequence Pane, and enter the instrument address in the address field in the Command Pane.

Working offline is a simulation mode where you can view and perform commands as usual, but the commands return default values. This is a good way to explore a command set, view documentation, and prototype sequences without having to connect to a physical instrument.

## Sequence Steps

Selecting a step in the Sequence Pane reveals details about the command and its parameters.

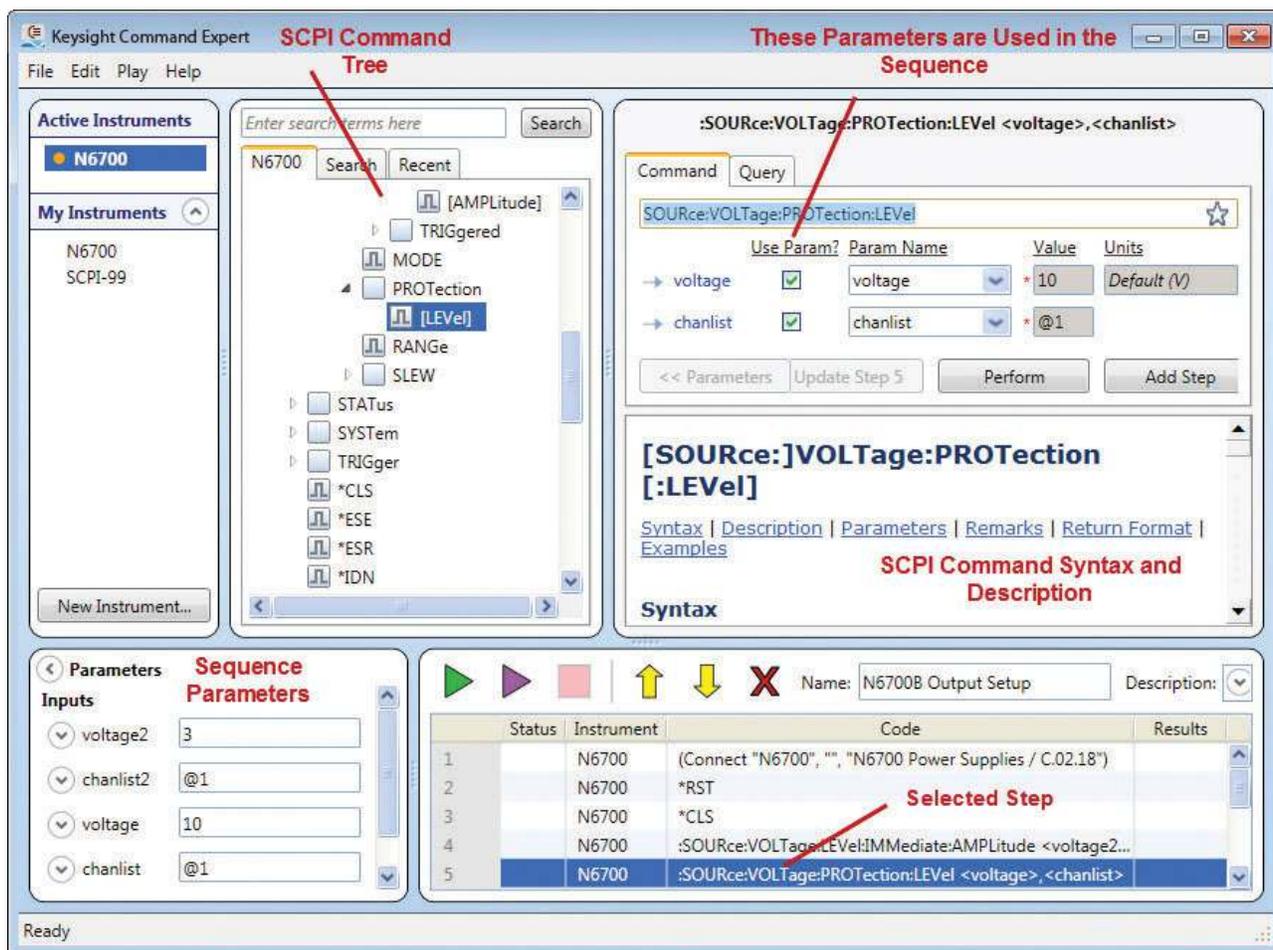


Figure 6. Command Details

### Command Expert uses these types of steps:

- Connect steps (to connect to instruments)
- Command steps (SCPI or IVI-COM commands)
- Wait statements
- Comments
- Steps to control timeouts and error handling

## Sequence Debugging

You can debug a sequence by inserting breakpoints. When you run the sequence, execution pauses at the first step with a breakpoint and Command Expert enters single-step mode. In single-step mode you can single-step the sequence, monitor parameters and results, replay the sequence, and play selected steps. When you are ready to run the sequence without pausing at the breakpoint, remove the breakpoint and run the sequence normally.

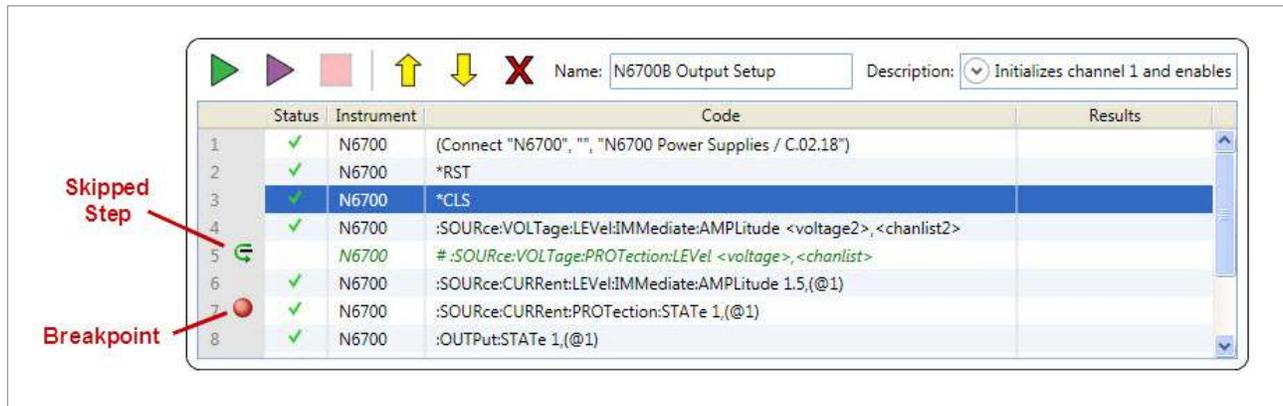


Figure 7. Debugging the Sequence

You can also skip steps to help with debugging.

### Substituting an instrument

You can temporarily switch command sets in a sequence to see the effects of switching to a different instrument. Any commands that aren't supported by the new instrument are highlighted in red.

## Using IVI-COM

If you prefer, you can use IVI-COM commands instead of SCPI commands. Command Expert has a number of IVI-COM examples and the operation is very similar to SCPI.

The example below (filename: *N67xx\_PowerSupply\_OutputSetup.xlsx*) uses IVI-COM commands:

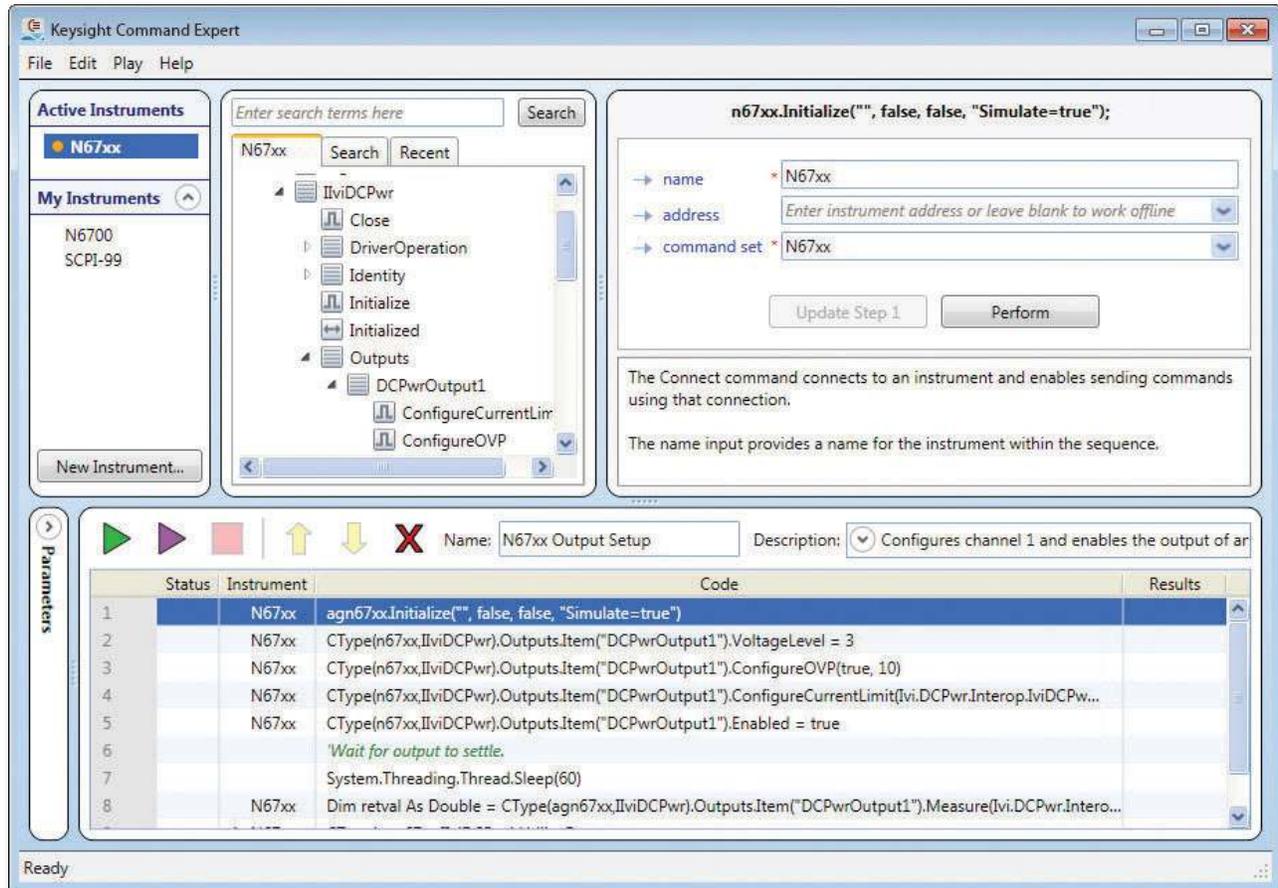


Figure 8. IVI-COM commands

### IVI-COM command sets and drivers

IVI-COM command sets are automatically extracted from IVI-COM drivers. You must install an IVI-COM driver (outside of Command Expert) before you can use the driver's command set in Command Expert.

You can download Keysight IVI-COM drivers from [www.keysight.com/find/ivi](http://www.keysight.com/find/ivi).

## Using IVI-COM cont'd

The Command Expert IVI-COM interface is very similar to the SCPI interface. All elements within the interface operate as described earlier in this application note. For more information, see *Command Expert for IVI-COM Tutorial* in the Command Expert help:

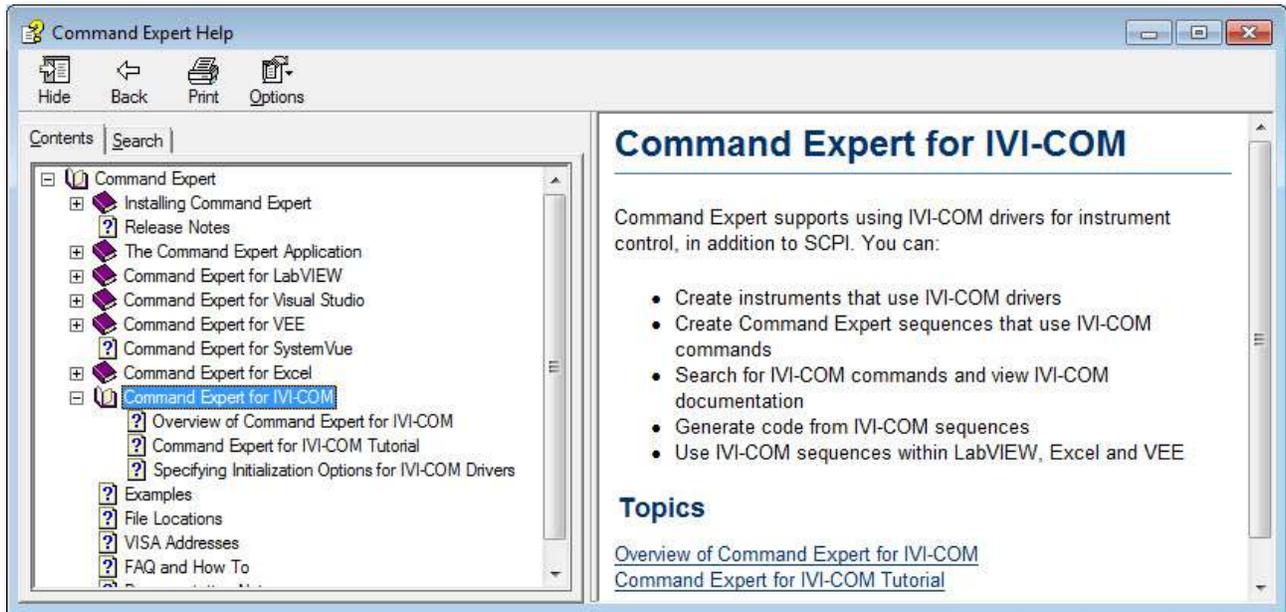


Figure 9. IVI-COM Help

## Using Command Expert with Non-Keysight Instruments

You can use Command Expert with any SCPI instrument that follows the SCPI-99 standard, using the *Generic SCPI-99 Instrument* command set. This command set provides the commands that are common to SCPI-99 instruments.

You can also use direct commands to send additional SCPI commands. Using direct commands, you can send any SCPI command to any SCPI instrument.

Any instrument that has an IVI-COM driver can be used with Command Expert, regardless of the manufacturer.

## Getting Started with Command Expert

To get started using Command Expert, you can start with one of the many example sequences and modify that sequence, or you can create your own sequence. For a step-by-step tutorial showing how to create a sequence, see *Command Expert Tutorial* in the Command Expert help:

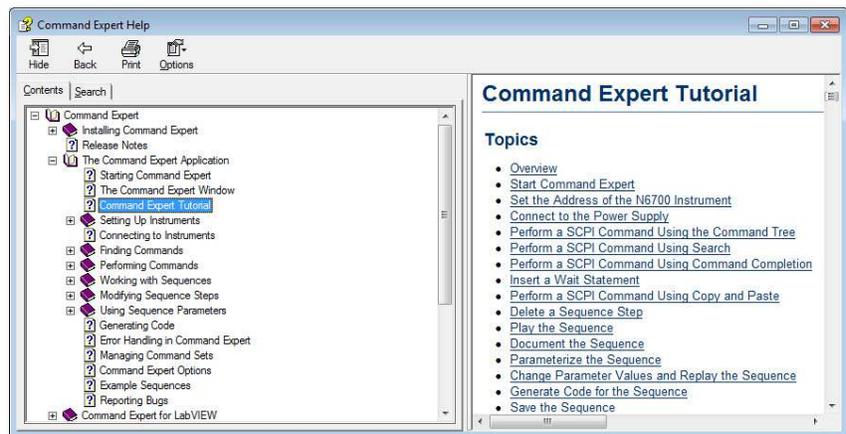


Figure 10. Command Expert Tutorial

## Command Expert in the Visual Studio Environment

You can use Command Expert to help automate instrument control in Visual Studio using either or both of these approaches:

- Generating code from Command Expert
- Using SCPI.NET drivers

### Generating Code from Command Expert

You can use Command Expert to automatically generate code from SCPI or IVI-COM command sequences. This allows you to efficiently develop and test instrument command sequences before incorporating the code into your Visual Studio project.

The steps for generating code are:

1. Create a SCPI or IVI-COM command sequence in Command Expert
2. Select a code generation option and export the sequence to the clipboard
3. Paste the generated code into a Visual Studio project
4. Add any required references to your Visual Studio project
5. Build and run the application

The Visual Studio code generation options for SCPI command sequences are:

- C/C++ with calls to VISA Formatted I/O
- C# with calls to SCPI.NET Drivers
- VB.NET with calls to SCPI.NET Drivers

The code generation options for IVI-COM command sequences are:

- C# with calls to IVI-COM Drivers
- VB.NET with calls to IVI-COM Drivers

#### Examples

This application note shows a code generation example for *C/C++ with calls to VISA Formatted I/O* and for *C# with calls to SCPI.NET Drivers*. The code generation process for the other options listed above is similar. Detailed information and tutorials are located in the Command Expert help.

## VISA Formatted I/O Code Generation Example

The following example uses the *SCPI N6700\_PowerSupply\_OutputSetup* example to show how to generate *C/C++ with calls to VISA Formatted IO* and paste that code into a Visual Studio C++ project. The advantages to using *C/C++ with calls to VISA Formatted I/O* are:

- The VISA C/C++ formatted I/O functions are an industry standard.
- The VISA C/C++ formatted I/O functions perform data translation; that is, the functions convert between programming language data structures and SCPI command/response strings.
- The generated code can be used in unmanaged C or C++ applications.
- The generated code can also be used in LabWindows/CVI applications.

### Procedure

1. If not already open, open the *N6700\_PowerSupply\_OutputSetup* example from the Welcome Window.
2. The example opens with the SCPI commands listed (default mode). This example sets the output voltage and current of a Keysight N6700B Power Supply:

The screenshot displays the Keysight Command Center software interface. The top-left pane shows 'Active Instruments' with 'N6700' selected. The middle pane shows a tree view of SCPI commands, with 'PROTection' expanded. The right pane shows the configuration for connecting to the instrument, with fields for 'name' (N6700), 'address', and 'command set' (N6700 Power Supplies / C.02.18). Below this is a 'Perform' button and explanatory text. The bottom pane shows a sequence of commands being executed, with a table of results.

| Status | Instrument | Code  | Results |
|--------|------------|---|---------|
| 1      | N6700      | {Connect "N6700", "", "N6700 Power Supplies / C.02.18"} |         |
| 2      | N6700      | *RST  |         |
| 3      | N6700      | *CLS  |         |
| 4      | N6700      | :SOURce:VOLTage:LEVel:IMMediate:AMPLitude 3,(@1)        |         |
| 5      | N6700      | :SOURce:VOLTage:PROTection:LEVel 10,(@1)                |         |
| 6      | N6700      | :SOURce:CURRent:LEVel:IMMediate:AMPLitude 1.5,(@1)      |         |
| 7      | N6700      | :SOURce:CURRent:PROTection:STATe 1,(@1)                 |         |
| 8      | N6700      | :OUTPut:STATe 1,(@1)                                    |         |
| 9      | N6700      | (Wait 25ms)   |         |
| 10     | N6700      | MEASure:SCALar:VOLTage:DC?(@1)                          |         |

Figure 11. N6700 Example

## VISA Formatted I/O Code Generation Example cont'd

3. To add Keysight VISA I/O calls to the SCPI commands and export the sequence, click **File > Export Sequence...** and select **C/C++ with calls to Visa Formatted I/O**:

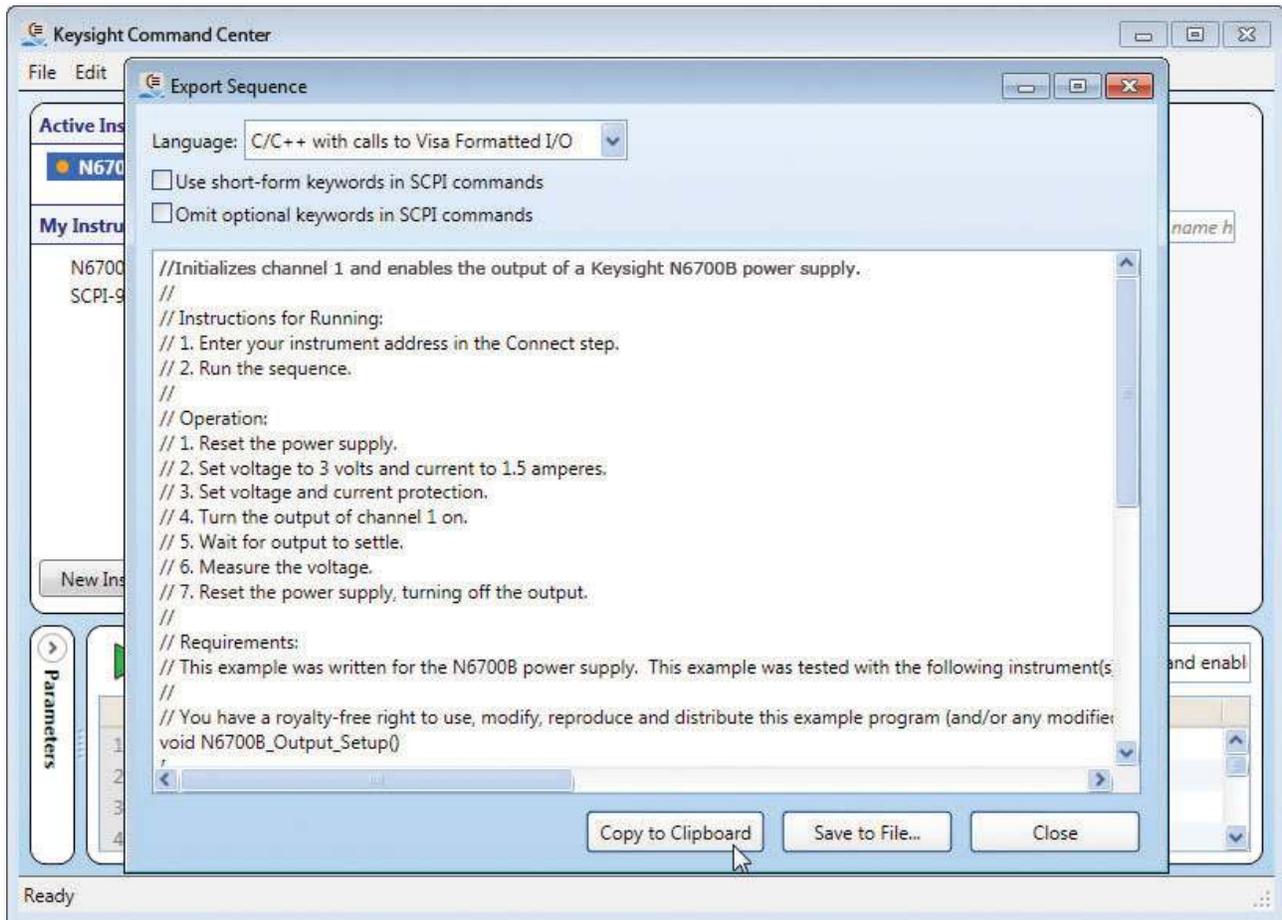


Figure 12. Exporting the Sequence (Visa Formatted I/O)

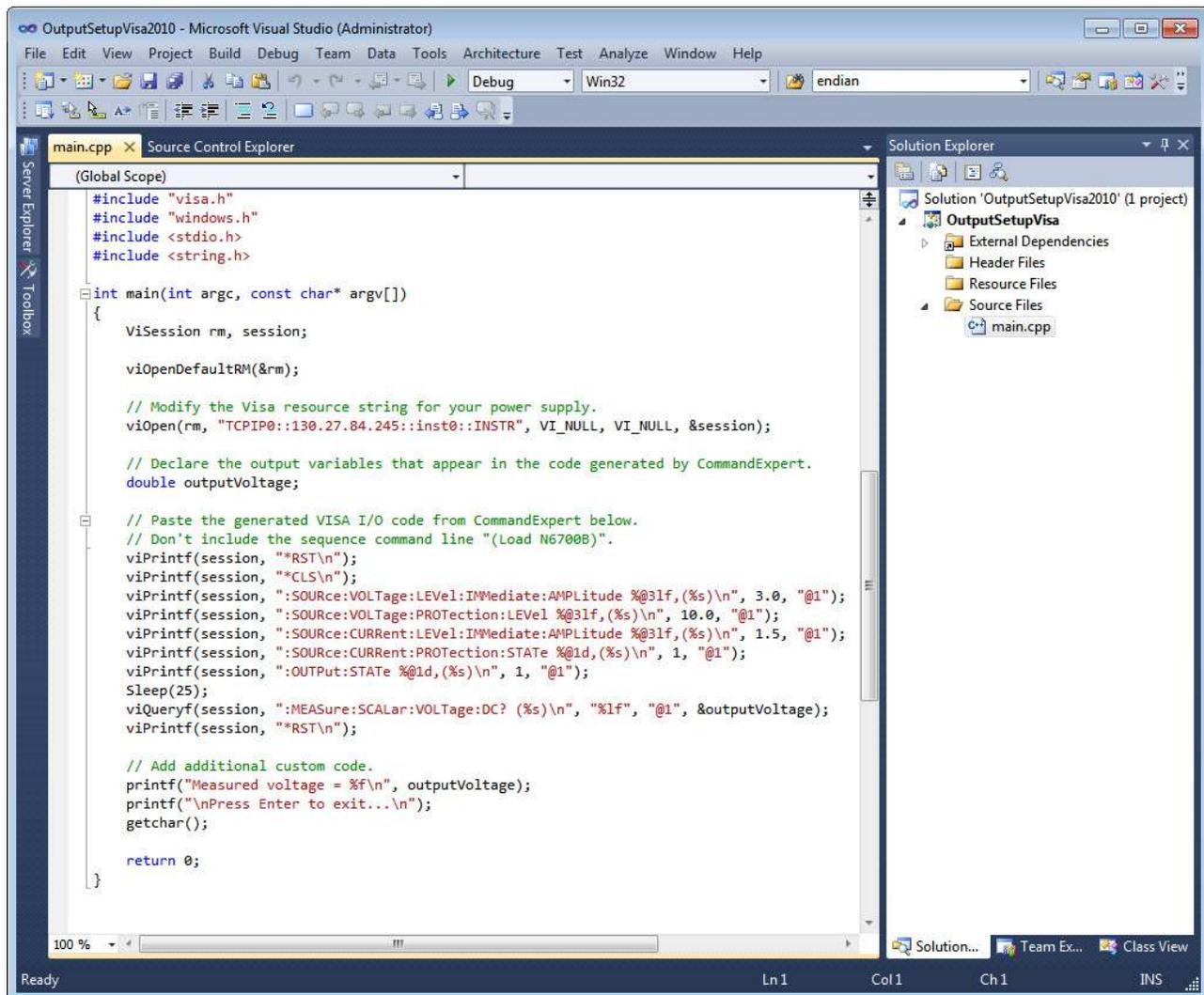
4. Click **Copy to Clipboard** followed by **Close**. The Keysight VISA I/O calls (`viOpen`, `viPrint`) are automatically added to the sequence and copied to the clipboard.

### When Command Expert generates code:

- The generated code for skipped statements is commented out.
- Comments in a sequence become comments in the generated code.
- Wait statements become calls to appropriate library functions.

5. You can now paste this code into a Visual Studio console application to create a working program. The following graphic shows the generated code from the `N6700_PowerSupply_OutputSetup` example pasted into a Visual Studio C++ console application. Be sure to add the appropriate `#include` statements (see the Command Expert help for details).

## VISA Formatted I/O Code Generation Example cont'd



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

int main(int argc, const char* argv[])
{
    ViSession rm, session;

    viOpenDefaultRM(&rm);

    // Modify the Visa resource string for your power supply.
    viOpen(rm, "TCPIP0::130.27.84.245::inst0::INSTR", VI_NULL, VI_NULL, &session);

    // Declare the output variables that appear in the code generated by CommandExpert.
    double outputVoltage;

    // Paste the generated VISA I/O code from CommandExpert below.
    // Don't include the sequence command line "(Load N6700B)".
    viPrintf(session, "**RST\n");
    viPrintf(session, "**CLS\n");
    viPrintf(session, ":SOURCE:VOLTage:LEVel:IMMediate:AMPLitude %03lf,(%s)\n", 3.0, "@1");
    viPrintf(session, ":SOURCE:VOLTage:PROTection:LEVel %03lf,(%s)\n", 10.0, "@1");
    viPrintf(session, ":SOURCE:CURRent:LEVel:IMMediate:AMPLitude %03lf,(%s)\n", 1.5, "@1");
    viPrintf(session, ":SOURCE:CURRent:PROTection:STATE %01d,(%s)\n", 1, "@1");
    viPrintf(session, ":OUTPut:STATE %01d,(%s)\n", 1, "@1");
    Sleep(25);
    viQueryf(session, ":MEASure:SCALar:VOLTage:DC? (%s)\n", "%lf", "@1", &outputVoltage);
    viPrintf(session, "**RST\n");

    // Add additional custom code.
    printf("Measured voltage = %f\n", outputVoltage);
    printf("\nPress Enter to exit...\n");
    getchar();

    return 0;
}
```

Figure 13. C++ Example

The above example is included with Command Expert as a Visual Studio C++ project. A number of examples are included for Visual Studio. These examples are located in:

*C:\Documents and Settings\All Users\Keysight\Command Expert\Examples* (for Windows XP)

*C:\ProgramData\Keysight\Command Expert\Examples* (for Windows 7)

Visual Studio examples are in these subfolders:

...\*Scpi\Visual Studio* (SCPI examples)

...\*IviCom\Visual Studio* (IVI-COM examples)

For More Information

These tutorials are available in the Command Expert help:

- *Tutorial on Using Generated VISA Code*
- *Command Expert for IVI-COM Tutorial*

## Using SCPI.NET Drivers

A SCPI.NET driver is a .NET assembly that provides a strongly typed interface to a SCPI command set. Using a SCPI.NET driver allows you to efficiently add instrument control steps without leaving the Visual Studio environment. This allows you to make use of standard Visual Studio productivity aids such as IntelliSense and compile-time type checking. Command Expert installs the SCPI.NET driver for a command set when you install the SCPI command set.

A typical process for using SCPI.NET drivers is:

1. Create a command sequence in Command Expert or open an example command sequence.
2. Export the sequence to the clipboard using the SCPI.NET code generation option.
3. Paste the generated code into your Visual Studio project.
4. Add references to required SCPI.NET drivers to the Visual Studio project.
5. In Visual Studio, modify the generated code by adding, removing or editing steps, and adding comments to the code.
6. Build and run the application.

### C# SCPI.NET Example

1. If not already open, open the *N6700\_PowerSupply\_OutputSetup* example from the Welcome Window.
2. The example opens with the SCPI commands listed (default mode). This example sets the output voltage and current of a Keysight N6700B Power Supply:

The screenshot shows the Keysight Command Center interface. On the left, the 'Active Instruments' pane shows 'N6700' selected. The 'My Instruments' pane shows 'N6700' and 'SCPI-99'. The main area is divided into three sections: a search bar, a tree view of instrument capabilities, and a configuration panel for the selected instrument.

The search bar contains 'N6700'. The tree view shows the following structure:

- [AMPLitude]
- TRIGgered
- MODE
- PROTection
- STATe
- RANGe
- DIGital
- LIST
- POWer
- CTED

The configuration panel is titled '(Connect "N6700", "", "N6700 Power Supplies / C.02.18")'. It contains the following fields:

- name: N6700
- address: Enter instrument address or leave blank to work c
- command set: N6700 Power Supplies / C.02.18

Buttons for 'Update Step 1' and 'Perform' are visible. Below the configuration panel, a text box explains: 'The Connect command connects to an instrument and enables sending commands using that connection. The name input provides a name for the instrument within the sequence.'

At the bottom, the 'Parameters' pane shows a table of commands:

| Status | Instrument | Code  | Results |
|--------|------------|---|---------|
| 1      | N6700      | (Connect "N6700", "", "N6700 Power Supplies / C.02.18") |         |
| 2      | N6700      | *RST  |         |
| 3      | N6700      | *CLS  |         |
| 4      | N6700      | :SOURce:VOLTage:LEVel:IMMediate:AMPLitude 3,(@1)        |         |
| 5      | N6700      | :SOURce:VOLTage:PROTection:LEVel 10,(@1)                |         |
| 6      | N6700      | :SOURce:CURRent:LEVel:IMMediate:AMPLitude 1.5,(@1)      |         |
| 7      | N6700      | :SOURce:CURRent:PROTection:STATe 1,(@1)                 |         |
| 8      | N6700      | :OUTPut:STATe 1,(@1)                                    |         |
| 9      | N6700      | (Wait 25ms)   |         |
| 10     | N6700      | MEASure:SCALar:VOLTage:DC?(@1)                          |         |

Figure 14. N6700 Example

## Using SCPI.NET Drivers cont'd

3. Click **File > Export Sequence...** and select **C# with calls to SCPI.NET Drivers**:

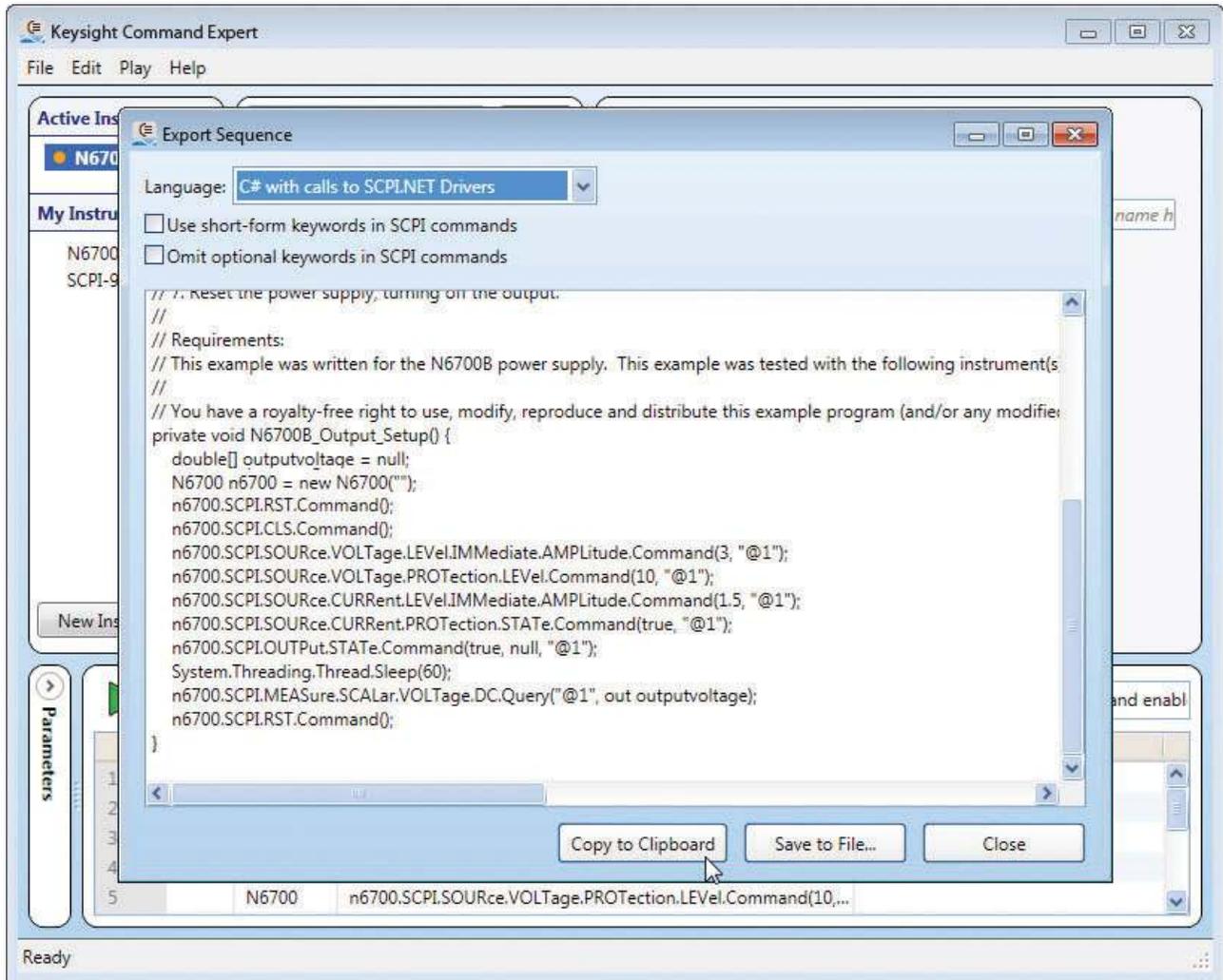


Figure 15. Exporting the Sequence (SCPI.NET)

4. Click **Copy to Clipboard** followed by **Close**. Command Expert automatically adds the C# SCPI.NET calls to the sequence and copies the sequence to the clipboard.
5. You can now paste this code into a Visual Studio console application to create a working program.

The following graphic shows the generated code from the *N6700\_PowerSupply\_OutputSetup* example pasted into a Visual Studio C# project. Be sure to add the required references (see the *SCPI.NET Drivers Tutorial* in the online help for details).

## Using SCPI.NET Drivers cont'd

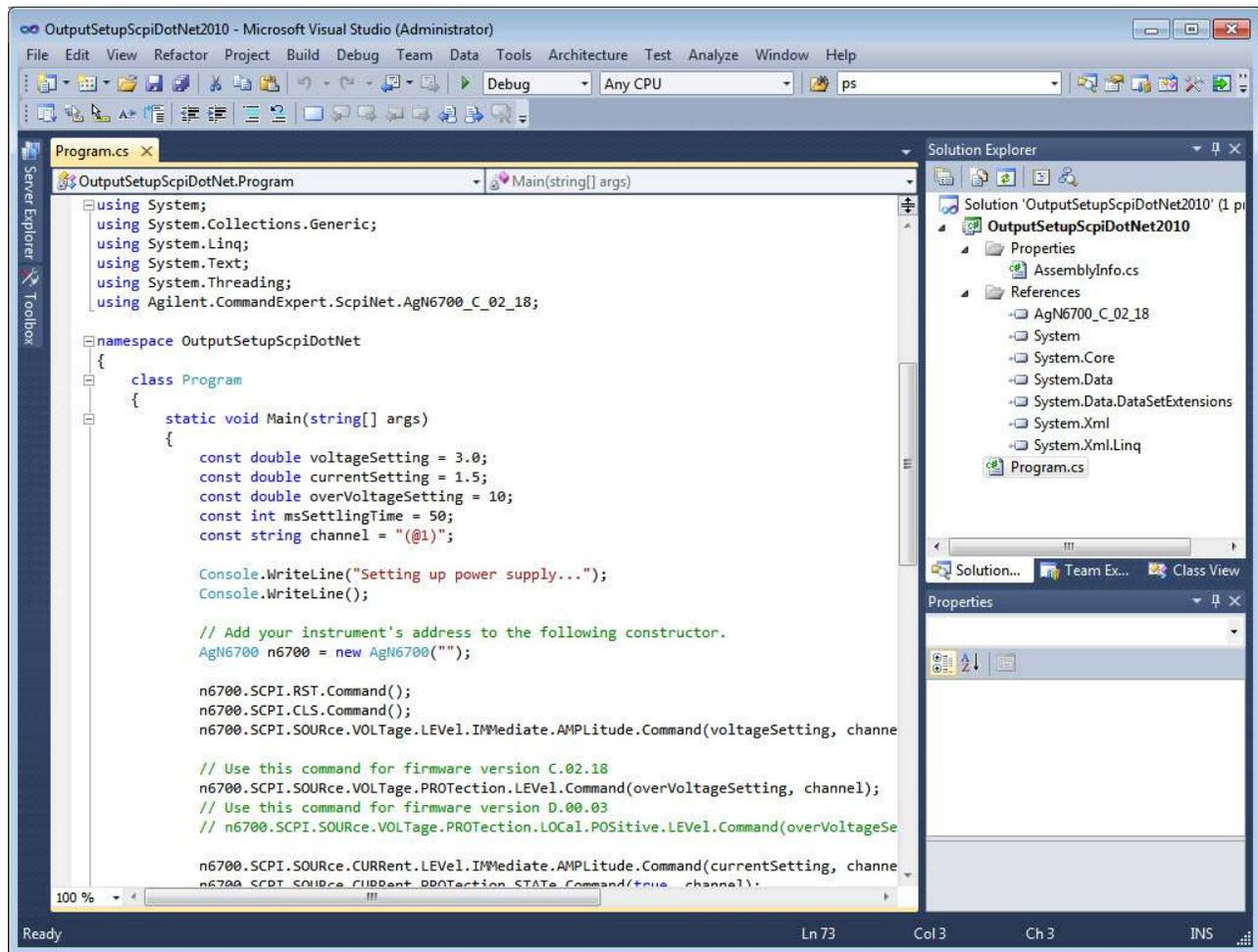


Figure 16. N6700 C# Example

6. To use IntelliSense in Visual Studio, begin typing a SCPI command string.

For example, type: `n6700.SCPi.SOURce.VOLTage.`

IntelliSense displays the available command strings and descriptions:

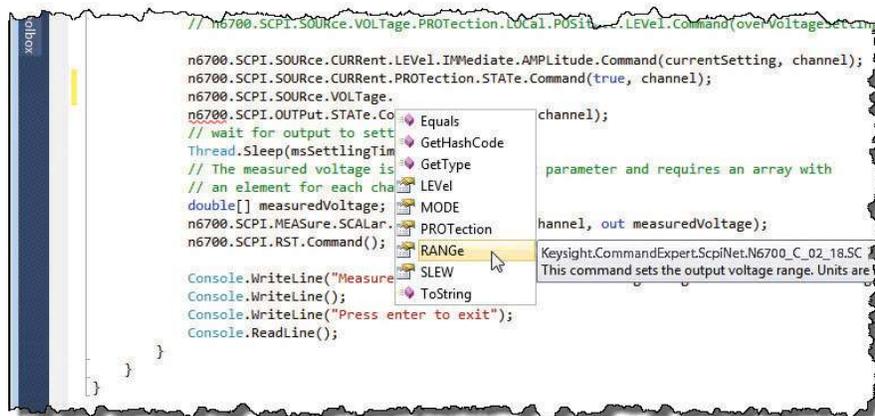


Figure 17. IntelliSense

Select a string, such as `RANGe`, to append it to the SCPI command.

## Using SCPI.NET Drivers cont'd

7. To view SCPI documentation in Visual Studio, right-click the rightmost SCPI keyword in the driver call. For example, right-click the *AMPLitude* keyword in this line of code:

```
n6700.SCPi.SOURce.CURRent.LEVel.IMMediate.AMPLitude.Command(currentSetting, channel);
```

Click **Go to Definition** from the Visual Studio context menu. Visual Studio displays the source code for the SCPI.NET driver class. Click the link directly under **// Remarks**: to view the HTML documentation for the *AMPLitude* command.

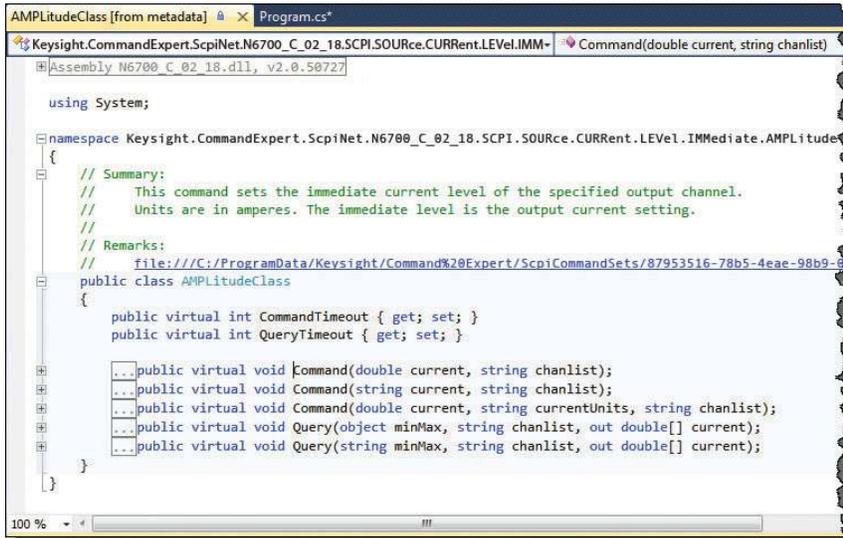


Figure 18. SCPI Documentation in Visual Studio

The preceding example is included with Command Expert as a Visual Studio C# project. A number of Visual Studio examples are included for Visual Studio. Examples are located in:

*C:\Documents and Settings\All Users\Keysight\Command Expert\Examples* (for Windows XP)

*C:\ProgramData\Keysight\Command Expert\Examples* (for Windows 7)

Visual Studio examples are in these subfolders:

...\*Scpi\Visual Studio* (SCPI examples)

...\*IviCom\Visual Studio* (IVI-COM examples)

For More Information

For a step-by-step tutorial, see *SCPI.NET Drivers Tutorial* in the Command Expert help.

## Where to Go Next

The easiest way to get started using Command Expert with Visual Studio is to browse through the example folders and select an example that is similar to your test and measurement application. Examples are provided for Visual Studio 2005, Visual Studio 2008, and Visual Studio 2010.

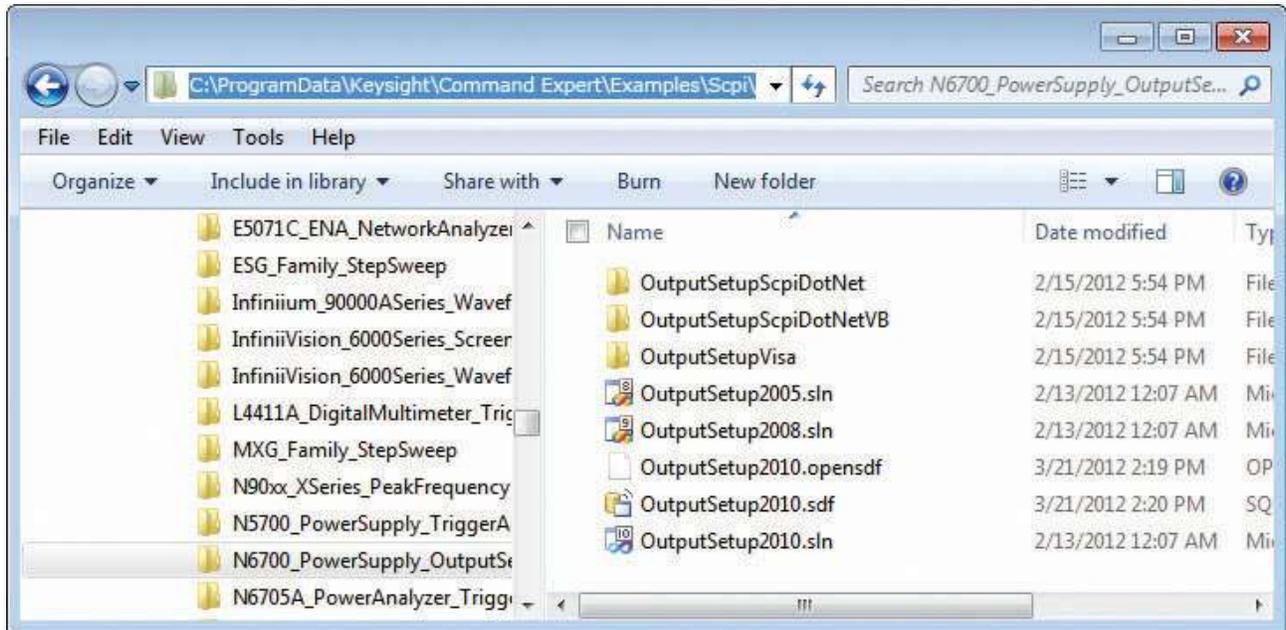


Figure 19. More Examples

Command Expert has extensive application documentation containing FAQs, tutorials, examples, and getting started information. You can use one of these tutorials, available in the Command Expert help, for step-by-step information on how to use Command Expert with Visual Studio:

- *Tutorial on Using Generated VISA Code*
- *Command Expert for IVI-COM Tutorial*
- *SCPI.NET Drivers Tutorial*

## Where to Go Next cont'd



Figure 20. Command Expert Tutorials

Be sure to check the Command Expert help for important information on using the various Visual Studio versions. You can find more information on Command Expert, including links to other application notes, at [www.keysight.com/find/commandexpert](http://www.keysight.com/find/commandexpert).

## PC Operating Requirements

|                             |   |
|-----------------------------|---|
| Operating System            | Windows XP, Service Pack 2 or above, 32-bit only.<br>Editions: Home, Professional<br>Windows 7, 32-bit or 64-bit.<br>Editions: Starter, Home Basic, Home Premium, Professional, Ultimate, or Enterprise |
| Disk                        | At least 1GB free disk space  |
| Keysight IO Libraries Suite | Version 15.0 or above <a href="http://www.keysight.com/find/iosuite">www.keysight.com/find/iosuite</a>  |
| Monitor                     | At least 1024x768 monitor resolution  |
| Browser                     | Internet Explorer 6 or above (7 or above recommended)   |

You can find the current list of instrument SCPI command sets at: [www.keysight.com/find/commandsetlist](http://www.keysight.com/find/commandsetlist)

## Application Development Environment Requirements

|               |   |
|---------------|---|
| Visual Studio | Visual Studio 2005, 2008, 2010 or above           |
| LabVIEW       | LabVIEW 8.2.1 or above.                           |
| VEE           | VEE Pro 9.22 or above.                            |
| Excel         | Excel 2007 or Excel 2010.                         |
| MATLAB        | MATLAB Instrument Control Toolbox R2009a or above |

Download Command Expert now and experience fast and easy instrument control: [www.keysight.com/find/commandexpert](http://www.keysight.com/find/commandexpert)

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[www.keysight.com/quality](http://www.keysight.com/quality)

Keysight Technologies, Inc.  
DEKRA Certified ISO 9001:2008  
Quality Management System

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(BP-07-10-14)

