Application Note

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Using LabVIEW to Write Programs for the Aeroflex PXI Modules

This application note explains how to use the LabVIEW graphical programming environment to develop software for the Aeroflex PXI 3000 Series radio frequency (RF) test instruments and signal analysis libraries. It focuses on the use of Dynamic Linked Libraries (DLLs) and their importation into the LabVIEW environment.

The Aeroflex PXI module hardware includes the 3020 Series RF Signal Generator, 3030 Series RF Digitizer, 3010 Series RF Synthesizer and 3060 Series RF Combiner. The signal generator and synthesizer modules combine to form the RF Signal Generator instrument. Likewise, the RF Digitizer module is combined with another RF Synthesizer module to form the RF Digitizer instrument.

Each instrument is programmed using functions from either a DLL or a COM interface library. The COM components are implemented as a lightweight wrapper around the underlying DLL. The signal generator software library treats the two module combination as a single instrument, with DLL or COM function calls denoted as Signal Generator function calls rather than calls to the individual modules. Similarly, the RF Digitizer software library treats its two module combinations as one instrument by using RF Digitizer function calls.

Data captured by the RF Digitizer is provided as in-phase and quadrature (I & Q) arrays. These data arrays can be processed and analyzed using the optional Aeroflex signal analysis libraries. Each signal analysis DLL consists of a set of functions that are used to perform various RF parametric measurements such as modulation quality, power level, adjacent channel power, frequency error, phase error, etc. The spectrum analysis library is always supplied with the RF digitizer and provides functionality for spectrum analyzer emulation. Aeroflex PXI signal analysis libraries include capabilities for analysis of various communication standards such as GSM / EDGE, CDMA 2000, UMTS, WLAN and WiMAX. These analysis libraries are only implemented as DLLs. COM interfaces are not provided.

The instrument hardware can be programmed either by using the DLL importation method explained in this paper or by using the provided COM interface. Another application note entitled "How to use Aeroflex PXI 3000 Series COM interface in place of ActiveX controls" provides a comprehensive description of the use of the COM interface with the instrument hardware.

Call Library Function Nodes and Dynamic Linked Libraries

The "Call Library Function Node" is the key mechanism used in LabVIEW to link with individual DLL function calls. This icon can be configured to represent a specific DLL function. Wiring terminals are created on the icon representing the assigned function's input and output variables. Once configured, a Call Library Function Node is typically utilized within a LabVIEW virtual instrument (VI). A VI created specifically for a configured Call Library Function Node can be thought of as a wrapper VI. A set of wrapper VIs, each containing a Call Library Function Node that represents a different DLL function, can be created to represent the set of functions from an entire DLL. The VIs can then be grouped into a LabVIEW user library that is analogous to the original DLL library it represents. For example, each function within the Spectrum Analysis library can be linked to its own Call Library Function Node. Each configured node is then wrapped in its own VI. Collectively, this set of wrapper VIs forms a LabVIEW Spectrum Analysis user library. The library itself can be presented as an icon in the User Library palette within the LabVIEW programming environment. This Spectrum Analysis user library allows the programmer to easily utilize individual functions from the DLL that are in the form of sub VIs. LabVIEW v8.0 and higher contains the capability to automate the process of creating wrapper VIs for an entire set of DLL functions.

Additional Software Information

Help files explaining available library functions exist as part of the PXI driver software installation. These help files can be easily accessed from the Windows desktop by navigating to Start->Programs->Aeroflex->PXI Libraries->Signal Generator, Digitizer or Combiner.

In addition to instrument level libraries, a set of low level module DLLs exist that provide access to the individual module's functions. Typically, the higher level instrument DLLs or COM libraries are used to write programs. The lower level DLLs can be tedious to work with when an instrument consists of two modules. When using the lower level module DLLs, additional steps are needed to coordinate operations between the signal generator module or digitizer module and their respective frequency synthesizer module.

Software drivers for the individual modules were created using the VXI Plug & Play conventions. Help files for the low level DLLs are found in the area where the VXI Plug & Play drivers are typically installed. For example, the path to the PXI 3010 RF Synthesizer module's help file is C:\VXIPNP\WinNT\af3010\af3010_C.hlp. Help files pertaining to the other module DLLs exist in folders labeled \af3020, \af3030 and \af3060.

Implementing DLL Functions Using LabVIEW

Figure 1 shows an example of a Call Library Function Node that has been configured. The function's input and output terminals are visible on the icon. In this example, the terminals are connected to LabVIEW VI front panel control and indicator terminals.

The Call Library Function Node icon can be found in the "Functions" palette in the LabVIEW block diagram window through the path "Functions -> Connectivity -> Libraries & Executables -> Call Library Function Node". Terminals representing input variables are on the left side of the icon. Output terminals are on the right.

The icon in Figure 1 has been configured to represent a specific DLL function from the Spectrum Analysis library. In this example, the analysis function is used to calculate Average Power from arrays of captured I & Q samples. The prototype of the function assigned to this Call Library Function Node is:

long afSpectrumDll_ZeroSpan (long nID, float *ptrIData, float *ptrQData, float *ptrAvgPower, long NumIQ);

Correlation between the names of the variables in the function prototype and the variables connected to the Call Library Function Node in Figure 1 can be seen. The I and Q input arrays are connected to the left side of the Call Library Function Node along with the integer variable NumIQ representing the number of elements in the equally sized I and Q arrays. The integer variable in the upper left, nID, is used to pass the instance ID of the Spectrum Analysis object to the function. The function's return value variable is represented on the upper right side of the icon.

The right side also has an output terminal with the value of the result of this function's average power calculation, AvgPower out.

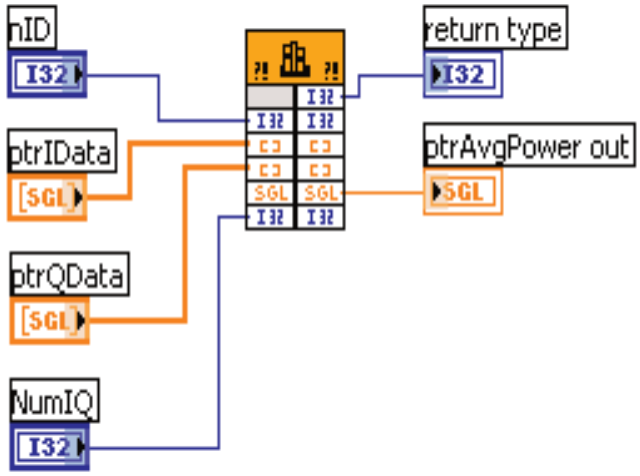

Figure 1. "Call Library Function Node" example with assigned input and output variables connected

Configuration of a Call Library Function Node

Call Library Function Node configuration can be performed manually or, for a group of functions within a single DLL, by using the automated method available in LabVIEW v8.0 or higher. Manual configuration will be explained first so that the reader is familiarized with the Call Library Function Node configuration process. Manually configuring a large number of nodes can be tedious and so it is preferable to utilize the automated configuration method. It is often necessary however to manually modify the configuration of some nodes that have previously been automatically configured.

Manual configuration is performed by right clicking at the top of the Call Library Function Node icon and selecting "configure" from the drop down menu. The window shown in Figure 2 appears.

Under the "Function" tab, the "Library name or path" field is shown. The browse button to the right of this field allows selection of the DLL to be linked to. The Aeroflex DLLs are typically found in the path C:\WINDOWS\System32\af.dll. The "Function name" field is then used to select the name of a function within the DLL.

In this example, the library named "afSpectrumDll.dll was selected. The function called "afSpectrumDll_ZeroSpan_AveragePower" was then chosen from the pull down list in the "Function name" field. An incomplete function prototype appears at the bottom of the window. Instead of a listing input and output variables within the parenthesis, the word "void" is simply shown. The variables are entered manually under the "Parameters" tab of this window. Variable names appear within the function prototype's parenthesis as they are added under the "Parameters" tab. The "Thread" and "Calling convention" parameters should be set up as shown in Figure 2.

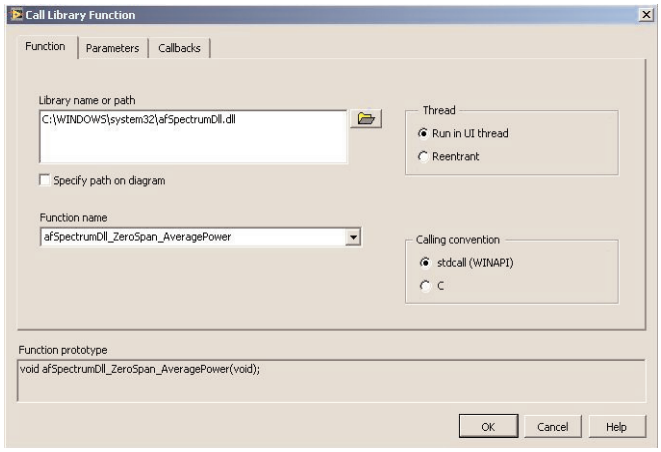

Figure 2. Call Library Function Node configuration window

Figure 3 shows the configuration window displayed with the "Parameters" tab selected. The assigned function's variable names are entered or edited on the left side. These can be obtained by referring to the function prototype in the library's include file. Function prototypes are found in the ".h" header files for each library. Header files are installed with the PXI driver installation and can typically be found in the path c:\Program Files\Aeroflex\PXI\Include. In this example, the path to the Spectrum analysis DLL include file is: C:\ProgramFiles\Aeroflex\PXI\Include\afSpectrumDll.h.

Highlighting a variable name on the left side allows variable type and data formatting parameters to be configured on the right side. These configuration parameters and data types must be manually selected from the pull down menus on the right. More information regarding the configuration of Call Library Function Nodes can be found in the LabVIEW help documentation.

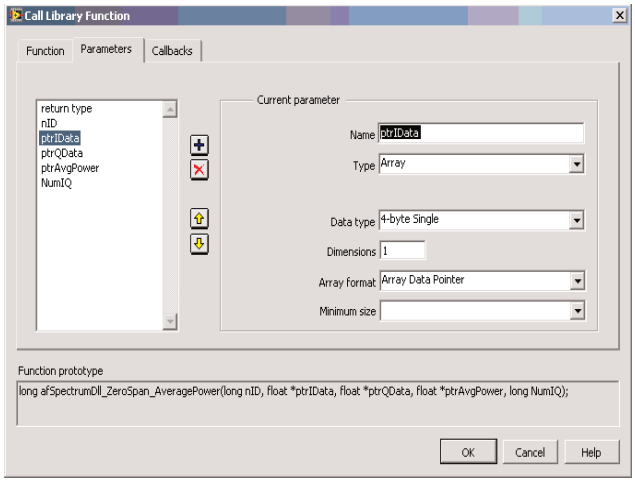

Figure 3. Call Library Function Node configuration window with 'Parameters' tab selected

The block diagram in Figure 4 shows the same Call Library Function Node configuration as above except that it is placed within its own wrapper VI, complete with Error In / Error Out terminals.

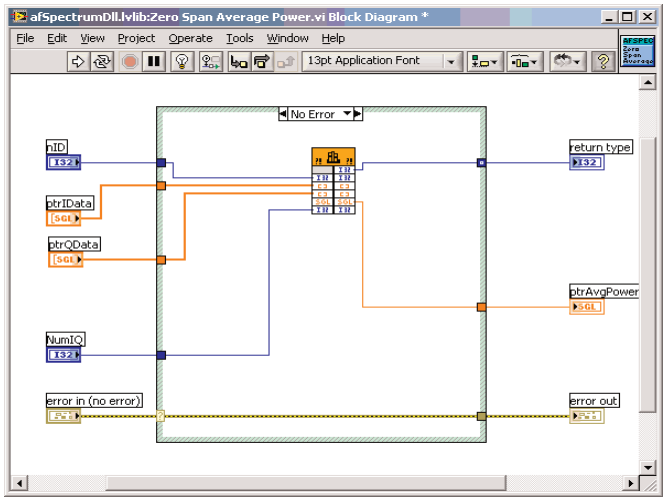

Figure 4. Diagram of the example Call Library Function Node within it's own wrapper VI

Automatic Porting of DLLs

The easiest and most efficient way to port DLLs into LabVIEW is to use the "Tools->Import->Shared Library(.dll)" menu feature in LabVIEW v8.0 and higher. This feature allows automatic creation of wrapper VIs based on user provided header and DLL location information. A sequence of pop up menus drives the library creation process. Newly create LabVIEW libraries, representing imported DLLs, contain sets of wrapper VIs. Each wrapper VI contains an automatically configured Call Library Function Node and represents an individual library function.

When creating a library, the user needs to select both the DLL file to be imported and the associated header (.h) file. For example, if porting the Spectrum Analyzer DLL, browse to C:\WINDOWS\system32\afSpectrumDll.dll when prompted for the "Shared Library" and select this DLL. Next, select the associated header file so that the function prototype variables are automatically assigned to the Call Library Function Nodes for each function. When prompted for the "Header (.h) File", Browse to C:\ProgramFiles\Aeroflex\PXI\Include\afSpectrumDll.h and select this header file. There may be more than one header file related to each library, such as type definition headers and other external code. The main header file for each library should have code that includes all others.

The automatic import process allows for the assignment of the new library's name and location. It allows for all or some of the target DLL's functions to be imported. The new library is placed in the LabVIEW user directory by default. This library is added to the User library's palette under the Functions palette in the diagram window.

The automatic import process is very convenient when a large number of DLL functions need to be transferred. Sometimes however, the automatic process does not select the correct parameter types. This happens when a particular function's header is misinterpreted. In these cases, wrapper VIs containing incorrectly configured nodes are created. This happens, for example, when the I and Q array parameters are used as input or output variables within a function. Aeroflex function prototypes typically list these array variables as pointers (float *ptrIData, float *ptrQData). In this case, the variables representing the I and Q arrays are automatically assigned as "Type : Numeric" instead of as "Type : Array". The parameter type must be manually set to "Array" using the pull down list found in the "Type" window under the "Parameters" tab in the Call Library Function Node configuration window. Figure 3 shows the appropriate settings. In this case, other parameters must be corrected including "Data type", "Dimensions" and "Array format". The wrapper VI's front panel controls must also be changed, in this case from a numeric type to an array type. Once corrected, the wrapper VI can be saved to the library.

Summary

The Aeroflex PXI instrument and analysis software libraries are implemented as DLLs. Creation of LabVIEW programs using these DLLs requires the use of Call Library Function Nodes. Typically, these nodes are contained within wrapper VIs. Writing programs that include the signal analysis DLLs require the use of these nodes. Programming instrument hardware requires the use of either these configured nodes or the available provided COM interfaces. The creation of LabVIEW user libraries, analogous to the specific DLLs, is a simple process when using LabVIEW version 8.0 or higher. Once created, these user libraries can be re-used any number of times.

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Part No. 46891/299, Issue 1, 09/07