N4010A Programming Made Easy for WLAN Applications

Application Note

Agilent Technologies

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1. Overview

This application note is a companion to the N4010A User Guide and has been written to assist software test developers and application engineers in the creation of effective integration test plans and manufacturing test sequences for the N4010A Wireless Connectivity Test Set. This application note steps you through the process of Wireless Local Area Network (WLAN) test development using the N4010A and its associated programming interfaces.

Using this application note will enable faster test development with the N4010A, resulting in lower initial test development cost and shorter time to volume.

It is assumed that the reader will be familiar with the fundamentals of programming in a .COM and .NET development environment.

1.1. N4010A WLAN Test Suite software installation

Installation of the N4010A WLAN Test Suite software will provide several components, which are available by following the menu selection: Start > All Programs > Agilent N4010 WLAN Test Suite. These components are:

• Example programs

• Agilent N4010A WLAN Test Suite documentation: Help guide and programmers reference

• N4010A WLAN Virtual Front Panel, graphical user interface enabling transmitter/receiver measurements

• About Agilent N4010A WLAN Test Suite, gives version number of installed version

If you do not already have it installed, the Agilent N4010A WLAN Test Suite software is provided on a CD that ships with the N4010A. The latest software is also available for download from **www.agilent.com/find/N4010A** by following the Technical Support link.

1.2. N4010A WLAN DLL compatibility

As part of the N4010A WLAN Test Suite software installation, the WLAN test dynamic link library (DLL) or driver is installed. The driver provides two DLL programming interfaces, which offer identical functionality:

• N4010 WLAN COM DLL, and

• N4010 WLAN .NET DLL

Providing both a COM DLL and a .NET DLL gives the option to use the specific DLL type most compatible with your test software development environment. The differences between interfacing with the COM and .NET DLL interfaces are summarized in *Appendix A—COM DLL and .NET DLL Use Comparison*.

1.3. Available example programs

Example programs can be accessed by following the menu selection Start > All Programs > Agilent N4010 WLAN Test Suite > Example Programs.

The COM and .NET programming interfaces are compatible with all programming languages that support either COM or .NET DLL programming. Example programs are available for:

• Microsoft® Visual C#® .NET   (.NET)

• Microsoft Visual Basic® .NET   (.NET)

• Microsoft Visual Basic 6.0   (COM)

• Microsoft Visual C++® 6.0   (COM)

• Visual Basic Script   (COM)

• Agilent VEE 6.2   (COM)

• Agilent VEE 7.0   (.NET)

• LabVIEW 6   (COM)

• LabVIEW 7.1   (.NET)

The example N4010A WLAN DLL commands used in this document demonstrate the COM DLL interface.

Throughout this document, programming examples are provided for WLAN test DLL commands. These are in Visual Basic 6.0 syntax.

2. Creating a WLAN Test Program —6 Basic Steps

There are six basic steps in creating a WLAN test program using the N4010A WLAN COM or .NET DLL.

1. Reference the dynamic link library (DLL)

2. Create the instrument object

3. Configure the measurement setup parameters

4. Run the measurement

5. Get the measurement results

6. Dispose the session

Steps 1, 2, and 6 of the instrument object must be performed if the PC or the N4010A is power cycled.

During software test development and debugging, it is advisable to deal with any exceptions. If, for example, the program aborts due to an exception, Step 6 may not be reached and the N4010A can be left in an unknown state.

Steps 3 to 5 can be repeated as many times as required to cover a full test sequence of measurements for the chosen test plan for the WLAN device under test.

2.1. Step 1. Reference the DLL

For programming environments such as the Microsoft Visual Studio® integrated development environment (IDE), the program needs to first reference the N4010A WLAN test driver DLL. There is one DLL reference required for COM DLL development, namely:

Agilent_N4010_WLanTest.dll
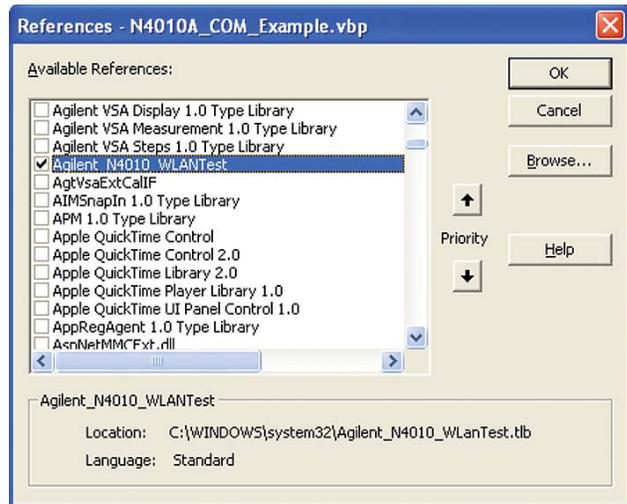
Figure 1. Adding a reference to the N4010A WLAN test COM DLL in Visual Basic 6

During installation the N4010A WLAN test driver, the DLL above is registered in the Microsoft Windows® registry. Among other things, this enables programs such as Visual Studio to present the DLL in the references list for easy selection. (See Figure 1.)

Example: Referencing the N4010A WLAN COM DLL in Microsoft Visual Basic 6
In Visual Basic 6.0 (VB6), select the Project, References...menu.

• This lists all the COM DLLs installed on the PC. The window that opens should look familiar to test developers using development environments such as Agilent VEE, Visual C++, National Instruments (NI) LabVIEW, where referencing a COM component's type library is carried out in a similar way.

• Note: In some development environments such as Agilent VEE, NI LabVIEW, and NI Lab Windows CVI, the COM DLL can be found and added through another naming terminology, ActiveX.

When referencing a COM component, you are actually referencing its type library, which provides the development environment compiler with definitions of types, methods, and properties that the component exposes.

2.2. Step 2. Create the instrument object

Each program begins with the creation of the instrument object to enable a communication link with the N4010A. The instrument object requires the setting of an instrument VISA resource string, which allows the N4010A DLL to communicate with the N4010A via the installed VISA libraries such as Agilent IO Suite. You must first create the instrument object before you can access the test set functionality through the WLAN DLL methods (also known as functions) and properties (or parameters).

COM object creation
The creation of the N4010A WLAN COM test driver object requires as a minimum, the VISA address of the N4010A specified by "InstrumentVISAResourceString", to setup a communication link between the PC and the N4010A over USB, LAN, or GPIB. On setting this parameter, the instrument object is created when a method named "ActivateInstrument()" is called.

Example code snippet: COM object creation

```
'Step 2 of 6: Create the instrument object named Inst
Private Inst As Agilent_N4010_WLanTest.Instrument
Set Inst = New Agilent_N4010_WLanTest.Instrument
Inst.InstrumentVISAResourceString = "
TCPIP0::123.456.789.123::inst0::INSTR"
Inst.ActivateInstrument
```

2.3. Step 3. Configure the measurement setup parameters

This stage configures the N4010A test set input settings to suit the WLAN device transmitter parameters and the measurement. For example, the set up of appropriate measurement frequency and triggering values.

Generic N4010A measurement setup parameters
Refer to the help file referenced in Section 1.1. Use "Agilent.N4010.WlanTest.Instrument" class for the default settings and ranges for generic parameters such as frequency, triggering, and expected maximum input power range. Ensure the triggering and measurement settings are appropriate for the signal being transmitted from the WLAN device under test to the N4010A test set; otherwise the measurement may timeout as the N4010A will not detect a signal.

Measurement-specific N4010A setup parameters
Refer to the help file referenced in Section 1.1. Use "Agilent.N4010.WlanTest.Measurements" class for default settings and ranges for measurement-specific settings. For example, the "TrackPhase" property is unique to the Measurement Demod 11b test.

WLAN device setup parameters
The WLAN device must also be in the correct state for the desired measurement. For WLAN Tx and Rx tests, the setup of the WLAN device is not controlled by the N4010A test set or the N4010A programming interface but by the WLAN chipset vendor-specific control software.

Example code snippet: Measurement setup

```
'Step 3 of 6: Configure measurement setup parameters
Inst.Frequency = 2412000000#
Inst.PowerRange = 0#
Inst.MaxPacketLength = 0.00097
Inst.TriggerDelay = -0.000002
Inst.TriggerHoldoff = 0.00001
Inst.TriggerLevel = 0.02
Inst.TriggerStyle = Agilent_N4010_WLan-Test.
TriggerStyleEnums_MagLevel

Inst.IEEE80211b_Demod_TrackPhase = True
Inst.IEEE80211b_Demod_MeasureGatedPower = True
Inst.IEEE80211b_Demod_LeftGatedPowerTime = 0
Inst.IEEE80211b_Demod_RightGated-PowerTime = 0.00001
```

2.4. Step 4. Perform the test

Measurement initiate methods
Measurements and collection of measurement data are started by using the measurement "Initiate" method.

Refer to the help file referenced in Section 1.1. Use "Agilent.N4010.WlanTest.Measurements" class for the full list of N4010A WLAN transmitter measurements.

Example code snippet: Running of measurement

```
'Step 4 of 6: Run the measurement
Inst.IEEE80211b_Demod_Initiate
```

2.5. Step 5. Get the measurement results

In the example test case below, the Measurement Demod 11b test includes several properties for retrieval of individual results including RMS EVM, peak EVM, IQ offset, frequency error, and gated power.

Refer to the help file referenced in Section 1.1. Use "Agilent. N4010.WlanTest.Measurements" class and select a measurement to view the results properties associated with the selected measurement.

Example code snippet: Retrieval of measurement results

```
'Step 5 of 6: Get the measurement results
Dim EvmPeakResult As Double
Dim EvmRmsResult As Double
Dim IqOffsetResult As Double
Dim FreqErrResult As Double
Dim ChipClockErrorResult As Double
Dim PowerResult As Double

EvmPeakResult = Inst.IEEE80211b_Demod_PeakEVM
EvmRmsResult = Inst.IEEE80211b_Demod_RmsEVM
IqOffsetResult = Inst.IEEE80211b_Demod_QOffset
FreqErrResult = Inst.IEEE80211b_Demod_FrequencyError
ChipClockErrorResult = Inst.IEEE80211b_Demod_
ChipClockFrequencyError
PowerResult = Inst.IEEE80211b_Demod_
GatedPowervmRmsResult
```

WLAN receiver measurements
WLAN receiver testing is performed using the N4010A arbitrary waveform generator (AWG). Known WLAN packet types are sent to the device and the receiver performance is monitored using its vendor-specific control software. This is covered in detail in the *Section 18: Receiver Minimum/Maximum Input Level Sensitivity.*

Refer to the help file referenced in Section 1.1. Use "Agilent. N4010.WlanTest.Generator" class for the default settings and ranges for parameters such as frequency and packet type of the N4010A signal generator.

2.6. Step 6. Close the session

The program is ended and the test released from communication using the "Dispose" method. As well as releasing memory space used by the N4010A WLAN DLL. This also releases the handle on the test set VISA resource allowing other applications to communicate with the N4010A.

Example code snippet: Disposal of session

```
'Step 6 of 6: Dispose the session
Inst.Dispose
```

Example code snippet: Full code example

```
Full code example
'Step 1 of 6: Reference the Dynamic Link
Library (DLL)

'Step 2 of 6: Create the instrument object
Private Inst As Agilent_N4010_WLanTest.Instrument
Set Inst = New Agilent_N4010_WLanTest.Instrument
Inst.InstrumentVISAResourceString =
" TCPIP0::123.456.789.123::inst0::INSTR"
Inst.ActivateInstrument

'Step 3 of 6: Configure measurement setup parameters
Inst.Frequency = 2412000000#
Inst.PowerRange = 0#
Inst.MaxPacketLength = 0.00097
Inst.TriggerDelay = -0.000002
Inst.TriggerHoldoff = 0.00001
Inst.TriggerLevel = 0.02
Inst.TriggerStyle = Agilent_N4010_WLan-Test.
TriggerStyleEnums_MagLevel

Inst.IEEE80211b_Demod_TrackPhase = True
Inst.IEEE80211b_Demod_MeasureGatedPower = True
Inst.IEEE80211b_Demod_LeftGatedPowerTime = 0
Inst.IEEE80211b_Demod_RightGated-PowerTime = 0.00001

'Step 4 of 6: Run the measurement
Inst.IEEE80211b_Demod_Initiate

'Step 5 of 6: Get the measurement results
Dim EvmPeakResult As Double
Dim EvmRmsResult As Double
Dim IqOffsetResult As Double
Dim FreqErrResult As Double
Dim ChipClockErrorResult As Double
Dim PowerResult As Double

EvmPeakResult = Inst.IEEE80211b_Demod_PeakEVM
EvmRmsResult = Inst.IEEE80211b_Demod_RmsEVM
IqOffsetResult = Inst.IEEE80211b_Demod_QOffset
FreqErrResult = Inst.IEEE80211b_Demod_FrequencyError
ChipClockErrorResult = Inst.IEEE80211b_Demod_
ChipClockFrequencyError
PowerResult = Inst.IEEE80211b_Demod_
GatedPowervmRmsResult

'Step 6 of 6: Dispose the session
Inst.Dispose
```

3. Auto Range and Measurement Setup (802.11a ⁄ b ⁄ g ⁄ n)

3.1. What auto range determines

The auto range feature is a very useful test development aide for setting up parameters for measuring bursted signals. The parameters below must be setup to allow successful and accurate measurements to be made.

- N4010A maximum input power range

- N4010A trigger level

- N4010A maximum packet length

- N4010A maximum symbols used

These parameters can be selected manually, or generated automatically using the auto range feature.

For manufacturing test it is not recommended to include auto range within the test script. It is recommended that the auto range functionality is only used during test development and that fixed values are used in the test script, for example, in the format of a look-up table. Auto range does take some time to compute and as part of an automated test script this would add unnecessarily to overall test time.

3.2. What auto range does not determine

Prior to using the auto range feature on a bursted signal, the N4010A frequency parameter must be set to the same as the WLAN device frequency for auto range to work. Other parameters that are not calculated by the auto range feature, but can be independently set for successful measurements, are listed below:

- N4010A carrier frequency (i.e. N4010A frequency = WLAN DUT frequency)

- N4010A trigger type

- N4010A trigger delay

- N4010A trigger holdoff

3.3. What is "Max Packet Length" or "Max Symbols Used"?

"Max Packet Length" for DSSS packets or "Max Symbols Used" for OFDM packets, described in measurement terms, is the equivalent to the measurement capture time or length. This is the interval of sampled data from which the measurement algorithm will calculate the measurement result. For the most accurate measurement the" Max Packet Length" or "Max Symbols Used" should equal the full length of the transmitted burst, packet, or frame. This parameter can be reduced from the full burst to reduce test time. Selecting the full packet length is recommended for optimum measurement accuracy. Data analysis can be performed to determine if a reduced packet length can be used to decrease test time. The data analysis would need to prove that reducing the packet length still allows the device measurement results to remain within the production line test line limits guard band for the device under test.

3.4. Bursted modulated measurement setup

For a bursted signal measurement:

- N4010A carrier frequency (i.e., N4010A frequency = WLAN DUT frequency)

- N4010A maximum input power range

- N4010A maximum packet length or maximum symbols used

- N4010A trigger type = MagLev

- N4010A trigger delay

- N4010A trigger holdoff

3.5. Continuous wave (CW) measurement setup

For a continuous wave signal measurement, the N4010A setup is different from the bursted signal measurement N4010A setup:

- N4010A carrier frequency (i.e. N4010A frequency = WLAN DUT frequency)

- N4010A maximum input power range

- N4010A maximum packet length

- N4010A trigger type = FreeRun

3.6. Auto range test procedure summary

The following steps summarize the procedure required to con-
figure the WLAN DUT and the N4010A, to make the auto range
measurement, and then to setup the N4010A with the required
results.

Step	Focus	Action
1.	N4010A	Set frequency, e.g. Channel 1 at 2.412 GHz, by setting the Frequency property
2.	WLAN DUT	Set frequency band, e.g. 802.11b
3.	WLAN DUT	Set channel, e.g. Channel 1 at 2.412 GHz (i.e. N4010A = WLAN DUT frequency)
4.	WLAN DUT	Set power
5.	WLAN DUT	Set modulation type, e.g. 11 Mbps, CCK
6.	WLAN DUT	Start transmitting packets
7.	N4010A	Initiate the auto range measurement
8.	N4010A	Set the PowerRange, to the value obtained from auto range
9.	N4010A	Set TriggerLevel, to the value obtained from auto range
10.	N4010A	Set MaxPacketLength, or MaxSymbolsUsed, to the value obtained from auto range

3.7. Auto range test procedure programming example

Using the same steps as in the procedure summary section
above, this section shows N4010A WLAN test DLL commands
required to set up the N4010A.

Step	Focus	Action
1.	N4010A	Inst.Frequency = 2412000000# ' Sets the N4010A Tx and Rx frequency
2.	WLAN DUT	' DUT specific command to set frequency band
3.	WLAN DUT	' DUT specific command to set transmit frequency
4.	WLAN DUT	' DUT specific command to set transmit power
5.	WLAN DUT	' DUT specific command to set modulation type
6.	WLAN DUT	' DUT specific command that turns transmitted power on ready for the measurement
7.	N4010A	Inst.IEEE80211b_Autorange_Run ' Initiates the N4010A DSSS 802.11b auto range measurement Or Inst.IEEE80211a_Autorange_Run ' Initiates the N4010A OFDM 802.11a or 802.11g auto range measurement
8.	N4010A	Inst.PowerRange = Inst.IEEE80211b_Autorange_PowerRange ' Sets the N4010A DSSS 802.11b max power range to optimize dynamic range Or Inst.PowerRange = Inst.IEEE80211a_Autorange_PowerRange ' Sets the N4010A OFDM 802.11a or 802.11g max power range to optimize dynamic range
9.	N4010A	Inst.TriggerLevel = Inst.IEEE80211b_Autorange_TriggerLevel ' Sets the N4010A DSSS 802.11b trigger level Or Inst.TriggerLevel = Inst.IEEE80211a_Autorange_TriggerLevel ' Sets the N4010A OFDM 802.11a or 802.11g trigger level
10.	N4010A	Inst.MaxPacketLength = Inst.IEEE80211b_Autorange_MaxPacketLength ' Sets the N4010A DSSS 802.11b max packet length Or Inst.MaxSymbolsUsed = Inst.IEEE80211a_Autorange_MaxSymbolsUsed ' Sets the N4010A OFDM 802.11a and 802.11g max symbols used

4. Transmitter Average Power Test (802.11a/b/g/n)

The transmitter average power test is a time-gated, frequency bandwidth-limited, power measurement that runs regardless of modulation format.

The transmit power test is detailed in the following IEEE 802.11 specifications. It is based on the maximum allowable output power in accordance with practices specified by the appropriate regulatory bodies. For more details of the measurement, refer to: IEEE Standard 802.11b-1999 16 September 1999 Paragraph 18.4.7.1 Transmit power levels and IEEE Standard 802.11a-1999 16 September 1999 Paragraph 17.3.9.1 Transmit power levels. This result can also be obtained from the 11a/b/g/n demod measurement.
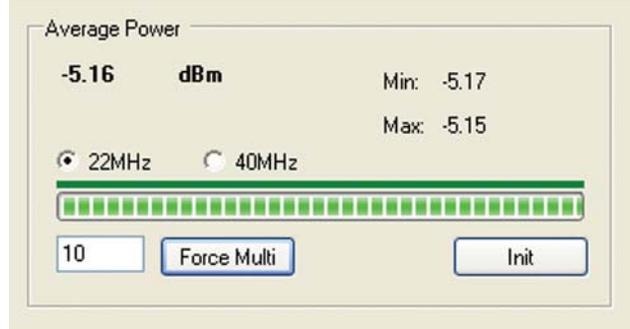
Figure 2 shows the implementation in the N4010A WLAN Virtual Front Panel.

Figure 2. Average power measurement

4.1. Average power test procedure summary

Step	Focus	Action
1.	N4010A	Set frequency, e.g. Channel 1 at 2.412 GHz, by setting the Frequency property
2.	N4010A	Set power range, e.g. 5 dBm, by setting the PowerRange property
3.	N4010A	Set max packet length, e.g. 970e-6, by setting the MaxPacketLength property
4.	N4010A	Set trigger style, e.g. MagLevel, by setting the TriggerStyle property
5.	N4010A	Set trigger level, e.g. 0.3 V, by setting the TriggerLevel property
6.	N4010A	Set trigger delay, e.g. -2e-6, by setting the TriggerDelay property
7.	N4010A	Set trigger holdoff, e.g. 60e-6, by setting the TriggerHoldoff property
8.	WLAN DUT	Set frequency band, e.g. 802.11b
9.	WLAN DUT	Set channel, e.g. Channel 1 at 2.412 GHz (N4010A = WLAN DUT frequency)
10.	WLAN DUT	Set transmit power
11.	WLAN DUT	Set modulation type, e.g. 11 Mbps, CCK
12.	WLAN DUT	Start transmitting packets
13.	N4010A	Initiate the average power measurement
14.	N4010A	Retrieve the average power measurement result

4.2. Average power test procedure programming example

Using the same steps as in the procedure summary section above, this section shows the required N4010A WLAN test DLL commands.

Step	Focus	Action
1.	N4010A	Inst.Frequency = 2412000000# ' Sets the N4010A Tx and Rx frequency
2.	N4010A	Inst.PowerRange = 5#
		' Sets the N4010A maximum expected power range to optimize dynamic range
3.	N4010A	Inst.MaxPacketLength = 0.0001 ' Sets the N4010A acquisition length
4.	N4010A	Inst.TriggerStyle = Agilent_N4010_WLanTest.TriggerStyleEnums_MagLevel
		' Sets the N4010A trigger style
5	N4010A	Inst.TriggerLevel = 0.03 ' Sets the N4010A trigger level
6.	N4010A	Inst.TriggerDelay = -0.000002 ' Sets the N4010A trigger delay
7.	N4010A	Inst.TriggerHoldoff = 0.00001 ' Sets the N4010A trigger holdoff
8.	WLAN DUT	' DUT specific command to set frequency band
9.	WLAN DUT	' DUT specific command to set transmit frequency
10.	WLAN DUT	' DUT specific command to set transmit power
11.	WLAN DUT	' DUT specific command to set modulation type
12.	WLAN DUT	' DUT specific command that turns transmitted power on ready for measurement
13.	N4010A	Inst.AveragePower_Initiate ' Initiates the N4010A average power measurement
14.	N4010A	Dim Result As Double
		Result = Inst.AveragePower_Result
		' Returns the N4010A average power measurement result

5. Transmitter Power and Frequency Offset Test (CW)

For WLAN device under test (DUT) continuous wave (CW) signal transmission there are two measurements available:

• Average power

• CW frequency offset

These measurements are intended to be used as part of a transmitter power or transmitter frequency calibration routine for the WLAN DUT. For details of the bursted average power measurement and its relation to the IEEE specification, refer to Section 4. For details of the bursted frequency error measurement and its relation to the IEEE specification, refer to Section 9.

Figure 3 shows the implementation in the N4010A WLAN Virtual Front Panel.
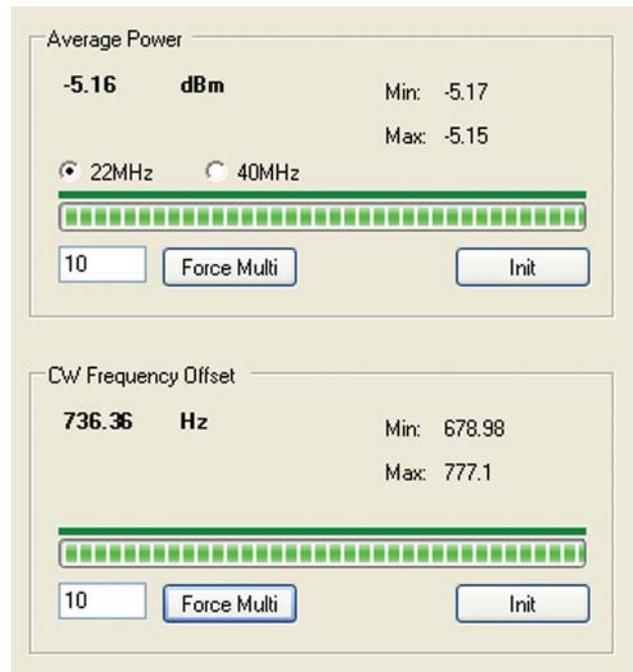

Figure 3. Average power and CW frequency offset measurement

5.1. CW calibration test procedure

The following steps summarize the procedure required to configure the WLAN DUT and the N4010A, to perform the average power, and CW frequency offset measurements, and retrieve the results.

Step	Focus	Action
1.	N4010A	Set frequency, e.g. Channel 1 at 2.412 GHz, by setting the Frequency property
2.	N4010A	Set power range, e.g. 5 dBm, by setting the PowerRange property
3.	WLAN DUT	Set frequency band, e.g. 802.11b
4.	WLAN DUT	Set channel, e.g. Channel 1 at 2.412 GHz (N4010A = WLAN DUT frequency)
5.	WLAN DUT	Set transmit power
6.	WLAN DUT	Start transmitting CW (single tone)
7.	N4010A	Measure the CW offset frequency
8.	N4010A	Measure the average power
9.	WLAN DUT	Adjust the DUT frequency and power and repeat Steps 7, 8, and 9

5.2. CW calibration test procedure programming detail

Using the same steps as in the procedure summary section above, this section shows the required N4010A WLAN test DLL commands.

Step	Focus	Action
1.	N4010A	Inst.Frequency = 2412000000# ' Sets the N4010A Tx and Rx frequency
2.	N4010A	Inst.PowerRange = 5# ' Sets the N4010A maximum expected power range to optimize dynamic range
3.	N4010A	Inst.MaxPacketLength = 0.0001 ' Sets the N4010A acquisition length
4.	N4010A	Inst.TriggerStyle = Agilent_N4010_WLanTest.TriggerStyleEnums_FreeRun N4010A trigger style
5.	WLAN DUT	' DUT specific command to set frequency band
6.	WLAN DUT	' DUT specific command to set transmit frequency
7.	WLAN DUT	' DUT specific command to set transmit power
8.	WLAN DUT	' DUT specific command that turns transmitted power on ready for measurement
9.	N4010A	Inst.CwFrequencyOffset_Initiate ' Initiates the N4010A CW frequency offset measurement
10.	N4010A	Dim Result As Double Result = Inst.CwFrequencyOffset_Result ' Returns the N4010A CW frequency offset measurement result

6. Transmitter Carrier Suppression Test (802.11b)

Some of the RF carrier signal can leak through and appear at the DUT transmitter output. RF carrier suppression measures the RF carrier leakage relative to the modulated output signal.

The IEEE specification states that the RF carrier suppression, measured at the channel center frequency, shall be at least 15 dB below the peak SIN(x)/x power spectrum. For more details about the measurement refer to: IEEE Standard 802.11b-1999 16 September 1999 Paragraph 18.4.7.7 RF Carrier Suppression. This result can also be obtained from the 11b demod measurement.

Figure 4 show the implementation in the N4010A WLAN Virtual Front Panel.
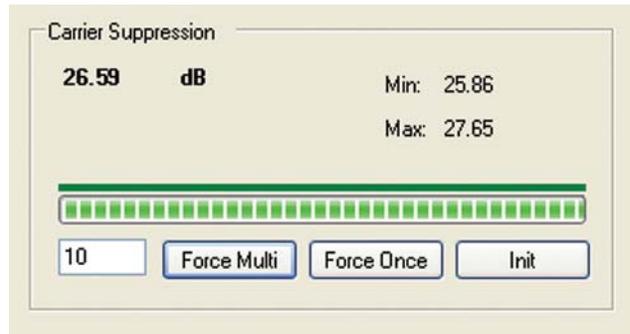

Figure 4. Carrier suppression measurement

6.1. Carrier suppression test procedure summary

The following steps summarize the procedure required to configure the WLAN DUT and the N4010A, to perform the carrier suppression measurement, and retrieve the results.

Step	Focus	Action
1.	N4010A	Set frequency, e.g. Channel 1 at 2.412 GHz, by setting the Frequency property
2.	N4010A	Set power range, e.g. 5 dBm, by setting the PowerRange property
3.	N4010A	Set max packet length, e.g. 970e-6, by setting the MaxPacketLength property
4.	N4010A	Set trigger style, e.g. MagLevel, by setting the TriggerStyle property
5.	N4010A	Set trigger level, e.g. 0.3 V, by setting the TriggerLevel property
6.	N4010A	Set trigger delay, e.g. -2e-6, by setting the TriggerDelay property
7.	N4010A	Set trigger holdoff, e.g. 60e-6, by setting the TriggerHoldoff property
8.	WLAN DUT	Set frequency band, e.g. 802.11b
9.	WLAN DUT	Set channel, e.g. Channel 1 at 2.412 GHz (N4010A = WLAN DUT frequency)
10.	WLAN DUT	Set transmit power
11.	WLAN DUT	Set modulation type, e.g. 11 Mbps, CCK
12.	WLAN DUT	Start transmitting packets
13.	N4010A	Initiate the carrier suppression measurement
14.	N4010A	Retrieve the carrier suppression measurement result

6.2. Carrier suppression test procedure programming example

Using the same steps as in the procedure summary section above, this section shows the required N4010A WLAN test DLL commands.

Step	Focus	Action
1.	N4010A	Inst.Frequency = 2412000000# ' Sets the N4010A Tx/Rx frequency
2.	N4010A	Inst.PowerRange = 5#
		' Sets the N4010A maximum expected power range to optimize dynamic range
3.	N4010A	Inst.MaxPacketLength = 0.00097 ' Sets the N4010A acquisition length
4.	N4010A	Inst.TriggerStyle = Agilent_N4010_WLanTest.TriggerStyleEnums_MagLevel
		' Sets the N4010A trigger style
5.	N4010A	Inst.TriggerLevel = 0.03 ' Sets the N4010A trigger level
6.	N4010A	Inst.TriggerDelay = -0.000002 ' Sets the N4010A trigger delay
7.	N4010A	Inst.TriggerHoldoff = 0.00001 ' Sets the N4010A trigger holdoff
8.	WLAN DUT	' DUT specific command to set frequency band
9.	WLAN DUT	' DUT specific command to set transmit frequency
10.	WLAN DUT	' DUT specific command to set transmit power
11.	WLAN DUT	' DUT specific command to set modulation type
12.	WLAN DUT	' DUT specific command that turns transmitted power on ready for measurement
13.	N4010A	Inst.IEEE80211b_CarrierSuppression_Initiate
		' Initiates the N4010A 802.11b carrier suppression measurement
14.	N4010A	Dim Result As Double
		Result = Inst.IEEE80211b_CarrierSuppression_Result
		' Returns the N4010A 802.11b carrier suppression measurement result

7. Transmitter Center Frequency Leakage Test (802.11a/g)

Center frequency leakage (CFL) is the portion of the transmitter energy that leaks through the transmitter components. This unwanted energy appears in the modulated signal at the signal center frequency. This test specifies center frequency leakage relative to total transmitted power of the sub-carriers. Energy at the center frequency of the carrier can cause problems with receiver structures that use zero frequency intermediate signals. 802.11a specifically avoids using the center carrier for transmission.

For more details about the measurement refer to: IEEE Standard 802.11a-1999 16 September 1999 Paragraph 17.3.6.1 Transmit Center Frequency Leakage. This result can also be obtained from the 11a/g demod measurement.

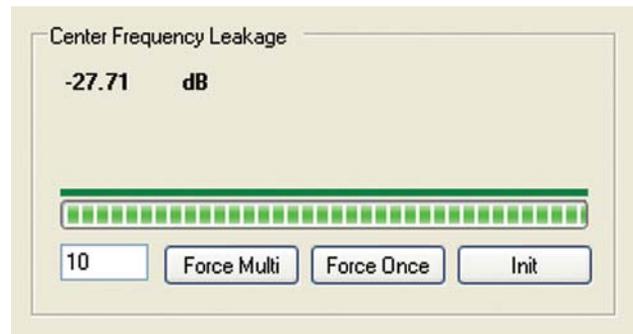Figure 5 show the implementation in the N4010A WLAN Virtual Front Panel.

Figure 5. Center frequency leakage measurement

7.1. CFL test procedure summary

The following steps summarize the procedure required to configure the WLAN DUT and the N4010A, to perform the CFL measurement and recover the results.

Step	Focus	Action
1.	N4010A	Set frequency, e.g. Channel 1 at 2.412 GHz, by setting the Frequency property
2.	N4010A	Set power range, e.g. 5 dBm, by setting the PowerRange property
3.	N4010A	Set max packet length, e.g. 970e-6, by setting the MaxPacketLength property
4.	N4010A	Set trigger style, e.g. MagLevel, by setting the TriggerStyle property
5.	N4010A	Set trigger level, e.g. 0.3 V, by setting the TriggerLevel property
6.	N4010A	Set trigger delay, e.g. -2e-6, by setting the TriggerDelay property
7.	N4010A	Set trigger holdoff, e.g. 60e-6, by setting the TriggerHoldoff property
8.	WLAN DUT	Set frequency band, e.g. 802.11b
9.	WLAN DUT	Set channel, e.g. Channel 1 at 2.412 GHz (N4010A = WLAN DUT frequency)
10.	WLAN DUT	Set transmit power
11.	WLAN DUT	Set modulation type, e.g. 11 Mbps, CCK
12.	WLAN DUT	Start transmitting packets
13.	N4010A	Initiate the CFL measurement
14.	N4010A	Retrieve the CFL measurement result

7.2. CFL test procedure programming detail

Using the same steps as in the procedure summary section above, this section shows the required N4010A WLAN test DLL commands.

Step	Focus	Action
1.	N4010A	Inst.Frequency = 2412000000# ' Sets the N4010A Tx/Rx frequency
2.	N4010A	Inst.PowerRange = 5# ' Sets the N4010A maximum expected power range to optimize dynamic range
3.	N4010A	Inst.MaxPacketLength = 0.0001723 ' Sets the N4010A acquisition length
4.	N4010A	Inst.TriggerStyle = Agilent_N4010_WLanTest.TriggerStyleEnums_MagLevel ' Sets the N4010A trigger style
5.	N4010A	Inst.TriggerLevel = 0.03 ' Sets the N4010A trigger level
6.	N4010A	Inst.TriggerDelay = -0.000002 ' Sets the N4010A trigger delay
7.	N4010A	Inst.TriggerHoldoff = 0.00001 ' Sets the N4010A trigger holdoff
8.	WLAN DUT	' DUT specific command to set frequency band
9.	WLAN DUT	' DUT specific command to set transmit frequency
10.	WLAN DUT	' DUT specific command to set transmit power
11.	WLAN DUT	' DUT specific command to set modulation type
12.	WLAN DUT	' DUT specific command that turns transmitted power on ready for measurement
13.	N4010A	Inst.IEEE80211a_CFL_Initiate ' Initiates the N4010A OFDM CFL measurement
14.	N4010A	Dim Result As Double Result = Inst.IEEE80211a_CFL_Result ' Returns the N4010A OFDM CFL measurement result

8. Transmitter Modulation Accuracy —EVM Test (802.11a/b/g)

Error vector magnitude (EVM), used to measure transmitter modulation accuracy, is calculated by comparing the actual measured signal with an ideal reference signal to determine the error vector. The EVM value is the root mean square (RMS) value of the error vector over time at the instants of the symbol (or chip) clock transitions. Every chip has its own error vector; EVM is the RMS average of all errors in a packet of 1000 chips.

For more details of the measurement refer to: IEEE Standard 802.11b-1999 16 September 1999 Paragraph 18.4.7.8 Transmit modulation accuracy and IEEE Standard 802.11a-1999 16 September 1999 Paragraph 17.3.9.7 Transmit modulation accuracy test. This result can also be obtained from the 11a/b/g demod measurement.

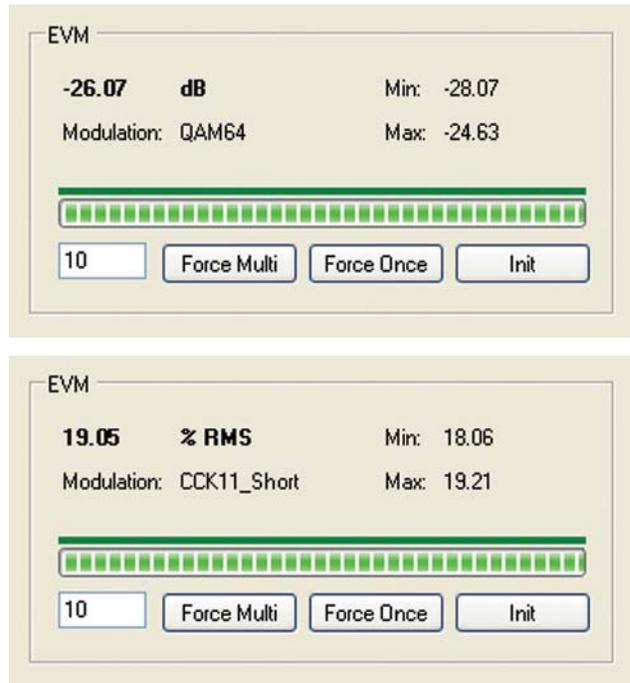Figure 6 shows the implementation in the N4010A WLAN Virtual Front Panel.

Figure 6. 802.11b and 802.11a/g EVM measurement

8.1. EVM test procedure summary

The following steps summarize the procedure required to configure the WLAN DUT and the N4010A to perform the EVM measurement and recover the results.

Step	Focus	Action
1.	N4010A	Set frequency, e.g. Channel 1 at 2.412 GHz, by setting the Frequency property
2.	N4010A	Set power range, e.g. 5 dBm, by setting the PowerRange property
3.	N4010A	Set max packet length, e.g. 970e-6, by setting the MaxPacketLength property
4.	N4010A	Set trigger style, e.g. MagLevel, by setting the TriggerStyle property
5.	N4010A	Set trigger level, e.g. 0.3 V, by setting the TriggerLevel property
6.	N4010A	Set trigger delay, e.g. -2e-6, by setting the TriggerDelay property
7.	N4010A	Set trigger holdoff, e.g. 60e-6, by setting the TriggerHoldoff property
8.	WLAN DUT	Set frequency band, e.g. 802.11b
9.	WLAN DUT	Set channel, e.g. Channel 1 at 2.412 GHz (N4010A = WLAN DUT frequency)
10.	WLAN DUT	Set transmit power
11.	WLAN DUT	Set modulation type, e.g. 11 Mbps, CCK
12.	WLAN DUT	Start transmitting packets
13.	N4010A	Initiate the EVM measurement
14.	N4010A	Retrieve the EVM measurement result

8.2. EVM test procedure programming example

Using the same steps as in the procedure summary section above, this section shows the required N4010A WLAN test DLL commands.

Step	Focus	Action
1.	N4010A	Inst.Frequency = 2412000000# ' Sets the N4010A Tx/Rx frequency
2.	N4010A	Inst.PowerRange = 5# ' Sets the N4010A maximum expected power range to optimize dynamic range
3.	N4010A	Inst.MaxPacketLength = 0.0001723 ' Sets the N4010A acquisition length
4.	N4010A	Inst.TriggerStyle = Agilent_N4010_WLanTest.TriggerStyleEnums_MagLevel ' Sets the N4010A trigger style
5.	N4010A	Inst.TriggerLevel = 0.03 ' Sets the N4010A trigger level
6.	N4010A	Inst.TriggerDelay = -0.000002 ' Sets the N4010A trigger delay
7.	N4010A	Inst.TriggerHoldoff = 0.00001 ' Sets the N4010A trigger holdoff
8.	WLAN DUT	' DUT specific command to set frequency band
9.	WLAN DUT	' DUT specific command to set transmit frequency
10.	WLAN DUT	' DUT specific command to set transmit power
11.	WLAN DUT	' DUT specific command to set modulation type
12.	WLAN DUT	' DUT specific command that turns transmitted power on
13.	N4010A	Inst.IEEE80211b_ EVM _Initiate ' Initiates the N4010A DSSS 802.11b EVM measurement Or Inst.IEEE80211a_ EVM _Initiate ' Initiates the N4010A OFDM 802.11a or 802.11g EVM measurement
14.	N4010A	Dim Result As Double Result = Inst.IEEE80211b_ EVM _Result ' Returns the N4010A DSSS 802.11b EVM measurement result Or Result = Inst.IEEE80211a_ EVM _Result ' Returns the OFDM 802.11a or 802.11g EVM measurement result

9. Transmitter Center Frequency Tolerance Test (802.11a/b/g)

The transmit center frequency tolerance (frequency error) is a measurement of the center frequency offset from the desired carrier frequency in units of parts per million (ppm).

For more details about the measurement refer to: IEEE Standard 802.11a-1999 16 September 1999 Paragraph 17.3.9.4 and IEEE Standard 802.11b-1999 16 September 1999 Paragraph 18.4.7.4.

This result can also be obtained from the transmitter demod test. The transmitter demod test performs multiple measurements from one data capture and can therefore reduce test time as part of an overall test script. The demod measurement is covered in detail in *Section 15. Transmitter Demod Test.*

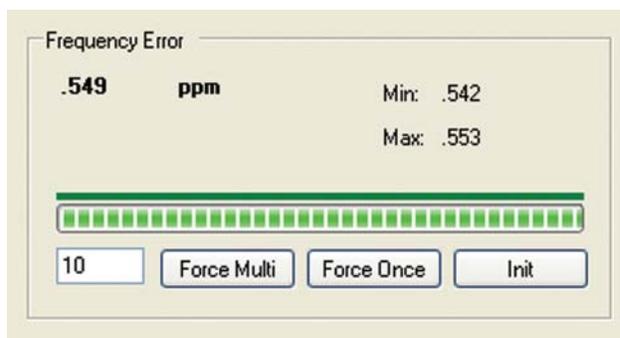Figure 7 shows the implementation in the N4010A WLAN Virtual Front Panel.

Figure 7. Center frequency tolerance measurement

9.1. Frequency error test procedure summary

The following steps summarize the procedure required to configure the WLAN DUT and the N4010A to perform the center frequency tolerance (frequency error) measurement and recover the results.

Step	Focus	Action
1.	N4010A	Set frequency, e.g. Channel 1 at 2.412 GHz, by setting the Frequency property
2.	N4010A	Set power range, e.g. 5 dBm, by setting the PowerRange property
3.	N4010A	Set max packet length, e.g. 970e-6, by setting the MaxPacketLength property
4.	N4010A	Set trigger style, e.g. MagLevel, by setting the TriggerStyle property
5.	N4010A	Set trigger level, e.g. 0.3 V, by setting the TriggerLevel property
6.	N4010A	Set trigger delay, e.g. -2e-6, by setting the TriggerDelay property
7.	N4010A	Set trigger holdoff, e.g. 60e-6, by setting the TriggerHoldoff property
8.	WLAN	DUT set frequency band, e.g. 802.11b
9.	WLAN DUT	Set channel, e.g. Channel 1 at 2.412 GHz (N4010A = WLAN DUT frequency)
10.	WLAN DUT	Set transmit power
11.	WLAN DUT	Set modulation type, e.g. 11 Mbps, CCK
12.	WLAN DUT	Start transmitting packets
13.	N4010A	Initiate the frequency error measurement
14.	N4010A	Retrieve the frequency error measurement result

9.2. Frequency error test procedure programming example

Using the same steps as in the procedure summary section above, this section shows the required N4010A WLAN test DLL commands.

Step	Focus	Action
1.	N4010A	Inst.Frequency = 2412000000# ' Sets the N4010A Tx/Rx frequency
2.	N4010A	Inst.PowerRange = 5# ' Sets the N4010A maximum expected power range to optimize dynamic range
3.	N4010A	Inst.MaxPacketLength = 0.000970 ' Sets the N4010A acquisition length
4.	N4010A	Inst.TriggerStyle = Agilent_N4010_WLanTest.TriggerStyleEnums_MagLevel ' Sets the N4010A trigger style
5.	N4010A	Inst.TriggerLevel = 0.03 ' Sets the N4010A trigger level
6.	N4010A	Inst.TriggerDelay = -0.000002 ' Sets the N4010A trigger delay
7.	N4010A	Inst.TriggerHoldoff = 0.00001 ' Sets the N4010A trigger holdoff
8.	WLAN DUT	' DUT specific command to set frequency band
9.	WLAN DUT	' DUT specific command to set transmit frequency
10.	WLAN DUT	' DUT specific command to set transmit power
11.	WLAN DUT	' DUT specific command to set modulation type
12.	WLAN DUT	' DUT specific command that turns transmitted power on ready for measurement
13.	N4010A	Inst.IEEE80211b_FrequencyError_Initiate ' Initiates the N4010A DSSS 802.11b frequency error measurement Or Inst.IEEE80211a_FrequencyError_Initiate ' Initiates the N4010A OFDM 802.11a or 802.11g frequency error measurement
14.	N4010A	Dim Result As Double Result = Inst.IEEE80211b_FrequencyError_Result ' Returns the N4010A DSSS 802.11b frequency error measurement result Or Result = Inst.IEEE80211a_FrequencyError_Result ' Returns the N4010A OFDM 802.11a or 802.11g frequency error measurement result

10. Transmitter Power On and Power Down Ramp Test (802.11b)

The transmitter power on and power down ramp test ensures that the power of the burst turns on and off at the correct rate, neither rising nor falling too quickly or too slowly.

For more details of the measurement, refer to: IEEE Standard 802.11b-1999 16 September 1999 Paragraph 18.4.7.6. This specifies that "The transmit power-on ramp for 10-90% of maximum power shall be no greater than 2 µsec." and "The transmit powerdown ramp for 90-10% shall be no greater than 2 µsec." The maximum packet length property (acquisition time) needs to be at least the full packet to be able to calculate the power down ramp time.

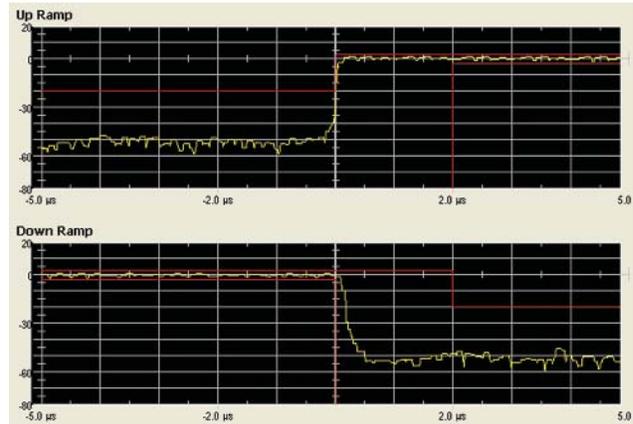Figure 8 shows the implementation in the N4010A WLAN Virtual Front Panel.

Figure 8. Power ramp on and power ramp off measurement

10.1. Power on and power down ramp test procedure summary

The following steps summarize the procedure required to configure the WLAN DUT and the N4010A to perform the power on and power down measurement and recover the results.

Step	Focus	Action
1.	N4010A	Set frequency, e.g. Channel 1 at 2.412 GHz, by setting the Frequency property
2.	N4010A	Set power range, e.g. 5 dBm, by setting the PowerRange property
3.	N4010A	Set max packet length, e.g. 970e-6, by setting the MaxPacketLength property
4.	N4010A	Set trigger style, e.g. MagLevel, by setting the TriggerStyle property
5.	N4010A	Set trigger level, e.g. 0.3 V, by setting the TriggerLevel property
6.	N4010A	Set trigger delay, e.g. -2e-6, by setting the TriggerDelay property
7.	N4010A	Set trigger holdoff, e.g. 60e-6, by setting the TriggerHoldoff property
8.	WLAN DUT	Set frequency band, e.g. 802.11b
9.	WLAN DUT	Set channel, e.g. Channel 1 at 2.412 GHz (N4010A = WLAN DUT frequency)
10.	WLAN DUT	Set transmit power
11.	WLAN DUT	Set modulation type, e.g. 11 Mbps, CCK
12.	WLAN DUT	Start transmitting packets
13.	N4010A	Initiate the power on/off measurement
14.	N4010A	Retrieve the power on time measurement result
15.	N4010A	Retrieve the power down time measurement result

10.2. Power on and power down ramp test procedure programming detail

Using the same steps as in the procedure summary section above, this section shows the required N4010A WLAN test DLL commands.

Step	Focus	Action
1.	N4010A	Inst.Frequency = 2412000000# ' Sets the N4010A Tx/Rx frequency
2.	N4010A	Inst.PowerRange = 5# ' Sets the N4010A maximum expected power range to optimize dynamic range
3.	N4010A	Inst.MaxPacketLength = 0.000970 ' Sets the N4010A acquisition length
4.	N4010A	Inst.TriggerStyle = Agilent_N4010_WLanTest.TriggerStyleEnums_MagLevel ' Sets the N4010A trigger style
5.	N4010A	Inst.TriggerLevel = 0.03 ' Sets the N4010A trigger level
6.	N4010A	Inst.TriggerDelay = -0.000002 ' Sets the N4010A trigger delay
7.	N4010A	Inst.TriggerHoldoff = 0.00001 ' Sets the N4010A trigger holdoff
8.	WLAN DUT	' DUT specific command to set frequency band
9.	WLAN DUT	' DUT specific command to set transmit frequency
10.	WLAN DUT	' DUT specific command to set transmit power
11.	WLAN DUT	' DUT specific command to set modulation type
12.	WLAN DUT	' DUT specific command that turns transmitted power on ready for measurement
13.	N4010A	Inst.IEEE80211b_PowerRamp_Initiate ' Initiates the N4010A DSSS 802.11b power ramp up and down measurement
14.	N4010A	Dim UpTimeResult As Double Dim DownTimeResult As Double UpTimeResult = Inst.IEEE80211b_PowerRamp_UpRampTime ' Returns the N4010A DSSS 802.11b power ramp up time measurement result DownTimeResult = Inst.IEEE80211b_PowerRamp_DownRampTime ' Returns the N4010A DSSS 802.11b power ramp up time measurement result

11. Transmitter Chip Clock Frequency Tolerance Test (802.11b)

Chip clock frequency tolerance is a measure of how much the chip clock frequency is offset from the desired chip clock frequency. Circuit transients can produce time-varying frequency changes in the local oscillator. The performance of the equalizer in the receiver depends on the preamble sequence used for training. This can be adversely affected by the transient frequency instabilities in the transmitter.

For more details about the measurement refer to: IEEE Standard 802.11b-1999 16 September 1999 Paragraph 18.4.7.5. This result can only be obtained from the 11b demod measurement.

Figure 9 shows the implementation in the N4010A WLAN Virtual Front Panel.

Figure 9. Demod measurement showing the chip clock frequency error result

11.1. Chip clock frequency tolerance test procedure summary

The following steps summarize the procedure required to con-
figure the WLAN DUT and the N4010A to perform the chip clock
frequency tolerance measurement and recover the results.

Step	Focus	Action
1.	N4010A	Set frequency, e.g. Channel 1 at 2.412 GHz, by setting the Frequency property
2.	N4010A	Set power range, e.g. 5 dBm, by setting the PowerRange property
3.	N4010A	Set max packet length, e.g. 970e-6, by setting the MaxPacketLength property
4.	N4010A	Set trigger style, e.g. MagLevel, by setting the TriggerStyle property
5.	N4010A	Set trigger level, e.g. 0.3 V, by setting the TriggerLevel property
6.	N4010A	Set trigger delay, e.g. -2e-6, by setting the TriggerDelay property
7.	N4010A	Set trigger holdoff, e.g. 60e-6, by setting the TriggerHoldoff property
8.	WLAN DUT	Set frequency band, e.g. 802.11b
9.	WLAN DUT	Set channel, e.g. Channel 1 at 2.412 GHz (N4010A = WLAN DUT frequency)
10.	WLAN DUT	Set transmit power
11.	WLAN DUT	Set modulation type, e.g. 11 Mbps, CCK
12.	WLAN DUT	Start transmitting packets
13.	N4010A	Initiate the 11b demod measurement
14.	N4010A	Retrieve the chip clock frequency tolerance measurement result

11.2. Chip clock frequency tolerance test procedure programming detail

Using the same steps as in the procedure summary section
above, this section shows the required N4010A WLAN test DLL
commands.

Step	Focus	Action
1.	N4010A	Inst.Frequency = 2412000000# ' Sets the N4010A Tx/Rx frequency
2.	N4010A	Inst.PowerRange = 5#
		' Sets the N4010A maximum expected power range to optimize dynamic range
3.	N4010A	Inst.MaxPacketLength = 0.000970 ' Sets the N4010A acquisition length
4.	N4010A	Inst.TriggerStyle = Agilent_N4010_WLanTest.TriggerStyleEnums_MagLevel
		' Sets the N4010A trigger style
5	N4010A	Inst.TriggerLevel = 0.03 ' Sets the N4010A trigger level
6.	N4010A	Inst.TriggerDelay = -0.000002 ' Sets the N4010A trigger delay
7.	N4010A	Inst.TriggerHoldoff = 0.00001 ' Sets the N4010A trigger holdoff
8.	WLAN DUT	' DUT specific command to set frequency band
9.	WLAN DUT	' DUT specific command to set transmit frequency
10.	WLAN DUT	' DUT specific command to set transmit power
11.	WLAN DUT	' DUT specific command to set modulation type
12.	WLAN DUT	' DUT specific command that turns transmitted power on ready for measurement
13.	N4010A	Inst.IEEE80211b_Demod_Initiate ' Initiates the N4010A DSSS 802.11b demod
14.	N4010A	Dim Result As Double
		Result = Inst.IEEE80211b_ChipClockFrequencyError_Result
		' Returns the N4010A DSSS 802.11b chip clock frequency error measurement result

12. Transmitter Symbol Clock Frequency Tolerance Test (802.11a/g)

Symbol clock frequency tolerance measures the symbol clock frequency offset from the desired symbol clock frequency. The symbol clock frequency tolerance is important because circuit transients can produce timevarying frequency changes in the local oscillator. The performance of the equalizer in the receiver depends on the preamble sequence used for training, which can be adversely affected by transient frequency instabilities in the transmitter.

For more details about the measurement refer to: IEEE Standard 802.11a-1999 16 September 1999 Paragraph 17.3.9.5. This result can only be obtained from the 11a/g demod measurement.

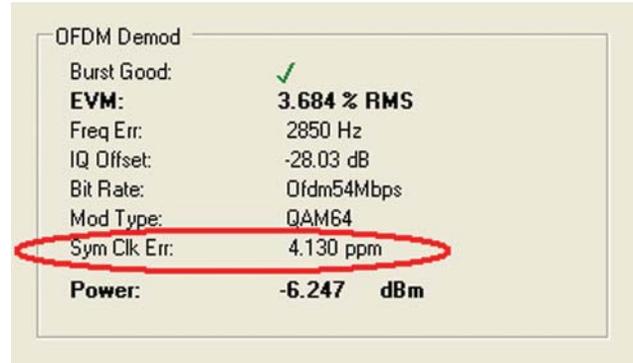Figure 10 shows the implementation in the N4010A WLAN Virtual Front Panel.

Figure 10. Demod measurement showing the symbol clock frequency error result

12.1. Symbol clock frequency tolerance test procedure summary

The following steps summarize the procedure required to configure the WLAN DUT and the N4010A to perform the symbol clock frequency tolerance measurement and recover the results.

Step	Focus	Action
1.	N4010A	Set frequency, e.g. Channel 1 at 2.412 GHz, by setting the Frequency property
2.	N4010A	Set power range, e.g. 5 dBm, by setting the PowerRange property
3.	N4010A	Set max packet length, e.g. 970e-6, by setting the MaxPacketLength property
4.	N4010A	Set trigger style, e.g. MagLevel, by setting the TriggerStyle property
5.	N4010A	Set trigger level, e.g. 0.3 V, by setting the TriggerLevel property
6.	N4010A	Set trigger delay, e.g. -2e-6, by setting the TriggerDelay property
7.	N4010A	Set trigger holdoff, e.g. 60e-6, by setting the TriggerHoldoff property
8.	WLAN DUT	Set frequency band, e.g. 802.11b
9.	WLAN DUT	Set channel, e.g. Channel 1 at 2.412 GHz (N4010A = WLAN DUT frequency)
10.	WLAN DUT	Set transmit power
11.	WLAN DUT	Set modulation type, e.g. 11 Mbps, CCK
12.	WLAN DUT	Start transmitting packets
13.	N4010A	Initiate the 11a demod measurement
14.	N4010A	Retrieve the symbol clock frequency tolerance measurement result

12.2. Symbol clock frequency tolerance test procedure programming detail

Using the same steps as in the procedure summary section above, this section shows the required N4010A WLAN test DLL commands.

Step	Focus	Action
1.	N4010A	Inst.Frequency = 2412000000# ' Sets the N4010A Tx/Rx frequency
2.	N4010A	Inst.PowerRange = 5# ' Sets the N4010A maximum expected power range to optimize dynamic range
3.	N4010A	Inst.MaxPacketLength = 0.0001723 ' Sets the N4010A acquisition length
4.	N4010A	Inst.TriggerStyle = Agilent_N4010_WLanTest.TriggerStyleEnums_MagLevel ' Sets the N4010A trigger style
5.	N4010A	Inst.TriggerLevel = 0.03 ' Sets the N4010A trigger level
6.	N4010A	Inst.TriggerDelay = -0.000002 ' Sets the N4010A trigger delay
7.	N4010A	Inst.TriggerHoldoff = 0.00001 ' Sets the N4010A trigger holdoff
8.	WLAN DUT	' DUT specific command to set frequency band
9.	WLAN DUT	' DUT specific command to set transmit frequency
10.	WLAN DUT	' DUT specific command to set transmit power
11.	WLAN DUT	' DUT specific command to set modulation type
12.	WLAN DUT	' DUT specific command that turns transmitted power on ready for measurement
13.	N4010A	Inst.IEEE80211a_Demod_Initiate ' Initiates the N4010A OFDM 802.11a or 802.11g demod
14.	N4010A	Dim Result As Double Result = Inst.IEEE80211a_SymbolClockFrequencyError_Result ' Returns the N4010A OFDM 802.11a or 802.11g symbol clock frequency error measurement result

13. Transmitter Spectral Mask Test (802.11a/b/g)

The transmitter spectral mask measurement includes both in-band and out-of-band spurious emissions. The spectral mask test specifies that the transmitted signal does not exceed the IEEE 802.11a/b/g specified spectral mask limits. This test ensures that multiple WLAN devices do not unduly interfere with each other. The spectral mask test can be a good indicator of deteriorating performance.

The reference level power is taken as the peak power spectral density (PSD) in the signal. The spectral mask applies to offset frequencies in the frequency band. For each frequency offset, the PSD is calculated and compared relative to the reference level. All frequency offset PSD results are available from the N4010A. If no point across the spectral response has failed relative to the reference point, then the margin result returned is a value of 0.0 and can be used for a go, no-go test. A negative value indicates the worst case amount for the PSD point which failed this test by the largest margin.

For more details about the measurement, refer to:
IEEE Standard 802.11b-1999 Paragraph 18.4.7.3 Transmit spectrum mask and IEEE Standard 802.11a-1999 Paragraph 17.3.9.2 Transmit spectrum mask.

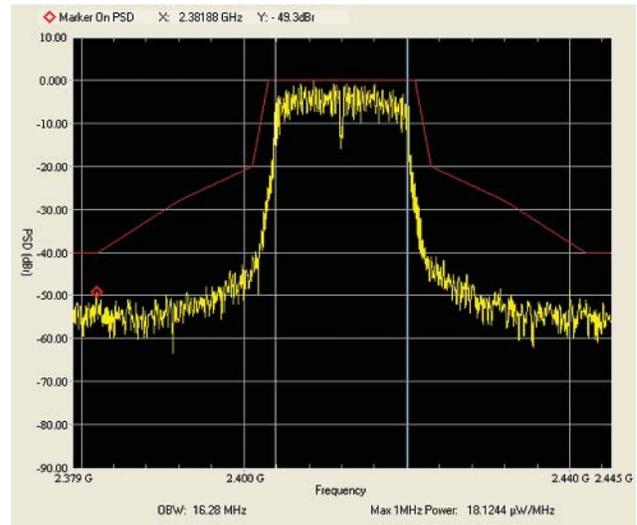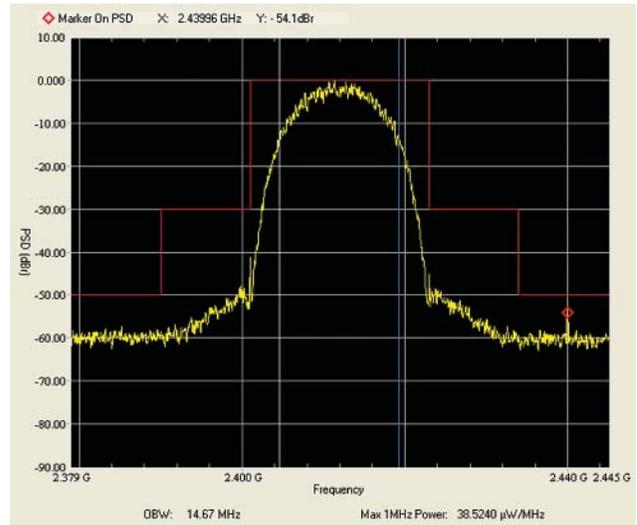Figure 11 shows the implementation in the N4010A WLAN Virtual Front Panel.

Figure 11. Spectral mask measurement a) 802.11b (top) and b) 802.11a/g (bottom)

13.1. Spectral mask test procedure summary

The following steps summarize the procedure required to con-
figure the WLAN DUT and the N4010A to perform the spectral
mask measurement and recover the results.

Step	Focus	Action
1.	N4010A	Set frequency, e.g. Channel 1 at 2.412 GHz, by setting the Frequency property
2.	N4010A	Set power range, e.g. 5 dBm, by setting the PowerRange property
3.	N4010A	Set max packet length, e.g. 970e-6, by setting the MaxPacketLength property
4.	N4010A	Set trigger style, e.g. MagLevel, by setting the TriggerStyle property
5.	N4010A	Set trigger level, e.g. 0.3 V, by setting the TriggerLevel property
6.	N4010A	Set trigger delay, e.g. -2e-6, by setting the TriggerDelay property
7.	N4010A	Set trigger holdoff, e.g. 60e-6, by setting the TriggerHoldoff property
8.	WLAN DUT	Set frequency band, e.g. 802.11b
9.	WLAN DUT	Set channel, e.g. Channel 1 at 2.412 GHz (N4010A = WLAN DUT frequency)
10.	WLAN DUT	Set transmit power
11.	WLAN DUT	Set modulation type, e.g. 11 Mbps, CCK
12.	WLAN DUT	Start transmitting packets
13.	N4010A	Initiate the spectral mask measurement
14.	N4010A	Retrieve the spectral mask margin measurement result

13.2. Spectral mask test procedure programming detail

Using the same steps as in the procedure summary section
above, this section shows the required N4010A WLAN test DLL
commands.

Step	Focus	Action
1.	N4010A	Inst.Frequency = 2412000000# ' Sets the N4010A Tx/Rx frequency
2.	N4010A	Inst.PowerRange = 5# ' Sets the N4010A maximum expected power range to optimize dynamic range
3.	N4010A	Inst.MaxPacketLength = 0.0001723 ' Sets the N4010A acquisition length
4.	N4010A	Inst.TriggerStyle = Agilent_N4010_WLanTest.TriggerStyleEnums_MagLevel ' Sets the N4010A trigger style
5.	N4010A	Inst.TriggerLevel = 0.03 ' Sets the N4010A trigger level
6.	N4010A	Inst.TriggerDelay = -0.000002 ' Sets the N4010A trigger delay
7.	N4010A	Inst.TriggerHoldoff = 0.00001 ' Sets the N4010A trigger holdoff
8.	WLAN DUT	' DUT specific command to set frequency band
9.	WLAN DUT	' DUT specific command to set transmit frequency
10.	WLAN DUT	' DUT specific command to set transmit power
11.	WLAN DUT	' DUT specific command to set modulation type
12.	WLAN DUT	' DUT specific command that turns transmitted power on ready for measurement
13.	N4010A	Inst.IEEE80211b_SpectralMask_Initiate ' Initiates the N4010A DSSS 802.11b spectral mask measurement Or Inst.IEEE80211a_SpectralMask_Initiate ' Initiates the N4010A OFDM 802.11a or 802.11g spectral mask measurement
14.	N4010A	Dim Result As Double Result = Inst.IEEE80211b_SpectralMask_Margin ' Returns the N4010A DSSS 802.11b spectral mask margin result Or Result = Inst.IEEE80211a_SpectralMask_Margin ' Returns the N4010A OFDM 802.11a or 802.11g spectral mask margin result ' A positive value indicates the minimum margin by which the PSD passed this test. ' A negative value indicates the worst-case amount by which the PSD failed this test.

14. Transmitter Spectral Flatness Test (802.11a/g)

Spectral flatness is a measurement of the power variations in the carriers of an OFDM (IEEE 802.11a/g) signal. It is measured during the 8 μs channel estimation phase of the burst, with all 52 carriers active but after the start of a normal burst. This test specifies a mask for the magnitude response of the transmitter channel. Spectral flatness must be within ±2 dB for the 16 sub-carriers either side of the center frequency, and within +2/−4 dB for all sub-carriers. The 0 dB level is established over ±16 subcarriers.

For more details about the measurement, refer to: IEEE Standard 802.11a-1999 16 September 1999 Paragraph 17.3.9.6.2 Spectral Flatness.

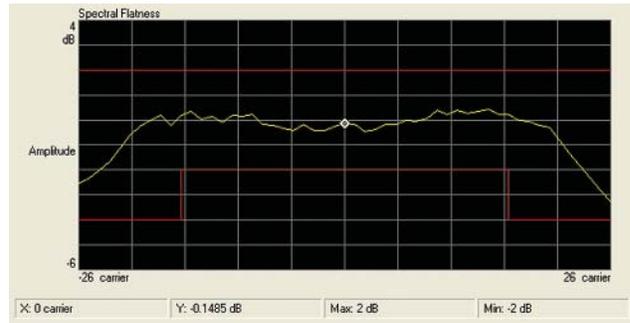Figure 12 shows the implementation in the N4010A WLAN Virtual Front Panel.

Figure 12. Spectral flatness measurement

14.1. Spectral flatness test procedure summary

The following steps summarize the procedure required to configure the WLAN DUT and the N4010A to perform the spectral flatness measurement and recover the results.

Step	Focus	Action
1.	N4010A	Set frequency, e.g. Channel 1 at 2.412 GHz, by setting the Frequency property
2.	N4010A	Set power range, e.g. 5 dBm, by setting the PowerRange property
3.	N4010A	Set max packet length, e.g. 970e-6, by setting the MaxPacketLength property
4.	N4010A	Set trigger style, e.g. MagLevel, by setting the TriggerStyle property
5.	N4010A	Set trigger level, e.g. 0.3 V, by setting the TriggerLevel property
6.	N4010A	Set trigger delay, e.g. -2e-6, by setting the TriggerDelay property
7.	N4010A	Set trigger holdoff, e.g. 60e-6, by setting the TriggerHoldoff property
8.	WLAN DUT	Set frequency band, e.g. 802.11b
9.	WLAN DUT	Set channel, e.g. Channel 1 at 2.412 GHz (N4010A = WLAN DUT frequency)
10.	WLAN DUT	Set transmit power
11.	WLAN DUT	Set modulation type, e.g. 11 Mbps, CCK
12.	WLAN DUT	Start transmitting packets
13.	N4010A	Initiate the spectral flatness measurement
14.	N4010A	Retrieve the spectral flatness margin measurement result

14.2. Spectral flatness test procedure programming detail

Using the same steps as in the procedure summary section above, this section shows the required N4010A WLAN test DLL commands.

Step	Focus	Action
1.	N4010A	Inst.Frequency = 2412000000# ' Sets the N4010A Tx/Rx frequency
2.	N4010A	Inst.PowerRange = 5# ' Sets the N4010A maximum expected power range to optimize dynamic range
3.	N4010A	Inst.MaxPacketLength = 0.0001723 ' Sets the N4010A acquisition length
4.	N4010A	Inst.TriggerStyle = Agilent_N4010_WLanTest.TriggerStyleEnums_MagLevel ' Sets the N4010A trigger style
5.	N4010A	Inst.TriggerLevel = 0.03 ' Sets the N4010A trigger level
6.	N4010A	Inst.TriggerDelay = -0.000002 ' Sets the N4010A trigger delay
7.	N4010A	Inst.TriggerHoldoff = 0.00001 ' Sets the N4010A trigger holdoff
8.	WLAN DUT	' DUT specific command to set frequency band
9.	WLAN DUT	' DUT specific command to set transmit frequency
10.	WLAN DUT	' DUT specific command to set transmit power
11.	WLAN DUT	' DUT specific command to set modulation type
12.	WLAN DUT	' DUT specific command that turns transmitted power on ready for measurement
13.	N4010A	Inst.IEEE80211a_SpectralFlatness_Initiate ' Initiates the N4010A OFDM spectral flatness measurement
14.	N4010A	Dim Result As Double Result = Inst.IEEE80211a_SpectralFlatness_Margin ' Returns the N4010A OFDM spectral flatness measurement result

15. Transmitter Demod Test (802.11a/b/g)

The transmitter demod test performs multiple measurements from one data capture. This means that if a test plan includes a full set of transmitter measurements overall test time can be dramatically improved. Figure 13 shows the individual measurement results available from the 802.11b and the 802.11a/g demod measurements.

With the demod measurement you have additional controls which are not available from the other standard measurements, for example the "TrackPhase" and "Equalization" settings. Changing from the default settings, however, means that the measurements may no longer comply with the IEEE specifications.

Figure 13 shows the implementation in the N4010A WLAN Virtual Front Panel.

802.11b Demod results:

- EVM RMS (same as *Section 8. Transmitter Modulation Accuracy—EVM Test*)

- EVM peak (same as *Section 8. Transmitter Modulation Accuracy—EVM Test*)

- IQ offset (same as Section *7. Transmitter Center Frequency Leakage Test[1]*)

- Freq error (same as *Section 9. Transmitter Center Frequency Tolerance Test*)

- Gated power (same as *Section 4. Transmitter Average Power Test[2]*)

- Chip clock frequency error (this result can only be obtained from the 11b demod measurement)

802.11a/g Demod results:

- EVM RMS (same as *Section 8. Transmitter Modulation Accuracy—EVM Test*)

- IQ offset (same as *Section 6. Transmitter Carrier Suppression Test[1]*)

- Freq error (same as *Section 9. Transmitter Center Frequency Tolerance Test*)

- Gated power (same as *Section 4. Transmitter Average Power Test[2]*)

- Symbol clock frequency error (this result can only be obtained from the 11a demod measurement)
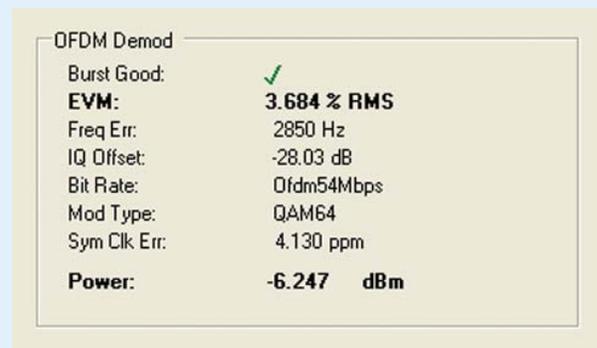
```
DSSS Demod
Burst Good:      ✓
EVM:             10.061 % RMS
Peak EVM:        20.940 % (over 1k chips)
Freq Err:        1566 Hz
IQ Offset:       -35.63 dB
Bit Rate:        Dsss11Mbps
Mod Type:        CCK11_Short
Chip Clk Err:    0.278 ppm

Hdr Stat:        Okay
Mac Stat:        Okay

Power:           -6.223    dBm
```

```
OFDM Demod
Burst Good:      ✓
EVM:             3.684 % RMS
Freq Err:        2850 Hz
IQ Offset:       -28.03 dB
Bit Rate:        Ofdm54Mbps
Mod Type:        QAM64
Sym Clk Err:     4.130 ppm

Power:           -6.247    dBm
```

Figure 13. Demod measurement

---

1. (IQ offset * –1) –9 converts IQ offset to carrier suppression result.
2. Gated power has a left and right gate setting to set the portion of the burst to be measured.

15.1. Demod test procedure summary

The following steps summarize the procedure required to configure the WLAN DUT and the N4010A to make the demod measurement and recover the results.

Step	Focus	Action
1.	N4010A	Set frequency, e.g. Channel 1 at 2.412 GHz, by setting the Frequency property
2.	N4010A	Set power range, e.g. 5 dBm, by setting the PowerRange property
3.	N4010A	Set max packet length, e.g. 970e-6, by setting the MaxPacketLength property
4.	N4010A	Set trigger style, e.g. MagLevel, by setting the TriggerStyle property
5.	N4010A	Set trigger level, e.g. 0.3 V, by setting the TriggerLevel property
6.	N4010A	Set trigger delay, e.g. -2e-6, by setting the TriggerDelay property
7.	N4010A	Set trigger holdoff, e.g. 60e-6, by setting the TriggerHoldoff property
8.	N4010A	Set measure gated power, e.g. true, by setting the MeasureGatedPower property
9.	WLAN DUT	Set frequency band, e.g. 802.11b
10.	WLAN DUT	Set channel, e.g. Channel 1 at 2.412 GHz (N4010A = WLAN DUT frequency)
11.	WLAN DUT	Set transmit power
12.	WLAN DUT	Set modulation type, e.g. 11 Mbps, CCK
13.	WLAN DUT	Start transmitting packets
14.	N4010A	Initiate the demod measurement
15.	N4010A	Retrieve the demod results

15.2. Demod test procedure programming example

Using the same steps as in the procedure summary section above, this section shows the required N4010A WLAN test DLL commands.

Step	Focus	Action
1.	N4010A	Inst.Frequency = 2412000000# ' Sets the N4010A Tx/Rx frequency
2.	N4010A	Inst.PowerRange = 5# ' Sets the N4010A maximum expected power range to optimize dynamic range
3.	N4010A	Inst.MaxPacketLength = 0.000970 ' Sets the N4010A acquisition length
4.	N4010A	Inst.TriggerStyle = Agilent_N4010_WLanTest.TriggerStyleEnums_MagLevel ' Sets the N4010A trigger style
5.	N4010A	Inst.TriggerLevel = 0.03 ' Sets the N4010A trigger level
6.	N4010A	Inst.TriggerDelay = -0.000002 ' Sets the N4010A trigger delay
7.	N4010A	Inst.TriggerHoldoff = 0.00001 ' Sets the N4010A trigger holdoff
8.	N4010A	Inst.IEEE80211b_Demod_TrackPhase = True Inst.IEEE80211b_Demod_MeasureGatedPower = True Inst.IEEE80211b_Demod_LeftGatedPowerTime = 0 Inst.IEEE80211b_Demod_RightGatedPowerTime = 0.00001 ' Sets up to measure gated power in the N4010A DSSS 802.11b demod measurement Or Inst.IEEE80211a_Demod_MeasureGatedPower = True Inst.IEEE80211a_Demod_LeftGatedPowerTime = 0 Inst.IEEE80211a_Demod_RightGatedPowerTime = 0.00001 ' Sets up to measure gated power in the N4010A 802.11a or 802.11g demod measurement

15.2 Demod test procedure programming example, continued.

Step	Focus	Action
9.	WLAN DUT	' DUT specific command to set frequency band
10.	WLAN DUT	' DUT specific command to set transmit frequency
11.	WLAN DUT	' DUT specific command to set transmit power
12.	WLAN DUT	' DUT specific command to set modulation type
13.	WLAN DUT	' DUT specific command that turns transmitted power on ready for measurement
14.	N4010A	Inst.IEEE80211b_Demod_Initiate ' Initiates the N4010A DSSS 802.11b demod measurement Or Inst.IEEE80211a_Demod_Initiate ' Initiates the N4010A OFDM 802.11a or 802.11g demod measurement
15.	N4010A	Dim EvmPeakResult As Double Dim EvmRmsResult As Double Dim IqOffsetResult As Double Dim FreqErrResult As Double Dim PowerResult As Double Dim ChipClockErrorResult As Double EvmPeakResult = Inst.IEEE80211b_Demod_PeakEVM EvmRmsResult = Inst.IEEE80211b_Demod_RmsEVM IqOffsetResult = Inst.IEEE80211b_Demod_IQOffset FreqErrResult = Inst.IEEE80211b_Demod_FrequencyError ChipClockErrorResult = Inst.IEEE80211b_Demod_ChipClockFrequencyError PowerResult = Inst.IEEE80211b_Demod_GatedPower ' Returns the N4010A DSSS 802.11b demod measurement results Or Dim EvmRmsResult As Double Dim IqOffsetResult As Double Dim FreqErrResult As Double Dim SymbolClockErrorResult As Double Dim PowerResult As Double EvmRmsResult = Inst.IEEE80211a_Demod_RmsEVM IqOffsetResult = Inst.IEEE80211a_Demod_IQOffset FreqErrResult = Inst.IEEE80211a_Demod_FrequencyError SymbolClockErrorResult = Inst.IEEE80211a_Demod_SymbolClockFrequencyError PowerResult = Inst.IEEE80211a_Demod_GatedPower ' Returns the N4010A OFDM 802.11a or 802.11g demod measurement results

16. Transmitter Demod Test (802.11n)

The transmitter 802.11n demod test performs multiple measurements from one data capture. The 802.11n demod measurement can be used on a single channel or a multi-channel, multiple input/multiple output (MIMO) device transmission. When measuring multiple channels the N4011A hardware is connected to the N4010A RF In/Out port and the device antennas are connected to the N4011A ports as illustrated in Figure 14. Setting up the N4010A/N4011A for a number (N) multiple channels results in the N4011A automatically switching to capture signals from N number of channels.

Figure 15 shows the implementation in the N4010A WLAN Virtual Front Panel.

Mod. Acc.	Burst Info	Impulse Response	Condition Numbers	Spectral

	Channel 1	Channel 2	Channel 3
EVM:	1.152 %rms	0.962 %rms	2.885 %rms
Peak EVM:	3.544 %	2.855 %	8.311 %
Pilot EVM:	0.949 %rms	1.338 %rms	2.369 %rms
Data EVM:	1.166 %rms	0.926 %rms	2.921 %rms
IQ Quad Err:	-0.583 °	0.144 °	0.312 °
IQ Gain Imbal:	-0.015 dB	0.017 dB	-0.003 dB
IQ Offset:	-43.63 dB	-40.96 dB	-38.44 dB
Cross Power:	-46.79 dB	-44.79 dB	-41.79 dB
Sync Corr:	0.998	0.952	0.989

	Stream1	Stream 2	Stream 3
EVM:	1.151 %rms	0.962 %rms	3.362 %rms
Peak EVM:	3.545 %	2.846 %	3.090 %
Pilot EVM:	0.947 %rms	1.337 %rms	2.736 %rms
Data EVM:	1.166 %rms	0.927 %rms	3.406 %rms

Sym Clk Err:	1.020 ppm	MCS:	23
Freq Err:	-1114 Hz -0.462 ppm	PSDU Length :	1058 bytes

Figure 14. Hardware diagram

Figure 15. 802.11n demod measurement

16.1. 802.11n demod test procedure summary

The following steps summarize the procedure required to configure the WLAN DUT and the N4010A to make the 802.11n demod measurement and recover the results.

Step	Focus	Action
1.	N4010A	Set frequency, e.g. Channel 1 at 2.412 GHz, by setting the Frequency property
2.	N4010A	Set power range, e.g. 5 dBm, by setting the PowerRange property
3.	N4010A	Set max packet length, e.g. 7.21e-5, by setting the MaxPacketLength property
4.	N4010A	Set max symbols used, e.g. 8, by setting the MaxSymbolsUsed property
5.	N4010A	Set trigger style, e.g. MagLevel, by setting the TriggerStyle property
6.	N4010A	Set trigger level, e.g. 0.3 V, by setting the TriggerLevel property
7.	N4010A	Set trigger delay, e.g. -2e-6, by setting the TriggerDelay property
8.	N4010A	Set trigger holdoff, e.g. 60e-6, by setting the TriggerHoldoff property
9.	N4010A	Set the number of MIMO channels to make the measurement over, e.g. by setting the NumChannels property
10.	N4010A	Set the expected transmitted signal bandwidth to be measured, e.g. by setting the ExpectedSignalBandwidth property
11.	WLAN DUT	Set frequency band, e.g. 802.11n
12.	WLAN DUT	Set channel, e.g. Channel 1 at 2.412 GHz (N4010A = WLAN DUT frequency)
13.	WLAN DUT	Set transmit power
14.	WLAN DUT	Set modulation type, e.g. MCS7
15.	WLAN DUT	Set the transmission bandwidth, e.g. 20 MHz
16.	WLAN DUT	Start transmitting packets
17.	N4010A	Initiate the demod measurement
18.	N4010A	Retrieve the demod results

16.2. 802.11n demod test procedure programming example

Using the same steps as in the procedure summary section above, this section shows the required N4010A WLAN test DLL commands.

Step	Focus	Action
1.	N4010A	Inst.Frequency = 2412000000# ' Sets the N4010A Tx/Rx frequency
2.	N4010A	Inst.PowerRange = 5# ' Sets the N4010A maximum expected power range to optimize dynamic range
3.	N4010A	Inst.MaxPacketLength = 0.0000721 ' Sets the N4010A acquisition length
4.	N4010A	Inst.MaxSymbolsUsed = 8 ' Sets the N4010A acquisition length
5.	N4010A	Inst.TriggerStyle = Agilent_N4010_WLanTest.TriggerStyleEnums_MagLevel ' Sets the N4010A trigger style
6.	N4010A	Inst.TriggerLevel = 0.03 ' Sets the N4010A trigger level
7.	N4010A	Inst.TriggerDelay = -0.000002 ' Sets the N4010A trigger delay
8.	N4010A	Inst.TriggerHoldoff = 0.00001 ' Sets the N4010A trigger holdoff
9.	N4010A	Inst.IEEE80211n_Demod_NumChannels = 3 ' Sets the number of MIMO channels to make the measurement over
10.	N4010A	Inst.IEEE80211n_ExpectedSignalBandwidth = Agilent_N4010_WLanTest. ExpectedSignalBandwidthEnum_Bandwidth_40MHz ' Sets the expected transmitted signal bandwidth to be measured
11.	WLAN DUT	' DUT specific command to set frequency band
12.	WLAN DUT	' DUT specific command to set transmit frequency
13.	WLAN DUT	' DUT specific command to set transmit power
14.	WLAN DUT	' DUT specific command to set modulation type
15.	WLAN DUT	' DUT specific command to set transmission bandwidth
16.	WLAN DUT	' DUT specific command that turns transmitted power on
17.	N4010A	Inst.IEEE80211n_Demod_Initiate ' Initiates the N4010A 802.11n demod measurement

16.2 802.11 demod test procedure programming example, continued.

Step	Focus	Action
18.	N4010A	Dim EvmRmsChan1 As Double
		Dim EvmRmsStream1 As Double
		Dim PowerChan1 As Double
		Dim IqOffsetChan1 As Double
		Dim CrossPowerChannel1 As Double
		Dim EvmRmsChan2 As Double
		Dim EvmRmsStream2 As Double
		Dim PowerChan2 As Double
		Dim IqOffsetChan2 As Double
		Dim CrossPowerChannel2 As Double
		Dim FreqErr As Double
		Dim SymbolClockError As Double
		EvmRmsChan1 = Inst.IEEE80211n_Demod_RmsEVMChannel1
		EvmRmsStream1 = Inst.IEEE80211n_Demod_RmsEVMStream1
		PowerChan1 = Inst.IEEE80211n_Demod_BurstPowerChannel1
		IqOffsetChan1 = Inst.IEEE80211n_Demod_IQOffsetChannel1
		CrossPowerChannel1 = Inst.IEEE80211n_Demod_CrossPowerChannel1
		EvmRmsChan2 = Inst.IEEE80211n_Demod_RmsEVMChannel2
		EvmRmsStream2 = Inst.IEEE80211n_Demod_RmsEVMStream2
		PowerChan2 = Inst.IEEE80211n_Demod_BurstPowerChannel2
		IqOffsetChan2 = Inst.IEEE80211n_Demod_IQOffsetChannel2
		CrossPowerChannel2 = Inst.IEEE80211n_Demod_CrossPowerChannel2
		FreqErr = Inst.IEEE80211n_Demod_FrequencyError
		SymbolClockError = Inst.IEEE80211n_Demod_SymbolClockFrequencyError
		' Returns the N4010A 802.11n demod measurement results

17. Transmitter Spectral Mask Test (802.11n)

The transmitter 802.11n spectral mask measurement includes both in-band and out-of-band spurious emissions. This test ensures that multiple WLAN devices do not unduly interfere with each other. The spectral mask test can be a good indicator of deteriorating performance.

The 802.11n specification allows for both 20 MHz transmission similar to 802.11a/g and also 40 MHz transmission. When the device is transmitting in a 40 MHz channel, the 802.11n spectral mask measurement allows a 120 MHz span selection. For the frequency channels that allow transmission over 20 MHz channels, the 66 MHz span setting is available.

The reference level power is taken as the peak power spectral density (PSD) in the signal. The spectral mask applies to offset frequencies in the frequency band. For each frequency offset the PSD is calculated and compared relative to the reference level. All frequency offset PSD results are available from the N4010A. If no point across the spectral response has failed relative to the reference point then the margin result returned is a value of 0.0 and can be used for a go, no-go test. A negative value indicates the worst case amount for the PSD point which failed this test by the largest margin.

When measuring multiple channels, the N4011A hardware is connected to the N4010A RF In/Out port and the device antennas are connected to the N4011A ports. The measurement channel is selected by choosing the relevant N4011A IO port.

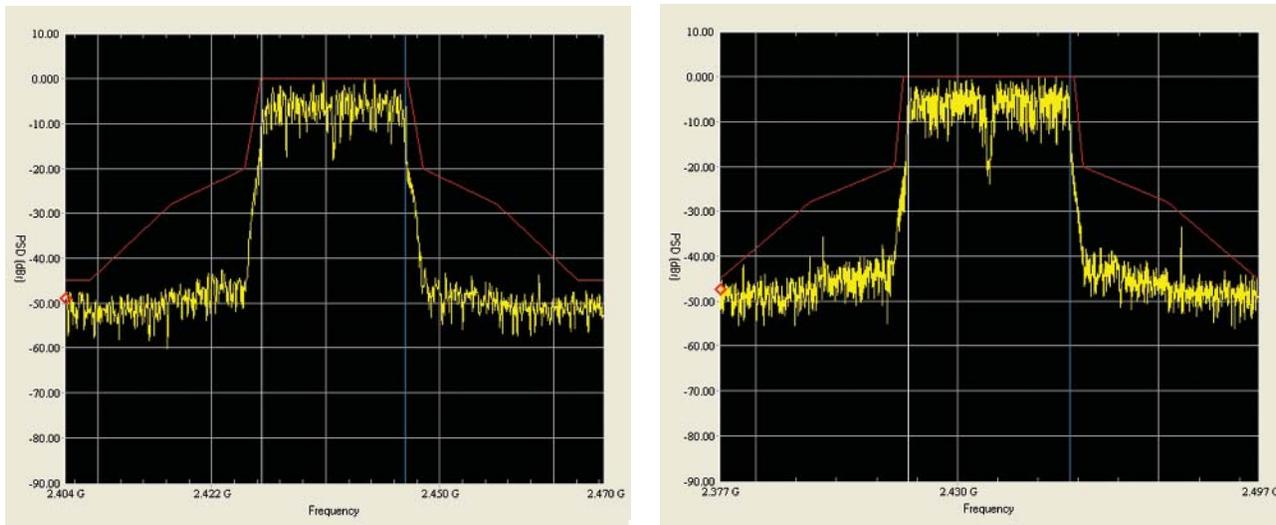Figure 16 shows the implementation in the N4010A WLAN Virtual Front Panel.

Figure 16. 802.11n spectral mask measurement a) 66 MHz span, b) 120 MHz span

17.1. 802.11n spectral mask test procedure summary

The following steps summarize the procedure required to configure the WLAN DUT and the N4010A to make the 802.11n spectral mask measurement and recover the results.

Step	Focus	Action
1.	N4010A	Set frequency, e.g. Channel 1 at 2.412 GHz, by setting the Frequency property
2.	N4010A	Set power range, e.g. 5 dBm, by setting the PowerRange property
3.	N4010A	Set max packet length, e.g. 7.21e-5, by setting the MaxPacketLength property
4.	N4010A	Set max symbols used, e.g. 8, by setting the MaxSymbolsUsed property
5.	N4010A	Set trigger style, e.g. MagLevel, by setting the TriggerStyle property
6.	N4010A	Set trigger level, e.g. 0.3 V, by setting the TriggerLevel property
7.	N4010A	Set trigger delay, e.g. -2e-6, by setting the TriggerDelay property
8.	N4010A	Set trigger holdoff, e.g. 60e-6, by setting the TriggerHoldoff property
9.	N4010A	Set the N4011A port to make the measurement over, e.g. by setting the PrimaryRFPort property
10.	N4010A	Set the expected transmitted signal bandwidth to be measured, e.g. by setting the ExpectedSignalBandwidth property
11.	WLAN DUT	Set frequency band, e.g. 802.11n
12.	WLAN DUT	Set channel, e.g. Channel 1 at 2.412 GHz (N4010A = WLAN DUT frequency), this will determine the transmission bandwidth, e.g. 40 MHz
13.	WLAN DUT	Set transmit power
14.	WLAN DUT	Set modulation type, e.g. MCS7
15.	WLAN DUT	Start transmitting packets
16.	N4010A	Initiate the spectral mask measurement
17.	N4010A	Retrieve the spectral mask margin measurement result

17.2. 802.11n spectral mask test procedure programming example

Using the same steps as in the procedure summary section above, this section shows the required N4010A WLAN test DLL commands.

Step	Focus	Action
1.	N4010A	Inst.Frequency = 2412000000# ' Sets the N4010A Tx/Rx frequency
2.	N4010A	Inst.PowerRange = 5# ' Sets the N4010A maximum expected power range to optimize dynamic range
3.	N4010A	Inst.MaxPacketLength = 0.0000721 ' Sets the N4010A acquisition length
4.	N4010A	Inst.MaxSymbolsUsed = 8 ' Sets the N4010A acquisition length
5.	N4010A	Inst.TriggerStyle = Agilent_N4010_WLanTest.TriggerStyleEnums_MagLevel ' Sets the N4010A trigger style
6.	N4010A	Inst.TriggerLevel = 0.03 ' Sets the N4010A trigger level
7.	N4010A	Inst.TriggerDelay = -0.000002 ' Sets the N4010A trigger delay
8.	N4010A	Inst.TriggerHoldoff = 0.00001 ' Sets the N4010A trigger holdoff
9.	N4010A	Inst.PrimaryRFPort = Agilent.N4010.WLanTest.Enums.RFPortEnum.Port1 ' Sets the N4011A port number for the spectral mask measurement ' Switch to port N for the DUT Tx Channel N
10.	N4010A	Inst.IEEE80211n_ExpectedSignalBandwidth = Agilent_N4010_WLanTest. ExpectedSignalBandwidthEnum_Bandwidth_40MHz ' Sets the expected transmitted signal bandwidth to be measured
11.	WLAN DUT	' DUT specific command to set frequency band
12.	WLAN DUT	' DUT specific command to set transmit frequency
13.	WLAN DUT	' DUT specific command to set transmit power
14.	WLAN DUT	' DUT specific command to set modulation type
15.	WLAN DUT	' DUT specific command that turns transmitted power on for all antennas ready for measurement
16.	N4010A	Inst.IEEE80211n_SpectralMask_Initiate ' Initiates the N4010A 802.11n spectral mask measurement
17.	N4010A	Dim MaskMargin As Double Dim MaxPowerDensity As Double Dim OBW As Double MaskMargin = Inst.IEEE80211n_SpectralMask_Margin MaxPowerDensity = Inst.IEEE80211n_SpectralMask_MaxPowerDensity OBW = Inst.IEEE80211b_SpectralMask_OBW ' Returns the N4010A 802.11n spectral mask measurement results

18. Receiver Minimum/Maximum Input Level Sensitivity (802.11a/b/g)

The receiver minimum input level sensitivity test requires, for a specified input power level at the antenna connector, that a WLAN receiver will receive and demodulate with a frame error rate (FER) (802.11b) or packet error rate (PER) (802.11a) at or below that specified in the IEEE standard.

For more details about the minimum input level sensitivity measurement, refer to: IEEE Standard 802.11b-1999 16 September 1999 Paragraph 18.4.8.1 Receiver minimum input level and IEEE Standard 802.11a-1999 16 September 1999 Paragraph 17.3.10.1 Receiver minimum input level.

For more details of the maximum input level sensitivity measurement, refer to: IEEE Standard 802.11b-1999 16 September 1999 Paragraph 18.4.8.2 Receiver maximum input level and IEEE Standard 802.11a-1999 16 September 1999 Paragraph 17.3.10.4 Receiver maximum input level.

For example, the 802.11b minimum input level sensitivity measurement FER shall be less than 0.08 at a PSDU length of 1024 octets for an input level of −76 dBm measured at the antenna connector. The FER is specified for 11 Mbps CCK modulation.

For example, the 802.11a minimum input level sensitivity measurement PER shall be less than ten percent at a PSDU length of 1,000 bytes for rate-dependent input levels shall be the numbers listed in Table 1 below. The minimum input levels are measured at the antenna connector.

Table 1. Data rate independent sensitivity levels

Data rate (Mbps)	Minimum sensitivity (dBm)
6	−82
9	−81
12	−79
18	−77
24	−74
36	−70
48	−66
54	−65

The N4010A arbitrary waveform generator allows transmission of a fully-coded WLAN test signal, enabling receiver FER/PER test to be performed.

An arbitrary waveform segment file is the equivalent of one WLAN packet. A sequence file created with a named waveform segment file, and a repeat count number (N), allows the N4010A to play the named waveform segment file a fixed N number of times, at a selected transmit power.

18.1. Creating a waveform segment file

- Create the arbitrary waveform segment file using, for example, N4010A 802.11 WLAN Signal Studio or one of the standard waveform files in the N4010A non-volatile RAM.

- The main test consideration is when to program the WLAN device MAC address. Programming the device MAC address at the beginning of the test process would mean that each device has a unique MAC address during the test process. Using unique MAC addresses would then require that that each device has a unique arbitrary waveform file for receiver testing as the MAC address is held in the header of the waveform file. (See Figure 18.) For this reason, it is recommended to use a generic MAC address for the test duration, for example all zeros, and then program the DUT MAC address at the end of the test process.
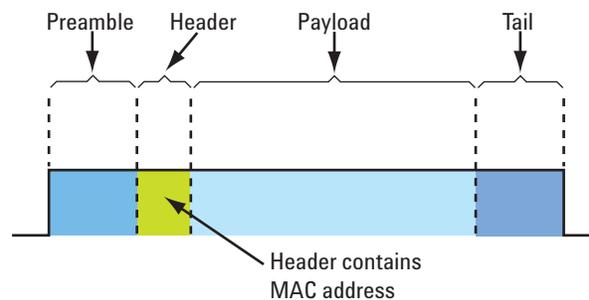

Figure 18. MAC address in WLAN signal header

18.2. Creating a waveform sequence file

- Download the arbitrary waveform segment file to the N4010A

- Create a sequence file, including a segment name, and a repeat count N

18.3. FER/PER test procedure summary

The following steps summarize the procedure required to con-
figure the WLAN DUT and the N4010A to perform the PER and
minimum input level measurement and recover the results.

Step	Focus	Action
1.	N4010A	Download the arbitrary waveform segment file to the N4010A (Optional, sequence may exist on N4010A already)
2.	N4010A	Download the sequence file to the N4010A (Optional, sequence may exist on N4010A already)
3.	N4010A	Select channel, e.g. Channel 1 at 2.412 GHz, by changing the Frequency property
4.	WLAN DUT	Select channel, e.g. Channel 1 at 2.412 GHz (i.e. N4010A = WLAN DUT frequency)
5.	N4010A	Select the sequence file name along with a transmit power to be generated
6.	WLAN DUT	Enabled/Start receiving packets
7.	N4010A	Call trigger to transmit the sequence file, i.e. the segment file N times
8.	WLAN DUT	Wait until sequence has completed
9.	WLAN DUT	Retrieve the successful received packets value
10.	PC	Calculate FER/PER is within specification limits

18.4. Calculate the PER

PER = (Sent packets-Received packets)/(Sent packets) * 100%

18.5. FER/PER test procedure programming detail

Using the same steps as in the procedure summary section
above, this section shows the required N4010A WLAN test DLL
commands.

Step	Focus	Action
1.	N4010A	Inst.AWG_LoadSegment "PC_FileName", "InstrumentFilename" ' Loads a segment file from PC to N4010A (Optional, sequence may exist on N4010A already)
2.	N4010A	Inst.AWG_LoadSequence "PC_FileName", "InstrumentFilename" ' Loads a sequence file from PC to N4010A (Optional, sequence may exist on N4010A already)
3.	N4010A	Inst.Frequency = 2412000000# ' Sets the N4010A Tx/Rx frequency
4.	WLAN DUT	' DUT specific code to change receive frequency
5.	N4010A	Inst.AWG_SelectSequenceB filename, –76.0, 0 ' Selects sequence file ready for trigger at –76.0 dBm ' Sets sample rate at 44 MHz for DSSS 802.11b transmission Or Inst.AWG_SelectSequenceA filename, –65.0, 0 ' Selects sequence file ready for trigger at –65.0 dBm ' Sets sample rate at 40 MHz for OFDM 802.11a or 802.11g transmission
6.	WLAN DUT	' DUT specific code ready to receive packets
7.	N4010A	Inst.AWG_TriggerSequence ' Sequence file plays/generates the segment ' A repeat count number of times specified in creating the sequence file. Later used in "SentPackets" variable

18.5. FER/PER test procedure programming detail, continued.

Step	Focus	Action
8.	N4010A	While (Inst.AWG_SequencePlaying)
		{
		' Setup timeout in case of problems
		}
9.	WLAN DUT	Dim RxPackets As Double
		SentPackets = <DUT Specific Command>
		' DUT specific code that returns received packets value "RxPackets"
10.	PC	Dim dbIPER As Double
		Dim SentPackets As Double
		dbIPER = ((SentPackets – RxPackets) / SentPackets) * 100
		' "SentPackets" is the number contained within the sequence
		' File repeat count N as described above

19. Appendix A— COM DLL and .NET DLL Comparison

As part of the N4010A WLAN Test Suite software installation, the WLAN test dynamic linklLibrary (DLL), or driver, is installed providing two DLL programming interfaces offering identical functionality:

- N4010 WLAN COM DLL, and

- N4010 WLAN .NET DLL

Having both a COM DLL and a .NET DLL gives the option to use the specific DLL type that is compatible with the software development environment being used for test.

19.1. NET DLL

As a test developer, the N4010A WLAN .NET DLL has a class structure available where you can access the functionality in a structured manner. For example, once the instrument object is created you have sub-classes, methods, and properties available to you. In the example below you can see that once you select the IEEE802_11b sub-class, you then have a subset of methods and properties available that are specific to the IEEE802_11b sub-class. When you then select the demod measurement this then gives you a subset of methods and properties that are specific to the demod sub-class, and so on until you can select the "Initiate" method to run the measurement.
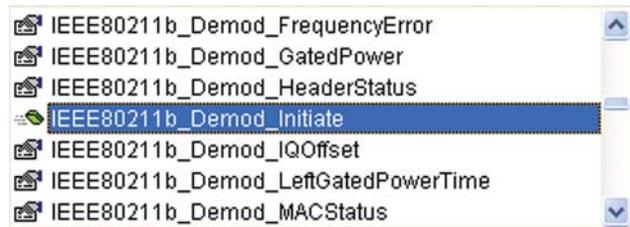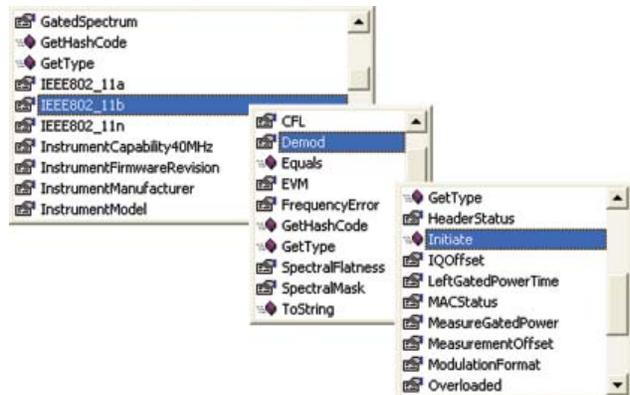
19.2. COM DLL

The primary difference between the COM DLL and the .NET DLL is that there is no sub-class structure. For example, when the instrument object is created, all methods and properties are available at that level. There is no class structure below that level, and all functionality is available at the instrument level in one list.

19.3. N4010A WLAN COM DLL and .NET DLL
code comparison example

WLAN COM DLL

```
'Step 3 of 6: Configure the measurement setup parameters
Inst.Frequency = 2412000000#
Inst.PowerRange = 5#
Inst.MaxPacketLength = 0.00097
Inst.TriggerDelay = -0.000002
Inst.TriggerHoldoff = 0.00001
Inst.TriggerLevel = 0.02
Inst.TriggerStyle = Agilent_N4010_WLanTest.
TriggerStyleEnums_MagLevel

Inst.IEEE80211b_Demod_TrackPhase = True
Inst.IEEE80211b_Demod_MeasureGatedPower = True
Inst.IEEE80211b_Demod_LeftGatedPowerTime = 0
Inst.IEEE80211b_Demod_RightGatedPowerTime = 0.00001

' Step 4 of 6: Run the measurement
Inst.IEEE80211b_Demod_Initiate

' Step 5 of 6: Get the measurement results
Dim EvmPeakResult As Double
Dim EvmRmsResult As Double
Dim IqOffsetResult As Double
Dim FreqErrResult As Double
Dim PowerResult As Double
Dim ChipClockErrorResult As Double

EvmPeakResult = Inst.IEEE80211b_Demod_PeakEVM
EvmRmsResult = Inst.IEEE80211b_Demod_RmsEVM
IqOffsetResult = Inst.IEEE80211b_Demod_IQOffset
FreqErrResult = Inst.IEEE80211b_Demod_FrequencyError
ChipClockErrorResult = Inst.IEEE80211b_Demod_
ChipClockFrequencyError
PowerResult = Inst.IEEE80211b_Demod_GatedPower
```

WLAN .NET DLL

```
// Step 3 of 6: Configure the measurement setup parameters
Inst.Frequency = 2412000000.0;
Inst.PowerRange = 5.0;
Inst.MaxPacketLength = 0.00097;
Inst.TriggerDelay = -0.000002;
Inst.TriggerHoldoff = 0.00001;
Inst.TriggerLevel = 0.02;
Inst.TriggerStyle = Agilent.N4010.WLanTest.Enums.
TriggerStyle.MagLevel;

Inst.IEEE802_11b.Demod.TrackPhase = true;
Inst.IEEE802_11b.Demod.MeasureGatedPower = true;
Inst.IEEE802_11b.Demod.LeftGatedPowerTime = 0.0;
Inst.IEEE802_11b.Demod.RightGatedPowerTime = 0.00001;

// Step 4 of 6: Run the measurement
Inst.IEEE802_11b.Demod.Initiate();

// Step 5 of 6: Get the measurement results
double EvmPeakResult;
double EvmRmsResult;
double IqOffsetResult;
double FreqErrResult;
double PowerResult;
double ChipClockErrorResult;

EvmPeakResult = Inst.IEEE802_11b.Demod.PeakEVM;
EvmRmsResult = Inst.IEEE802_11b.Demod.RmsEVM;
IqOffsetResult = Inst.IEEE802_11b.Demod.IQOffset;
FreqErrResult = Inst.IEEE802_11b.Demod.FrequencyError;
ChipClockErrorResult = Inst.IEEE802_11b.Demod.
ChipClockFrequencyError;
PowerResult = Inst.IEEE802_11b.Demod.GatedPower;
```

20. Appendix B— Measurement Listing

20.1. Auto range measurements

11b	11a	11g	11n
IEEE80211b_Autorange_Run			
	IEEE80211a_Autorange_Run		
		IEEE80211a_Autorange_Run	
			IEEE80211n_Autorange_Run

20.2. Format independent measurements

CW, 11b, 11a, 11g, 11n
AveragePower_Initiate
CW Only
CwFrequencyOffset_Initiate

20.3. Standards measurements

11b	11a	11g	11n
IEEE80211b_ CarrierSuppression_Initiate			
	IEEE80211a_CFL_Initiate	IEEE80211a_CFL_Initiate	
IEEE80211b_ EVM _Initiate			
	IEEE80211a_ EVM _Initiate	IEEE80211a_ EVM _Initiate	
IEEE80211b_ FrequencyError_Initiate			
	IEEE80211a_ FrequencyError_Initiate	IEEE80211a_ FrequencyError_Initiate	
IEEE80211b_ PowerRamp_Initiate			
IEEE80211b_ SpectralMask_Initiate			
	IEEE80211a_ SpectralMask_Initiate	IEEE80211a_ SpectralMask_Initiate	
	IEEE80211a_ SpectralFlatness_Initiate	IEEE80211a_ SpectralFlatness_Initiate	

20.4. Multiple demod measurements from one capture

11b	11a	11g	11n
IEEE802_11b.Demod.Initiate			
	IEEE802_11a.Demod.Initiate		
		IEEE802_11a.Demod.Initiate	
			IEEE802_11n.Demod.Initiate

From the demod measurement you get results for:
burst power, EVM, frequency error, clock frequency error,
and IQ offset.

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