

# IEEE 802.11a/b/g/n Manufacturing Test with the N8300A

Part 2: Implementation of a WLAN test plan using  
SCPI programming

Application Note



**Agilent Technologies**

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## Introduction

This application note is one of a four-part series of documents on IEEE 802.11a/b/g/n WLAN testing using the Agilent N8300A wireless networking test set.

### **1. IEEE 802.11a/b/g/n Manufacturing Test with the N8300A: Theory and Techniques**

*Part 1: Introduction to a WLAN manufacturing test plan and theory of implementation*

Part 1 introduces a typical WLAN manufacturing test plan for testing IEEE 802.11a/b/g/n format devices. The document provides background and theory on the test phases using an example test plan. This is useful for development and production engineers wishing to understand the key tests in manufacturing. The N8300A measurements are introduced at each test phase with pseudo code used to demonstrate how a test may be implemented with the device under test (DUT.) As a result, the engineer should be ready to progress to the implementation of a test plan and N8300A test code.

### **2. IEEE 802.11a/b/g/n Manufacturing Test with the N8300A**

*Part 2: Implementation of a WLAN test plan using SCPI programming*

This application note builds upon the pseudo code examples and test phases presented in Part 1 of the series by providing standard commands for programmable instruments (SCPI) scripts. This document is particularly useful for test and production engineers who wish to programmatically implement tests with a DUT. These examples are easily leveraged into any programming environment.

### **3. IEEE 802.11a/g/b/n Manufacturing Test with the N8300A**

*Part 3: Techniques for optimizing WLAN device testing*

Test speed is influenced by a range of variables including the DUT, test methodology, and the test instrumentation. Part 3 of the series presents test techniques, test methods, and programming recommendations that are aimed at optimizing speed. This document is aimed at engineers who want to optimize existing tests, or, are aiming to obtain best practices for maximizing speed and efficiency of a new test plan.

### **4. IEEE 802.11a/b/g/n Manufacturing Test with the N8300A**

*Part 4: How to migrate from the N4010A to N8300A for WLAN testing*

This document presents two different options for backwards compatibility with the existing Agilent N4010A wireless connectivity test set WLAN measurements. Engineers may choose to use the Agilent N8300A wireless networking test set hardware as a drop-in replacement instead of the N4010A, thereby re-using existing test software. In contrast, engineers who wish to migrate away from the N4010A driver application programmable interface (API) to standard commands for programmable instruments (SCPI) may do so with the guidance contained within this application note.

The purpose of this application note is to help explain which measurements are required to test an IEEE 802.11a/b/g/n device in manufacturing. By focusing on common customer requirements, problems, and measurements, this document provides insights into how tests can be performed.

The example test plan presented is general and not designed to fit any one particular DUT or test requirement. However, the key tests presented will undoubtedly be a consideration for any WLAN manufacturer. The test plan is primarily intended to check that the device has been manufactured properly and is functioning correctly. The tests can be edited as required to meet specific requirements of the WLAN IEEE specifications. For example, minor changes to examples such as averaging and equalizer settings will ensure exact conformance.

## The Test Plan

**Error! Reference source not found.** shows the example WLAN test plan that was introduced in Part 1 of this application note series [1]. As before, this document will follow the same test phases.

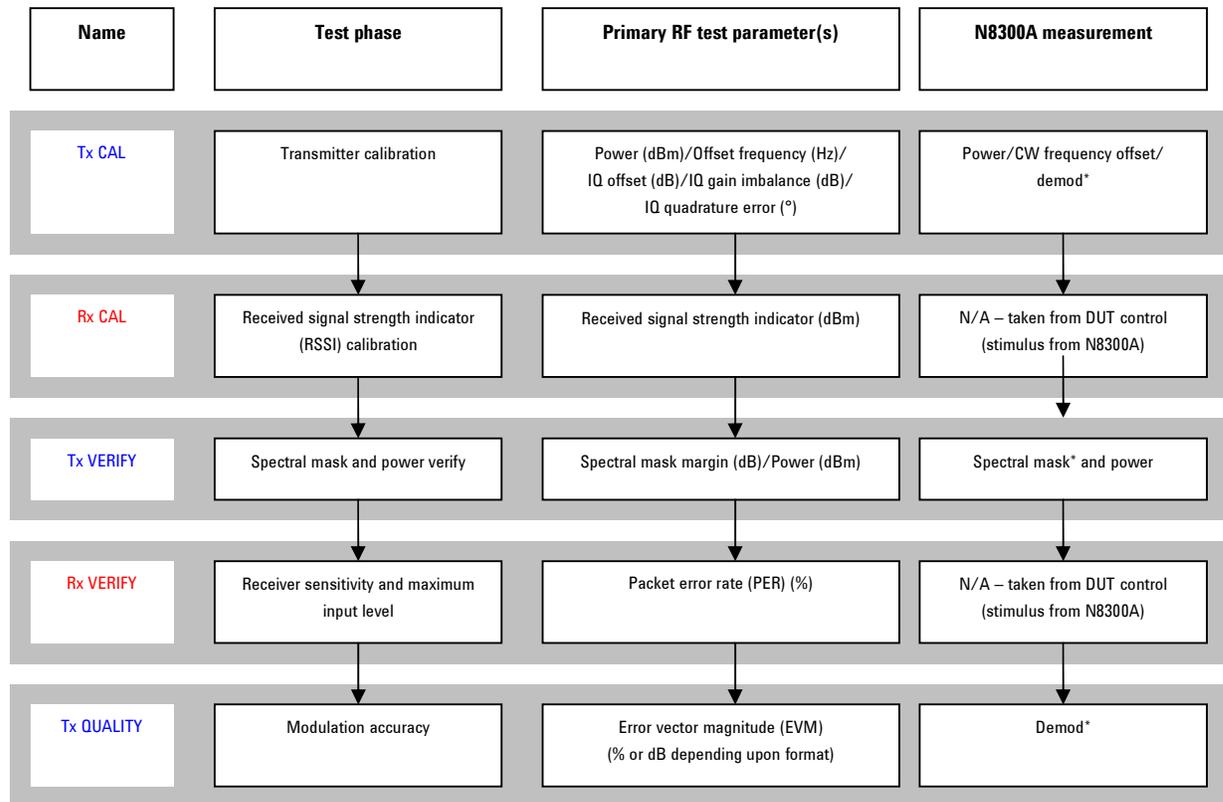


Figure 1: WLAN test plan example

\*Dependent on the WLAN standard

The test plan is broken down into stages to include calibration and verification tests with IEEE 802.11a/b/g/n signals. The mix of different WLAN formats, and therefore standards, is normal in a test plan to test and calibrate all the capabilities of a multi-format device. It also serves as a good demonstration on how to carry out all different measurements with the N8300A. For devices not supporting all WLAN formats, or additional IEEE 802.11 standards, similar tests can be substituted where required.

Pseudo code is used in to illustrate how a test sequence may be structured and what functions it might call to operate on both the instrument and DUT [1]. It is presented as follows:

```
// basic setup
N8300A: setWLANFormat( A )
DUT: setFrequency( 2.412 GHz )
```

This pseudo code relates specifically to N8300A SCPI commands used in this document. For example:

Operation	SCPI command
setWLANFormat( A )	SENSe:RADio:STANdard:SElect:WLAN A
setFrequency( 2.412 GHz )	SENSe:FREQuency:CENTer 2.412 GHz

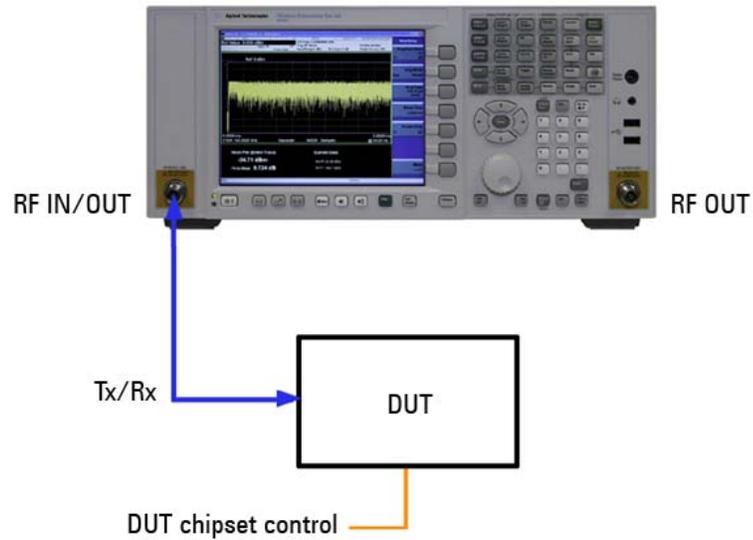
Note that all N8300A WLAN measurements that follow assume a single, rather than continuous, measurement operation<sup>1</sup>. A single measurement is the expectation in a manufacturing context.

---

<sup>1</sup> Single refers to a measurement operation and *not* acquisitions. For example, if averaging is switched on in a single measurement operation, the instrument must obtain a number of captures as defined in the averaging. For example, if averaging is set to ten, then ten different acquisitions must be made to finish the measurement operation.

## Test Setup

The N8300A and a DUT are illustrated in the following diagrams. In the first diagram, the N8300A uses only a single RF IN/OUT port providing both transmit and receive testing.



**Figure 2: N8300A and device test setup 1: Single channel testing**

The N8300A may also be configured with four RF IN/OUT ports for multiple-channel IEEE 802.11n testing (as well as for other use models including multi-up testing). The N8300A supports up to 4x4 MIMO testing with four RF IN/OUT ports providing both transmit and receive testing. This application note uses the setup shown in Figure 3 to enable 802.11n testing. This RF setup offers the same fundamental benefits in MIMO testing as the Agilent N4010A wireless connectivity test set when used in conjunction with the N4011A MIMO/Multi-port adapter. For more information on why the RF setup is so important for MIMO testing see reference documents [5] and [6].

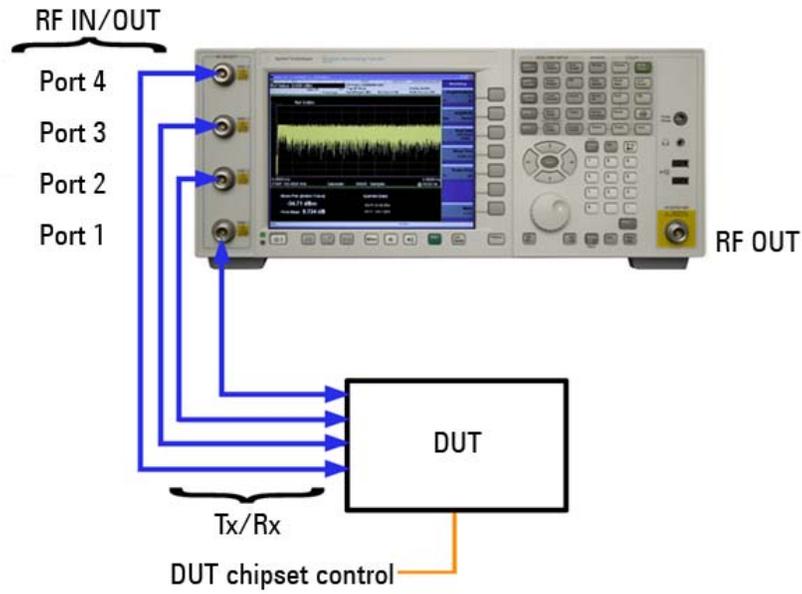


Figure 3: N8300A and device test setup 2: Multiple channel testing

In Figure 3 the single RF OUT port on the right-hand side is not included in the test setup. However, it is possible to switch output to this port for similar receiver testing requirements (subject to different specifications.) The port may prove useful as a source for loss compensation in test fixtures using the N8300A RF IN/OUT ports for analysis (see Appendix A in [1].) Use of the ports is covered in the multiple-port control section.

The following assumptions have been made about the WLAN device being tested:

1. Test modes exist to facilitate transmitter and receiver testing via chipset control code
2. The device supports IEEE 802.11a/b/g/n formats
3. No use of protocol is required
4. The device can generate a signal at a requested power level and frequency
5. The device can report a count of the number of packets successfully received (on each channel for IEEE 802.11n)
6. The device can report the received signal strength indicator (RSSI) of the received signal (for each channel and/or as a "composite RSSI" for IEEE 802.11n)

## Basic settings

There are some basic and common measurement parameters and operations that a test engineer must configure for specific measurements. N8300A measurements made in each of the test phases that follow can only be accurate and reliable if these parameters are correctly set.

## WLAN and WiMAX™ testing

The N8300A supports WiMAX and WLAN testing. In order to switch between the two modes, use the following SCPI commands. To switch to WLAN from WiMAX use:

```
INSTRument:SElect WLAN
```

To switch to Mobile WiMAX™ use:

```
INSTRument:SElect WIMAXOFDMA
```

## Choosing an IEEE 802.11 WLAN standard

The N8300A can test IEEE 802.11a/b/g/n formats, as well as other less common IEEE 802.11 formats by customizing some of the existing format settings. Throughout this application note it should be clear which of the standard commands for programmable instruments (SCPI) format (or standard) is being tested in the examples provided, or, the example should indicate that the format is not important (e.g. with continuous wave (CW) tones being tested.) When the standard of IEEE 802.11a/ b/g/n is relevant to a measurement, the following SCPI command must be used:

```
SENSe:RADio:STANdard:SElect:WLAN <format>
```

The format SCPI parameters here are A, B, GDSSs, GOFDM, and N.

This means that the execution of measurements should be the same for all formats: only the basic settings and results should vary. Use this command as required to switch between formats as appropriate.

Table 1 summarizes the measurements that are format-independent and therefore do not require the SCPI command above:

**Table 1: Format-independent measurements**

Format-independent	
Measurement	Example SCPI
Power	READ:TXPower??
CW Frequency Offset	READ:CWFoffset?
IQ Capture	READ:IQCapture?
Multi_step Power	READ:MSPower?
Power versus Time	READ:PVTime?

<sup>2</sup> The compound READ? SCPI query is used for demonstration of returning measurements throughout the application note.

Table 2 to Table 5 show which measurements require the WLAN format to be set:

**Table 2: IEEE 802.11a measurements**

IEEE 802.11a format	
Measurement	Example SCPI
Center Frequency Leakage	READ:CFLeakage?
11a Demod	READ:EVM?
Spectral Flatness	READ:SFLatness?
11a Spectral Mask	READ:SMASK?

**Table 3: IEEE 802.11b measurements**

IEEE 802.11b format	
Measurement	Example SCPI
11b Demod	READ:EVM?
Power Ramp	READ:PRAMP?
Carrier Suppression	READ:CSUPpression?
11b Spectral Mask	READ:SMASK?

**Table 4: IEEE 802.11g measurements**

IEEE 802.11g format	
Measurement	Example SCPI
Center Frequency Leakage	READ:CFLeakage?
11g Demod	READ:EVM?
Spectral Flatness	READ:SFLatness?
11g Spectral Mask	READ:SMASK?

**Table 5: IEEE 802.11n measurements**

IEEE 802.11n format	
Measurement	Example SCPI
11n Demod	READ:EVM?
11n Spectral Mask	READ:SMASK?

## Frequency

Setting the frequency is a basic requirement for any transmitter or receiver measurement. For example:

```
SENSe:FREQuency:CENTer 2.412 GHz
```

This example sets the frequency to 2.412 GHz for both the N8300A analyzer and N8300A source.

## Input power range

The N8300A input power range prepares the instrument to receive at a required input power level and at the optimum sensitivity for the analog to digital convertor (ADC.) The power range should be based on the expected average power transmitting from the device and must be configured for all measurements.

For **IEEE 802.11b direct sequencing spread spectrum (DSSS)** signals, the power range should be set about 5 dB above the expected average power from the device.

For **IEEE 802.11a/g/n orthogonal frequency-division multiplexing (OFDM) signals**, the power range should be set about 8 dB higher than the average power level expected from the device. This power range will be around 3 dB lower than the peak power from the signal. There is a need to set the power range higher than DSSS to accommodate WLAN OFDM signals that have high peak to average ratios.

Remember that IEEE 802.11n devices have multiple channels. The power range should be set to account for any slight power differences in the channels for the selected channel under test.

The following diagram summarizes how the power range and trigger level might be set for measurements (trigger level is only required for burst signals) depending upon WLAN format. The input power range and trigger level of the N8300A is based on the expected average power transmitting from the device.

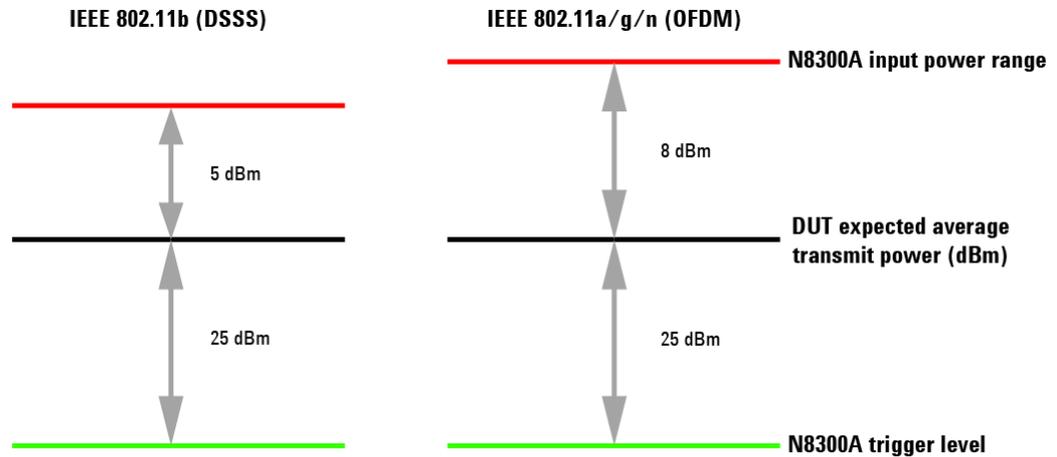


Figure 4: Setting power range and trigger level for an expected power level for WLAN formats

An example SCPI command is as follows:

```
SENSe:POWer:RANGe -20 dBm
```

For CW measurements, the power range setting should be set to the expected input power, perhaps 3 dBm higher in case there is some variance. Check whether the ADC is being overloaded by looking for the overload condition.

### Maximum packet length

The following SCPI command sets the maximum packet length (often referred to as the acquisition length) for analysis:

```
SENSe:RADio:MPACketlen 180.3 us
```

This setting influences all transmitter measurements.

### Maximum number of symbols

The following SCPI command sets the maximum number of symbols that should be analyzed from each packet to generate a result. It only applies to OFDM signals and not DSSS:

```
SENSe:RADio:MSYMBOLs 16
```

Note that the maximum packet length defines how many symbols are available to set, as it is not possible to demodulate something that the instrument has not acquired.

## Triggering

An independent trigger exists for every WLAN measurement. Trigger options are external, free run, and RF burst. An example of setting a trigger type (also referred to as trigger source) for a measurement (TXPower) is shown below:

```
SENSE:TXPower:TRIGger:SOURce RFBurst
```

For the RF burst, a trigger level must also be set. Normally a trigger level 25 dB below the average power is a good rule of thumb. An example SCPI command is as follows:

```
TRIGger:SEQuence:RFBurst:LEVel:ABSolute -40 dBm
```

## The autorange tool

The autorange feature is a development tool that allows the N8300A to calculate the following parameters automatically, based on a specified WLAN format:

1. Input power range
2. Maximum packet length (acquisition time)
3. Number of symbols (802.11a/g/n OFDM signals only)
4. The trigger level

By transmitting the test signal into the N8300A, the instrument analyzes the signal and returns the setup parameters discussed above. The parameters are recommended settings based on what the N8300A analyzes. The autorange produces reliable results unless the signal from the DUT exhibits unusual characteristics (such as spikes or ramps in the power versus time trace.)

```
READ:ARANge?
```

It is important to remember that the setup parameters returned by the autorange tool should be verified and used to manually setup the N8300A. Once the settings are proven, the autorange tool can be omitted to eliminate any time penalty for analyzing the input automatically. The test engineer should setup the parameters manually in accordance with the signal to be analyzed and autorange should not be considered for production test.

## Averaging

Averaging can be switched on for any transmitter measurement. Remember that averaging requires the N8300A to make more acquisitions to complete a measurement. This impacts test time. IEEE specifications state a required number of averages for certain measurements, such as modulation quality. An example of enabling averaging for a transmit power measurement is shown below:

```
SENSe:TXPOWer:AVERAge:COUNT 10  
SENSe:TXPOWer:AVERAge:STAT ON
```

## **Multiple port control**

Port control is required to configure the N8300A's front panel RF ports for both transmit and receive.

### ***Receiver testing***

For the purposes of receiver testing, every N8300A has at least two physical output path options (see ports in Figures 2 and 3), whether the unit be a single-channel or multi-channel N8300A. The source defaults to a transmit path from the RF OUPUT port (as it also would for WiMAX, for example.) This default setting can be changed so that the source output is the RF I/O port (Port 1 RF I/O on a multi-channel N8300A) using the following command:

```
:SOURce:DECouple OFF
```

With decoupling on, the source and analyzer paths are separate. The above command turns decoupling off, which means input and output can be via the same port (one of the RF I/O ports.)

In order to configure individual and multiple output paths (RF I/O ports) on a multi-channel N8300A for receiver testing decoupling will need to be switched off. For example, if transmit and receive are required through RF I/O Port 2, first set decoupling to OFF and then set the primary port:

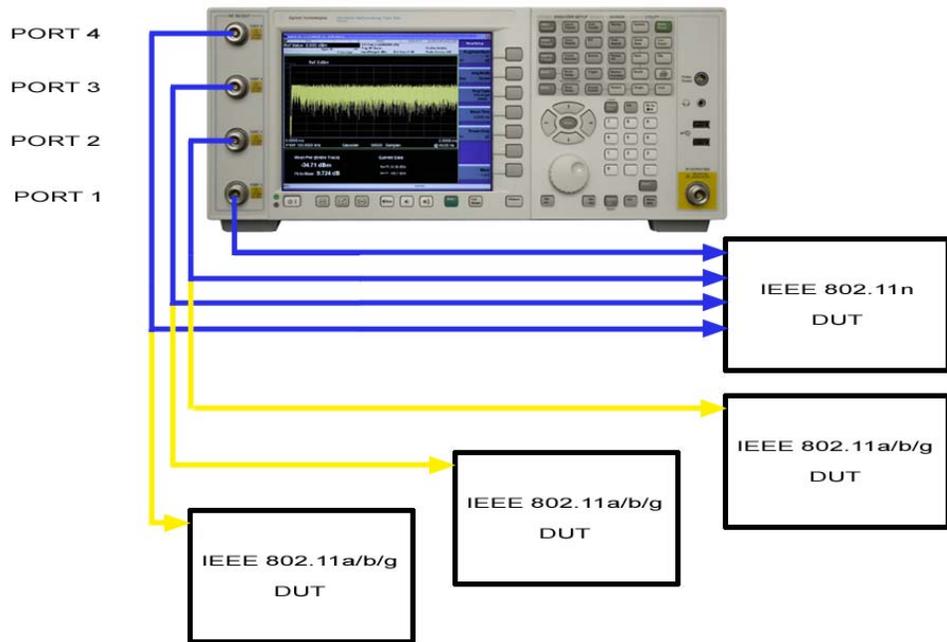
```
:SOURce:PORT:PRIMary RFIO2
```

The primary RF port sets or queries the RF I/O port to be used for transmit and receive on a multi-channel N8300A.

### **Broadcast mode**

Broadcast mode allows the N8300A source to route a signal through any combination of ports. This means any WLAN signal can be sent to all ports—to one device with multiple RF chains or multiple devices with single chains (see Figure 5.)

Specifically, for IEEE 802.11n testing, this is useful for sending a signal to all receivers at the same time and is often used for RSSI calibration using “composite” RSSI results. However, remember that the N8300A contains one source and so can generate one MIMO stream (MCS0-7) at any one time.



**Figure 5: MIMO N8300A using Broadcast Mode for Rx testing of a) an 802.11n device b) multiple devices at one time**

Broadcast mode is demonstrated in Phase 2 of the test plan.

### **Transmitter testing**

For a single-channel N8300A there is only one transmit path.

Port control for transmitter testing on a multi-channel N8300A is influenced by the number of channels required for a MIMO demodulation. For example, the setting for a two-channel demodulation is to use RF I/O Ports 1 and 2. A three-channel demodulation would be RF I/O Ports 1, 2, and 3. The ports are used in that order for a sequential capture [5]. This is demonstrated in Phase 5 of the test plan.

For any other single transmitter port changes, use the primary RF port SCPI command as above.

## Phase 1: Transmitter Calibration (“TX CAL”)

There are three main stages to transmitter calibration:

1. Crystal trim calibration
2. IQ calibration
3. Power calibration

### N8300A SCPI commands<sup>3</sup>

#### Crystal trim calibration

The following set of SCPI commands are used for calibrating the transmitter’s crystal using the **CW frequency offset (Hz)** measurement based on a **CW tone**:

Operation	SCPI command
setTriggerSource( FREERUN )	SENSE:TXPower:TRIGger:SOURce IMMEDIATE
setMaxPacketLength( 100 us )	SENSe:RADio:MPACketlen 100 us
setPowerRange( dBm )	SENSe:POWer:RANGe -20 dBm
setFrequency( F )	SENSe:FREQuency:CENTer 2.412 GHz
measureCWOOffset()	READ:CWFOffset?
checkNotOverrange()	STATus:QUEStionable:INTegrity:CONDition?

The triggering is set to free run in order to analyze a CW tone and the maximum packet length set at 100  $\mu$ s. The acquisition length does not need to be long for CW tones. Depending upon the tone, the engineer may wish to employ a positive trigger delay in order to be triggering off a particular part of the tone, so as to avoid any curve at the start—this has been omitted in this example. Power range is set according to the expected input level from the CW tone. Typically, the power range will be the same as the expected average power and there is no need to leave headroom (in contrast to high peak to average OFDM signals where an engineer may choose to set the power range around 8 dB higher. See the input power range section.) The final SCPI command checks that the ADC was not overranged.

---

<sup>3</sup> As with all examples throughout this application note, typical parameters have been inserted to demonstrate how to use each command (parameters such as receiver waveform file names, frequencies, and power levels.)

## IQ calibration

The following commands demonstrate how to complete an IQ calibration on a bursted WLAN signal. The example below is for **an IEEE 802.11a 54-Mbps OFDM signal**:

Operation	SCPI command
// basic setup	
setWLANFormat( A )	SENSe:RADio:STANdard:SElect:WLAN A
setFrequency( 2.412 GHz )	SENSe:FREQuency:CENTer 2.412 GHz
setMaxPacketLength( 181.3 )	SENSe:RADio:MPACketlen 181.3 us
setPowerRange( -21 )	SENSe:POWer:RANGe -21 dBm
setMaximumSymbols( 43 )	SENSe:RADio:MSYMBOLs 43
// triggering	
setTriggerSource( RF BURST )	SENSe:EVM:TRIGger:SOURce RFBURst
setTriggerLevel( -52 )	TRIGger:SEQuence:RFBurst:LEVel:ABSolute -52
setTriggerDelay( -1 us )	TRIGger:SEQuence:RFBurst:DELay -1 us
setTriggerDelayState( ON )	TRIGger:SEQuence:RFBurst:DELay:STATe ON
setTriggerHoldoff( 1 us )	TRIGger:SEQuence:HOLDoff 1 us
setTriggerHoldoffState( ON )	TRIGger:SEQuence:HOLDoff:STATe ON
// demod measurement setup	
setAveraging( ON )	SENSe:EVM:AVERage:STATe ON
setNumaverages( 3 )	SENSe:EVM:AVERage:COUNt 3
setEqualizer( NORMAL )	CALCulate:EVM:OFDM:EQTYpe NORMal
setGatedPower( OFF )	CALCulate:EVM:OFDM:GPOWer:ENABle OFF
setOffset( 0 )	CALCulate:EVM:OFDM:MOFFset 0
setTrackAmp( OFF )	CALCulate:EVM:OFDM:TAMPLitude OFF
setTrackPhase( OFF )	CALCulate:EVM:OFDM:TPHase OFF
setTrackTiming( OFF )	CALCulate:EVM:OFDM:TTIMing OFF
// execute measurement	
measDemod()	READ:EVM?
checkNotOverrange()	STATus:QUEStionable:INTegrity:CONDition?

The use of demod measurements is covered in more detail in Section 6 and provides more detail on the above SCPI (although with a focus on the likes of error vector magnitude (EVM).) Note that the default of normal equalization is used. There should be no need to change the default since the IQ results are obtained in the measurement algorithm before any equalization is obtained, which would then be used to produce other results such as EVM. It is therefore more efficient to use the normal equalizer as the quickest means of running the demod measurement. For the same reasons, amplitude, phase, or time tracking requirements should not need to be set. However, averaging should be enabled to avoid any instability in individual bursts from the un-calibrated device. The number of averages required is entirely dependent on the stability of the device. The IQ gain imbalance is Position 4 and IQ quadrature error is Position 6 of the EVM result array (indexed from 0.)

## Power calibration

The first set of SCPI commands are concerned with calibrating the transmitter's output **power level** in dBm. As calibration and power measurements are independent of the WLAN format, these commands apply to **all WLAN formats**. The example below assumes a **burst signal**:

Operation	SCPI command
// trigger & power setup	
setTriggerSource( RFBurst )	SENSE:TXPower:TRIGger:SOURce RFBurst
setMaxPacketLength( 180.3 us )	SENSe:RADio:MPACketlen 180.3 us
setPeakPower( OFF )	CALCulate:TXPower:PPOWer:ENABled OFF
setBandwidth( 20 )	CALCulate:TXPower:EXPeCted:BWIDth BW20
// set 1 <sup>st</sup> channel	
setFrequency( F )	SENSe:FREQuency:CENTer 2.412 GHz
// loop by DUT power level	
setPowerRange( dBm )	SENSe:POWer:RANGe -21 dBm
setTriggerLevel( dBm )	TRIGger:SEQuence:RFBurst:LEVel:ABSolute -51
// execute measurement	
measurePower()	READ:TXPower?
checkNotOverrange()	STATus:QUEStionable:INTEgrity:CONDition?

The first command sets up the trigger source. Next, the maximum packet length is setup, followed by choosing if the peak power was enabled. The bandwidth is set at 20 MHz. The frequency is then set according to the list of channels required for test. The power range is set depending on power control values. The trigger level is also set depending upon the required DUT output. The power is then read from the N8300A. If the peak power was enabled, then this is also returned in the result array. The final SCPI command checks that the ADC was not overranged.

If power measurements need to be analyzed further (e.g. for debug purposes) then the power-versus-time trace may be obtained as follows:

READ:PVTime?

This returns a comma-delineated list of power points (in dBm) which can be plotted.

## Phase 2: RSSI ("RX CAL")

As with transmitter calibration, the DUT will normally need to be supplied with a set of signals of varying power levels and frequencies.

### N8300A SCPI commands

The following SCPI commands may be used for **CW receiver calibration**:

Operation	SCPI command
// set first channel in 1 <sup>st</sup> frequency band & play	
setFrequency( B )	:SENSe:FREQuency:CENTer 2.412 GHz
playCW( SP, 0 )	:SOURce:CWTone -60,0
// loop by powers and channels	
adjustOutput( PL, OF )	:SOURce:ADJust -68,5000000
// continue looping by power & channels	
// stop once finished	
stopTX()	:SOURce:STOP

The first command sets the frequency of the source. The source is then switched on to output a CW tone at a specified power level, assuming no frequency offset. The source is then adjusted to loop through different power levels (using the power level parameter) for multiple channels (using the offset frequency parameter.) The source is then stopped.

The following SCPI commands may be used for **receiver calibration using continuous bursted signals**:

Operation	SCPI command
// set first channel in 1 <sup>st</sup> frequency band & play	
setFrequency( B )	:SENSe:FREQuency:CENTer 2.412 GHz
playSegment( SEGMENT, SP, SR, 0 )	SOURce:SEGment:PLAY "60FDM_BPSK_1000B.WF1",-60,40000000,0
// loop by powers and channels	
adjustOutput( PL, OF )	:SOURce:ADJust -68,5000000
// continue looping by power & channels	
// stop once finished	
stopTX()	:SOURce:STOP

The first command sets the frequency of the source. A signal can be produced by selecting a segment file, a power level, a sampling rate, and frequency offset. In this example a 1,000-byte, 6-Mbps OFDM signal is used (one that is supplied with the instrument) at a -20-dBm, 40-MHz sampling rate and with no frequency offset.

The following SCPI commands may be used for **receiver calibration using continuous bursted signals** with **broadcast mode**:

Operation	SCPI command
<i>// setup broadcast mode</i>	
setBroadcastMode( ON )	SOURce:PORT:SELECTION BMASK
setPorts( RFIO1 & RFIO2 & RFIO3 )	SOURce:PORT:BMASK 7
<i>// set first channel in 1<sup>st</sup> frequency band &amp; play</i>	
setFrequency( F )	SENSe:FREQUency:CENTer 2.412 GHz
playSegment( SEGMENT, SP, SR, 0 )	SOURce:SEGment:PLAY "60FDM_BPSK_1000B.WF1",-60,40000000,0
<i>// loop by powers and channels</i>	
adjustOutput( PL, OF )	:SOURce:ADJust -68,5000000
<i>// continue looping by powers &amp; channels . . .</i>	
<i>// stop once finished</i>	
stopTX()	:SOURce:STOP

The first command switches broadcast mode on, with the following command defining which ports to be enabled. In this case Ports 1, 2, and 3 (decimal 7 is equal to binary 0111 where the least significant bit is Port 1.) The frequency of the source is then set. Once looping by power levels, a signal can be produced by selecting a segment file with a power level, a sampling rate, and frequency offset. This produces an output on all three ports.

For further information on how to use the source efficiently see reference document [2].

## Phase 3: Spectral Mask and Power Verification (“TX VERIFY”)

Phase 3 contains two types of measurements in the N8300A: power (as with Phase 1) and spectral mask.

### N8300A SCPI commands

#### Power verification

The following commands demonstrate the power verification part of this test phase by making **power measurements** on a **burst WLAN signal**. Power measurements are independent of the WLAN format in terms of SCPI commands so these commands apply to **all WLAN formats**. Note: triggering and maximum packet length would need changed for different bursts:

Operation	SCPI command
// basic setup & power triggering	
setTriggerSource( RFBurst )	:SENSE:TXPower:TRIGger:SOURce RFBurst
setMaxPacketLength( 967 )	:SENSE:RADio:MPACketlen 967 us
setTriggerDelay( -2 )	:TRIGger:SEQuence:RFBurst:DELay -2 us
setTriggerDelayState( ON )	:TRIGger:SEQuence:RFBurst:DELay:STATe ON
setTriggerHoldoff( 1 us )	:TRIGger:SEQuence:HOLDoff 1 us
setTriggerHoldoffState( ON )	:TRIGger:SEQuence:HOLDoff:STATe ON
// power measurement setup	
setPeakPower( OFF )	:CALCulate:TXPower:PPOWer:ENABled OFF
setBandwidth( 20 )	:CALCulate:TXPower:EXPEcted:BWIDth BW20
// set 1 <sup>st</sup> channel	
setFrequency( F )	:SENSe:FREQuency:CENTer 2.412 GHz
// loop by DUT power level	
setPowerRange( dBm )	:SENSe:POWer:RANGe -29 dBm
setTriggerLevel( dBm )	:TRIGger:SEQuence:RFBurst:LEVel:ABSolute -54
measPower()	:READ:TXPower?
checkNotOverrange()	:STATus:QUEStionable:INTegrity:CONDition?
// continue looping by powers & channels . . .	

The SCPI commands for the power verification are identical to that used in Phase 1 in TX CAL. The main difference is that the expectation is that the device is transmitting bursts at calibrated power levels. For this reason, the triggering is set as RF burst and some extra trigger commands are introduced for trigger delay and trigger holdoff. Trigger delay is used for obtaining the most accurate results so that the analysis algorithm can “see” both edges of the burst. Trigger holdoff sets the time between triggers. When the trigger condition is satisfied, trigger conditions are ignored until the holdoff time expires. The next command configures whether a peak power result is returned or not. The bandwidth over which the measurement is then set as 20 MHz

Once looping by frequency, the frequency of the N8300A must be set. The following line is a comment to note that the next few commands are executed within a loop of device power levels. For this reason the next SCPI command sets the power range and trigger level. The measurement is then made and an overload checked.

## Spectral mask

The following commands demonstrate the spectral mask verification part of this test phase by making **spectral mask measurements** on a bursted **IEEE 802.11b, 11-Mbps WLAN** signal:

Operation	SCPI command
// basic setup & spectral mask triggering	
setTriggerSource( RFBurst )	SENSE:SMASK:TRIGger:SOURce RFBUrst
setMaxPacketLength( 967 )	SENSe:RADio:MPACketlen 967 us
setTriggerDelay( -2 )	TRIGger:SEQuence:RFBurst:DELay -2 us
setTriggerDelayState( ON )	TRIGger:SEQuence:RFBurst:DELay:STATe ON
setTriggerHoldoff( 1 us )	TRIGger:SEQuence:HOLDoff 1 us
setTriggerHoldoffState( ON )	TRIGger:SEQuence:HOLDoff:STATe ON
// spectral mask setup	
setWLANFormat( B )	SENSe:RADio:STANdard:SElect:WLAN B
setMaskAveraging( OFF )	SENSe:SMASK:AVERage:STAT OFF
setFastMask( ON )	CALCulate:SMASK:FMASK ON
setRelativeLevel( AUTO )	CALCulate:SMASK:RLEVel:AUTO ON
setSpan( 66 )	CALCulate:SMASK:SPAN SPAN66
setWindowing( GAUSSIAN )	CALCulate:SMASK:WTPe GAUSSian
// execute measurement	
measSpectralMask()	READ:SMASK1?
checkNotOverrange()	STATus:QUEStionable:INTegrity:CONDition?

The first six commands cover triggering and maximum packet length. The correct WLAN format is then set. Averaging is switched off and then fast mask is enabled. The setRelativeLevel() is set to automatic. This means that the relative mask made is referenced to the peak of the analyzed signal. This is calculated from 9 MHz each side of the detected power spectral density's center frequency. This is the normal way to make this measurement. It is possible to set this setting to off and then specify the level manually using :CALCulate:WLAN:SMASK:RLEVel <value>.

The next command sets the mask to a span of 66 MHz and the following command enables Gaussian windowing. The measurement is then made using `:READ:SMASK1?`. This returns:

- The margin: The most important parameter for this test
- Max power density: Maximum power in any 1-MHz wide portion of measured spectrum
- Occupied bandwidth (OBW)
- OBW high frequency
- OBW low frequency
- The reference level used for the measurement

The failure margin is the key result being returned and it is the worst difference between the spectral mask and the measured power spectral density. The final SCPI command checks that the ADC was not overranged.

It is also possible to return all amplitude and frequency points as required, but typically this is only required for more in-depth analysis of the spectrum:

`FETCH:SMASK0?`

Note that `FETCH?` is used because the measurement has already been initiated and the results required are already available. A `FETCH` ensures that amplitude and frequency points correlate with the previous mask results.

## Phase 4: Receiver Sensitivity and Maximum Input Level (“RX VERIFY”)

It is now time to find out whether the receiver can receive bursted signals and to verify the receiver calibration.

### N8300A SCPI commands

The following procedure sends **1,000, 54-OFDM, 64QAM packets** to the device:

Operation	SCPI command
// set 1 <sup>st</sup> channel	
setFrequency( F )	SENSe:FREQUency:CENTer 2.412 GHz
// setup signal source	
setSequence ( SEQUENCE, P1, SR, 0 )	SOURce:SEQUence:SElect "54OFDM_64QAM_1000B.SEQ",-65,40000000,0
// trigger output	
triggerSequence()	SOURce:TRIGger
// check when finished	
sequenceComplete()	SOURce:SEQUence:PLAYing?
// loop by channels & powers as required ...	

Having set the frequency, the second command selects a sequence file with a chosen power level, sampling rate, and offset frequency. The next command begins playback of the 1,000 packets. The final command checks to see whether the N8300A has finished transmitting. The command `SOURce:SEQUence:PLAYing?` returns 1 if a sequence is playing or 0 if the sequence is not playing. So a “while” loop can be used to wait on a 0 being returned before asking the DUT for a result.

## Phase 5: Modulation Accuracy ("TX QUALITY")

The EVM is the main result of interest in this stage of the test plan.

### N8300A SCPI commands

The following commands demonstrate modulation accuracy on a bursted WLAN signal. The example below is for an **IEEE 802.11a, 54-Mbps OFDM signal**:

Operation	SCPI command
// basic setup signal source	
setWLANFormat( A )	:SENSe:RADio:STANdard:SElect:WLAN A
setMaximumSymbols( 43 )	:SENSe:RADio:MSYMBOLS 43
setTriggerSource( RFBurst )	:SENSe:EVM:TRIGger:SOURce RFBURst
setMaxPacketLength( 185.2 us )	:SENSe:RADio:MPACKETlen 185.2 us
setTriggerDelay( -5 us )	:TRIGger:SEQuence:RFBURst:DELay -5 us
setTriggerDelayState( ON )	:TRIGger:SEQuence:RFBURst:DELay:STATe ON
setTriggerHoldoff( 1 us )	:TRIGger:SEQuence:HOLDoff 1 us
setTriggerHoldoffState( ON )	:TRIGger:SEQuence:HOLDoff:STATe ON
// demod measurement setup	
setEVMAveraging( OFF )	:SENSe:EVM:AVERage:STATe OFF
setEqualizer( ENHANCED )	:CALCulate:EVM:OFDM:EQType ENHanced
setEstimation( OFF )	:CALCulate:EVM:OFDM:CESTimation OFF
setGatedPower( ON )	:CALCulate:EVM:OFDM:GPOWer:ENABLE ON
setLeftGate( -15 us )	:CALCulate:EVM:OFDM:LGTime -15 us
setRightGate( 0 us )	:CALCulate:EVM:OFDM:RGTime 0 us
setOffset( 0 )	:CALCulate:EVM:OFDM:MOFFset 0
setTrackAmp( OFF )	:CALCulate:EVM:OFDM:TAMPliTude OFF
setTrackPhase( ON )	:CALCulate:EVM:OFDM:TPHase ON
setTrackTiming( OFF )	:CALCulate:EVM:OFDM:TTIMing OFF
// set 1 <sup>st</sup> channel	
setFrequency( F )	:SENSe:FREQuency:CENTer 2.412 GHz
// loop by DUT power level	
setPowerRange( dBm )	:SENSe:POWer:RANGe -21 dBm
setTriggerLevel( dBm )	:TRIGger:SEQuence:RFBURst:LEVel:ABSolute -52
// execute measurement	
measDemod()	:READ:EVM?
checkNotOverrange()	:STATus:QUEStionable:INTegrity:CONDition?

The following commands demonstrate modulation accuracy on a bursted WLAN signal. The example below is for an **IEEE 802.11n, MCS15, two-stream, OFDM signal**:

Operation	SCPI command
// basic setup signal source	
setWLANFormat( N )	:SENSe:RADio:STANdard:SElect:WLAN N
setMaximumSymbols( 17 )	:SENSe:RADio:MSYMBols 17
setTriggerSource( RFBurst )	:SENSe:EVM:TRIGger:SOURce RFBUrst
setMaxPacketLength( 109 us )	:SENSe:RADio:MPACketlen 109 us
setTriggerDelay( -1 us )	:TRIGger:SEQuence:RFBurst:DELay -1 us
setTriggerDelayState( ON )	:TRIGger:SEQuence:RFBurst:DELay:STATe ON
setTriggerHoldoff( 1 )	:TRIGger:SEQuence:HOLDoff 1 us
setTriggerHoldoffState( ON )	:TRIGger:SEQuence:HOLDoff:STATe ON
// demod measurement setup	
setEVMAveraging( OFF )	:SENSe:EVM:AVERage:STATe OFF
setEqualizer( ENHANCED )	:CALCulate:EVM:MIMO11N:EQTYpe ENHanced
setOffset( 0 )	:CALCulate:EVM:MIMO11N:MOFFset 0
setTrackAmp( OFF )	:CALCulate:EVM:MIMO11N:TAMPliitude OFF
setTrackPhase( ON )	:CALCulate:EVM:MIMO11N:TPHase ON
setTrackTiming( OFF )	:CALCulate:EVM:MIMO11N:TTIMing OFF
setSymbolTimeAdjust( -3.125% )	:CALCulate:EVM:MIMO11N:STADjust -3.125
setGuardInterval( LONG )	:CALCulate:EVM:MIMO11N:GINTerval LONG
setBW( 20 MHz )	:CALCulate:EVM:MIMO11N:BWIDth BW20
setNumChannels( 2 )	:CALCulate:EVM:MIMO11N:NCHannels 2
// set 1 <sup>st</sup> channel	
setFrequency( F )	:SENSe:FREQuency:CENTer 2.412 GHz
// loop by DUT power level	
setPowerRange( dBm )	:SENSe:POWer:RANGe -21 dBm
setTriggerLevel( dBm )	:TRIGger:SEQuence:RFBurst:LEVel:ABSolute -52
// execute measurements	
measDemod()	:READ:EVM?
fetchBurstInfo()	:FETCh:EVM0?
checkNotOverrange()	:STATus:QUEStionable:INTegrity:CONDition?

The commands above are similar to the OFDM examples. The key differences are in the demod measurement setup parameters: symbol time adjust, guard interval, bandwidth, and the number of channels.

The :READ:EVM? (defaults to :READ:EVM1?) returns 84 comprehensive results (consult the Agilent N8300A wireless networking test set Help for detailed information [4].) These results include those common to all streams and channels, as well as those individual to a channel. For example, results common to all channels include:

1. Frequency error: Index 1 of the array
2. The total burst power of all channels : 8 of the array

An example of results individual to a channel are:

1. Power in burst for channel 1: Index 10
2. Data EVM measurement result for Channel 2: Index 21
3. Normalized cross channel power result for Channel 1 from Stream 2: Index 71

Following the :READ:EVM?, the example also includes a :FETCh:EVM0? command. This command returns 36 results related to burst information, such as the length of certain fields, their modulation format, and power. Note that the SCPI query used is a FETCh? and not a READ?. This is because the READ initiates the measurement and so there is no need to do this again—the data is there to be fetched. An additional READ? would result in no correlation between the results since another acquisition would be taken.

FETCh:EVM2? is not included. It may be used to return spectral flatness results.

The following commands demonstrate **modulation accuracy** on a bursted WLAN signal. The example below is for an **IEEE 802.11b, 11-Mbps DSSS signal**:

Operation	SCPI command
<i>// basic setup</i>	
setWLANFormat( A )	:SENSe:RADio:STANdard:SElect:WLAN B
setTriggerSource( RFBurst )	:SENSe:EVM:TRIGger:SOURce RFBUrst
setMaxPacketLength( 967 )	:SENSe:RADio:MPACKETlen 967 us
setTriggerDelay( -2 )	:TRIGger:SEQuence:RFBurst:DElay -2 us
setTriggerDelayState( ON )	:TRIGger:SEQuence:RFBurst:DElay:STATe ON
setTriggerHoldoff( 1 )	:TRIGger:SEQuence:HOLDoff 1 us
setTriggerHoldoffState( ON )	:TRIGger:SEQuence:HOLDoff:STATe ON
<i>// demod measurement setup</i>	
setEVMAveraging( OFF )	:SENSe:EVM:AVERage:STATe OFF
setEqualizer( ENHANCED )	:CALCulate:EVM:DSSS:EQTYpe ENHanced
setGatedPower( ON )	:CALCulate:EVM:DSSS:GPOWer:ENABLE ON
setLeftGate( 0 )	:CALCulate:EVM:DSSS:LGTime 0 us
setRightGate( 100 )	:CALCulate:EVM:DSSS:RGTime 100 us
setOffset( 22 )	:CALCulate:EVM:DSSS:MOFFset 22
setTrackPhase( OFF )	:CALCulate:EVM:DSSS:TPHase OFF
<i>// set 1<sup>st</sup> channel</i>	
setFrequency( F )	:SENSe:FREQuency:CENTer 2.412 GHz
<i>// loop by DUT power level</i>	
setPowerRange( dBm )	:SENSe:POWer:RANGe -29 dBm
setTriggerLevel( dBm )	:TRIGger:SEQuence:RFBurst:LEVel:ABSolute -54
<i>// execute measurement</i>	
measDemod()	:READ:EVM?
checkNotOverrange()	:STATus:QUEStionable:INTegrity:CONDition?

## Error Handling and Programming Issues

Appropriate error handling must be written into test code to handle failed measurements and error conditions. There is also a requirement to carry out some general house keeping and calibration before commencing any tests.

### House keeping

In any system there is a requirement to automate some processes before commencing a test plan. Be sure to separate house keeping operations with test code in order to avoid any overhead in testing. Tasks are likely to include loading waveforms for receiver testing (see Appendix A), calibration of instruments (see Appendix B) and stations, preparing logging tools, and databases. Such operations will ensure that the system is ready to start testing and reduce the chance of encountering problems.

### Error checking

Making correct use of the N8300A error queue (the `:SYST:ERR?` command) allows for errors to be read back effectively into a test environment. The error queue can indicate several different types of errors, the most common of which include:

- Incorrect instrument setting (e.g. a parameter out of range)
- Critical error situations encountered during test
- Non-critical measurement errors encountered during test. Although they are reported as errors, they do not necessarily mean that the test results are non-valid. An example would be an overrange condition, although this condition should be checked and verified as it can point towards failures and setup issues

As a single SCPI transaction or measurement event can cause multiple errors, the error queue should be continually read (polled) until '+0, "No error"' is returned. Once that condition is met, then any errors that have been gathered should be analyzed and appropriate action should be taken. Test code should validate all errors by polling `SYST:ERR?`, then ignore (or passively log) any of those non-critical errors.

### Pacing tests

A good practice is to use the following process to pace the progress of a test sequence:

1. Configure the measurement
2. Initiate the measurement using a `READ` command
3. Gather the measurement results

In Step 3 if the initial results indicate a problem, a subsequent debug stage or further retrieval of results may be considered. Note that in many cases this requires a `FETCh?` of results as the measurement has already been initiated—for example, if a spectral mask fails, fetching the amplitude and frequency points for a debug and log to file.

## Timeouts

N8300A tests can exceed the default timeout settings of software development applications and/or the test executive. If a timeout is not handled correctly then the test executive can hang or abort.

Users should:

- a. During development, use long enough timeouts to understand the timing of the SCPI request/response of the various actions they are requesting the N8300A to perform
- b. Once the timing has been understood, that information should be used to dynamically change the timeout length during the course of test
- c. Provide robust routines within the test code to handle any timeouts. For example, if a timeout occurs the code should be written to instruct that the test be aborted, or that the test be re-tried

## References

- [1] *IEEE 802.11a/b/g/n Manufacturing Test with the N8300A, Part 1: Introduction to a WLAN manufacturing test plan and theory of implementation*, application note, literature number 5989-9958EN
- [2] *IEEE 802.11a/b/g/n Manufacturing Test with the N8300A, Part 3: Techniques for optimizing WLAN device testing*, application note, literature number 5989-9960EN
- [3] *IEEE 802.11a/b/g/n Manufacturing Test with the N8300A, Part 4: How to migrate from the N4010A to N8300A for WLAN testing*, application note, literature number 5989-9961EN
- [4] Agilent N8300A Wireless Networking Test Set Help
- [5] *Agilent MIMO Manufacturing Solution*, application note, literature number 5989-7037EN
- [6] N4010A WLAN IEEE 802.11a/b/g/n Video Series, section "N4010A/N4011A 802.11n Test", [http://www.agilent.com/find/n4010A\\_videos](http://www.agilent.com/find/n4010A_videos)

## Glossary of Terms

ADC	Analog to digital convertor
AWG	Arbitrary waveform generator
API	Application programmable interface
CW	Continuous wave
DSSS	Direct-sequencing spread spectrum
DUT	Device under test (the device being tested)
EVM	Error vector magnitude
MAC	Media access control
MCS	Modulation and coding scheme
OBW	Occupied bandwidth
OFDM	Orthogonal frequency-division multiplexing
RSSI	Received signal strength indicator
Segment file	A file containing a representation of a waveform, which can be played by the N8300A source
Sequence file	A file containing one or more pairs of (segment file name, count) which is used to cause the segment file to be generated a specific number of times
SCPI	Standard commands for programmable instruments
WiMAX	Worldwide interoperability for microwave access
WLAN	Wireless local area network
VFP	Virtual front panel
VISA	Virtual instrument software architecture

## Appendix A: Working with Segment and Sequence Files

In Phase 1 a segment file was used to playback a signal continuously. In Phase 3 a sequence file was used to allow a fixed number of repetitions of a waveform to be played. This section explains how both segment and sequence files can be loaded into the N8300A.

### A.1 Loading standard N8300A segment and sequence files into the instrument

Before any receiver testing involving bursts, the arbitrary waveform generator (AWG) must contain the necessary segment files in the N8300A. The best place to store files for future testing is in non-volatile memory. This placement allows files to remain saved after a power off of the instrument.

The N8300A comes complete with segment and associated sequence files that are commonly used for receiver testing. These may be loaded into non-volatile memory using the following command:

```
:SOURce:DATA:STANdard
```

For more information on the files loaded, see Table 6 and 7. Corresponding sequence files are also loaded that playback each of the files 1,000 times. The media access control (MAC) address used for 802.11a/b/g segments is as follows (the following screenshots are taken from Agilent Signal Studio):

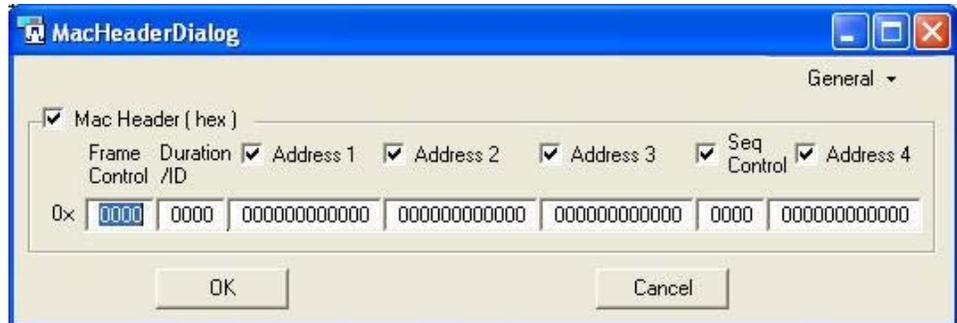


Figure 6: IEEE 802.11a/b/g MAC header

For 802.11n segment files:

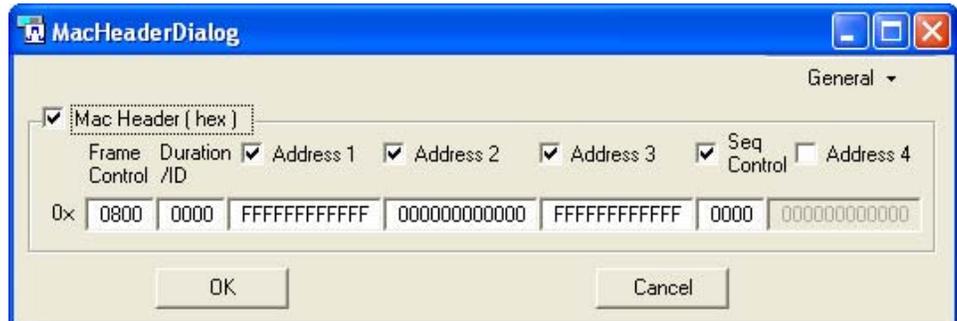


Figure 7: IEEE 802.11n MAC header

**Table 6: N8300A standard 802.11a/b/g/n segment files**

N8300A segment file name	Data rate (Mbps)	Format	Modulation	Encoder rate	Data length (bytes)
11DSSS_CCK_1024B.WF1	11	DSSS	CCK	N/A	1000
60FDM_BPSK_1000B.WF1	6	OFDM	BPSK	1/2	1000
90FDM_BPSK_1000B.WF1	9	OFDM	BPSK	3/4	1000
120FDM_QPSK_1000B.WF1	12	OFDM	QPSK	1/2	1000
180FDM_QPSK_1000B.WF1	18	OFDM	QPSK	3/4	1000
240FDM_16QAM_1000B.WF1	24	OFDM	16QAM	1/2	1000
360FDM_16QAM_1000B.WF1	36	OFDM	16QAM	3/4	1000
480FDM_64QAM_1000B.WF1	48	OFDM	64QAM	2/3	1000
540FDM_64QAM_1000B.WF1	54	OFDM	64QAM	3/4	1000

**Table 6: N8300A standard 802.11a/b/g/n segment files (continued)**

Preamble format	Filter type	bT/alpha	File size (samples)	File size (bytes)	Sample rate (MHz)	Idle interval ( $\mu$ S)
Long	Gaussian	0.5	46880	187520	44	100
N/A	Root cosine	0.5	60560	242240	40	110
N/A	Root cosine	0.5	42160	168640	40	110
N/A	Root cosine	0.5	32880	131520	40	110
N/A	Root cosine	0.5	23760	95040	40	110
N/A	Root cosine	0.5	19120	76480	40	110
N/A	Root cosine	0.5	14480	57920	40	110
N/A	Root cosine	0.5	12240	48960	40	110
N/A	Root cosine	0.5	11440	45760	40	110

**Table 7: N8300A standard 802.11n segment files**

N8300A segment file name	Bandwidth (MHz)	Spatial streams	MCS index	Operating mode	Modulation	Coding rate	Pilot sub-carriers
MCS0-20MHZ.WF1	20	1	0	Mixed mode	BPSK	1/2	4
MCS1-20MHZ.WF1	20	1	1	Mixed mode	QPSK	1/2	4
MCS2-20MHZ.WF1	20	1	2	Mixed mode	QPSK	3/4	4
MCS3-20MHZ.WF1	20	1	3	Mixed mode	16QAM	1/2	4
MCS4-20MHZ.WF1	20	1	4	Mixed mode	16QAM	3/4	4
MCS5-20MHZ.WF1	20	1	5	Mixed mode	64QAM	2/3	4
MCS6-20MHZ.WF1	20	1	6	Mixed mode	64QAM	3/4	4
MCS7-20MHZ.WF1	20	1	7	Mixed mode	64QAM	5/6	4
MCS0-40MHZ.WF1	40	1	0	Mixed mode	BPSK	1/2	6
MCS1-40MHZ.WF1	40	1	1	Mixed mode	QPSK	1/2	6
MCS2-40MHZ.WF1	40	1	2	Mixed mode	QPSK	3/4	6
MCS3-40MHZ.WF1	40	1	3	Mixed mode	16QAM	1/2	6
MCS4-40MHZ.WF1	40	1	4	Mixed mode	16QAM	3/4	6
MCS5-40MHZ.WF1	40	1	5	Mixed mode	64QAM	2/3	6
MCS6-40MHZ.WF1	40	1	6	Mixed mode	64QAM	3/4	6
MCS7-40MHZ.WF1	40	1	7	Mixed mode	64QAM	5/6	6

**Table 7: N8300A standard 802.11n segment files (continued)**

Number of coded bits per single carrier	Data sub-carriers	Number of coded bits per symbol	Number of data bits per symbol	Data length (bytes)	File size (Samples)	File size (bytes)	Sample rate (MHz)	Idle interval (µS)	800ns GI
1	52	52	26	1024	54240	216960	40	20	6.50
2	52	104	52	1024	28320	113280	40	20	13.00
2	52	104	78	1024	19680	78720	40	20	19.50
4	52	208	104	1024	15360	61440	40	20	26.00
4	52	208	156	1024	11040	44160	40	20	39.00
6	52	312	208	1024	8800	35200	40	20	52.00
6	52	312	234	1024	8160	32640	40	20	58.50
6	52	312	260	1024	7520	30080	40	20	65.00
1	108	108	54	1024	54720	218880	80	20	13.50
2	108	216	108	1024	29760	119040	80	20	27.00
2	108	216	162	1024	21440	85760	80	20	40.50
4	108	432	216	1024	17280	69120	80	20	54.00
4	108	432	324	1024	13120	52480	80	20	81.00
6	108	648	432	1024	10880	43520	80	20	108.00
6	108	648	486	1024	10240	40960	80	20	121.50
6	108	648	540	1024	9600	38400	80	20	135.00

## A.2 Loading custom segment and sequence files into the instrument

If there is a need to use additional custom files, beyond the standard files listed previously for receiver testing, there are a number of ways to load a file from an external PC:

1. Using the N8300A WLAN Virtual Front Panel (VFP)
2. Transferring a BinBlock containing the binary data of the segment or sequence file

Using an external PC with the N8300A driver and N8300A Virtual Front Panel installed, load the VFP. Enter the virtual instrument software architecture (VISA) resource (or alias) of the instrument to connect and choose the **AWG** tab. This tab allows control of the source. A file can be loaded by selecting **Load** under either **Vol. Seg** (volatile memory) or **NV Seg** (non-volatile memory). **Load** can also be used in the sequences section to load sequences. Sequence files can also be created within the VFP using the **Make Seq** button after having selected an appropriate segment files and entering the required number of iterations. The sequence files should then be saved to the PC and subsequently loaded into the N8300A using **Load**.

The following SCPI command may also be used to load a segment file:

```
:SOURce:DATA:SEGment "60FDM_BPSK_1000B.WF1", <binblock data>
```

Similarly for a sequence file:

```
:SOURce:DATA:SEQuence "sequence1.seq", <binblock data>
```

## A.3 Verifying what segment and sequence files are loaded

Use the following SCPI command to return segment files that are loaded in non-volatile memory:

```
:SOURce:LOADed:NVSegments?
```

Use the following SCPI command to return segment files that are loaded in volatile memory:

```
:SOURce:LOADed:SEGments?
```

Use the following SCPI command to return sequence files that are loaded in memory. Note that sequence files only exist in non-volatile memory:

```
:SOURce:LOADed:SEQuences?
```

## A.4 Copying files to/from volatile/non-volatile memory

Segment files may be copied between volatile and non-volatile memory. For example, to copy a file from non-volatile to volatile memory (from where it can be selected for playback) and rename it:

```
SOURce:COPY:SEGment  
"WLAN_FILE", "60FDM_BPSK_1000B.WF1", NVTOV
```

## **Appendix B: Calibration**

The following command is used to calibrate the source inside the N8300A:

```
:SOURce:CALibration:IQ:FULL
```



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