

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

Part 3: Techniques for optimizing WLAN device testing
Application Note



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.



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*

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 Agilent 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/b/g/n Manufacturing Test with the Agilent 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, 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 Agilent N8300A*

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

Part 4 of the application note series presents two different options for backwards compatibility with the existing Agilent N4010A wireless connectivity test set. For engineers wishing to leverage the benefits of the SCPI, guidance is given on migration from existing driver application programmable interface (API) code on the N4010A. In contrast, using the N8300A as a drop-in replacement with existing code based on the N4010A driver API is also explained.

Since reducing test time is important for lowering the cost of test and increasing throughput efficiency on a production line, this portion of the application note series focuses on test speed. The following sections cover techniques for increasing test speed both for transmit and receive measurements by optimizing the use of the instrument and DUT. These techniques are relevant for test engineers wishing to optimize existing test plans and code (following on from [2]), or, for those wishing to take guidance before architecting potential solutions.

Optimizing Transmitter Testing

Measurements requiring looping by power and frequency

In many of the test phases explained in Parts 1 and 2 of this application note series, a DUT was looped by power and frequency (by channel) for each measurement. This is a common requirement in every test plan. An example of this is the need to loop a device through different power levels for transmitter power calibration (making power measurements) for each operational channel.

For an instrument and a device, a change in power or frequency requires a finite time for configuration to take place. Typically a change of frequency takes the longest. For this reason, it is important to work out what testing can be carried out on a set channel at particular power levels before switching frequency. Power levels should be looped with a set channel before moving the frequency to reduce the amount of channel changes. This is demonstrated in Figure 1. The dashed lines represent test point requirements for frequency and power levels. The power is increased from the lowest to highest (blue) power for each channel before a change of frequency (green.)

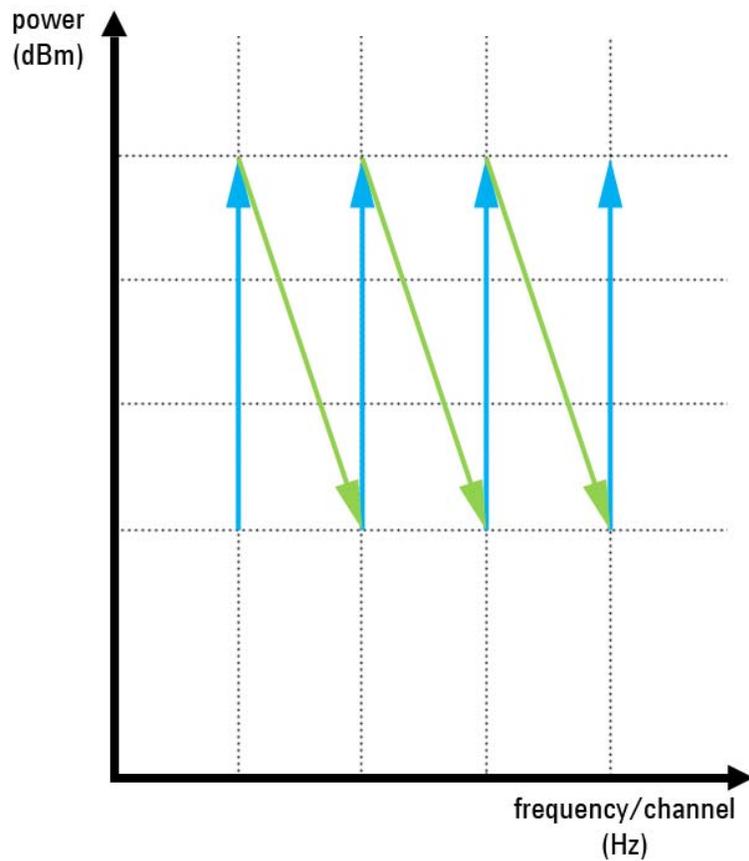


Figure 1: Approach for optimization of measurements requiring looping by power and frequency

Optimizing spectral mask measurements

In Phase 3 [2], spectral mask measurements were made as part of the transmitter verification. A parameter called “FastMask” was set to on.

Operation	SCPI command
setFastMask(ON)	CALCulate:SMASk:FMASk ON

Fast Mask is a setting that is on by default. It is a setting used to optimize the instrument for fast test by changing the resolution bandwidth (RBW) to 108.2 kHz. The higher resolution bandwidth makes the fast Fourier transform (FFT) half the size. As a WLAN spectral mask is a relative measurement, the net effect has been shown to be negligible versus the lower RBW.

Using demodulation measurements to verify power

In Phase 5 [2] demodulation measurements were used to analyze modulation accuracy, in particular error vector magnitude (EVM.) Phase 4 [2] was the transmitter verification that checked power levels. If the power verification is shown to be stable and repeatable, the power verification check can be added to the end phase (Phase 5) inside the modulation accuracy. This allows re-use of the acquisition from the demodulation capture, as opposed to two separate captures: one for power and one for modulation accuracy.

The demodulation measurements for IEEE 802.11a/b/g allow a gate to be setup across a burst to measure power. This gate can be configured across the whole burst (like it would be in the power measurement) as well as across a particular portion of the burst. For example, it could be configured across the header of the burst. Reducing the gate to just the header is also quicker in test.

The example below is for an **IEEE 802.11a 54 Mbps OFDM signal**

Operation	SCPI command
setGatedPower(ON)	:CALCulate:EVM:OFDM:GPOWER:ENABLE ON
setLeftGate(-15)	:CALCulate:EVM:OFDM:LGTime -15 us
setRightGate(0)	:CALCulate:EVM:OFDM:RGTime 0 us

Demodulation of IEEE 802.11n MIMO devices using the sequential capture technique [4]

The N8300A sequential capture technique reduces test time by switching to each RF chain of a device sequentially. The captures are then used to provide a MIMO demodulation. This provides a comprehensive range of measurements, individual to each chain and indicates the isolation between them. This technique uses the instrument’s RF port switching to make a MIMO measurement and requires no reconfiguration of RF chains during the measurement. For example, the need to switch individual RF chains on and off to transmit single streams. The sequential capture technique allows the device to be setup to transmit a multi-stream signal (e.g. MCS23) with no further reconfiguration. This means that test time is reduced since the DUT control is not required for the demodulation.

The following command enables the sequential capture technique by configuring multiple channels for analysis (in this case for three channels, such as a MCS23 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
//demod measurement setup	
setNumChannels(3)	:CALCulate:EVM:MIMO11N:NCHannels 3

Optimizing Receiver Testing

The N8300A flexible port configuration and source control allow for test times to be improved. The following examples show how N8300A programming and DUT control can be optimized. The techniques below also show how broadcast mode can cut receiver testing significantly for MIMO devices, if devices be able to return the received signal strength indicator (RSSI) or packet error rate on all channels at one time.

Dynamically changing output power and frequency

During receiver calibration (test Phase 2) and receiver verification (test Phase 4) the N8300A source was used across different power levels and frequencies. As with optimization for transmitter testing, it is sensible to do as much testing as possible within each channel across power levels before a frequency change. In addition, it is advisable not to start and stop the N8300A source for each change because it takes time for the instrument to do this. It is preferable to use a SCPI command that permits the frequency and power to be adjusted within a WLAN band without the need to switch the N8300A on and off.

`:SOURce:ADJust <new power level>,<frequency offset from centre frequency>`

Dynamic control of the N8300A source was demonstrated in [1] previously for continuous wave (CW) receiver calibration:

Operation	SCPI command
setFrequency(B)	:SENSe:FREQuency:CENTer 2.412 GHz
playCW(SP, 0)	:SOURce:CWTone -60,0
adjustOutput(SP, OF)	:SOURce:ADJust -60,5000000
stopTX()	:SOURce:STOP

Dynamically changing output ports

Note that the previous example made no reference to the output port(s) being used in test. The source control is independent from the port switching. This means it is possible to dynamically control the N8300A source and dynamically change the ports in use without stopping the source. This dramatically reduces test time taken up by reconfigurations.

Broadcast mode on the N8300A allows for transmission on any configuration of multiple ports, and was introduced in [2]. This is especially useful for testing multiple channels of an IEEE 802.11n device or multiple devices at the same time.

For single-channel receiver testing on a N8300A with multiple ports, the primary RF port may be changed sequentially to output to each port in turn. For example, outputting on Port 1 first, then switching to transmit on Port 2 and then 3. The signal being transmitted by the N8300A source does not need to be stopped during this time. The following example demonstrates how to **dynamically change port configuration while the source remains on** (also incorporating power level and frequency changes from before with the source remaining on):

```

// setup variables
SP = startPower
SEGMENT = "6OFDM_BPSK_100B"
SR = 40 MHz

N8300A: setBroadcastMode( OFF )
N8300A: setPrimaryRFPort( RFIO1 )
DUT: setFrequency( F )
N8300A: setFrequency( F )

N8300A: playSegment( SEGMENT, SP, SR, 0 )
wait()
DUT: readRSSIvalue()
N8300A: adjustOutput( SP-10dBm, OF+5MHz)
N8300A: setPrimaryRFPort( RFIO2 )
wait()
DUT: readRSSIvalue()
N8300A: adjustOutput( SP-20dBm, OF+10MHz)
N8300A: setPrimaryRFPort( RFIO3 )
wait()
DUT: readRSSIvalue()
•
•
•
•
N8300A: stopTX()

```

Operation	SCPI command
setBroadcastMode(OFF)	:SOURce:PORT:SELECTION Primary
setPrimaryRFPort(RFIO1)	:SOURce:PORT:PRIMary RFIO1
setFrequency(F)	:SENSe:FREQuency:CENTer 2.412 GHz
playSegment()	:SOURce:SEGment:PLAY "6OFDM_BPSK_1000B",-20,40000000,0
adjustOutput()	:SOURce:ADJust -30,5000000
setPrimaryRFPort(RFIO2)	:SOURce:PORT:PRIMary RFIO2
adjustOutput()	:SOURce:ADJust -40,1000000
setPrimaryRFPort(RFIO3)	:SOURce:PORT:PRIMary RFIO3
stopTX()	:SOURce:STOP

The procedures above switch on the source to output on a single port, outputting first on Port 1, then Port 2 and then switching to Port 3, each time adjusting the power and frequency within the 2.4 GHz industrial, scientific, and medical (ISM) band. Note that the above port configurations can be replicated using broadcast mode by making sure that the broadcast mask is only specifying single ports each time e.g. :SOURce:PORT:BMASK 2 switches on Port 2 only, in the same way that setPrimaryRFPort(RFIO2) would.

Using broadcast mode to reduce test time

In the previous example, a single port was used to output a signal to each N8300A output port sequentially. The N8300A ports may also be configured to broadcast to all ports (see "Port Control" in [2].) This is useful for the simultaneous calibration of multiple RF chains. The RF chains may belong to one 802.11n device or be single RF chains belonging to multiple devices. Either way, this capability allows for parallel measurements to be made for receiver calibration or verification purposes using device chipset control.

```

N8300A: setBroadcastMode( ON )
N8300A: setPorts( RFIO1 & RFIO2 )
DUT: setFrequency( F )
N8300A: setFrequency( F )

N8300A: playSegment()
wait()
DUT: readRSSIvalue()
N8300A: adjustOutput()
N8300A: setPorts( RFIO3 & RFIO4 )
wait()
DUT: readRSSIvalue()
•
•
•
N8300A: stopTX()

```

Operation	SCPI command
setBroadcastMode(ON)	:SOURce:PORT:SELection BMASk
setPorts(RFIO1 & RFIO2)	:SOURce:PORT:BMASk 3
setFrequency(F)	:SENSe:FREQuency:CENTer 2.412 GHz
playSegment()	:SOURce:SEGment:PLAY "6OFDM_BPSK_1000B",- 20,40000000,0
adjustOutput()	:SOURce:ADJust 0,5000000
setPorts(RFIO3 & RFIO4)	:SOURce:PORT:BMASk 12
stopTX()	:SOURce:STOP

The above example incorporates dynamic power adjustments in the source, dynamic port control, and use of broadcast mode.

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: The first steps towards test automation*, 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 MIMO Manufacturing Solution*, application note, literature number 5989-7037EN

More Information

Agilent N8300A Wireless Networking Test Set Help

N4010A WLAN IEEE 802.11a/b/g/n Video Series, section "N4010A/N4011A 802.11n Test", http://www.agilent.com/find/N4010A_videos

Glossary of Terms

API	Application programmable interface
CW	Continuous wave
DUT	Device under test (the device being tested)
EVM	Error vector magnitude
FFT	Fast Fourier transform
ISM	Industrial, scientific, and medical
MCS	Modulation and coding scheme
OFDM	Orthogonal frequency-division multiplexing
RBW	Resolution bandwidth
RSSI	Received signal strength indicator
SCPI	Standard commands for programmable instruments
WiMAX	Worldwide interoperability for microwave access
WLAN	Wireless local area network



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