Test Plan for RF Performance Evaluation of Wi-Fi Mobile Converged Devices

Version 2.0.2
October 2015

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Change History

Version	Date	Comments
1.0	08-Aug-2006	Document Approved
1.1	20-Aug-2007	• Updated Purpose and References sections • Clarified text and added footnote in Radiated RF Tests nomenclature section • Clarified text in Minimum Measurement Distance section • Clarified testing conditions for cellular inactive state • Corrected step reference in step 14 of Receive Sensitivity Measurement. Removed repeated text. • Removed reference to CTIA website for traffic generator software download • Corrected step 1 and clarified language in step 9 regarding antenna connection in WLAN Access Point Testing Methodology section • Removed requirement for OFMD transmit mask test on Mobile Stations and Access Points • Updated WLAN Test Set Estimated Signal Level tables • Added Sample Summation test report table • Corrected title on Test 5.2.2. and 6.2.2 test report table • Added text to clarify that Wi-Fi desense testing is done in free-space only • Clarified that cellular desense testing is done in free-space only, and to perform reference measurements if not previously done • Removed references to specific test equipment from document
1.2	26-June-2008	• 5 GHz TRP, TIS, & Reference Measurement frequency changes – Sections 5.1.1.2, 5.1.2.2, 5.2.1.2, 5.2.2.2, Table 5.2 5, 6.1.1.2, 6.1.2.2, 6.2.1.2, 6.2.2.2, Table B2 , Table B3, Table B4, Table B5, Table B6, Table B7, New Appendix D • Other sections changed: Table B1 - CID Added, section 1.4 - CTIA Reference updated, Table A1 Channel change UTRA FDD Band I - IV, 4120/824.0 changed to 4132/826.4, Table B3 Reference changed from (2) to (1), Table 5.1.1 and table 6.1.1 - removed "Check Tx Mask" from comments column
1.3	01-June-2009	• Added footnote to Section 2.1, 2nd sentence. • Added text to Section 4.1, 2nd sentence. • Added CTIA Request # to Appendix B table. • Added Appendix E Device Capabilities Testing Matrix
2.0	27-Feb-2015	• Added 802.11n • Added LTE and TD-SCDMA protocols • Updated cellular and Wi-Fi desense sections • Updated Appendix B Device Capabilities Test Matrix, removed right head and added right and left hand phantoms • Added Appendix C – Radio Access Technologies that require testing, but are not covered in the CTIA Test Plan. • Added Appendix D - Notebook and Tablet PC Requirements • Added Appendix E - WLAN-LTE emulator test equipment notes when testing EUTs that support LTE band 40 or 41 (Informative)

Version	Date	Comments
		• Added Appendix F - Table of Wi-Fi Radio channels interfered by cellular radio harmonics • Revised Wi-Fi test procedure Sections 3.1, 4.1, 4.2 & 4.3 • Updated the Acknowledgements list • Updated Section 4.1.3 Measurement Frequencies for Radiated tests • Updated Table 2 parameters • Split Table 3 to Table 3 and Table 4 for Tx and Rx and also changed Rx parameters • Updated Section 2.1 • Replaced WLAN with Wi-Fi thought out the document as appropriate • Revised Section 4.3.2 to specify PING as the primary mode for packet generation • Revised Tables 17 and 18 to replace DER with Pass/Fail info on Intermediate Channels • Updated title and introduction text of Appendix A • Updated Table 12 consistent with the test case requirements of Section 4.6 and 4.17 • Updated Appendix F to include Wi-Fi desensitization matrix • Reference Polarization columns added to all Appendix A tables that include Reference Position information
2.0.1	01-July-2015	• Modified document reference in 5th paragraph of Section 2.2. • Updated RAT Channel Number and RAT Uplink Frequency columns in Table 4-5 • Updated channel for UNII Low, Middle and Upper Bands in Table A-5 and Table A-6. • Deleted first sentence of Appendix A.3. • Added text to section 1.6.2. • Removed stray text in Table A-2. • Fixed cross-references
2.0.2	07-Oct-2015	• “Draft 1” removed from the footnote • Publication and footnote dates updated based on CTIA format • Tables A-7 and A-8 modified to include a field for Lab comments on maximum EIS • Modified Section 2.2 to provide explicit guidelines for PING method for 802.11n • Applied other purely editorial changes to the titles in Appendices sections and tables • Removed “(WI-FI U-NII MIDDLE BAND)” from the titles and references to Channel 60 in Tables A-10 and A-12 • Requirement for usage of Hand Phantoms is clarified in Appendix B

Table of Contents

List of Acronyms and Definitions

ACK	Acknowledge
APSD	Automatic Power Save Delivery
CDMA	Code Division Multiple Access
EIS	Effective Isotropic Sensitivity
EUT	Equipment Under Test
GSM	Global System for Mobile communication
LAN	Local Area Network
LTE	Long Term Evolution
MIMO	Multiple Input Multiple Output
PER	Packet Error Rate
RAT	Radio Access Technology
Rx	Receive
TD-SCDMA	Time Division Synchronous Code Division Multiple Access
TIS	Total Isotropic Sensitivity
TRP	Total Radiated Power
Tx	Transmit
UMTS	Universal Mobile Telecommunications System
UTRA-FDD	UMTS Terrestrial Radio Access - Frequency Division Duplexing
UTRA-TDD	UMTS Terrestrial Radio Access - Time Division Duplexing
WCDMA	Wideband Code Division Multiple Access
WLAN	Wireless Local Area Network
WWAN	Wireless Wide Area Network

Section 1 Introduction

1.1 Background

Increasingly the wireless market is seeing converged devices that incorporate both cellular and wireless local area network (WLAN or Wi-Fi) functionality. Due to the many potential applications and deployment scenarios that converged devices may ultimately function in, operators and device vendors are interested in a uniform and standard way for profiling the RF performance of the devices and associated test methodology. With this standard approach, equipment designers, system operators, and RF engineers have the flexibility to determine their own appropriate RF performance criteria based on their engineering assessments and can easily identify equipment that is suitable for each deployment and application.

1.2 Scope

This test document specifies test methodologies and performance criteria for the RF performance evaluation of Wi-Fi mobile converged devices. The scope of testing includes Handheld, self-contained Wi-Fi/Mobile Module, Access Point, Notebook and Tablet devices that support IEEE 802.11a, 802.11b,802.11g or 802.11n [2] as well as cellular technologies. Support for IEEE 802.11 standards must be confirmed through Wi-Fi Alliance baseline certification—that is, devices tested using this test plan must first be Wi-Fi CERTIFIED for IEEE 802.11a, 802.11b, 802.11g or 802.11n [4]. Cellular technologies include GSM, CDMA, UMTS (WCDMA), LTE and TD-SCDMA.

1.3 Purpose

The purpose of this document is to define the test methodology for the RF testing of Wi-Fi mobile converged devices and to specify the test conditions for each test case. The testing covers client devices and access points and specifies conducted as well as radiated tests.

1.4 References

[1] "Test Plan for Mobile Device Over-the-Air Performance/Method of Measurement for Radiated RF Power and Receiver Performance", latest revision, CTIA http://www.ctia.org/policy-initiatives/wireless-device-certification/certification-test-plans

[2] "IEEE Std. 802.11-2012 IEEE Standard for Information technology--Telecommunications and information exchange between systems Local and metropolitan area networks--Specific requirements Part 11: Wireless LAN Medium Access Control (MAC) and Physical Layer (PHY) Specifications", IEEE http://standards.ieee.org/about/get/802/802.11.html

[3] "User Equipment (UE) / Mobile Station (MS) Over The Air (OTA) antenna performance; Conformance testing (3GPP TS 34.114)", Latest Revision, 3GPP http://www.3gpp.org/DynaReport/34114.htm

[4] Check the product's Wi-Fi Certificate at http://certifications.www.wi-fi.org/wbcs_certified_products.php?lang=en

[5] RFC 792 "Internet Control Message Protocol", IETF, September 1981, https://tools.ietf.org/html/rfc792

[6] RFC 1122 "Requirements for Internet Hosts – Communication Layers", IETF, October 1989, https://tools.ietf.org/html/rfc1122

1.5 Test Nomenclature Overview

1.5.1. Conducted RF Tests

Conducted tests are those RF Tests where the test equipment is connected to the antenna connector of the device under test by co-axial cables. These tests are formulated to measure basic RF performance such as sensitivity and transmit power.

1.5.2. Radiated RF Tests

Radiated tests are those RF Tests that are carried out in a test environment which meets the requirements of the CTIA Test Plan [1]. These include Wi-Fi Tx Power (TRP), Wi-Fi Receive Sensitivity (TIS), Wi-Fi Single Point Radiated Measurements, Radiated Receive Sensitivity of Wi-Fi with cellular active, and Radiated Receive Sensitivity of the cellular radio(s) with Wi-Fi active.

1.5.3. Desensitization Tests

Desensitization tests measure the impact that the cellular radio, when transmitting, has upon W-Fi reception and visa-versa. These tests are performed as radiated tests in according to Device Testing Configurations.

1.6 Baseline Methodology

1.6.1. Measurement Techniques and Test Methodologies

TRP and TIS in cellular mode are defined in both the CTIA Test Plan for Mobile Device Over-the-Air Performance [1] and User Equipment (UE) / Mobile Station (MS) Over The Air (OTA) antenna performance; Conformance testing (3GPP TS 34.114) [3].

This document relies on the measurement techniques and methodologies within the CTIA Test Plan[1] for Mobile Device Over-the-Air Performance (referred to in this document hereafter as "CTIA Test Plan") developed specifically for the purposes of measurement of radiated transmit power and sensitivity. The techniques specified in the CTIA Test Plan shall be used as the baseline test methodologies for all tests in here, unless otherwise stated. This document contains information to expand the CTIA Test Plan for use with 802.11 a, b, g and n devices. These sections are meant to clarify for the user how the CTIA Test Plan can be utilized for Wi-Fi enabled converged devices.

1.6.2. Measurement Uncertainty

Refer to CTIA Test Plan Section 7 for the uncertainty budget tables for TRP and TIS. The lab shall report their estimated measurement uncertainty for both the 2.4 and 5 GHz bands. However, the criteria in Section 7.5 [1] are only required for the 2.4 GHz band.

1.6.3. Minimum Measurement Distance

This section describes the minimum measurement distance, *R*, which the Far-Field test site shall provide. The measurement distance is defined as the distance from the center of rotation of the EUT to the phase center (alternatively, if not accurately known, the nearest point) of the Measurement Antenna.

For Cellular minimum measurement distance, refer to CTIA Test Plan Section 3.1. For Wi-Fi 2.4 GHz band, the minimum measurement distance specification specified for Band 41 shall be used. For Wi-Fi 5 GHz band, the minimum measurement distance is FFS; refer to Sections G.7.4 and G.19.1 of the CTIA Test Plan for more information.

1.6.4. Quiet Zone Test Frequencies

Quiet zone test frequencies shall be measured for the following Wi-Fi bands.

1. ISM-band: 2450 MHz ± 1MHz (sleeve dipole and loop probe antenna)
2. U-NII-band: 5500 MHz ± 1MHz (sleeve dipole and loop probe antenna)

1.7 Form Factor Submission for Self-contained Wi-Fi/Mobile Modules

The following two cases are considered regarding the antenna subsystem options and required form factor submission for self-contained Wi-Fi/Mobile modules. Also, please refer to Appendix D for Notebook and Tablet.

The test results shall include a description and diagram or photograph of the test conditions used for the device under test.

CASE 1 with Internal Antenna: If the EUT is a self-contained Wi-Fi/Mobile Module with internal antennas, such as a PC Card, then the vendor may choose to

Either

Supply the EUT together with one of its intended host platforms, e.g., a laptop computer. In this case, the combination shall then be placed on the turntable and the results sheet shall clearly state the combination that was used in the measurements.

Or

Test the Module, on its own, mounted in a holder that orientates the module in the position that represents its normal use. In this case the results sheet shall clearly state that the test did not include a host device.

Or

Carry out both tests as above. This is the preferred method, but not mandatory.

CASE 2 without Internal Antenna: If the EUT is a self-contained Wi-Fi/Mobile Module without internal antennas, such as an mPCI Card, then the vendor must supply the complete device, which includes the antennas, for testing. No individual module testing is acceptable.

Section 2 Test Conditions and Device Configuration

2.1 Cellular and Wi-Fi Modes

The test methodology requires the device be placed in a standard operational mode. This includes all sensors in the device as well as proximity sensors. If it becomes evident that EUT thermal protection mechanisms are preventing Wi-Fi and cellular transmitters from maintaining full output power during the course of testing, the test lab shall work with the OEM to identify a suitable mitigation method.

Although recognizing that the use of special test modes would enable more simplified testing and the use of formal test equipment, the test methodology proposed in this document allows the testing of any Wi-Fi mobile device in a mode that is as close as possible to its native operation. However, the methodology does require certain specific behavior of the device so that the test can be executed. EUT vendors are required to supply instructions for the lab to configure the devices as specified in this test plan.

All Radiated tests shall be made according to configurations specified in Device Testing Configurations with the device oriented as specified in Section A.1.1 or A.1.5 (as appropriate) of the CTIA Test Plan [1], applicable to the Wi-Fi mode being tested.

2.2 Wi-Fi Mode

The EUT is expected to be able to associate with the WLAN tester and stay fixed on the same RF channel for the duration of the test even when the WLAN tester signal appears to be below the sensitivity level of EUT.

In this test plan, the PING based method is the primary method for packet generation for UL Power measurement while the ACK based method is the fall back option if the EUT does not support the PING method. The PING method is the only method to test the conducted (or radiated) power for the 802.11n mode of an 802.11 device.

In the PING based method, the WLAN tester will generate ICMP echo request packets with configurable transmit interval, payload size and payload type. The ICMP echo request packets are targeted at the EUT's IP stack. The EUT is expected to answer with a well-defined echo reply packet whose payload is identical to the payload of the corresponding request. For this method to be usable, the device must conform to RFC 792 [5] and RFC 1122 [6] section 3.2.2.6.

In the ACK based method, the WLAN tester will be transmitting data frames addressed to the EUT, and the EUT is expected to be able to respond to all of these data frames with an ACK message.

Because 802.11n ACKs are sent in the basic service set (which is in the legacy mode), the 802.11n ACK will be sent at 6 Mbps. However, the lowest data rate for 802.11n is 6.5 Mbps. Therefore, PING method is the only method to test the conducted (or radiated) power for the 802.11n mode of an 802.11 device. In this method, IP traffic message will force the EUT to answer and generate defined uplink traffic using an 802.11n data rate.

The following EUT settings are required to perform the test:

- Disable scan mode during testing; scanning for AP/client on other channels must be disabled,
- If applicable, disable Power Save Mode (Note that the WLAN tester will not support WMM APSD),
- If applicable, disable the Bluetooth radio during tests,
- Except for the desense testing, the cellular transmitter in the EUT shall be inactive.

Radiated testing shall be performed on an unmodified device using all active antennas. Conducted tests shall be performed on each antenna port with the other antenna port(s) properly terminated. If necessary, an equivalent device maybe modified to provide conducted access to each antenna port.

For all Wi-Fi RATs, including 802.11n, 20 MHz channels are used. 802.11n should be configured for a long guard interval.

Section 3 Conducted Measurements

3.1 Wi-Fi Conducted RF Power Output and Receiver Sensitivity Tests

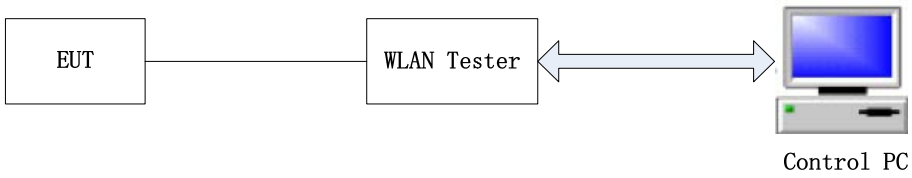
3.1.1. Test Purpose

The purpose of this test is to measure the output power level and receiver sensitivity of the Wi-Fi transceiver in the device in the conducted mode.

3.1.2. Test Setup

The basic test setup is shown in Figure 3- 1.

FIGURE 3- 1. BLOCK DIAGRAM FOR WI-FI CONDUCTED MEASUREMENT



Please note that Figure 3- 1 is intentionally generalized to maximize test equipment design flexibility. A WLAN tester may include receiver and access point capability sub modules as well as internally implemented attenuators to control transmit and receive power to and from EUT.

The EUT shall be provided to the Test Laboratory with the facility to connect directly to the RF test equipment. This may be via an existing antenna connector, or it may be a carefully modified unit to allow such connection. In the latter case, it is the responsibility of the supplier of the EUT to ensure that the connection is present and suitable.

It is recommended that the conducted measurements be performed inside a shielded environment.

A reference measurement shall be made in order to account for the attenuation of the cable used for connecting EUT and WLAN tester, see e.g. Section 4.1.

For more information about possible test setup configurations and details, refer to Appendix A of CTIA Test Plan for setup illustrations.

3.1.3. Measurement Frequencies and Data Rates for Conducted tests

The measurements shall be performed on the lowest, middle[1] and highest channels supported by the device, in each of the 2.4 GHz and 5 GHz bands, at all data rates specified in Table 3-1 and Table 3-2.

[1]For 5 GHz bands refer to Table 4-1 for the middle channel numbers per sub band.

TABLE 3-1 TX TEST DATA RATES FOR CONDUCTED TESTING

Band	Mode	Tx Data Rate (Mbps)
2.4GHz	IEEE 802.11b	11
	IEEE 802.11g	6
	IEEE 802.11n	6.5
5GHz	IEEE 802.11a	6
	IEEE 802.11n	6.5

TABLE 3-2. RX TEST DATA RATES FOR CONDUCTED TESTING

Band	Mode	Rx Data Rate (Mbps)
2.4GHz	IEEE 802.11b	11
	IEEE 802.11g	6, 54
	IEEE 802.11n	6.5, 65
5GHz	IEEE 802.11a	6, 54
	IEEE 802.11n	6.5,65

3.1.4. Test Procedure for Output Power Level

This test procedure defines the basic method for measuring the transmit power of the EUT. A WLAN tester is used to establish the connection and generate traffic to and from the EUT. A calibrated WLAN tester or other applicable power measurement device (e.g. signal analyzer) is used to provide traceable power measurements.

With the PING based packet generation method used, the WLAN tester will generate ICMP echo request packets with configurable transmit interval, payload size and payload type. The ICMP echo request packets are targeted at the EUT's IP stack. The EUT is expected to answer with a well-defined echo reply packet whose payload is identical to the payload of the corresponding request.

If ACK based packet generation method is used, the power is measured across multiple ACK control frames from the EUT rather than full data packets. The ACK control frames are sent in response to unicast data packets generated by the WLAN tester. The measurement is taken across multiple packets and a mean value calculated.

For client devices, the tester is typically configured as an AP, although the tested may alternatively be configured as a non-AP STA operating in ad-hoc mode to perform the measurement. The tester shall be configured to the channel (frequency) and data rate to be tested as specified in Table 3-1. Additional tester settings may also be needed to ensure that the EUT responds at the target data rate.

For access points and hotspots, the tester is configured as a client. In this case, the EUT must typically be configured for the channel to be tested. The tester shall be configured for the data rate to be tested as specified in Table 3-1. Additional tester settings may also be needed to ensure that the EUT responds at the target data rate.

The EUT shall be configured to transmit at maximum power.

To generate the traffic for power measurement using PING based method, the WLAN tester will generate ICMP echo request packets with configurable transmit interval and payload size and payload type as specified in Table 3-3. The reported result is determined from the power measured over the entire payload part of the packet, ignoring the preamble and avoiding the leading and falling edge transitions in the burst. A minimum of 85% of the payload shall be covered by the measurement.

To generate the traffic for power measurement using ACK based method, the tester is configured to send UDP packets as specified in Table 3-3. Table 3-3 specifies the size and payload of the packets to be transmitted and the target interval between packets. The transmitted power of the EUT is measured using the WLAN tester or other calibrated receiver capable of measuring the average power of the DATA portion of each ACK message. The reported result is determined from the power measured per ACK averaged over the number of ACKs specified in Table 3-3.

Create a table of channel, data rate, and average power for each measurement. See Appendix A for recommended data reporting formats.

TABLE 3-3. PARAMETER SETTINGS FOR OUTPUT POWER LEVEL TEST

Parameter	Value
Number of measurements to be averaged	PING Based: 10 ACK Based: 100
Interval between packets (ms)*	10
Tester payload size (bytes)	PING Based: 1000** ACK Based: 60
Tester packet payload	Pseudo random
*Note: The Interval between packets is defined as the interval between the end of a transmitted unicast packet and the beginning of the next transmitted unicast packet. If the device is capable of responding reliably to packets at the 10 ms interval, this time interval may be decreased. If the device is not capable of responding reliably to packets at the 10 ms interval, this time interval may be increased as required. Indicate the used interval size in the test report. Note**: If a device does not support the required packet size, use the maximum supported and indicate the used packet size in the test report.	

3.1.5. Test Procedure for Receiver Sensitivity

This test procedure measures the Wi-Fi receiver sensitivity of the EUT using the WLAN tester to determine the packet error rate (PER) by counting the number of ACK control frames received from the EUT in response to repeated unicast data packets transmitted by the WLAN tester. The PER is generally defined as the ratio of packets lost divided by the number of packets transmitted to the EUT. For the purposes of this test plan, the PER is defined at the WLAN tester as the ratio of (Packets Sent – ACKs Received) / Packets Sent, or (1 – ACKs Received / Packets Sent). Receiver Sensitivity measurements shall be performed using the calibrated WLAN tester to determine the EUT's receiver sensitivity by reporting the minimum forward-link power resulting in a Packet Error Rate (PER) of 10% or less with 95% confidence. The sensitivity is reported as the last passing power level measured within 1 dB of the target sensitivity level. The system shall be configured as specified in Section 3.1.4 with the exception of the changes specified in Table 3-4.

TABLE 3-4. PARAMETER SETTINGS FOR RECEIVER SENSITIVITY TEST

Parameter		Value
Interval between packets (ms)*		1
Packet size (bytes)	802.11a/b/g/n	1000**
Min number of packets		1000
*Note: If the device is not capable of responding reliably to packets at the 1 ms interval, this time interval may be increased as required; indicate the used interval size in the test report. **Note: If a device does not support the required packet size, use the maximum supported and indicate the used packet size in the test report.		

3.1.6. Results

Results shall be represented in dBm.

There are no Pass/Fail criteria. Refer to Appendix A for sample report templates.

Section 4 Radiated Measurements

4.1 Wi-Fi Total Radiated Measurements (TRP/TIS)

4.1.1. Test Purpose

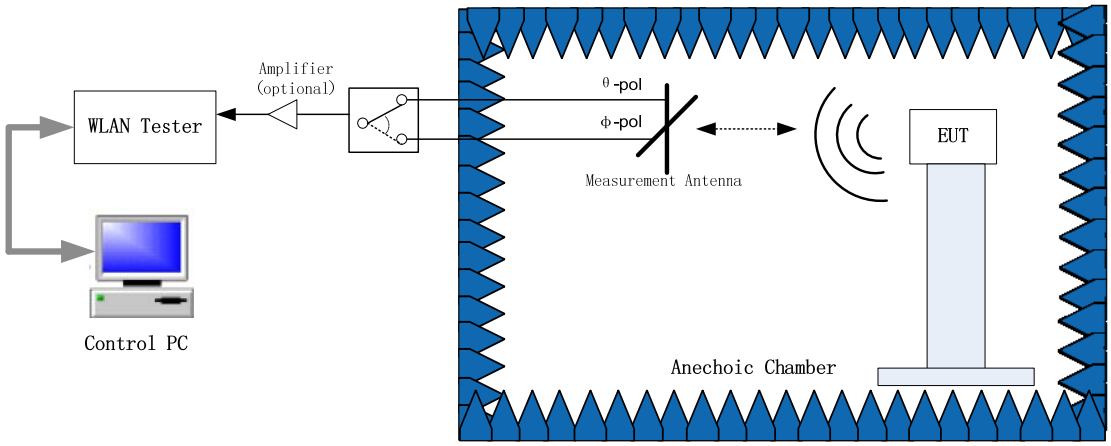
The purpose of this test is to measure the Total Radiated Power and Total Isotropic Sensitivity of the Wi-Fi transceiver in the device.

4.1.2. Test Setup

Typical system schematics for both TRP and TIS measurements are shown in the following figures. The configurations shown are only representative examples of test systems configuration.

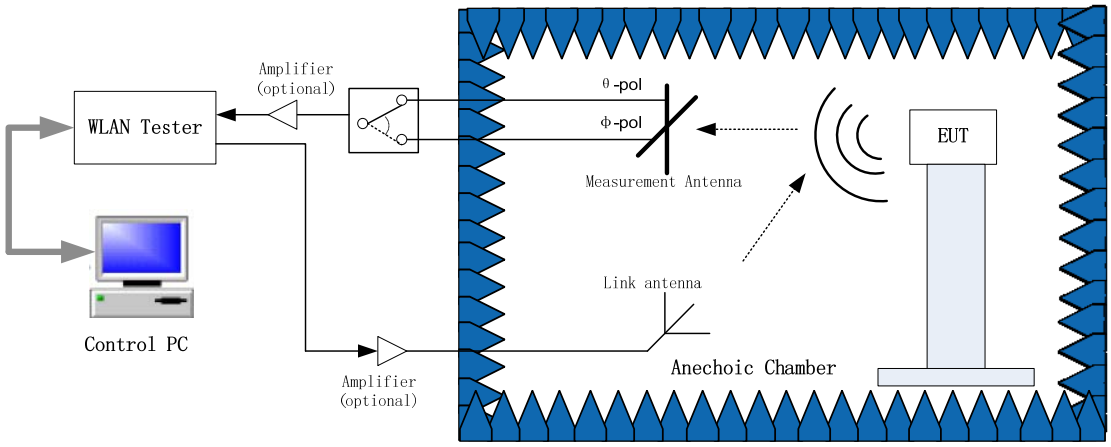
The figure below shows a configuration where both uplink and downlink communications are transmitted through the measurement antenna. This configuration does not support independent amplification of both signal paths if necessary.

FIGURE 4- 1 SIMPLIFIED BLOCK DIAGRAM SHOWING A COMMON CONFIGURATION FOR TRP/TIS MEASUREMENT



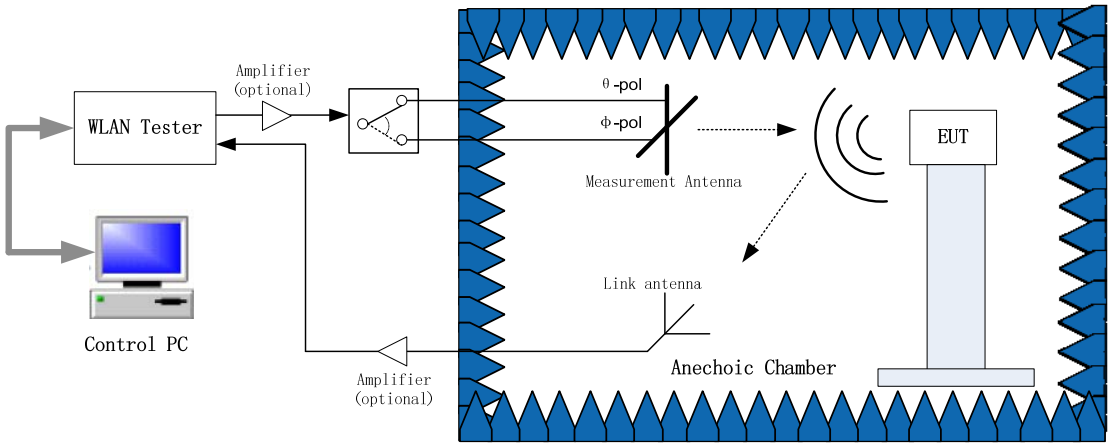
The figure below shows a simplified block diagram showing a configuration for TRP measurement. The uplink communication is transmitted through the measurement antenna and the downlink is transmitted through the link antenna. This configuration supports amplification of both signal paths if necessary.

FIGURE 4- 2 SIMPLIFIED BLOCK DIAGRAM SHOWING A CONFIGURATION FOR TRP MEASUREMENT



The figure below shows a simplified block diagram showing a configuration for TIS measurement. The downlink communication is transmitted through the measurement antenna and the uplink is transmitted through the link antenna. This configuration supports amplification of both signal paths if necessary.

FIGURE 4- 3 SIMPLIFIED BLOCK DIAGRAM SHOWING A CONFIGURATION FOR TIS MEASUREMENT



For more information about possible test setup configurations and details, refer to Appendix A of CTIA Test Plan for setup illustrations.

4.1.3. Measurement Frequencies for Radiated Tests

For 2.4 GHz IEEE 802.11b/g/n devices the TRP/TIS measurement is made on Channel 6.

For 5 GHz IEEE 802.11a/n devices the TRP/TIS measurement is made on the middle channels.

Table 4-1 lists the TIS/TRP measurement channels for IEEE 802.11a and n commonly supported sub-band cases.

TABLE 4-1.TIS/TRP MEASUREMENT CHANNELS FOR IEEE 802.11A AND N SUPPORTED SUB-BANDS

Sub Band	Channel Range	TIS/TRP Channel
UNII Low Band	36 to 48	44
UNII Middle Band	52 to 64	60
ETSI European band	100 to 140	120
UNII Upper Band	149 to 161	157
USA	165	165

4.1.4. Test Procedure for Total Radiated Power Measurement

This test procedure is primarily based on the TRP measurement procedure specified in CTIA Test Plan [1].For more details, please refer to the procedure specified in CTIA Test Plan Sections 2 and 5 for TRP measurement.

A calibrated WLAN tester capable of maintaining the connection over the air is required. The WLAN tester or other applicable power measurement device (e.g. signal analyzer) is used to provide traceable power measurements. For TRP measurement use the same parameter setting as specified in Section 3.1.4.

In order to obtain accurate results of radiated performance of Wi-Fi, it is necessary to perform a range reference measurement to account for the various factors affecting the measurement of these quantities. These factors include components like range length path loss, gain of the receive antenna, cable losses, and so forth. Please refer to the CTIA Test Plan [1] Section 4 for more details.

For client devices, the tester is typically configured as an AP, although ad-hoc mode may also be used to communicate with the EUT. The tester shall be configured to the channel (frequency) and data rate to be tested as specified in Table 3-1. Additional tester settings may also be needed to ensure that the EUT responds at the target data rate.

For access points and hotspots, the tester is configured as a client. In this case, the EUT must typically be configured for the channel to be tested. The tester shall be configured for the data rate to be tested as specified in Table 3-1. Additional tester settings may also be needed to ensure that the EUT responds at the target data rate.

Capture measurement results. See Appendix A for recommended data reporting format.

Note: The test lab may choose to use Alternative Test Procedures as specified in CTIA Test Plan [1] Sections 5.11.

4.1.5. Test Procedure for Total Isotropic Sensitivity Measurement

The test procedure is primarily based on the TIS measurement procedure specified in CTIA Test Plan [1]. Use procedure specified in CTIA Test Plan [1] Sections 2 and 6 to measure TIS.

Before accurate measurements of radiated performance of Wi-Fi, it is necessary to perform a reference measurement to account for the various factors affecting the measurement of these quantities. These factors include components like range length path loss, gain of the receive antenna, cable losses, and so forth. Please refer to the CTIA Test Plan [1] Section 4 for more details.

A calibrated WLAN tester capable of maintaining the connection over the air is required. For TIS measurement, configure the WLAN tester as specified in Section 3.1.5 with the exception of parameters specified in Table 4-2..

TABLE 4-2. PARAMETER SETTINGS FOR RECEIVER SENSITIVITY TEST

Parameter	Value
Min number of packets	100

The tester shall be configured to the channel (frequency) and data rate to be tested as specified in Table 4-3.

Note: The test lab may choose to use RSSI based Alternative Test Procedures as specified in CTIA Test Plan [1] Section 6.15.

4.1.6. TRP Data Rates

For each of the channels mentioned above, the transmit power output shall be measured at data rates given in Table 3-1.

For devices which have more than one protocol in the same frequency band, such as 802.11b/g/n or 802.11a/n, an alternate test procedure to determine the offset in TRP between different protocols on equivalent channels can be used by referring to CTIA Test Plan [1], Section 5.11 Alternate Test Procedure for TRP.

4.1.7. TIS Data Rates

On the mid channel, the receive sensitivity shall be measured at the following data rates:

TABLE 4-3. RECEIVER SENSITIVITY TEST DATA RATES

Band	Protocol (Mode)	Test Data Rate (Mbps)
2.4GHz	IEEE 802.11b	11
	IEEE 802.11g	54
	IEEE 802.11n	65
5GHz	IEEE 802.11a	54
	IEEE 802.11n	65

For devices which have more than one protocol in the same frequency band, such as 802.11b/g/n or 802.11a/n, an alternate test procedure to determine the offset in TIS between different protocols on equivalent channels can be used by referring to CTIA test plan, Section 6.15Alternate Test Procedure for TIS. If the alternate test procedure is used, the highest data rate protocol (mode) shall be used for doing full TIS measurements.

4.1.8. Results

Results shall be represented in dBm.

There are no Pass/Fail criteria. Refer to Appendix A for sample report templates.

4.2 Wi-Fi Desense Measurements with Cellular Transmitter ON

4.2.1. Test Purpose

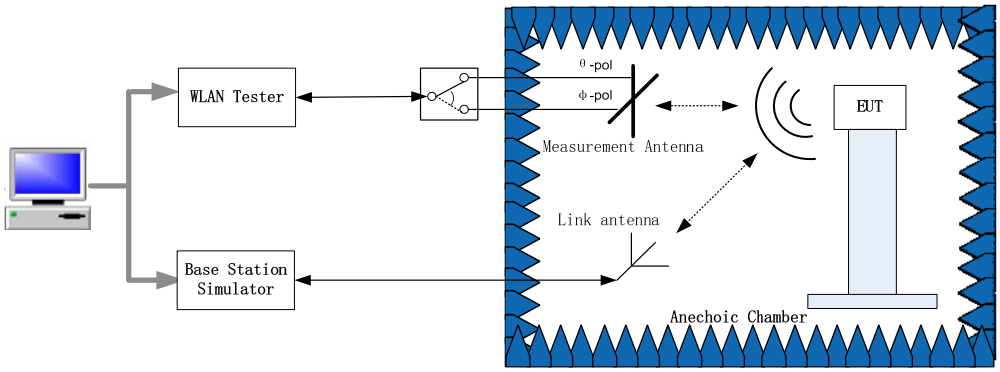
The following measurements measure the desensitization of the Wi-Fi radio when the Cellular radio is operating.

4.2.2. Test Setup

Typical system diagrams for Wi-Fi Desense measurements are shown in Figure 4-4 and Figure 4-5. The configurations shown are only representative examples of common systems and do not represent an exhaustive list of possible configurations.

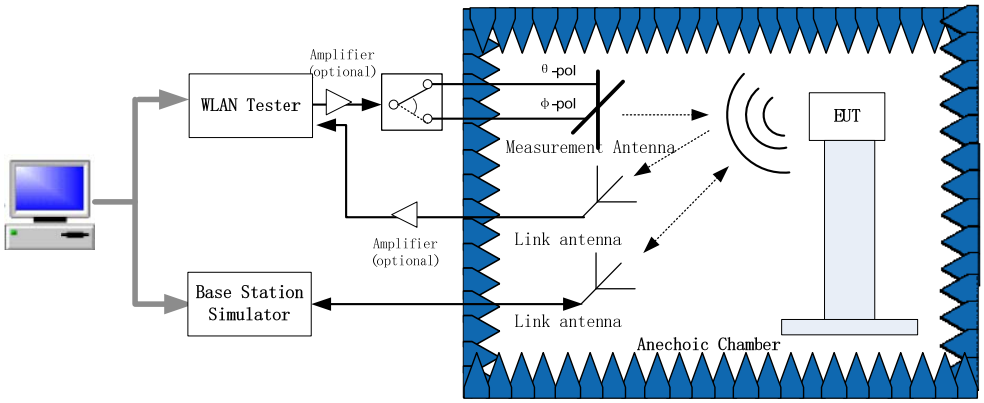
The figure below is a simplified block diagram showing a common configuration for Wi-Fi desense measurements.

FIGURE 4- 4 SIMPLIFIED BLOCK DIAGRAM SHOWING A COMMON CONFIGURATION FOR WI-FI DESENSE MEASUREMENTS



The figure below shows a simplified block diagram showing another common configuration for Wi-Fi desense measurements.

FIGURE 4- 5 SIMPLIFIED BLOCK DIAGRAM SHOWING ANOTHER COMMON CONFIGURATION FOR WI-FI DESENSE MEASUREMENTS



For more information about possible test setup configurations and details, refer to Appendix A of CTIA Test Plan for setup illustrations.

4.2.3. Test Procedures for Wi-Fi Radio Desensitization

The Wi-Fi Desensitization tests consist of two groups of test scenarios related to the desensitization by closest cellular uplink frequency and desensitization by cellular uplink harmonics. Section 4.2.4 covers the test scenario and details for the closest cellular uplink frequency case while Section 4.2.5 covers the details related to the cellular uplink harmonics.

All cellular Tx parameter settings shall be set according to Section 5 of the CTIA Test Plan [1] or Appendix C.

For the Wi-Fi desensitization tests, configure the test as specified in Section 4.1.5 for the TIS (both cellular downlink and EUT cellular are disabled) testing with the exception of the setup corresponding to the desensitizing cellular signal that is specified here. Desense measurements shall be made at the same data rates used for the TIS measurements of Section 4.1.5.

The Wi-Fi Desensitization test consists of four basic steps as follows.

Step 1. The EUT and chamber positioner(s) are moved to the location & polarization resulting in the best-radiated free-space sensitivity (EIS) measured for the closest, in frequency, channel for which the TIS has been determined, as covered in Section 4.1.5.
Step 2. For the Wi-Fi channels specified in Sections 4.2.4 or 4.2.5, perform a single EIS measurement using the number of packets specified in Table 4-4..

TABLE 4-4. PARAMETER SETTINGS FOR WI-FI RADIO DESENSITIZATION TEST

Parameter	Value
Min number of packets	1000

Step 3. Enable the cellular radio in the EUT and establish a cellular connection to turn on the cellular interferer and repeat for all interfering channels specified in Sections 4.2.4 or 4.2.5.
Step 4. Subtract the EIS measured in Step 2 from the EIS measured in Step 3 and report the results as the resulting desensitization. An example result table is given in Appendix A.

Depending on the details of the equipment used to conduct the tests there will be a limit to which desensitization can be measured. The search for the desense level shall be continued until a passing error rate is achieved or the test system limit is reached. If the EUT reaches this limit and the actual value cannot be measured, record the max EIS that the test system can produce and indicate that the limit was reached in the test report. The test equipment should be capable of measuring a desense level of 40 dB or more.

Appendix C lists the RATs considered in the construction of the interfering signal for these tests. If a Test Lab is presented with a device containing a RAT that is not listed, the test Lab shall contact certifications@Wi-Fi.org for clarification.

4.2.4. Wi-Fi Radio Desensitization by Closest Cellular Uplink Frequency

A cellular radio transmitter in the converged device can overload the front-end of the Wi-Fi radio, or desensitize it by an out of band emission. This can happen at any cellular frequency but is usually most prevalent at cellular frequencies closest to the Wi-Fi bands.

Desensitization of the lowest Wi-Fi channel, channel 1, shall be measured for all RATs supported by the device whose Tx frequencies (center of channel) fall between 1880 MHz and 2400 MHz.

Desensitization of the highest supported Wi-Fi channel,(for example, channel 11 or channel 13) shall be measured for all RATs supported by the device whose Tx frequencies (center of channel) fall between 2483.5 MHz and 3003.5 MHz.

If the device supports more than one band with the same RAT, then only the closest frequency (which is either the center of the channel or center of the resource blocks for LTE as specified by the CTIA test plan) to the 2400 MHz Wi-Fi band shall be tested.

All modes b, g and n (if supported by the Wi-Fi radio) shall be tested.

Example – Device 1

- 4 band GSM (1900, 1800, 900, 850),
- 5 band WCDMA (bands 1, 2, 4, 5, 8),
- 5 band LTE (2, 4, 5, 13, 17)
- 802.11 a, b, g, n (channels 1-11 supported @ 2400 MHz).

Bands and RATs within 520 MHz of Wi-Fi for this device are:

- WCDMA band 1 (high channel - 9888, Tx uplink = 1977.60 MHz) and
- LTE band 2 (high channel - 19150, 1908.42 MHz @ center of uplink RB allocation)
- GSM 1900 (high channel – 810, 1909.80 MHz)

Set Wi-Fi to lowest supported channel, channel 1, 2412 MHz, for b/g/n modes.

WCDMA band 2 is also within the range, but its uplink frequency (1907.6 MHz, channel 9538) is lower in frequency than WCDMA band 1 and the same RAT does not need to be tested again.

Example – Device 2

- Single band LTE TDD band 41 device and 802.11 b, g, n (channels 1-11).

Bands and RATs within 520 MHz of Wi-Fi for this device are:

- LTE TDD band 41 (low channel, 39650, Tx = 2496 MHz).

Set Wi-Fi to highest supported channel, channel 11, 2462 MHz, for b/g/n modes.

4.2.5. Wi-Fi Radio Desensitization by Cellular Radio Uplink Harmonics

The cellular transmitter can produce unwanted harmonics that may interfere with certain Wi-Fi channels depending upon the combination of cellular technologies and Wi-Fi channels implemented in a converged device. Appendix F all known RATs and their interaction with Wi-Fi channels and many other details in a large spreadsheet. A subset of Wi-Fi channels has been selected that cover the interaction with as many RATs as possible to simplify the test selection and these are compiled into Table 4-5 below.

The EUT desensitization shall be tested for all relevant interactions in Table 4-5 below. Relevant interaction is defined by supported RAT implementation or as specified by the manufacturer.

TABLE 4-5. DESENSITIZATION CASES

Cellular RAT & Wi-Fi channel pairs for Testing Harmonic Desensitization of Wi-Fi by Cellular Uplink Tx						
Wi-Fi Channel	**Test Case**	**Cellular RAT**	**RAT Channel Number**	**RAT Uplink Frequency (MHz)**	**Call Setup Reference**	**Special Setup**
11	11.1	GSM 850	128	824.2	CTIA Test Plan	
	11.2	CDMA 800 Cellular BC0	1013	824.7	CTIA Test Plan	
	11.3	UMTS 850 3GPP Band V	4132	826.4	CTIA Test Plan	
	11.4	LTE Band 5(not needed if LTE Band 26 is tested)	20450	825.58	CTIA Test Plan	10.0 MHz BW, UL: 12 RB, RBstart = 0
	11.5	LTE Band 26	26815	824.97	CTIA Test Plan	5.0 MHz BW, UL: 8 RB, RBstart=0
13	13.1	GSM 850	128	824.2	CTIA Test Plan	
	13.2	CDMA 800 Cellular BC0	1013	824.7	CTIA Test Plan	
	13.3	UMTS 850 3GPP Band V	4132	826.4	CTIA Test Plan	
	13.4	LTE Band 5(not needed if LTE Band 26 is tested)	20450	825.58	CTIA Test Plan	10.0 MHz BW, UL: 12 RB, RBstart = 0
	13.5	LTE Band 26	26815	824.97	CTIA Test Plan	5.0 MHz BW, UL: 8 RB, RBstart=0
44	44.1	DCS 1800	661	1740.0	CTIA Test Plan Appendix M	
	44.2	UMTS (WCDMA) Band III	1075	1740.0	CTIA Test Plan Appendix M	
	44.3	UMTS 2100/1700 3GPP Band IV	1450	1740.0	CTIA Test Plan	
	44.4	LTE Band 3	19534	1739.98	CTIA Test Plan Appendix M	10 MHz BW, UL: 12 RB, RBstart=0
	44.5	LTE Band 4	20284	1739.98	CTIA Test Plan	10 MHz BW, UL: 12

						RB, RBstart=0
	44.6	LTE Band 38	38224	2610.02	Appendix C	20 MHz BW, UL: 18 RB, RBstart=0
	44.7	LTE Band 41	40864	2610.02	CTIA Test Plan Appendix M	20 MHz BW, UL: 18 RB, RBstart=0
60	60.1	DCS 1800	794	1766.6	CTIA Test Plan Appendix M	
	60.2	CDMA 1700/2100 AWS-1 BC 4	334	1766.7	CTIA Test Plan	
	60.3	UMTS (WCDMA) Band III	1208	1766.6	CTIA Test Plan appendix M	
	60.4	LTE Band 3	19800	1766.58	CTIA Test Plan Appendix M	10 MHz BW, UL: 12 RB, RBstart=0
	60.5	LTE Band 41	41264	2650.56	CTIA Test Appendix M	20 MHz BW, UL: 18 RB, RBstart=0
124	124.1	GSM 1900	628	1873.4	CTIA Test Plan	
	124.2	CDMA 1900 PCS BC1	468	1873.4	CTIA Test Plan	
	124.3	UMTS 1900 3GPP Band II	9367	1873.4	CTIA Test Plan	
	124.4	LTE Band 2 (not needed if LTE Band 25 is tested)	18866	1873.18	CTIA Test Plan	10 MHz BW, UL: 12 RB, RBstart=0
	124.5	LTE Band 25	26287	1873.17	CTIA Test Plan	5 MHz BW, UL: 8 RB, RBstart=0
132	132.1	TD-SCDMA Band F1	9436	1887.2	Appendix C	
140	140.1	LTE Band 39	38524	1900.0	Appendix C	20 MHz BW, UL: 18 RB, RBstart=0
	140.2	TD-SCDMA Band F2	9492	1898.4	Appendix C	
157	157.1	CDMA 1900 BC6	167	1928.4	CTIA Test Plan	
	157.2	UMTS (WCDMA) Band I	9642	1928.4	CTIA Test Plan Appendix M	
	157.3	LTE Band 1	18118	1928.38	CTIA Test Plan Appendix M	10 MHz BW, UL: 12 RB, RBstart=0

Example – Device 1

- 4 band GSM (1900, 1800, 900, 850),
- 5 band WCDMA (bands 1, 2, 4, 5, 8),
- 5 band LTE (2, 4, 5, 13, 17)
- 802.11 b, g, n (channels 1-11 supported @ 2400 MHz).
- 802.11 a channels 36 – 64

Test the following

- Wi-Fi ch 11 against GSM 850 ch 128, 824.2 MHz
- Wi-Fi ch 11 against UMTS 850 3GPP Band V ch 4357, 826.4 MHz
- Wi-Fi ch 11 against LTE Band 5 ch 20450, 825.6 MHz
- Wi-Fi ch 44 against DCS 1800 GSM 1800 ch 661, 1740.0 MHz
- Wi-Fi ch 44 against UMTS (WCDMA) Band III ch 1300, 1740.0 MHz
- Wi-Fi ch 44 against LTE Band 4 ch 20250, 1740.0 MHz
- Wi-Fi ch 60 against DCS 1800 GSM 1800 ch 794, 1766.6 MHz

Example – Device 2

- Single band LTE TDD band 41 device and 802.11 b, g, n (channels 1-11).

No test is required.

4.2.6. Results

Results shall be represented in dB.

There are no Pass/Fail criteria. Refer to Appendix A for sample report templates.

4.3 Cellular Desense Measurements with Wi-Fi transmitter ON

4.3.1. Test Purpose

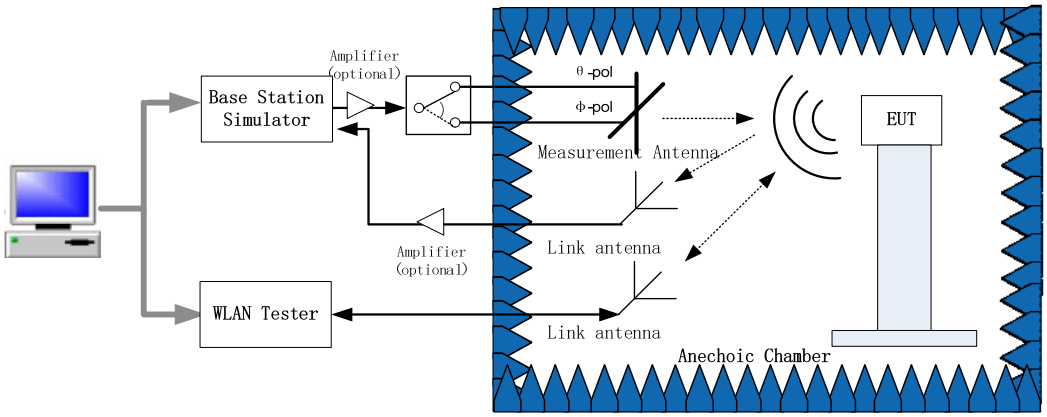
The purpose of this test is to conduct cellular desensitization test when the EUT's Wi-Fi transmitter is ON.

4.3.2. Test Setup

The figure below shows an example test system configuration for the cellular desense measurement.

All desense tests of this section are performed in Free Space condition.

FIGURE 4- 6 EXAMPLE TEST SYSTEM CONFIGURATION FOR CELLULAR DESENSE MEASUREMENTS



For more information about possible test setup configurations and details, refer to Appendix A of CTIA Test Plan [1] for setup illustrations.

For Wi-Fi EUT transmitter stimulus, unicast UDP packets are transmitted by the WLAN tester using the MAC address of the Wi-Fi EUT. The RF port of the WLAN tester is connected to the link antenna inside the chamber.

For this test, ACK based packet generation shall be used to create the Wi-Fi interference signal. The ACK control frames are sent in response to unicast data packets generated by the WLAN tester according to the parameters specified in

Table 3-4. The EUT will respond with repeated ACKs which will be transmitted at maximum power.

Cellular desense tests shall only be performed with 802.11b, 2.4 GHz (unless the device only supports 802.11g, then use 802.11g, if the device only supports 802.11n, then use 802.11n) and 802.11a, 5 GHz (unless the device only supports 802.11n, then use 802.11n).Data rates of Table 3-1 shall be used for Wi-Fi interference signal.

All desense tests of this section are performed according to configurations specified in Appendix B.

Cellular antenna selection for devices that support receive diversity is according to the following.
For all RATs listed in the CTIA Test Plan [1] that support diversity, the device shall be tested using only the primary antenna (as defined by the CTIA Test Plan [1]).

For all RATs listed in the CTIA Test Plan [1] Appendix M "Optional GSM, UMTS and LTE Bands (Informative)" and for RATs listed in Appendix C of this test plan that support receive diversity, the device shall be tested per the 3GPP OTA test plan diversity requirements using only the primary antenna.

4.3.3. Test Procedure for GSM, CDMA and UMTS RATs listed in the CTIA Test Plan

For GSM, CDMA and UMTS RATs listed in the CTIA Test Plan [1] Section 6, perform the following steps.

Initial Conditions

Step 1. Turn on the Wi-Fi radio and let the Wi-Fi EUT associate with the WLAN tester using appropriate settings of the EUT and WLAN tester

Step 2. Start Wi-Fi EUT Transmitter Stimulus as specified in Section 4.3.2

Test Procedures

Step 3. With Wi-Fi Radio on, perform the Relative Sensitivity on Intermediate Channels test at all intermediate channels according to the appropriate Receive Performance Test Procedure section of the CTIA Test Plan [1].

Step 4. Compare the resulting digital error rate or throughput rate as specified in CTIA Test Plan [1] and determine which channels are desensitized beyond requirements specified in OTA Test Plan [1].

Step 5. Repeat Step 3 and Step 4 for all RATS and corresponding supporting bands.

Step 6. Report only the intermediate channels that exceed the limit as specified in the CTIA Test Plan [1].

4.3.4. Test Procedure for RATs Listed in Appendix C here and non-LTE RATs listed in the CTIA Test Plan Appendix M

In this case, the Intermediate Channels are not defined and M1 margin values may not be available as TIS values are not available.

For all non LTE RATs listed in the CTIA Test Plan [1] Appendix M "Optional GSM, UMTS and LTE Bands (Informative)" and RATs listed in Appendix C of this test plan, perform the following steps.

Test Procedures

Step 1. Determine the TIS of the EUT at the low channel with the Wi-Fi radio transmitter switched OFF, using the data captured previously per the procedures in the CTIA Test Plan [1].

Step 2. Use the CTIA Test Plan procedures to determine position and polarization that results in the maximum EIS value associated to Step 1.

Step 3. Use the corresponding position and polarization of Step 2 and measure the EIS(peak)of the EUT at the low channel with the Wi-Fi radio transmitter switched OFF.

Step 4. Capture the measured EIS results as Value A Low.

Step 5. Turn on the Wi-Fi radio and let the Wi-Fi EUT associate with the WLAN tester using appropriate settings of the EUT and WLAN tester.

Step 6. Start Wi-Fi EUT Transmitter Stimulus as specified in Section 4.3.2.

Step 7. Without re-positioning and keeping the same corresponding position and polarization of Step 2, measure the EIS(peak)of the EUT at the low channel with the Wi-Fi radio transmitter switched ON. Capture the results as Value B Low.

Step 8. Repeat Step 1 to Step 7 for the mid and high channels.

Step 9. Repeat Step 1 to Step 8 for all RATs and corresponding supporting bands.

4.3.5. Test Procedure for all LTE cases

Note: The CTIA Test Plan [1] includes a list of LTE intermediate channels for Northern American bands in Section O.7.1, however, no M1 margin values are available as the test plan does not currently specify minimum TIS requirements for LTE devices.

For all LTE RATs perform the following steps.

Test Procedures

Follow the procedure of Section 4.3.4.

4.3.6. Wi-Fi Frequency

Devices that operate in the 2.4 GHz band shall be set to operate on channel 6 (f_c = 2.437 GHz). Devices that operate in the 5 GHz band shall be set to operate only on the middle channel of the lowest frequency supported sub-band. The Middle Channel numbers corresponding to each sub-band are listed in Table 4-6.

TABLE 4-6. MIDDLE CHANNELS FOR WI-FI U-NII SUB-BAND FOR TIS CELLULAR DESENSE

Sub Band	Middle Channel #	Middle Channel Center Frequency f_c
U-NII Lower Band (5.15 GHz to 5.25 GHz)	44	5.220 GHz
U-NII Middle Band (5.25 GHz to 5.35 GHz)	60	5.300 GHz
U-NII Upper Band (5.725 GHz to 5.825 GHz)	157	5.785 GHz
European ETSI Band	120	5.600 GHz

4.3.7. Error Rate Measure

According to the CTIA Test Plan [1], each airlink protocol (such as GSM, CDMA, UMTS and TD-SCDMA) specifies a different digital error rate as the EUT cellular receiver performance metric, while LTE FDD/ LTE TDD specify the measurement of the EUT cellular receiver's throughput rate as the applicable performance metric. The error rates or throughput values shall be applied to all bands as specified in the CTIA Test Plan [1] and Appendix C of this specification.

4.3.8. Results

There are no Pass/Fail criteria.

When performing the test according to Section 4.3.3, results shall be represented by giving the channel(s) exceeding the limit. When performing the test according to Section 4.3.4, results shall be represented in dBm for the EIS values.

Refer to Appendix A for sample report templates.

Appendix A. Summary Test Report

The following content shall be included in the test report. The tables are provided as examples for information.

TABLE A- 1 SAMPLE SUMMATION

Manufacturer	
Model	
Wi-Fi Alliance CID2	
CTIA Request #	
Serial Number (e.g., MEID, IMEI).	
Regulatory Approval ID (e.g., FCCID)	
Hardware Version	
Software Version	

A.1. Wi-Fi Conducted Tests

TABLE A- 2 CONDUCTED RF POWER OUTPUT AND RECEIVER SENSITIVITY RESULTS

Mode	**Channel**	**Data Rate, Mbps**	**Output Power dBm**	**Receiver Sensitivity dBm**
802.11b 2.4 GHz	Low	11		
	6	11		
	High	11		
802.11g 2.4 GHz	Low	6		
		54	N/A	
	6	6		
		54	N/A	
	High	6		
		54	N/A	
802.11n 2.4 GHz	Low	6.5		
		65	N/A	
	6	6.5		
		65	N/A	
	High	6.5		
		65	N/A	
802.11a 5 GHz	Low	6		
		54	N/A	
	Mid	6		
		54	N/A	
	High	6		
		54	N/A	
	Low	6.5		

[2] Vendor supplies the Wi-Fi Alliance CID (Certification Identifier) during the CWG application process.

802.11n 5 GHz		65	N/A	
	Mid	6.5		
		65	N/A	
	High	6.5		
		65	N/A	

A.2. Total Radiated Power (TRP)and Total Isotropic Sensitivity (TIS) for 2.4 GHz 802.11b, 802.11g and 802.11n

TABLE A- 3 TRP FOR 2.4 GHZ 802.11B/G/N

Mode	Channel	Data Rate, Mbps	Result, dBm TRP
IEEE 802.11b	6	11	
IEEE 802.11g	6	6	
IEEE 802.11n	6	6.5	

TABLE A- 4 TIS FOR 2.4 GHZ 802.11B/G/N

Mode	Channel	Data Rate, Mbps	Result, dBm TIS
IEEE 802.11b	6	11	
IEEE 802.11g	6	54	
IEEE 802.11n	6	65	

A.3. Total Radiated Power (TRP) and Total Isotropic Sensitivity (TIS) for 802.11a and 802.11n

The tables below provide the list of Sub-band options and corresponding Channel Frequency and Data Rates scenarios for TRP and TIS.

TABLE A- 5 TRP FOR 5 GHZ 802.11A/N

Sub Band	Channel	Data Rate, Mbps	Result, dBm TRP
UNII Low Band	44	6	
		6.5	
UNII Middle Band	60	6	
		6.5	
ETSI European band	120	6	
		6.5	
UNII Upper Band	157	6	
		6.5	
USA	165	6	
		6.5	

TABLE A- 6 TIS FOR 5 GHZ 802.11A/N

Sub Band	Channel	Data Rate, Mbps	Result, dBm TIS
UNII Low Band	44	54	
		65	
UNII Middle Band	60	54	
		65	
ETSI European band	120	54	
		65	
UNII Upper Band	157	54	
		65	
USA	165	54	
		65	

A.4. Wi-Fi Desense Measurements (with cellular transmitter on)

TABLE A- 7 WI-FI RADIO DESENSITIZATION BY CLOSEST CELLULAR UPLINK FREQUENCY

802.11		Closest Cellular Uplink Frequency		802.11	Reference Polarization	Reference Position		Desense dB	Max provided EIS in case of Complete Failure dBm
Mode	Channel	Mode	Channel	Data Rate, Mbps		Theta	Phi		
802.11b									
802.11g									
802.11n 2.4 GHz									

Note: In case of complete failure, include the maximum EIS that the test system can provide in the last column; leave unused otherwise.

TABLE A- 8 WI-FI RADIO DESENSITIZATION BY CELLULAR RADIO UPLINK HARMONICS 802.11B/G/N/A

802.11		Cellular Uplink Frequency		802.11	Reference Polarization	Reference Position		Desense dB	Max provided EIS in case of Complete Failure dBm
Mode	Channel	Mode	Channel	Data Rate, Mbps		Theta	Phi		
802.11b									
802.11g									
802.11n 2.4 GHz									
802.11a 5 GHz									
802.11n 5 GHz									

Note: In case of complete failure, include the maximum EIS that the test system can provide in the last column; leave unused otherwise.

A.5. Cellular Desense Measurements (with Wi-Fi transmitter on)

Reporting Format for Intermediate Channel Sensitivity Tests according to Section 4.3.3.

TABLE A- 9 CELLULAR DESENSE TEST RESULTS FOR 802.11B OPERATION (WI-FI 2.4 GHZ BAND)

Cellular Technology/ Band	Wi-Fi Channel	Reference Polarization	Reference Position Theta[o]	Reference Position Phi[o]	Intermediate Channels Exceeding Limit
	802.11b Ch. 6 (2.437GHz)				

TABLE A- 10 CELLULAR DESENSE TEST RESULTS FOR 802.11A OPERATION

Cellular Technology/ Band	Wi-Fi Channel	Reference Polarization	Reference Position Theta[o]	Reference Position Phi[o]	Intermediate Channels Exceeding Limit
	802.11a middle channel of the lowest supported sub-band				

Reporting Format for EIS Tests according to Section 4.3.4.

TABLE A- 11 CELLULAR DESENSE TEST RESULTS FOR 802.11B OPERATION (WI-FI 2.4 GHZ BAND)

Cellular Technology channel	Wi-Fi Channel	Reference Polarization	Reference Position Theta[o]	Reference Position Phi[o]	EIS Value A dBm			EIS Value B dBm		
					Low	Mid	High	Low	Mid	High
	802.11b Ch. 6 (2.437GHz)									

TABLE A- 12 CELLULAR DESENSE TEST RESULTS FOR 802.11A OPERATION

Cellular Technology channel	Wi-Fi Channel	Reference Polarization	Reference Position Theta[o]	Reference Position Phi[o]	EIS Value A dBm			EIS Value B dBm		
					Low	Mid	High	Low	Mid	High
	802.11a middle channel of the lowest supported sub-band									

Appendix B. Device Testing Configurations

All handheld devices shall be tested in their primary mechanical mode, as defined by the manufacturer and noted in the test report. All hand phantom guidelines with each type of wireless device shall be followed as written in the CTIA Test Plan. Hand phantoms meeting CTIA Test Plan [1] specifications up to 3 GHz shall be used regardless of Wi-Fi operating band until hand phantoms meeting CTIA Test Plan specifications up to 6 GHz are available.

For a given device class, the test shall be performed as indicated in the following table. Please note that some cases require testing with multiple configurations.

TABLE B- 1 DEVICE CAPABILITIES TESTING MATRIX

Device Capabilities	TIS/TRP	Wi-Fi Desense	Cellular Desense
Wi-Fi	Free Space	Free Space	Free Space
Wi-Fi Browser [3]	HR = Hand Right Phantom	Free Space	Free Space
Wi-Fi Browser [4]	HL = Hand Left Phantom	Free Space	Free Space

[3] As specified in Appendix O.4 of OTA Test Plan.
[4] As specified in Appendix O.4 of OTA Test Plan.

Appendix C. Radio Access Technologies that Require Testing, but are not Normative in the CTIA Test Plan

C.1 TD-SCDMA

The TIS measurements of TD-SCDMA shall be the same as described in the latest approved version of the CTIA Test Plan [1] unless otherwise defined in this section. This section only defines differences compared to CTIA Test Plan [1], and that parts shall be performed referring to 3GPP 34.114, Section 6.4. Using the Generic Call Setup procedures described in 3GPP TS 34.108 Section 7, page the EUT and place it into the loopback mode as described in 3GPP TS 34.109 Section 5.3, set the UL and DL reference measurement channel as described in 3GPP 34.122, C.2.1.2 and C.3.1.2.

Tests shall be performed for low, mid and high channel across the TD-SCDMA bands supported by the EUT, as defined in 3GPP 34.114, section 4.1.3, Table 4.5 and Table 4.6.

C.2 LTE TDD

TIS measurements and parameter call setup of LTE TDD radio access technology shall use the same methods as described in the latest approved version of the CTIA Test Plan [1] unless otherwise defined in the table below.

LTE TDD bands 38, 39 and 40 shall be tested (in addition to the LTE TDD bands listed in the CTIA Test Plan [1]).

Tests shall be performed for low, mid and high channels across the LTE TDD bands supported by the EUT, as defined in the table below.

TABLE C- 1 LTE TDD MEASUREMENT TABLE

Band	Channel Bandwidth (MHz)	Channel	Frequency (MHz) [center of DL RB allocation]	UL RB Allocation	DL RB Allocation
38	20	37850	2580	100RB with RBstart=0	100RB with RBstart=0
38	20	38000	2595	100RB with RBstart=0	100RB with RBstart=0
38	20	38150	2610	100RB with RBstart=0	100RB with RBstart=0
39	20	38350	1890	100RB with RBstart=0	100RB with RBstart=0
39	20	38450	1900	100RB with RBstart=0	100RB with RBstart=0
39	20	38550	1910	100RB with RBstart=0	100RB with RBstart=0
40	20	38750	2310	100RB with RBstart=0	100RB with RBstart=0
40	20	39150	2350	100RB with RBstart=0	100RB with RBstart=0
40	20	39550	2390	100RB with RBstart=0	100RB with RBstart=0

Appendix D. Notebook AND Tablet Requirements

The purpose of this addendum is to define the requirements for Notebooks and Tablets with embedded WWAN and Wi-Fi radio modules.

D.1 Parent/Child Relationships

During product development the Manufacturer is expected to determine what represents the most popular configuration of components and to use that configuration for the receiver performance assessment. Once the most popular version of a Parent has been identified, all Child Devices will be assessed against only that specific version of the Parent. This will hold true even if that particular version of the Parent does not remain the most popular over time.

D.2 Parent/Child Antenna Subsystem Considerations

The antenna subsystem in a Child Device must be similar in design and performance to that of its Parent (e.g. the antenna itself may be provided by a manufacturer which differs from that used in the Parent or the transmission line type/length may differ, but the antenna subsystem must be based on the same design specification).

D.3 Test configurations and setup procedures

For testing configuration and setup procedures refer to CTIA Test Plan [1] Appendix L. The setup configuration in Section L.4 will be identical with the exception of the Transmitting Wi-Fi radio which will be "ON".

TABLE D- 1 TEST APPLICABILITY MATRIX

Device Capabilities	Wi-Fi TRP/TIS	Wi-Fi Desense	Cellular Desense
Case 1: Simultaneous WWAN and Wi-Fi operation	Free Space	Free Space	Free Space
Case 2: WWAN and Wi-Fi not operating simultaneously	Free Space	Test not Required	Test not Required

Case 1: Notebooks and Tablets that are capable of simultaneous WWAN and Wi-Fi operation

Case 2: Notebooks and Tablets that are not capable of simultaneous WWAN/Wi-Fi operation

TABLE D- 2 DEFINITIONS

Child Device	A Notebook platform utilizing an embedded WWAN Module, which is derived from a Parent Notebook platform. A Child Device is unique in that the only allowable changes relative to its Parent product are those applicable to the Notebook platform itself.
Module	Modules are finished WWAN radio devices that do not directly connect to a host via a standardized external interface such as PCMCIA, RS-232, USB, PCIExpress, etc. A module may or may not include an integral antenna system or SIM/USIM interface.

Notebook	See definition in CTIA Test Plan Appendix L.
Parent	A device (of any type) from which a Child device can be derived.
Simultaneous operation	A Notebook/Tablet that is capable of simultaneous Wi-Fi/Cellular operation and the user experience is that both radios are on at the same time. An example would be Hot Spot operation.
Tablet	See definition in CTIA Test Plan Appendix L.
WLAN	Wireless Local Area Network (WLAN) links two or more devices using some wireless distribution method and usually providing a connection through an access point to the wider internet. Most modern WLANs are based on IEEE 802.11 standards, marketed under the Wi-Fi brand name.
WWAN	Wireless Wide Area Network refers to cellular airlink technologies as noted in Section 1.2.

Appendix E. Wi-Fi-LTE Emulator Test Equipment Notes when Testing EUTs that Support LTE Band 40 or 41 (Informative)

This is an informative appendix. The information in this appendix is to inform test labs that care must be used with test equipment when performing tests with EUTs that support LTE band 40 or 41. With an incorrect test setup, results may be incorrect because of test equipment desense. Proper RF isolation is required between the cellular and Wi-Fi emulators. The test diagrams shown in this appendix are examples and variations of the test setup may differ or may not be required for each test lab.

Proper Wi-Fi and LTE emulator test equipment setup is required for Wi-Fi or cellular desense measurements for EUTs that support LTE bands 40 or 41. LTE bands 40 and 41 are next to the 2.4 GHz Wi-Fi band with little or no guard bands (see the figures that follow). There is the possibility that the Wi-Fi or LTE emulator would be unable to attach to the EUT when performing these measurements due to test equipment immunity issues. The test lab must insure they are measuring the over the air EUT Wi-Fi or cellular desense and not Wi-Fi or LTE emulator test equipment immunity.

FIGURE E- 1 LTE BAND 40 AND WI-FI 2.4 GHZ FREQUENCY DIAGRAM

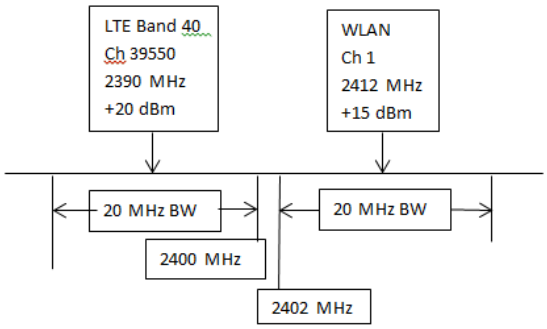
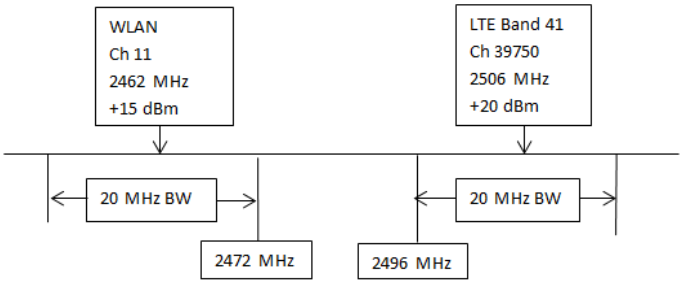


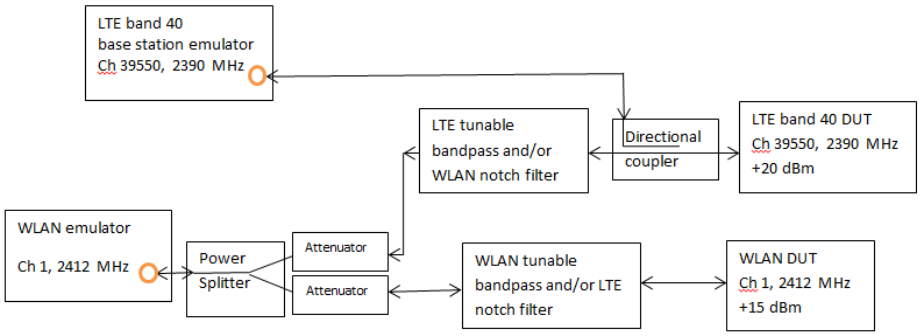
FIGURE E- 2 LTE BAND 41 AND WI-FI 2.4 GHZ FREQUENCY DIAGRAM



The test lab can verify Wi-Fi emulator test equipment immunity with the example test equipment diagram in the figure below. RF cavity tuned notch and/or bandpass filters are used to ensure the EUT is not desensed by the LTE device and for the LTE device to stay attached to the LTE emulator due to interference from the Wi-Fi. Attenuators can be used to simulate expected RF levels present at the Wi-Fi emulator while performing Wi-Fi EUT over the air desense measurements. Perform sensitivity measurements with the EUT only (without LTE band 40) and note results. Then attach LTE band 40 EUT to the LTE emulator (at maximum output power). With the LTE band 40 EUT attached, re-measure the Wi-Fi EUT. If the Wi-Fi sensitivity measurements are the same and Wi-Fi/LTE EUTs

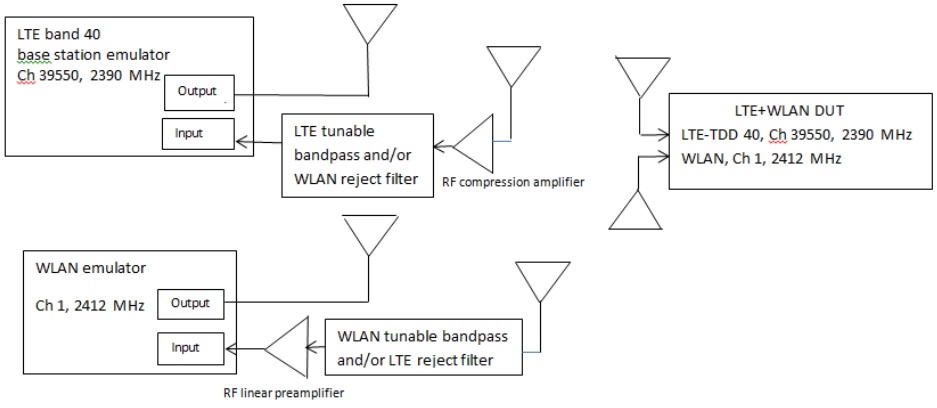
remain attached, the Wi-Fi emulator is immune to the adjacent channel interference. LTE base station emulator test equipment immunity can be verified by exchanging the positions of the emulators, RF filters and EUTs in the diagram.

FIGURE E- 3 WI-FI EMULATOR TEST EQUIPMENT VERIFICATION TEST SETUP (TO TEST THE LTE BASE STATION



If the Wi-Fi or LTE emulator does show immunity problems, Figure E-4 diagram shows an example on how to eliminate these problems (use RF filters as needed). If the lab is using an RF compression amplifier for the LTE input emulator, the RF filter must be installed after the output of the amplifier. If the device can stay attached to the LTE emulator, no RF filter is required. If the lab is using an RF preamplifier for the Wi-Fi emulator input, the RF filter should be connected to the input of the preamplifier. Care must be used when tuning the RF filters. If a Wi-Fi bandpass RF filter is used, be sure to add its loss into the system path loss and remove the filters when performing Wi-Fi TRP or TIS measurements.

FIGURE E- 4 EXAMPLE TEST SYSTEM DIAGRAM (ONLY FOR WI-FI DESENSE OR LTE CELLULAR DESENSE TESTS, IF THE EUT SUPPORTS LTE BAND 40)



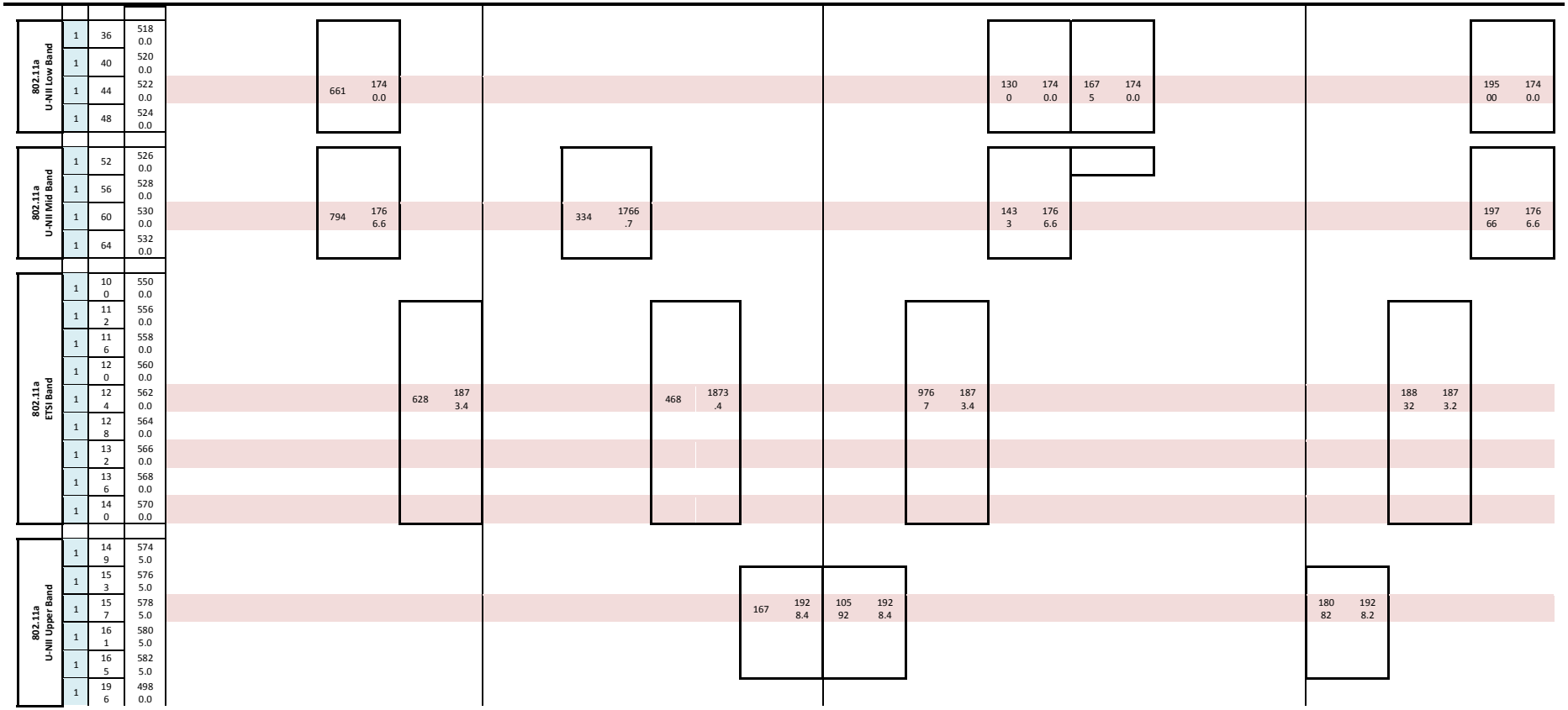
Appendix F. Table of Wi-Fi Radio channels interfered by Cellular Radio Harmonics

RAT	GSM 850		E-GSM 900		DCS 1800		GSM 1900		CDMA 800 Cellular BC0		CDMA 1700/2100 AWS-1 BC 4		CDMA 1900 PCS BC1		CDMA 1900 BC6		UMTS (WCDMA) Band I		UMTS 1900 3GPP Band II		UMTS (WCDMA) Band III		UMTS 2100/1700 3GPP Band IV		UMTS 850 3GPP Band V		UMTS (WCDMA) Band VIII		LTE Band 1		LTE Band 2		LTE Band 3	
Region	USA, China (CT)		EU, China (CU, CMCC)		EU, China (CU, CMCC)		USA		USA		USA		USA		USA		EU, ASIA		USA		EU, ASIA		USA		International		EU, ASIA		JAPNA , Europe, the Middle East and Africa		JAPNA , Europe, the Middle East and Africa		JAPNA , Europe, the Middle East and Africa	
Suggested alternate name																																		
Call setup defined in reference document	CTIA OTA Sec [1]		CTIA Appendix M [1]		CTIA Appendix M [1]		CTIA OTA Sec [1]		CTIA OTA Sec [1]		CTIA OTA Sec [1]		CTIA OTA Sec [1]		CTIA OTA Sec [1]		CTIA Appendix M [1]		CTIA OTA Sec [1]		CTIA Appendix M [1]		CTIA OTA Sec [1]		CTIA OTA Sec [1]		CTIA Appendix M [1]		CTIA Appendix M [1]		CTIA OTA Sec [1]		CTIA Appendix M [1]	
Special setup																													5.0 MHz Tx BW = 25 RBs, RB start = 12		5.0 MHz Tx BW = 25 RBs, RB start = 12		5.0 MHz Tx BW = 25 RBs, RB start = 12	
Band Edges																																		
Uplink Freq	82	84	88	91	171	178	185	190	82	848	1711	1753	1851	1908	192	198	192	198	185	190	171	178	171	175	82	84	88	91	192	197	185	190	171	178
	4.2	8.8	0.2	4.8	0.2	4.8	0.2	9.8	4.7	.31	.25	.75	.25	.75	0.0	0.0	0.0	0.0	2.4	7.6	0.0	5.0	2.4	2.6	6.4	6.6	2.4	2.6	5.0	5.0	5.0	5.0	5.0	0.0
Downlink Freq	86	89	92	95	180	187	193	198	86	881	2111	2153	1931	1988	211	217	211	216	193	198	211	215	211	215	87	88	92	95	211	216	193	198	181	187
	9.2	3.8	5.2	9.8	5.2	9.8	0.2	9.8	9.7	.52	.25	.75	.25	.75	0.0	0.0	2.4	7.1	2.4	7.6	2.4	2.6	2.4	2.6	1.4	1.6	7.4	7.6	5.0	5.0	5.0	5.0	0.0	5.0

Desensitization of Wi-Fi Rx by Cellular Tx Uplink

		Chan	Freq	Chan	Freq	Chan	Freq	Chan	Freq	Chan	Freq	Chan	Freq	Chan	Freq	Chan	Freq	Chan	Freq	Chan	Freq	Chan	Freq	Chan	Freq	Chan	Freq	Chan	Freq	Chan	Freq	Chan	Freq	Chan	Freq
802.11b/g/n	1	1	2412.0																																
	1	2	2417.0																																
	1	3	2422.0																																
	1	4	2427.0																																
	1	5	2432.0																																
	1	6	2437.0																																
	1	7	2442.0																																
	1	8	2447.0																																
	1	9	2452.0																																
	1	10	2457.0																																
	1	11	2462.0	12	82							10	824															43	82						
				8	4.2							13	.7															57	6.4						
	1	12	2467.0																																
	1	13	2472.0	12	82							10	824															43	82						
				8	4.2							13	.7															57	6.4						
	1	14	2484.0	14	82							77	827															43	82						
				7	8.0								.3															65	8.0						
802.11a ?? Band		7	5035.0																																
		8	5040.0																																

Black boxes indicate Wi-Fi Rx vulnerability due to Cellular uplink Tx


802.11a U-NII Low Band
1 36 5180.0
1 40 5200.0
1 44 5220.0
1 48 5240.0
802.11a U-NII Mid Band
1 52 5260.0
1 56 5280.0
1 60 5300.0
1 64 5320.0
802.11a ETSI Band
1 100 5500.0
1 112 5560.0
1 116 5580.0
1 120 5600.0
1 124 5620.0
1 128 5640.0
1 132 5660.0
1 136 5680.0
1 140 5700.0
802.11a U-NII Upper Band
1 149 5745.0
1 153 5765.0
1 157 5785.0
1 161 5805.0
1 165 5825.0
1 196 4980.0
661 1740.0
794 1766.6
628 1873.4
468 1873.4
334 1766.7
976 1873.4
167 1928.4
10592 1928.4
1300 1740.0
1675 1740.0
14333 1766.6
18882 1873.2
19500 1740.0
19766 1766.6
18082 1928.2

RAT	LTE Band 4	LTE Band 5	LTE Band 7	LTE Band 8	LTE Band 12	LTE Band 13 Note: only one channel, 23230	LTE Band 14 Note: only one channel, 23330	LTE Band 17	LTE Band 20	LTE Band 25	LTE Band 38	LTE Band 39	LTE Band 40	LTE Band 41	TD-SCDMA Band A	TD-SCDMA Band F1	TD-SCDMA Band F2
Region	JAPNA , Europe, the Middle East and Africa	JAPNA , Europe, the Middle East and Africa	JAPNA , Europe, the Middle East and Africa		USA	USA	USA	USA	Europe Digital Dividend, EMEA	NORTH AMERICA	CHINA	CHINA	CHINA	NORTH AMERICA	CHINA	CHINA	CHINA
Suggested alternate name		E-UTRA Band 5							E-UTRA Band 20								
Call setup defined in reference document	CTIA OTA Sec [1]	CTIA OTA Sec [1]	CTIA Appendix M [1]	CTIA Appendix M [1]	CTIA OTA Sec [1]	CTIA OTA Sec [1]	CTIA OTA Sec [1]	CTIA OTA Sec [1]	CTIA Appendix M [1]	CTIA OTA Sec [1]	CWG Appendix C	CWG Appendix C	CWG Appendix C	CTIA Appendix M [1]	CWG Appendix C	CWG Appendix C	CWG Appendix C
Special setup	5.0 MHz Tx BW = 25 RBs, RB start = 12	5.0 MHz Tx BW = 25 RBs, RB start = 12	5.0 MHz Tx BW = 25 RBs, RB start = 12	5.0 MHz Tx BW = 25 RBs, RB start = 12	5.0 MHz Tx BW = 25 RBs, RB start = 12	5.0 MHz Tx BW = 25 RBs, RB start = 12	5.0 MHz Tx BW = 25 RBs, RB start = 12	5.0 MHz Tx BW = 25 RBs, RB start = 12	5.0 MHz Tx BW = 25 RBs, RB start = 0	5.0 MHz Tx BW = 25 RBs, RB start = 0	5.0 MHz Tx BW = 25 RBs, RB start = 0	5.0 MHz Tx BW = 25 RBs, RB start = 0	5.0 MHz Tx BW = 25 RBs, RB start = 0	5.0 MHz Tx BW = 25 RBs, RB start = 0			
Band Edges																	
Uplink Freq	171 175 5.0 0.0	829 844 .0 .0	250 256 5.0 5.0	895 920 .0 .0	704 711 .0 .0	782 782 .0 .0	793 793 .0 .0	709 711 .0 .0	837 857 .0 .0	1852 191 .5 2.5	257 262 0 0	188 192 0 0	23 24 00 00	249 268 6.0 9.9	201 202 0.0 5.0	188 189 0.0 0.0	189 189 0.0 8.4
Downlink Freq	211 215 5.0 0.0	874 889 .0 .0	262 268 5.0 5.0	930 955 .0 .0	734 741 .0 .0	751 751 .0 .0	763 763 .0 .0	739 741 .0 .0	796 816 .0 .0	1932 199 .5 2.5	257 262 0 0	188 192 0 0	23 24 00 00	249 268 6.0 9.9	201 202 0.0 5.0	188 189 0.0 0.0	189 189 0.0 8.4

Desensitization of Wi-Fi Rx by Cellular Tx Uplink

		Chan	Freq	Chan	Freq	Chan	Freq	Chan	Freq	Chan	Freq	Chan	Freq	Chan	Freq	Chan	Freq	Chan	Freq	Chan	Freq	Chan	Freq	Chan	Freq	Chan	Freq	Chan	Freq	Chan	Freq	Chan	Freq
802.11b/g/n	1	1	2412.0			20450	825.6																										
	1	2	2417.0																														
	1	3	2422.0																														
	1	4	2427.0																														
	1	5	2432.0																														
	1	6	2437.0																														
	1	7	2442.0																														
	1	8	2447.0																														
	1	9	2452.0																														
	1	10	2457.0																														
	1	11	2462.0			20450	825.6																										
	1	12	2467.0																														
	1	13	2472.0			20450	825.6																										
	1	14	2484.0			20450	825.6																										
802.11a ?? Band		7	5035.0																														
		8	5040.0																														
802.11a U-NII Low Band	1	36	5180.0																														
	1	40	5200.0																														

	1	44	5220.0	20250	1740.0			38150	2610.0			38150	2610.0				
	1	48	5240.0														
802.11a U-NII Mid Band	1	52	5260.0														
	1	56	5280.0														
	1	60	5300.0									41190	2650.0				
	1	64	5320.0														
802.11a ETSI Band	1	100	5500.0														
	1	112	5560.0														
	1	116	5580.0														
	1	120	5600.0														
	1	124	5620.0			18832.0	1873.2										
	1	128	5640.0											9404	1880.4		
	1	132	5660.0											9436	1887.2		
	1	136	5680.0													9468	1893.6
	1	140	5700.0							19100	1900.0					9492	1898.4
802.11a U-NII Upper Band	1	149	5745.0							36150	1915.0						
	1	153	5765.0														
	1	157	5785.0														
	1	161	5805.0														
	1	165	5825.0														
	1	196	4980.0														