NTS Silicon Valley
www.nts.com
41039 Boyce Road
Fremont, CA 94538
510-578-3500 Phone
510-440-9525 Fax

EMC Test Report

Application for FCC Grant of Equipment Authorization

FCC Part 15, Subpart E

Model: GFHD254

FCC ID:	A4RGFHD254
APPLICANT:	Google Inc. 1600 Amphitheatre Pky Mountain View, CA 94043
TEST SITE(S):	National Technical Systems - Silicon Valley 41039 Boyce Road. Fremont, CA. 94538-2435
IC SITE REGISTRATION #:	2845B-4, 2845B-7
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PROGRAM MGR /
TECHNICAL REVIEWER:

Mark E Hill
Staff Engineer

QUALITY ASSURANCE DELEGATE /
FINAL REPORT PREPARER:

David Guidotti
Senior Technical Writer

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Testing Cert #0214.26

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REVISION HISTORY

Rev#	Date	Comments	Modified By
-	November 16, 2016	First release	
1.0	January 12, 2017	Updated cabling information. Clarified the VBW requirement for n20 modes during radiated measurements.	MEH
2.0	February 8, 2017	Updated support equipment information	MEH

TABLE OF CONTENTS

REVISION HISTORY **2**
TABLE OF CONTENTS **3**
SCOPE **4**
OBJECTIVE **4**
STATEMENT OF COMPLIANCE **5**
DEVIATIONS FROM THE STANDARDS **5**
TEST RESULTS SUMMARY **6**
UNII / LELAN DEVICES 6
MEASUREMENT UNCERTAINTIES 9
EQUIPMENT UNDER TEST (EUT) DETAILS **10**
GENERAL 10
OTHER EUT DETAILS 10
ANTENNA SYSTEM 10
ENCLOSURE 10
MODIFICATIONS 10
SUPPORT EQUIPMENT 11
EUT INTERFACE PORTS 11
EUT OPERATION 11
TEST SITE **12**
GENERAL INFORMATION 12
CONDUCTED EMISSIONS CONSIDERATIONS 12
RADIATED EMISSIONS CONSIDERATIONS 12
MEASUREMENT INSTRUMENTATION **13**
RECEIVER SYSTEM 13
INSTRUMENT CONTROL COMPUTER 13
LINE IMPEDANCE STABILIZATION NETWORK (LISN) 13
FILTERS/ATTENUATORS 14
ANTENNAS 14
ANTENNA MAST AND EQUIPMENT TURNTABLE 14
INSTRUMENT CALIBRATION 14
TEST PROCEDURES **15**
EUT AND CABLE PLACEMENT 15
CONDUCTED EMISSIONS 15
RADIATED EMISSIONS 15
CONDUCTED EMISSIONS FROM ANTENNA PORT 19
BANDWIDTH MEASUREMENTS 19
SPECIFICATION LIMITS AND SAMPLE CALCULATIONS 20
CONDUCTED EMISSIONS SPECIFICATION LIMITS: FCC 15.207; FCC 15.107(A), RSS GEN 20
GENERAL TRANSMITTER RADIATED EMISSIONS SPECIFICATION LIMITS 21
FCC 15.407 (A) OUTPUT POWER LIMITS 22
SPURIOUS EMISSIONS LIMITS –UNII AND LELAN DEVICES 22
SAMPLE CALCULATIONS - CONDUCTED EMISSIONS 23
SAMPLE CALCULATIONS - RADIATED EMISSIONS 23
SAMPLE CALCULATIONS - FIELD STRENGTH TO EIRP CONVERSION 24
APPENDIX A TEST EQUIPMENT CALIBRATION DATA **25**
APPENDIX B TEST DATA **30**
END OF REPORT **138**

SCOPE

An electromagnetic emissions test has been performed on the Google Inc. model GFHD254, pursuant to the following rules:

FCC Part 15, Subpart E requirements for UNII Devices

Conducted and radiated emissions data has been collected, reduced, and analyzed within this report in accordance with measurement guidelines set forth in the following reference standards and as outlined in National Technical Systems - Silicon Valley test procedures:

FCC General UNII Test Procedures KDB789033

The intentional radiator above has been tested in a simulated typical installation to demonstrate compliance with the relevant Industry Canada performance and procedural standards.

Final system data was gathered in a mode that tended to maximize emissions by varying orientation of EUT, orientation of power and I/O cabling, antenna search height, and antenna polarization.

Every practical effort was made to perform an impartial test using appropriate test equipment of known calibration. All pertinent factors have been applied to reach the determination of compliance.

The EUT support an IEEE 802.11 5GHz and Bluetooth radio. This report only covers the IEEE 802.11 5GHz radio. Refer to NTS reports R103317 and R103316.

OBJECTIVE

The primary objective of the manufacturer is compliance with the regulations outlined in the previous section.

Prior to marketing in the USA, all unlicensed transmitters and transceivers require certification. Receive-only devices operating between 30 MHz and 960 MHz are subject to either certification or a manufacturer's declaration of conformity, with all other receive-only devices exempt from the technical requirements.

Certification is a procedure where the manufacturer submits test data and technical information to a certification body and receives a certificate or grant of equipment authorization upon successful completion of the certification body's review of the submitted documents. Once the equipment authorization has been obtained, the label indicating compliance must be attached to all identical units, which are subsequently manufactured.

Maintenance of compliance is the responsibility of the manufacturer. Any modification of the product which may result in increased emissions should be checked to ensure

compliance has been maintained (i.e., printed circuit board layout changes, different line filter, different power supply, harnessing or I/O cable changes, etc.).

STATEMENT OF COMPLIANCE

The tested sample of Google Inc. model GFHD254 complied with the requirements of the following regulations:

FCC Part 15, Subpart E requirements for UNII Devices

Maintenance of compliance is the responsibility of the manufacturer. Any modifications to the product should be assessed to determine their potential impact on the compliance status of the device with respect to the standards detailed in this test report.

The test results recorded herein are based on a single type test of Google Inc. model GFHD254 and therefore apply only to the tested sample. The sample was selected and prepared by Weifeng Pan of Google Inc..

DEVIATIONS FROM THE STANDARDS

No deviations were made from the published requirements listed in the scope of this report.

TEST RESULTS SUMMARY

UNII / LELAN DEVICES

OPERATION IN THE 5.15 – 5.25 GHZ BAND – ACCESS POINTS

FCC Rule Part		Description	Measured Value / Comments	Limit / Requirement	Result
15.407 (a) (1) (ii)		Output Power (non-beamforming)	a: 17.5 dBm (55.6 mW) n20: 18.3 dBm (68.0 mW) n40: 20.8 dBm (120.0 mW) ac80: 17.4 dBm (55.1 mW)	30 dBm EIRP <= 4W	Complies
15.407 (a) (1) (ii)		Output Power (beamforming)	n20: 18.3 dBm (68.0 mW) n40: 20.3 dBm (107.8 mW) ac80: 17.4 dBm (55.1 mW)	30 dBm EIRP <= 4W	Complies
15.407 (a) (1) (ii)		Power Spectral Density (non-beamforming)	a: 6.7 dBm/MHz n20: 7.3 dBm/MHz n40: 6.8 dBm/MHz ac80: 0.8 dBm/MHz	17 dBm/MHz	Complies
15.407 (a) (1) (ii)		Power Spectral Density (beamforming)	n20: 7.3 dBm/MHz n40: 6.1 dBm/MHz ac80: 0.8 dBm/MHz	17 dBm/MHz	Complies
15.407(b) (1) / 15.209		Spurious Emissions	68.1 dBµV/m @ 10360.3 MHz (-0.2 dB)	Refer to the limits section (p21) for restricted bands, all others -27 dBm/MHz EIRP	Complies

OPERATION IN THE 5.725 – 5.85 GHZ BAND

FCC Rule Part	RSS Rule Part	Description	Measured Value / Comments	Limit / Requirement	Result (margin)
15.407(e)	-	6dB Bandwidth	All modes >500kHz	<= 500 kHz	Complies
15.407(a) (3)	-	Output Power (non-beamforming)	a: 24.2 dBm (261.5 mW) n20: 24.1 dBm (257.1 mW) n40: 24.5 dBm (279.9 mW) ac80: 24.2 dBm (266.0 mW)	30 dBm (1 W) EIRP <= 4W	Complies
15.407(a) (3)	-	Output Power (beamforming)	n20: 24.1dBm (257.1 mW) n40: 24.5dBm (279.9 mW) ac80: 24.2dBm (266.0 mW)	30 dBm (1 W) EIRP <= 4W	Complies
15.407(a) (3)	-	Power Spectral Density (non-beamforming)	a: 13.5 dBm/MHz n20: 13.2 dBm/MHz n40: 10.6 dBm/MHz ac80: 7.6 dBm/MHz	30 dBm / 500 kHz	Complies
15.407(a) (3)	-	Power Spectral Density (beamforming)	n20: 20.9 dBm/MHz n40: 11.4 dBm/MHz ac80: 5.7 dBm/MHz	30 dBm / 500 kHz	Complies
15.407(b) (4) / 15.209	-	Spurious Emissions	53.9 dBµV/m @ 11649.6 MHz (-0.1 dB)	Refer to the limits section (p21) for restricted bands, all others -17 dBm/MHz EIRP bandedge and -27 dBm/MHz EIRP	Complies

REQUIREMENTS FOR ALL U-NII/LELAN BANDS

FCC Rule Part	RSS Rule Part	Description	Measured Value / Comments	Limit / Requirement	Result
15.407	-	Modulation	Digital Modulation is used	Digital modulation is required	Complies
15.31 (m)	-	Channel Selection	Emissions tested at outermost and middle channels in each band	Device was tested on the top, bottom and center channels in each band	N/A
15.407 (c)	-	Operation in the absence of information to transmit	Operation is discontinued in the absence of information	Device shall automatically discontinue operation in the absence of information to transmit	Complies
15.407 (g)	-	Frequency Stability	Frequency stability is better than 20 ppm.	Signal shall remain within the allocated band	Complies
15.407 (h1)	RSS-247 6.2.2 (1) 6.2.3 (1)	Transmit Power Control	TCP mechanism is discussed in the Operational Description	The U-NII device shall have the capability to operate with a mean EIRP value lower than 24dBm (250mW)	Complies
15.407 (h2)	RSS-247 6.3	Dynamic frequency Selection (device with radar detection)	Device does not operate in either 5470 – 5725 or 5250 – 5350 MHz bands.		N/A

GENERAL REQUIREMENTS APPLICABLE TO ALL BANDS

FCC Rule Part	RSS Rule part	Description	Measured Value / Comments	Limit / Requirement	Result (margin)
15.203	-	RF Connector	Antenna is internal	Unique or integral antenna required	Complies
15.407 (b) (6)	RSS-Gen Table 3	AC Conducted Emissions	45.1 dBµV @ 0.447 MHz (-1.8 dB)	Refer to page 20	Complies
15.247 (i) 15.407 (f)	RSS 102	RF Exposure Requirements	Refer to MPE calculations in separate exhibit	Refer to OET 65, FCC Part 1 and RSS 102	Complies

MEASUREMENT UNCERTAINTIES

ISO/IEC 17025 requires that an estimate of the measurement uncertainties associated with the emissions test results be included in the report. The measurement uncertainties given below are based on a 95% confidence level and were calculated in accordance with UKAS document LAB 34.

Measurement Type	Measurement Unit	Frequency Range	Expanded Uncertainty
RF power, conducted (power meter)	dBm	25 to 7000 MHz	± 0.52 dB
RF power, conducted (Spectrum analyzer)	dBm	25 to 7000 MHz	± 0.7 dB
Conducted emission of transmitter	dBm	25 to 26500 MHz	± 0.7 dB
Conducted emission of receiver	dBm	25 to 26500 MHz	± 0.7 dB
Radiated emission (substitution method)	dBm	25 to 26500 MHz	± 2.5 dB
Radiated emission (field strength)	dBµV/m	25 to 1000 MHz	± 3.6 dB
		1000 to 40000 MHz	± 6.0 dB
Conducted Emissions (AC Power)	dBµV	0.15 to 30 MHz	± 2.4 dB

EQUIPMENT UNDER TEST (EUT) DETAILS

GENERAL

The Google Inc. model GFHD254 is a residential set-top box that supports the use of a IEEE 802.11 a/n/ac 5GHz radio and a Bluetooth 4.1 radio. The EUT is powered from an external AC/DC adapter.

The sample was received on May 2, 2016 and tested on May 2, 4, 9, 11, 17, 18, 19, 20 and 24, August 24, September 2, 19, 20, 21, 22, 23, 27 and 28, 2016. The EUT consisted of the following component(s):

Company	Model	Description	Serial Number	FCC ID
Google	GFHD254	Set-top box	See test data	A4RGFHD254
Google	OTD018	External power supply	-	-

OTHER EUT DETAILS

IEEE 802.11a/n/ac 4x4 radio
Supports 11a, HT/VHT20, HT/VHT40, VHT80
Does not support less Tx chains at higher Tx power per chain
Beamforming supported for HT/VHT modes
Indoor Use
DFS Client
Bluetooth 4.1 radio supporting Basic/EDR and Low Energy Modes
Simultaneous Transmission of 802.11 and BT radio supported

ANTENNA SYSTEM

4 internal stamped metal antennas. Refer to operational description exhibit for details.

ENCLOSURE

The EUT enclosure measures approximately 24.3cm by 15.5cm by 3.5cm. It is primarily constructed of uncoated plastic.

MODIFICATIONS

No modifications were made to the EUT during the time the product was at NTS Silicon Valley.

SUPPORT EQUIPMENT

The following equipment was used as support equipment for testing:

Company	Model	Description	Serial Number	FCC ID
Samsung	UN22F5000	LCD monitor	-	-

The following equipment was used as remote support equipment for emissions testing:

Company	Model	Description	Serial Number	FCC ID
Netgear	GS605	Ethernet switch	-	-

EUT INTERFACE PORTS

The I/O cabling configuration during testing was as follows:

Port	Connected To	Cable(s)		
		Description	Shielded or Unshielded	Length(m)
HDMI	LCD	Multiwire	Shielded	1.0
Audio out	LCD	Multiwire	Shielded	1.0
Ethernet	Switch	Cat 5	Unshielded	10.0
DC power	External power supply	2 wire	Unshielded	2.0
AC in (ext supply)	AC mains	2 wire	Unshielded	2.0
USB	Not connected*	-	-	-

* - USB port not supported for the current product release

EUT OPERATION

During testing, the EUT was configured to continuously transmit on the noted channel using the 802.11 radio. Refer to the test data in the Appendix of this report for details on the duty cycle of the transmission and the channels/frequencies used.

Additional testing was done with both the Bluetooth radio and the Wifi radio transmitting. Both radios were configured for continuous transmission, with the power set to the maximum power setting.

TEST SITE

GENERAL INFORMATION

Final test measurements were taken at the test sites listed below. Pursuant to section 2.948 of the FCC's Rules and section 3.3 of RSP-100, construction, calibration, and equipment data has been filed with the Commission and with industry Canada.

Site	Designation / Registration Numbers		Location
	FCC	Canada	
Chamber 4	US0027	2845B-4	41039 Boyce Road Fremont, CA 94538-2435
Chamber 7	US0027	2845B-7	

ANSI C63.4 recommends that ambient noise at the test site be at least 6 dB below the allowable limits. Ambient levels are below this requirement. The test site(s) contain separate areas for radiated and conducted emissions testing. Considerable engineering effort has been expended to ensure that the facilities conform to all pertinent requirements of ANSI C63.4.

CONDUCTED EMISSIONS CONSIDERATIONS

Conducted emissions testing is performed in conformance with ANSI C63.10. Measurements are made with the EUT connected to the public power network through a nominal, standardized RF impedance, which is provided by a line impedance stabilization network, known as a LISN. A LISN is inserted in series with each current-carrying conductor in the EUT power cord.

RADIATED EMISSIONS CONSIDERATIONS

The FCC has determined that radiation measurements made in a shielded enclosure are not suitable for determining levels of radiated emissions. Radiated measurements are performed in an open field environment or in a semi-anechoic chamber. The test sites are maintained free of conductive objects within the CISPR defined elliptical area incorporated in ANSI C63.4 guidelines and meet the Normalized Site Attenuation (NSA) requirements of ANSI C63.4.

MEASUREMENT INSTRUMENTATION

RECEIVER SYSTEM

An EMI receiver as specified in CISPR 16-1-1 is used for emissions measurements. The receivers used can measure over the frequency range of 9 kHz up to 2000 MHz. These receivers allow both ease of measurement and high accuracy to be achieved. The receivers have Peak, Average, and CISPR (Quasi-peak) detectors built into their design so no external adapters are necessary. The receiver automatically sets the required bandwidth for the CISPR detector used during measurements. If the repetition frequency of the signal being measured is below 20Hz, peak measurements are made in lieu of Quasi-Peak measurements.

For measurements above the frequency range of the receivers, a spectrum analyzer is utilized because it provides visibility of the entire spectrum along with the precision and versatility required to support engineering analysis. Average measurements above 1000MHz are performed on the spectrum analyzer using the linear-average method with a resolution bandwidth of 1 MHz and a video bandwidth of 10 Hz, unless the signal is pulsed in which case the average (or video) bandwidth of the measuring instrument is reduced to onset of pulse desensitization and then increased.

INSTRUMENT CONTROL COMPUTER

Software is used to view and convert receiver measurements to the field strength at an antenna or voltage developed at the LISN measurement port, which is then compared directly with the appropriate specification limit. This provides faster, more accurate readings by performing the conversions described under Sample Calculations within the Test Procedures section of this report. Results are printed in a graphic and/or tabular format, as appropriate. A personal computer is used to record all measurements made with the receivers. The software used for radiated and conducted emissions measurements is NTS EMI Test Software (rev 2.10)

LINE IMPEDANCE STABILIZATION NETWORK (LISN)

Line conducted measurements utilize a fifty microhenry Line Impedance Stabilization Network as the monitoring point. The LISN used also contains a 250 uH CISPR adapter. This network provides for calibrated radio frequency noise measurements by the design of the internal low pass and high pass filters on the EUT and measurement ports, respectively.

FILTERS/ATTENUATORS

External filters and precision attenuators are often connected between the receiving antenna or LISN and the receiver. This eliminates saturation effects and non-linear operation due to high amplitude transient events.

ANTENNAS

A loop antenna is used below 30 MHz. For the measurement range 30 MHz to 1000 MHz either a combination of a biconical antenna and a log periodic or a bi-log antenna is used. Above 1000 MHz, horn antennas are used. The antenna calibration factors to convert the received voltage to an electric field strength are included with appropriate cable loss and amplifier gain factors to determine an overall site factor, which is then programmed into the test receivers or incorporated into the test software.

ANTENNA MAST AND EQUIPMENT TURNTABLE

The antennas used to measure the radiated electric field strength are mounted on a non-conductive antenna mast equipped with a motor-drive to vary the antenna height. Measurements below 30 MHz are made with the loop antenna at a fixed height of 1m above the ground plane.

ANSI C63.10 specifies that the test height above ground for table mounted devices shall be 80 centimeters. Floor mounted equipment shall be placed on the ground plane if the device is normally used on a conductive floor or separated from the ground plane by insulating material from 3 to 12 mm if the device is normally used on a non-conductive floor as specified in ANSI C63.4. During radiated measurements, the EUT is positioned on a motorized turntable in conformance with this requirement.

INSTRUMENT CALIBRATION

All test equipment is regularly checked to ensure that performance is maintained in accordance with the manufacturer's specifications. All antennas are calibrated at regular intervals with respect to tuned half-wave dipoles. An exhibit of this report contains the list of test equipment used and calibration information.

TEST PROCEDURES

EUT AND CABLE PLACEMENT

The regulations require that interconnecting cables be connected to the available ports of the unit and that the placement of the unit and the attached cables simulate the worst case orientation that can be expected from a typical installation, so far as practicable. To this end, the position of the unit and associated cabling is varied within the guidelines of ANSI C63.10, and the worst-case orientation is used for final measurements.

CONDUCTED EMISSIONS

Conducted emissions are measured at the plug end of the power cord supplied with the EUT. Excess power cord length is wrapped in a bundle between 30 and 40 centimeters in length near the center of the cord. Preliminary measurements are made to determine the highest amplitude emission relative to the specification limit for all the modes of operation. Placement of system components and varying of cable positions are performed in each mode. A final peak mode scan is then performed in the position and mode for which the highest emission was noted on all current carrying conductors of the power cord.

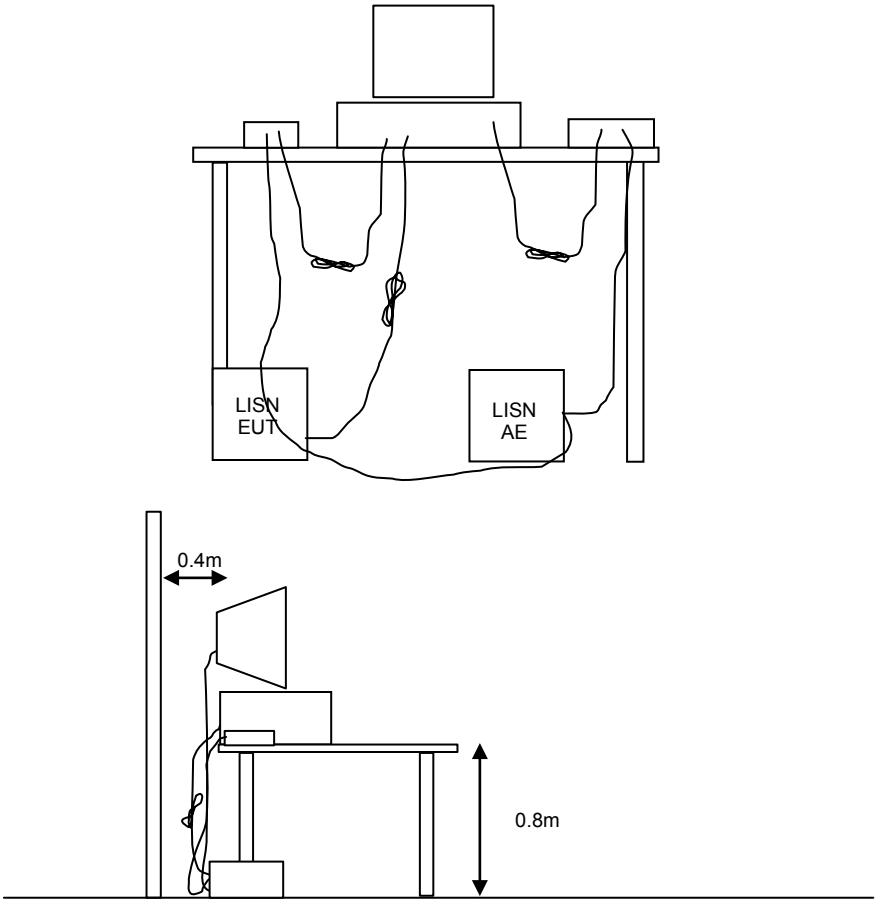


Figure 1 Typical Conducted Emissions Test Configuration

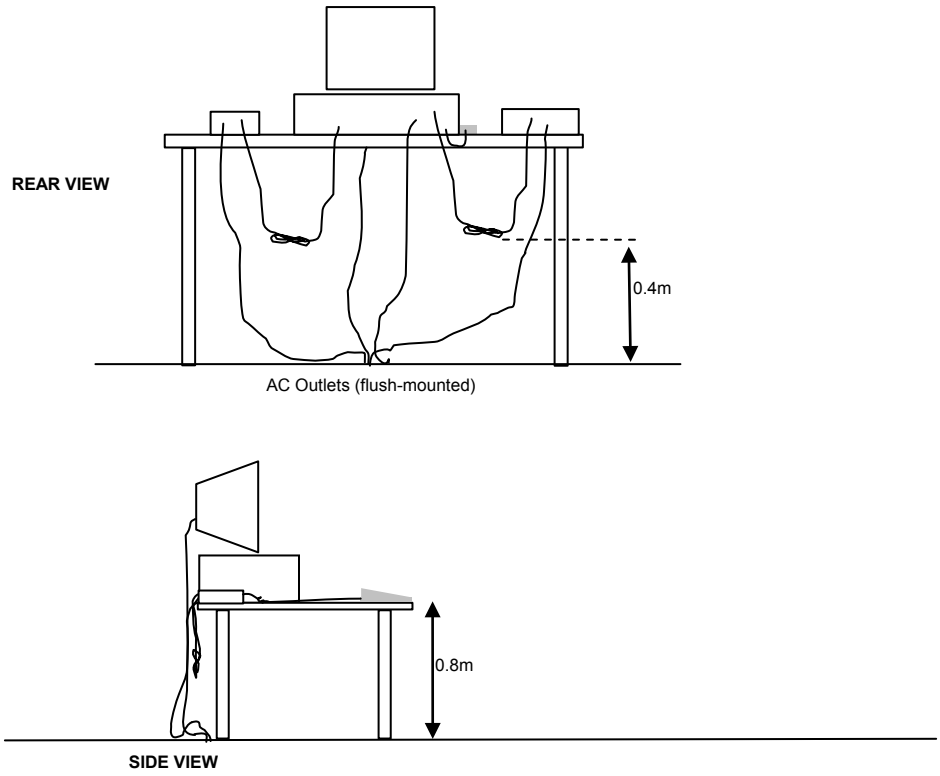
RADIATED EMISSIONS

A preliminary scan of the radiated emissions is performed in which all significant EUT frequencies are identified with the system in a nominal configuration. At least two scans are performed, one scan for each antenna polarization (horizontal and vertical; loop parallel and perpendicular to the EUT). During the preliminary scans, the EUT is rotated through 360˚, the antenna height is varied (for measurements above 30 MHz) and cable positions are varied to determine the highest emission relative to the limit. Preliminary scans may be performed in a fully anechoic chamber for the purposes of identifying the frequencies of the highest emissions from the EUT.

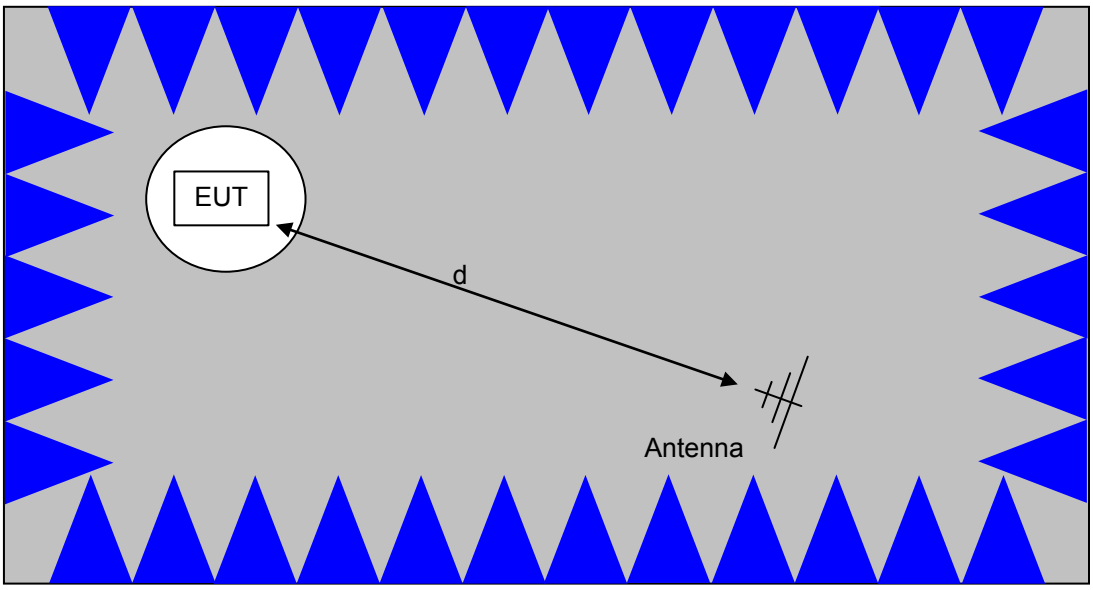
A speaker is provided in the receiver to aid in discriminating between EUT and ambient emissions. Other methods used during the preliminary scan for EUT emissions involve scanning with near field magnetic loops, monitoring I/O cables with RF current clamps, and cycling power to the EUT.

Final maximization is a phase in which the highest amplitude emissions identified in the spectral search are viewed while the EUT azimuth angle is varied from 0 to 360 degrees relative to the receiving antenna. The azimuth, which results in the highest emission is then maintained while varying the antenna height from one to four meters (for measurements above 30 MHz, measurements below 30 MHz are made with the loop antenna at a fixed height of 1m). The result is the identification of the highest amplitude for each of the highest peaks. Each recorded level is corrected in the receiver using appropriate factors for cables, connectors, antennas, and preamplifier gain.

When testing above 18 GHz, the receive antenna is located at 1meter from the EUT and the antenna height is restricted to a maximum of 2.5 meters.

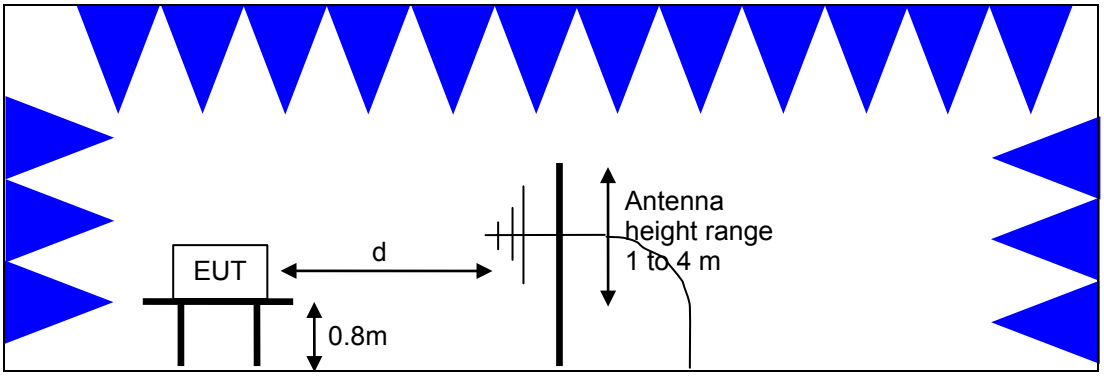


Typical Test Configuration for Radiated Field Strength Measurements



The anechoic materials on the walls and ceiling ensure compliance with the normalized site attenuation requirements of CISPR 16 / CISPR 22 / ANSI C63.4 for an alternate test site at the measurement distances used.

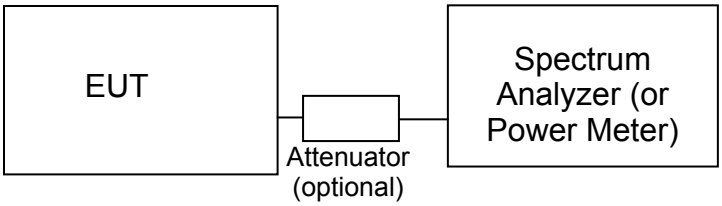
Floor-standing equipment is placed on the floor with insulating supports between the unit and the ground plane.



Test Configuration for Radiated Field Strength Measurements
Semi-Anechoic Chamber, Plan and Side Views

CONDUCTED EMISSIONS FROM ANTENNA PORT

Direct measurements of power, bandwidth and power spectral density are performed, where possible, with the antenna port of the EUT connected to either the power meter or spectrum analyzer via a suitable attenuator and/or filter. These are used to ensure that the front end of the measurement instrument is not overloaded by the fundamental transmission.



Test Configuration for Antenna Port Measurements

Measurement bandwidths (video and resolution) are set in accordance with the relevant standards and NTS Silicon Valley's test procedures for the type of radio being tested. When power measurements are made using a resolution bandwidth less than the signal bandwidth the power is calculated by summing the power across the signal bandwidth using either the analyzer channel power function or by capturing the trace data and calculating the power using software. In both cases the summed power is corrected to account for the equivalent noise bandwidth (ENBW) of the resolution bandwidth used.

If power averaging is used (typically for certain digital modulation techniques), the EUT is configured to transmit continuously. Power averaging is performed using either the built-in function of the analyzer or, if the analyzer does not feature power averaging, using external software. In both cases the average power is calculated over a number of sweeps (typically 100). When the EUT cannot be configured to continuously transmit then either the analyzer is configured to perform a gated sweep to ensure that the power is averaged over periods that the device is transmitting or power averaging is disabled and a max-hold feature is used.

If a power meter is used to make output power measurements the sensor head type (peak or average) is stated in the test data table.

BANDWIDTH MEASUREMENTS

The 6dB, 20dB, 26dB and/or 99% signal bandwidth are measured using the bandwidths recommended by ANSI C63.10 and RSS GEN.

SPECIFICATION LIMITS AND SAMPLE CALCULATIONS

The limits for conducted emissions are given in units of microvolts, and the limits for radiated emissions are given in units of microvolts per meter at a specified test distance. Data is measured in the logarithmic form of decibels relative to one microvolt, or dB microvolts (dBuV). For radiated emissions, the measured data is converted to the field strength at the antenna in dB microvolts per meter (dBuV/m). The results are then converted to the linear forms of uV and uV/m for comparison to published specifications.

For reference, converting the specification limits from linear to decibel form is accomplished by taking the base ten logarithm, then multiplying by 20. These limits in both linear and logarithmic form are as follows:

CONDUCTED EMISSIONS SPECIFICATION LIMITS: FCC 15.207; FCC 15.107(a), RSS GEN

The table below shows the limits for the emissions on the AC power line from an intentional radiator and a receiver.

Frequency (MHz)	Average Limit (dBuV)	Quasi Peak Limit (dBuV)
0.150 to 0.500	Linear decrease on logarithmic frequency axis between 56.0 and 46.0	Linear decrease on logarithmic frequency axis between 66.0 and 56.0
0.500 to 5.000	46.0	56.0
5.000 to 30.000	50.0	60.0

GENERAL TRANSMITTER RADIATED EMISSIONS SPECIFICATION LIMITS

The table below shows the limits for the spurious emissions from transmitters that fall in restricted bands[1].

Frequency Range (MHz)	Limit (uV/m)	Limit (dBuV/m @ 3m)
0.009-0.490	$2400/F_{KHz}$ @ 300m	$67.6-20*\log_{10}(F_{KHz})$ @ 300m
0.490-1.705	$24000/F_{KHz}$ @ 30m	$87.6-20*\log_{10}(F_{KHz})$ @ 30m
1.705 to 30	30 @ 30m	29.5 @ 30m
30 to 88	100 @ 3m	40 @ 3m
88 to 216	150 @ 3m	43.5 @ 3m
216 to 960	200 @ 3m	46.0 @ 3m
Above 960	500 @ 3m	54.0 @ 3m

[1] The restricted bands are detailed in FCC 15.205 and RSS-Gen Table 6

FCC 15.407 (a) OUTPUT POWER LIMITS

The table below shows the limits for output power and output power density.

Operating Frequency (MHz)	Output Power	Power Spectral Density
5150 – 5250	1Watt (30 dBm)	17 dBm/MHz
5725 – 5825	1 Watt (30 dBm)	30 dBm/500kHz

For system using antennas with gains exceeding 6dBi, the output power and power spectral density limits are reduced by 1dB for every dB the antenna gain exceeds 6dBi.

SPURIOUS EMISSIONS LIMITS –UNII and LELAN DEVICES

The spurious emissions limits for signals below 1GHz are the FCC/RSS-Gen general limits. For emissions above 1GHz, signals in restricted bands are subject to the FCC/RSS-Gen general limits. All other signals have a limit of –27dBm/MHz, which is field strength of 68.3dBuV/m/MHz at a distance of 3m. For devices operating in the 5725-5850 MHz bands under the LELAN/UNII rules, the limit within 10MHz of the allocated band is increased to –17dBm/MHz.

SAMPLE CALCULATIONS - CONDUCTED EMISSIONS

Receiver readings are compared directly to the conducted emissions specification limit (decibel form) as follows:

$$R_r - S = M$$

where:
R_r = Receiver Reading in dBuV
S = Specification Limit in dBuV
M = Margin to Specification in +/- dB

SAMPLE CALCULATIONS - RADIATED EMISSIONS

Receiver readings are compared directly to the specification limit (decibel form). The receiver internally corrects for cable loss, preamplifier gain, and antenna factor. The calculations are in the reverse direction of the actual signal flow, thus cable loss is added and the amplifier gain is subtracted. The Antenna Factor converts the voltage at the antenna coaxial connector to the field strength at the antenna elements.

A distance factor, when used for electric field measurements above 30MHz, is calculated by using the following formula:

$$F_d = 20*LOG_{10} (D_m/D_s)$$

where:
F_d = Distance Factor in dB
D_m = Measurement Distance in meters
D_s = Specification Distance in meters

For electric field measurements below 30MHz the extrapolation factor is either determined by making measurements at multiple distances or a theoretical value is calculated using the formula:

$$F_d = 40*LOG_{10} (D_m/D_s)$$

Measurement Distance is the distance at which the measurements were taken and Specification Distance is the distance at which the specification limits are based. The antenna factor converts the voltage at the antenna coaxial connector to the field strength at the antenna elements.

The margin of a given emission peak relative to the limit is calculated as follows:

$$R_c = R_r + F_d$$

and

$$M = R_c - L_s$$

where:
R_r = Receiver Reading in dBuV/m
F_d = Distance Factor in dB
R_c = Corrected Reading in dBuV/m
L_s = Specification Limit in dBuV/m
M = Margin in dB Relative to Spec

SAMPLE CALCULATIONS - FIELD STRENGTH TO EIRP CONVERSION

Where the radiated electric field strength is expressed in terms of the equivalent isotropic radiated power (eirp), or where a field strength measurement of output power is made in lieu of a direct measurement, the following formula is used to convert between eirp and field strength at a distance of d (meters) from the equipment under test:

$$E = \frac{1000000 \sqrt{30 P}}{d} \quad \text{microvolts per meter}$$

where P is the eirp (Watts)

For a measurement at 3m the conversion from a logarithmic value for field strength (dBuV/m) to an eirp power (dBm) is -95.3dB.

Appendix A Test Equipment Calibration Data

Manufacturer	Description	Model	Asset #	Calibrated	Cal Due
Radiated Emissions, 1000 - 18,000 MHz, 02-May-16					
EMCO	Antenna, Horn, 1-18GHz	3115	868	6/26/2014	6/26/2016
Hewlett Packard	High Pass filter, 8.2 GHz	P/N 84300-80039	1152	7/10/2015	7/10/2016
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB7	1538	12/19/2015	12/19/2016
Hewlett Packard	Microwave Preamplifier, 1-26.5GHz	8449B	2199	10/9/2015	10/9/2016
Micro-Tronics	Band Reject Filter, 5150-5350 MHz	BRC50703-02	2239	9/16/2015	9/16/2016
Hewlett Packard	Spectrum Analyzer (SA40) Purple 9 kHz - 40 GHz,	8564E (84125C)	2415	3/19/2016	3/19/2017
Radiated Emissions, 1000 - 18,000 MHz, 04-May-16					
Narda West	High Pass Filter, 8 GHz	HPF 180	821	1/27/2016	1/27/2017
Hewlett Packard	Microwave Preamplifier, 1-26.5GHz	8449B	870	1/21/2016	1/21/2017
Hewlett Packard	Spectrum Analyzer (SA40) Red 30 Hz -40 GHz	8564E (84125C)	1148	10/17/2015	10/17/2016
Micro-Tronics	Band Reject Filter, 5725-5875 MHz	BRC50705-02	1682	7/8/2015	7/8/2016
Micro-Tronics	Band Reject Filter, 5470-5725 MHz	BRC50704-02	1730	7/10/2015	7/10/2016
EMCO	Antenna, Horn, 1-18 GHz	3115	2733	11/18/2014	11/18/2016
Radiated Emissions, 1000 - 40,000 MHz, 09-May-16					
NTS	NTS EMI Software (rev 2.10)	N/A	0		N/A
Hewlett Packard	Microwave Preamplifier, 1-26.5GHz	8449B	870	1/21/2016	1/21/2017
HP / Miteq	SA40 Head (Red)	TTA1840-45-5P-HG-S	1145	7/17/2015	7/17/2016
Hewlett Packard	Spectrum Analyzer (SA40) Red 30 Hz -40 GHz	8564E (84125C)	1148	10/17/2015	10/17/2016
Micro-Tronics	Band Reject Filter, 5725-5875 MHz	BRC50705-02	1682	7/8/2015	7/8/2016
A. H. Systems	Purple System Horn, 18-40GHz	SAS-574, p/n: 2581	2160	8/28/2014	8/28/2017
EMCO	Antenna, Horn, 1-18 GHz	3115	2733	11/18/2014	11/18/2016
Radiated Spurious Emissions, 1000 - 18,000 MHz, 11-May-16					
NTS	NTS EMI Software (rev 2.10)	N/A	0		N/A
Hewlett Packard	Microwave Preamplifier, 1-26.5GHz	8449B	870	1/21/2016	1/21/2017
Hewlett Packard	Spectrum Analyzer (SA40) Red 30 Hz -40 GHz	8564E (84125C)	1148	10/17/2015	10/17/2016
Micro-Tronics	Band Reject Filter, 5725-5875 MHz	BRC50705-02	1682	7/8/2015	7/8/2016
Micro-Tronics	Band Reject Filter, 5470-5725 MHz	BRC50704-02	1730	7/10/2015	7/10/2016
Micro-Tronics	Band Reject Filter, 5150-5350 MHz	BRC50703-02	2239	9/16/2015	9/16/2016
EMCO	Antenna, Horn, 1-18 GHz	3115	2733	11/18/2014	11/18/2016

Manufacturer	Description	Model	Asset #	Calibrated	Cal Due
Radiated Emissions, 1000 - 40,000 MHz, 11-May-16					
Hewlett Packard	Microwave Preamplifier, 1-26.5GHz	8449B	870	1/21/2016	1/21/2017
HP / Miteq	SA40 Head (Red)	TTA1840-45-5P-HG-S	1145	7/17/2015	7/17/2016
Hewlett Packard	Spectrum Analyzer (SA40) Red 30 Hz -40 GHz	8564E (84125C)	1148	10/17/2015	10/17/2016
Hewlett Packard	High Pass filter, 8.2 GHz	P/N 84300-80039	1152	7/10/2015	7/10/2016
A. H. Systems	Purple System Horn, 18-40GHz	SAS-574, p/n: 2581	2160	8/28/2014	8/28/2017
EMCO	Antenna, Horn, 1-18 GHz	3115	2733	11/18/2014	11/18/2016
Radiated Emissions, 1000 - 18,000 MHz, 17-May-16					
Hewlett Packard	Microwave Preamplifier, 1-26.5GHz	8449B	870	1/21/2016	1/21/2017
Hewlett Packard	Spectrum Analyzer (SA40) Red 30 Hz -40 GHz	8564E (84125C)	1148	10/17/2015	10/17/2016
Hewlett Packard	High Pass filter, 8.2 GHz	P/N 84300-80039	1152	7/10/2015	7/10/2016
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB7	1538	12/19/2015	12/19/2016
EMCO	Antenna, Horn, 1-18 GHz	3115	2733	11/18/2014	11/18/2016
Radiated Emissions, 30 - 1,000 MHz, 18-May-16					
NTS	NTS EMI Software (rev 2.10)	N/A	0		N/A
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB7	1538	12/19/2015	12/19/2016
Sunol Sciences	Biconilog, 30-3000 MHz	JB3	1549	6/2/2015	6/2/2017
Hewlett Packard	9KHz-1300MHz pre-amp	8447F	2777	1/26/2016	1/26/2017
Radiated Emissions, 1000 - 6,500 MHz, 18-May-16					
NTS	NTS EMI Software (rev 2.10)	N/A	0		N/A
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB7	1538	12/19/2015	12/19/2016
EMCO	Antenna, Horn, 1-18 GHz	3115	2733	11/18/2014	11/18/2016
Radiated Emissions, 1000 - 6,000 MHz, 18-May-16					
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB7	1538	12/19/2015	12/19/2016
EMCO	Antenna, Horn, 1-18 GHz	3115	2733	11/18/2014	11/18/2016
Radiated Emissions, 1000 - 6,000 MHz, 19-May-16					
EMCO	Antenna, Horn, 1-18 GHz	3115	487	7/29/2014	7/29/2016
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB7	1538	12/19/2015	12/19/2016
Radiated Emissions, 1000 - 6,000 MHz, 20-May-16					
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB7	1538	12/19/2015	12/19/2016
EMCO	Antenna, Horn, 1-18 GHz	3115	2733	11/18/2014	11/18/2016
Radio Antenna Port (Power and Spurious Emissions), 24-May-16					
Agilent Technologies	PSA, Spectrum Analyzer, (installed options, 111, 115, 123, 1DS, B7J, HYX,	E4446A	2139	6/22/2015	6/22/2016

Manufacturer	Description	Model	Asset #	Calibrated	Cal Due
Radiated Emissions, 1000 - 40,000 MHz, 24-Aug-16					
Hewlett Packard	High Pass filter, 8.2 GHz	P/N 84300-80039	1156	5/5/2016	5/5/2017
EMCO	Antenna, Horn, 1-18 GHz	3115	1561	7/8/2016	7/8/2018
Micro-Tronics	Band Reject Filter, 5725-5875 MHz	BRC50705-02	1728	5/11/2016	5/11/2017
HP / Miteq	SA40 Head (Purple)	TTA1840-45-5P-HG-S	1772	12/21/2015	N/A
Hewlett Packard	Microwave Preamplifier, 1-26.5GHz	8449B	1780	10/9/2015	10/9/2016
A. H. Systems	Spare System Horn, 18-40GHz	SAS-574, p/n: 2581	2162	7/29/2015	7/29/2017
Micro-Tronics	Band Reject Filter, 5150-5350 MHz	BRC50703-02	2239	9/16/2015	9/16/2016
Micro-Tronics	Band Reject Filter, 5470-5725 MHz	BRC50704-02	2240	9/16/2015	9/16/2016
Hewlett Packard	Spectrum Analyzer (SA40) Purple 9 kHz - 40 GHz,	8564E (84125C)	2415	3/19/2016	3/19/2017
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB7	1538	12/19/2015	12/19/2016
Radiated Emissions, 1,000 - 18,000 MHz, 02-Sep-16					
Hewlett Packard	High Pass filter, 8.2 GHz (Blu System)	P/N 84300-80039 (84125C)	1392	5/5/2016	5/5/2017
EMCO	Antenna, Horn, 1-18 GHz	3115	1561	7/8/2016	7/8/2018
Hewlett Packard	Microwave Preamplifier, 1-26.5GHz	8449B	1780	10/9/2015	10/9/2016
Micro-Tronics	Band Reject Filter, 5725-5875 MHz	BRC50705-02	2241	9/16/2015	9/16/2016
Hewlett Packard	Spectrum Analyzer (SA40) Purple 9 kHz - 40 GHz,	8564E (84125C)	2415	3/19/2016	3/19/2017
Radio Antenna Port (Power and Spurious Emissions), 19-23-Sep-16					
Agilent Technologies	3Hz -44GHz PSA Spectrum Analyzer	E4446A	2796	5/6/2016	5/6/2017
NTS	NTS UNII Power Software (rev 3.8)	N/A	0		N/A
NTS	NTS Capture Analyzer Software (rev 3.8)	N/A	0		N/A
Radio Antenna Port (Power and Spurious Emissions), 27 and 28-Sep-16					
Agilent Technologies	3Hz -44GHz PSA Spectrum Analyzer	E4446A	2796	5/6/2016	5/6/2017
NTS	NTS UNII Power Software (rev 3.8)	N/A	0		N/A
NTS	NTS Capture Analyzer Software (rev 3.8)	N/A	0		N/A
Radiated Emissions, 1,000 - 12,000 MHz, 06-Oct-16 & 07-Oct-16					
EMCO	Antenna, Horn, 1-18GHz	3115	868	6/30/2016	6/30/2018
Hewlett Packard	Microwave Preamplifier, 1-26.5GHz	8449B	870	1/21/2016	1/21/2017
Hewlett Packard	Spectrum Analyzer (SA40) Red 30 Hz -40 GHz	8564E (84125C)	1148	10/17/2015	10/17/2016
Micro-Tronics	Band Reject Filter, 2400-2500 MHz	BRM50702-02	1683	6/29/2016	6/29/2017

Manufacturer	Description	Model	Asset #	Calibrated	Cal Due
Radiated Spurious Emissions, 1000 - 25,000 MHz, 11-Oct-16					
NTS	NTS EMI Software (rev 2.10)	N/A	0		N/A
EMCO	Antenna, Horn, 1-18GHz	3115	868	6/30/2016	6/30/2018
Hewlett Packard	Microwave Preamplifier, 1-26.5GHz	8449B	870	1/21/2016	1/21/2017
HP / Miteq	SA40 Head (Red)	TTA1840-45-5P-HG-S	1145	8/24/2016	8/24/2017
Hewlett Packard	Spectrum Analyzer (SA40) Red 30 Hz -40 GHz	8564E (84125C)	1148	10/17/2015	10/17/2016
Micro-Tronics	Band Reject Filter, 2400-2500 MHz	BRM50702-02	1683	6/29/2016	6/29/2017
A. H. Systems	Purple System Horn, 18-40GHz	SAS-574, p/n: 2581	2160	8/28/2014	8/28/2017
Radiated Emissions, 1,000 - 18,000 MHz, 13-Oct-16					
EMCO	Antenna, Horn, 1-18GHz	3115	868	6/30/2016	6/30/2018
Hewlett Packard	Microwave Preamplifier, 1-26.5GHz	8449B	870	1/21/2016	1/21/2017
Hewlett Packard	Spectrum Analyzer (SA40) Red 30 Hz -40 GHz	8564E (84125C)	1148	10/17/2015	11/17/2016
Hewlett Packard	High Pass filter, 8.2 GHz	P/N 84300-80039	1152	6/28/2016	6/28/2017
Micro-Tronics	Band Reject Filter, 2400-2500 MHz	BRM50702-02	2238	9/19/2016	9/19/2017
Micro-Tronics	Band Reject Filter, 5150-5350 MHz	BRC50703-02	2251	9/19/2016	9/19/2017
Rohde & Schwarz	EMI Test Receiver, 20 Hz-40 GHz	ESIB40 (1088.7490.40)	2493	2/20/2016	2/20/2017
Radiated Emissions, 30 - 1,000 MHz, 14-Oct-16					
Micro-Tronics	Band Reject Filter, 5725-5875 MHz	BRC50705-02	1682	5/9/2016	5/9/2017
Micro-Tronics	Band Reject Filter, 2400-2500 MHz	BRM50702-02	1683	6/29/2016	6/29/2017
Micro-Tronics	Band Reject Filter, 5150-5350 MHz	BRC50703-02	2251	9/19/2016	9/19/2017
Rohde & Schwarz	EMI Test Receiver, 20 Hz-40 GHz	ESIB40 (1088.7490.40)	2493	2/20/2016	2/20/2017
Com-Power	Preamplifier, 1-1000 MHz	PAM-103	2885	9/16/2016	9/16/2017
Sunol Sciences	Biconilog, 30-3000 MHz	JB3	1657	7/27/2016	7/27/2018
Radio Antenna Port (Power and Spurious Emissions), 14-Oct-16					
Agilent Technologies	3Hz -44GHz PSA Spectrum Analyzer	E4446A	2796	5/6/2016	5/6/2017
Conducted Emissions - AC Power Ports, 20-Oct-16					
EMCO	LISN, 10 kHz-100 MHz	3825/2	1292	8/1/2016	8/1/2017
EMCO	LISN, 10 kHz-100 MHz	3825/2	1293	6/7/2016	6/7/2017
Rohde & Schwarz	Pulse Limiter	ESH3 Z2	1594	8/31/2016	8/31/2017
Rohde & Schwarz	EMI Test Receiver, 20 Hz-7 GHz	ESIB7	1756	6/29/2016	6/29/2017
Radio Antenna Port (Frequency Stability), 26-Oct-16					
NTS	NTS Capture Analyzer Software (rev 3.8)	N/A	0		N/A
Rohde & Schwarz	Signal Analyzer 20 Hz - 26.5 GHz	FSQ26	2327	6/17/2016	6/17/2017

Manufacturer	Description	Model	Asset #	Calibrated	Cal Due
Honeywell	Chart Recorder	DR45AT-1000-00-001-0 (Trueline)	2406	11/17/2015	11/17/2016
Envirotronics	Temperature/Humidity chamber	SH16C	3195		N/A

Appendix B Test Data

T101543 Pages 31 – 137

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Product	GFHD254	T-Log Number:	T101543
System Configuration:	-	Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Emissions Standard(s):	FCC 15.247 and 15.407	Class:	B
Immunity Standard(s):	-	Environment:	-

EMC Test Data

For The

Google, Inc.

Product

GFHD254

Date of Last Test: 10/20/2016

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	B

Conducted Emissions

(NTS Silicon Valley, Fremont Facility, Semi-Anechoic Chamber)

Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

Date of Test: 10/20/2016
Test Engineer: Rafael Varelas
Test Location: Fremont Chamber #3
Config. Used: 1
Config Change: None
EUT Voltage: 120V/60Hz

General Test Configuration

For tabletop equipment, the EUT was located on a wooden table inside the semi-anechoic chamber, 40 cm from a vertical coupling plane and 80cm from the LISN. A second LISN was used for all local support equipment. Remote support equipment was located outside of the semi-anechoic chamber. Any cables running to remote support equipment where routed through metal conduit and when possible passed through a ferrite clamp upon exiting the chamber.

Ambient Conditions:

Temperature: 23.2 °C
Rel. Humidity: 39 %

Summary of Results

Run #	Test Performed	Limit	Result	Margin
1	CE, AC Power,120V/60Hz	Class B	Pass	45.1 dBµV @ 0.447 MHz (-1.8 dB)

Modifications Made During Testing

No modifications were made to the EUT during testing

Deviations From The Standard

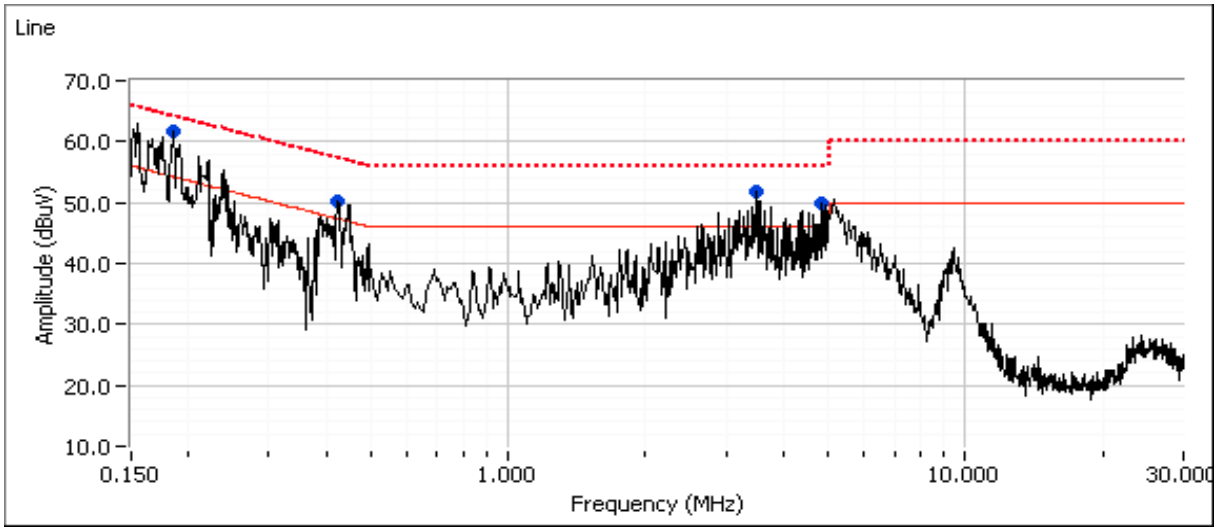
No deviations were made from the requirements of the standard.

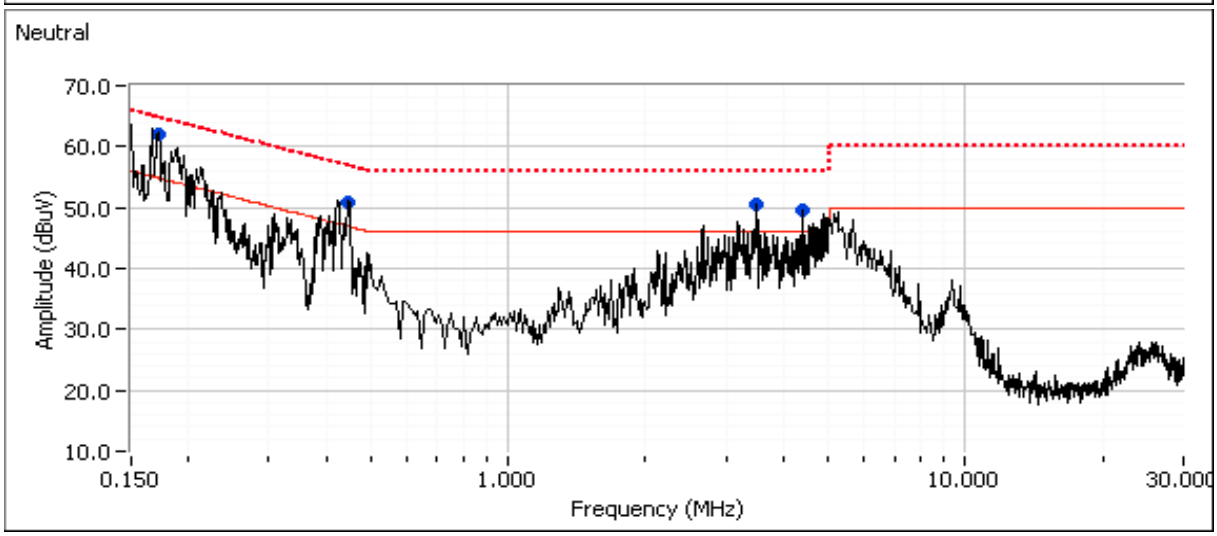
Sample Notes

Sample S/N: GTCFNS1630E0091
Driver:

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	B

Run #1: AC Power Port Conducted Emissions, 0.15 - 30MHz,120V/60Hz
The EUT was configured to transmit at 2440 MHz (BLE) and 5785 MHz (802.11a)





Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	B

Preliminary peak readings captured during pre-scan (peak readings vs. average limit)

Frequency	Level	AC	Class B		Detector	Comments
MHz	dBµV	Line	Limit	Margin	QP/Ave	
0.188	61.7	Line 1	54.2	7.5	Peak	
0.423	50.3	Line 1	47.4	2.9	Peak	
3.501	51.7	Line 1	46.0	5.7	Peak	
4.865	49.8	Line 1	46.0	3.8	Peak	
0.174	62.0	Neutral	54.8	7.2	Peak	
0.447	50.9	Neutral	46.9	4.0	Peak	
3.499	50.4	Neutral	46.0	4.4	Peak	
4.421	49.5	Neutral	46.0	3.5	Peak	

Final quasi-peak and average readings

Frequency	Level	AC	Class B		Detector	Comments
MHz	dBµV	Line	Limit	Margin	QP/Ave	
0.447	**45.1**	Neutral	46.9	**-1.8**	AVG	AVG (0.10s)
0.423	44.3	Line 1	47.4	-3.1	AVG	AVG (0.10s)
0.188	50.1	Line 1	54.1	-4.0	AVG	AVG (0.10s)
0.188	58.4	Line 1	64.1	-5.7	QP	QP (1.00s)
0.447	50.7	Neutral	56.9	-6.2	QP	QP (1.00s)
0.423	50.7	Line 1	57.4	-6.7	QP	QP (1.00s)
3.501	47.7	Line 1	56.0	-8.3	QP	QP (1.00s)
4.865	37.6	Line 1	46.0	-8.4	AVG	AVG (0.10s)
4.865	47.1	Line 1	56.0	-8.9	QP	QP (1.00s)
0.174	55.6	Neutral	64.8	-9.2	QP	QP (1.00s)
3.499	46.5	Neutral	56.0	-9.5	QP	QP (1.00s)
3.501	36.4	Line 1	46.0	-9.6	AVG	AVG (0.10s)
3.499	35.6	Neutral	46.0	-10.4	AVG	AVG (0.10s)
4.421	41.5	Neutral	56.0	-14.5	QP	QP (1.00s)
0.174	40.2	Neutral	54.8	-14.6	AVG	AVG (0.10s)
4.421	29.5	Neutral	46.0	-16.5	AVG	AVG (0.10s)

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	B

RSS-247, FCC 15.247, FCC 15.407 Radiated Spurious Emissions

Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

Date of Test: See below
Test Engineer: See below
Test Location: Fremont CH 5
Config. Used: 1
Config Change: None
EUT Voltage: 120V/60Hz

General Test Configuration

The EUT and all local support equipment were located on the turntable for radiated spurious emissions testing.
For radiated emissions testing the measurement antenna was located 3 meters from the EUT, unless otherwise noted.

Ambient Conditions:

Temperature: 21.8 °C
Rel. Humidity: 43 %

Summary of Results

Run #	Mode	Freq.	Power Setting	Passing Power Setting	Test Performed	Limit	Result / Margin
Simultaneous Tx operation							
1	BLE a	2440 5300	Max 15	Max 15	Radiated Emissions, 30 - 1000MHz	FCC 15.209 / 15.247 / 15 E	31.0 dBµV/m @ 75.51 MHz (-9.0 dB)
	BLE a	2440 5300	Max 15	Max 15	Radiated Emissions, 1 - 40 GHz		53.0 dBµV/m @ 21199.8 MHz (-1.0 dB)
2	BLE a	2440 5785	Max 19	Max 19	Radiated Emissions, 30 - 1000MHz		35.2 dBµV/m @ 226.92 MHz (-10.8 dB)
	BLE a	2440 5785	Max 19	Max 19	Radiated Emissions, 1 - 40 GHz		52.1 dBµV/m @ 4880.1 MHz (-1.9 dB)

Modifications Made During Testing

No modifications were made to the EUT during testing

Deviations From The Standard

No deviations were made from the requirements of the standard.

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	B

Procedure Comments:

Measurements performed in accordance with FCC KDB 789033
Peak measurements performed with: RBW=1MHz, VBW=3MHz, peak detector, max hold, auto sweep time
Unless otherwise stated/noted, emission has duty cycle ≥ 98% and was measured using RBW=1MHz, VBW=10Hz, peak detector, linear average mode, auto sweep time, max hold 50 traces. (method VB of KDB 789033)

Mode	Data Rate	Duty Cycle (x)	Constant DC?	T (ms)	Pwr Cor Factor*	Lin Volt Cor Factor**	Min VBW for FS (Hz)
BLE	1Mbps	62.6%	Yes	2.44	2.03	4.07	410
11a	6Mbps	90.1%	Yes	0.567	0.45	0.90	1764

Sample Notes

Sample S/N: GTCFNS1630E0091
Driver:
Antenna: Internal

Measurement Specific Notes:

Note 1:	For emissions outside of the restricted bands the limit is -27dBm/MHz eirp (68.3dBuV/m). The measurement method required is a peak measurement (RB=1MHz, VB≥3MHz, peak detector). Per KDB 789033 2) c) (i), compliance can be demonstrated by meeting the average and peak limits of 15.209, as an alternative.
Note 2:	Emission has constant duty cycle < 98%, average measurement performed: RBW=1MHz, VBW>1/T but not less than 10Hz, peak detector, linear averaging, auto sweep,max hold 50*1/DC traces (method VB of KDB 789033)

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	B

Run #1, Radiated Spurious Emissions

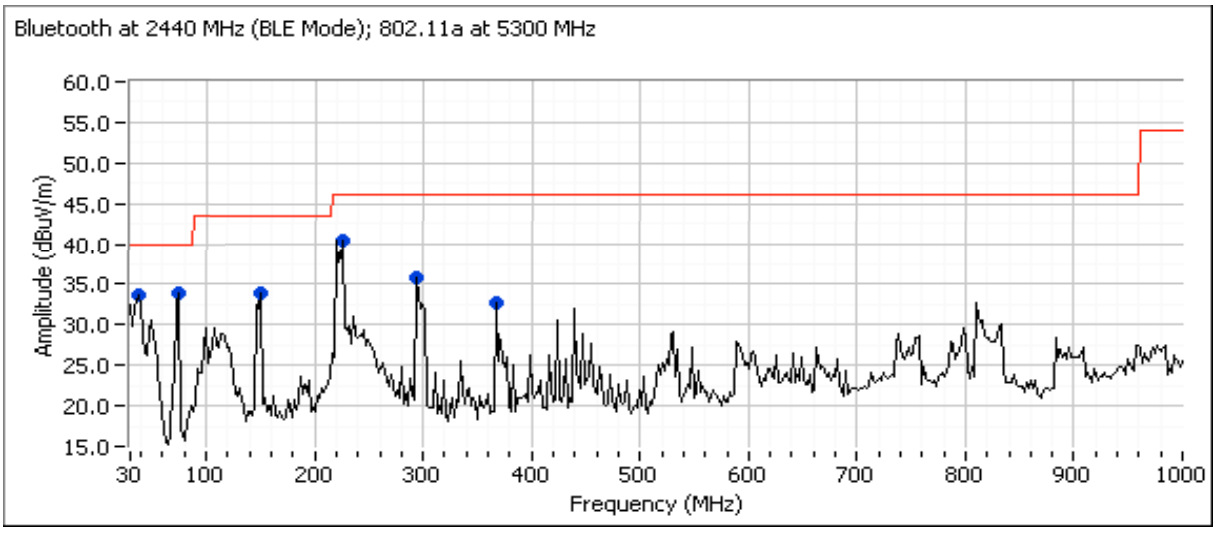
Date of Test: 10/13-14/16
Test Engineer: M. Birgani
Test Location: Chamber 5

Config. Used: 1
Config Change: -
EUT Voltage: 120V/ 60Hz

Freq:	2440	Mode:	BLE
Tx Chain:	-	Data Rate:	1Mbps
Freq:	5300	Mode:	11a
Tx Chain:	4Tx	Data Rate:	6Mbps

Run #1a: 30-1000MHz

Frequency	Level	Pol	15.209 / 15.247 / 15E		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
75.514	**31.0**	V	40.0	**-9.0**	QP	267	1.0	QP (1.00s)
223.709	35.4	H	46.0	-10.6	QP	200	1.0	QP (1.00s)
151.209	30.7	H	43.5	-12.8	QP	231	1.2	QP (1.00s)
296.014	29.9	H	46.0	-16.1	QP	191	1.9	QP (1.00s)
31.956	22.3	V	40.0	-17.7	QP	116	1.0	QP (1.00s)
370.370	23.8	H	46.0	-22.2	QP	214	1.5	QP (1.00s)



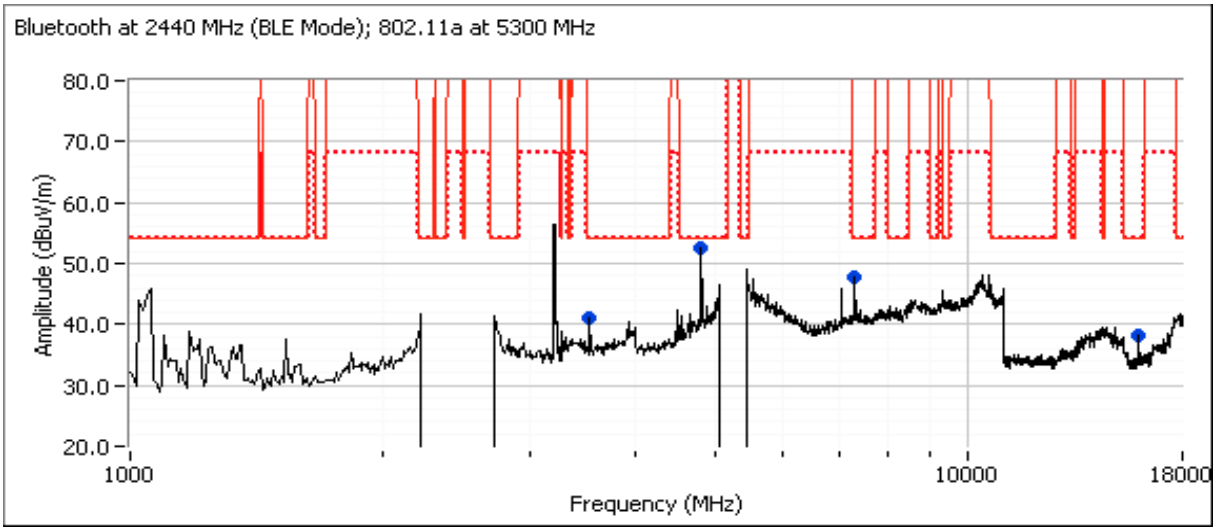
Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	B

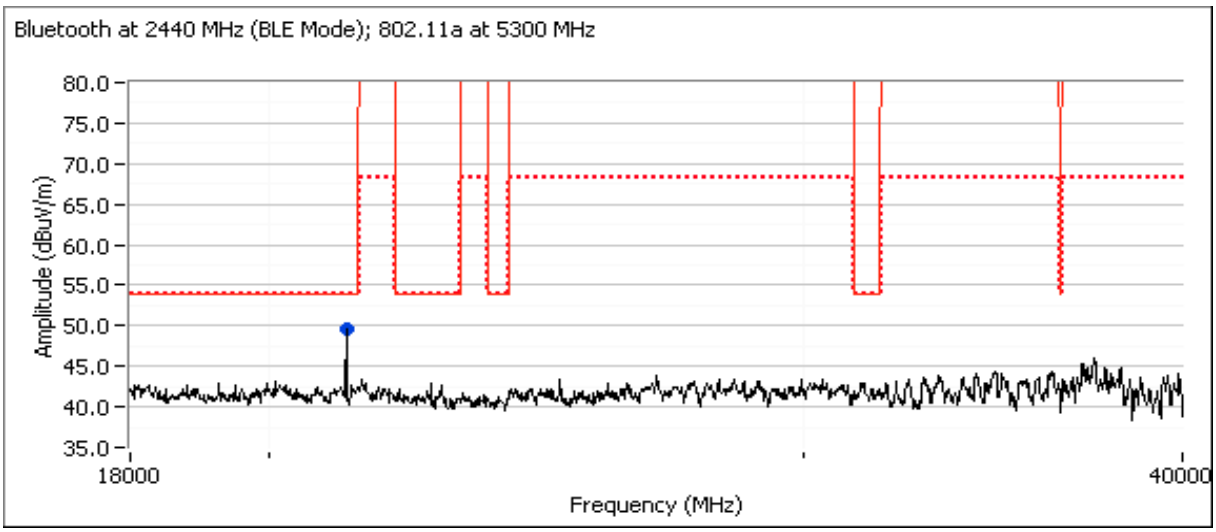
Run #1b: 1000-40000MHz

Freq:	2440	Mode:	BLE
Tx Chain:	-	Data Rate:	1Mbps
Freq:	5300	Mode:	11a
Tx Chain:	4Tx	Data Rate:	6Mbps

Frequency	Level	Pol	15.209 / 15E		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
21199.770	**53.0**	V	54.0	**-1.0**	PK	338	0.97	RB 1 MHz;VB 3 MHz;Peak
4880.080	52.1	H	54.0	-1.9	VAVG	295	1.67	BLE 2nd Harmonic
21199.770	47.0	V	54.0	-7.0	VAVG	338	0.97	RB 1 MHz;VB 3 kHz;Peak
3533.380	45.7	V	54.0	-8.3	PK	88	1.08	RB 1 MHz;VB 3 MHz;Peak
15899.800	42.9	V	54.0	-11.1	Avg	203	1.96	VB 3 kHz, note 2
3533.350	40.6	V	54.0	-13.4	VAVG	88	1.08	RB 1 MHz;VB 1 kHz;Peak
4880.530	54.6	H	74.0	-19.4	PK	295	1.67	BLE 2nd Harmonic
15900.270	52.2	V	74.0	-21.8	PK	203	1.96	

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	B





Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	B

Run #2, Radiated Spurious Emissions

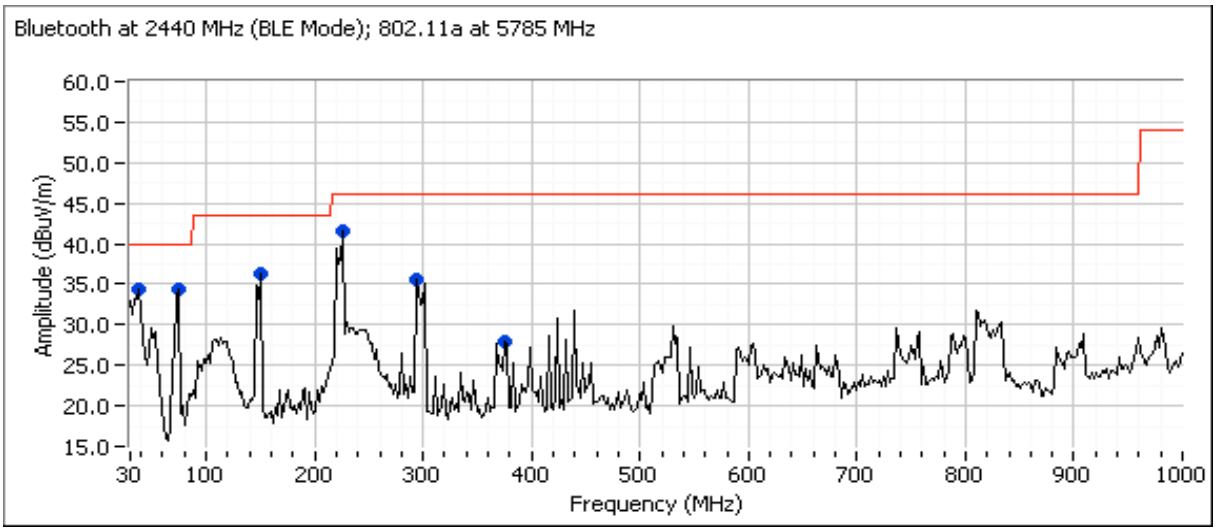
Date of Test: 10/13-14/16
Test Engineer: M. Birgani
Test Location: Chamber 5

Config. Used: 1
Config Change: -
EUT Voltage: 120V/ 60Hz

Freq:	2440	Mode:	BLE
Tx Chain:	-	Data Rate:	1Mbps
Freq:	5785	Mode:	11a
Tx Chain:	4Tx	Data Rate:	6Mbps

Run #2a: 30-1000MHz

Frequency	Level	Pol	15.209 / 15.247 / 15E		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
226.916	**35.2**	H	46.0	**-10.8**	QP	178	2.9	QP (1.00s)
75.152	27.4	V	40.0	-12.6	QP	242	1.0	QP (1.00s)
34.669	25.1	V	40.0	-14.9	QP	121	1.0	QP (1.00s)
149.378	27.6	H	43.5	-15.9	QP	59	1.1	QP (1.00s)
296.025	29.5	H	46.0	-16.5	QP	178	2.1	QP (1.00s)
384.060	21.4	H	46.0	-24.6	QP	173	1.6	QP (1.00s)



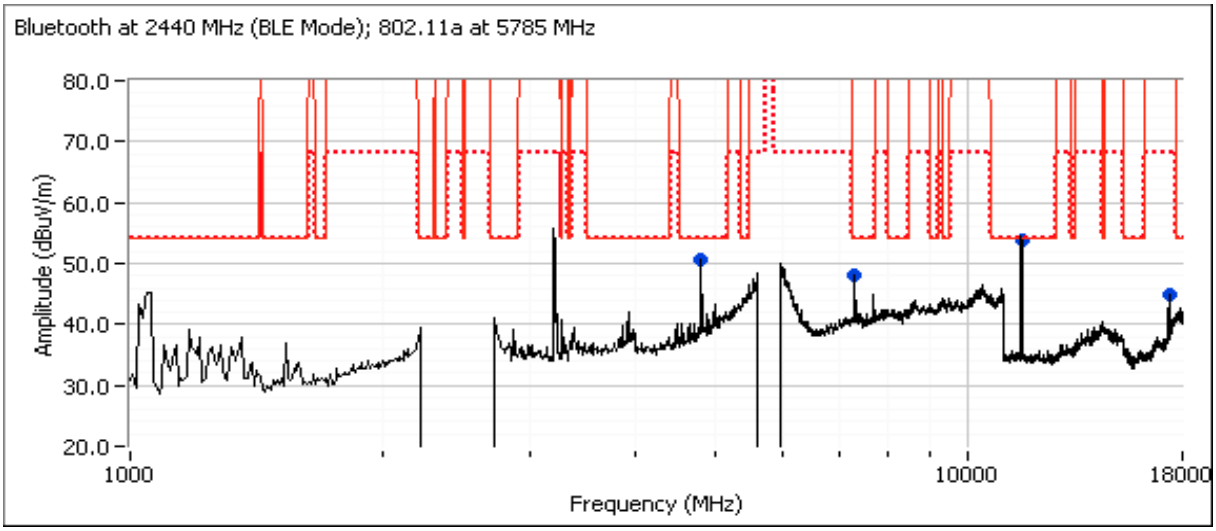
Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	B

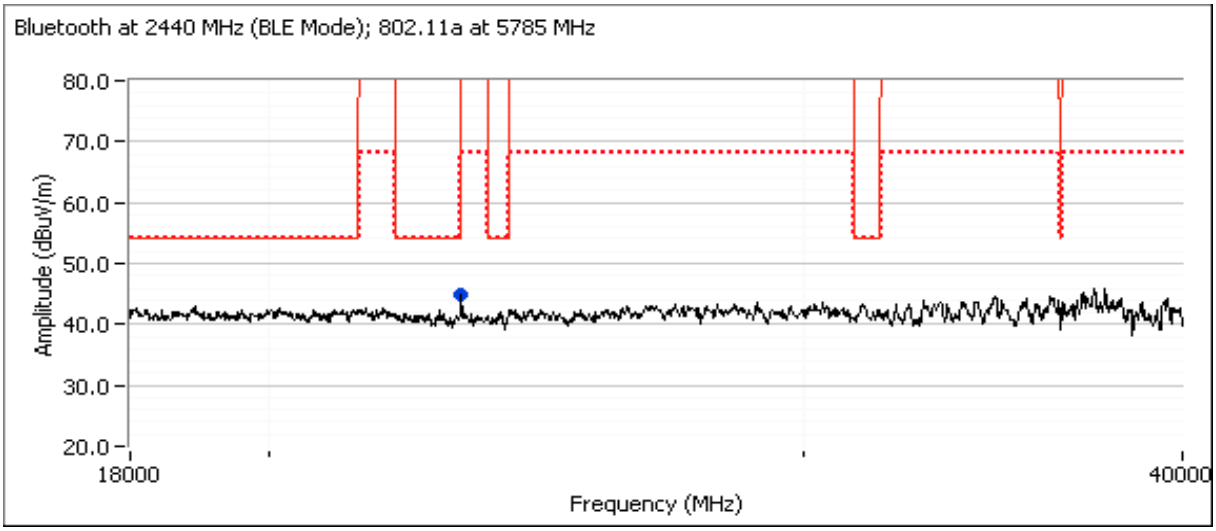
Run #2b: 1000-40000MHz

Freq:	2440	Mode:	BLE
Tx Chain:	-	Data Rate:	1Mbps
Freq:	5785	Mode:	11a
Tx Chain:	4Tx	Data Rate:	6Mbps

Frequency	Level	Pol	15.209 / 15E		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
4880.080	**52.1**	H	54.0	**-1.9**	VAVG	295	1.67	BLE 2nd Harmonic
11569.940	50.6	H	54.0	-3.4	Avg	130	1.11	VB 3 kHz, note 2.
17359.600	64.0	H	68.3	-4.3	PK	242	2.49	
11569.940	61.4	H	74.0	-12.6	PK	130	1.11	
23139.830	51.7	V	68.3	-16.6	PK	144	1.51	
4880.530	54.6	H	74.0	-19.4	PK	295	1.67	BLE 2nd Harmonic

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	B





Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

FCC Part 15
Frequency Stability

Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

General Test Configuration

All measurements are made with the EUT's rf port connected to the measurement instrument via an attenuator. All amplitude measurements are adjusted to account for the attenuation between EUT and measuring instrument. For frequency stability measurements the EUT was placed inside an environmental chamber.

Ambient Conditions:

Temperature: 22 °C
Rel. Humidity: 47 %

Run #			Test Performed	Limit	Pass / Fail	
1			Frequency Stability	Stays in band	Pass	

Modifications Made During Testing

No modifications were made to the EUT during testing

Deviations From The Standard

No deviations were made from the requirements of the standard.

Date of Test: 10/26/2016
Test Engineer: Mehran Birgani
Test Location: Lab 3

Config. Used: Conducted
Config Change: None
EUT Voltage: 120V/60Hz

Sample Notes

Sample S/N: GTCFNS1630E0091
Driver:

°

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Run #1: Frequency Stability

Nominal Frequency: 5200 MHz

Frequency Stability Over Temperature

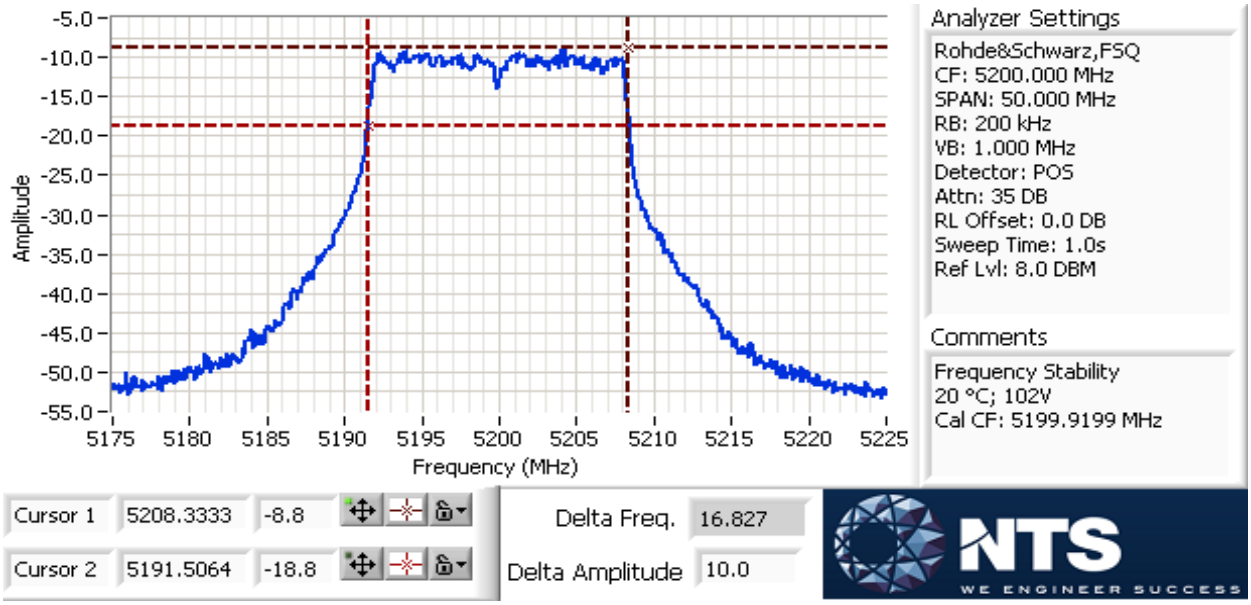
The EUT was soaked at each temperature for a minimum of 30 minutes prior to starting the transmitter and making the measurements to ensure the EUT and chamber had stabilized at that temperature.

Temperature	Frequency Measured	Drift	
(Celsius)	(MHz)	(Hz)	(ppm)
0	5199.9599	-40100	-7.7
20	5199.9199	-80100	-15.4
50	5199.9199	-80100	-15.4
	Worst case:	-80100	-15.4

Frequency Stability Over Input Voltage

Nominal Voltage is 120Vac.

Voltage	Frequency Measured	Drift	
(DC)	(MHz)	(Hz)	(ppm)
102.00	5199.9199	-80100	-15.4
138.00	5199.9199	-80100	-15.4
	Worst case:	-80100	-15.4



Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Duty Cycle

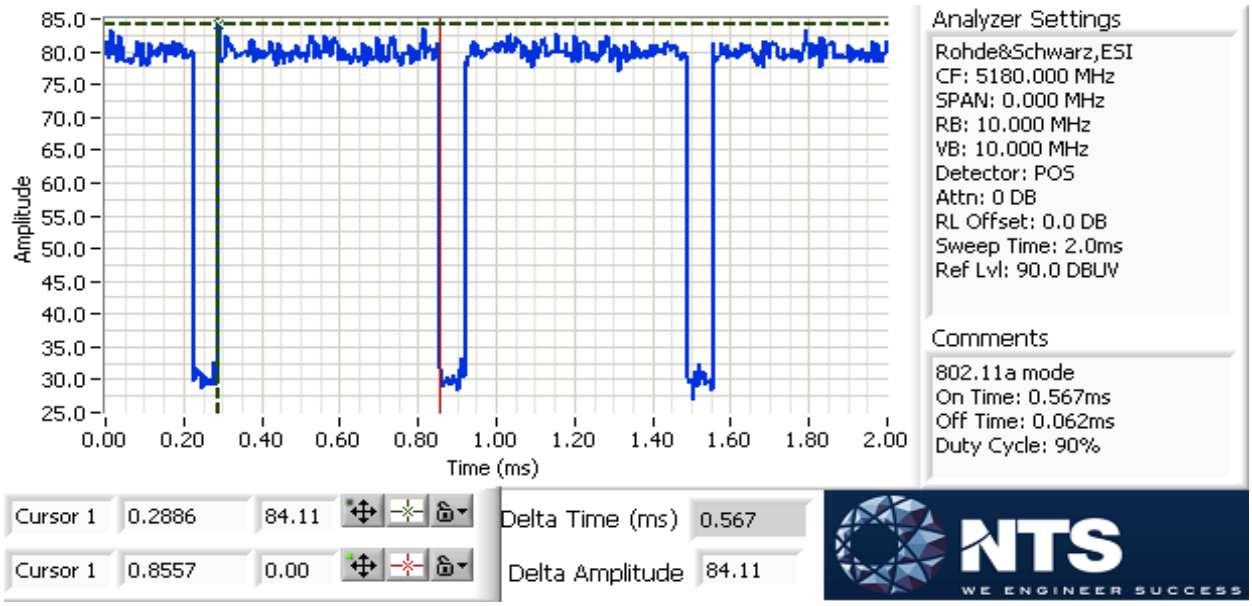
Date of Test: 5/2/2016
Test Engineer: Rafael Varelas
Test Location: FT Chamber #7

Duty cycle measurements performed on the worse case data rate for power.

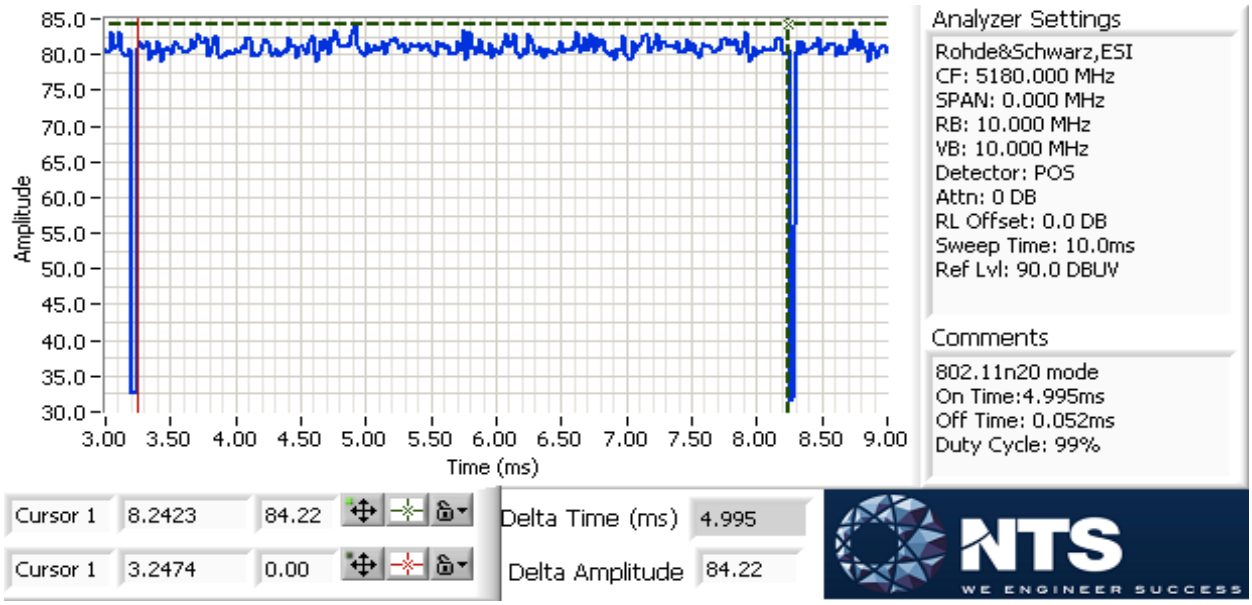
Notes: Measurements taken with maximum RBW/VBW settings allowed.

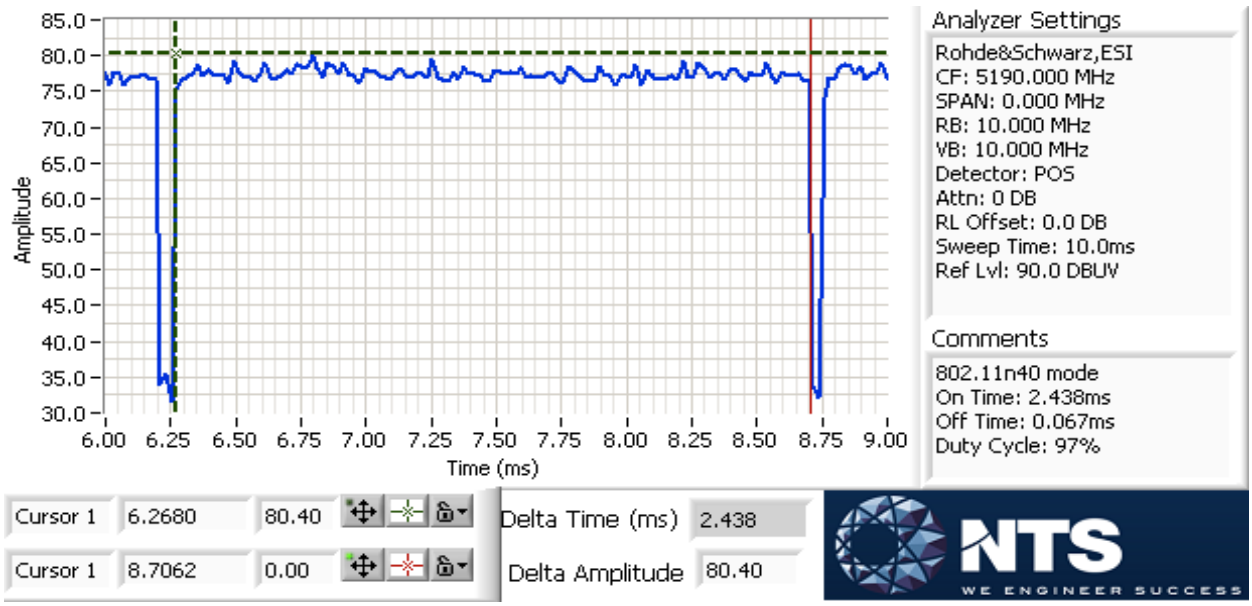
Mode	Data Rate	Duty Cycle (x)	Constant DC?	T (ms)	Pwr Cor Factor*	Lin Volt Cor Factor**	Min VBW for FS (Hz)
11a	6Mbps	0.90	Yes	0.567	0.45	0.90	1764
n20	MCS0	0.99	Yes	4.995	0	0	200
n40	MCS0	0.97	Yes	2.438	0.12	0.24	410
ac80	VHT0	0.94	Yes	1.124	0.25	0.50	890

* Correction factor when using RMS/Power averaging - 10*log(1/x)
** Correction factor when using linear voltage average - 20*log(1/x)
T = Minimum transmission duration

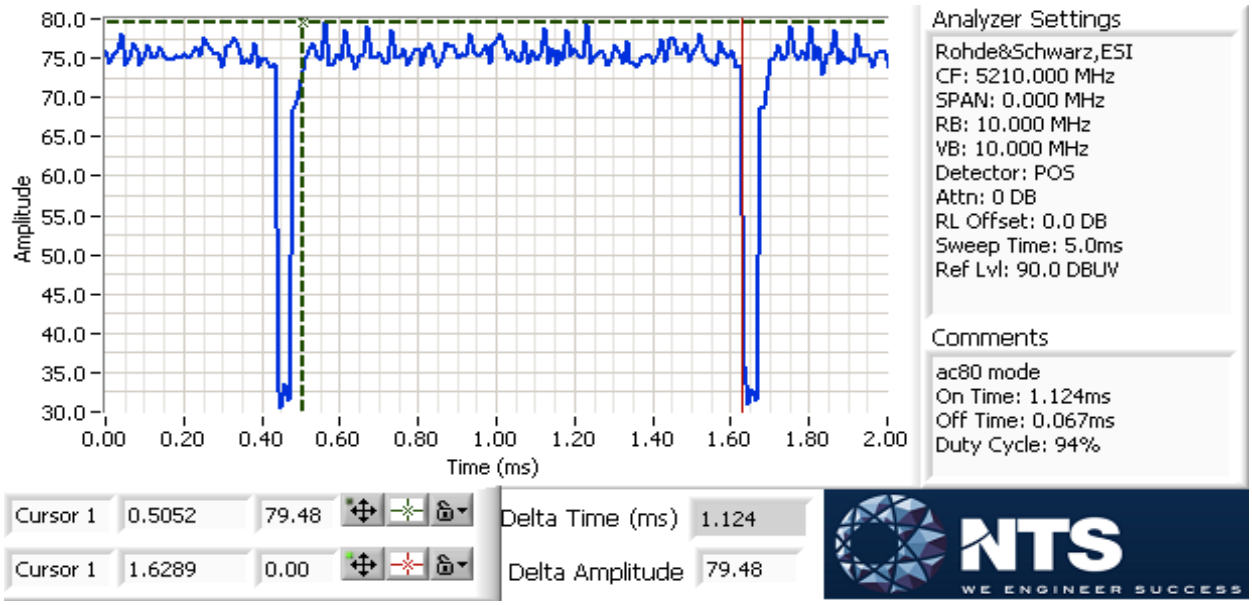


Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A





Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A



Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

RSS-247 and FCC 15.407 (UNII) Radiated Spurious Emissions

Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

General Test Configuration

The EUT and all local support equipment were located on the turntable for radiated spurious emissions testing.
For radiated emissions testing the measurement antenna was located 3 meters from the EUT, unless otherwise noted.

Ambient Conditions:

Temperature: 22.4 °C
Rel. Humidity: 36 %

Summary of Results

Run #	Mode	Channel	Target Power Setting	Final Power Setting	Test Performed	Limit	Result / Margin
20MHz Bandwith Modes							
1	a	36 - 5180MHz	25	18	Restricted Band Edge at 5150 MHz	15.209	53.4 dBµV/m @ 5149.9 MHz (-0.6 dB)
		40 - 5200MHz	25	23	Restricted Band Edge at 5150 MHz	15.209	53.5 dBµV/m @ 5147.5 MHz (-0.5 dB)
4	a	149 - 5745MHz	25	25	Bandedge at 5725MHz	15.407(4)(i)	refer to plot
	a	165 - 5825MHz	25	25	Bandedge at 5850MHz	15.407(4)(i)	refer to plot
5	n20	36 - 5180MHz	25	18	Restricted Band Edge at 5150 MHz	15.209	53.3 dBµV/m @ 5149.8 MHz (-0.7 dB)
	n20	40 - 5200MHz	25	25	Restricted Band Edge at 5150 MHz	15.209	72.5 dBµV/m @ 5149.2 MHz (-1.5 dB)
8	n20	149 - 5745MHz	25	25	Bandedge at 5725MHz	15.407(4)(i)	63.9 dBµV/m @ 5638.6 MHz (-4.4 dB)
	n20	165 - 5825MHz	25	25	Bandedge at 5850MHz	15.407(4)(i)	64.0 dBµV/m @ 5934.8 MHz (-4.3 dB)

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Summary of Results

Run #	Mode	Channel	Target Power Setting	Final Power Setting	Test Performed	Limit	Result / Margin
40MHz Bandwith Modes							
9	n40	38 - 5190MHz	25	13	Restricted Band Edge at 5150 MHz	15.209	53.7 dBµV/m @ 5149.0 MHz (-0.3 dB)
	n40	46 - 5230MHz	25	22	Restricted Band Edge at 5150 MHz	15.209	53.3 dBµV/m @ 5149.9 MHz (-0.7 dB)
12	n40	151 - 5755MHz	25	24	Bandedge at 5725MHz	15.407(4)(i)	65.5 dBµV/m @ 5645.0 MHz (-2.8 dB)
	n40	159 - 5795MHz	25	25	Bandedge at 5850MHz	15.407(4)(i)	75.8 dBµV/m @ 5909.7 MHz (-3.8 dB)
80MHz Bandwith Modes							
13	ac80	42 - 5210MHz	25	12	Restricted Band Edge at 5150 MHz	15.209	52.6 dBµV/m @ 5135.0 MHz (-1.4 dB)
16	ac80	155 - 5775MHz	25	21	Bandedge at 5745MHz	15.407(4)(i)	67.9 dBµV/m @ 5642.5 MHz (-0.4 dB)
	ac80	155 - 5775MHz	25	21	Bandedge at 5850MHz	15.407(4)(i)	67.1 dBµV/m @ 5922.8 MHz (-2.8 dB)

Modifications Made During Testing

No modifications were made to the EUT during testing

Deviations From The Standard

No deviations were made from the requirements of the standard.

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Procedure Comments:

Measurements performed in accordance with FCC KDB 789033
Peak measurements performed with: RBW=1MHz, VBW=3MHz, peak detector, max hold, auto sweep time
Unless otherwise stated/noted, emission has duty cycle ≥ 98% and was measured using RBW=1MHz, VBW=10Hz, peak detector, linear average mode, auto sweep time, max hold 50 traces. (method VB of KDB 789033)

Mode	Data Rate	Duty Cycle (x)	Constant DC?	T (ms)	Pwr Cor Factor*	Lin Volt Cor Factor**	Min VBW for FS (Hz)
11a	6Mbps	0.90	Yes	0.567	0.45	0.90	1764
n20	MCS0	0.99	Yes	4.995	0	0	10
n40	MCS0	0.97	Yes	2.438	0.12	0.24	410
ac80	VHT0	0.94	Yes	1.124	0.25	0.50	890

Sample Notes

Sample S/N: EVT4A, S/N:GTCFSJ1617E0378
Driver:
Antenna: Internal

Measurement Specific Notes:

Note 1:	For emissions outside of the restricted bands the limit is -27dBm/MHz eirp (68.3dBuV/m). The measurement method required is a peak measurement (RB=1MHz, VB≥3MHz, peak detector). Per KDB 789033 2) c) (i), compliance can be demonstrated by meeting the average and peak limits of 15.209, as an alternative.
Note 2:	Emission has a duty cycle ≥ 98%, average measurement performed: RBW=1MHz, VBW=3MHz, RMS, Power averaging, auto sweep, trace average 100 traces (method AD of KDB 789033)
Note 3:	Emission has constant duty cycle < 98%, average measurement performed: RBW=1MHz, VBW>1/T but not less than 10Hz, peak detector, linear averaging, auto sweep,max hold 50*1/DC traces (method VB of KDB 789033)
Note 4:	Emission has a duty cycle < 98%, average measurement performed: RBW=1MHz, VBW=3MHz, RMS, Power averaging, auto sweep, trace average 100*1/DC traces, measurement corrected by Pwr correction factor (method AD of KDB 789033)
Note 5:	Plots of the average and peak bandedge do not account for any duty cycle correction. Refer to the tabular results for final measurements.

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Run #1: Radiated Bandedge Measurements, 5150-5250MHz

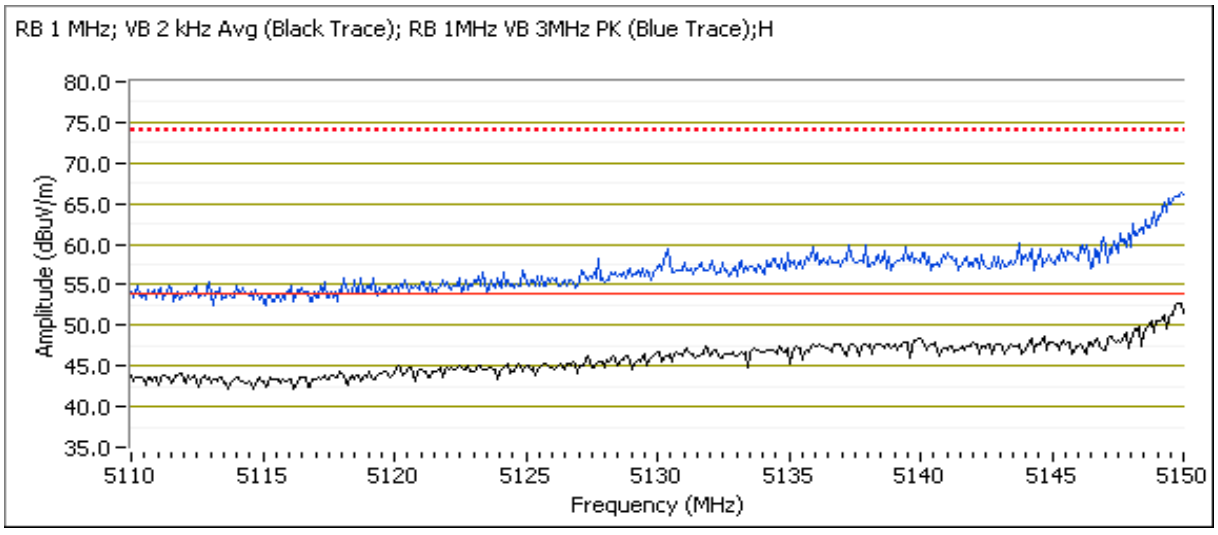
Date of Test: 5/17/2016 0:00
Test Engineer: Rafael Varelas
Test Location: FT Chamber #7

Config. Used: 1
Config Change: None
EUT Voltage: 120V/60Hz

Channel: 36 - 5180 MHz
Tx Chain: 4Tx
Mode: a
Data Rate: 6Mbps

5150 MHz Band Edge Signal Radiated Field Strength

Frequency	Level	Pol	FCC 15.209		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
Power setting = 18								
5149.920	53.4	H	54.0	-0.6	Avg	46	1.0	POS; RB 1 MHz; VB: 2 kHz
5149.520	65.4	H	74.0	-8.6	PK	46	1.0	POS; RB 1 MHz; VB: 3 MHz

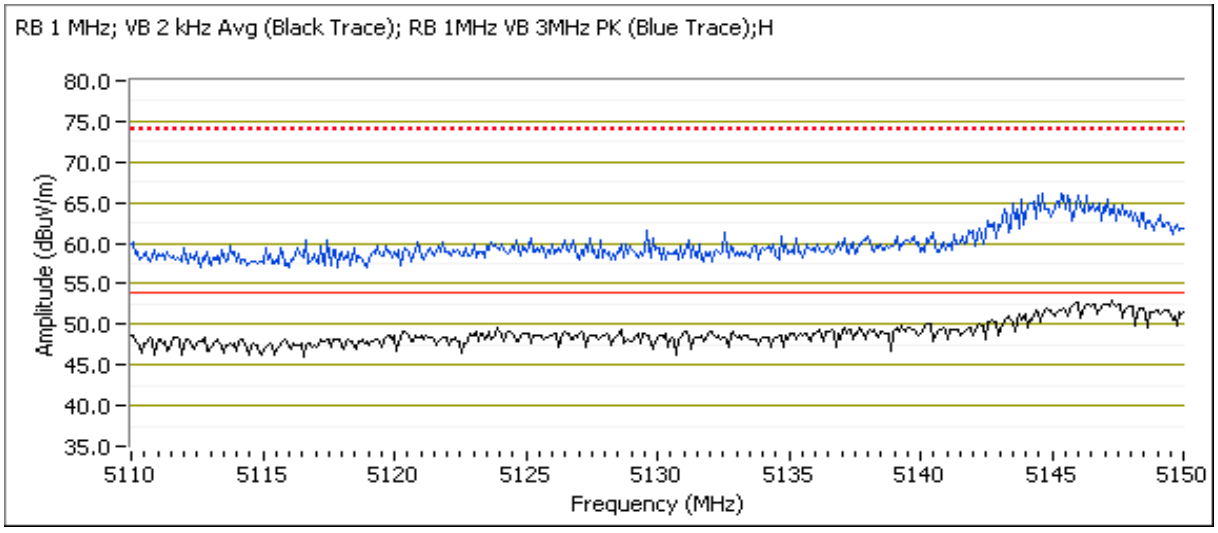


Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Channel: 40 - 5200 MHz
Tx Chain: 4Tx
Mode: a
Data Rate: 6Mbps

5150 MHz Band Edge Signal Radiated Field Strength

Frequency	Level	Pol	FCC 15.209		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
Power setting = 23								
5147.520	53.5	H	54.0	-0.5	Avg	121	1.7	POS; RB 1 MHz; VB: 2 kHz
5145.990	66.1	H	74.0	-7.9	PK	121	1.7	POS; RB 1 MHz; VB: 3 MHz
5149.880	51.1	V	54.0	-2.9	Avg	294	1.0	POS; RB 1 MHz; VB: 2 kHz
5143.210	63.9	V	74.0	-10.1	PK	294	1.0	POS; RB 1 MHz; VB: 3 MHz



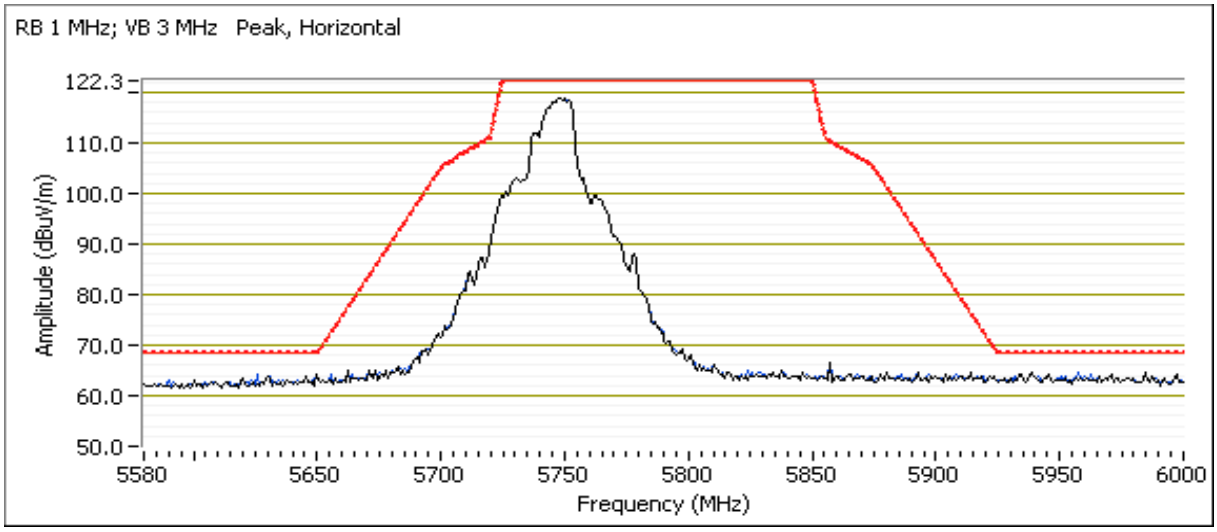
Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Run #4: Radiated Bandedge Measurements, 5725-5850MHz

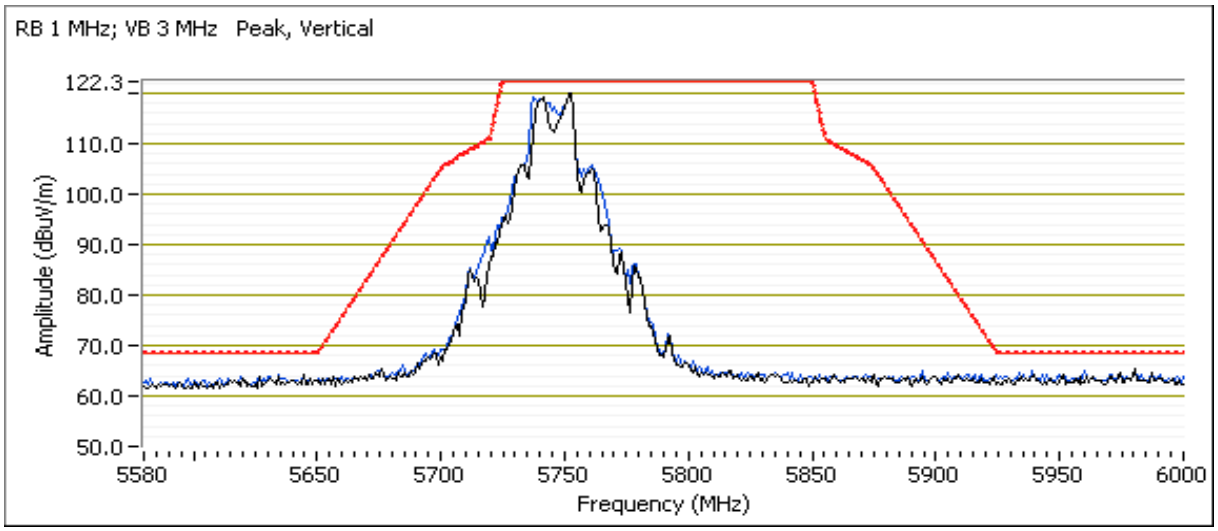
Date of Test: 5/18/2016 0:00
Test Engineer: John Caizzi / R. Varelas
Test Location: Chamber 7

Config. Used: 1
Config Change: none
EUT Voltage: 120V / 60Hz

Channel: 149 - 5745MHz
Tx Chain: 4Tx
Mode: a
Data Rate: 6 Mbps

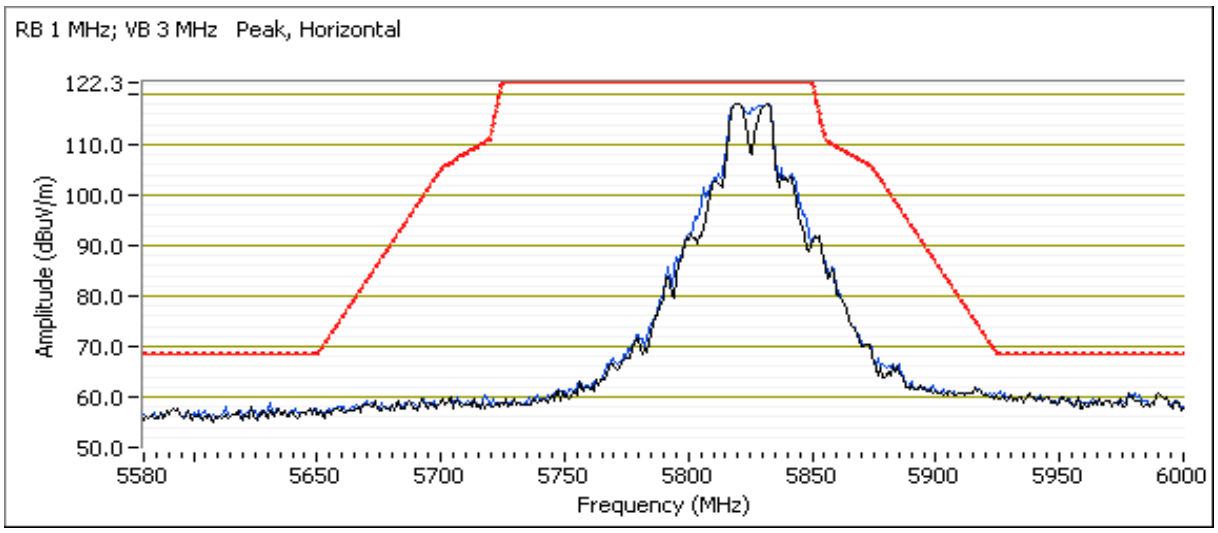


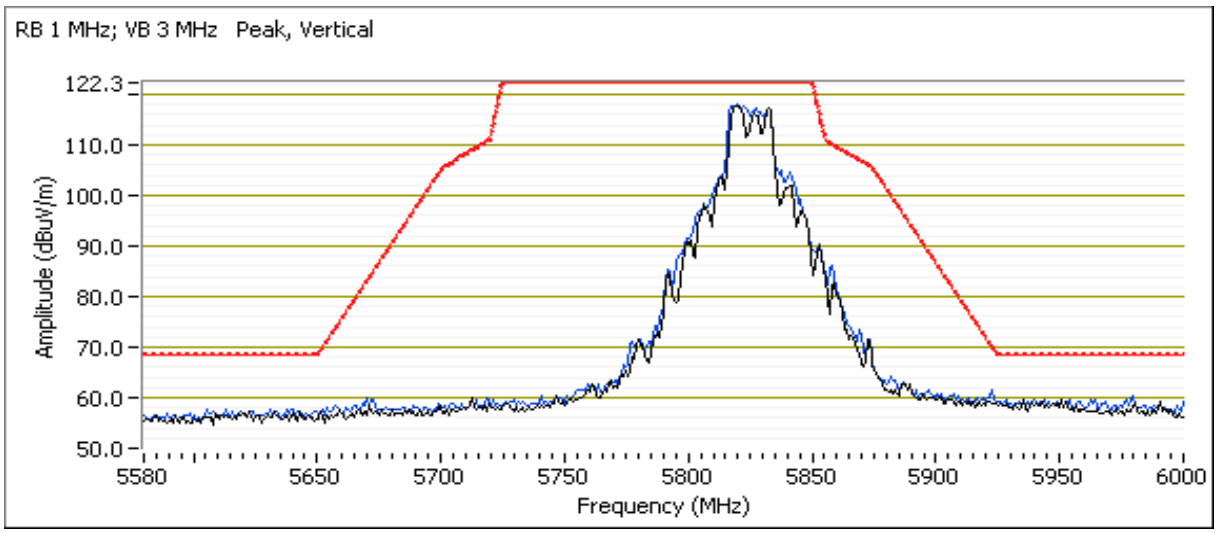
Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A



Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Channel: 165 - 5825MHz
Tx Chain: 4Tx
Mode: a
Data Rate: 6 Mbps





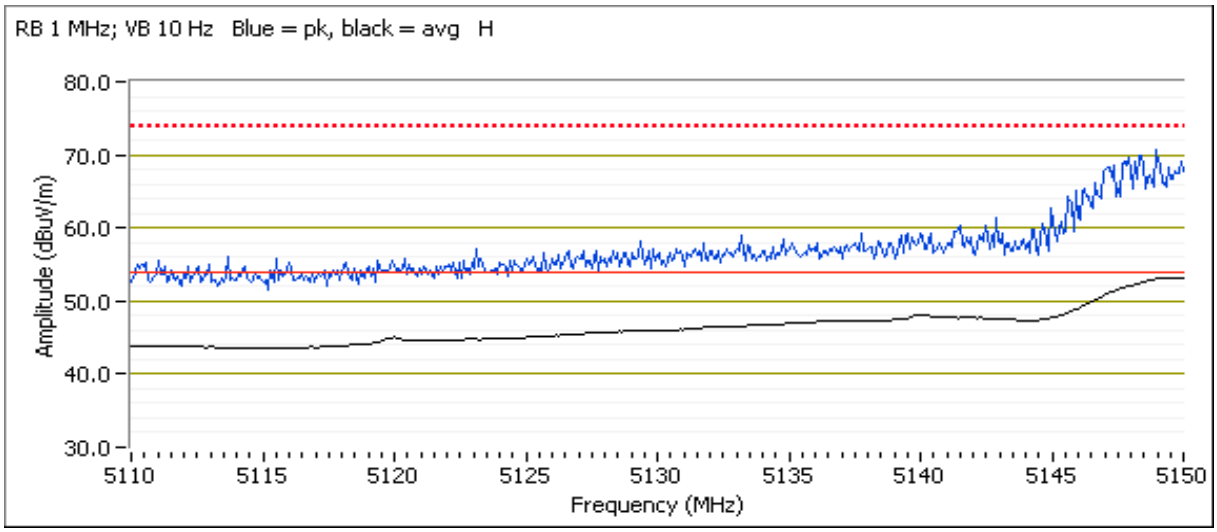
Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Run #5: Radiated Bandedge Measurements, 5150-5250MHz

Channel: 36 - 5180 MHz
Tx Chain: 4Tx
Mode: n20
Data Rate: MCS0

5150 MHz Band Edge Signal Radiated Field Strength

Frequency	Level	Pol	FCC 15.209		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
5149.840	53.3	H	54.0	**-0.7**	AVG	141	1.27	POS; RB 1 MHz; VB: 10 Hz
5147.920	70.2	H	74.0	-3.8	PK	141	1.27	POS; RB 1 MHz; VB: 3 MHz
5150.000	51.8	V	54.0	-2.2	AVG	276	1.20	POS; RB 1 MHz; VB: 10 Hz
5149.280	67.5	V	74.0	-6.5	PK	276	1.20	POS; RB 1 MHz; VB: 3 MHz

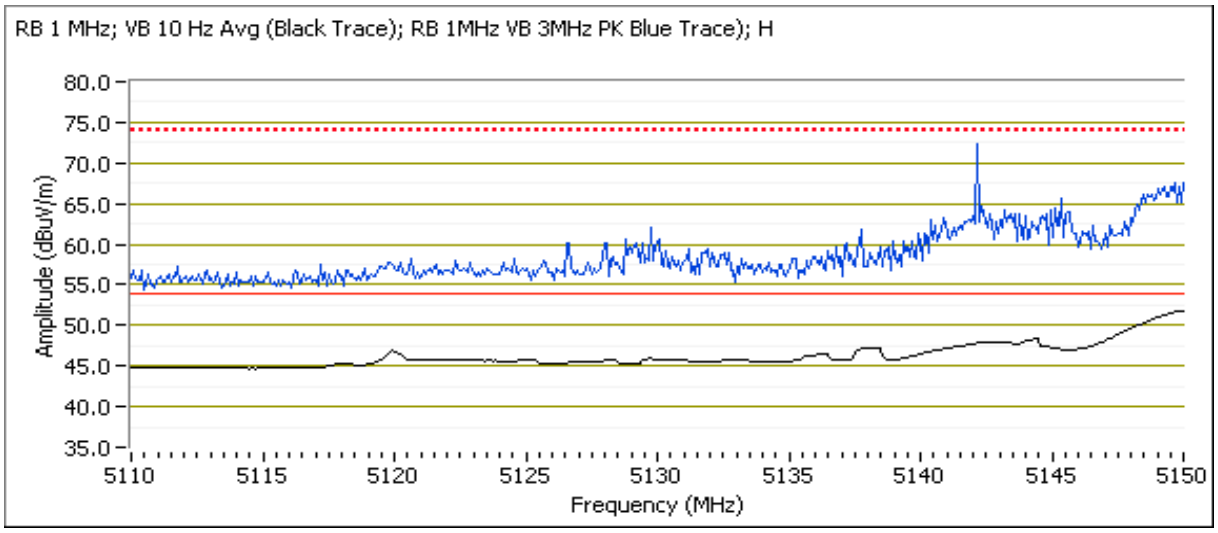


Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Channel: 40 - 5200 MHz
Tx Chain: 4Tx
Mode: n20
Data Rate: MCS0

5150 MHz Band Edge Signal Radiated Field Strength

Frequency	Level	Pol	FCC 15.209		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
5150.000	51.1	H	54.0	-2.9	AVG	58	1.3	POS; RB 1 MHz; VB: 10 Hz
5149.200	72.5	H	74.0	-1.5	PK	58	1.3	POS; RB 1 MHz; VB: 3 MHz
5149.640	52.3	V	54.0	-1.7	AVG	335	1.0	POS; RB 1 MHz; VB: 10 Hz
5145.370	69.4	V	74.0	-4.6	PK	335	1.0	POS; RB 1 MHz; VB: 3 MHz



Note - the spike observed at ~5143MHz was a transient

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Run #8: Radiated Bandedge Measurements, 5725-5850MHz

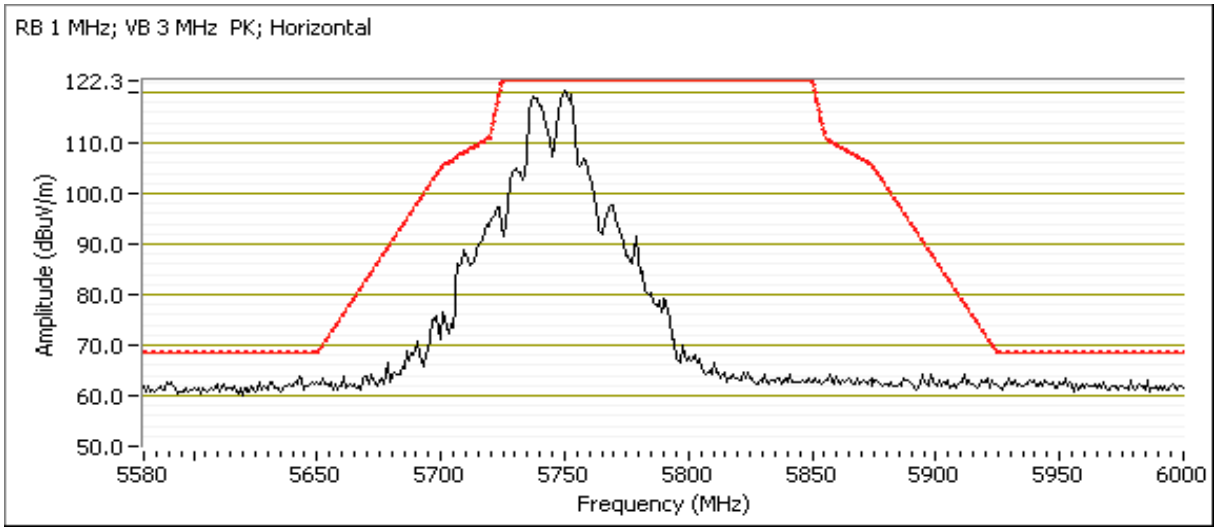
Date of Test: 5/18/2016 0:00
Test Engineer: Rafael Varelas
Test Location: FT Chamber #7

Config. Used: 1
Config Change: None
EUT Voltage: 120V/60Hz

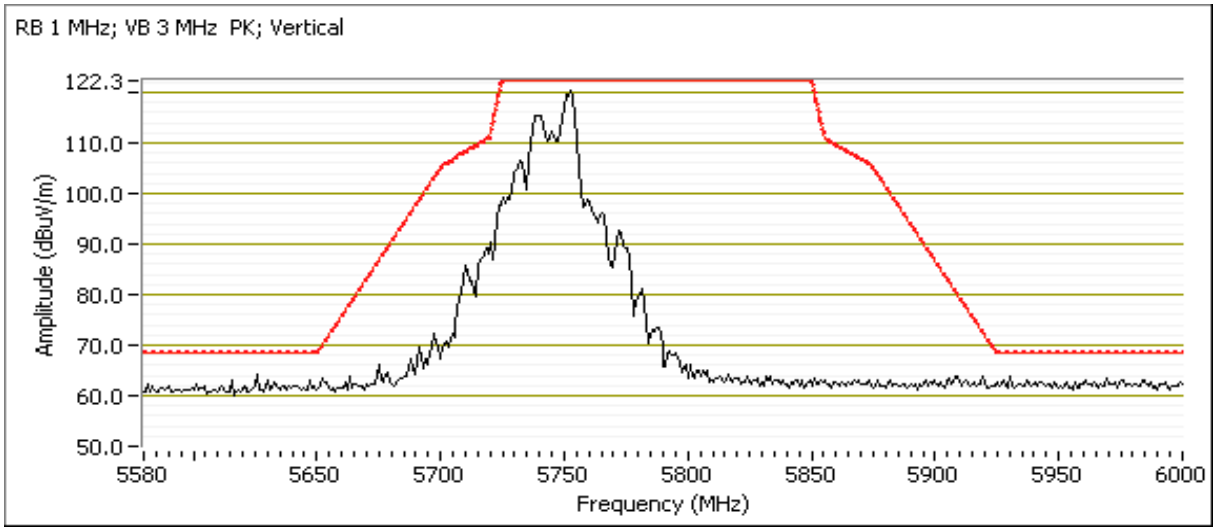
Channel: 149 -5745MHz
Tx Chain: 4Tx
Mode: n20
Data Rate: MCS0

Band Edge Signal Radiated Field Strength - Using mask of 15.407(4)(i)

Frequency	Level	Pol	15.E		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
5638.580	63.9	H	68.3	-4.4	PK	36	1.0	POS; RB 1 MHz; VB: 3 MHz
5616.190	63.2	V	68.3	-5.1	PK	306	1.0	POS; RB 1 MHz; VB: 3 MHz



Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

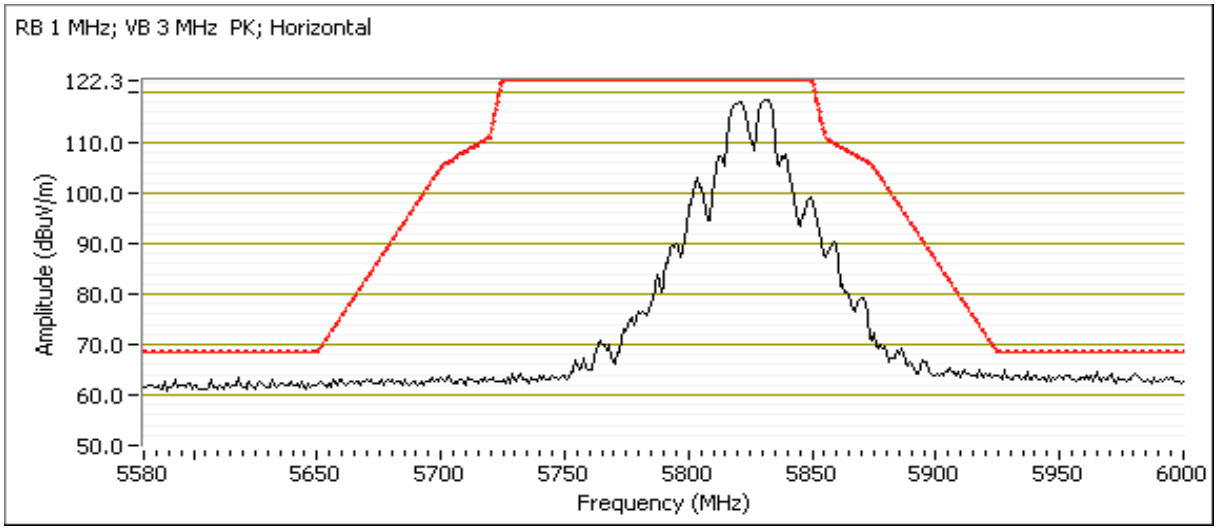


Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

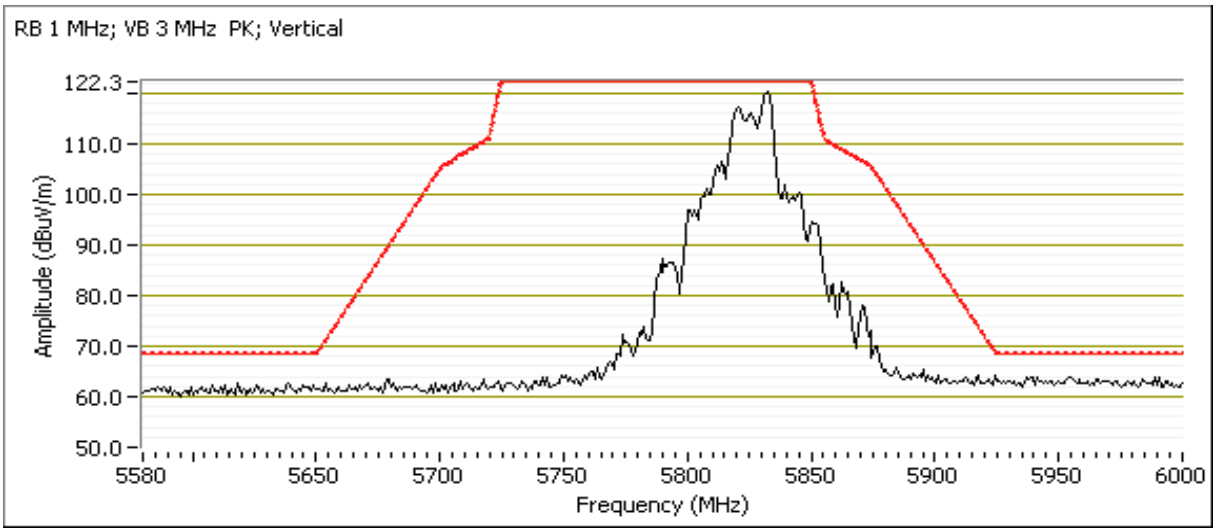
Channel: 165 - 5825MHz
Tx Chain: 4Tx
Mode: n20
Data Rate: MCS0

Band Edge Signal Radiated Field Strength - Using mask of 15.407(4)(i)

Frequency	Level	Pol	15.E		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
5934.770	64.0	H	68.3	-4.3	PK	40	1.1	POS; RB 1 MHz; VB: 3 MHz
5626.990	63.2	V	68.3	-5.1	PK	305	1.1	POS; RB 1 MHz; VB: 3 MHz



Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A



Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Run #9: Radiated Bandedge Measurements, 5150-5250MHz

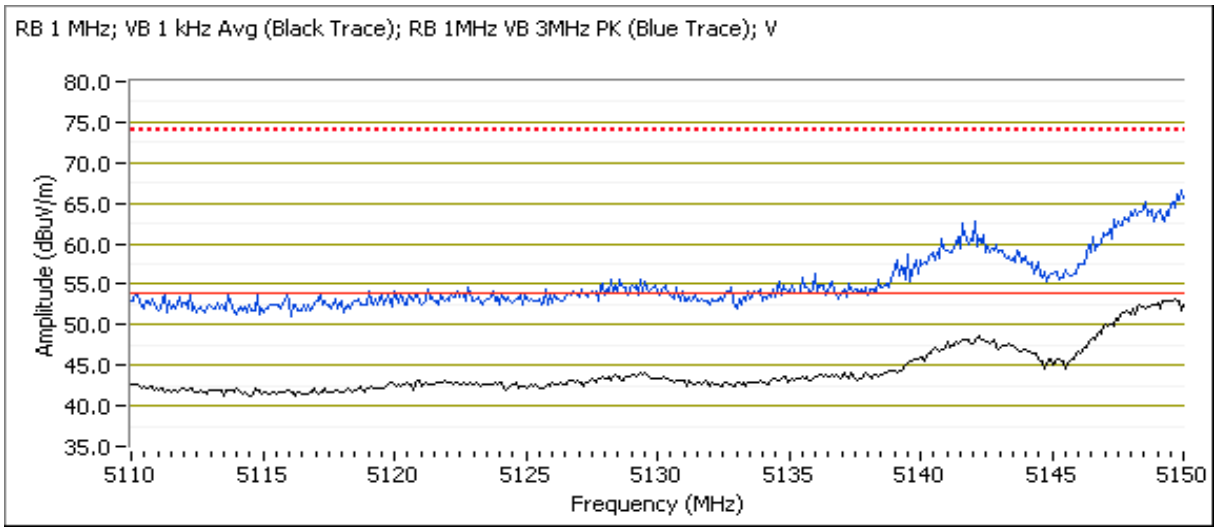
Date of Test: 5/18/2016 0:00
Test Engineer: Rafael Varelas
Test Location: FT Chamber #7

Config. Used: 1
Config Change: None
EUT Voltage: 120V/60Hz

Channel: 38 - 5190 MHz
Tx Chain: 4Tx
Mode: n40
Data Rate: MCS0

5150 MHz Band Edge Signal Radiated Field Strength

Frequency	Level	Pol	FCC 15.209		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
Power setting = 13								
5149.040	53.7	V	54.0	-0.3	Avg	319	1.1	POS; RB 1 MHz; VB: 1 kHz
5149.840	65.3	V	74.0	-8.7	PK	319	1.1	POS; RB 1 MHz; VB: 3 MHz

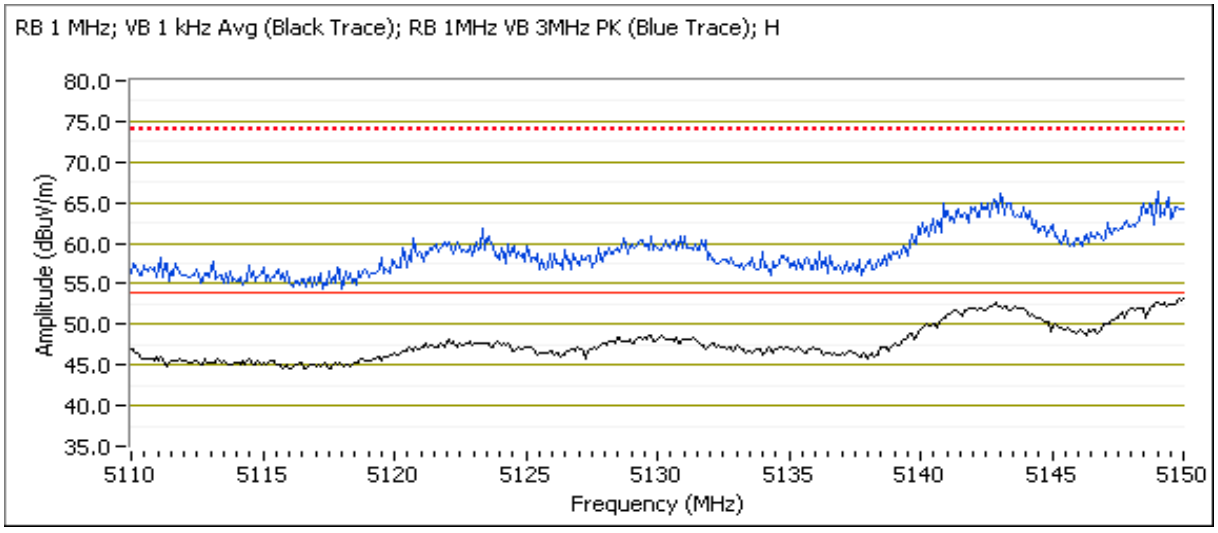


Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Channel: 46 - 5230 MHz
Tx Chain: 4Tx
Mode: n40
Data Rate: MCS0

5150 MHz Band Edge Signal Radiated Field Strength

Frequency	Level	Pol	FCC 15.209		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
Power setting = 22								
5149.920	53.3	H	54.0	-0.7	Avg	56	1.1	POS; RB 1 MHz; VB: 1 kHz
5149.600	66.1	H	74.0	-7.9	PK	56	1.1	POS; RB 1 MHz; VB: 3 MHz
5150.000	52.9	V	54.0	-1.1	Avg	302	1.1	POS; RB 1 MHz; VB: 1 kHz
5139.660	63.5	V	74.0	-10.5	PK	302	1.1	POS; RB 1 MHz; VB: 3 MHz



Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Run #12: Radiated Bandedge Measurements, 5725-5850MHz

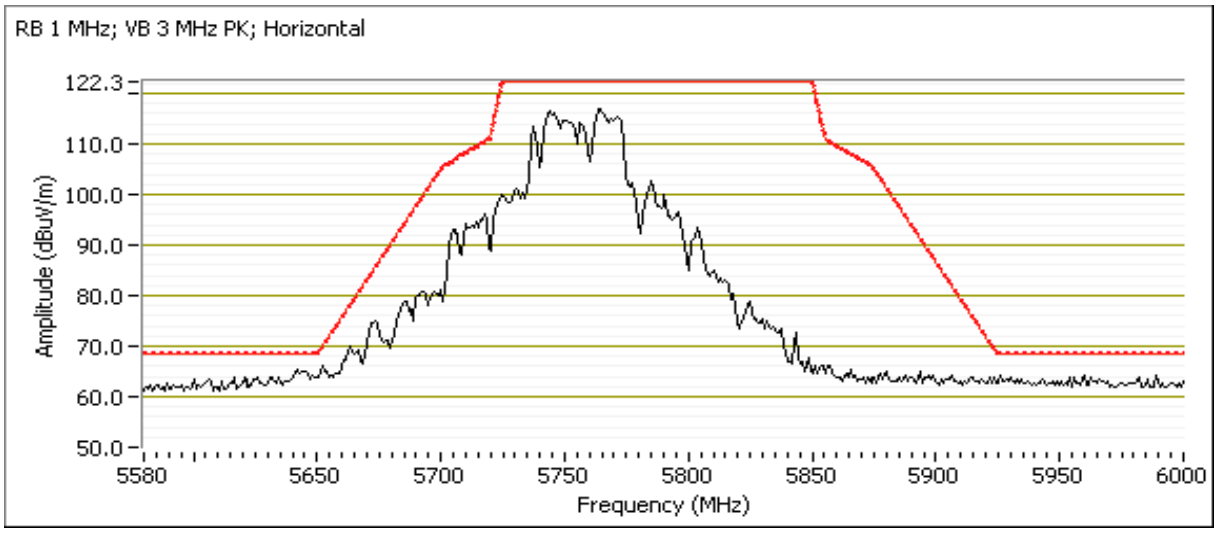
Date of Test: 5/19/2016 0:00
Test Engineer: Rafael Varelas
Test Location: FT Chamber #7

Config. Used: 1
Config Change: None
EUT Voltage: 120V/60Hz

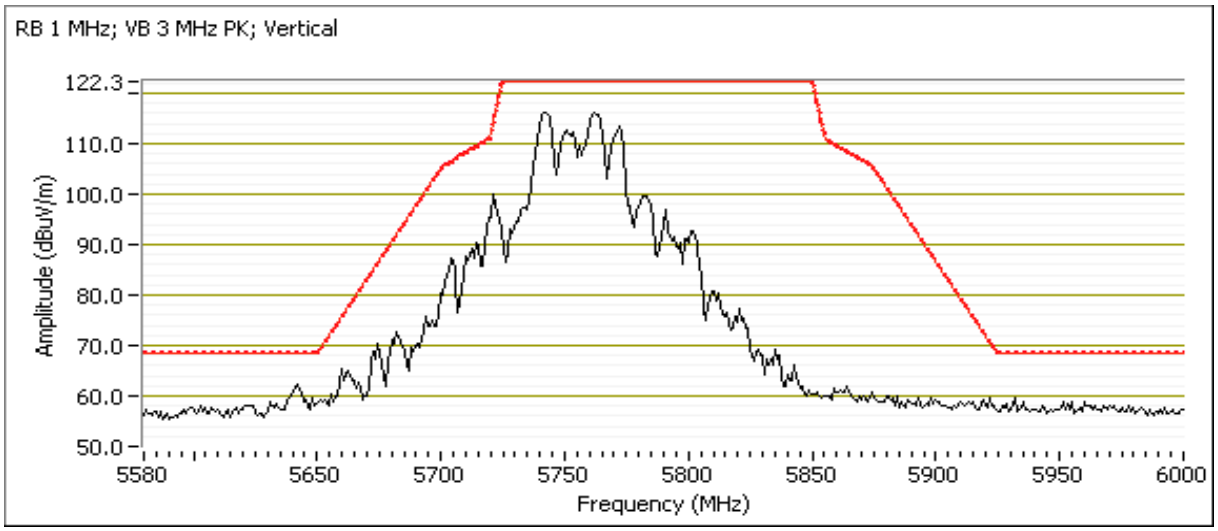
Channel: 151 -5755MHz
Tx Chain: 4Tx
Mode: n40
Data Rate: MCS0

Band Edge Signal Radiated Field Strength - Using mask of 15.407(4)(i)

Frequency	Level	Pol	15.E		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
Power setting = 24								
5645.010	65.5	H	68.3	-2.8	PK	45	1.0	POS; RB 1 MHz; VB: 3 MHz
5641.220	62.6	V	68.3	-5.7	PK	300	1.0	POS; RB 1 MHz; VB: 3 MHz



Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

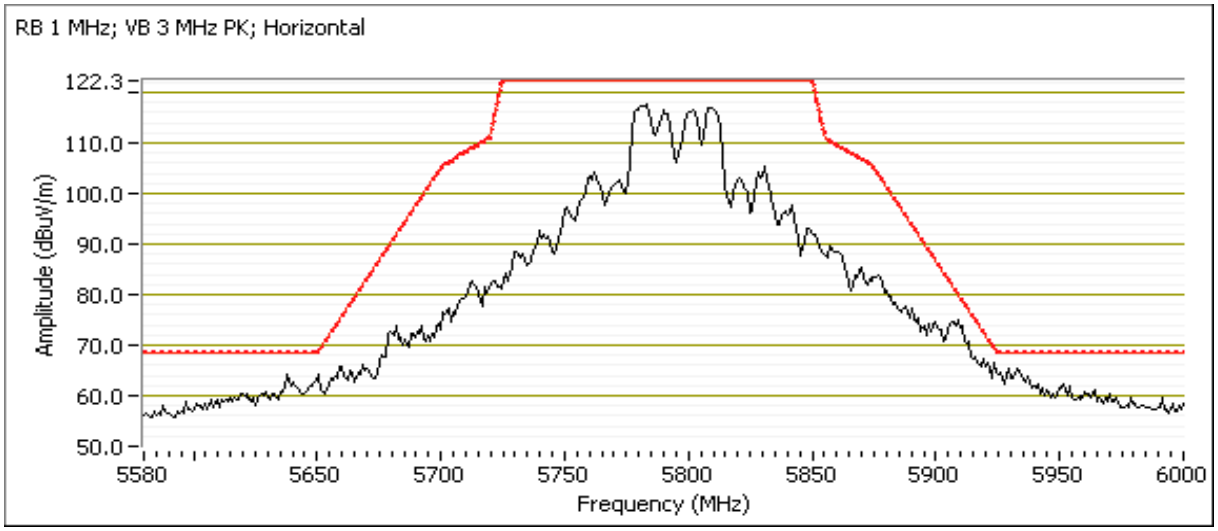


Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

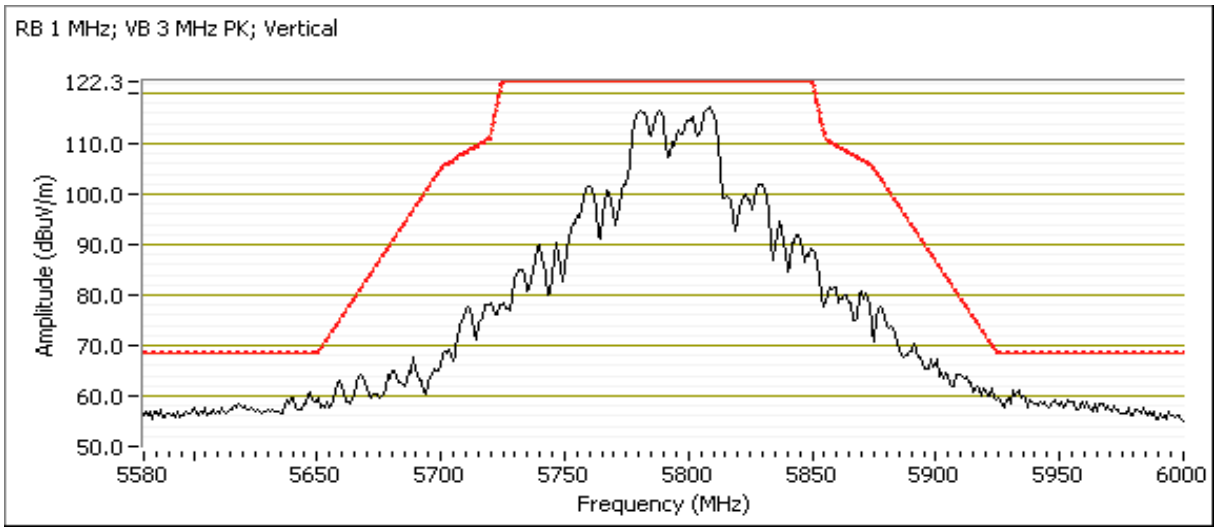
Channel: 159 - 5795MHz
Tx Chain: 4Tx
Mode: n40
Data Rate: MCS0

Band Edge Signal Radiated Field Strength - Using mask of 15.407(4)(i)

Frequency	Level	Pol	15.E		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
5909.720	75.8	H	79.6	-3.8	PK	30	1.0	POS; RB 1 MHz; VB: 3 MHz
5931.660	60.9	V	68.3	-7.4	PK	284	1.0	POS; RB 1 MHz; VB: 3 MHz



Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A



Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Run #13: Radiated Bandedge Measurements, 5150-5250MHz

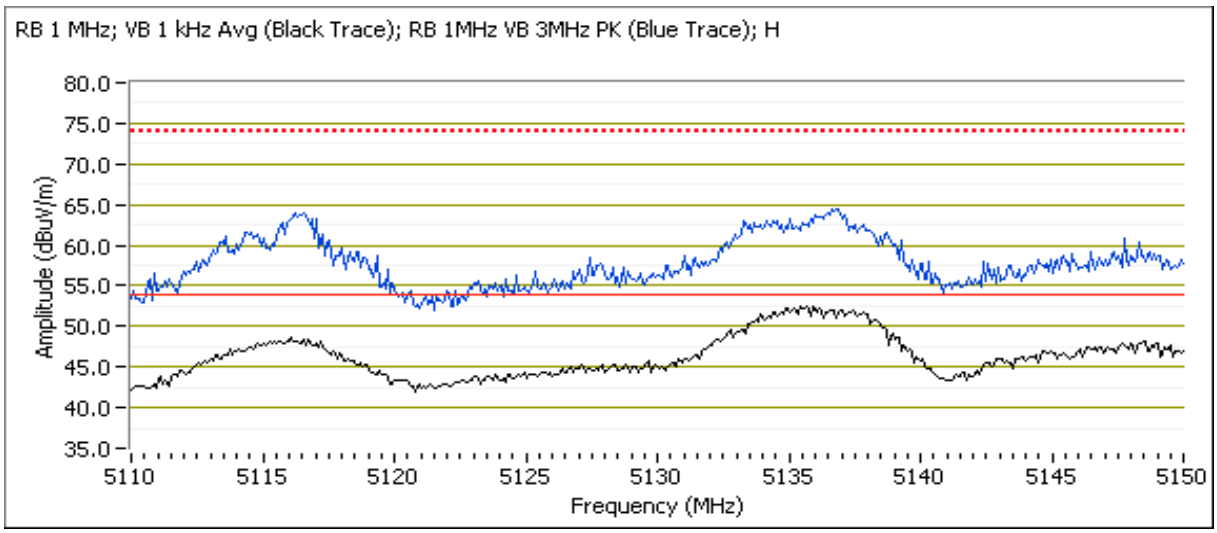
Date of Test: 5/19/2016 0:00
Test Engineer: Rafael Varelas
Test Location: FT Chamber #7

Config. Used: 1
Config Change: None
EUT Voltage: 120V/60Hz

Channel: 42 - 5210MHz
Tx Chain: 4Tx
Mode: ac80
Data Rate: VHT0

5150 MHz Band Edge Signal Radiated Field Strength

Frequency	Level	Pol	FCC 15.209		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
Power setting = 12								
5135.010	52.6	H	54.0	-1.4	Avg	126	1.4	POS; RB 1 MHz; VB: 1 kHz
5116.090	64.4	H	74.0	-9.6	PK	126	1.4	POS; RB 1 MHz; VB: 3 MHz
5146.390	51.3	V	54.0	-2.7	Avg	329	1.0	POS; RB 1 MHz; VB: 1 kHz
5147.440	63.4	V	74.0	-10.6	PK	329	1.0	POS; RB 1 MHz; VB: 3 MHz



Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Run #16: Radiated Bandedge Measurements, 5725-5850MHz

Date of Test: 5/20/2016 0:00
Test Engineer: Rafael Varelas
Test Location: FT Chamber #7

Config. Used: 1
Config Change: None
EUT Voltage: 120V/60Hz

Channel: 155 - 5775MHz
Tx Chain: 4Tx
Mode: ac80
Data Rate: VHT0

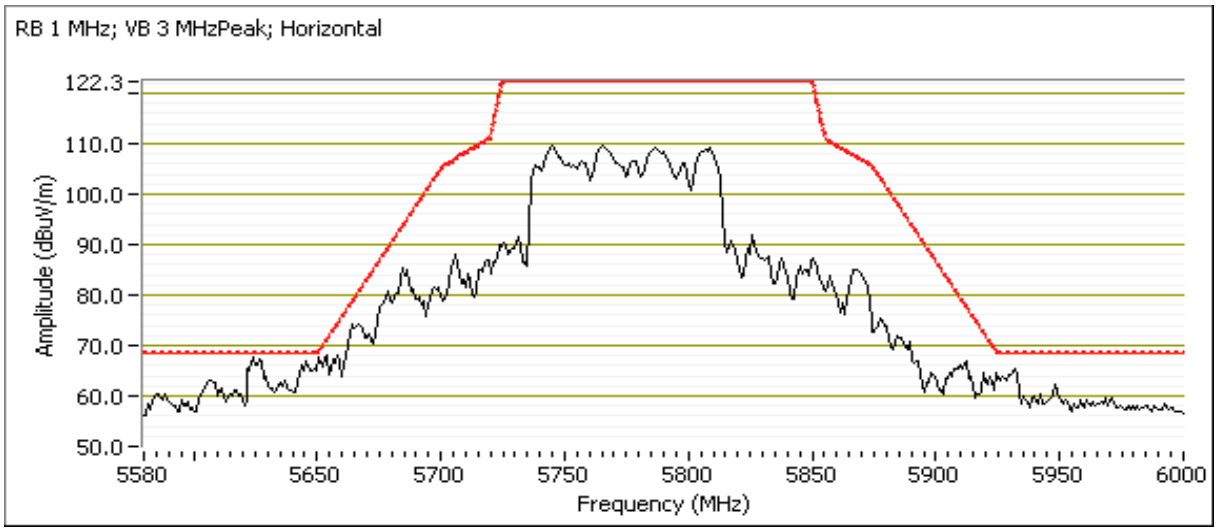
Band Edge Signal Radiated Field Strength - Using mask of 15.407(4)(i) - At the low side of the band

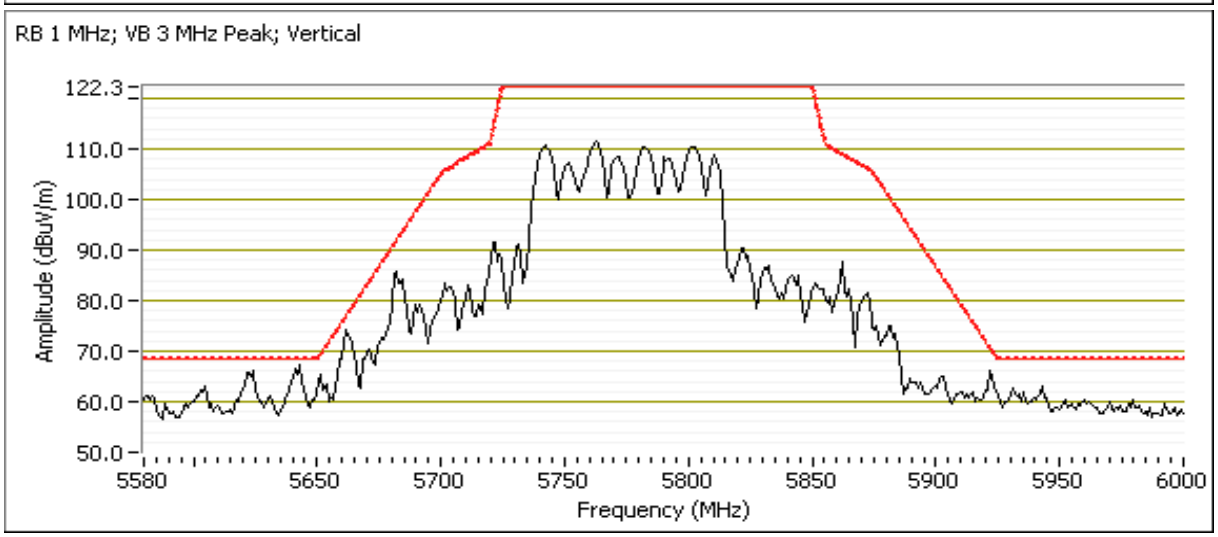
Frequency	Level	Pol	15.E		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
Power setting = 21								
5642.480	67.9	V	68.3	-0.4	PK	305	1.0	POS; RB 1 MHz; VB: 3 MHz

Band Edge Signal Radiated Field Strength - Using mask of 15.407(4)(i) - At the high side of the band

Frequency	Level	Pol	15.E		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
Power setting = 21								
5922.830	67.1	V	69.9	-2.8	PK	305	1.0	POS; RB 1 MHz; VB: 3 MHz

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A





Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

RSS-247 and FCC 15.407 (UNII) Radiated Spurious Emissions

Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

General Test Configuration

The EUT and all local support equipment were located on the turntable for radiated spurious emissions testing.
For radiated emissions testing the measurement antenna was located 3 meters from the EUT, unless otherwise noted.

Ambient Conditions:

Temperature: 21.8 °C
Rel. Humidity: 36 %

Summary of Results

Run #	Mode	Channel	Target Power Setting	Final Power Setting	Test Performed	Limit	Result / Margin
Scans on "center" channel in all four OFDM modes to determine the worst case mode.							
1	a	40 - 5200MHz	25	17	Radiated Emissions, 1 - 40 GHz	FCC 15.209 / 15 E	67.2 dBµV/m @ 10397.0 MHz (-1.1 dB)
	n20	40 - 5200MHz	25	16	Radiated Emissions, 1 - 40 GHz	FCC 15.209 / 15 E	67.9 dBµV/m @ 10400.3 MHz (-0.4 dB)
	n40	38 - 5190MHz	25	25	Radiated Emissions, 1 - 40 GHz	FCC 15.209 / 15 E	64.4 dBµV/m @ 10380.5 MHz (-3.6 dB)
	ac80	42 - 5210MHz	25	25	Radiated Emissions, 1 - 40 GHz	FCC 15.209 / 15 E	52.4 dBµV/m @ 4983.3 MHz (-1.6 dB)
Measurements on low and high channels in worst-case OFDM mode.							
2	n20	36 - 5180MHz	25	17	Radiated Emissions, 1 - 40 GHz	FCC 15.209 / 15 E	68.1 dBµV/m @ 10360.3 MHz (-0.2 dB)
		48 - 5240MHz		16			67.2 dBµV/m @ 10478.3 MHz (-1.1 dB)

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Run #	Mode	Channel	Target Power Setting	Final Power Setting	Test Performed	Limit	Result / Margin
Scans on "center" channel in all four OFDM modes to determine the worst case mode.							
7	a	157 - 5785MHz	25	25	Radiated Emissions, 1 - 40 GHz	FCC 15.209 / 15 E	refer to test run
	n20	157 - 5785MHz		20			53.8 dBµV/m @ 11569.8 MHz (-0.2 dB)
	n40	151 - 5755MHz		25			refer to test run
	ac80	155 - 5775MHz		25			refer to test run
Measurements on low and high channels in worst-case OFDM mode.							
8	n20	149 - 5745MHz	25	19	Radiated Emissions, 1 - 40 GHz	FCC 15.209 / 15 E	52.9 dBµV/m @ 11490.4 MHz (-1.1 dB)
		165 - 5825MHz		20			53.9 dBµV/m @ 11649.6 MHz (-0.1 dB)

Modifications Made During Testing

No modifications were made to the EUT during testing

Deviations From The Standard

No deviations were made from the requirements of the standard.

Procedure Comments:

Measurements performed in accordance with FCC KDB 789033
Peak measurements performed with: RBW=1MHz, VBW=3MHz, peak detector, max hold, auto sweep time
Unless otherwise stated/noted, emission has duty cycle ≥ 98% and was measured using RBW=1MHz, VBW=10Hz, peak detector, linear average mode, auto sweep time, max hold 50 traces. (method VB of KDB 789033)

Mode	Data Rate	Duty Cycle (x)	Constant DC?	T (ms)	Pwr Cor Factor*	Lin Volt Cor Factor**	Min VBW for FS (Hz)
11a	6Mbps	0.90	Yes	0.567	0.45	0.90	1764
n20	MCS0	0.99	Yes	4.995	0	0	10
n40	MCS0	0.97	Yes	2.438	0.12	0.24	410
ac80	VHT0	0.94	Yes	1.124	0.25	0.50	890

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Sample Notes

Sample S/N: EVT4A, S/N:GTCFSJ1617E0378
Driver:
Antenna: Internal

Measurement Specific Notes:

Note 1:	For emissions outside of the restricted bands the limit is -27dBm/MHz eirp (68.3dBuV/m). The measurement method required is a peak measurement (RB=1MHz, VB≥3MHz, peak detector). Per KDB 789033 2) c) (i), compliance can be demonstrated by meeting the average and peak limits of 15.209, as an alternative.
Note 3:	Emission has constant duty cycle < 98%, average measurement performed: RBW=1MHz, VBW>1/T but not less than 10Hz, peak detector, linear averaging, auto sweep,max hold 50*1/DC traces (method VB of KDB 789033)
Note 5:	Signal was looked at with bandedge setup. High level caused by noise sidebands on the fundamental, not by any disrete spurious signals in the restricted band, and was lower than the level at the bandedge. Since spurious associated with the fundamental would be measured during bandedge measurements, no final average & peak measurements were done.
Note 6:	Signal is unmodulated, 100% duty cycle. No correction factor applied to avg measurement.
Note 7:	Signal not related to the radio under test.

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Run #1, Radiated Spurious Emissions, 1,000 - 40,000 MHz. Operation in the 5150-5250 MHz Band

Date of Test: 5/2/2016, 5/9/16 Config. Used: 1
Test Engineer: Rafael Varelas, John Caizzi Config Change: None
Test Location: FT Chamber #7 EUT Voltage: 120V/60Hz

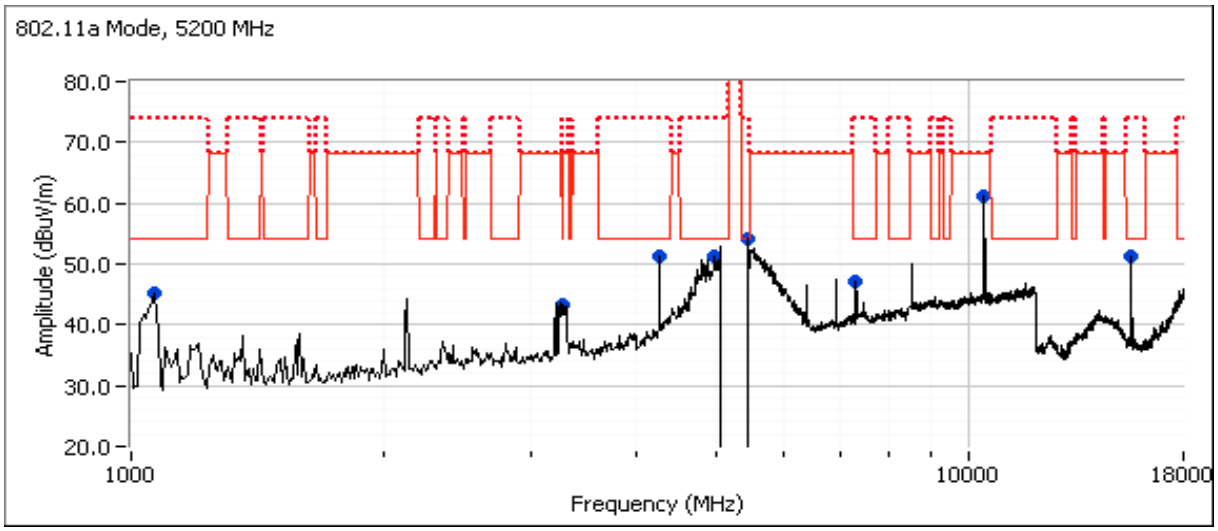
Run #1a: Center Channel

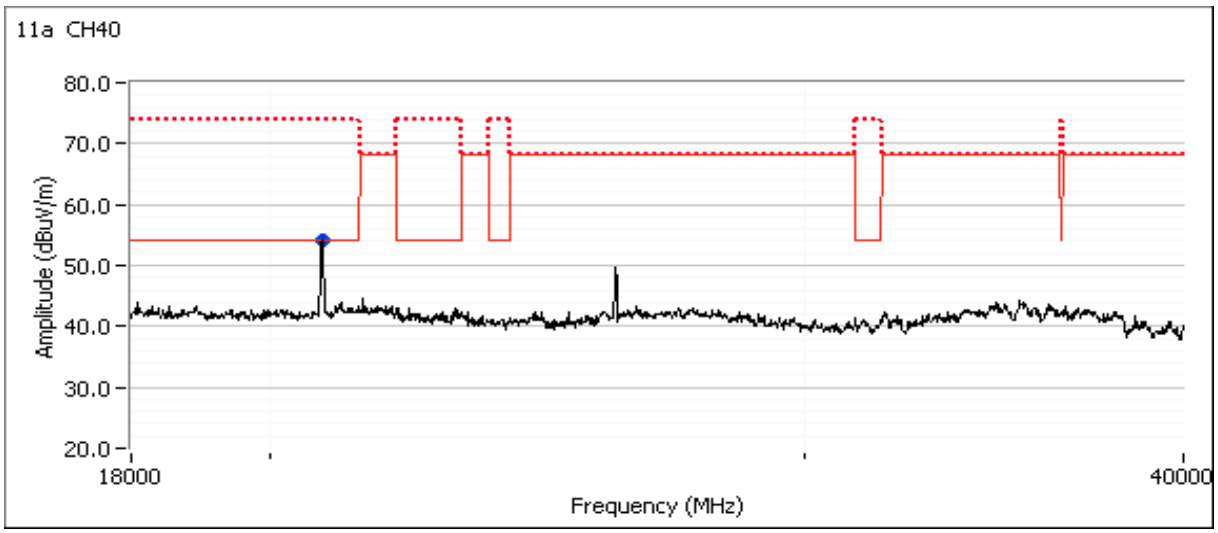
Channel: 40 Mode: a
Tx Chain: 4Tx Data Rate: 6Mbps

Frequency	Level	Pol	15.209 / 15E		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
4960.100	49.4	H	54.0	-4.6	Avg	124	1.2	RB 1 MHz;VB 3 kHz;Peak
4961.430	59.5	H	74.0	-14.5	PK	124	1.2	RB 1 MHz;VB 3 MHz;Peak
5445.930	53.0	H	54.0	-1.0	Avg	171	1.8	RB 1 MHz;VB 3 kHz;Peak
5446.730	63.3	H	74.0	-10.7	PK	171	1.8	RB 1 MHz;VB 3 MHz;Peak
3259.800	42.2	H	68.3	-26.1	PK	318	1.0	RB 1 MHz;VB 3 MHz;Peak
7320.000	46.2	H	54.0	-7.8	Avg	196	1.2	RB 1 MHz;VB 3 kHz;Peak
7320.030	52.2	H	74.0	-21.8	PK	196	1.2	RB 1 MHz;VB 3 MHz;Peak
1065.890	35.8	V	54.0	-18.2	Avg	204	1.0	RB 1 MHz;VB 3 kHz;Peak
1066.030	43.0	V	74.0	-31.0	PK	204	1.0	RB 1 MHz;VB 3 MHz;Peak
4263.930	40.2	H	54.0	-13.8	Avg	291	1.1	RB 1 MHz;VB 3 kHz;Peak
4263.800	48.0	H	74.0	-26.0	PK	291	1.1	RB 1 MHz;VB 3 MHz;Peak
15603.800	50.2	V	54.0	-3.8	Avg	111	1.9	RB 1 MHz;VB 3 kHz;Peak
15604.200	63.2	V	74.0	-10.8	PK	111	1.9	RB 1 MHz;VB 3 MHz;Peak
20799.600	52.0	V	54.0	-2.0	Avg	138	1.49	RB 1 MHz;VB 3 kHz, note 3.
20801.400	64.7	V	74.0	-9.3	PK	138	1.49	
Power setting = 17								
10397.000	67.2	H	68.3	-1.1	PK	49	1.09	RB 1 MHz;VB 3 MHz;Peak

Note 1:	For emissions in restricted bands, the limit of 15.209 was used which requires average and peak measurements.

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A





Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

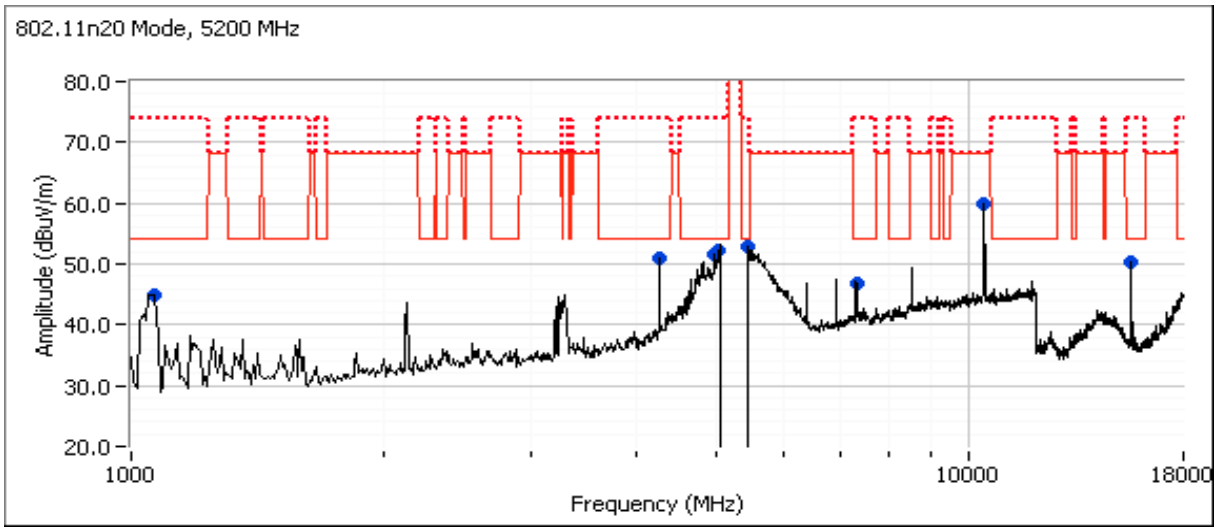
Run #1b: Center Channel

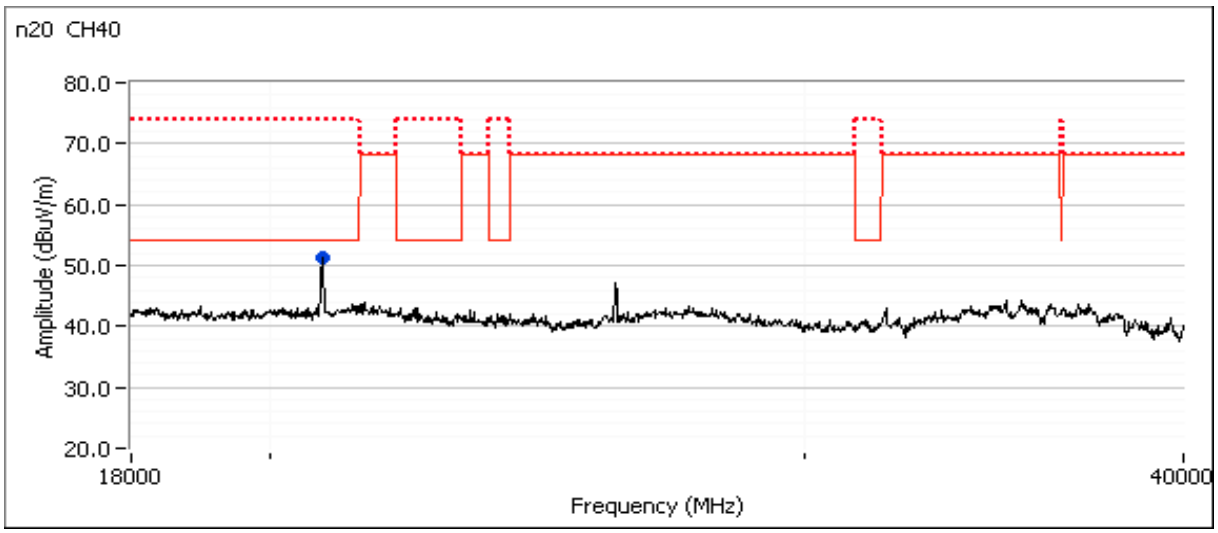
Channel: 40 Mode: 11n20
Tx Chain: 4Tx Data Rate: MCS0

Frequency	Level	Pol	15.209 / 15E		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
4263.890	33.8	H	54.0	-20.2	Avg	340	1.4	RB 1 MHz;VB 10 Hz;Peak
4264.370	45.4	H	74.0	-28.6	PK	340	1.4	RB 1 MHz;VB 3 MHz;Peak
1065.950	45.5	H	54.0	-8.5	AVG	212	1.1	RB 1 MHz;VB 10 Hz;Peak
1065.870	48.0	H	74.0	-26.0	PK	212	1.1	RB 1 MHz;VB 3 MHz;Peak
7338.280	38.9	H	54.0	-15.1	AVG	158	1.0	RB 1 MHz;VB 10 Hz;Peak
7336.180	51.0	H	74.0	-23.0	PK	158	1.0	RB 1 MHz;VB 3 MHz;Peak
5039.920	50.2	H	54.0	-3.8	AVG	112	1.0	RB 1 MHz;VB 10 Hz;Peak
5039.990	59.8	H	74.0	-14.2	PK	112	1.0	RB 1 MHz;VB 3 MHz;Peak
4959.970	48.9	H	54.0	-5.1	AVG	118	2.0	RB 1 MHz;VB 10 Hz;Peak
4959.730	61.2	H	74.0	-12.8	PK	118	2.0	RB 1 MHz;VB 3 MHz;Peak
5446.980	52.7	H	54.0	-1.3	AVG	123	1.9	RB 1 MHz;VB 10 Hz;Peak
5446.140	64.1	H	74.0	-9.9	PK	123	1.9	RB 1 MHz;VB 3 MHz;Peak
15603.890	47.5	V	54.0	-6.5	AVG	58	1.7	RB 1 MHz;VB 10 Hz;Peak
15605.290	60.2	V	74.0	-13.8	PK	58	1.7	RB 1 MHz;VB 3 MHz;Peak
20805.000	*51.4*	*H*	*54.0*	*-2.6*	*Peak*	*46*	*1.0*	
Power setting = 16								
10400.330	67.9	H	68.3	-0.4	PK	54	1.1	RB 1 MHz;VB 3 MHz;Peak

Note 1:	For emissions in restricted bands, the limit of 15.209 was used which requires average and peak measurements.

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A





Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

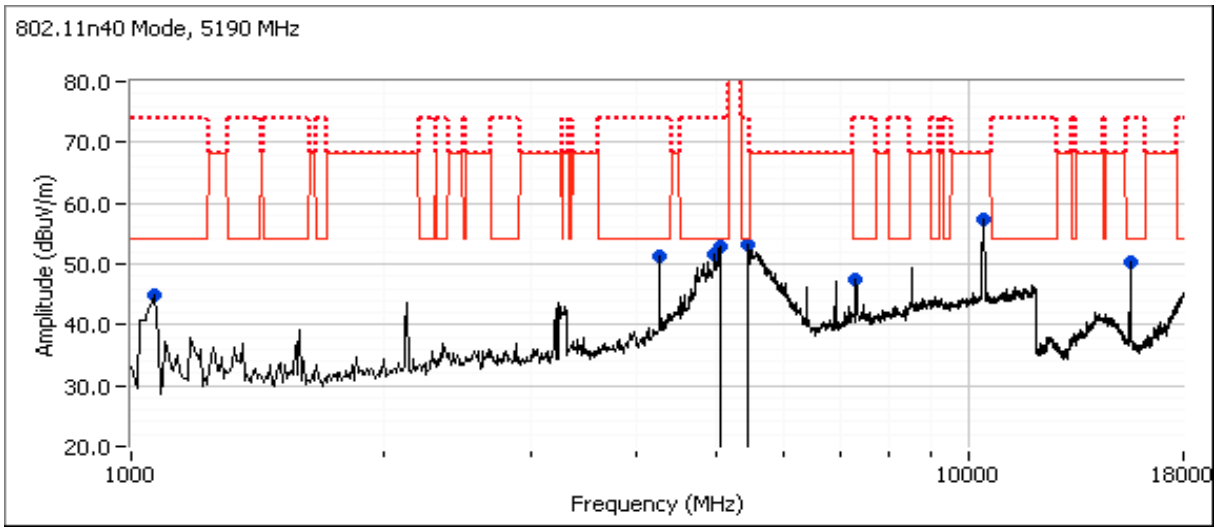
Run #1c: Center Channel

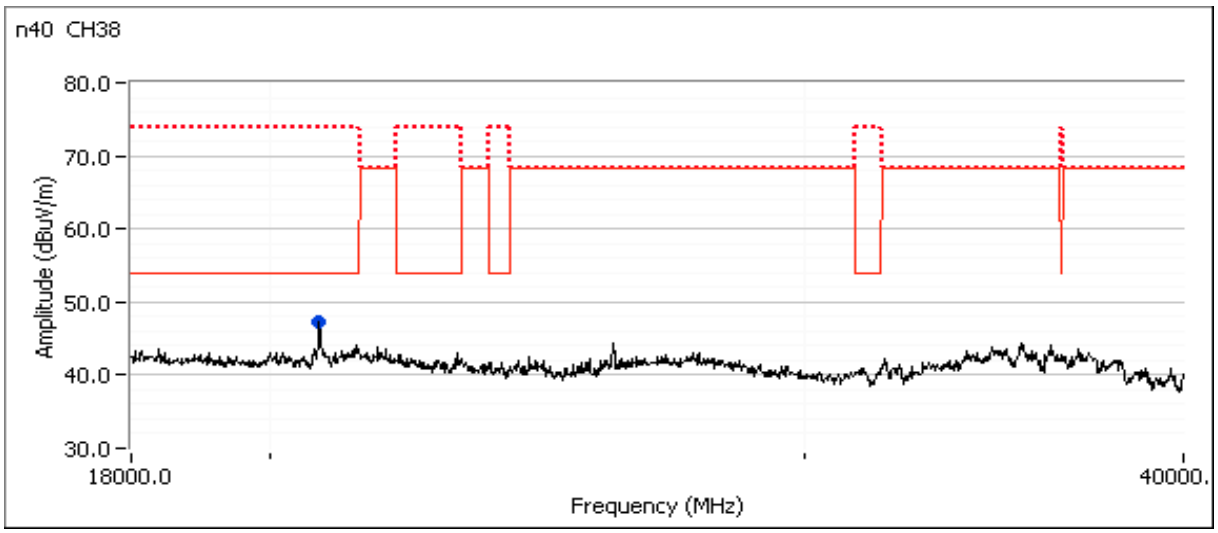
Channel: 38 Mode: 11n40
Tx Chain: 4Tx Data Rate: MCS0

Frequency	Level	Pol	15.209 / 15E		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
10380.540	64.7	H	68.3	-3.6	PK	44	1.3	RB 1 MHz;VB 3 MHz;Peak
4263.860	50.2	V	54.0	-3.8	Avg	360	2.0	RB 1 MHz;VB 1 kHz;Peak
4263.770	53.8	V	74.0	-20.2	PK	360	2.0	RB 1 MHz;VB 3 MHz;Peak
4960.300	47.2	H	54.0	-6.8	Avg	124	1.1	RB 1 MHz;VB 1 kHz;Peak
4950.600	58.8	H	74.0	-15.2	PK	124	1.1	RB 1 MHz;VB 3 MHz;Peak
5445.920	50.4	H	54.0	-3.6	Avg	169	1.1	RB 1 MHz;VB 1 kHz;Peak
5445.300	61.7	H	74.0	-12.3	PK	169	1.1	RB 1 MHz;VB 3 MHz;Peak
5014.700	48.7	H	54.0	-5.3	Avg	169	1.0	RB 1 MHz;VB 1 kHz;Peak
5013.600	60.4	H	74.0	-13.6	PK	169	1.0	RB 1 MHz;VB 3 MHz;Peak
7319.890	46.4	H	54.0	-7.6	Avg	200	2.0	RB 1 MHz;VB 1 kHz;Peak
7319.790	53.1	H	74.0	-20.9	PK	200	2.0	RB 1 MHz;VB 3 MHz;Peak
1065.990	35.5	V	54.0	-18.5	Avg	202	1.0	RB 1 MHz;VB 1 kHz;Peak
1066.010	40.7	V	74.0	-33.3	PK	202	1.0	RB 1 MHz;VB 3 MHz;Peak
15573.670	48.4	V	54.0	-5.6	Avg	110	1.9	RB 1 MHz;VB 1 kHz;Peak
15573.070	59.6	V	74.0	-14.4	PK	110	1.9	RB 1 MHz;VB 3 MHz;Peak
20759.860	47.2	V	54.0	-6.8	Peak	140	2.0	

Note 1:	For emissions in restricted bands, the limit of 15.209 was used which requires average and peak measurements.

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A





Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

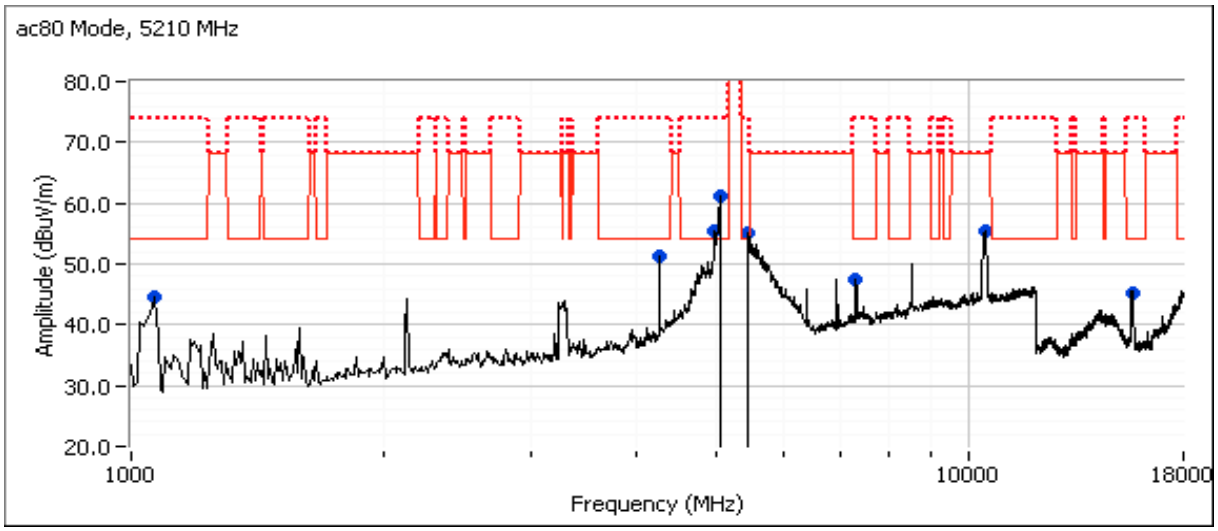
Run #1d: Center Channel

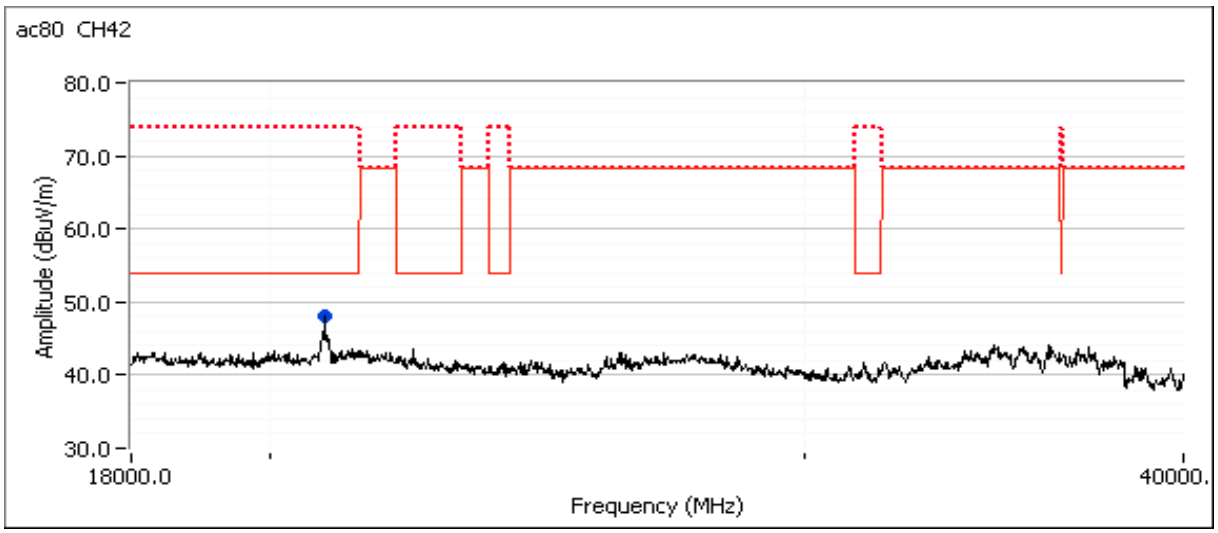
Channel: 42 Mode: ac80
Tx Chain: 4Tx Data Rate: VHT0

Frequency	Level	Pol	15.209 / 15E		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
Power setting = 25								
1066.000	36.4	H	54.0	-17.6	Avg	334	1.0	RB 1 MHz;VB 1 kHz;Peak
1065.980	42.8	H	74.0	-31.2	PK	334	1.0	RB 1 MHz;VB 3 MHz;Peak
7319.980	46.4	H	54.0	-7.6	Avg	194	1.3	RB 1 MHz;VB 1 kHz;Peak
7320.100	52.5	H	74.0	-21.5	PK	194	1.3	RB 1 MHz;VB 3 MHz;Peak
10419.160	62.1	V	68.3	-6.2	PK	184	2.3	RB 1 MHz;VB 3 MHz;Peak
4983.320	52.4	H	54.0	-1.6	Avg	129	1.4	RB 1 MHz;VB 1 kHz;Peak
4983.780	69.2	H	74.0	-4.8	PK	129	1.4	RB 1 MHz;VB 3 MHz;Peak
4263.790	52.1	V	54.0	-1.9	Avg	0	2.0	RB 1 MHz;VB 1 kHz;Peak
4263.830	54.8	V	74.0	-19.2	PK	0	2.0	RB 1 MHz;VB 3 MHz;Peak
15616.330	44.4	V	54.0	-9.6	Avg	67	1.8	RB 1 MHz;VB 1 kHz;Peak
15648.070	57.4	V	74.0	-16.6	PK	67	1.8	RB 1 MHz;VB 3 MHz;Peak
5458.450	67.1	H	-	-	PK	89	1.4	Refer to bandedge measurements
5055.820	72.6	H	-	-	PK	119	1.3	Refer to bandedge measurements

Note 1: For emissions in restricted bands, the limit of 15.209 was used which requires average and peak measurements.

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A





Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Run #2: Radiated Spurious Emissions, 1,000 - 40000 MHz. Operating Mode: Worse case from Run #1

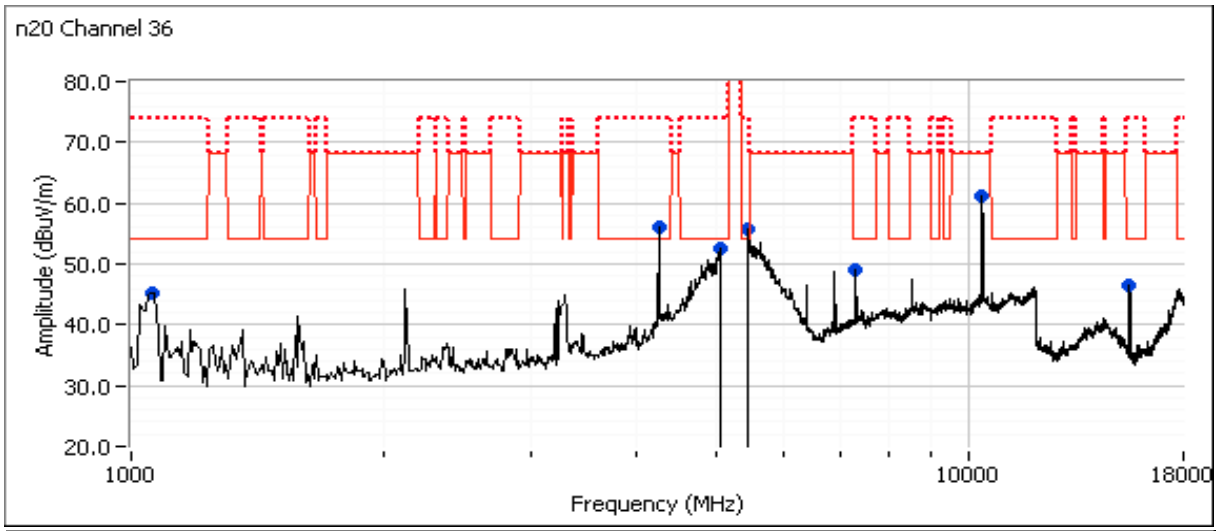
Date of Test: 5/9/2016, 5/11/16 Config. Used: 1
Test Engineer: R. Varelas, J. Caizzi, Yew-Kwong Config Change: None
Test Location: FT Chamber #7 EUT Voltage: 120V/60Hz

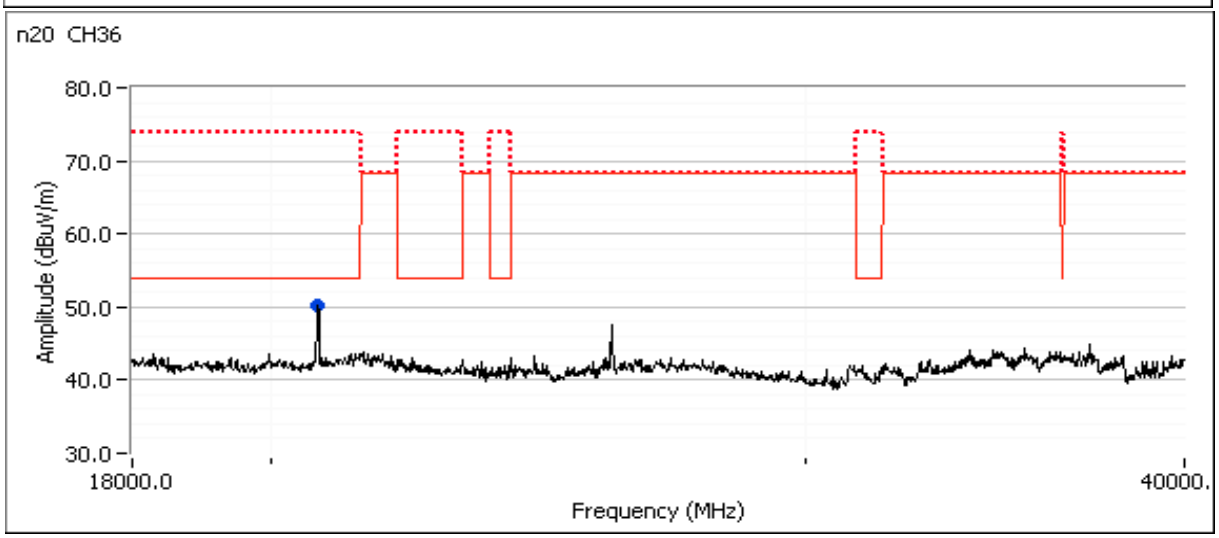
Run #2a: Low Channel

Channel: 36 Mode: 11n20
Tx Chain: 4Tx Data Rate: MCS0

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
20719.840	45.9	V	54.0	-8.1	AVG	164	1.4	RB 1 MHz;VB 10 Hz;Peak
20716.510	57.6	V	74.0	-16.4	PK	164	1.4	RB 1 MHz;VB 3 MHz;Peak
15534.000	50.9	V	54.0	-3.1	AVG	350	1.9	RB 1 MHz;VB 10 Hz;Peak
15535.600	63.5	V	74.0	-10.5	PK	350	1.9	RB 1 MHz;VB 3 MHz;Peak
1058.330	45.3	H	54.0	-8.7	Peak	188	1.5	Note 7
4258.330	56.2	V	54.0	2.2	Peak	8	2.0	Note 7
5041.670	52.5	H	54.0	-1.5	Peak	126	1.5	Note 5
5441.670	55.9	H	54.0	1.9	Peak	99	1.5	Note 5
7320.000	49.1	H	54.0	-4.9	Peak	183	2.0	Note 7
10359.930	59.0	H	54.0	5.0	AVG	52	1.0	
10360.200	71.4	H	74.0	-2.6	PK	52	1.0	
10360.200	71.4	H	68.3	3.1	PK	52	1.0	
10360.070	55.2	H	54.0	1.2	AVG	52	1.0	Pwr = 17
10360.330	68.1	H	74.0	-5.9	PK	52	1.0	Pwr = 17
10360.330	68.1	H	68.3	**-0.2**	PK	52	1.0	Pwr = 17

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A



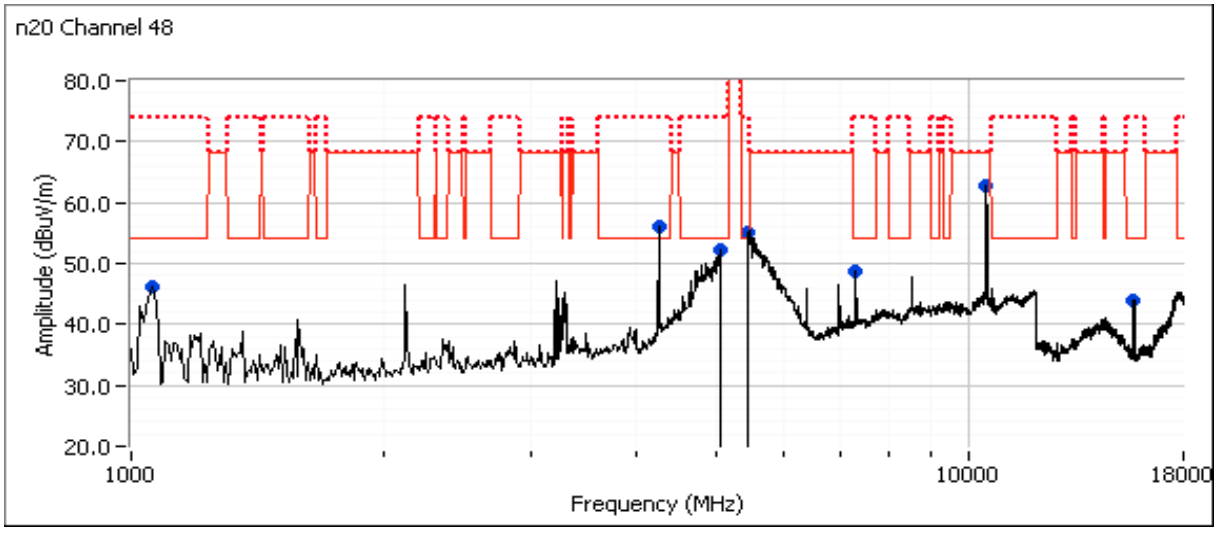


Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

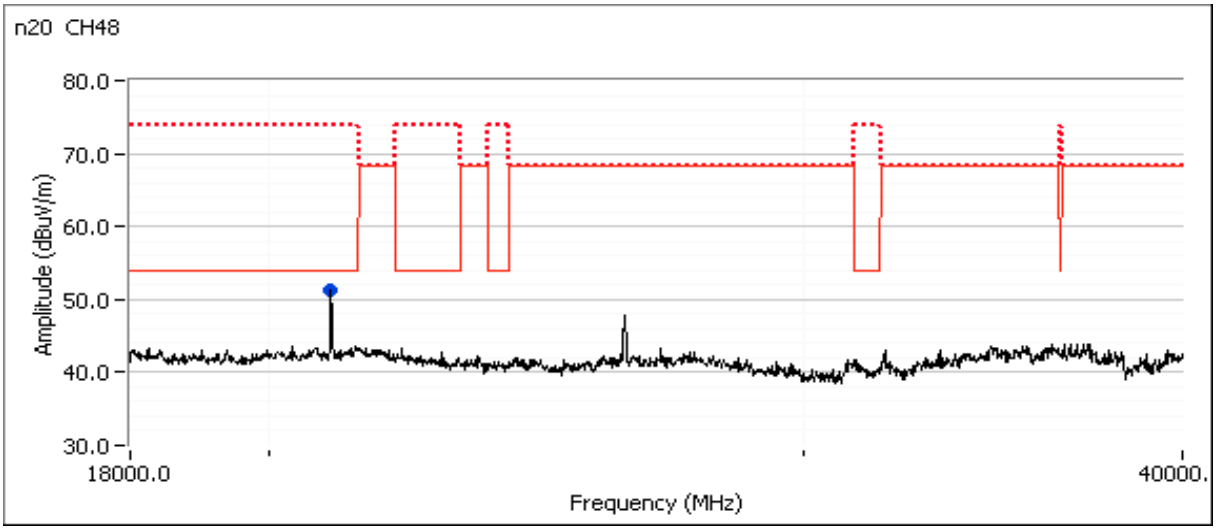
Run #2b: High Channel

Channel: 48 Mode: 11n20
Tx Chain: 4Tx Data Rate: MCS0

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
10478.330	67.2	H	68.3	**-1.1**	PK	48	1.1	Pwr = 16
20959.970	46.4	V	54.0	-7.6	AVG	64	1.0	RB 1 MHz;VB 10 Hz;Peak
20960.640	59.5	V	74.0	-14.5	PK	64	1.0	RB 1 MHz;VB 3 MHz;Peak
15723.870	50.4	V	54.0	-3.6	AVG	104	1.5	RB 1 MHz;VB 10 Hz;Peak
15724.000	62.5	V	74.0	-11.5	PK	104	1.5	RB 1 MHz;VB 3 MHz;Peak
5041.670	52.3	H	-	-	Peak	133	1.5	Note 5
5441.670	55.2	H	-	-	Peak	98	1.5	Note 5
7320.000	48.8	H	-	-	Peak	181	2.0	Note 7
1058.330	46.1	V	-	-	Peak	133	1.0	Note 7
4258.330	56.1	V	-	-	Peak	8	2.0	Note 7



Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A



Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Run #7, Radiated Spurious Emissions, 1,000 - 40,000 MHz. Operation in the 5725-5850 MHz Band

Date of Test: 5/4/2016 & 5/9/16 Config. Used: 1
Test Engineer: Rafael Varelas, John Caizzi Config Change: None
Test Location: FT Chamber #7 EUT Voltage: 120V/60Hz

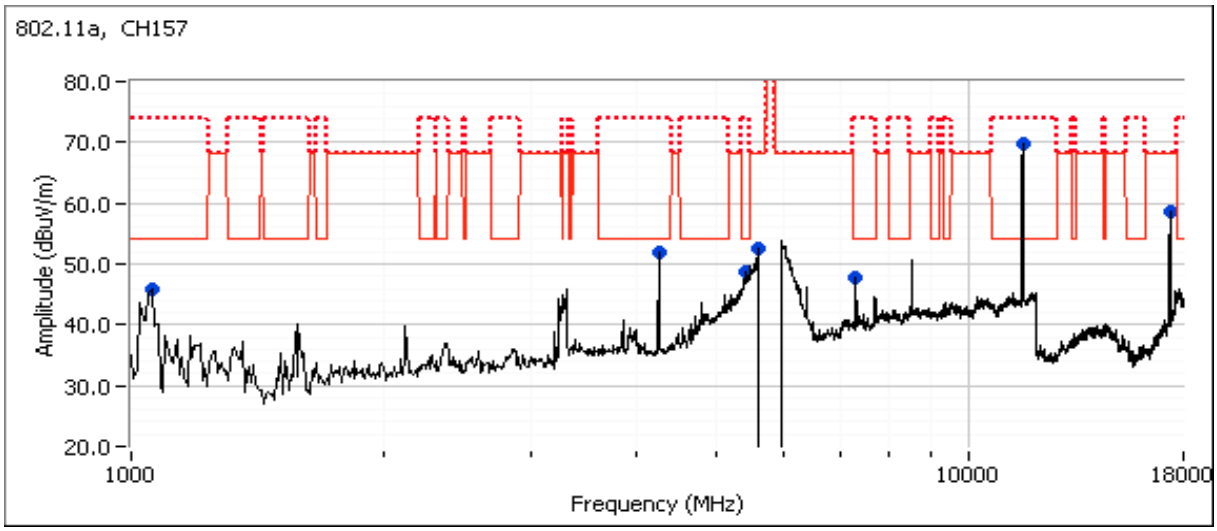
Run #7a: Center Channel

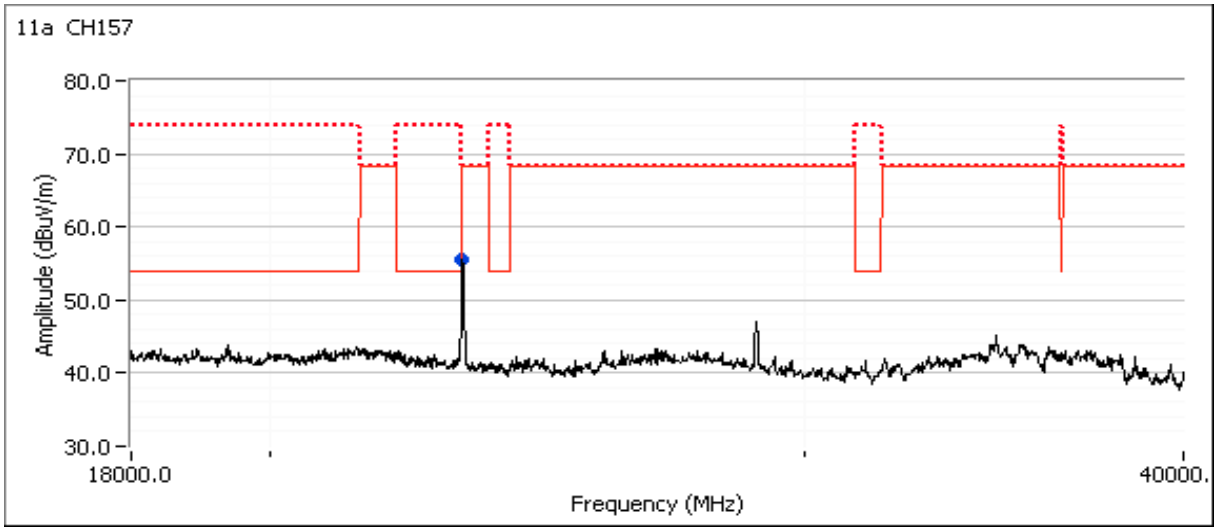
Channel: 157 Mode: a
Tx Chain: 4Tx Data Rate: 6Mbps

Frequency	Level	Pol	15.209 / 15E		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
1058.330	45.9	V	54.0	-8.1	Peak	148	2.5	
4258.330	51.8	H	54.0	-2.2	Peak	0	2.5	
5400.000	48.7	H	54.0	-5.3	Peak	100	1.3	
5600.000	52.5	H	68.3	-15.8	Peak	100	1.6	
7320.000	47.9	H	54.0	-6.1	Peak	191	1.9	
17350.000	58.5	V	68.3	-9.8	Peak	204	1.5	
23146.290	55.5	V	68.3	-12.8	Peak	332	2.5	
11571.770	-	H	54.0	-	Avg	56	1.0	RB 1 MHz;VB 3 kHz;Peak, note 8
23133.200	63.8	H	68.3	-4.5	PK	63	1.1	RB 1 MHz;VB 3 MHz;Peak

Note 8:	Broadband scans performed at a higher output power setting than the final power setting. The worse case mode was n20 and the final n20 power is equal to or higher than the final power for this mode.

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A





Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

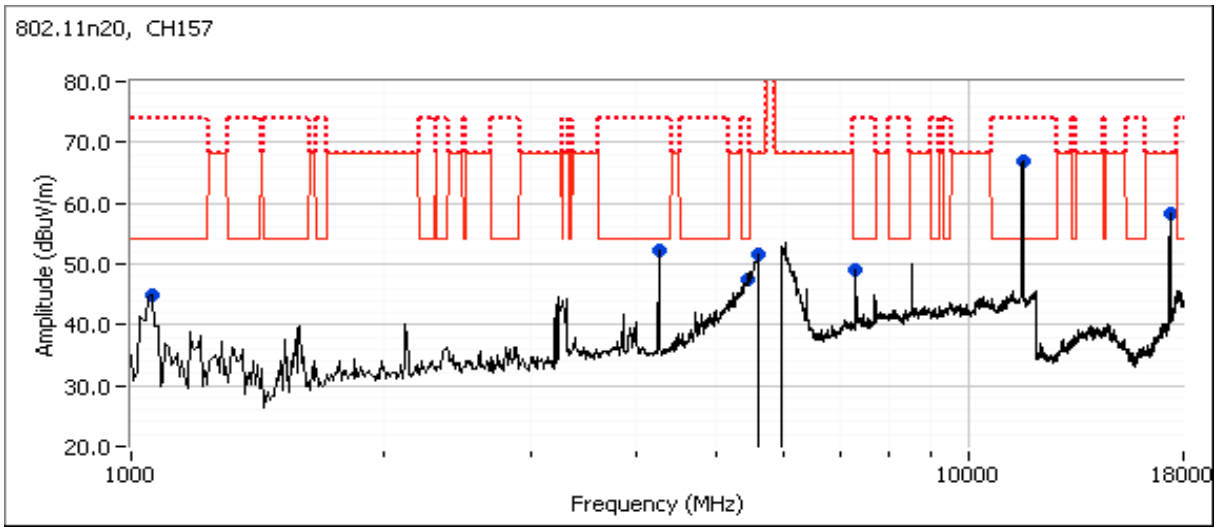
Run #7b: Center Channel

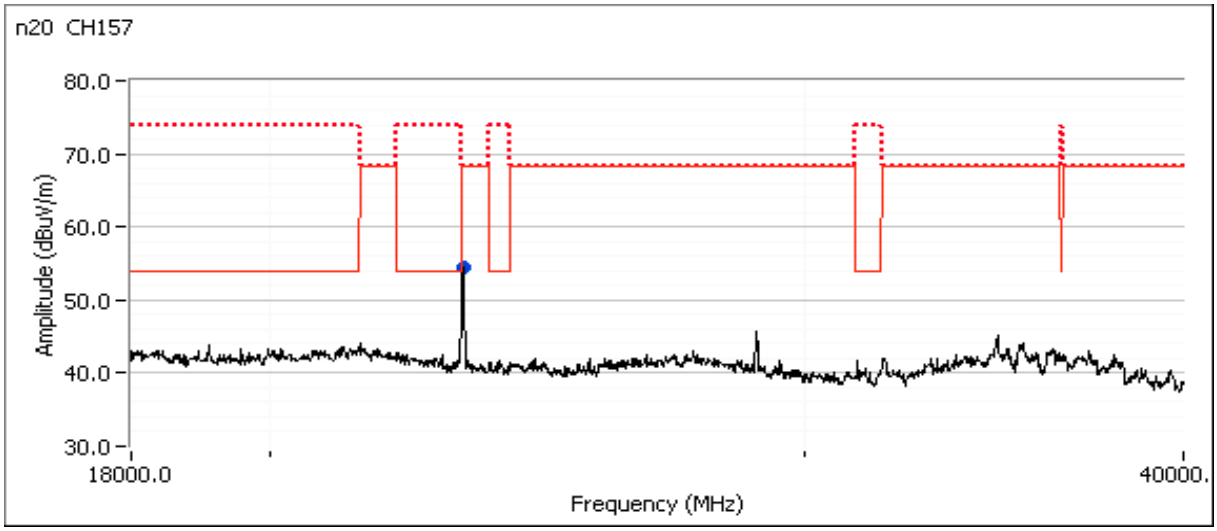
Channel: 157 Mode: 11n20
Tx Chain: 4Tx Data Rate: MCS0

Frequency	Level	Pol	15.209 / 15E		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
1058.330	44.9	V	54.0	-9.1	Peak	156	2.5	
4258.330	52.3	H	54.0	-1.7	Peak	0	2.5	
5441.670	47.4	H	54.0	-6.6	Peak	99	1.6	
5608.330	51.5	H	68.3	-16.8	Peak	162	1.6	
7320.000	49.2	H	54.0	-4.8	Peak	185	2.2	
17350.000	58.2	V	68.3	-10.1	Peak	203	1.5	
23156.670	54.6	H	68.3	-13.7	Peak	63	1.0	
23137.200	54.6	H	68.3	-13.7	Peak	63	1.0	
23130.930	66.3	H	68.3	-2.0	PK	61	1.1	RB 1 MHz;VB 3 MHz;Peak
11569.800	53.8	V	54.0	-0.2	AVG	274	1.1	RB 1 MHz;VB 10 Hz;Peak
11575.530	68.3	V	74.0	-5.7	PK	274	1.1	RB 1 MHz;VB 3 MHz;Peak

Note: Broadband scans performed at a higher output power setting than the final power setting.

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A





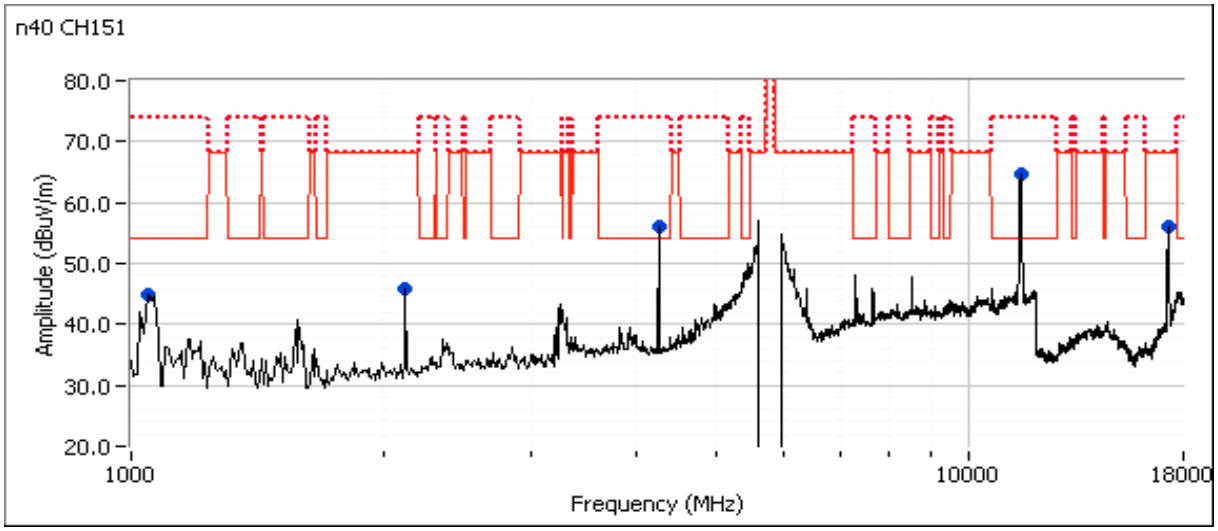
Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Run #7c: Center Channel

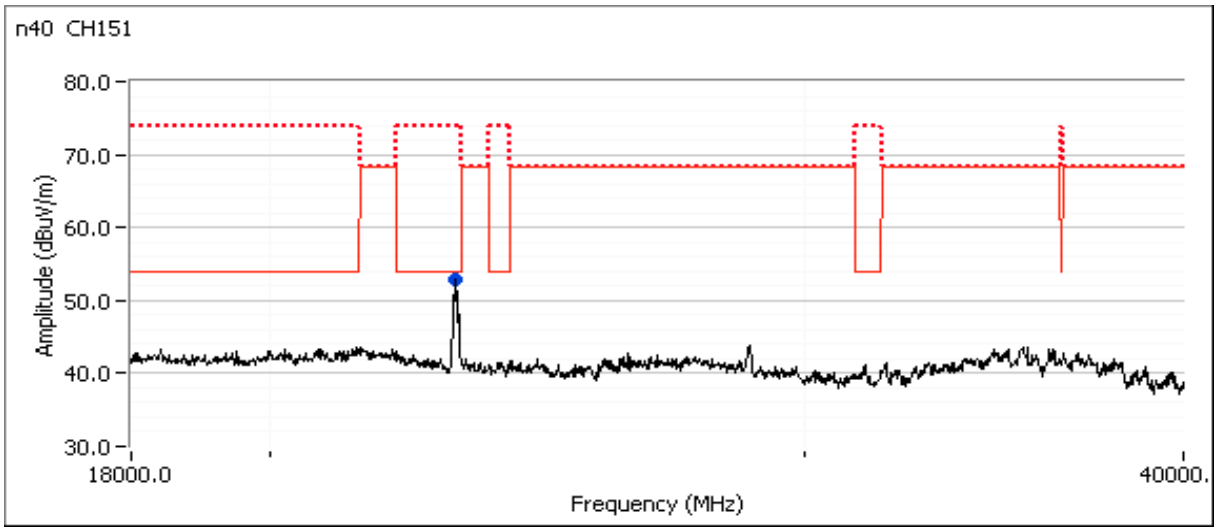
Channel: 151 Mode: 11n40
Tx Chain: 4Tx Data Rate: MCS0

Frequency	Level	Pol	15.209 / 15E		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
1050.000	45.0	V	54.0	-9.0	Peak	166	2.5	
2125.000	45.8	H	68.3	-22.5	Peak	57	1.5	
17250.000	56.1	V	68.3	-12.2	Peak	128	1.50	
23013.040	52.0	H	54.0	-2.0	Avg	64	1.08	RB 1 MHz;VB 1 kHz; note 3
23013.700	63.9	H	74.0	-10.1	PK	64	1.08	RB 1 MHz;VB 3 MHz;Peak
11510.000	-	V	54.0	-	Avg	169	2.01	Note 8
11509.730	-	V	74.0	-	PK	169	2.01	Note 8
4258.330	56.2	V	-	-	Peak	9	2.0	Note 7

Note 8:	Broadband scans performed at a higher output power setting than the final power setting. The worse case mode was n20 and the final n20 power is equal to or higher than the final power for this mode.



Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A



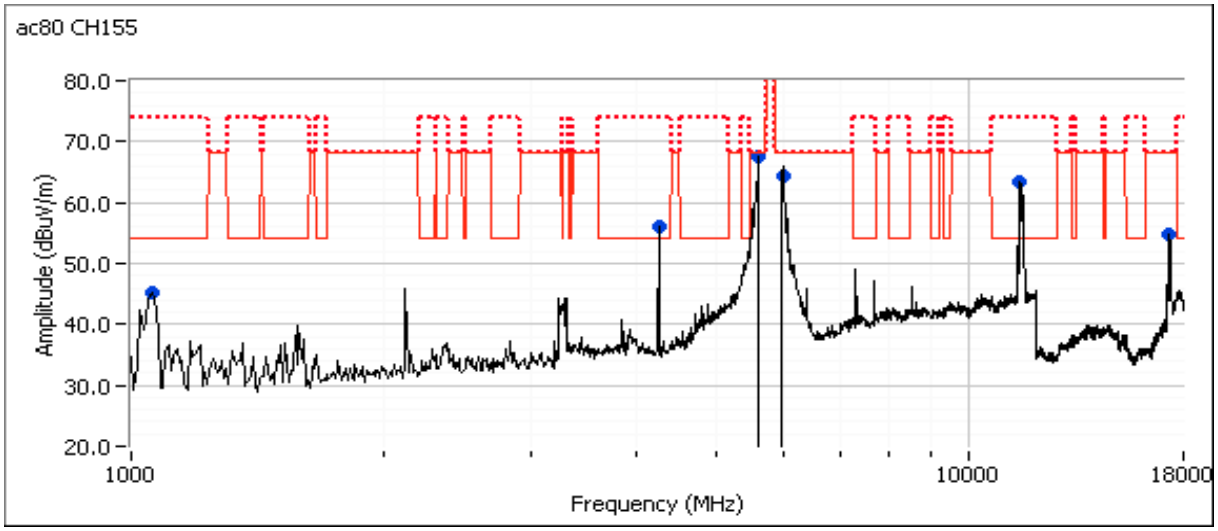
Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Run #7d: Center Channel

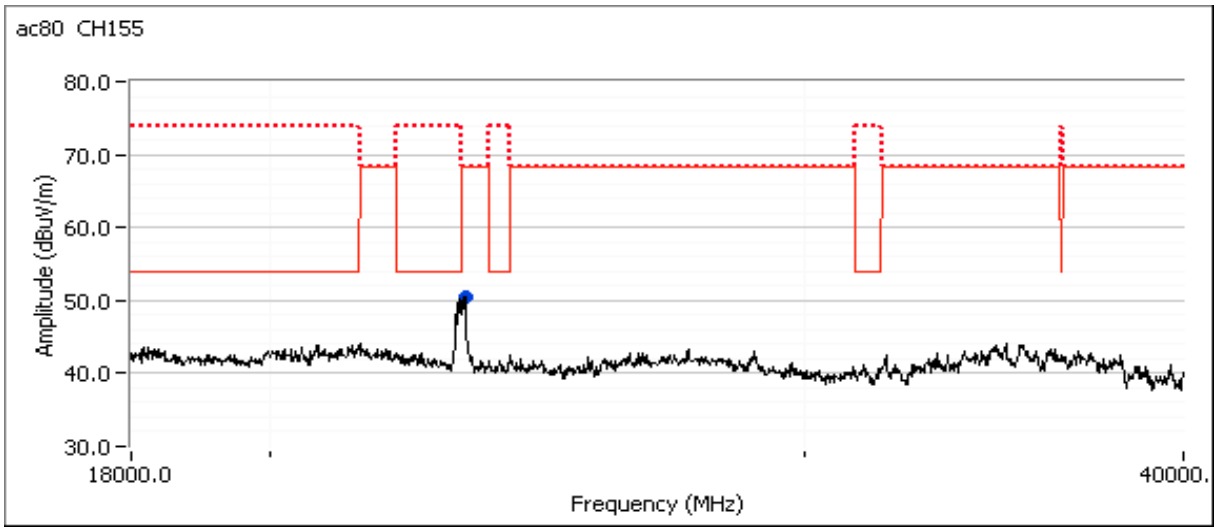
Channel: 155 Mode: ac80
Tx Chain: 4Tx Data Rate: VHT0

Frequency	Level	Pol	15.209 / 15E		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
1058.330	45.3	V	54.0	-8.7	Peak	162	2.0	
5608.330	-	H	68.3	-	Peak	100	1.5	Refer to bandedge
6000.000	-	H	68.3	-	Peak	39	1.0	Refer to bandedge
17330.000	54.7	V	68.3	-13.6	Peak	128	1.5	
23185.000	50.5	V	68.3	-17.8	Peak	286	2.0	
11550.030	-	V	-	-	Avg	176	2.0	Note 8
11549.830	-	V	-	-	PK	176	2.0	Note 8
4258.330	56.0	V	-	-	Peak	13	2.0	Note 8

Note 8:	Broadband scans performed at a higher output power setting than the final power setting. The worse case mode was n20 and the final n20 power is equal to or higher than the final power for this mode.



Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A



Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Run #8: Radiated Spurious Emissions, 1,000 - 40000 MHz. Operating Mode: Worse case from Run #7

Date of Test: 5/11/2016 0:00 Config. Used: 1
Test Engineer: Rafael Varelas, John Caizzi Config Change: None
Test Location: FT Chamber #7 EUT Voltage: 120V/60Hz

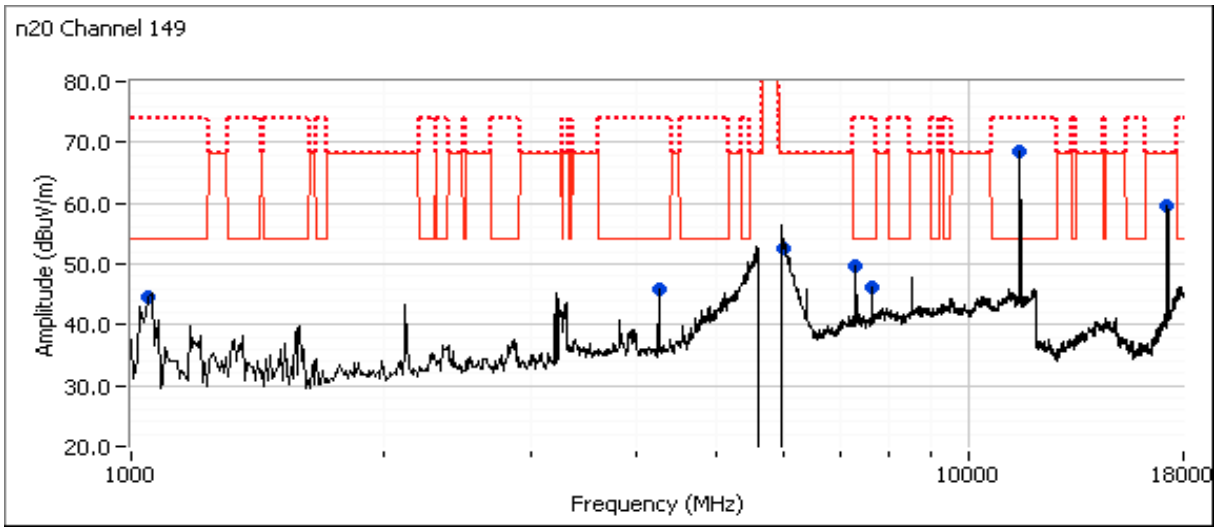
Run #8a: Low Channel

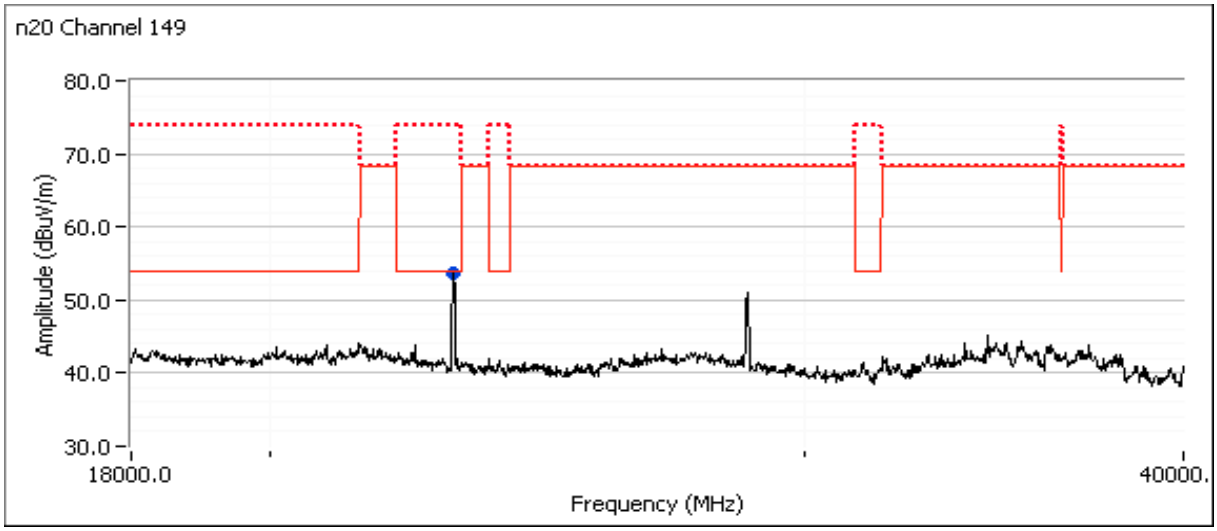
Channel: 149 Mode: 11n20
Tx Chain: 4Tx Data Rate: MCS0

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
6010.000	52.5	H	68.3	-15.8	Peak	134	1.5	Note 5
7660.000	46.1	H	54.0	-7.9	Peak	152	1.5	Measured in run 6.
17223.200	68.0	H	68.3	-0.3	PK	346	1.4	RB 1 MHz;VB 3 MHz;Peak
22980.120	50.1	V	54.0	-3.9	AVG	95	1.0	RB 1 MHz;VB 10 Hz;Peak
23002.120	61.8	V	74.0	-12.2	PK	95	1.0	RB 1 MHz;VB 3 MHz;Peak
11490.370	52.9	H	54.0	-1.1	AVG	55	1.0	RB 1 MHz;VB 10 Hz;Peak
11490.040	68.2	H	74.0	-5.8	PK	55	1.0	RB 1 MHz;VB 3 MHz;Peak
1050.000	44.6	V	54.0	-9.4	Peak	168	2.5	Note 7
4266.670	45.7	V	54.0	-8.3	Peak	224	2.0	Note 7
7320.000	49.7	H	54.0	-4.3	Peak	188	2.0	Note 7

Note: Broadband scans performed at a higher output power setting than the final power setting.

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A





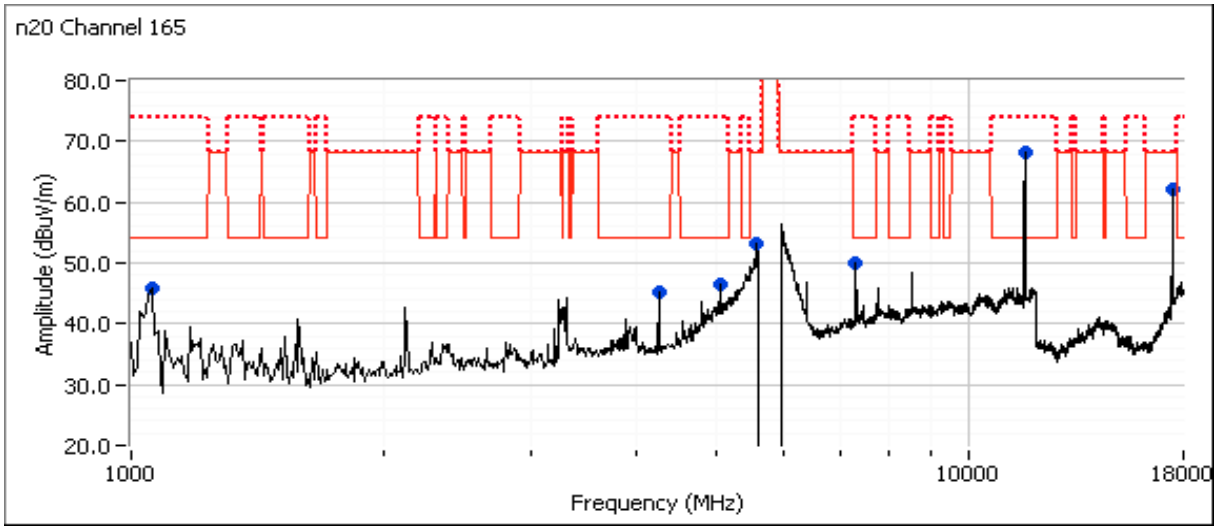
Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Run #8b: High Channel

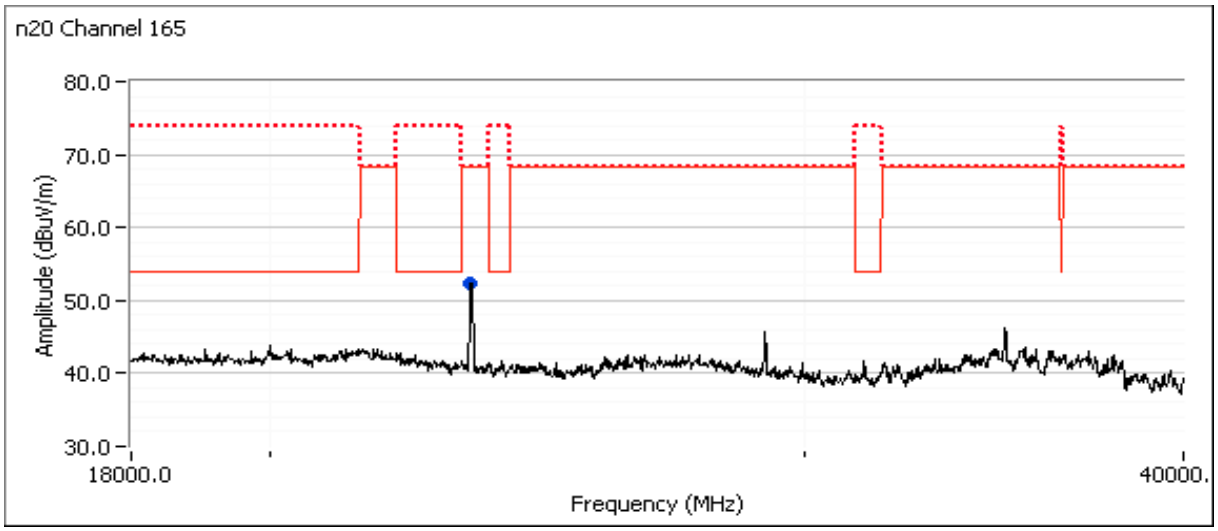
Channel: 165 Mode: 11n20
Tx Chain: 4Tx Data Rate: MCS0

Frequency	Level	Pol	15.209 / 15.247		Detector	Azimuth	Height	Comments
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters	
5041.670	46.4	H	54.0	-7.6	Peak	133	1.5	peak vs avg limit
5575.000	53.2	V	68.3	-15.1	Peak	312	1.0	refer to bandedge
11650.000	68.2	V	54.0	14.2	Peak	174	2.0	
23280.330	61.6	V	68.3	-6.7	PK	136	1.0	RB 1 MHz;VB 3 MHz;Peak
17482.530	64.3	H	68.3	-4.0	PK	348	1.3	RB 1 MHz;VB 3 MHz;Peak
11649.600	53.9	V	54.0	-0.1	AVG	180	1.9	RB 1 MHz;VB 10 Hz;Peak
11650.200	68.2	V	74.0	-5.8	PK	180	1.9	RB 1 MHz;VB 3 MHz;Peak
1058.330	45.9	V	54.0	-8.1	Peak	161	2.5	Note 7
4266.670	45.2	V	54.0	-8.8	Peak	2	2.0	Note 7
7320.000	50.0	H	54.0	-4.0	Peak	182	2.0	Note 7
5575.000	53.2	V	68.3	-15.1	Peak	312	1.0	refer to bandedge

Note:	Broadband scans performed at a higher output power setting than the final power setting.



Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A



Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

RSS-247 (LELAN) and FCC 15.407(UNII)
Antenna Port Measurements
Power, PSD, Bandwidth and Spurious Emissions

Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

Summary of Results

Run #	Test Performed	Limit	Pass / Fail	Result / Margin
1	Power, 5150 - 5250MHz	15.407(a) (1) (iv)	Pass	a: 17.5 dBm (55.6 mW) n20: 18.3 dBm (68.0 mW) n40: 20.8 dBm (120.0 mW) ac80: 17.4 dBm (55.1 mW)
1	PSD, 5150 - 5250MHz	15.407(a) (1) (iv)	Pass	a: 6.7 dBm/MHz n20: 7.3 dBm/MHz n40: 6.8 dBm/MHz ac80: 0.8 dBm/MHz
1	99% Bandwidth	RSS-247 (Information only)	N/A	a: 16.9 MHz n20: 18.1 MHz n40: 36.4 MHz ac80: 75.2 MHz

General Test Configuration

When measuring the conducted emissions from the EUT's antenna port, the antenna port of the EUT was connected to the spectrum analyzer or power meter via a suitable attenuator to prevent overloading the measurement system. All measurements are corrected to allow for the external attenuators and cables used.

Ambient Conditions:

Temperature: 22-26 °C
Rel. Humidity: 40-45 %

Modifications Made During Testing

No modifications were made to the EUT during testing

Deviations From The Standard

No deviations were made from the requirements of the standard.

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Procedure Comments:

Measurements performed in accordance with FCC KDB 789033 D01

Mode	Data Rate	Duty Cycle (x)	Constant DC?	T (ms)	Pwr Cor Factor*	Lin Volt Cor Factor**	Min VBW for FS (Hz)
11a	6Mbps	90.1%	Yes	0.57	0.45	0.90	1764
n20	MCS0	99.0%	Yes	5.00	0	0	10
n40	MCS0	97.3%	Yes	2.44	0.12	0.24	410
ac80	VHT0	94.4%	Yes	1.12	0.25	0.50	890

Sample Notes

Sample S/N: GTCFNS1630E0091

Driver:

	Chain 1	Chain 2	Chain 3	Chain 4
Port Assignment:	J403	J404	J405	J406

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Run #1: Bandwidth, Output Power and Power Spectral Density - MIMO Systems

Date of Test: 9/19/16 and 9/20/16
Test Engineer: M. Birgani; J. Caizi
Test Location: Lab 4

Config. Used: Conducted
Config Change: -
EUT Voltage: 120V/ 60Hz

Note 1:	Duty Cycle ≥ 98%. Output power measured using a spectrum analyzer (see plots below). RBW=1MHz, VB=3 MHz, Span > OBW, # of points in sweep ≥ 2*span/RBW, auto sweep, RMS detector, power averaging on (transmitted signal was continuous, duty cycle ≥ 98%) and power integration over the OBW (method SA-1 of ANSI C63.10).
Note 1:	Constant Duty Cycle < 98%. Output power measured using a spectrum analyzer (see plots below). RBW=1MHz, VB=3 MHz, Span > OBW, # of points in sweep ≥ 2*span/RBW, RMS detector, trace average 100 traces (at least 100 traces, increase the number to get true average), power averaging on and power integration over the OBW. Tthe measurements were adjusted by adding YY dB. This is based on 10log(1/x), where x is the duty cycle. (method SA-2 of ANSI C63.10)
Note 2:	Measured using the same analyzer settings used for output power.
Note 3:	For RSS-247 the limit for the 5150 - 5250 MHz band accounts for the antenna gain as the maximum eirp allowed is 10dBm/MHz. The limits are also corrected for instances where the highest measured value of the PSD exceeds the average PSD (calculated from the measured power divided by the measured 99% bandwidth) by more than 3dB by the amount that the measured value exceeds the average by more than 3dB.
Note 4:	99% Bandwidth measured in accordance with C63.10 - RB between 1-5 % of OBW and VB ≥ 3*RB, Span between 1.5 and 5 times OBW.
Note 5:	For MIMO systems the total output power and total PSD are calculated from the sum of the powers of the individual chains (in linear terms). The antenna gain used to determine the EIRP and limits for PSD/Output power depends on the operating mode of the MIMO device. If the signals on the non-coherent between the transmit chains then the gain used to determine the limits is the highest gain of the individual chains and the EIRP is the sum of the products of gain and power on each chain. If the signals are coherent then the effective antenna gain is the sum (in linear terms) of the gains for each chain and the EIRP is the product of the effective gain and total power.

Antenna Gain Information

Freq	Antenna Gain (dBi) / Chain				BF	MultiChain Legacy	CDD	Sectorized / Xpol	Dir G (PWR)	Dir G (PSD)
	1	2	3	4						
5150-5250	3.06	2.97	4.86	3.01	No	Yes	Yes	No	3.55	9.48
5250-5350	3.57	2.97	5.42	3.48	No	Yes	Yes	No	3.96	9.86
5470-5725	3.37	3.78	6.18	4.91	No	Yes	Yes	No	4.70	10.59
5725-5825	3.61	3.72	6.57	4.76	No	Yes	Yes	No	4.84	10.60

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

For devices that support CDD modes

Min # of spatial streams: 1

Max # of spatial streams: 4

Notes:	BF = beamforming mode supported, Multichain Legacy = 802.11 legacy data rates supported for multichain transmissions, CDD = Cyclic Delay Diversity (or Cyclic Shift Diversity) modes supported, Sectorized / Xpol = antennas are sectorized or cross polarized.
Notes:	Dir G (PWR) = total gain (Gant + Array Gain) for power calculations; GA (PSD) = total gain for PSD calculations based on FCC KDB 662911. Depending on the modes supported, the Array Gain value for power could be different from the PSD value.
Notes:	Array gain for power/psd calculated per KDB 662911 D01.
Notes:	For systems with Beamforming and CDD, choose one the following options: Option 1: Delays are optimized for beamforming, rather than being selected from cyclic delay table of 802.11; Array gains calculated based on beamforming criteria. Option 2: Antennas are paired for beamforming, and the pairs are configured to use the cyclic delay diversity of 802.11; the array gain associated with beamforming with 2 antennas (3dB), and the array gain associated with CDD with two antennas (3dB for PSD and 0 dB for power)

FCC UNII-1 Limits		Pwr	PSD
	Outdoor AP	30	17
	Indoor AP	30	17
X	Station (e.g. Client)	24	11
	Outdoor AP (>30° Elv.)	21	-

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

MIMO Device - 5150-5250 MHz Band - FCC

Mode: 11a Max EIRP (mW): 125.9

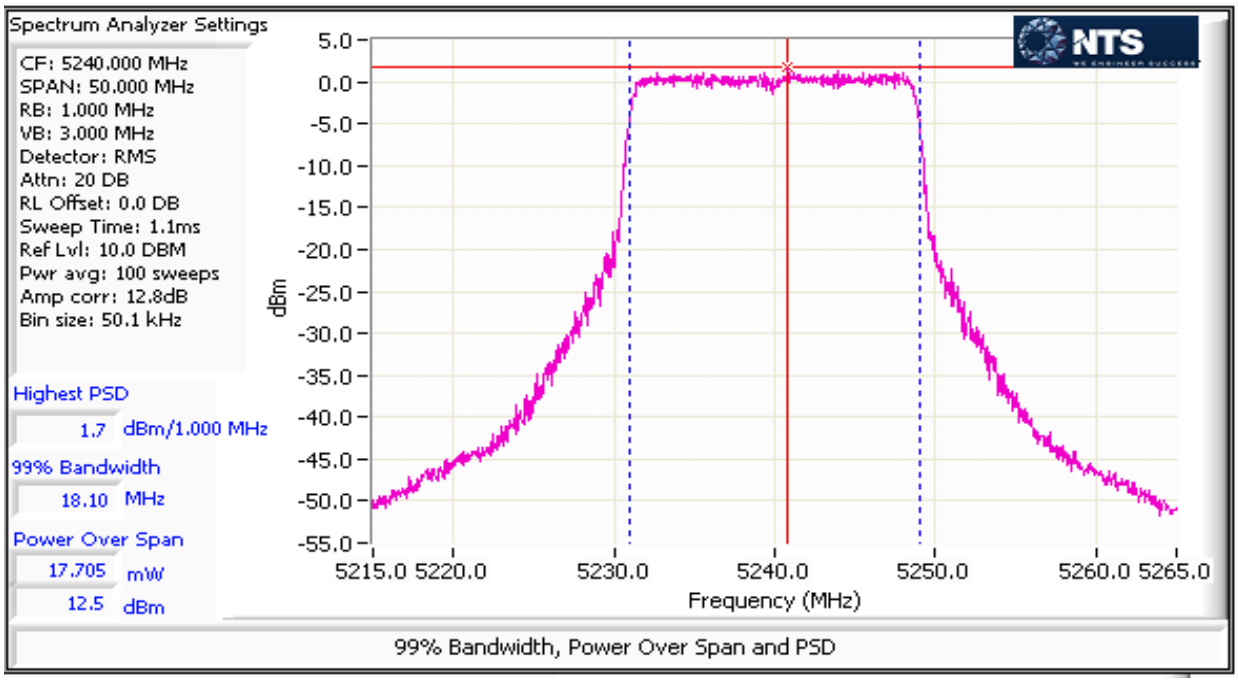
Frequency (MHz)	Chain	Software Setting	26dB BW (MHz)	Duty Cycle %	Power[1] dBm	Total Power mW	Total Power dBm	FCC Limit dBm	Max Power (W)	Result
5180	1	12		90.1	10.9	54.3	17.3	24.0	0.056	Pass
	3				10.9					
	4				10.8					
	2				10.9					
5200	1	12		90.1	11.0	53.4	17.3	24.0		Pass
	3				10.9					
	4				10.6					
	2				10.7					
5240	1	12		90.1	11.1	55.6	17.5	24.0		Pass
	3				11.0					
	4				10.7					
	2				11.1					

5150-5250 PSD - FCC

Mode: 11a

Frequency (MHz)	Chain	Software Setting	99% BW (MHz)	Duty Cycle %	PSD dBm/MHz	Total PSD[1] mW/MHz	Total PSD[1] dBm/MHz	FCC Limit dBm/MHz	Result
5180	1	12	16.9	90.1	0.2	4.5	6.5	7.5	Pass
	3				0.1				
	4				-0.1				
	2				0.2				
5200	1	12	16.9	90.1	0.5	4.6	6.6	7.5	Pass
	3				0.2				
	4				0.0				
	2				-0.3				
5240	1	12	16.9	90.1	0.2	4.7	6.7	7.5	Pass
	3				0.2				
	4				-0.1				
	2				0.5				

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A



Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

MIMO Device - 5150-5250 MHz Band - FCC

Mode: n20 Max EIRP (mW): 154.0

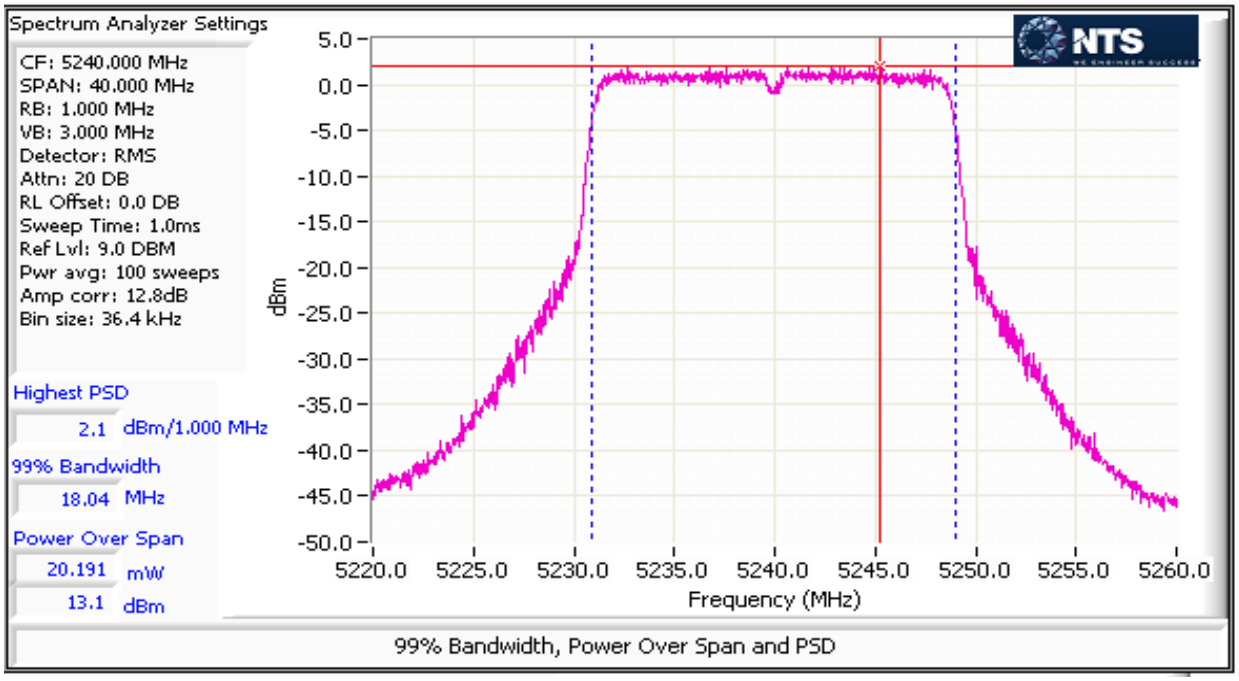
Frequency (MHz)	Chain	Software Setting	26dB BW (MHz)	Duty Cycle %	Power[1] dBm	Total Power mW	Total Power dBm	FCC Limit dBm	Max Power (W)	Result
5180	1	13		99.0	12.5	68.0	18.3	24.0	0.068	Pass
	3				12.3					
	4				12.0					
	2				12.4					
5200	1	13		99.0	12.2	64.2	18.1	24.0		Pass
	3				11.9					
	4				12.0					
	2				12.1					
5240	1	13		99.0	12.5	68.0	18.3	24.0		Pass
	3				12.4					
	4				11.9					
	2				12.4					

5150-5250 PSD - FCC

Mode: n20

Frequency (MHz)	Chain	Software Setting	99% BW (MHz)	Duty Cycle %	PSD dBm/MHz	Total PSD[1] mW/MHz	Total PSD[1] dBm/MHz	FCC Limit dBm/MHz	Result
5180	1	13	18.1	99.0	1.3	5.2	7.2	7.5	Pass
	3				1.2				
	4				0.8				
	2				1.2				
5200	1	13	18.1	99.0	1.2	5.0	7.0	7.5	Pass
	3				1.1				
	4				0.7				
	2				1.0				
5240	1	13	18.1	99.0	1.7	5.4	7.3	7.5	Pass
	3				1.2				
	4				1.1				
	2				1.2				

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A



Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

MIMO Device - 5150-5250 MHz Band - FCC

Mode: n40 Max EIRP (mW): 271.8

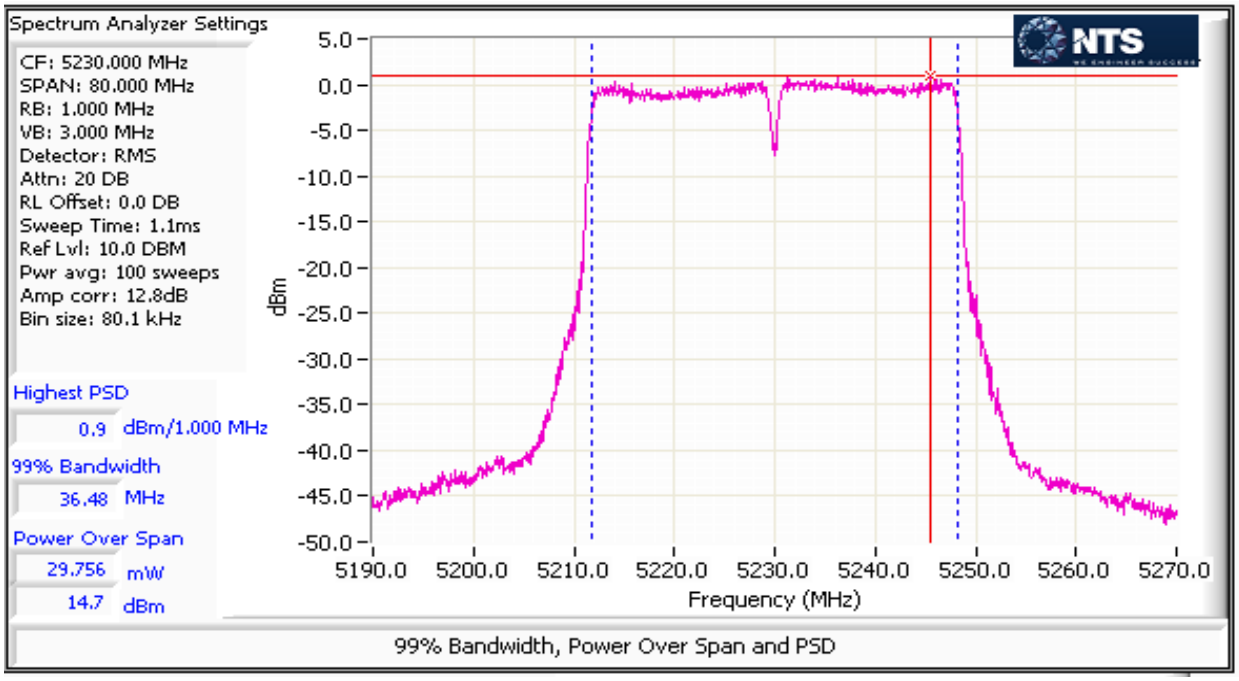
Frequency (MHz)	Chain	Software Setting	26dB BW (MHz)	Duty Cycle %	Power dBm	Total Power[1] mW	Total Power[1] dBm	FCC Limit dBm	Max Power (W)	Result
5190	1	13		97.3	12.7	72.7	18.6	24.0	0.120	Pass
	3				12.3					
	4				12.4					
	2				12.5					
5230	1	15		97.3	14.7	120.0	20.8	24.0		Pass
	3				14.5					
	4				14.7					
	2				14.7					

5150-5250 PSD - FCC

Mode: n40

Frequency (MHz)	Chain	Software Setting	99% BW (MHz)	Duty Cycle %	PSD dBm/MHz	Total PSD[1] mW/MHz	Total PSD[1] dBm/MHz	FCC Limit dBm/MHz	Result
5190	1	13	36.4	97.3	-1.4	2.9	4.6	7.5	Pass
	3				-1.7				
	4				-1.5				
	2				-1.7				
5230	1	15	36.4	97.3	0.6	4.8	6.8	7.5	Pass
	3				0.7				
	4				0.9				
	2				0.6				

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A



Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

MIMO Device - 5150-5250 MHz Band - FCC

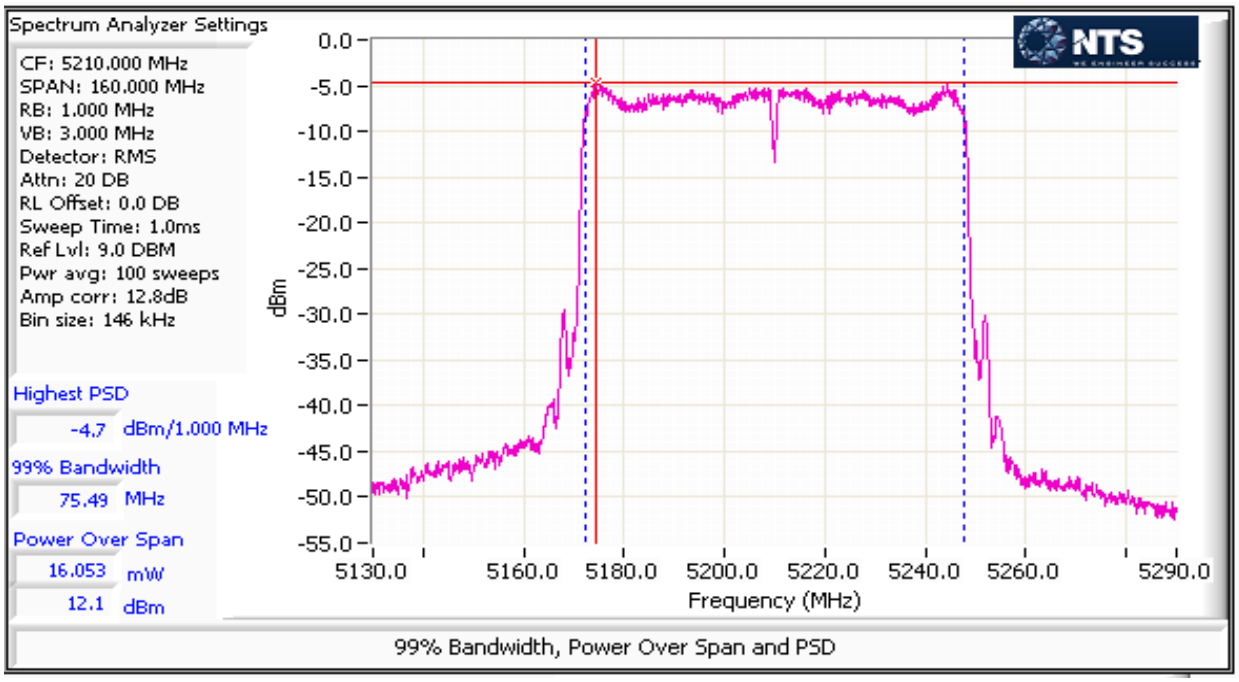
Mode: **ac80** Max EIRP (mW): 124.8

Frequency (MHz)	Chain	Software Setting	26dB BW (MHz)	Duty Cycle %	Power dBm	Total Power[1] mW	Total Power[1] dBm	FCC Limit dBm	Max Power (W)	Result
5210	1	12		94.4	11.5	55.1	17.4	24.0	0.055	Pass
	3				11.4					
	4				10.5					
	2				11.1					

5150-5250 PSD - FCC

Mode: **ac80**

Frequency (MHz)	Chain	Software Setting	99% BW (MHz)	Duty Cycle %	PSD dBm/MHz	Total PSD[1] mW/MHz	Total PSD[1] dBm/MHz	FCC Limit dBm/MHz	Result
5210	1	12	75.2	94.4	-5.4	1.2	0.8	7.5	Pass
	3				-5.0				
	4				-6.0				
	2				-5.4				



Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

FCC 15.407(UNII)
Antenna Port Measurements
Power, PSD, Bandwidth and Spurious Emissions

Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

Summary of Results

Run #	Test Performed	Limit	Pass / Fail	Result / Margin
1	Power, 5150 - 5250MHz	15.407(a) (1) (iv)	Pass	n20: 18.3 dBm (68.0 mW) n40: 20.3 dBm (107.8 mW) ac80: 17.4 dBm (55.1 mW)
1	PSD, 5150 - 5250MHz	15.407(a) (1) (iv)	Pass	n20: 7.3 dBm/MHz n40: 6.1 dBm/MHz ac80: 0.8 dBm/MHz
1	99% Bandwidth	RSS-247 (Information only)	N/A	n20: 18.1 MHz n40: 36.4 MHz ac80: 75.2 MHz

General Test Configuration

When measuring the conducted emissions from the EUT's antenna port, the antenna port of the EUT was connected to the spectrum analyzer or power meter via a suitable attenuator to prevent overloading the measurement system. All measurements are corrected to allow for the external attenuators and cables used.

Ambient Conditions:

Temperature: 20-22 °C
Rel. Humidity: 35-40 %

Modifications Made During Testing

No modifications were made to the EUT during testing

Deviations From The Standard

No deviations were made from the requirements of the standard.

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Procedure Comments:

Measurements performed in accordance with FCC KDB 789033 D01

Mode	Data Rate	Duty Cycle (x)	Constant DC?	T (ms)	Pwr Cor Factor*	Lin Volt Cor Factor**	Min VBW for FS (Hz)
11a	6Mbps	90.1%	Yes	0.567	0.45	0.90	1764
n20	MCS0	99.0%	Yes	4.995	0	0	10
n40	MCS0	97.3%	Yes	2.438	0.12	0.24	410
ac80	VHT0	94.4%	Yes	1.124	0.25	0.50	890

Sample Notes

Sample S/N: GTCFNS1630E0091

Driver:

	Chain 1	Chain 2	Chain 3	Chain 4
Port Assignment:	J403	J404	J405	J406

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Run #1: Bandwidth, Output Power and Power Spectral Density - MIMO Systems

Date of Test: 09/27/16 Config. Used: Conducted
Test Engineer: Mehran Birgani Config Change: -
Test Location: FT Lab 4 EUT Voltage: 120V/60Hz

Note 1:	Duty Cycle ≥ 98%. Output power measured using a spectrum analyzer (see plots below). RBW=1MHz, VB=3 MHz, Span > OBW, # of points in sweep ≥ 2*span/RBW, auto sweep, RMS sample detector, power averaging on (transmitted signal was continuous, duty cycle ≥ 98%) and power integration over the OBW (method SA-1 of ANSI C63.10).
Note 1:	Duty Cycle < 98%. Output power measured using a spectrum analyzer (see plots below). RBW=1MHz, VB=3 MHz, Span > OBW, # of points in sweep ≥ 2*span/RBW, auto sweep, RMS sample detector, power averaging on (transmitted signal was not continuous, but the analyzer was configured to trigger only on full power pulses such that the analyzer was only sweeping when the device was transmitting) and power integration over the OBW (method SA-1 of ANSI C63.10).
Note 2:	Measured using the same analyzer settings used for output power.
Note 3:	For RSS-247 the limit for the 5150 - 5250 MHz band accounts for the antenna gain as the maximum eirp allowed is 10dBm/MHz. The limits are also corrected for instances where the highest measured value of the PSD exceeds the average PSD (calculated from the measured power divided by the measured 99% bandwidth) by more than 3dB by the amount that the measured value exceeds the average by more than 3dB.
Note 4:	99% Bandwidth measured in accordance with C63.10 - RB between 1-5 % of OBW and VB ≥ 3*RB, Span between 1.5 and 5 times OBW.
Note 5:	For MIMO systems the total output power and total PSD are calculated from the sum of the powers of the individual chains (in linear terms). The antenna gain used to determine the EIRP and limits for PSD/Output power depends on the operating mode of the MIMO device. If the signals on the non-coherent between the transmit chains then the gain used to determine the limits is the highest gain of the individual chains and the EIRP is the sum of the products of gain and power on each chain. If the signals are coherent then the effective antenna gain is the sum (in linear terms) of the gains for each chain and the EIRP is the product of the effective gain and total power.

Antenna Gain Information

Freq	Antenna Gain (dBi) / Chain				BF	MultiChain Legacy	CDD	Sectorized / Xpol	Dir G (PWR)	Dir G (PSD)
	1	2	3	4						
5150-5250	3.06	2.97	4.86	3.01	Yes	Yes	Yes	No	9.48	9.48
5250-5350	3.57	2.97	5.42	3.48	Yes	Yes	Yes	No	9.86	9.86
5470-5725	3.37	3.78	6.18	4.91	Yes	Yes	Yes	No	10.59	10.59
5725-5825	3.61	3.72	6.57	4.76	Yes	Yes	Yes	No	10.60	10.60

For devices that support CDD modes

Min # of spatial streams: 1
Max # of spatial streams: 4

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Notes:	BF = beamforming mode supported, Multichain Legacy = 802.11 legacy data rates supported for multichain transmissions, CDD = Cyclic Delay Diversity (or Cyclic Shift Diversity) modes supported, Sectorized / Xpol = antennas are sectorized or cross polarized.
Notes:	Dir G (PWR) = total gain (Gant + Array Gain) for power calculations; Dir G (PSD) = total gain for PSD calculations based on FCC KDB 662911. Depending on the modes supported, the Array Gain value for power could be different from the PSD value.
Notes:	Array gain for power/psd calculated per KDB 662911 D01.

FCC UNII-1 Limits		Pwr	PSD
	Outdoor AP	30	17
	Indoor AP	30	17
X	Station (e.g. Client)	24	11
	Outdoor AP (>30° Elv.)	21	-

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

MIMO Device - 5150-5250 MHz Band - FCC

Mode: n20 Max EIRP (mW): 603.26609

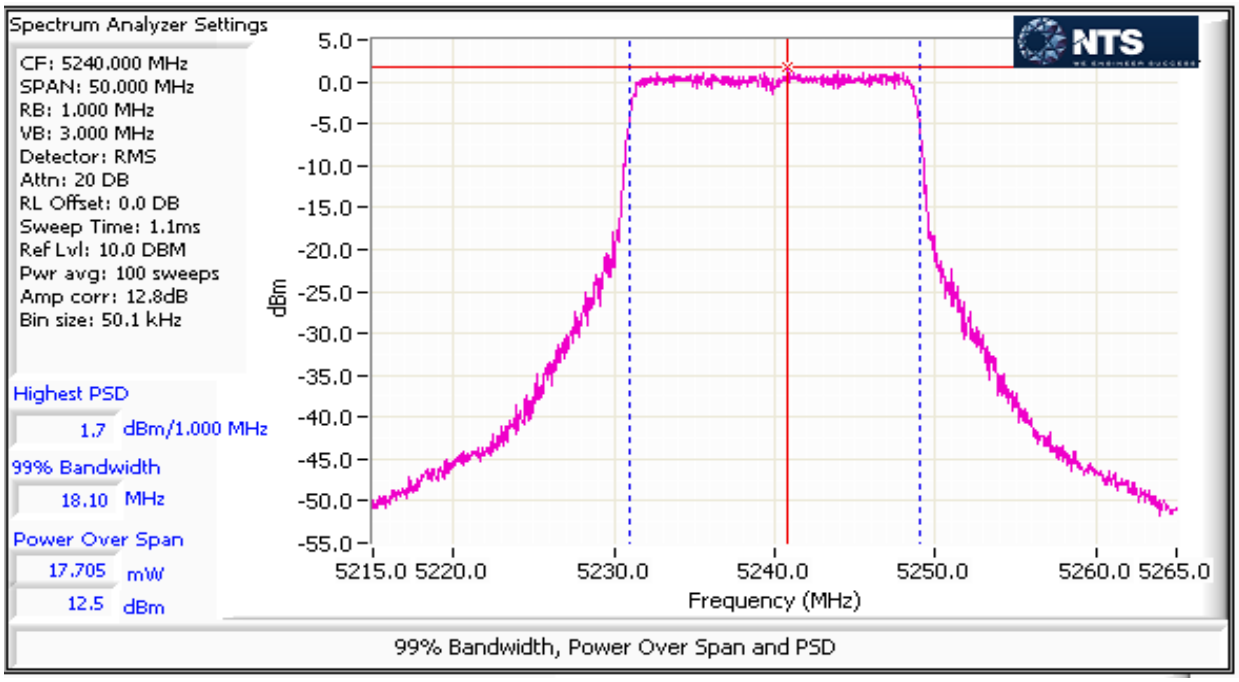
Frequency (MHz)	Chain	Software Setting	26dB BW (MHz)	Duty Cycle %	Power[1] dBm	Total Power mW	Total Power dBm	FCC Limit dBm	Max Power (W)	Result
5180	1	13		99.0	12.5	68.0	18.3	20.5	0.068	Pass
	3				12.3					
	4				12.0					
	2				12.4					
5200	1	13		99.0	12.2	64.2	18.1	20.5		Pass
	3				11.9					
	4				12.0					
	2				12.1					
5240	1	13		99.0	12.5	68.0	18.3	20.5		Pass
	3				12.4					
	4				11.9					
	2				12.4					

5150-5250 PSD - FCC

Mode: n20

Frequency (MHz)	Chain	Software Setting	99% BW (MHz)	Duty Cycle %	PSD dBm/MHz	Total PSD[1] mW/MHz	Total PSD[1] dBm/MHz	FCC Limit dBm/MHz	Result
5180	1	13	18.1	99.0	1.3	5.2	7.2	7.5	Pass
	3				1.2				
	4				0.8				
	2				1.2				
5200	1	13	18.1	99.0	1.2	5.0	7.0	7.5	Pass
	3				1.1				
	4				0.7				
	2				1.0				
5240	1	13	18.1	99.0	1.7	5.4	7.3	7.5	Pass
	3				1.2				
	4				1.1				
	2				1.2				

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A



Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

MIMO Device - 5150-5250 MHz Band - FCC

Mode: n40 Max EIRP (mW): 956.35418

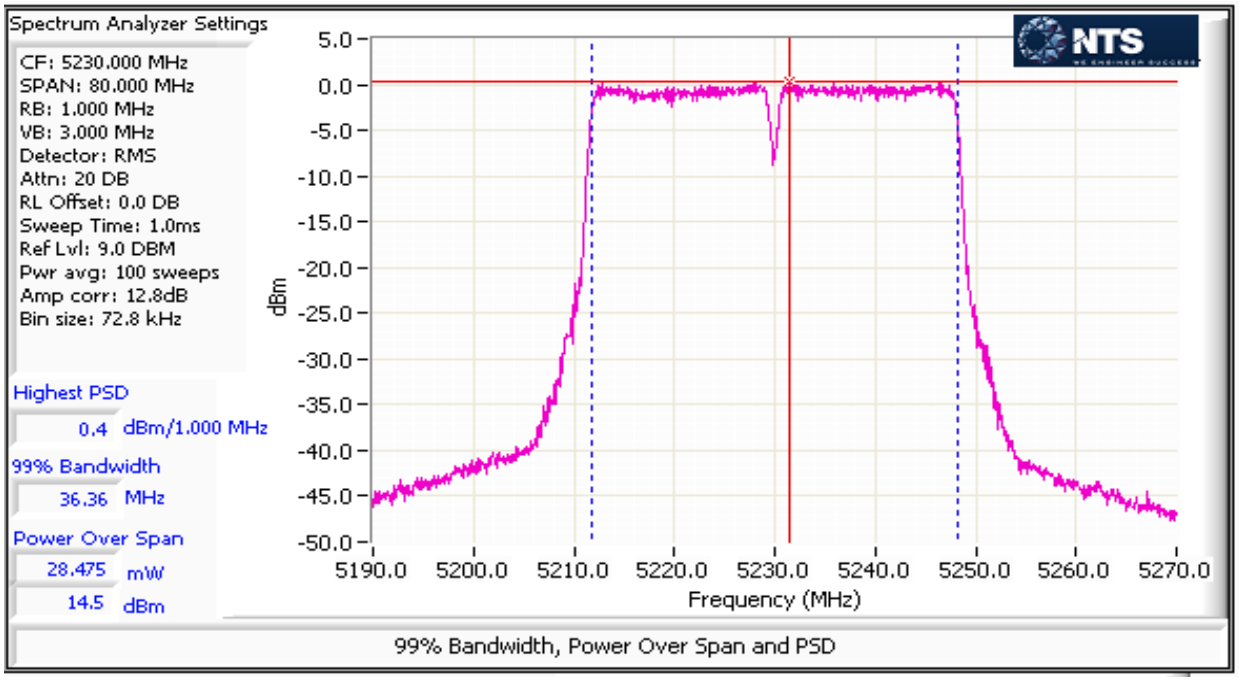
Frequency (MHz)	Chain	Software Setting	26dB BW (MHz)	Duty Cycle %	Power dBm	Total Power[1] mW	Total Power[1] dBm	FCC Limit dBm	Max Power (W)	Result
5190	1	13		97.3	12.7	72.7	18.6	20.5	0.108	Pass
	3				12.3					
	4				12.4					
	2				12.5					
5230	1	14		97.3	14.4	107.8	20.3	20.5		Pass
	3				14.5					
	4				14.1					
	2				13.7					

5150-5250 PSD - FCC

Mode: n40

Frequency (MHz)	Chain	Software Setting	99% BW (MHz)	Duty Cycle %	PSD dBm/MHz	Total PSD[1] mW/MHz	Total PSD[1] dBm/MHz	FCC Limit dBm/MHz	Result
5190	1	13	36.4	97.3	-1.4	2.9	4.6	7.5	Pass
	3				-1.7				
	4				-1.5				
	2				-1.7				
5230	1	14		97.3	0.1	4.1	6.1	7.5	Pass
	3				0.4				
	4				-0.1				
	2				-0.3				

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A



Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

MIMO Device - 5150-5250 MHz Band - FCC

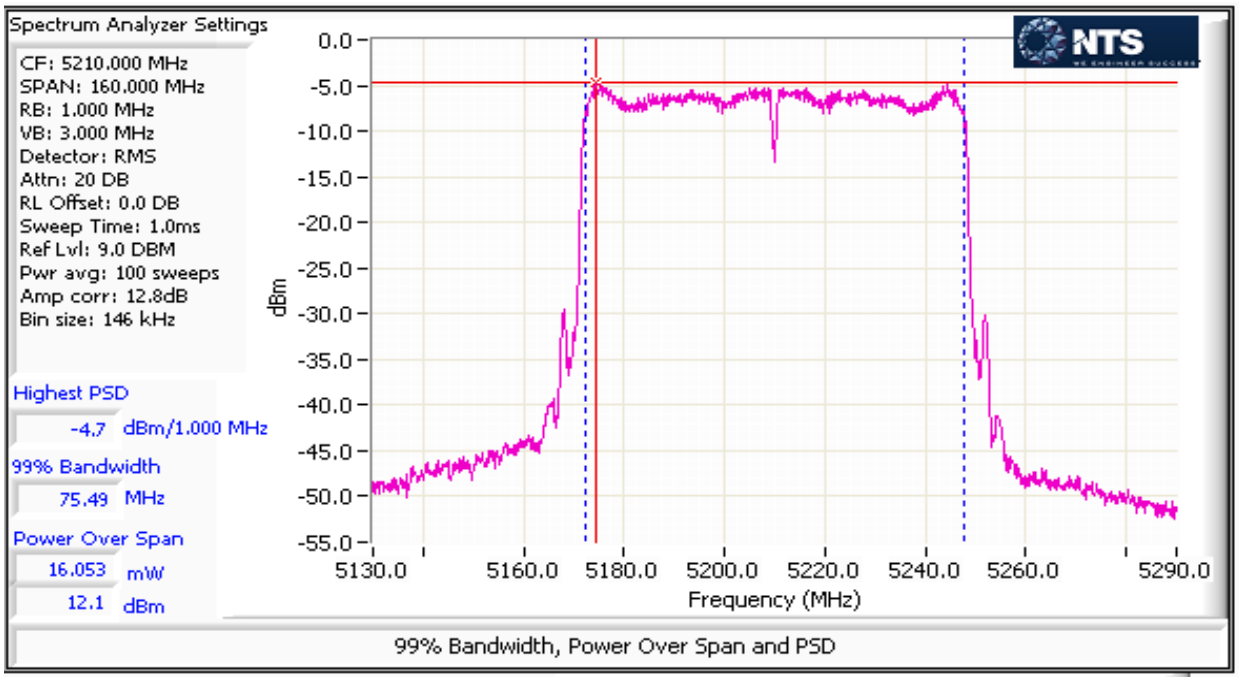
Mode: ac80 Max EIRP (mW): 488.82296

Frequency (MHz)	Chain	Software Setting	26dB BW (MHz)	Duty Cycle %	Power dBm	Total Power[1] mW	Total Power[1] dBm	FCC Limit dBm	Max Power (W)	Result
5210	1	12		94.4	11.5	55.1	17.4	20.5	0.055	Pass
	3				11.4					
	4				10.5					
	2				11.1					

5150-5250 PSD - FCC

Mode: ac80

Frequency (MHz)	Chain	Software Setting	99% BW (MHz)	Duty Cycle %	PSD dBm/MHz	Total PSD[1] mW/MHz	Total PSD[1] dBm/MHz	FCC Limit dBm/MHz	Result
5210	1	12	75.2	94.4	-5.4	1.2	0.8	7.5	Pass
	3				-5.0				
	4				-6.0				
	2				-5.4				



Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

FCC 15.407(UNII)
Antenna Port Measurements
Power, PSD, Bandwidth and Spurious Emissions

Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

Summary of Results

Run #	Test Performed	Limit	Pass / Fail	Result / Margin
1	Power, 5725 - 5850MHz	15.407(a) (3)	Pass	a: 24.2 dBm (261.5 mW) n20: 24.1 dBm (257.1 mW) n40: 24.5 dBm (279.9 mW) ac80: 24.2 dBm (266.0 mW)
1	PSD, 5725 - 5850MHz	15.407(a) (3)	Pass	a: 13.5 dBm/MHz n20: 13.2 dBm/MHz n40: 10.6 dBm/MHz ac80: 7.6 dBm/MHz
1	99% Bandwidth	RSS-GEN (Information only)	N/A	a: 17.0 MHz n20: 18.2 MHz n40: 36.5 MHz ac80: 75.6 MHz
2	Antenna Conducted - Out of Band Spurious	15.407(b) -27dBm/MHz	N/A	All emissions below the -27dBm/MHz limit

General Test Configuration

When measuring the conducted emissions from the EUT's antenna port, the antenna port of the EUT was connected to the spectrum analyzer or power meter via a suitable attenuator to prevent overloading the measurement system. All measurements are corrected to allow for the external attenuators and cables used.

Ambient Conditions:

Temperature: 21-23 °C
Rel. Humidity: 40-45 %

Modifications Made During Testing

No modifications were made to the EUT during testing

Deviations From The Standard

No deviations were made from the requirements of the standard.

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Procedure Comments:

Measurements performed in accordance with FCC KDB 789033 D01

Mode	Data Rate	Duty Cycle (x)	Constant DC?	T (ms)	Pwr Cor Factor*	Lin Volt Cor Factor**	Min VBW for FS (Hz)
11a	6Mbps	90.1%	Yes	0.57	0.45	0.90	1764
n20	MCS0	99.0%	Yes	5.00	0	0	10
n40	MCS0	97.3%	Yes	2.44	0.12	0.24	410
ac80	VHT0	94.4%	Yes	1.12	0.25	0.50	890

Sample Notes

Sample S/N: GTCFNS1630E0091

Driver:

	Chain 1	Chain 2	Chain 3	Chain 4
Port Assignment:	J403	J404	J405	J406

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Run #1: Bandwidth, Output Power and Power Spectral Density - MIMO Systems

Date of Test: 09/23/16 Config. Used: Conducted
Test Engineer: Mehran Birgani Config Change: -
Test Location: Lab 4 EUT Voltage: 120V/ 60Hz

Note 1:	Duty Cycle ≥ 98%. Output power measured using a spectrum analyzer (see plots below). RBW=1MHz, VB=3 MHz, Span > OBW, # of points in sweep ≥ 2*span/RBW, auto sweep, RMS detector, power averaging on (transmitted signal was continuous, duty cycle ≥ 98%) a
Note 1:	Constant Duty Cycle < 98%. Output power measured using a spectrum analyzer (see plots below). RBW=1MHz, VB=3 MHz, Span > OBW, # of points in sweep ≥ 2*span/RBW, RMS detector, trace average 100 traces (at least 100 traces, increase the number to get true
Note 2:	Measured using the same analyzer settings used for output power.
Note 3:	For RSS-247 the limit for the 5150 - 5250 MHz band accounts for the antenna gain as the maximum eirp allowed is 10dBm/MHz. The limits are also corrected for instances where the highest measured value of the PSD exceeds the average PSD (calculated from the
Note 4:	99% Bandwidth measured in accordance with C63.10 - RB between 1-5 % of OBW and VB ≥ 3*RB, Span between 1.5 and 5 times OBW.
Note 5:	For MIMO systems the total output power and total PSD are calculated from the sum of the powers of the individual chains (in linear terms). The antenna gain used to determine the EIRP and limits for PSD/Output power depends on the operating mode of the M

Antenna Gain Information

Freq	Antenna Gain (dBi) / Chain				BF	MultiChain Legacy	CDD	Sectorized / Xpol	Dir G (PWR)	Dir G (PSD)
	1	2	3	4						
5150-5250	3.06	2.97	4.86	3.01	No	Yes	Yes	No	3.55	9.48
5250-5350	3.57	2.97	5.42	3.48	No	Yes	Yes	No	3.96	9.86
5470-5725	3.37	3.78	6.18	4.91	No	Yes	Yes	No	4.70	10.59
5725-5825	3.61	3.72	6.57	4.76	No	Yes	Yes	No	4.84	10.60

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

For devices that support CDD modes

Min # of spatial streams: 1

Max # of spatial streams: 4

Notes:	BF = beamforming mode supported, Multichain Legacy = 802.11 legacy data rates supported for multichain transmissions, CDD = Cyclic Delay Diversity (or Cyclic Shift Diversity) modes supported, Sectorized / Xpol = antennas are sectorized or cross polarized.
Notes:	Dir G (PWR) = total gain (Gant + Array Gain) for power calculations; GA (PSD) = total gain for PSD calculations based on FCC KDB 662911. Depending on the modes supported, the Array Gain value for power could be different from the PSD value.
Notes:	Array gain for power/psd calculated per KDB 662911 D01.
Notes:	For systems with Beamforming and CDD, choose one the following options: Option 1: Delays are optimized for beamforming, rather than being selected from cyclic delay table of 802.11; Array gains calculated based on beamforming criteria. Option 2: Antennas are paired for beamforming, and the pairs are configured to use the cyclic delay diversity of 802.11; the array gain associated with beamforming with 2 antennas (3dB), and the array gain associated with CDD with two antennas (3dB for PSD and 0 dB for power)

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

MIMO Device - 5725-5850 MHz Band - FCC/IC

Mode: 11a Max EIRP (mW): 797.0

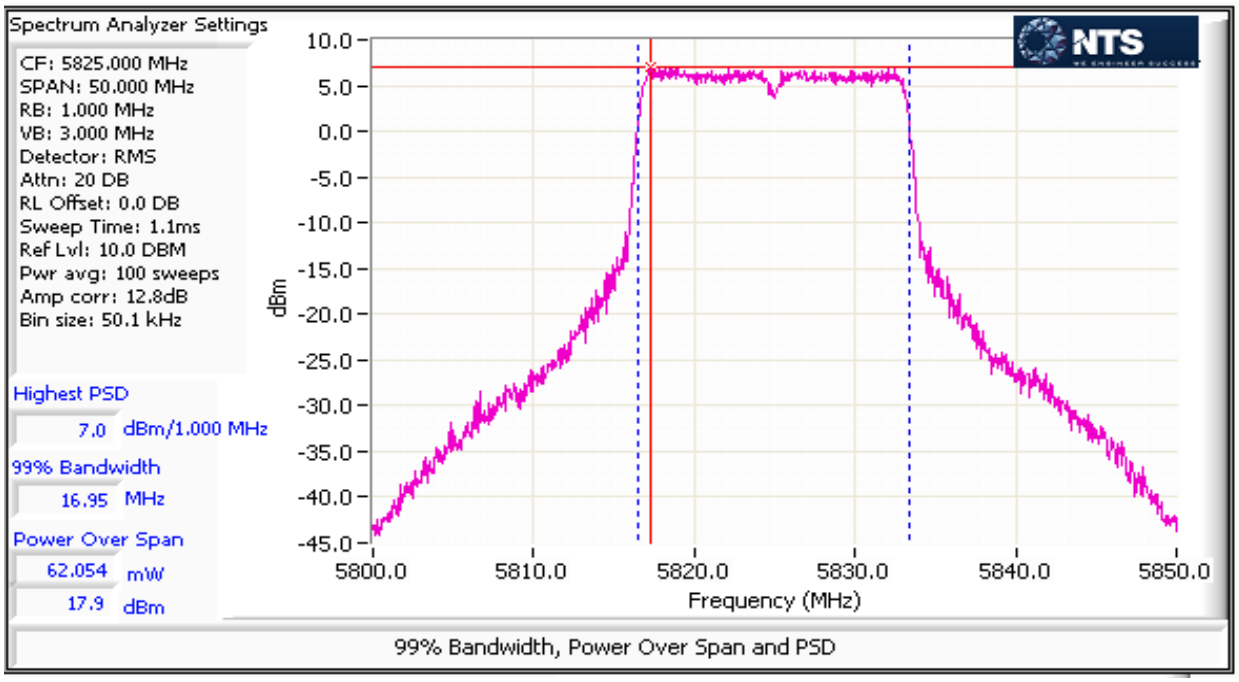
Frequency (MHz)	Chain	Software Setting	99% BW (MHz)	Duty Cycle %	Power dBm	Total Power[1] mW	Total Power[1] dBm	Limit dBm	Max Power (W)	Result
5745	1	19	17.0	90.1	17.2	233.3	23.7	30.0	0.262	Pass
	3				17.5					
	4				17.2					
	2				16.9					
5785	1	19	16.9	90.1	17.3	221.6	23.5	30.0		Pass
	3				17.1					
	4				16.6					
	2				16.9					
5825	1	19	17.0	90.1	17.7	261.5	24.2	30.0		Pass
	3				17.9					
	4				17.6					
	2				17.6					

5725-5850 PSD - FCC/IC

Mode: 11a

Frequency (MHz)	Chain	Software Setting	99% BW (MHz)	Duty Cycle %	PSD dBm/MHz	Total PSD[1] mW/MHz	Total PSD[1] dBm/MHz	FCC Limit dBm/500kHz	IC Limit dBm/500kHz	Result
5745	1	19	17.0	90.1	6.8	20.0	13.0	25.4	25.4	Pass
	3				6.8					
	4				6.4					
	2				6.1					
5785	1	19	16.9	90.1	6.5	18.7	12.7	25.4	25.4	Pass
	3				6.3					
	4				6.0					
	2				6.2					
5825	1	19	17.0	90.1	7.0	22.4	13.5	25.4	25.4	Pass
	3				7.0					
	4				7.1					
	2				7.0					

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A



Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

MIMO Device - 5725-5850 MHz Band - FCC/IC

Mode: n20 Max EIRP (mW): 783.6

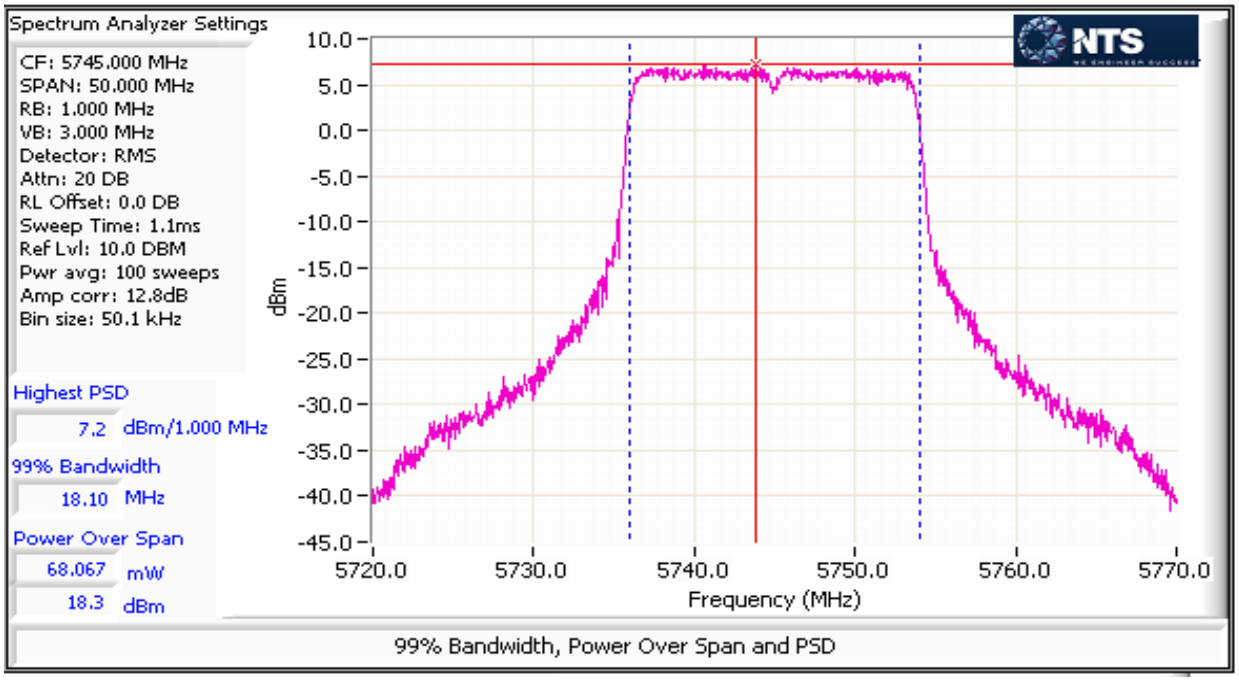
Frequency (MHz)	Chain	Software Setting	99% BW (MHz)	Duty Cycle %	Power dBm	Total Power[1] mW	Total Power[1] dBm	FCC Limit dBm	Max Power (W)	Result
5745	1	19	18.1	99.0	18.1	257.1	24.1	30.0	0.257	Pass
	3				18.3					
	4				18.2					
	2				17.7					
5785	1	19	18.2	99.0	17.7	238.6	23.8	30.0		Pass
	3				18.1					
	4				17.7					
	2				17.5					
5825	1	19	18.2	99.0	18.0	256.8	24.1	30.0		Pass
	3				18.2					
	4				18.0					
	2				18.1					

5250-5350 PSD - FCC/IC

Mode: n20

Frequency (MHz)	Chain	Software Setting	99% BW (MHz)	Duty Cycle %	PSD dBm/MHz	Total PSD[1] mW/MHz	Total PSD[1] dBm/MHz	FCC Limit dBm/MHz	IC Limit dBm/MHz	Result
5745	1	19	18.1	99.0	7.4	20.9	13.2	25.4	25.4	Pass
	3				7.2					
	4				7.3					
	2				6.8					
5785	1	19	18.2	99.0	6.8	18.9	12.8	25.4	25.4	Pass
	3				7.0					
	4				6.7					
	2				6.5					
5825	1	19	18.2	99.0	6.8	20.9	13.2	25.4	25.4	Pass
	3				7.2					
	4				7.3					
	2				7.4					

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A



Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

MIMO Device - 5725-5850 MHz Band - FCC/IC

Mode: n40 Max EIRP (mW): 853.1

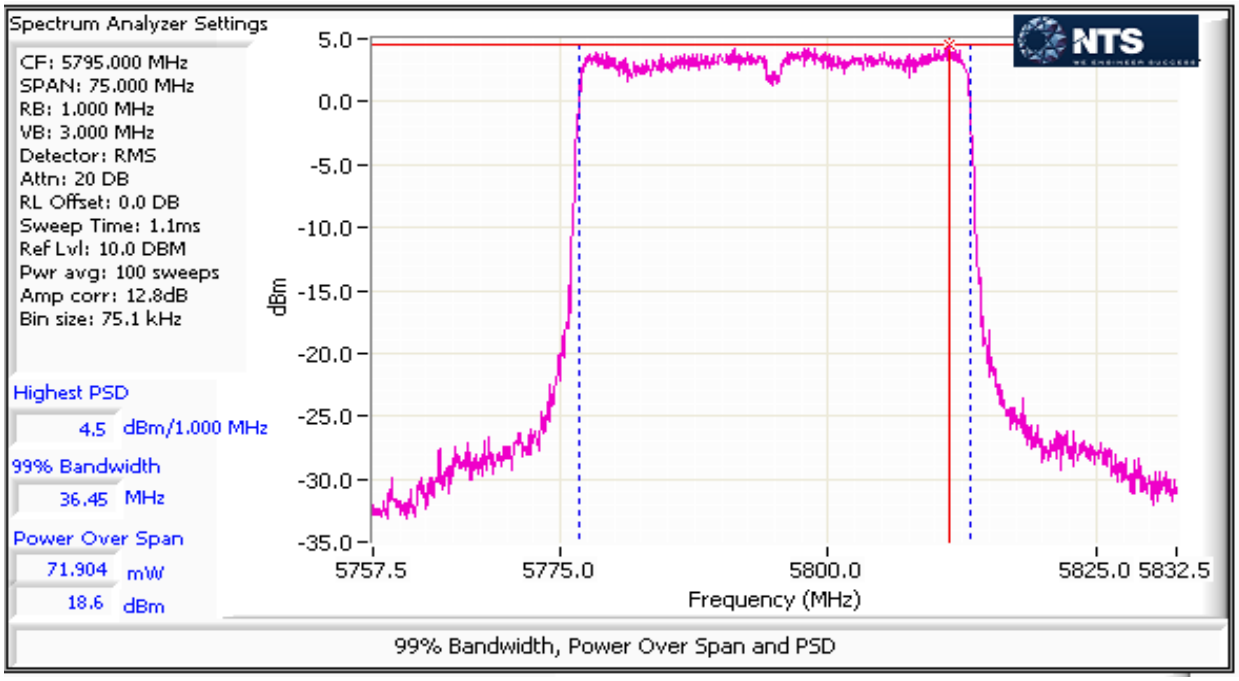
Frequency (MHz)	Chain	Software Setting	99% BW (MHz)	Duty Cycle %	Power dBm	Total Power[1] mW	Total Power[1] dBm	FCC Limit dBm	Max Power (W)	Result
5755	1	19	36.5	97.3	18.6	279.9	24.5	30.0	0.280	Pass
	3				18.3					
	4				18.4					
	2				18.0					
5795	1	19	36.5	97.3	18.6	279.7	24.5	30.0		Pass
	3				18.2					
	4				18.2					
	2				18.3					

MIMO Device 5250-5350 PSD - FCC/IC

Mode: n40

Frequency (MHz)	Chain	Software Setting	99% BW (MHz)	Duty Cycle %	PSD dBm/MHz	Total PSD[1] mW/MHz	Total PSD[1] dBm/MHz	FCC Limit dBm/MHz	IC Limit dBm/MHz	Result
5755	1	19	36.5	97.3	4.5	11.4	10.6	25.4	25.4	Pass
	3				4.4					
	4				4.5					
	2				4.3					
5795	1	19	36.5	97.3	4.5	11.1	10.5	25.4	25.4	Pass
	3				4.2					
	4				4.2					
	2				4.4					

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A



Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

MIMO Device - 5725-5850 MHz Band - FCC/IC

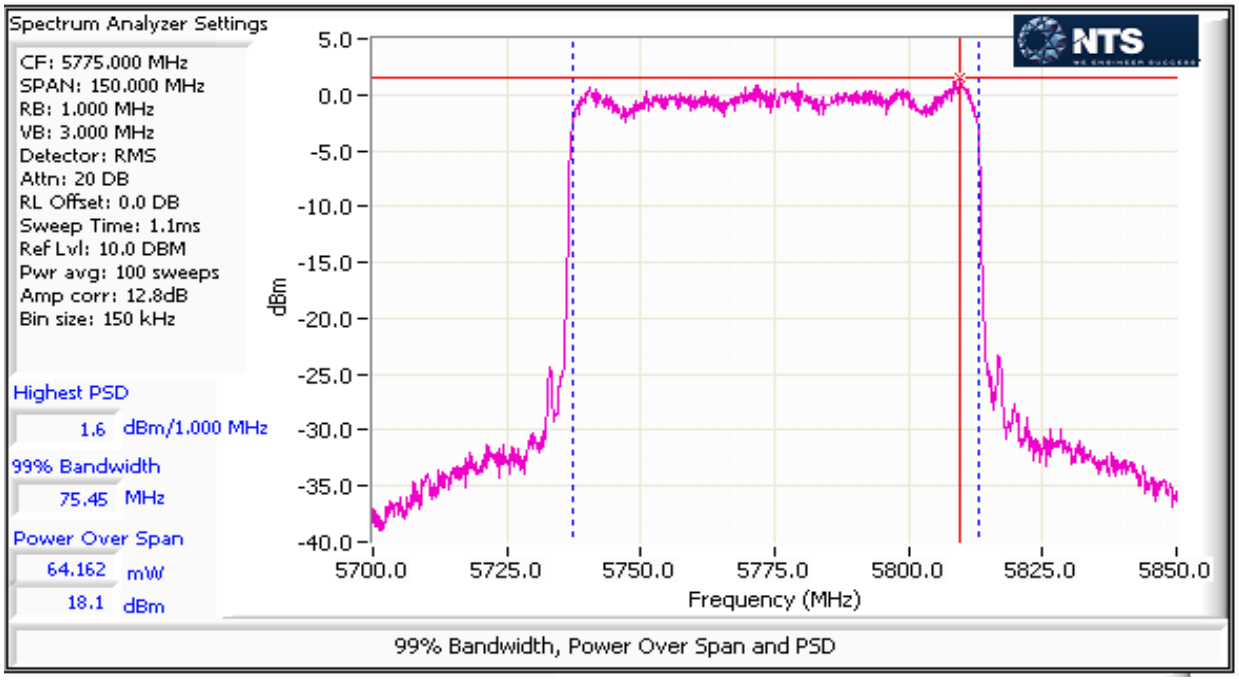
Mode: ac80 Max EIRP (mW): 810.7

Frequency (MHz)	Chain	Software Setting	99% BW (MHz)	Duty Cycle %	Power dBm	Total Power[1] mW	Total Power[1] dBm	FCC Limit dBm	Max Power (W)	Result
5775	1	19	75.6	94.4	18.1	266.0	24.2	30.0	0.266	Pass
	3				18.1					
	4				18.0					
	2				17.7					

MIMO Device 5250-5350 PSD - FCC/IC

Mode: ac80

Frequency (MHz)	Chain	Software Setting	99% BW (MHz)	Duty Cycle %	PSD dBm/MHz	Total PSD[1] mW/MHz	Total PSD[1] dBm/MHz	FCC Limit dBm/MHz	IC Limit dBm/MHz	Result
5775	1	19	75.6	94.4	1.6	5.7	7.6	25.4	25.4	Pass
	3				1.4					
	4				1.1					
	2				0.9					



Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

FCC 15.407(UNII)
Antenna Port Measurements
Power, PSD, Bandwidth and Spurious Emissions

Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

Summary of Results

Run #	Test Performed	Limit	Pass / Fail	Result / Margin
1	Power, 5725 - 5850MHz	15.407(a) (3)	Pass	n20: 24.1dBm (257.1 mW) n40: 24.5dBm (279.9 mW) ac80: 24.2dBm (266.0 mW)
1	PSD, 5725 - 5850MHz	15.407(a) (3)	Pass	n20: 20.9 dBm/MHz n40: 11.4 dBm/MHz ac80: 5.7 dBm/MHz
1	99% Bandwidth	RSS-GEN (Information only)	N/A	n20: 18.2 MHz n40: 36.5 MHz ac80: 75.6 MHz
2	Antenna Conducted - Out of Band Spurious	15.407(b) -27dBm/MHz	N/A	All emissions below the -27dBm/MHz limit

General Test Configuration

When measuring the conducted emissions from the EUT's antenna port, the antenna port of the EUT was connected to the spectrum analyzer or power meter via a suitable attenuator to prevent overloading the measurement system. All measurements are corrected to allow for the external attenuators and cables used.

Ambient Conditions:

Temperature: 21-23 °C
Rel. Humidity: 40-45 %

Modifications Made During Testing

No modifications were made to the EUT during testing

Deviations From The Standard

No deviations were made from the requirements of the standard.

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Procedure Comments:

Measurements performed in accordance with FCC KDB 789033 D01

Mode	Data Rate	Duty Cycle (x)	Constant DC?	T (ms)	Pwr Cor Factor*	Lin Volt Cor Factor**	Min VBW for FS (Hz)
11a	6Mbps	90.1%	Yes	0.57	0.45	0.90	1764
n20	MCS0	99.0%	Yes	5.00	0	0	10
n40	MCS0	97.3%	Yes	2.44	0.12	0.24	410
ac80	VHT0	94.4%	Yes	1.12	0.25	0.50	890

Sample Notes

Sample S/N: GTCFNS1630E0091

Driver:

	Chain 1	Chain 2	Chain 3	Chain 4
Port Assignment:	J403	J404	J405	J406

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

Run #1: Bandwidth, Output Power and Power Spectral Density - MIMO Systems

Date of Test: 09/28/16 Config. Used: Conducted
Test Engineer: Mehran Birgani Config Change: -
Test Location: Lab 4 EUT Voltage: 120V/ 60Hz

Note 1:	Duty Cycle ≥ 98%. Output power measured using a spectrum analyzer (see plots below). RBW=1MHz, VB=3 MHz, Span > OBW, # of points in sweep ≥ 2*span/RBW, auto sweep, RMS detector, power averaging on (transmitted signal was continuous, duty cycle ≥ 98%) a
Note 1:	Constant Duty Cycle < 98%. Output power measured using a spectrum analyzer (see plots below). RBW=1MHz, VB=3 MHz, Span > OBW, # of points in sweep ≥ 2*span/RBW, RMS detector, trace average 100 traces (at least 100 traces, increase the number to get true
Note 2:	Measured using the same analyzer settings used for output power.
Note 3:	For RSS-247 the limit for the 5150 - 5250 MHz band accounts for the antenna gain as the maximum eirp allowed is 10dBm/MHz. The limits are also corrected for instances where the highest measured value of the PSD exceeds the average PSD (calculated from the
Note 4:	99% Bandwidth measured in accordance with C63.10 - RB between 1-5 % of OBW and VB ≥ 3*RB, Span between 1.5 and 5 times OBW.
Note 5:	For MIMO systems the total output power and total PSD are calculated from the sum of the powers of the individual chains (in linear terms). The antenna gain used to determine the EIRP and limits for PSD/Output power depends on the operating mode of the M

Antenna Gain Information

Freq	Antenna Gain (dBi) / Chain				BF	MultiChain Legacy	CDD	Sectorized / Xpol	Dir G (PWR)	Dir G (PSD)
	1	2	3	4						
5150-5250	3.06	2.97	4.86	3.01	Yes	Yes	Yes	No	9.48	9.48
5250-5350	3.57	2.97	5.42	3.48	Yes	Yes	Yes	No	9.86	9.86
5470-5725	3.37	3.78	6.18	4.91	Yes	Yes	Yes	No	10.59	10.59
5725-5825	3.61	3.72	6.57	4.76	Yes	Yes	Yes	No	10.60	10.60

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
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		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

For devices that support CDD modes

Min # of spatial streams: 1

Max # of spatial streams: 4

Notes:	BF = beamforming mode supported, Multichain Legacy = 802.11 legacy data rates supported for multichain transmissions, CDD = Cyclic Delay Diversity (or Cyclic Shift Diversity) modes supported, Sectorized / Xpol = antennas are sectorized or cross polarized.
Notes:	Dir G (PWR) = total gain (Gant + Array Gain) for power calculations; GA (PSD) = total gain for PSD calculations based on FCC KDB 662911. Depending on the modes supported, the Array Gain value for power could be different from the PSD value.
Notes:	Array gain for power/psd calculated per KDB 662911 D01.
Notes:	For systems with Beamforming and CDD, choose one the following options: Option 1: Delays are optimized for beamforming, rather than being selected from cyclic delay table of 802.11; Array gains calculated based on beamforming criteria. Option 2: Antennas are paired for beamforming, and the pairs are configured to use the cyclic delay diversity of 802.11; the array gain associated with beamforming with 2 antennas (3dB), and the array gain associated with CDD with two antennas (3dB for PSD and 0 dB for power)

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

MIMO Device - 5725-5850 MHz Band - FCC/IC

Mode: **n20** Max EIRP (mW): 2951.9

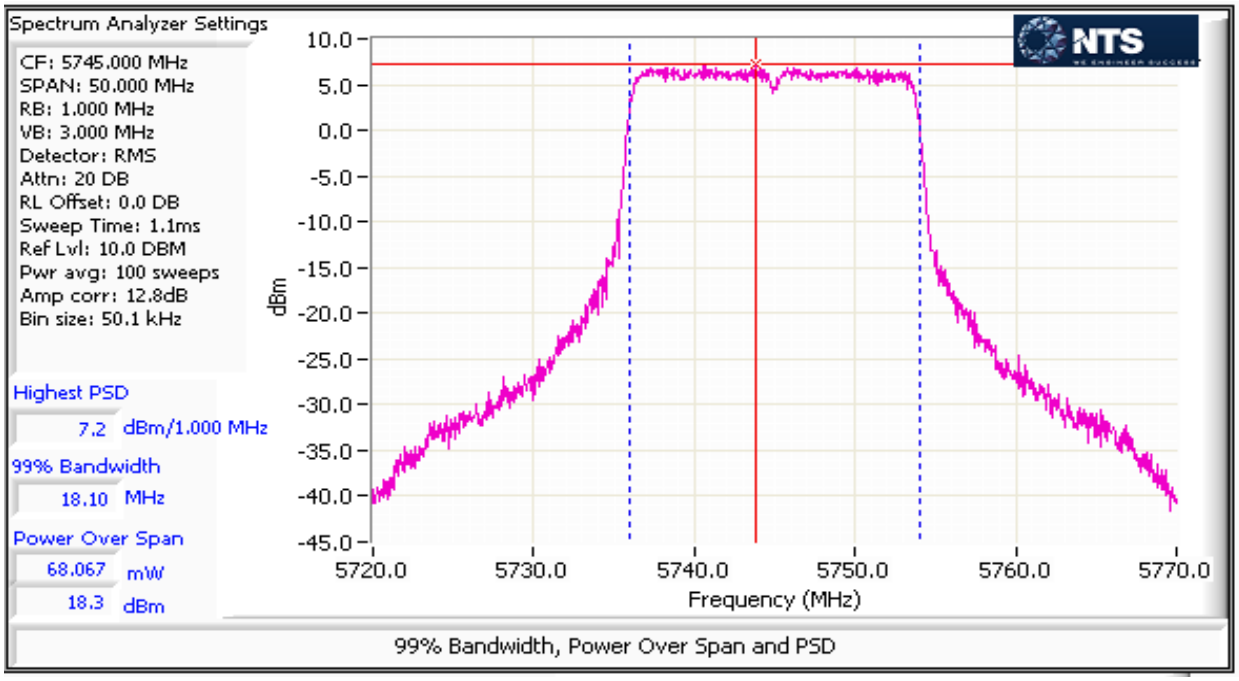
Frequency (MHz)	Chain	Software Setting	99% BW (MHz)	Duty Cycle %	Power dBm	Total Power[1] mW	Total Power[1] dBm	FCC Limit dBm	Max Power (W)	Result
5745	1	19	18.1	99.0	18.1	257.1	24.1	25.4	0.257	Pass
	3				18.3					
	4				18.2					
	2				17.7					
5785	1	19	18.2	99.0	17.7	238.6	23.8	25.4		Pass
	3				18.1					
	4				17.7					
	2				17.5					
5825	1	19	18.2	99.0	18.0	256.8	24.1	25.4		Pass
	3				18.2					
	4				18.0					
	2				18.1					

5250-5350 PSD - FCC/IC

Mode: **n20**

Frequency (MHz)	Chain	Software Setting	99% BW (MHz)	Duty Cycle %	PSD dBm/MHz	Total PSD[1] mW/MHz	Total PSD[1] dBm/MHz	FCC Limit dBm/MHz	IC Limit dBm/MHz	Result
5745	1	19	18.1	99.0	7.4	20.9	13.2	25.4	25.4	Pass
	3				7.2					
	4				7.3					
	2				6.8					
5785	1	19	18.2	99.0	6.8	18.9	12.8	25.4	25.4	Pass
	3				7.0					
	4				6.7					
	2				6.5					
5825	1	19	18.2	99.0	6.8	20.9	13.2	25.4	25.4	Pass
	3				7.2					
	4				7.3					
	2				7.4					

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A



Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

MIMO Device - 5725-5850 MHz Band - FCC/IC

Mode: **n40** Max EIRP (mW): 3213.7

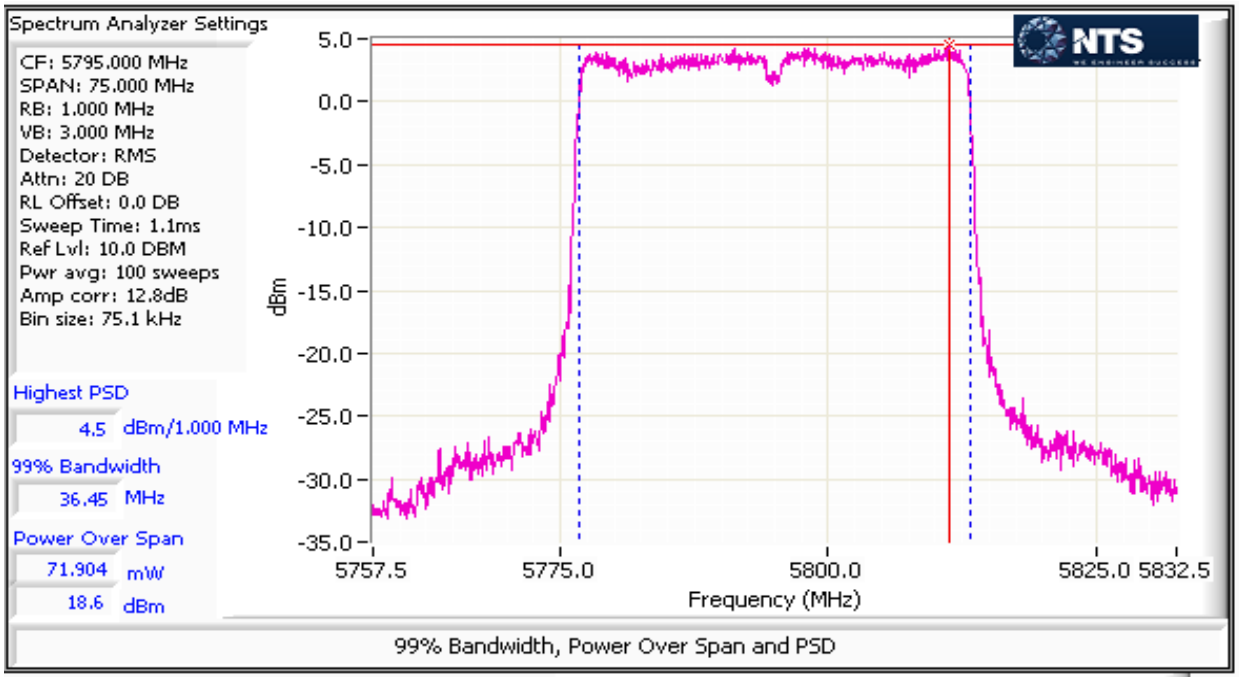
Frequency (MHz)	Chain	Software Setting	99% BW (MHz)	Duty Cycle %	Power dBm	Total Power[1] mW	Total Power[1] dBm	FCC Limit dBm	Max Power (W)	Result
5755	1	19	36.5	97.3	18.6	279.9	24.5	25.4	0.280	Pass
	3				18.3					
	4				18.4					
	2				18.0					
5795	1	19	36.5	97.3	18.6	279.7	24.5	25.4		Pass
	3				18.2					
	4				18.2					
	2				18.3					

MIMO Device 5250-5350 PSD - FCC/IC

Mode: **n40**

Frequency (MHz)	Chain	Software Setting	99% BW (MHz)	Duty Cycle %	PSD dBm/MHz	Total PSD[1] mW/MHz	Total PSD[1] dBm/MHz	FCC Limit dBm/MHz	IC Limit dBm/MHz	Result
5755	1	19	36.5	97.3	4.5	11.4	10.6	25.4	25.4	Pass
	3				4.4					
	4				4.5					
	2				4.3					
5795	1	19	36.5	97.3	4.5	11.1	10.5	25.4	25.4	Pass
	3				4.2					
	4				4.2					
	2				4.4					

Client:	Google, Inc.	Job Number:	JD101521 and JD101837
Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A



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Model:	GFHD254	T-Log Number:	T101543
		Project Manager:	Deepa Shetty
Contact:	Weifeng Pan	Project Coordinator:	-
Standard:	FCC 15.247 and 15.407	Class:	N/A

MIMO Device - 5725-5850 MHz Band - FCC/IC

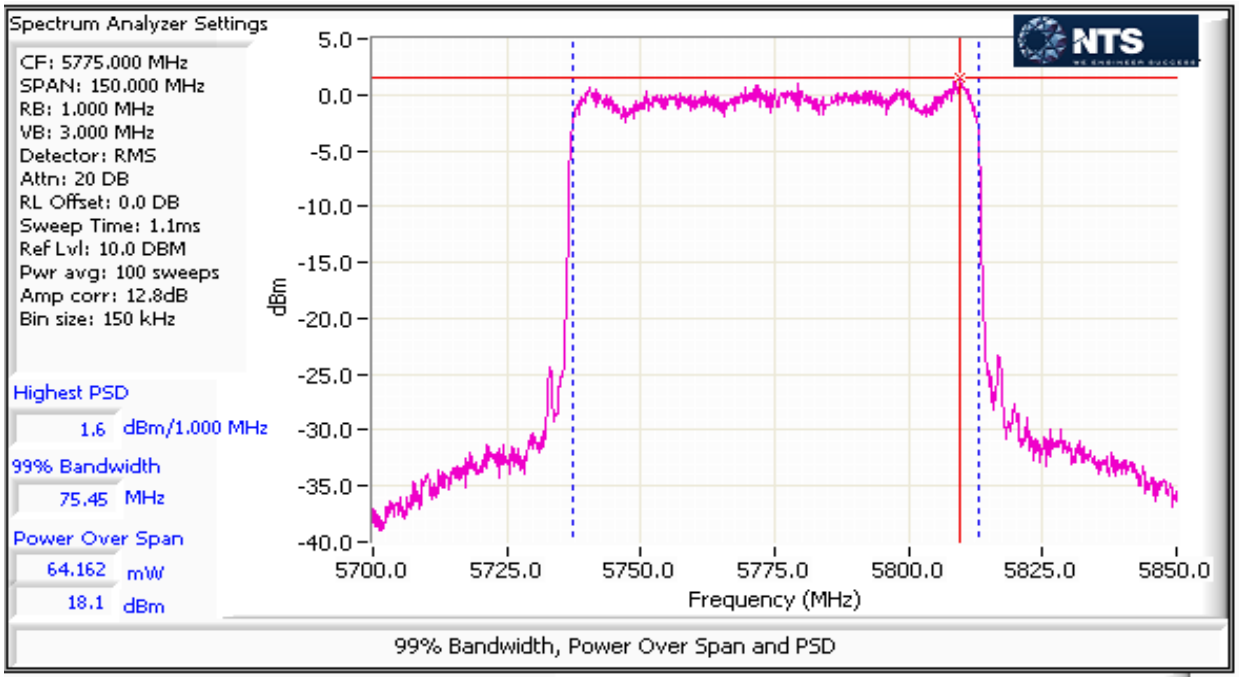
Mode: **ac80** Max EIRP (mW): 3054.1

Frequency (MHz)	Chain	Software Setting	99% BW (MHz)	Duty Cycle %	Power dBm	Total Power[1] mW	Total Power[1] dBm	FCC Limit dBm	Max Power (W)	Result
5775	1	19	75.6	94.4	18.1	266.0	24.2	25.4	0.266	Pass
	3				18.1					
	4				18.0					
	2				17.7					

MIMO Device 5250-5350 PSD - FCC/IC

Mode: **ac80**

Frequency (MHz)	Chain	Software Setting	99% BW (MHz)	Duty Cycle %	PSD dBm/MHz	Total PSD[1] mW/MHz	Total PSD[1] dBm/MHz	FCC Limit dBm/MHz	IC Limit dBm/MHz	Result
5775	1	19	75.6	94.4	1.6	5.7	7.6	25.4	25.4	Pass
	3				1.4					
	4				1.1					
	2				0.9					



End of Report

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