HAC T-COIL SIGNAL TEST REPORT

CLASS II PERMISSIVE CHANGE

FCC CFR47 PART 20.19
ANSI C63.19-2011

For
CDMA/GSM/WCDMA/LTE PHONE + BLUETOOTH, DTS/UNII a/b/g/n/ac & NFC

FCC ID: ZNFH790
Model Name: LG-H790, LGH790, H790

Report Number: 15I21523-S3V1
Issue Date: 9/11/2015

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NVLAP LAB CODE 200065-0

Revision History

Rev.	Date	Revisions	Revised By
V1	9/11/2015	Initial Issue	--

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Table of Contents

1. Attestation of Test Results 4

2. Test Methodology 5

3. Facilities and Accreditation 5

4. Calibration and Uncertainty 5

4.1. Measuring Instrument Calibration 5

4.2. Measurement Uncertainty 6

5. Test Procedures for all Technologies 7

6. Audio Level and Gain Measurements 9

7. T-coil Measurement Criteria 10

7.1. Frequency Response 10

7.2. Signal to Noise 11

8. Device Under Test 12

8.1. Air Interfaces and Operating Mode 12

9. HAC (T-coil) Test Results 13

9.1. Worst Case T-Coil Test Plot 15

Appendix 16

15I21523-S3V1 HAC_App A Setup Photo 16

15I21523-S3V1 HAC_App B Frequency Response & SNR Test Plots 16

15I21523-S3V1 HAC_App C Probe Cal. Certificates 16

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1. Attestation of Test Results

Applicant Name	LG ELECTRONICS MOBILECOMM USA, INC.
FCC ID	ZNFH790
Model Name	LG-H790, LGH790, H790
Applicable Standards	FCC 47 CFR § 20.19 ANSI C63.19-2011 KDB 285076 D01 HAC Guidance KDB 285076 D02 T-Coil testing for CMRS IP TCB workshop updates
HAC Rating	T4
Date Tested	8/19/2015 to 9/1/2015
Test Results	Pass

UL Verification Services Inc. tested the above equipment in accordance with the requirements set forth in the above standards. All indications of Pass/Fail in this report are opinions expressed by UL Verification Services Inc. based on interpretations and/or observations of test results. Measurement Uncertainties were not taken into account and are published for informational purposes only. The test results show that the equipment tested is capable of demonstrating compliance with the requirements as documented in this report.

Note: The results documented in this report apply only to the tested sample, under the conditions and modes of operation as described herein. This document may not be altered or revised in any way unless done so by UL Verification Services Inc. and all revisions are duly noted in the revisions section. Any alteration of this document not carried out by UL Verification Services Inc. will constitute fraud and shall nullify the document. This report must not be used by the client to claim product certification, approval, or endorsement by NVLAP, NIST, any agency of the Federal Government, or any agency of any government (NIST Handbook 150, Annex A). This report is written to support regulatory compliance of the applicable standards stated above.

Approved & Released By:	Prepared By:
Bobby Bayani Senior Engineer UL Verification Services Inc.	Hung.Thai Laboratory Technician UL Verification Services Inc.

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2. Test Methodology

The tests documented in this report were performed in accordance with ANSI C63.19-2011 Methods of Measurement of Compatibility between Wireless Communications Devices and Hearing Aids and FCC published procedure KDB 285076 D01 HAC Guidance v04 and KDB 285076 D02 T-Coil testing for CMRS IP v01r01 and TCB workshop updates

3. Facilities and Accreditation

The test sites and measurement facilities used to collect data are located at

47173 Benicia Street	47266 Benicia Street
SAR Lab C	SAR Lab 2

UL Verification Services Inc. is accredited by NVLAP, Laboratory Code 200065-0.

4. Calibration and Uncertainty

4.1. Measuring Instrument Calibration

The measuring equipment used to perform the tests documented in this report has been calibrated in accordance with the manufacturers' recommendations, and is traceable to recognized national standards.

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
Robot - Six Axes	Stäubli	TX90 XL	N/A	N/A
Robot Remote Control	Stäubli	CS8C	N/A	N/A
DASY5 Measurement Server	SPEAG	SEUMS001BA	1041	N/A
Probe Alignment Unit	SPEAG	LB (V2)	261	N/A
Audio Magnetic Measuring Ins.I	SPEAG	AMMI	1127	N/A
Coordinating SystemI	SPEAG	AMCC	N/A	N/A
ABM Probe	SPEAG	AM1DV3	3092	7/9/2016
Data Acquisition Electronics	SPEAG	DAE3	427	1/14/2016
Radio Communication Tester	R & S	CMW 500	125236	1/19/2016

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4.2. Measurement Uncertainty

Measurement Uncertainty for Audio Band Magnetic Measurement

Error Description	Uncertainty values (±%)	Probe Dist.	Div.	c_i ABM1	c_i ABM2	Std. Unc. ABM1 (±%)	Std. Unc. ABM2 (±%)
Probe Sensitivity							
Reference level	3.0	N	1	1	1	3.0	3.0
AMCC geometry	0.4	R	√3	1	1	0.2	0.2
AMCC current	1.0	R	√3	1	1	0.6	0.6
Probe positioning during calibration	0.1	R	√3	1	1	0.1	0.1
Noise contribution	0.7	R	√3	0.0143	1	0.0	0.4
Frequency slope	5.9	R	√3	0.1	1.00	0.3	3.5
Probe System							
Repeatability / drift	1.0	R	√3	1	1	0.6	0.6
Linearity / Dynamic range	0.6	R	√3	1	1	0.4	0.4
Acoustic noise	1.0	R	√3	0.1	1	0.1	0.6
Probe angle	2.3	R	√3	1	1	1.4	1.4
Spectral processing	0.9	R	√3	1	1	0.5	0.5
Integration time	0.6	N	1	1	5	0.6	3.0
Field disturbation	0.2	R	√3	1	1	0.1	0.1
Test Signal							
Reference signal spectral response	0.6	R	√3	0	1	0.0	0.4
Positioning							
Probe positioning	1.9	R	√3	1	1	1.1	1.1
Phantom positioning	0.9	R	√3	1	1	0.5	0.5
EUT positioning	1.9	R	√3	1	1	1.1	1.1
External Contributions							
RF interference	0.0	R	√3	1	0.3	0.0	0.0
Test signal variation	2.0	R	√3	1	1	1.2	1.2
Combined Std. Uncertainty (ABM field)						4.1	6.1
Expanded Std. Uncertainty (%)						8.1	12.3

Notes for table
1. N - Nomal
2. R - Rectangular
3. Div. - Divisor used to obtain standard uncertainty

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5. Test Procedures for all Technologies

ANSI C63.19-2011, Section 7

This document describes the procedures used to measure the ABM (T-Coil) performance of the WD. In addition to measuring the absolute signal levels, the A-weighted magnitude of the unintended signal shall also be determined. In order to assure that the required signal quality is measured, the measurement of the intended signal and the measurement of the unintended signal must be made at the same location for all measurement positions. In addition, the RF field strength at each measurement location must be at or below that required for the assigned category.

Measurements shall not include undesired properties from the WD's RF field; therefore, use of a coaxial connection to a base station simulator or non-radiating load may be necessary. However, even then with a coaxial connection to a base station simulator or non-radiating load there may still be RF leakage from the WD, which may interfere with the desired measurement. Pre-measurement checks should be made to avoid this possibility. All measurements shall be done with the WD operating on battery power with an appropriate normal speech audio signal input level given in Table 7.1. If the device display can be turned off during a phone call then that may be done during the measurement as well.

Measurements shall be performed at two locations specified in A.3, with the correct probe orientation for a particular location, in a multistage sequence by first measuring the field intensity of the desired T-Coil signal (ABM1) that is useful to a hearing aid T-Coil. The undesired magnetic components (ABM2) must be measured at the same location as the desired ABM or T-Coil signal (ABM1), and the ratio of desired to undesired ABM signals must be calculated. For the perpendicular field location, only the ABM1 frequency response shall be determined in a third measurement stage. The flow chart in Figure 7.3 illustrates this three-stage, two orientation process.

The following steps summarize the basic test flow for determining ABM1[1] and ABM2[2]. These steps assume that a sine wave or narrowband 1/3 octave signal can be used for the measurement of ABM1.

a. A validation of the test setup and instrumentation may be performed using a TMFS or Helmholtz coil. Measure the emissions and confirm that they are within the specified tolerance.

b. Position the WD in the test setup and connect the WD RF connector to a base station simulator or a non-radiating load as shown in Figure 7.1 or Figure 7.2. Confirm that equipment that requires calibration has been calibrated, and that the noise level meets the requirements given in 7.3.1.

c. The drive level to the WD is set such that the reference input level specified in Table 7.1 is input to the base station simulator (or manufacturer's test mode equivalent) in the 1 kHz, 1/3 octave band. This drive level shall be used for the T-Coil signal test (ABM1) at f = 1 kHz. Either a sine wave at 1025 Hz or a voice-like signal, band-limited to the 1 kHz 1/3 octave, as defined in 7.4.2, shall be used for the reference audio signal. If interference is found at 1025 Hz an alternative nearby reference audio signal frequency may be used.46 The same drive level will be used for the ABM1 frequency response measurements at each 1/3 octave band center frequency. The WD volume control may be set at any level up to maximum, provided that a signal at any frequency at maximum modulation would not result in clipping or signal overload.

d. Determine the magnetic measurement locations for the WD device (A.3), if not already specified by the manufacturer, as described in 7.4.4.1.1 and 7.4.4.2.

[1] ***Audio Band Magnetic signal - desired (ABM1):*** *Measured quantity of the desired magnetic signal*

[2] ***Audio Band Magnetic signal - undesired (ABM2):*** *Measured quantity of the undesired magnetic signal, such as interference from battery current and similar non-signal elements.*

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e. At each measurement location, measure and record the desired T-Coil magnetic signals (ABM1 at f_i) as described in 7.4.4.2 in each individual ISO 266-1975 R10 standard 1/3 octave band. The desired audio band input frequency (f_i) shall be centered in each 1/3 octave band maintaining the same drive level as determined in item c) and the reading taken for that band.

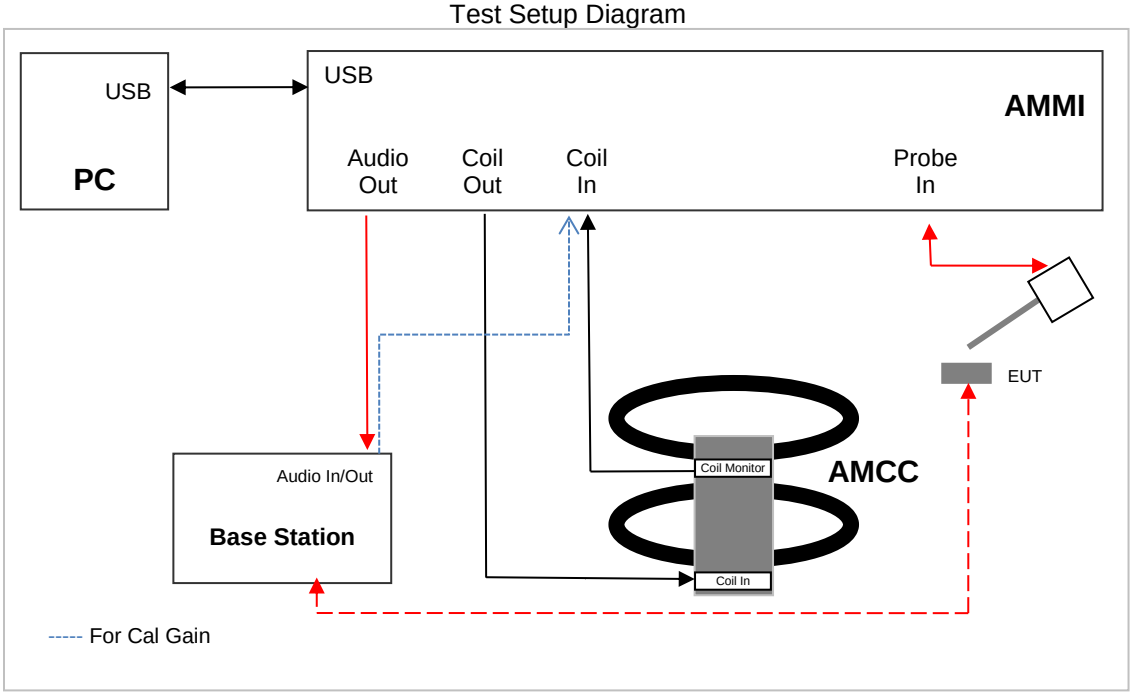
Equivalent methods of determining the frequency response may also be employed, such as fast Fourier transform (FFT) analysis using noise excitation or input–output comparison using simulated speech. The full-band integrated or half-band integrated probe output, as specified in D.9, may be used, as long as the appropriate calibration curve is applied to the measured result, so as to yield an accurate measurement of the field magnitude. (The resulting measurement shall be an accurate measurement in dB A/m.)

All measurements of the desired signal shall be shown to be of the desired signal and not of an undesired signal. This may be shown by turning the desired signal ON and OFF with the probe measuring the same location. If the scanning method is used the scans shall show that all measurement points selected for the ABM1 measurement meet the ambient and test system noise criteria in 7.3.1.

f. At the measurement location for each orientation, measure and record the undesired broadband audio magnetic signal (ABM2) as specified in 7.4.4.4 with no audio signal applied (or digital zero applied, if appropriate) using A-weighting and the half-band integrator. Calculate the ratio of the desired to undesired signal strength (i.e., signal quality).

g. Obtain the data from the postprocessor, SEMCAD, and determine the category that properly classifies the signal quality based on Table 8.5.

Test Setup Diagram



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6. Audio Level and Gain Measurements

CDMA

No correction gain factors were measured for CDMA due to the Rohde & Schwarz CMW500, Serial No. 125236, hosting a calibrated audio board. The gains used to measure CDMA are set to 100.

W-CDMA/GSM

No correction gain factors were measured for W-CDMA/GSM due to the Rohde & Schwarz CMW500, Serial No. 125236, hosting a calibrated audio board. The gains used to measure W-CDMA/GSM are set to 100.

VoLTE

No correction gain factors were measured for VoLTE due to the Rohde & Schwarz CMW500, Serial No. 125236, hosting a calibrated audio board. The gains used to measure VoLTE are set to100.

The following software/firmware was used to simulate the VoLTE server for testing:

Firmware	License Keys	Software Name
V3.2.70 for LTE	KS500	LTE FDD R8 SIG BASIC
V3.2.30 for Audio	KA100	IP APPL ENABLING IPv4
	KA150	IP APPL ENABLING IPv4
	KAA20	IP APPL IMS BASIC
	KM050	DATA APPL MEAS

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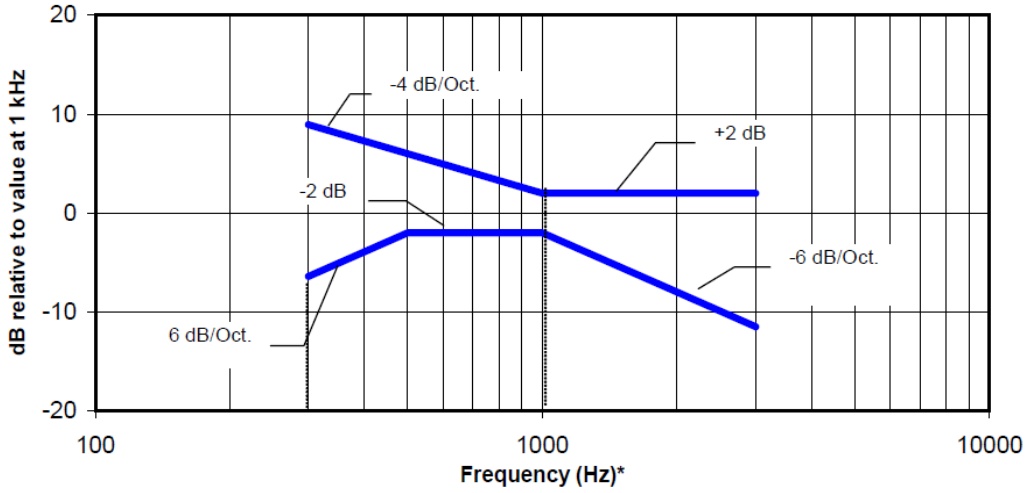
7. T-coil Measurement Criteria

7.1. Frequency Response

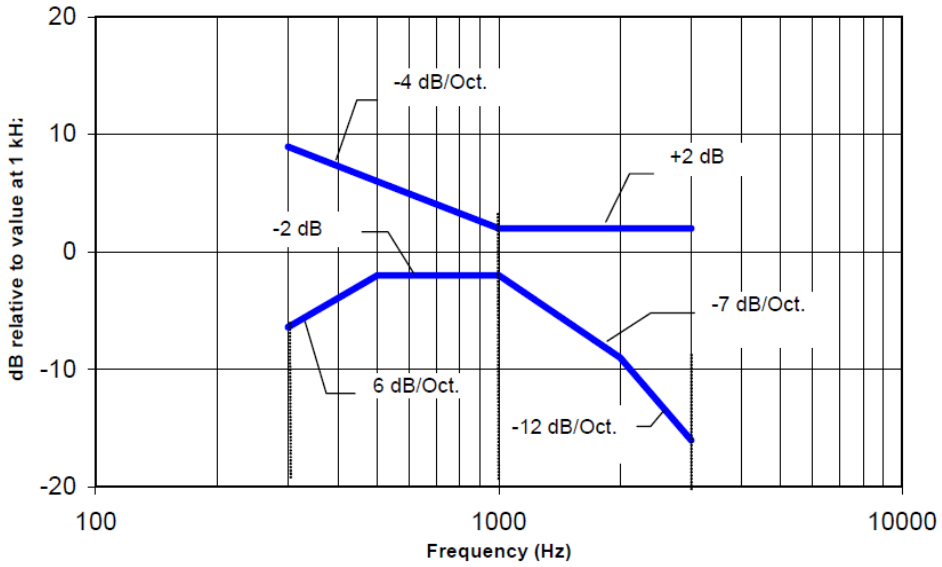
The frequency response of the axial component of the magnetic field, measured in 1/3 octave bands, shall follow the response curve, over the frequency range 300 Hz to 3000 Hz.

Figure 8.1 and Figure 8.2 provide the boundaries for the specified frequency. These response curves are for true field strength measurements of the T-Coil signal. Thus the 6 dB/octave probe response has been corrected from the raw readings.



NOTE—The frequency response is between 300 Hz and 3000 Hz.

Figure 8.1—Magnetic field frequency response for WDs with field strength ≤ –15 dB (A/m) at 1 kHz



NOTE—The frequency response is between 300 Hz and 3000 Hz.

Figure 8.2—Magnetic field frequency response for WDs with a field that exceeds –15 dB(A/m) at 1 kHz

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7.2. Signal to Noise

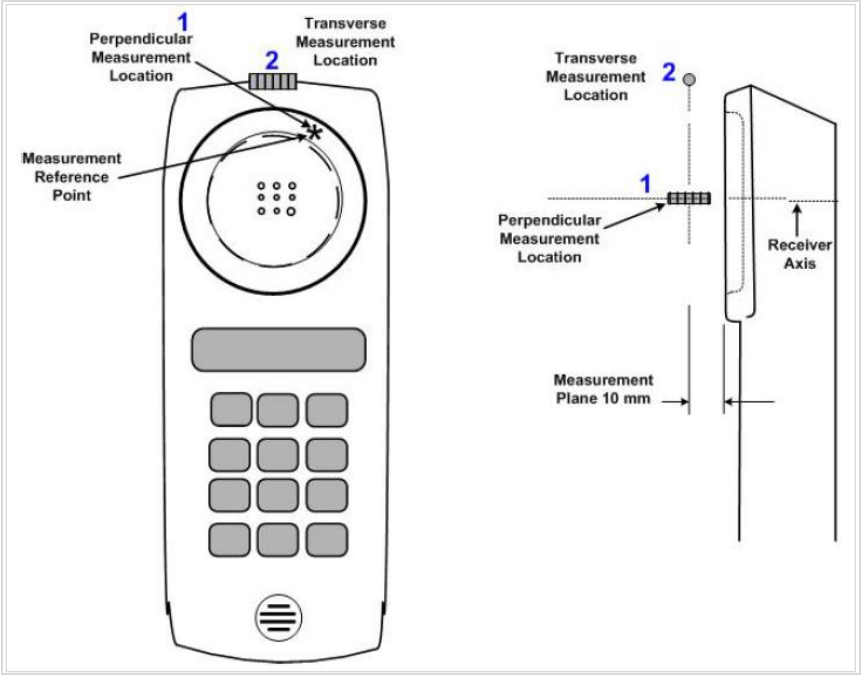
This specifies the signal-to-noise quality requirement for the intended T-Coil signal from a WD. The worst signal to noise of the two T-Coil signal measurements, as determined in Clause 7, shall be used to determine the T-Coil mode category per Table 8.5.

Only the RF immunity of the hearing aid is measured in T-Coil mode. It is assumed that a hearing aid can have no immunity to an interference signal in the audio band, which is the intended reception band for this mode. So, the only criterion that can be measured is the RF immunity in T-Coil Mode. This is measured using the same procedure as for the audio coupling mode and at the same levels as specified in 6.4.

Table 8.5—T-Coil signal-to-noise categories

Category	Telephone parameters WD signal quality [(signal + noise)-to-noise ratio in decibels]
Category T1	0 dB to 10 dB
Category T2	10 dB to 20 dB
Category T3	20 dB to 30 dB
Category T4	>30 dB

Measurement locations and reference plane to be used for the T-coil measurements



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8. Device Under Test

Normal operation	Held to head		
Back Cover	☒ The rechargeable battery is not user accessible.		
Test Sample information	**S/N**	**IMEI**	**Notes**
	2190604	353626-07-002266-5	HAC SAMPLE
	2198893	353626-07-002273	HAC SAMPLE

8.1. Air Interfaces and Operating Mode

Air-Interface	Bands (MHz)	Type Transport	HAC Tested	Simultaneous but not Tested	Voice over digital Transport OTT Capability	Power Reduction
GSM	850	VO	Yes	Yes – Wi-Fi/BT	NA	NA
	1900					
	GPRS/EDGE	DT	No	Yes – Wi-Fi/BT	Yes	NA
W-CDMA	850	VO	No	Yes - Wi-Fi/BT	NA	NA
	1700					
	1900					
	HSPA	DT	No	Yes – Wi-Fi/BT	Yes	NA
CDMA	800	VO	Yes	Yes – Wi-Fi/BT	NA	NA
	1900					
	EVDO	DT	No	Yes – Wi-Fi/BT	NA	NA
LTE - FDD	700	VD[1]	Yes	Yes – Wi-Fi/BT	Yes	NA
	850					
	1700					
	1900					
	2600					
LTE - TDD	2500	VD[1]	Yes	Yes – Wi-Fi/BT	Yes	NA
Wi-Fi	2450	VD[1]	No	Yes – WWAN and BT	NA	NA
	5200					
	5300					
	5500					
	5800					
BT	2450	DT	No	Yes – WWAN and Wi-Fi	NA	NA

Type Transport
VO=CMRS Voice Service
DT – Digital Transport
VD=CMRS IP Voice Service and Digital Transport

Note:

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9. HAC (T-coil) Test Results

Mode	Channel and Frequency	Probe Orientation	Frequency Response	ABM1 (A/m)	BWC Factor (dB)	ABM SNR (dB)	T-Rating
CDMA2000 BC0 RC1 / SO3 Voice Coder: 8K EVRC Low	384 836.52 MHz	z (axial)	Pass	-2.59	0.16	41.04	T4
		y (Transversal)		-11.23	0.16	38.44	T4
CDMA2000 BC1 RC1 / SO3 Voice Coder: 8K EVRC Low	600 1880 MHz	z (axial)	Pass	-2.85	0.16	44.67	T4
		y (Transversal)		-10.62	0.16	40.71	T4
CDMA2000 BC10 RC1 / SO3 Voice Coder: 8K EVRC Low	580 820.5 MHz	z (axial)	Pass	-3.48	0.16	40.02	T4
		y (Transversal)		-11.11	0.16	39.45	T4
GSM850 Voice Coder Speechcodec Low	190 836.6 MHz	z (axial)	Pass	5.78	0.16	43.37	T4
		y (Transversal)		-8.67	0.16	33.18	T4
GSM1900 Voice Coder Speechcodec Low	661 1880 MHz	z (axial)	Pass	5.72	0.16	48.86	T4
		y (Transversal)		-7.89	0.16	39.86	T4
W-CDMA Band V Voice Coder Speechcodec Low	4183 836.6 MHz	z (axial)	Pass	3.57	0.16	46.89	T4
		y (Transversal)		-5.80	0.16	41.74	T4
W-CDMA Band IV Voice Coder Speechcodec Low	1413 1732.6 MHz	z (axial)	Pass	3.33	0.16	45.29	T4
		y (Transversal)		-6.48	0.16	42.60	T4
W-CDMA Band II Voice Coder Speechcodec Low	9400 1880 MHz	z (axial)	Pass	3.66	0.16	51.09	T4
		y (Transversal)		-7.98	0.16	42.97	T4
LTE Band 2 Voice Wideband AMR Codec: 12.65 kbit/s	20 MHz BW 18900 1880 MHz	z (axial)	Pass	3.49	0.16	41.29	T4
		y (Transversal)		-7.89	0.16	41.17	T4
LTE Band 4 Voice Wideband AMR Codec: 12.65 kbit/s	20 MHz BW 20175 1732.5 MHz	z (axial)	Pass	3.51	0.16	41.59	T4
		y (Transversal)		-7.88	0.16	41.52	T4
LTE Band 5 Voice Wideband AMR Codec: 12.65 kbit/s	10 MHz BW 20525 836.5 MHz	z (axial)	Pass	2.41	0.16	46.32	T4
		y (Transversal)		-6.79	0.16	42.09	T4
LTE Band 7 Voice Wideband AMR Codec: 12.65 kbit/s	20 MHz BW 21100 2535 MHz	z (axial)	Pass	2.91	0.16	39.59	T4
		y (Transversal)		-7.34	0.16	41.91	T4
LTE Band 12 Voice Wideband AMR Codec: 12.65 kbit/s	10 MHz BW 23095 707.5 MHz	z (axial)	Pass	2.86	0.16	45.56	T4
		y (Transversal)		-5.26	0.16	44.51	T4
LTE Band 13 Voice Wideband AMR Codec: 12.65 kbit/s	10 MHz BW 23230 782 MHz	z (axial)	Pass	2.71	0.16	44.97	T4
		y (Transversal)		-6.09	0.16	44.18	T4
LTE Band 17 Voice Wideband AMR Codec: 12.65 kbit/s	10 MHz BW 23790 710 MHz	z (axial)	Pass	2.59	0.16	47.48	T4
		y (Transversal)		-6.07	0.16	43.69	T4
LTE Band 25 Voice Wideband AMR Codec: 12.65 kbit/s	20 MHz BW 26365 1882.5 MHz	z (axial)	Pass	-0.99	0.16	40.94	T4
		y (Transversal)		-9.66	0.16	41.81	T4
LTE Band 26 Voice Wideband AMR Codec: 12.65 kbit/s	15 MHz BW 26865 831.5 MHz	z (axial)	Pass	-0.03	0.16	37.83	T4
		y (Transversal)		-10.05	0.16	38.31	T4

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Mode	Channel and Frequency	Probe Orientation	Frequency Response	ABM1 (A/m)	BWC Factor (dB)	ABM SNR (dB)	T-Rating
LTE Band 41 Voice Wideband AMR Codec: 12.65 kbit/s	20 MHz BW 40620 2593 MHz	z (axial)	Pass	-0.94	0.16	34.74	T4
		y (Transversal)		-13.83	0.16	32.97	T4

Note:

The radial longitudinal (x axis) measurements are no longer required per ANSI C63.19-2011

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9.1. Worst Case T-Coil Test Plot

Test Laboratory: UL Verification Services Inc. SAR Lab C Date: 9/1/2015

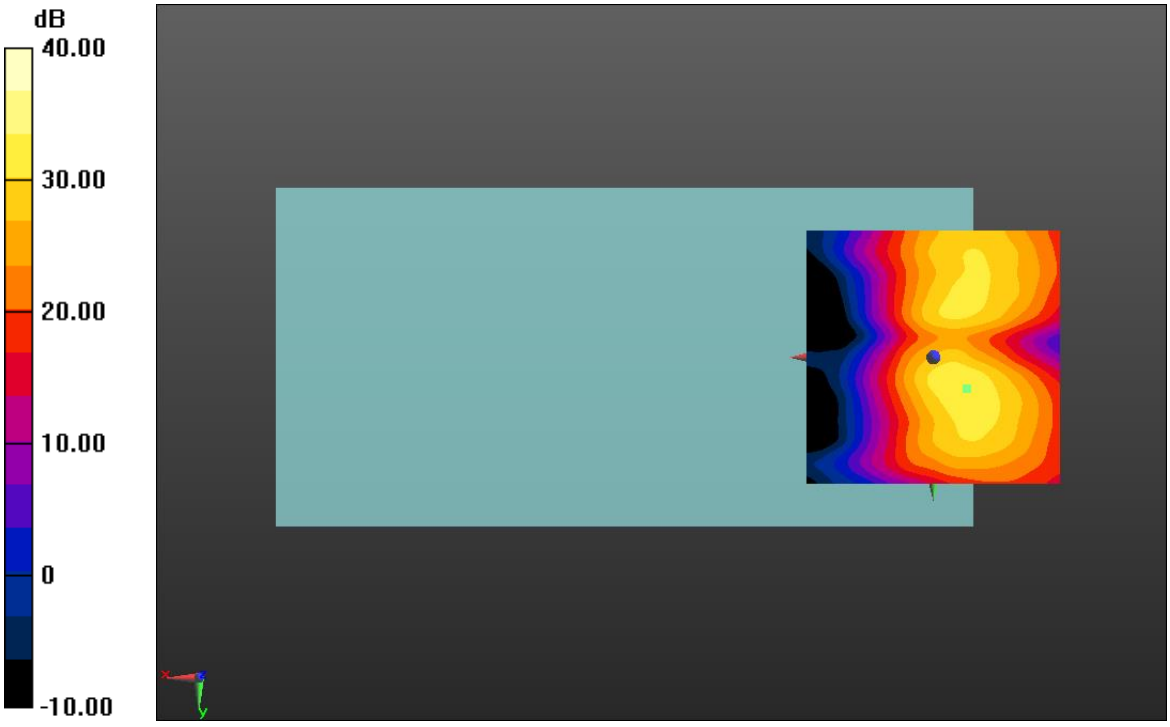
LTE Band 41

Communication System: UID 0, LTE (TDD) (0); Frequency: 2593 MHz; Duty Cycle: 1:1
Phantom section: TCoil Section
DASY5 Configuration:
- Probe: AM1DV3 - 3092; ; Calibrated: 7/9/2015
- Sensor-Surface: 0mm (Fix Surface)
- Electronics: DAE3 Sn427; Calibrated: 1/14/2015
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BB
- Measurement SW: DASY52, Version 52.8 (7);SEMCAD X Version 14.6.10 (7164)

T-Coil scan (scan for ANSI C63.19-2007 & 2011 compliance)/General Scans ch 40620/y (transversal) 4.2mm 50 x 50/ABM Interpolated SNR(x,y,z) (121x121x1): Interpolated grid:

dx=1.000 mm, dy=1.000 mm
Signal Type: Audio File (.wav) 48k_voice_1kHz_1s.wav
Output Gain: 27.48
Measure Window Start: 300ms
Measure Window Length: 1000ms
BWC applied: 0.16 dB
Device Reference Point: 0, 0, -6.3 mm

Cursor:
ABM1/ABM2 = 32.97 dB
ABM1 comp = -13.83 dBA/m
BWC Factor = 0.16 dB
Location: -6.7, 6.2, 3.7 mm



0 dB = 1.000 = 0.00 dB

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Appendix

Refer to separated files for the following appendixes

15I21523-S3V1 HAC_App A Setup Photo

15I21523-S3V1 HAC_App B Frequency Response & SNR Test Plots

15I21523-S3V1 HAC_App C Probe Cal. Certificates

END OF REPORT

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