HAC RF EMISSIONS TEST REPORT

FCC 47 CFR § 20.19
ANSI C63.19-2011

For
Dolphin CT50

FCC ID: HD5-CT50LFN
Model Name: CT50LFN

Report Number: 12441959-S4V2
Issue Date: 10/8/2018

Prepared for
HONEYWELL INTERNATIONAL INC
9680 OLD BAILES ROAD
Fort Mill, South Carolina 29715, United States

Prepared by
UL VERIFICATION SERVICES INC.
47173 BENICIA STREET
FREMONT, CA 94538, U.S.A.
TEL: (510) 771-1000
FAX: (510) 661-0888

NVLAP LAB CODE 200065-0

Revision History

Rev.	Date	Revisions	Revised By
V1	10/5/2018	Initial Issue	--
V2	10/8/2018	Section 8.1: Updated Table	Coltyce Sanders

Table of Contents

1. Attestation of Test Results

Applicant Name	HONEYWELL INTERNATIONAL INC
FCC ID	HD5-CT50L0N
Model Name	CT50L0N
Applicable Standards	FCC 47 CFR § 20.19 ANSI C63.19-2011
HAC Rating	M4
Date Tested	8/14/2018
Test Results	Pass

Note: This report only contains HAC RF Emission test results for CDMA 2000 Bands BC0 and BC1. For the HAC RF Emission test results for all other technologies, refer to the original filling HAC RF Emission Report: 15U20259-S4.

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:
	
Dave Weaver Operations Leader UL Verification Services Inc.	AJ Newcomer Laboratory Engineer UL Verification Services Inc.

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 abd FCC Published procedure

KDB 285076 D01 HAC Guidance v05
KDB 285076 D03 HAC FAQ v01
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
	SAR Lab 7

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

4. Calibration and Uncertainty

4.1. Measuring Instrument Calibration

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

Name of Equipment	Manufacturer	Type/Model	Serial No.	Cal. Due Date
Signal Generator	Agilent	N5181A	MY50140630	5/25/2019
Power Meter	Keysight	N1912A	MY500001018	10/17/2018
Power Sensor	Agilent	N1921A	MY52270022	12/28/2018
Power Sensor	Agilent	N1921A	MY52200012	10/27/2018
Amplifier	MITEQ	AMF-4D-00400600-50-30P	1795092	N/A
Bi-directional coupler	Werlatone, Inc.	C8060-102	2141	N/A
DC Power Supply	BK Precision	1611	215-02292	N/A
Data Acquisition Electronics	SPEAG	DAE4	1547	5/3/2019
E-Field Probe*	SPEAG	EF3DV3	4028	7/13/2019
Calibration Dipole	SPEAG	CD835V3	1014	2/8/2019
Calibration Dipole	SPEAG	CD1880V3	1122	2/8/2019
Radio Communication Tester	R &S	CMW 500	134855-bw	2/15/2019

Note(s):

*: According to SPEAG's Technical Report, "MIF Verification", Doc # TR-FB-12.09.04-1, issued date: 9/4/2012. E-field probes are calibrated with specified uncertainty according to ISO 17025 as described in their calibration certificate. The MIF according to the definition in ANSI C63.19 is specific for a modulation and can therefore be used as a constant value if the probe has been PMR calibrated.

4.2. Measurement Uncertainty

Error Description	Uncertainty value (±%)	Probe Dist.	Div.	(Ci) E	Std. Unc.(±%) E
Measurement System					
Probe Calibration	5.1	N	1	1	5.1
Axial Isotropy	4.7	R	1.732	1	2.7
Sensor Displacement	16.5	R	1.732	1	9.5
Boundary Effects	2.4	R	1.732	1	1.4
Phantom Boundary Effects	7.2	R	1.732	1	4.1
Linearity	4.7	R	1.732	1	2.7
Scaling to PMR Calibration	10.0	R	1.732	1	5.8
System Detection Limit	1.0	R	1.732	1	0.6
Readout Electronics	0.3	N	1	1	0.3
Response Time	0.8	R	1.732	1	0.5
Integration Time	2.6	R	1.732	1	1.5
RF Ambient Conditions	3.0	R	1.732	1	1.7
RF Reflections	12.0	R	1.732	1	6.9
Probe Positioner	1.2	R	1.732	1	0.7
Probe Positioning	4.7	R	1.732	1	2.7
Extrapolation and Interpolation	1.0	R	1.732	1	0.6
Test sample Related					
Test Positioning Vertical	4.7	R	1.732	1	2.7
Test Positioning Lateral	1.0	R	1.732	1	0.6
Power Drift	5.0	R	1.732	1	2.9
Phantom and Setup Related					
Phantom Thickness	2.4	R	1.732	1	1.4
Combined Std. Uncertainty					16.3
Expanded Std. Uncertainty on Power (Coverage Factor for 95%, k = 2)					**32.6**
Expanded Std. Uncertainty on Field					**16.3**

Notesfor table
1. N - Nomal
2. R - Rectangular
3. Div. - Divisor used to obtain standard uncertainty
4. Ci - is te sensitivity coefficient

5. System Specifications

E-field measurements are performed using the DASY52 automated dosimetric assessment system. The DASY52 is made by Schmid & Partner Engineering AG (SPEAG) in Zurich, Switzerland.

The DASY52 HAC Extension consists of the following parts:

Test Arch Phantom

The specially designed Test Arch allows high precision positioning of both the device and any of the validation dipoles.

EF3DV3 Isotropic E-Field Probe

Construction:	One dipole parallel, two dipoles normal to probe axis Interleaved sensors Built-in shielding against static charges PEEK enclosure material
Calibration:	In air from 100 MHz to 3.0 GHz (absolute accuracy ±6.0%, k=2) ISO/IEC 17025 calibration service available.
Frequency:	40 MHz – >6 GHz (can be extended to < 20 MHz); Linearity: ±0.2 dB (100 MHz – 3 GHz)
Directivity:	± 0.2 dB in air (rotation around probe axis) ± 0.4 dB in air (rotation normal to probe axis)
Dynamic Range:	2 V/m to > 1000 V/m; Linearity: ± 0.2 dB
Dimensions:	Overall length: 337 mm (Tip: 20 mm) Tip diameter: 3.9 mm (Body: 12 mm) Distance from probe tip to dipole centers: 1.5 mm Sensor displacement to probe's calibration point: <0.7 mm
Application:	General near-field measurements up to 6 GHz HAC measurements up to 6 GHz Field component measurements Fast automatic scanning in phantoms

6. System Validation

The test setup was validated when first configured and verified periodically thereafter to ensure proper function. The procedure provided in this section is a validation procedure using dipole antennas for which the field levels were computed by numeric modeling.

Procedure:

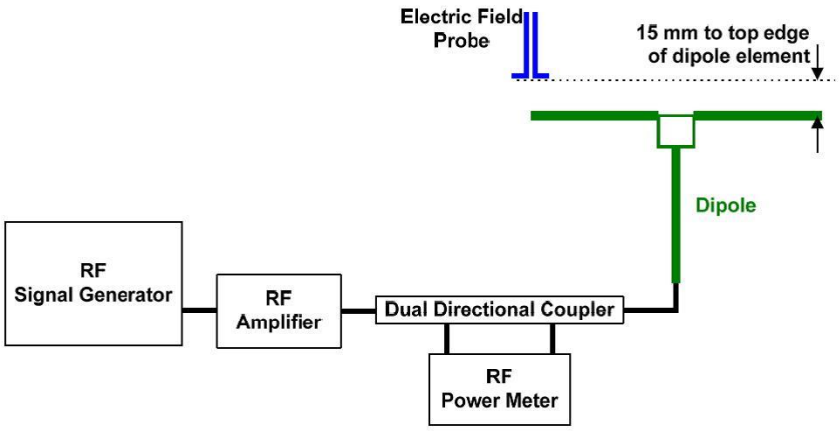
Place a dipole antenna meeting the requirements given in ANSI C63.19 in the normally occupied by the WD.

The dipole antenna serves as a known source for an electrical and magnetic output. Position the E-field probe so that the following occurs:

- The probes and their cables are parallel to the coaxial feed of the dipole antenna
- The probe cables and the coaxial feed of the dipole antenna approach the measurement area from opposite directions
- The center point of the probe element(s) is 15 mm from the closest surface of the dipole elements.

Scan the length of the dipole with the E-field probe and record the two maximum values found near the dipole ends. Average the two readings and compare the reading to the expected value in the calibration certificate or the expected value in this standard.

Setup diagram



6.1. System Validation Results

SAR Lab	Date	Dipole Type_Serial #_Freq.	Dipole Cal. Due Data	Max. measured from		Average max. above arm (V/m)	Target (V/m) (From SPEAG)	Deviation (note 1) ± %	Plot No.
				above high end (V/m)	above low end (V/m)				
7	8/14/2018	CD835V3_SN:1014_(835 MHz)	2/8/2019	119.30	120.70	120.00	108.90	10.19	1
7	8/14/2018	CD1880V3_SN:1122_(1880 MHz)	2/8/2019	93.62	94.38	94.00	88.40	6.33	2

Notes:

1) Delta (Deviation) % = 100 * (Measured value minus Target value) divided by the Target value. Deltas within ±25% are acceptable, of which 12% is deviation and 13% is measurement uncertainty.
2) The maximum E-field or were evaluated and compared to the target values provided by SPEAG in the calibration certificate of specific dipoles.
3) Please refer to the appendix for detailed measurement data and plots.

7. Average Antenna Input Power & Evaluation for Low-power Exemption

An RF air interface technology of a device is exempt from testing when its average antenna input power plus its **MIF is ≤17 dBm** for any of its operating modes. If a device supports multiple RF air interfaces, each RF air interface shall be evaluated individually.

Air-Interface	Average Antenna Input Power (dBm)[1]	Worst Case MIF (dB)	Input Power plus its MIF (dBm)	HAC Tested
CDMA BC0	24.5	3.26	27.76	Yes
CDMA BC1	24.0	3.26	27.26	Yes

Note(s):

1. Max tune-up limit
2. This report only contains HAC RF Emission test results for CDMA 2000 Bands BC0 and BC1. For the HAC RF Emission test results for all other technologies, refer to the original filling HAC RF Emission Report: 15U20259-S4.

8. Device Under Test

Normal operation	Held to head		
Back Cover	Standard – Lithium-ion battery, Rating 3.6 Vdc, 14.5 Wh		
Test sample information	**S/N**	**IMEI**	**Notes**
	16299407C7	990006210562616	Radiated Sample

8.1. Air Interfaces and Operating Mode

Air Interface	Bands (MHz)	Type	C63.19 Tested[1]	Simultaneous Transmitter	OTT Testing Required? Name of Voice Service[2]	GSM 1900 MHz Power Reduction
GSM	850	VO	No	Wi-Fi and BT	NA	NA
	1900					No
	GPRS/EDGE	VD	No	Wi-Fi and BT	NA	NA
W-CDMA (UMTS)	850	VO	No	Wi-Fi and BT	NA	NA
	1900					
	HSPA	VD	No	Wi-Fi and BT	NA	NA
CDMA	800	VO	Yes	Wi-Fi and BT	NA	NA
	1900					
	EVDO	VD	No	Wi-Fi and BT	NA	NA
LTE - FDD	700 (B17)	VD	No	Wi-Fi and BT	NA	NA
	850 (B5)					
	1700 (B4)					
	1900 (B2)					
Wi-Fi	2450	VD	No	WWAN and BT	NA	NA
	5200 (U-NII-1)					
	5300 (U-NII-2A)					
	5500 (U-NII-2C)					
	5800 (U-NII-3)					
BT	2450	DT	No	WWAN and Wi-Fi	NA	NA

Type
VO: legacy Cellular Voice Service
DT: Digital Transport only (no voice)
VD: IP Voice Service over Digital Transport
BT: Bluetooth

Note:
1. This report only contains HAC RF Emission test results for CDMA 2000 Bands BC0 and BC1. For the HAC RF Emission test results for all other technologies, refer to the original filling HAC RF Emission Report: 15U20259-S4.
2. OTT Testing was performed by another lab. This report contains data for Voice Service option only for CDMA 2000

9. Modulation Interference Factor (MIF)

The HAC Standard ANSI C63.19 defines a new scaling using the Modulation Interference Factor (MIF) which replaces the need for the Articulation Weighting Factor (AWF) during the evaluation and is applicable to any modulation scheme.

The Modulation Interference factor (MIF, in dB) is added to the measured average E-field (in dBV/m) and converts it to the RF Audio Interference level (in dBV/m). This level considers the audible amplitude modulation components in the RF E-field. CW fields without amplitude modulation are assumed to not interfere with the hearing aid electronics. Modulations without time slots and low fluctuations at low frequencies have low MIF values, TDMA modulations with narrow transmission and repetition rates of few 100 Hz have high MIF values and give similar classifications as ANSI C63.19.

Definitions

E-field probes have a bandwidth <10 kHz and can therefore not evaluate the RF envelope in the full audio band. DASY52 is therefore using the “indirect” measurement method according to ANSI C63.19 which is the primary method. These near field probes read the averaged E-field measurement. Especially for the new high peak-to-average (PAR) signal types, the probes shall be linearized by probe modulation response (PMR) calibration in order to not overestimate the field reading.

The evaluation method or the MIF is defined in ANSI C63.19 section D.7. An RMS demodulated RF signal is fed to a spectral filter (similar to an A weighting filter) and forwarded to a temporal filter acting as a quasi-peak detector. The averaged output of these filtering is called to a 1 kHz 80% AM signal as reference. MIF measurement requires additional instrumentation and is not well suited for evaluation by the end user with reasonable uncertainty It may alternatively be determined through analysis and simulation, because it is constraint and characteristic for a communication signal. DASY52 uses well defined signals for PMR calibration. The MIF of these signals has been determined by simulation and is automatically applied.

MIF values were not tested by a probe or as specified in the standards but are based on analysis provided by SPEAG for all the air interfaces (GSM, WCDMA, CDMA, LTE). The data included in this report are for the worst case operating modes. The UIDs used are listed below:

UID	Communication System Name	MIF (dB)
10295-AAB	CDMA2000 (1xRTT, RC1, SO3, 1/8th Rate 25 fr.)	3.26

A PMR calibrated probe is linearized for the selected waveform over the full dynamic range within the uncertainty specified in its calibration certificate. E-field probes have a bandwidth <10 kHz and can therefore not evaluate the RF envelope in the full audio band. DASY52 is therefore using the \indirect" measurement method according to ANSI C63.19 which is the primary method. These near field probes read the averaged E-field measurement. Especially for the new high peak-to-average (PAR) signal types, the probes shall be linearized by PMR calibration in order to not overestimate the field reading.

The MIF measurement uncertainty is estimated as follows, for modulation frequencies from slotted waveforms with fundamental frequency and at least 2 harmonics within 10 kHz:

- *0.2 dB for MIF -7 to +5 dB,*
- *0.5 dB for MIF -13 to +11 dB*
- *1 dB for MIF > -20 dB*

Note(s):

This report only contains HAC RF Emission test results for CDMA 2000 Bands BC0 and BC1. For the HAC RF Emission test results for all other technologies, refer to the original filling HAC RF Emission Report: 15U20259-S4.

10. HAC RF Emissions Test Procedure

The following are step-by-step test procedures.

a) Confirm proper operation of the field probe, probe measurement system and other instrumentation and the positioning system.

b) Position the WD in its intended test position.

c) Set the WD to transmit a fixed and repeatable combination of signal power and modulation characteristic that is representative of the worst case (highest interference potential) encountered in normal use. Transiently occurring start-up, changeover, or termination conditions, or other operations likely to occur less than 1% of the time during normal operation, may be excluded from consideration.

d) The center sub-grid shall be centered on the T-Coil mode perpendicular measurement point or the acoustic output, as appropriate. Locate the field probe at the initial test position in the 50 mm by 50 mm grid, which is contained in the measurement plane, refer to illustrated in Figure 1. If the field alignment method is used, align the probe for maximum field reception.

e) Record the reading at the output of the measurement system

f) Scan the entire 50 mm by 50 mm region in equally spaced increments and record the reading at each measurement point. The distance between measurement points shall be sufficient to assure the identification of the maximum reading.

g) Identify the five contiguous sub-grids around the center sub-grid whose maximum reading is the lowest of all available choices. This eliminates the three sub-grids with the maximum readings. Thus, the six areas to be used to determine the WD's highest emissions are identified.

h) Identify the maximum reading within the non-excluded sub-grids identified in step g).

i) Convert the highest field reading within identified in step h) to RF audio interference level, in V/m, by taking the square root of the reading and then dividing it by the measurement system transfer function, established in 5.5.1.1 Convert this result to dB(V/m) by taking the base-10 logarithm and multiplying by 20.

   Indirect measurement method

   Replacing step i), the RF audio interference level in dB (V/m) is obtained by adding the MIF (in dB) to the maximum steady-state rms field-strength reading, in dB (V/m), from step h). Use this result to determine the category rating

j) Compare this RF audio interference level with the categories in Clause 8 (ANSI C63.19) and record the resulting WD category rating

k) For the T-Coil mode M-rating assessment, determine whether the chosen perpendicular measurement point is contained in an included sub-grid of the first scan. If so, then a second scan is not necessary. The first scan and resultant category rating may be used for the T-Coil mode M rating.

   Otherwise, repeat step a) through step i), with the grid shifted so that it is centered on the perpendicular measurement point. Record the WD category rating.

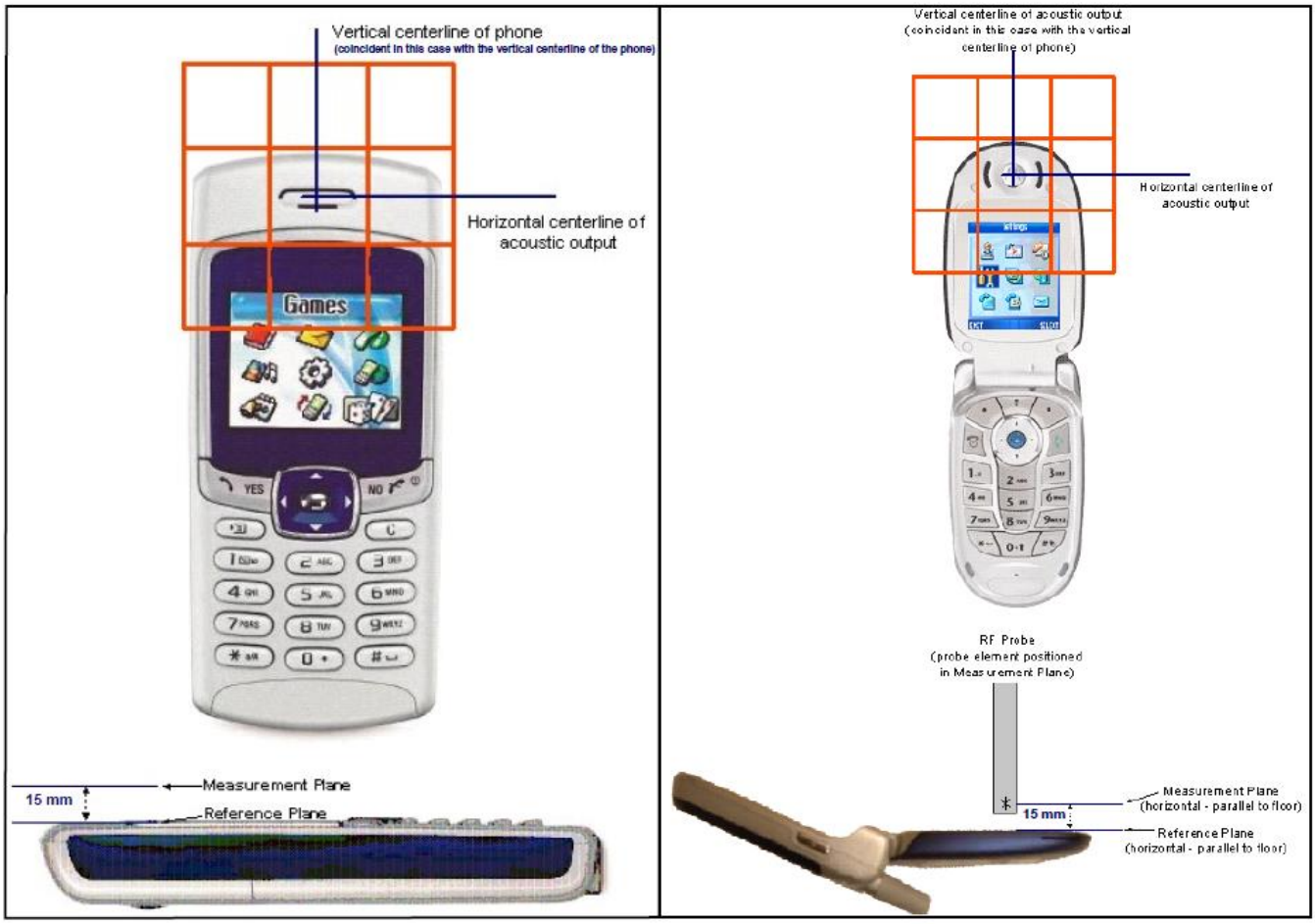
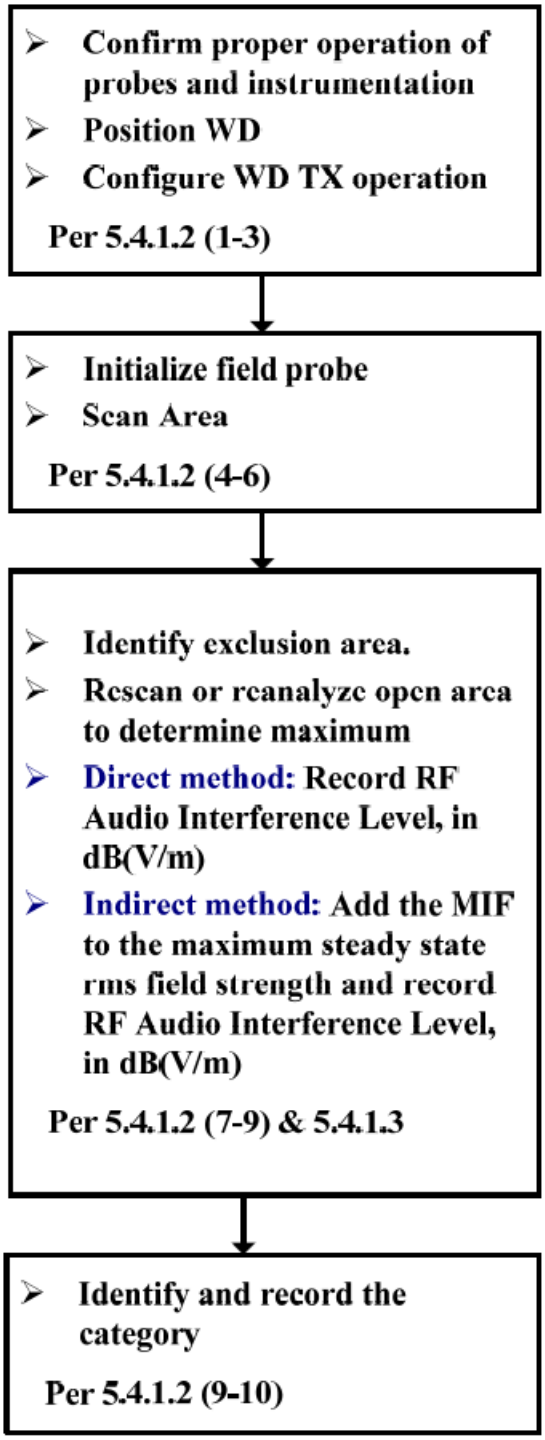


Figure 1 - WD reference and plane for RF emission measurements

Test flowchart Per ANSI-63.19-2011



11. RF Emissions Measurement Criteria

WD RF audio interference level caterories in logarithmic units

Emission Categories	E-field emissions	
	< 960 MHz	> 960 MHz
Category M1	50 to 55 dB (V/m)	40 to 45 dB (V/m)
Category M2	45 to 50 dB (V/m)	35 to 40 dB (V/m)
Category M3	40 to 45 dB (V/m)	30 to 35 dB (V/m)
Category M4	<40 dB (V/m)	<30 dB (V/m)

12. HAC (RF Emissions) Test Results

MIF values were not tested by a probe or as specified in the standards but are based on analysis provided by SPEAG for the following User Identifiers and air interfaces.

The data included in this report are for the worst case operating modes. Refer to Appendix D and G for the MIF vales that represent the worst case operation modes.

This report only contains HAC RF Emission test results for CDMA 2000 Bands BC0 and BC1. For the HAC RF Emission test results for all other technologies, refer to the original filling HAC RF Emission Report: 15U20259-S4.

Air-Interface	Ch. No.	Freq. (MHz)	Results* (dB V/m)	Results plus 0.2dB uncertainty (dB V/m)	Margin (dB)	M-Rating	Plot No.
CDMA2000 BC0	1013	824.7	30.80	31.00	9.00	M4	1
	384	836.6	30.82	**31.02**	**8.98**	**M4**	2
	777	848.31	30.01	30.21	9.79	M4	3
CDMA2000 BC1	25	1851.25	15.96	16.16	13.84	M4	4
	600	1880	16.59	16.79	13.21	M4	5
	1175	1908.75	20.02	20.22	9.78	M4	6

Note(s):

*: Measured Audio Interference level in dB (V/m): indirect method (max rms field strength Plus MIF)

12.1. Worst Case RF Emission Test Plot

Test Laboratory: UL Verification Services Inc. SAR Lab 7 Date: 8/14/2018

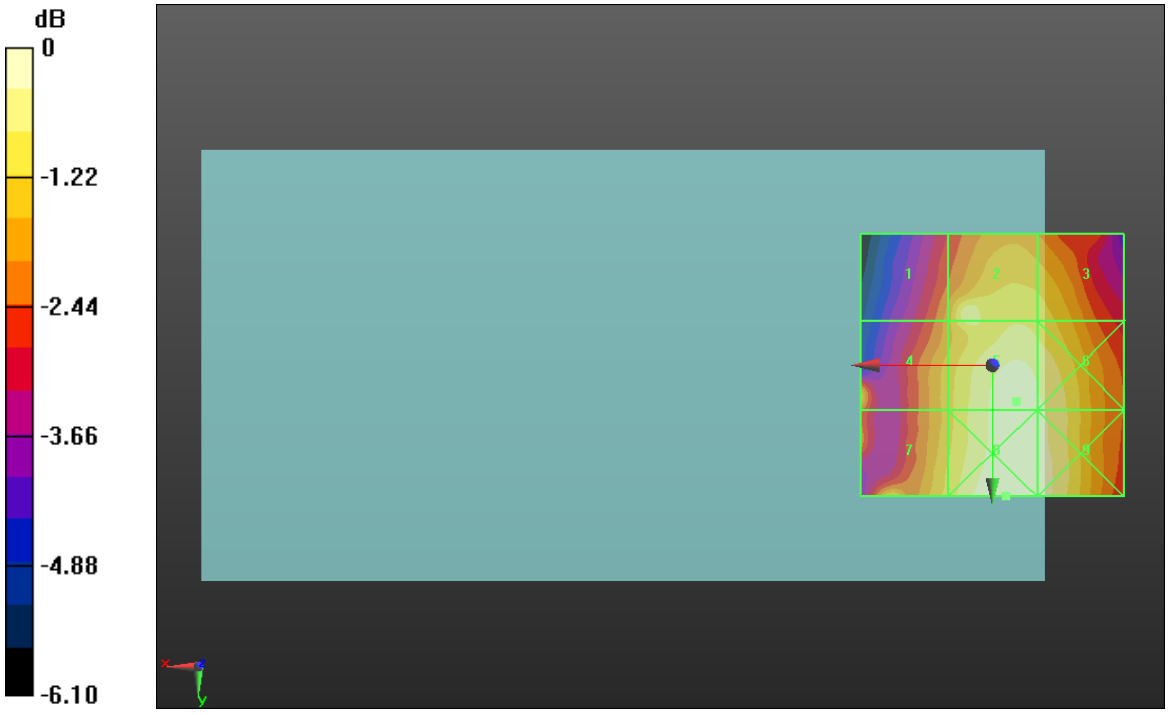
HAC-RF Emission

Communication System: UID 10295 - AAB, CDMA2000, RC1, SO3, 1/8th Rate 25 fr.; Frequency: 836.52 MHz; Duty Cycle: 1:17.7419
Phantom section: RF Section
DASY5 Configuration:
- Probe: EF3DV3 - SN4028; ConvF(1, 1, 1) @ 836.52 MHz; Calibrated: 7/13/2018
- Sensor-Surface: (Fix Surface)
- Electronics: DAE4 Sn1547; Calibrated: 5/3/2018
- Phantom: HAC Test Arch with AMCC; Type: SD HAC P01 BB
- Measurement SW: DASY52, Version 52.10 (1);SEMCAD X Version 14.6.11 (7439)

CDMA BC0 E-Field measurement/RC1_SO3_Ch 384/Hearing Aid Compatibility Test (101x101x1):
Interpolated grid: dx=0.5000 mm, dy=0.5000 mm
Device Reference Point: 0, 0, -6.3 mm
Reference Value = 29.40 V/m; Power Drift = 0.04 dB
Applied MIF = 3.26 dB
RF audio interference level = 30.82 dBV/m
Emission category: M4

MIF scaled E-field

Grid 1 **M4** **29.21 dBV/m**	Grid 2 **M4** **30.56 dBV/m**	Grid 3 **M4** **30.08 dBV/m**
Grid 4 **M4** **29.74 dBV/m**	Grid 5 **M4** **30.82 dBV/m**	Grid 6 **M4** **30.72 dBV/m**
Grid 7 **M4** **29.99 dBV/m**	Grid 8 **M4** **31.03 dBV/m**	Grid 9 **M4** **30.88 dBV/m**



0 dB = 35.59 V/m = 31.03 dBV/m

Appendixes

Refer to separated files for the following appendixes

12441959-S4V1 Appendix A: HAC RF Emission Setup Photo

12441959-S4V1 Appendix B: System Validation Plots

12441959-S4V1 Appendix C: HAC RF Emission Test Plots

12441959-S4V1 Appendix D: MIF Attestation Letter

12441959-S4V1 Appendix E: Probe Calibration Certificates

12441959-S4V1 Appendix F: Dipole Calibration Certificates

12441959-S4V1 Appendix G: UID Specifications

END OF REPORT