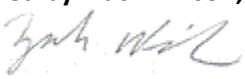
Test Report # TR 317213 RFx

Equipment Under Test:	Human Headphones
Test Date(s):	January 2nd – January 21st, 2019
Prepared for:	Human Inc. Attn: Jingping Ma 3100 Airport Way 25-512 Seattle, WA 98134

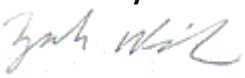
Report Issued by: Zach Wilson, EMC Engineer

Signature:  Date: 2/5/2019

Report Reviewed by: Khairul Aidi Zainal, Laboratory manager

Signature:  Date: 2/4/2019

Report Constructed by: Zach Wilson, EMC Engineer

Signature:  Date: 2/4/2019

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Laird Technologies Test Services in Review

The Laird Technologies, Inc. laboratory located at W66 N220 Commerce Court Cedarburg, Wisconsin, 53012 USA is recognized through the following organizations:

TESTING CERT #1255.01

A2LA – American Association for Laboratory Accreditation

Accreditation based on ISO/IEC 17025: 2005 with Electrical (EMC) Scope
A2LA Certificate Number: 1255.01
Scope of accreditation includes all test methods listed herein, unless otherwise noted.

Federal Communications Commission (FCC) – USA

Accredited recognition of two 3 meter Semi-Anechoic Chambers

Accredited Test Firm Registration Number: 953492

Government of Canada

Innovation, Science and Economic Development Canada

ISED Site listing of two 3 meter Semi-Anechoic Chambers based on RSS-GEN – Issue 4
File Number: IC 3088A-2
File Number: IC 3088A-3

1 Test Report Summary

During **1/2/19-1/21/19** the Equipment Under Test (EUT), **Human Headphones**, as provided by **Human Inc.** was tested to the following requirements:

Requirement	Description	Specification	Method	Result
FCC Part 1.1307, 2.1091, 2.1093	RF Exposure and equipment authorization requirements	Reported	FCC KDB 447498	Reported

Notice:

The results relate only to the item tested and described in this report. Any modifications made to the equipment under test after the specified test date(s) may invalidate the data herein.

If the resulting measurement margin is seen to be within the uncertainty value, as listed in this report, the possibility exists that this unit may not meet the required limit specification if subsequently tested.

2 Client Information

Company Name	Human Inc.
Contact Person	Jingping Ma
Address	3100 Airport Way 25-512 Seattle, WA 98134

2.1 Equipment Under Test (EUT) Information

The following information has been supplied by the client

Product Name	Human Headphones
Model Number	1701, 1702
Serial Number	7406, 7354
FCC ID Left	2ARJG-1701
FCC ID Right	2ARJG-1702

2.2 Product Description

Left (model 1701) and right (model 1702) ear headphone units. The unit has two modes of operation; amplify mode when both ears are together and headphone mode when the units are on the user's head. The units use 10.5 MHz NFMI when in headphone mode to communicate with each other and 14.8 MHz NFMI while in amplify mode. The right ear unit receives audio via Bluetooth classic and input commands via BLE. The left ear unit receives OTA updates via BLE/BT.

The units are powered via 3.7 VDC Li-ion batteries. They are charged via a 5-pin charging port connected to a wall wart capable of an input voltage of 100-240 VAC, 50-60 Hz. The antenna for BLE/BT is a custom monopole antenna with a peak gain of 2.5 dBi. The manufacturer declared tune up tolerance is ±1 dB.

2.3 Modifications Incorporated for Compliance

N/A

2.4 Deviations and Exclusions from Test Specifications

N/A

2.5 Programming Information

Two software applications were used to program the radios. Airoha AB152C Lab Test Tool, v2.1.1.15730 and Docklight v2.2.8.

3 REFERENCES

Publication	Edition	Date
CFR 47 Part 1	-	2017
CFR 47 Part 2	-	2017

4 UNCERTAINTY SUMMARY

Using the guidance of the following publications the calculated measurement uncertainty represents an expanded uncertainty expressed at approximately the 95 % confidence level, using a coverage factor of k = 2.

References	Version / Date
CISPR 16-4-1	Ed. 2 (2009-02)
CISPR 16-4-2	Ed. 2 (2011-06)
CISPR 32	Ed. 1 (2012-01)
ANSI C63.23	2012
A2LA P103	February 4, 2016
A2LA P103c	August 10, 2015
ETSI TR 100-028	V1.3.1 (2001-03)

Measurement Type	Configuration	Uncertainty ±
Radiated Emissions	Biconical Antenna	5.0 dB
Radiated Emissions	Log Periodic Antenna	5.3 dB
Radiated Emissions	Horn Antenna	4.7 dB
AC Line Conducted Emissions	Artificial Mains Network	3.4 dB
Telecom Conducted Emissions	Asymmetric Artificial Network	4.9 dB
Disturbance Power Emissions	Absorbing Clamp	4.1 dB
Radiated Immunity	3 Volts/meter	2.2 dB
Conducted Immunity	CDN/EM/BCI	2.4/3.5/3.4 dB
EFT Burst/Surge	Peak pulse voltage	164 volts
ESD Immunity	15 kV level	1377 Volts

Parameter	ETSI U.C. ±	U.C. ±
Radio Frequency, from F0	$1x10^{-7}$	$0.55x10^{-7}$
Occupied Channel Bandwidth	5 %	2 %
RF conducted Power (Power Meter)	1.5 dB	1.2 dB
RF conducted emissions (Spectrum Analyzer)	3.0 dB	1.7 dB
All emissions, radiated	6.0 dB	5.3 dB
Temperature	1° C	0.65° C
Humidity	5 %	2.9 %
Supply voltages	3 %	1 %

5 TEST DATA

5.1 Fundamental Measurements

Operator	Anthony Smith / Zach Wilson
QA	Zach Wilson
Test Date	10/16/2017
Location	BT/BLE: Conducted Radio Bench NFMI: Chamber 3
Temp. / R.H.	21.8°C/31.3%
Requirement	15.247 (b) (3)
Method	FCC KDB 558074 D01 DTS Meas Guidance V04, section 9.1.3

Test Parameters

Frequency	BT/BLE: 2402 MHz, 2440 MHz, 2480 MHz NFMI: 10.5 MHz, 14.8 MHz
RBW	BLE: 1 MHz BT: 3 MHz NFMI: 9 kHz
VBW	BLE: 3 MHz BT: 50 MHz NFMI: 90 kHz
Detector	Peak max hold with a peak detector for BT/BLE. Max peak hold with quasi peak detector for NFMI.
Notes	EUT supply = 3.7VDC. NFMI data converted from field strength to power.
Data Rates and Channels	Worst case based on output power: BT, Left Ear (1701): EDR2 High Channel BT, Right Ear (1702): EDR3 High Channel BLE, Left Ear (1701): BLE 125kbit/s, High Channel BLE, Right Ear (1702): BLE 125kbit/s, High Channel NFMI 10.5 MHz and 14.8 MHz: Single Channel, Single Data Rate

Tables

BLE Left Ear (1701)	
Channel	**Output Power (dBm)**
Low	2.1
Mid	3.3
High	3.5

BLE Right Ear (1702)	
Channel	**Output Power (dBm)**
Low	3.9
Mid	4.7
High	4.9

BT EDR2 Left Ear (1701)	
Channel	**Output Power (dBm)**
Low	3.3
Mid	4.4
High	4.6

BT EDR3 Right Ear (1702)	
Channel	**Output Power (dBm)**
Low	5.5
Mid	6.7
High	6.8

NFMI Left Ear (1701)	
Radio	**Output Power (dBm)**
10.5 MHz	-58.73

NFMI Right Ear (1702)		
Radio	**EIRP (dBm)**	**Field Strength (dBuV/m)**
10.5 MHz	-55.5	39.8

NFMI Units Together		
Radio	**EIRP Power (dBm)**	**Field Strength (dBuV/m)**
14.9 MHz	-66.3	28.9

Calculation converting field strength to EIRP:

Per ANSI C63.10 2013 Annex G

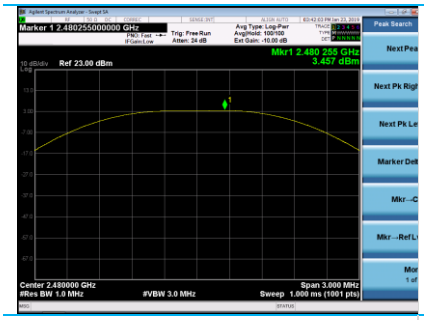
$EIRP = p_T \times g_T = (E \times d)^2/30$

EIRP (dBm) = EIRP (dBuV/m) + (20 log (d) - 104.77), d = 3m

$EIRP_{10.5MHz}$ = 39.8dBuV/m + (20 log (3) - 104.77) = **-55.5dBm**

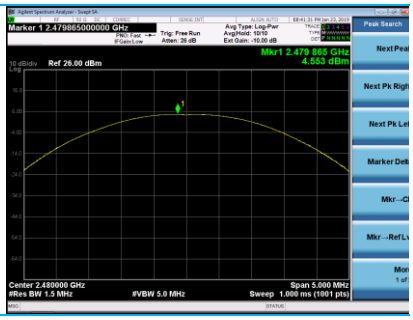
$EIRP_{14.9MHz}$ = 28.9dBuV/m + (20 log (3) - 104.77) = **-66.3dBm**

Plots

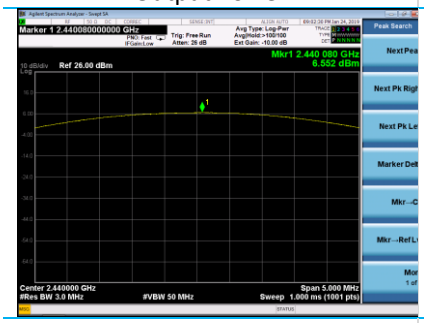


BLE High Channel, Left Ear (1701) Output Power

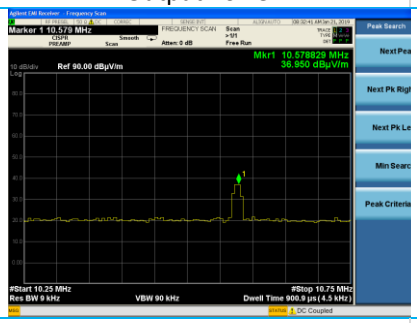
BLE High Channel, Right Ear (1702) Output Power



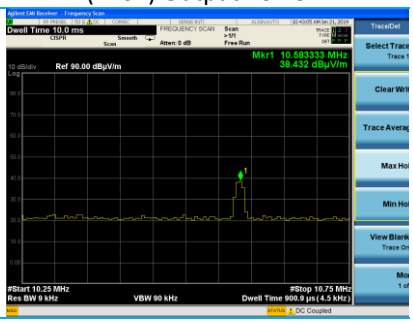
BT High Channel, EDR2 Left Ear (1701) Output Power



BT High Channel, EDR3 Right Ear (1702), Output Power



NFMI 10.5 MHz, Left Ear (1701) Output Power



NFMI 10.5 MHz, Right Ear (1702) Output Power

NFMI 14.8 MHz, Units Together Output Power

6 EXEMPTION CALCULATION

6.1 Duty Cycle

Units able to continuously transmit. 100% duty cycle used for output power measurements and calculations.

6.2 Portable Single Transmitter- Bluetooth

Limit/Equation:

For 100 MHz to 6 GHz and *test separation distances* ≤ 50 mm, the 1-g and 10-g *SAR test exclusion thresholds* are determined by the following:
[(*max. power of channel, including tune-up tolerance, mW*) / (*min. test separation distance, mm*)] · [$\sqrt{f_{(GHz)}}$] ≤ 3.0 for 1-g SAR, and ≤ 7.5 for 10-g extremity SAR

Calculations:

Conducted output power = 6.8 dBm
Frequency/Channel = 2480MHz
Tune-up tolerance = 1dB
Test separation distance: **< 5mm**

Channel power = Conducted output power + tune-up tolerance
= 6.8dBm + 1dB = **7.8dBm**
= **6.03mW**

(6.03/5)*(√(2.480)) = 1.89 < 3.0

Conclusion:

The above calculations were based off the worst-case output power and frequency for a single portable radio. The **Human Headphones** Bluetooth radio is exempt from SAR evaluation when used at a distance of ≤ 5mm in portable situations.

6.3 Portable Single Transmitter- BLE

Limit/Equation:

For 100 MHz to 6 GHz and *test separation distances* ≤ 50 mm, the 1-g and 10-g *SAR test exclusion thresholds* are determined by the following:
[(*max. power of channel, including tune-up tolerance, mW*) / (*min. test separation distance, mm*)] · [$\sqrt{f_{(GHz)}}$] ≤ 3.0 for 1-g SAR, and ≤ 7.5 for 10-g extremity SAR

Calculations:

Conducted output power = 4.9 dBm
Frequency/Channel = 2480MHz
Tune-up tolerance = 1dB
Test separation distance: **< 5mm**

Channel power = Conducted output power + tune-up tolerance
= 4.9dBm + 1dB = **5.9dBm**
= **3.89mW**

(3.89/5)*(√(2.480)) = 0.94 < 3.0

Conclusion:

The above calculations were based off the worst-case output power and frequency for a single portable radio. The **Human Headphones** BLE radio is exempt from SAR evaluation when used at a distance of ≤ 5mm in portable situations.

6.4 Portable Single Transmitter- NFMI 10.5 MHz

Limit/Equation:

c) For frequencies below 100 MHz, the following may be considered for SAR test exclusion (also illustrated in Appendix C):[33]

1) For *test separation distances* > 50 mm and < 200 mm, the power threshold at the corresponding test separation distance at 100 MHz in step b) is multiplied by [1 + log(100/$f_{(MHz)}$)]

2) For *test separation distances* ≤ 50 mm, the power threshold determined by the equation in c) 1) for 50 mm and 100 MHz is multiplied by ½

b) For 100 MHz to 6 GHz and *test separation distances* > 50 mm, the 1-g and 10-g *SAR test exclusion thresholds* are determined by the following (also illustrated in Appendix B):[32]

1) {[Power allowed at *numeric threshold* for 50 mm in step a)] + [(test separation distance – 50 mm)·($f_{(MHz)}$/150)]} mW, for 100 MHz to 1500 MHz

a) For 100 MHz to 6 GHz and *test separation distances* ≤ 50 mm, the 1-g and 10-g *SAR test exclusion thresholds* are determined by the following:

[(*max. power of channel, including tune-up tolerance, mW*) / (*min. test separation distance, mm*)] · [$\sqrt{f_{(GHz)}}$] ≤ 3.0 for 1-g SAR, and ≤ 7.5 for 10-g extremity SAR,[30] where

- $f_{(GHz)}$ is the RF channel transmit frequency in GHz

Calculations:

Max Power = -55.5dBm
Frequency/Channel = 10.5MHz
Tune-up tolerance = 1dB
Test separation distance: < 5mm

Channel power = Conducted output power + tune-up tolerance
= -55.5dBm + 1dB = **-54.5dBm**
= **0.0000035mW**

Power Allowed at Numeric Threshold = **467.97mW**

Final Equation: [(0.0000035mW)/(5mm*0.015GHz)] = **0.000047mW < 467.97mW**

Conclusion:

The above calculations were based off the worst-case output power and frequency for a single portable radio. The **Human Headphones** NFMI 10.5 MHz radio is exempt from SAR evaluation when used at a distance of ≤ 5mm in portable situations.

6.5 Portable Simultaneous Transmitters- NFMI 10.5 MHz, BLE, Bluetooth

Limit/Equation:

b) When an antenna qualifies for the standalone SAR test exclusion of 4.3.1 and also transmits simultaneously with other antennas, the standalone SAR value must be estimated according to the following to determine the simultaneous transmission SAR test exclusion criteria:[36]

1) [(*max. power of channel, including tune-up tolerance, mW*) / (*min. test separation distance, mm*)]·[$\sqrt{f_{(GHz)}}/x$] W/kg, for *test separation distances* ≤ 50 mm;
where x = 7.5 for 1-g SAR and x = 18.75 for 10-g SAR.

Limit: (Sum of all SAR Values for all radios) ≤ 1.6 W/kg

Bluetooth SAR Value:

Conducted Power = 6.8dBm
Tune-up tolerance = 1dBm
Max Power = 6.03mW
Test separation distance: < 5mm
Frequency = 2.48 GHz
X = 7.5 for 1-g SAR

[(6.03)/(5)]*[(√2.48)/7.5] W/kg = 0.25W/kg

BLE Estimated SAR Value:

Conducted Power = 4.9dBm
Tune-up tolerance = 1dBm
Max Power = 3.89mW
Test separation distance: < 5mm
Frequency = 2.48 GHz
X = 7.5 for 1-g SAR

[(3.89)/(5)]*[(√2.48)/7.5] W/kg = 0.16W/kg

NFMI 10.5MHz Estimated SAR Value:

Conducted Power = -55.5dBm
Tune-up tolerance = 1dBm
Max Power = 0.0000035mW
Test separation distance: < 5mm
Frequency = 0.0105 GHz
X = 7.5 for 1-g SAR

[(0.0000035)/(5)]*[(√0.0105)/7.5] W/kg ≈ 10E-9W/kg

Total = (0.25+0.16+0)W/kg = 0.41W/kg

0.41W/kg ≤ 1.6W/kg

Conclusion:

The above calculations were based off the worst-case output power and frequency for each portable radio capable of transmitting simultaneously. The **Human Headphones** is exempt from SAR evaluation when used at a distance of ≤ 5mm with all radios transmitting simultaneously in portable situations.

6.6 Mobile Transmitters Introduction

7.2. Transmitters used in mobile device exposure conditions for simultaneous transmission operations

For *mobile exposure host* platform devices to qualify for simultaneous transmission MPE test exclusion, all transmitters and antennas in the host must either be evaluated for MPE compliance, by measurement or computational modeling, or qualify for the standalone MPE test exclusion in 7.1. When modular transmitters are used, the minimum *test separation distance* required for each simultaneously transmitting antenna installed in the host device must satisfy MPE compliance for both standalone and simultaneous transmission operations. When simultaneous transmission MPE test exclusion applies, transmitter modules may be incorporated in host devices according to Class I permissive change requirements to document the test exclusion conditions.[68]

Simultaneous transmission MPE test exclusion applies when the sum of the MPE ratios for all simultaneously transmitting antennas incorporated in a host device is ≤ 1.0, according to calculated/estimated, numerically modeled, or measured field strengths or power density. The MPE ratio of each antenna is determined at the minimum *test separation distance* required by the operating configurations and exposure conditions of the host device, according to the ratio of field strengths or power density to the MPE limit at the test frequency.[69]

6.7 Mobile Transmitter Stand Alone MPE - Bluetooth

Prediction of MPE limit at a given distance

Equation from page 18 of OET Bulletin 65, Edition 97-01

$$S = \frac{PG}{4\pi R^2}$$

where: S = power density
P = power input to the antenna
G = power gain of the antenna in the direction of interest relative to an isotropic radiator
R = distance to the center of radiation of the antenna

Maximum peak output power at antenna input terminal:	7.80	(dBm)
Maximum peak output power at antenna input terminal:	6.026	(mW)
Antenna gain(typical):	2.5	(dBi)
Maximum antenna gain:	1.778	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	2480	(MHz)
MPE limit for uncontrolled exposure at prediction frequency:	1	(mW/cm^2)
Power density at prediction frequency:	0.002132	(mW/cm^2)

6.8 Mobile Transmitter Stand Alone MPE - BLE

Prediction of MPE limit at a given distance

Equation from page 18 of OET Bulletin 65, Edition 97-01

$$S = \frac{PG}{4\pi R^2}$$

where: S = power density
P = power input to the antenna
G = power gain of the antenna in the direction of interest relative to an isotropic radiator
R = distance to the center of radiation of the antenna

Maximum peak output power at antenna input terminal:	5.90	(dBm)
Maximum peak output power at antenna input terminal:	3.890	(mW)
Antenna gain(typical):	2.5	(dBi)
Maximum antenna gain:	1.778	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	2480	(MHz)
MPE limit for uncontrolled exposure at prediction frequency:	1	(mW/cm^2)
Power density at prediction frequency:	0.001376	(mW/cm^2)

6.9 Mobile Transmitter Stand Alone MPE – NFMI 14.8 MHz

MPE Limit = $180/f^2 = 180/(14.8^2)$ = **0.822 mW/cm²**

Prediction of MPE limit at a given distance

Equation from page 18 of OET Bulletin 65, Edition 97-01

$$S = \frac{PG}{4\pi R^2}$$

where: S = power density
P = power input to the antenna
G = power gain of the antenna in the direction of interest relative to an isotropic radiator
R = distance to the center of radiation of the antenna

Maximum peak output power at antenna input terminal:	-62.80	(dBm)
Maximum peak output power at antenna input terminal:	0.000	(mW)
Antenna gain(typical):	0	(dBi)
Maximum antenna gain:	1.000	(numeric)
Prediction distance:	20	(cm)
Prediction frequency:	14.9	(MHz)
MPE limit for uncontrolled exposure at prediction frequency:	0.811	(mW/cm^2)
Power density at prediction frequency:	1.04E-10	(mW/cm^2)

6.10 Mobile Transmitter Simultaneous MPE – Bluetooth, BLE, NFMI 14.8 MHz

MPE Ratios:

Bluetooth = 0.002132 mW/cm^2
BLE = 0.001376 mW/cm^2
NFMI (14.8 MHz) = 1.04E-10 mW/cm^2

Total:

0.006254 mW/cm^2 < 1 mW/cm^2

Conclusion:

The above calculations were based off the worst-case output power and frequency for each mobile radio capable of transmitting simultaneously. The **Human Headphones** is exempt from SAR mobile evaluation when used at a distance of > 20mm with all radios transmitting simultaneously in mobile situations.

7 REVISION HISTORY

Version	Date	Notes	Person
V0	2/1/2019	Initial Draft	Zach Wilson
V1	2/4/2019	Revised Draft	Zach Wilson

END OF REPORT