

Test Report # 319122 B

Equipment Under Test: HC1

Test Date(s): 8/29/19

Prepared for: ATTN: Basman Dahleh
Guardhat
1520 Woodward Ave 3rd floor
Detroit, MI 48226

Report Issued by: Khairul Aidi Zainal, Laboratory Manager

Signature: 

Date: 12/13/2019

Report Reviewed by: Adam Alger, Quality Manager

Signature: 

Date: 12/13/2019

Report Constructed by: Shane Dock, EMC Engineer

Signature: 

Date: 8/29/2019

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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:



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

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1 TEST REPORT SUMMARY

During **8/29/19** the Equipment Under Test (EUT), **HC1**, as provided by **Guardhat** 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
ISED Canada RSS-102	Radiofrequency Radiation Exposure Evaluation: Portable	Reported	RSS-102 Section 2.5.2	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	Guardhat
Contact Person	Basman Dahleh
Address	1520 Woodward Ave 3rd floor Detroit, MI 48226

2.1 Equipment Under Test (EUT) Information

The following information has been supplied by the client

Product Name	HC1
Model Number	HC1
Serial Number	P240
FCC/IC ID	FCC ID: 2AR6OHC1000 IC ID: 24751-HC1000

2.2 Modifications Incorporated for Compliance

None noted at time of test

2.3 Deviations and Exclusions from Test Specifications

None noted at time of test

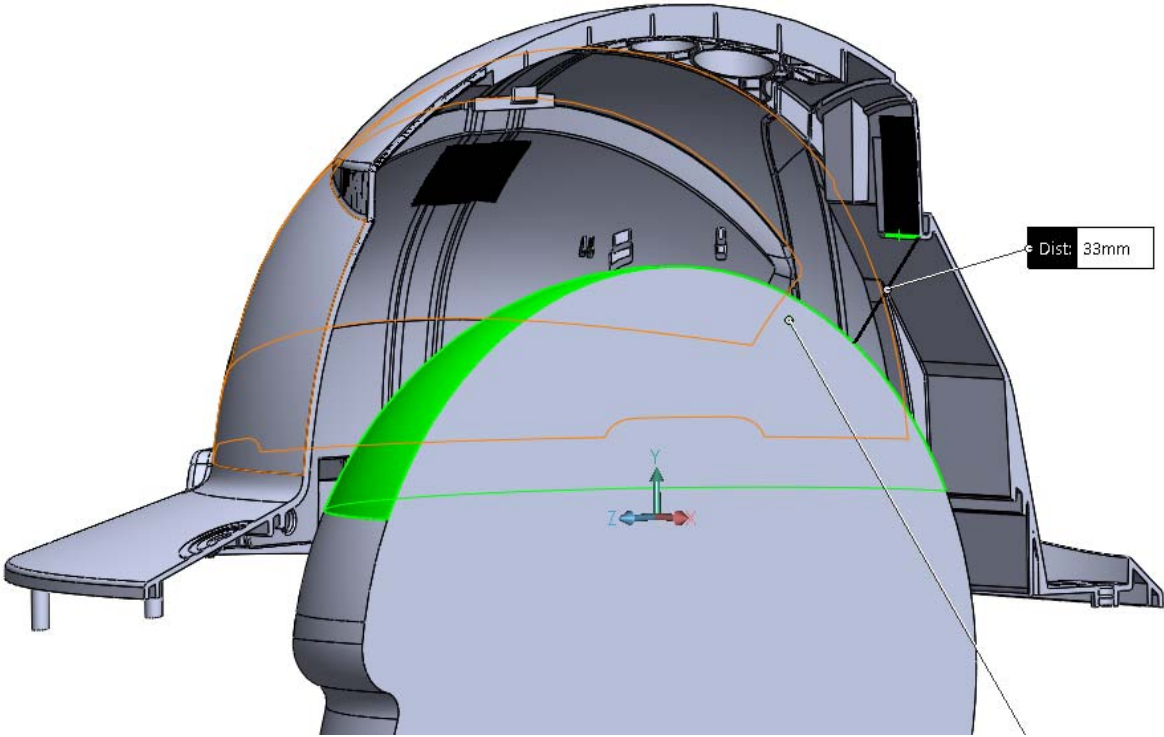
2.4 Additional Information

EUT features an NFC radio at 13.56 MHz manufactured by NXP (Part Number PN7150B0HN/C11002Y) with a FxR.80.52 antenna. EUT tested in a modulated Tx mode for radiated emissions testing and in an unmodulated mode for frequency stability.

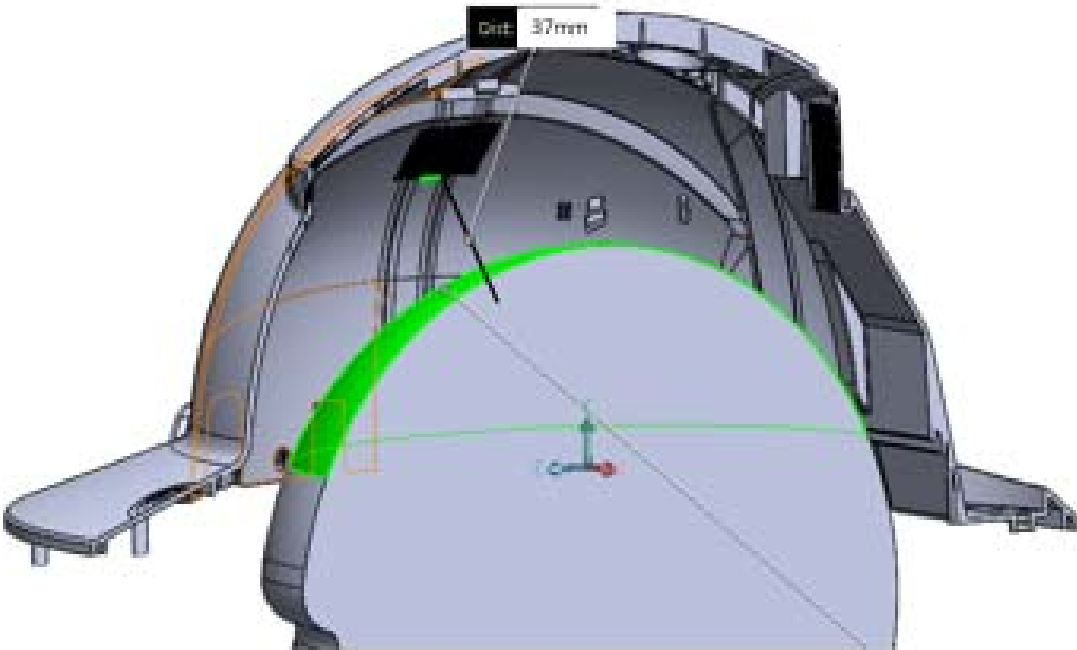
The EUT also includes additional radio modules. Refer to Section 5.2 for more information.

2.5 Additional Information – Antenna Distance Pictures

UWB



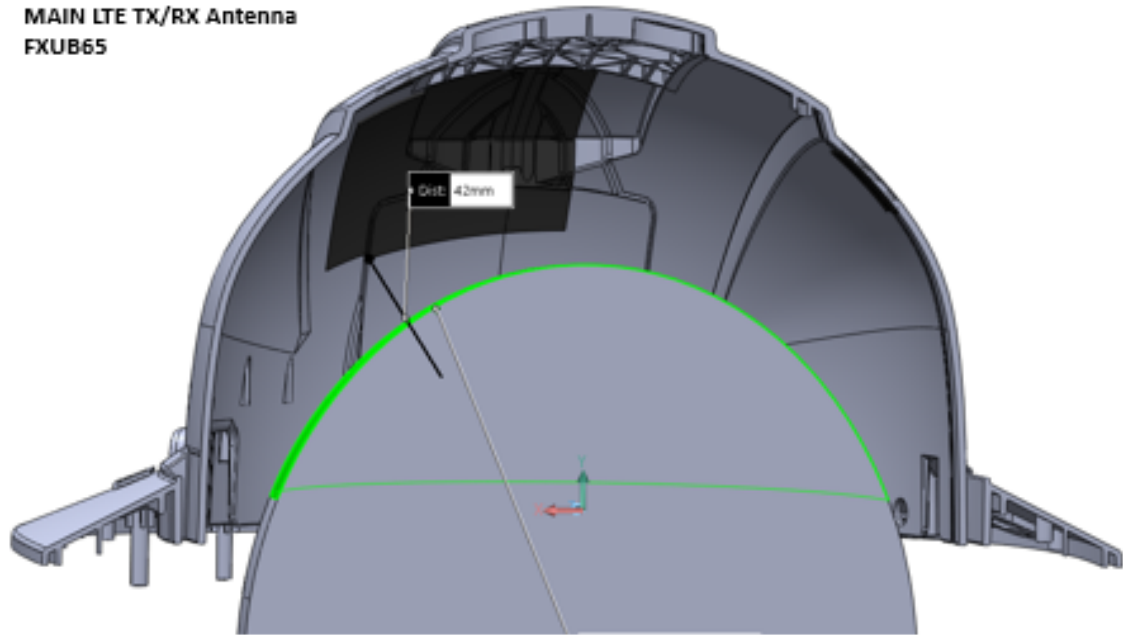
Zigbee



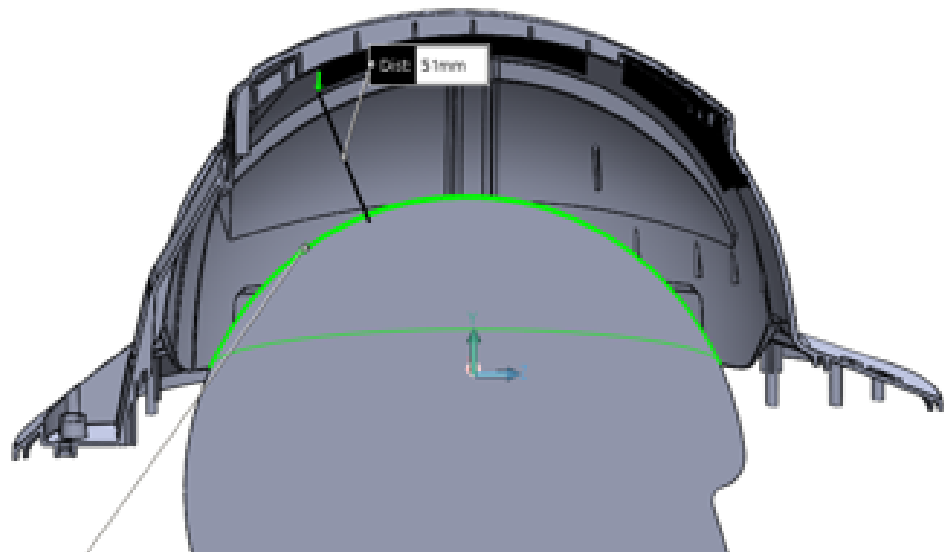
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LTE

**MAIN LTE TX/RX Antenna
FXUB65**



**LTE RX Only Antenna
FXUB63**



Wifi/BT/BLE



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NFC



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3 REFERENCES

Publication	Edition	Date
CFR 47 Part 15	-	2019
ANSI C63.10	-	2013
RSS-247	2	2017
RSS GEN	4	2014
RSS-102	5	2015
CFR 47 Part 1 and 2	-	2019
FCC KDB 447498	6	2015

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 \pm
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. \pm	U.C. \pm
Radio Frequency, from F0	1×10^{-7}	0.55×10^{-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 Emission

Operator	Jon Dilley; Braden Smith	QA	Laura Zehnder; Shane Dock
Temperature	23.6 degrees C	R.H. %	43.20%
Test Date	7/30/2019-8/1/2019	Location	Chamber 3
Requirement	FCC 15.225 a-d	Method	ANSI C63.10

Limits:

(a) The field strength of any emissions within the band 13.553-13.567 MHz shall not exceed 15,848 microvolts/meter at 30 meters.

(b) Within the bands 13.410-13.553 MHz and 13.567-13.710 MHz, the field strength of any emissions shall not exceed 334 microvolts/meter at 30 meters.

(c) Within the bands 13.110-13.410 MHz and 13.710-14.010 MHz the field strength of any emissions shall not exceed 106 microvolts/meter at 30 meters.

(d) The field strength of any emissions appearing outside of the 13.110-14.010 MHz band shall not exceed the general radiated emission limits in §15.209.

Frequency (MHz)	Field strength (microvolts/meter)	Measurement distance (meters)
0.009-0.490	2400/F(kHz)	300
0.490-1.705	24000/F(kHz)	30
1.705-30.0	30	30
30-88	100**	3
88-216	150**	3
216-960	200**	3
Above 960	500	3

Test Parameters

Frequency	150 kHz-30 MHz; 30 -1000 MHz	Distance	3m
Detector(s)	Avg (150-490 kHz), QP (490kHz-1000MHz)	Table height	80cm
RBW	9 kHz; 120 kHz	VBW	90 kHz; 1.2 MHz
Notes	EUT tested in modulated Tx Mode.		

Instrumentation



Date : 29-Jul-2019 Test : NFC Tx Job : C-3227
 PE : Shane Dock Customer : Guardhat Quote : 319122

No.	Asset	Description	Manufacturer	Model	Serial	Cal Date	Cal Due Date	Equipment Status
1	EE 960088	Analyzer - EMI Receiver	Agilent	N9038A	MY51210138	4/23/2019	4/23/2020	Active Calibration
2	AA 960006	Antenna - Active Loop	EMCO	6502	9205-2753	8/28/2017	8/28/2019	Active Calibration
3	AA 960150	Antenna - Biconical	ETS Lindgren	3110B	0003-3346	4/20/2018	4/20/2020	Active Calibration
4	AA 960195	Antenna - Log Periodic	A.H. Systems, Inc	SAS-512-2	557	1/30/2018	1/30/2020	Active Calibration

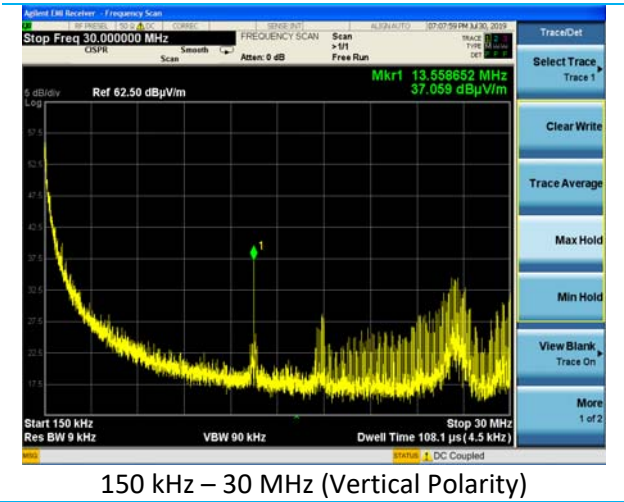
EUT Parameters

Input Power	4 VDC (Power supply under turn table)	Mode	NFC Modulated Tx
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Table

Frequency (MHz)	Antenna Polarity	EUT Orient.	Height (cm)	Azimuth (degree)	Quasi-Peak Reading (dBμV/m)	Quasi-Peak Reading @ 30m (dBμV/m)	Quasi-Peak Limit @ 30m (dBμV/m)	Quasi-Peak Margin (dB)
13.560	Horizontal	Flat	100	345	40.0	18.6	29.5	10.9
13.560	Horizontal	Side	100	103	40.3	18.9	29.5	10.6
13.560	Horizontal	Vertical	100	195	34.1	12.7	29.5	16.8
13.560	Skew	Vertical	100	308	36.1	14.7	29.5	14.8
13.560	Skew	Side	100	192	42.8	21.4	29.5	8.1
13.560	Skew	Flat	100	66	41.6	20.2	29.5	9.3
13.560	Vertical	Flat	100	47	30.5	9.1	29.5	20.4
13.560	Vertical	Side	100	146	31.5	10.1	29.5	19.4
13.560	Vertical	Vertical	100	263	29.4	8.0	29.5	21.5
13.560	Skew	Side	100	192	42.6	21.2	29.5	8.3

Plots



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5.2 Radio Information

Wireless Function	Manufacturer	Manufacturer/Module Part Number	Output Power (dBm)	Tune Up Tolerance (dB)	Antenna Gain (dBi)	Minimum Test Separation Distance (mm)
NFC	NXP	PN7150B0HN/C11002Y	-52.4	0.0	-	30.0
LTE (US)	Sierra Wireless	HL7588	23.0	2.0	2.0	42.0
WLAN	Qualcomm on Intrinsic Integrated SOM	WCN3680B Qualcomm on Intrinsic 626 SOM (integration)	19.0	2.0	3.3	57.0
UNII	Qualcomm on Intrinsic Integrated SOM	WCN3680B Qualcomm on Intrinsic 626 SOM (integration)	19.0	1.1	6.1	57.0
BT	Qualcomm on Intrinsic Integrated SOM	WCN3680B Qualcomm on Intrinsic 626 SOM (integration)	13.0	2.5	3.3	57.0
BLE	Qualcomm on Intrinsic Integrated SOM	WCN3680B Qualcomm on Intrinsic 626 SOM (integration)	13.0	2.5	3.3	57.0
UWB	DECAWAVE	Decawave DW1000 on 2AR6OGHP2470	-21.0	1.5	5.0	33.0
ZB	ATMEL	ATMEGA256RFR2ZU on 2AR6OGHP2470	9.0	1.0	5.0	37.0

Notes:

1. Minimum Test Distances are provided by the manufacturer and indicates the distance between the antenna and the head of the user.
2. For the NFC value, the field strength measured was converted to dBm by subtracting 95.2 dB from the 42.8 dBuV/m measured value. This is an EIRP value.

6 EXCLUSION CALCULATION

6.1 FCC

For Standalone SAR exclusion per KDB 447498 4.3.1

- 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:

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

- $f_{(\text{GHz})}$ is the RF channel transmit frequency in GHz
- Power and distance are rounded to the nearest mW and mm before calculation³¹
- The result is rounded to one decimal place for comparison
- The values 3.0 and 7.5 are referred to as *numeric thresholds* in step b) below

The test exclusions are applicable only when the minimum *test separation distance* is ≤ 50 mm, and for transmission frequencies between 100 MHz and 6 GHz. When the minimum *test separation distance* is < 5 mm, a distance of 5 mm according to 4.1 f) is applied to determine SAR test exclusion.

- 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) · ($f_{(\text{MHz})}/150$)]} mW, for 100 MHz to 1500 MHz
- 2) {[Power allowed at *numeric threshold* for 50 mm in step a)] + [(test separation distance – 50 mm) · 10]} mW, for > 1500 MHz and ≤ 6 GHz

- 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 $[1 + \log(100/f_{(\text{MHz})})]$
- 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 $\frac{1}{2}$
- 3) SAR measurement procedures are not established below 100 MHz.

When SAR test exclusion cannot be applied, a KDB inquiry is required to determine SAR evaluation requirements for any SAR test results below 100 MHz to be acceptable.³⁴

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6.1.1 Stand-alone SAR test exclusion Evaluation:

SAR test Exclusion evaluation for test distance $\leq 50\text{mm}$ using equation from section (a):

Wireless Function	Worst Case Frequency (MHz)	Output Power (dBm)	Tune Up Tolerance (dB)	Output Power (mW)	Antenna Gain (dBi)	Test Distance (mm)	SAR Exclusion Threshold Value	SAR Exclusion Threshold limit (1-g)	SAR test Excluded (Yes/No)
LTE (US)	704	23.0	2.0	316.23	2.0	42.0	6.32	3.00	No
UWB	3500	-21.0	1.5	0.01	5.0	33.0	0.00	3.00	Yes
ZB	2410	9.0	1.0	10.00	5.0	37.0	0.42	3.00	Yes

SAR test Exclusion evaluation for distance $> 50\text{mm}$ using equation from section (b)

Wireless Function	Worst Case Frequency (MHz)	Output Power (dBm)	Tune Up Tolerance (dB)	Output Power (mW)	Antenna Gain (dBi)	Test Distance (mm)	SAR Exclusion Threshold (mW)	SAR test Excluded (Yes/No)
WLAN	2412	19.0	2.0	125.89	3.3	57	166.58	Yes
UNII	5180	19.0	1.1	102.33	6.1	57	135.91	Yes
BT	2402	13.0	2.5	35.48	3.3	57	166.78	Yes
BLE	2402	13.0	2.5	35.48	3.3	57	166.78	Yes

SAR test Exclusion evaluation for distance $\leq 50\text{mm}$ and frequency below 100MHz using equation from section (c)

Wireless Function	Worst Case Frequency (MHz)	Output Power (dBm)	Tune Up Tolerance (dB)	Output Power (mW)	Antenna Gain (dBi)	Test Distance (mm)	SAR Exclusion Threshold (mW)	SAR test Excluded (Yes/No)
NFC	13.56	-52.4	0.0	5.75E-06	-	30	14.01	Yes

Conclusion:

All radio modules on the EUT except for *LTE*, are excluded from stand-alone SAR testing at the specified test distance.

6.1.2 Simultaneous transmission SAR test exclusion Evaluation:

Simultaneous Tx SAR Exclusion per Section 4.3.2 (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) $[(\text{max. power of channel, including tune-up tolerance, mW}) / (\text{min. test separation distance, mm})] \cdot [\sqrt{f_{(\text{GHz})}}/x] \text{ W/kg}$, for test separation distances $\leq 50 \text{ mm}$;
 where $x = 7.5$ for 1-g SAR and $x = 18.75$ for 10-g SAR.
- 2) 0.4 W/kg for 1-g SAR and 1.0 W/kg for 10-g SAR, when the test separation distance is $> 50 \text{ mm}$.³⁷

Per Part 2.1093, the requirement is:

(2) The SAR limits for general population/uncontrolled exposure are 0.08 W/kg, as averaged over the whole body, and a peak spatial-average SAR of 1.6 W/kg, averaged over any 1 gram of tissue (defined as a tissue volume in the shape of a cube). Exceptions are the parts of the human body treated as extremities, such as hands, wrists, feet, ankles, and pinnae, where the peak spatial-average SAR limit is 4 W/kg, averaged over any 10 grams of tissue (defined as a tissue volume in the shape of a cube). Exposure may be averaged over a time period not to exceed 30 minutes to determine compliance with general population/uncontrolled SAR limits.

SAR estimation for each radio per equations in section 4.3.2 (b):

Wireless Function	Worst Case Frequency (MHz)	Output Power (dBm)	Tune Up Tolerance (dB)	Output Power (mW)	Antenna Gain (dBi)	Test Distance (mm)	1-g SAR Value (W/kg)
NFC	13.56	-52.6	0.0	5.75E-06	-	30	0.01
LTE (US)	704	23.0	2.0	316.23	2.0	42	0.37
WLAN	2412	19.0	2.0	125.89	3.3	57	0.40
UNII	5180	19.0	1.1	102.33	6.1	57	0.40
BT	2402	13.0	2.5	35.48	3.3	57	0.40
BLE	2402	13.0	2.5	35.48	3.3	57	0.40
UWB	3500	-21.0	1.5	0.01	5.0	33	0.01
ZB	2410	9.0	1.0	10.0	5.0	37	0.06

SAR test exclusion evaluation based on simultaneous transmission scenarios:

A. Scenario 1:

Wireless Function	Worst Case Frequency (MHz)	Output Power (dBm)	Tune Up Tolerance (dB)	Output Power (mW)	Antenna Gain (dBi)	Test Distance (mm)	Estimated 1-g SAR Value (W/kg)
NFC	13.56	-52.6	0.0	5.75E-06	-	30	0.01
LTE (US)	704	23.0	2.0	316.23	2.0	42	0.37
WLAN	2412	19.0	2.0	125.89	3.3	57	0.40
UWB	3500	-21.0	1.5	0.01	5.0	33	0.01
ZB	2410	9.0	1.0	10.0	5.0	37	0.06

Sum of estimated SAR for Scenario 1 = 0.85 W/kg

Conclusion:

Since the 1-g Value is less than 1.6 W/kg, scenario 1 is excluded from Simultaneous SAR Testing.

B. Scenario 2:

Wireless Function	Worst Case Frequency (MHz)	Output Power (dBm)	Tune Up Tolerance (dB)	Output Power (mW)	Antenna Gain (dBi)	Test Distance (mm)	1-g SAR Value (W/kg)
NFC	13.56	-52.6	0.0	5.75E-06	-	30	0.01
LTE (US)	704	23.0	2.0	316.23	2.0	42	0.37
UNII	5180	19.0	1.1	102.33	6.1	57	0.40
UWB	3500	-21.0	1.5	0.01	5.0	33	0.01
ZB	2410	9.0	1.0	10.0	5.0	37	0.06

Sum of estimated SAR for Scenario 2 = 0.85W/kg

Conclusion:

Since the 1-g Value is less than 1.6 W/kg, scenario 2 is excluded from Simultaneous SAR Testing.

C. Scenario 3:

Wireless Function	Worst Case Frequency (MHz)	Output Power (dBm)	Tune Up Tolerance (dB)	Output Power (mW)	Antenna Gain (dBi)	Test Distance (mm)	1-g SAR Value (W/kg)
NFC	13.56	-52.6	0.0	5.75E-06	-	30	0.01
LTE (US)	704	23.0	2.0	316.23	2.0	42	0.37
BT	2402	13.0	2.5	35.48	3.3	57	0.40
UWB	3500	-21.0	1.5	0.01	5.0	33	0.01
ZB	2410	9.0	1.0	10.0	5.0	37	0.06

Sum of estimated SAR for Scenario 3 = 0.85W/kg

Conclusion:

Since the 1-g Value is less than 1.6 W/kg, scenario 3 is excluded from Simultaneous SAR Testing.

D. Scenario 4:

Wireless Function	Worst Case Frequency (MHz)	Output Power (dBm)	Tune Up Tolerance (dB)	Output Power (mW)	Antenna Gain (dBi)	Test Distance (mm)	1-g SAR Value (W/kg)
NFC	13.56	-52.6	0.0	5.75E-06	-	30	0.01
LTE (US)	704	23.0	2.0	316.23	2.0	42	0.37
BLE	2402	13.0	2.5	35.48	3.3	57	0.40
UWB	3500	-21.0	1.5	0.01	5.0	33	0.01
ZB	2410	9.0	1.0	10.0	5.0	43	0.06

Sum of estimated SAR for Scenario 4 = 0.85W/kg

Conclusion:

Since the 1-g Value is less than 1.6 W/kg, scenario 4 is excluded from Simultaneous SAR Testing.

6.2 Industry Canada (ISED)

From RSS-102:

Table 1: SAR evaluation – Exemption limits for routine evaluation based on frequency and separation distance^{4,5}

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of ≤ 5 mm	At separation distance of 10 mm	At separation distance of 15 mm	At separation distance of 20 mm	At separation distance of 25 mm
≤ 300	71 mW	101 mW	132 mW	162 mW	193 mW
450	52 mW	70 mW	88 mW	106 mW	123 mW
835	17 mW	30 mW	42 mW	55 mW	67 mW
1900	7 mW	10 mW	18 mW	34 mW	60 mW
2450	4 mW	7 mW	15 mW	30 mW	52 mW
3500	2 mW	6 mW	16 mW	32 mW	55 mW
5800	1 mW	6 mW	15 mW	27 mW	41 mW

Frequency (MHz)	Exemption Limits (mW)				
	At separation distance of 30 mm	At separation distance of 35 mm	At separation distance of 40 mm	At separation distance of 45 mm	At separation distance of ≥ 50 mm
≤ 300	223 mW	254 mW	284 mW	315 mW	345 mW
450	141 mW	159 mW	177 mW	195 mW	213 mW
835	80 mW	92 mW	105 mW	117 mW	130 mW
1900	99 mW	153 mW	225 mW	316 mW	431 mW
2450	83 mW	123 mW	173 mW	235 mW	309 mW
3500	86 mW	124 mW	170 mW	225 mW	290 mW
5800	56 mW	71 mW	85 mW	97 mW	106 mW

For each radio, the worst-case limit is:

Wireless Function	Worst Case Frequency (MHz)	Output Power (dBm)	Tune Up Tolerance (dB)	Antenna Gain (dBi)	Adjusted Output Power (mW)	Test Distance (mm)	RSS-102 table 1 Distance (mm)	Exemption Limit (mW)
NFC	13.56	-52.6	0.0	-	5.5E-06	30	30	223.0
<i>LTE (US)</i>	704	23.0	2.0	2.0	<i>501.2</i>	42	40	129.5
WLAN	2412	19.0	2.0	3.3	269.2	57	>50	317.4
<i>UNII</i>	5180	19.0	1.1	6.1	<i>416.9</i>	57	>50	155.6
BT	2402	13.0	2.5	3.3	75.9	57	>50	319.6
BLE	2402	13.0	2.5	3.3	75.9	57	>50	319.6
UWB	3500	-21.0	1.5	5.0	3.5E-2	33	30	86.0
ZB	2410	9.0	1.0	5.0	31.6	37	35	125.2

Notes:

1. Each Exemption Limit value is interpolated for frequency.
2. Items in red font identified as NOT being excluded from SAR testing
3. Adjusted Output power (dBm) = Output power (dBm) + tune up tolerance(dB) + Antenna gain (dBi)
Adjusted Output power (mW) = Inverse Log [Adjusted Output power (dBm)/10]

Conclusion:

All radio modules on the EUT except for *LTE and UNII*, are excluded from stand-alone SAR testing at the specified test distance.

7 REVISION HISTORY

Version	Date	Notes	Person
V0	8/30/19	First Draft	Shane Dock
V1	8/30/19	Revised Draft	Shane Dock
V2	8/30/19	Final	Aidi Zainal
V3	10/29/19	Customer Info Updated	Shane Dock
V4	11/26/19	Added Distance Pictures	Shane Dock
V5	12/13/19	Addressed additional TCB comments	Aidi Zainal

END OF REPORT