FCC / IC RF REPORT

Certification

Applicant Name:
Universal Electronics Inc

Address:
201 East Sandpointe Ave 7th Floor
Santa Ana, CA 92707, U.S.A.

Date of Issue:
June 19, 2020

Test Site/Location:
Hyundai C-Tech, Inc. dba HCT America, Inc.
1726 Ringwood Avenue San Jose, California USA

Report No.: HCTA-R-2002-005-01

FCC ID:	**MG3-R324854**
IC:	**2575A-R324854**
APPLICANT:	**Universal Electronics Inc**

Model Name:	R324854
Part Number:	R324854A98-00001
Project Name:	BV KITA Android Platform RCU 2019
EUT Type:	BLE Remote Control Unit
RF Peak Output Power:	4.49 dBm (2.81 mW)
Frequency Range:	2402 MHz -2480 MHz
Modulation Type	GFSK
FCC Classification:	Digital Transmission System (DTS)
FCC Rule Part(s):	Part 15.247
IC Rule Part(s):	RSS-247 Issue 2 (February 2017), RSS-Gen Issue 5(March 2019)

Engineering Statement:

The measurements shown in this report were made in accordance with the procedures indicated, and the emissions from this equipment were found to be within the limits applicable. I assume full responsibility for the accuracy and completeness of these measurements, and for the qualifications of all persons taking them.

Steve In
Test Engineer
Certification Division

Sunwoo Kim
Technical Manager
Certification Division

Report History

TEST REPORT NO.	DATE	DESCRIPTION
HCTA-R-2002-005	February 26, 2020	First Issue
HCTA-R-2002-005-01	June 19, 2020	Revision due to Radiated Test Configuration revised.

Hyundai C-Tech, Inc. dba HCT America, Inc., 1726 Ringwood Avenue, San Jose, CA 95131, USA
TEL: +1-510-933-8848 FAX: +1-510-933-8849

Table of Contents

Hyundai C-Tech, Inc. dba HCT America, Inc., 1726 Ringwood Avenue, San Jose, CA 95131, USA
TEL: +1-510-933-8848 FAX: +1-510-933-8849

1. EUT DESCRIPTION

Model Name	R324854
Part Number	R324854A98-00001
Project Name	BV KITA Android Platform RCU 2019
EUT Type	BLE Remote Control Unit
Manufacturer	Gemstar Technology (Yangzhou) Co., Ltd.
Power Supply	DC 3.7 V (Lithium Polymer Battery)
Frequency Range	2402 MHz - 2480 MHz
Max. RF Output Power	Peak : 4.49 dBm (2.81 mW)
Modulation Type	GFSK
Number of Channels	40 Channels
Antenna Specification	Peak Gain: 1.96 dBi
Firmware Version	7061.00.08_0.0
Hardware Version	60301-5072000 A01
Date(s) of Tests	January 20, 2020 ~ February 24, 2020

* Firmware and Hardware Version are as received by the client.

Hyundai C-Tech, Inc. dba HCT America, Inc., 1726 Ringwood Avenue, San Jose, CA 95131, USA
TEL: +1-510-933-8848 FAX: +1-510-933-8849

2. METHODOLOGY

FCC KDB 558074 D01 DTS Measurement Guidance v05r02 dated April 2nd, 2019 entitled “Guidance for Performing Compliance Measurements on Digital Transmission Systems(DTS) and the measurement procedure described in ANSI C63.10(Version : 2013) ‘the American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices’.

EUT CONFIGURATION

The EUT configuration for testing is installed on RF field strength measurement to meet the Commissions requirement and operating in a manner that intends to maximize its emission characteristics in a continuous normal application.

EUT EXERCISE

The EUT was operated in the engineering mode to fix the Tx frequency that was for the purpose of the measurements. According to its specifications, the EUT must comply with the requirements of the Section 15.207, 15.209 and 15.247 under the FCC Rules Part 15 Subpart C / the RSS-GEN issue 5, RSS-247 issue 2.

GENERAL TEST PROCEDURES

Conducted Emissions

The EUT is placed on the turntable, which is 0.8 m above ground plane. According to the requirements in Section 6.2 of ANSI C63.10. (Version :2013) Conducted emissions from the EUT measured in the frequency range between 0.15 MHz and 30MHz using CISPR Quasi-peak and average detector modes.

Radiated Emissions

The EUT is placed on a turn table, which is 0.8 m above ground plane below 1GHz. Above 1GHz with 1.5m using absorbers between the EUT and receive antenna. The turntable shall rotate 360 degrees to determine the position of maximum emission level. EUT is set 3 m away from the receiving antenna, which varied from 1 m to 4 m to find out the highest emission. And also, each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical. In order to find out the max. emission, the relative positions of this hand-held transmitter (EUT) was rotated through three orthogonal axes according to the requirements in Section 6.6.5 of ANSI C63.10. (Version: 2013)

Conducted Antenna Terminal

KDB 558074 D01 v05r02

Hyundai C-Tech, Inc. dba HCT America, Inc., 1726 Ringwood Avenue, San Jose, CA 95131, USA
TEL: +1-510-933-8848 FAX: +1-510-933-8849

DESCRIPTION OF TEST MODES

The EUT has been tested under BLE Test mode operating condition. Radio control console V3.1.0.0 test program used to control the EUT for staying in continuous transmitting and receiving mode.

Channel	Software Setting Level
0	5
19	5
39	5

3. INSTRUMENT CALIBRATION

The measuring equipment, which was utilized in performing the tests documented herein, has been calibrated in accordance with the manufacturer's recommendations for utilizing calibration equipment's, which is traceable to recognized national standards.

Especially, all antenna for measurement is calibrated in accordance with the requirements of C63.5 (Version : 2017).

4. FACILITIES AND ACCREDITATIONS

FACILITIES

The SAC (Semi-Anechoic Chamber) and conducted measurement facility used to collect the radiated data are located at 1726 Ringwood Avenue, San Jose, California 95131, USA.

The site is constructed in conformance with the requirements of ANSI C63.4. (Version :2014) and CISPR Publication 22.

EQUIPMENT

Radiated emissions are measured with one or more of the following types of Linearly polarized antennas: tuned dipole, bi-conical, log periodic, bi-log, and/or ridged waveguide, horn. Spectrum analyzers with pre-selectors and quasi-peak detectors are used to perform radiated measurements.

Conducted emissions are measured with Line Impedance Stabilization Networks and EMI Test Receivers. Calibrated wideband preamplifiers, coaxial cables, and coaxial attenuators are also used for making measurements.

All receiving equipment conforms to CISPR Publication 16-1, "Radio Interference Measuring Apparatus and Measurement Methods."

Hyundai C-Tech, Inc. dba HCT America, Inc., 1726 Ringwood Avenue, San Jose, CA 95131, USA
TEL: +1-510-933-8848 FAX: +1-510-933-8849

5. ANTENNA REQUIREMENTS

According to FCC 47 CFR §15.203:

"An intentional radiator antenna shall be designed to ensure that no antenna other than that furnished by the responsible party can be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section."

* The antennas of this E.U.T are permanently attached.

* The E.U.T Complies with the requirement of §15.203

Hyundai C-Tech, Inc. dba HCT America, Inc., 1726 Ringwood Avenue, San Jose, CA 95131, USA
TEL: +1-510-933-8848 FAX: +1-510-933-8849

6. MEASUREMENT UNCERTAINTY

The measurement uncertainties shown below were calculated in accordance with the requirements of ANSI C63.10-2013.

All measurement uncertainty values are shown with a coverage factor of k = 2 to indicate a 95 % level of confidence.

The measurement data shown herein meets or exceeds the U_{CISPR} measurement uncertainty values specified in CISPR 16-4-2 and, thus, can be compared directly to specified limits to determine compliance.

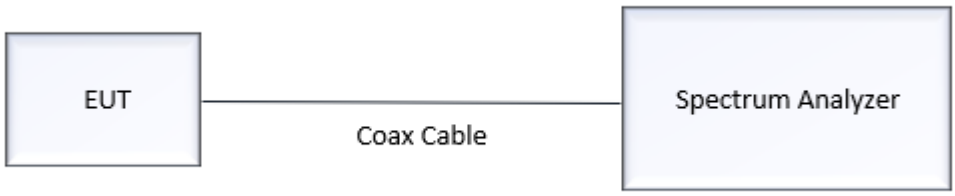
Parameter	Expanded Uncertainty (±dB)
Conducted Disturbance (150 kHz ~ 30 MHz)	2.55
Radiated Disturbance (9 kHz ~ 30 MHz)	3.20
Radiated Disturbance (30 MHz ~ 1 GHz)	4.73
Radiated Disturbance (1 GHz ~ 18 GHz)	5.21
Radiated Disturbance (18 GHz ~ 40 GHz)	5.18

Hyundai C-Tech, Inc. dba HCT America, Inc., 1726 Ringwood Avenue, San Jose, CA 95131, USA
TEL: +1-510-933-8848 FAX: +1-510-933-8849

7. DESCRIPTION OF TESTS

7.1. Duty Cycle

Test Configuration



Test Procedure

The transmitter output is connected to the Spectrum Analyzer.

We tested according to the zero-span measurement method, 6 (b) in KDB 558074 D01 v05r02.

The largest available value of RBW is 8 MHz and VBW is 50 MHz.

The zero-span method of measuring duty cycle shall not be used if T ≤ 6.25 microseconds. (50/6.25 = 8)

The zero-span method was used because all measured T data are > 6.25 microseconds and both RBW and VBW are > 50/*T*.

1. RBW = 8 MHz (the largest available value)
2. VBW = 8 MHz (≥ RBW)
3. SPAN = 0 Hz
4. Detector = Peak
5. Number of points in sweep > 100
6. Trace mode = Clear write
7. Measure T_{total} and T_{on}
8. Calculate Duty Cycle = T_{on}/ T_{total} and Duty Cycle Factor = 10*log(1/Duty Cycle)

Hyundai C-Tech, Inc. dba HCT America, Inc., 1726 Ringwood Avenue, San Jose, CA 95131, USA
TEL: +1-510-933-8848 FAX: +1-510-933-8849

7.2. 6 dB Bandwidth

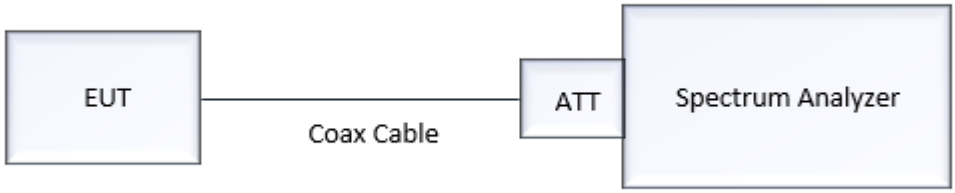
Limit

Test Requirements and limit, §15.247(a)(2) / RSS-247(Issue 2) Section 5.2.

The bandwidth at 6 dB down from the highest in-band spectral density is measured with a spectrum analyzer connected to the receive antenna while the EUT is operating in transmission mode at the appropriate frequencies.

The minimum permissible 6 dB bandwidth is 500 kHz.

Test Configuration



Test Procedure

The transmitter output is connected to the Spectrum Analyzer.

The Spectrum Analyzer is set to (Section 8.2 in KDB 558074 D01 v05r02, Subclause 11.8 in ANSI 63.10-2013)

1) RBW = 100 kHz
2) VBW ≥ 3 x RBW
3) Detector = Peak
4) Trace mode = max hold
5) Sweep = auto couple
6) Allow the trace to stabilize
7) We tested 6 dB bandwidth using the automatic bandwidth measurement capability of a spectrum analyzer, setting X dB as 6 dB.

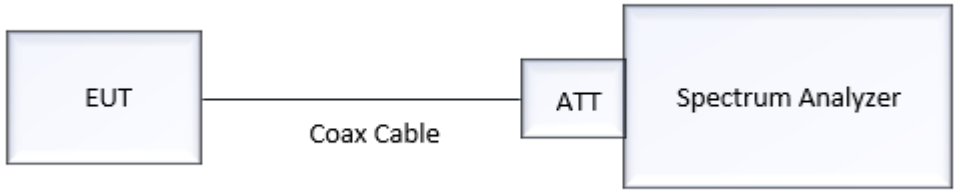
7.3. Output Power

Limit

Test Requirements and limit, §15.247(b)(3) / RSS-247(Issue2) Section 5.4.4.

The maximum permissible conducted output power is 1 Watt.

Test Configuration



Test Procedure

The transmitter output is connected to the Spectrum Analyzer.

TX condition of the EUT is the actual operating mode by BT LE test program.

The Spectrum Analyzer is set to

- Peak Power (Section 8.3.1.1 in KDB 558074 D01 v05r02, Subclause 11.9.1.1 in ANSI 63.10-2013)
  1) RBW ≥ DTS Bandwidth
  2) VBW ≥ 3 x RBW
  3) SPAN ≥ 3 x RBW
  4) Detector Mode = Peak
  5) Sweep = auto couple
  6) Trace Mode = max hold
  7) Allow trace to fully stabilize.
  8) Use peak marker function to determine the peak amplitude level

- Average Power (Section 8.3.2.2 in KDB 558074 D01 v05r02, Subclause 11.9.2.2 in ANSI 63.10-2013)
  1) We use the spectrum analyzer's integrated band power measurement function.
  2) Measure the duty cycle
  3) Set span to at least 1.5 times the OBW
  4) RBW = 1-5 % of the OBW, not to exceed 1 MHz.
  5) VBW ≥ 3 x RBW.

6) Number of points in sweep ≥ 2 x span / RBW. (This gives bin-to-bin spacing ≤ RBW/2, so that narrowband signals are not lost between frequency bins.)
7) Sweep time = auto.
8) Detector = RMS (i.e., power averaging)
9) Do not use sweep triggering. Allow the sweep to "free run".
10) Trace average at least 100 traces in power averaging (RMS) mode.
11) Compute power by integrating the spectrum across the OBW of the signal using the instrument's band power measurement function with band limits set equal to the OBW band edges.
12) Add 10 log (1/x), where x is the duty cycle, to the measured power in order to compute the average power during the actual transmission times.

Sample Calculation

- Conducted Output Power (Peak) = Reading Value + ATT loss + Cable loss
- Conducted Output Power (Average) = Reading Value + ATT loss + Cable loss + Duty Cycle Factor

Hyundai C-Tech, Inc. dba HCT America, Inc., 1726 Ringwood Avenue, San Jose, CA 95131, USA
TEL: +1-510-933-8848 FAX: +1-510-933-8849

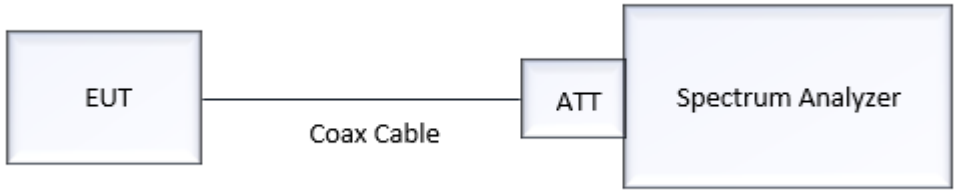
7.4. Power Spectral Density

Limit

Test Requirements and limit, §15.247(e) / RSS-247(Issue 2) Section 5.2.

The transmitter power density average over 1-second interval shall not be greater than 8dBm in any 3kHz BW.

Test Configuration



Test Procedure

The transmitter output is connected to the Spectrum Analyzer.

We tested according to Procedure 8.4 in KDB 558074 D01 v05r02, Procedure 11.10 in ANSI 63.10-2013.

The spectrum analyzer is set to :

1) Set analyzer center frequency to DTS channel center frequency.
2) Set span to at least 1.5 times the OBW.
3) RBW = 3 kHz ≤ RBW ≤ 100 kHz.
4) VBW ≥ 3 x RBW.
5) Sweep = auto couple
6) Detector = power averaging (rms) or sample detector (when rms not available).
7) Ensure that the number of measurement points in the sweep ≥[2 ×span / RBW].
8) Employ trace averaging (rms) mode over minimum of 100 traces
9) Use the peak marker function to determine the maximum amplitude level.
10) Use the peak marker function to determine the maximum amplitude level within the RBW.
    If measured value exceeds limit, reduce RBW (no less than 3 kHz) and repeat.
11) if then duty factor shall be added to adjust the result if the duty cycle is less than 98%

7.5. Conducted Band Edge (Out of Band Emissions) & Conducted Spurious Emissions

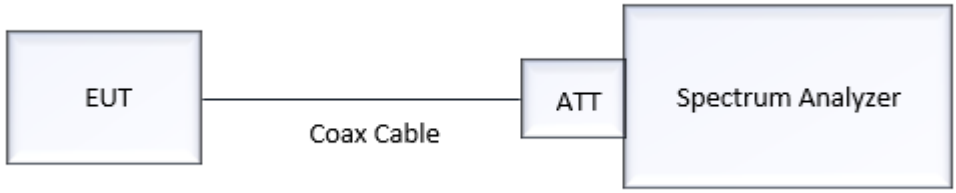
Limit

Test Requirements and limit, §15.247(d) / RSS-247(Issue 2) Section 5.5.

The maximum conducted (average) output power was used to demonstrate compliance, then the peak power in any 100 kHz bandwidth outside of the authorized frequency band shall be attenuated by at least 20 dB relative to the maximum in-band peak PSD level in 100 kHz.

[Conducted > 20 dBc]

Test Configuration



Test Procedure

The transmitter output is connected to the spectrum analyzer.

(Procedure 8.5 in KDB 558074 D01 v05r02, Procedure 11.11 in ANSI 63.10-2013)

1) RBW = 100 kHz
2) VBW ≥ 3 x RBW
3) Set span to encompass the spectrum to be examined
4) Detector = Peak
5) Trace Mode = max hold
6) Sweep time = auto couple
7) Ensure that the number of measurement points ≥ 2*Span/RBW
8) Allow trace to fully stabilize.
9) Use peak marker function to determine the maximum amplitude level.

Measurements are made over the 30 MHz to 25 GHz range with the transmitter set to the lowest, middle, and highest channels.

Factors for frequency

Freq [MHz]	Factor [dB]	Freq [MHz]	Factor [dB]
30	20.13	11000	21.19
100	20.31	12000	21.32
200	20.21	13000	21.44
300	20.16	14000	21.39
400	20.22	15000	21.51
500	20.15	16000	21.66
600	20.26	17000	21.72
700	20.17	18000	21.88
800	20.23	19000	21.92
900	20.21	20000	22.04
1000	20.19	21000	22.17
2000	20.38	22000	22.31
2400*	20.42	23000	22.57
2500*	20.51	24000	22.41
3000	20.53	25000	22.53
4000	20.61		
5000	20.97		
6000	20.73		
7000	21.01		
8000	20.88		
9000	21.11		
10000	21.21		

Note :

1. '*' is fundamental frequency range.
2. Factor = Attenuator loss + Cable loss + EUT Cable loss

7.6. Radiated Test

Limit

FCC

Frequency (MHz)	Field Strength (uV/m)	Measurement Distance (m)
0.009 – 0.490	2400/F(kHz)	300
0.490 – 1.705	24000/F(kHz)	30
1.705 – 30	30	30

IC

Frequency (MHz)	Field Strength (uA/m)	Measurement Distance (m)
0.009 – 0.490	6.37/F(kHz)	300
0.490 – 1.705	63.7/F(kHz)	30
1.705 – 30	0.08	30

FCC & IC

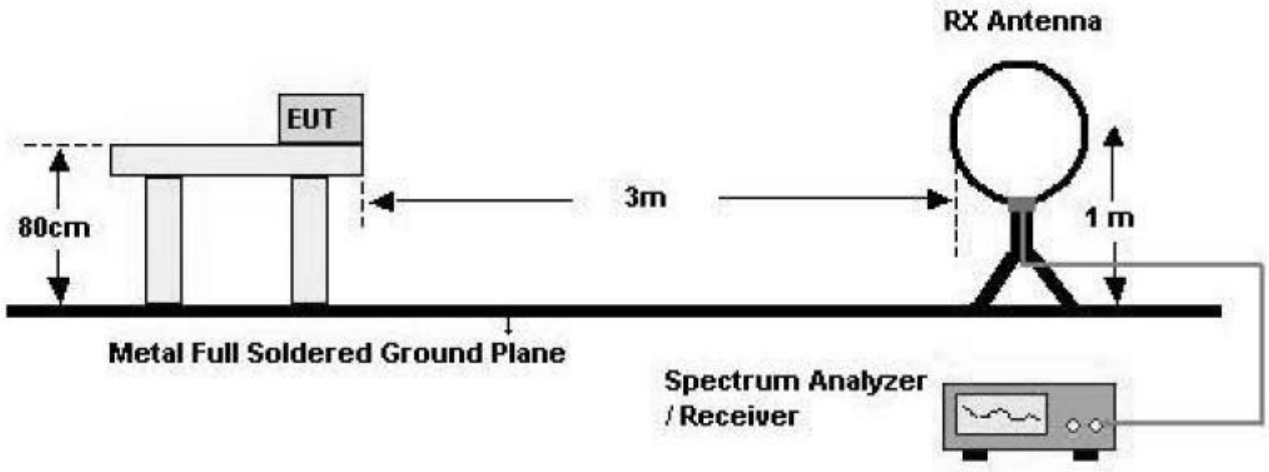
Frequency (MHz)	Field Strength (uV/m)	Measurement Distance (m)
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

Receiver Spurious Emissions

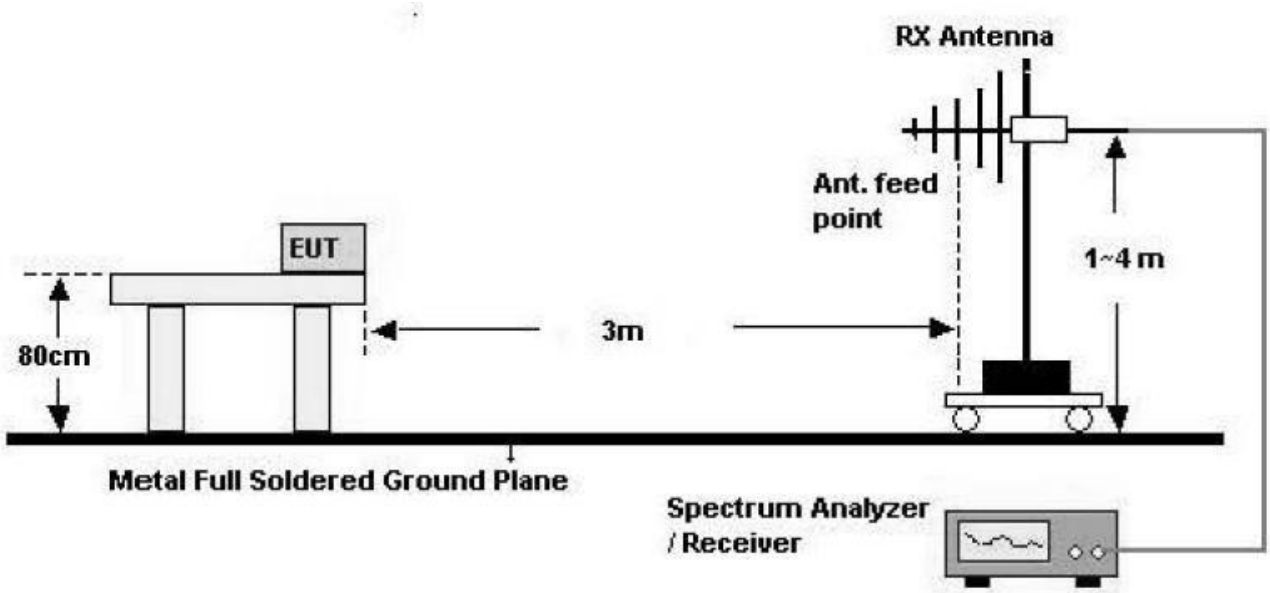
Frequency (MHz)	Field Strength (uV/m)	Measurement Distance (m)
30-88	100	3
88-216	150	3
216-960	200	3
Above 960	500	3

Test Configuration

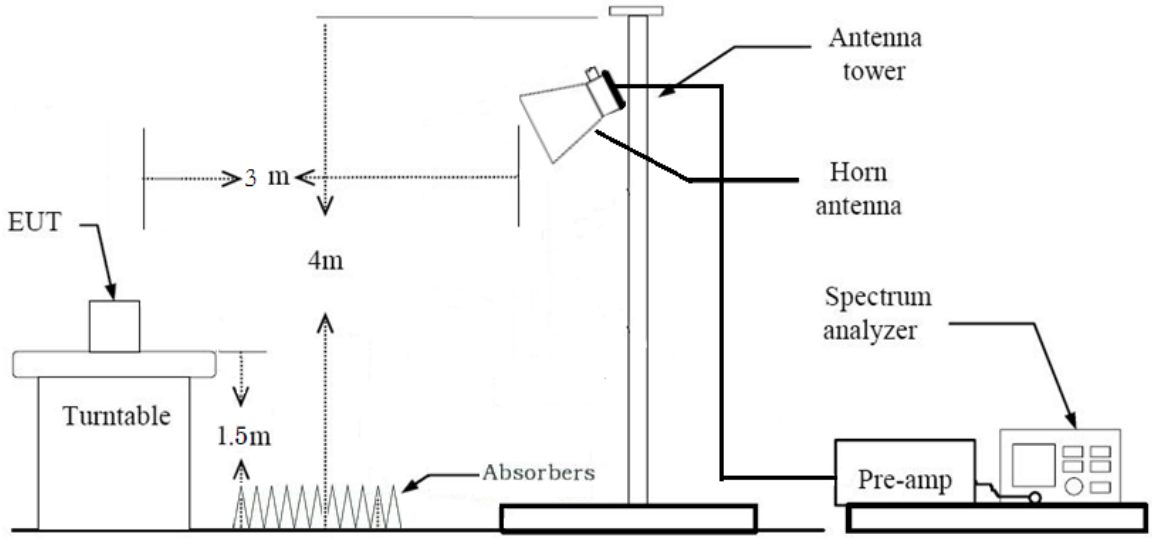
Below 30 MHz



30 MHz - 1 GHz



Above 1 GHz



Test Procedure of Radiated spurious emissions (Below 30 MHz)

1. The EUT was placed on a non-conductive table located on semi-anechoic chamber.
2. The loop antenna was placed at a location 3m from the EUT.
3. The EUT is placed on a turntable, which is 0.8m above ground plane.
4. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
5. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
6. Distance Correction Factor (0.009 MHz – 0.490 MHz) = 40*log(3 m/300 m) = - 80 dB
   Measurement Distance: 3 m
7. Distance Correction Factor (0.490 MHz – 30 MHz) = 40*log(3 m/30 m) = - 40 dB
   Measurement Distance: 3 m
8. Spectrum Setting
   - Frequency Range = 9 kHz ~ 30 MHz
   - Detector = Peak
   - Trace = Maxhold
   - RBW = 9 kHz
   - VBW ≥ 3*RBW
9. Total = Reading Value + Antenna Factor (A.F) + Cable Loss (C.L) + Distance Factor (D.F)
10. There is a comparison data both open-field test site and alternative test site – semi-Anechoic chamber according to 414788 D01. And the results are properly calibrated.

Test Procedure of Radiated spurious emissions (Below 1GHz)

1. The EUT was placed on a non-conductive table located on semi-anechoic chamber.
2. The EUT is placed on a turntable, which is 0.8m above ground plane.
3. EUT is set 3 m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emissions.
4. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
5. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
6. Spectrum Setting

   (1) Measurement Type (Peak):

   - Measured Frequency Range: 30 MHz – 1 GHz
   - Detector = Peak
   - Trace = Maxhold
   - RBW = 100 kHz
   - VBW ≥ 3*RBW

   (2) Measurement Type(Quasi-peak):

   - Measured Frequency Range: 30 MHz – 1 GHz
   - Detector = Quasi-Peak
   - RBW = 120 kHz

   *In general, (1) is used mainly

6. Total = Reading Value + Antenna Factor (A.F) + Cable Loss (C.L)

Hyundai C-Tech, Inc. dba HCT America, Inc., 1726 Ringwood Avenue, San Jose, CA 95131, USA
TEL: +1-510-933-8848 FAX: +1-510-933-8849

Test Procedure of Radiated spurious emissions (Above 1 GHz)

1. The EUT is placed on a turntable, which is 1.5 m above ground plane.
2. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
3. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
4. EUT is set 3 m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emissions.
5. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
6. Each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
7. The unit was tested with its standard battery.
8. Spectrum Setting

(1) Measurement Type(Peak, G.5 in KDB 789033 v02r01):

- RBW = 1 MHz
- VBW ≥ 3 MHz
- Detector = Peak
- Sweep Time = auto
- Trace mode = Max hold
- Allow sweeps to continue until the trace stabilizes.
- Note that if the transmission is not continuous, the time required for the trace to stabilize will increase by a factor of approximately 1/x, where x is the duty cycle.

(2) Measurement Type(Average, G.6.d in KDB 789033 v02r01):

- RBW = 1 MHz
- VBW(Duty cycle ≥ 98 percent) = VBW ≤ RBW/100(i.e., 10 kHz) but not less than 10 Hz.
- VBW(Duty cycle is < 98 percent) = VBW ≥ 1/T, where T is the minimum transmission duration.
- The analyzer is set to linear detector mode.
- Detector = Peak.
- Sweep time = auto.
- Trace mode = Max hold.
- Allow max hold to run for at least 50 traces if the transmitted signal is continuous or has at least 98 percent duty cycle. For lower duty cycles, increase the minimum number of traces by a factor of 1/x, where x is the duty cycle.

9. Measurement value only up to 6 maximum emissions noted or would be lesser if no specific emissions from the EUT are recorded (i.e.: margin > 20 dB from the applicable limit) and considered that's already beyond the background noise floor
10. Measuring frequencies from 1 GHz to the 10th harmonic of highest fundamental frequency or upto 40 GHz, whichever comes less.
11. Total = Reading Value + Antenna Factor(A.F) + Cable Loss(C.L) - Amp Gain(G)

Hyundai C-Tech, Inc. dba HCT America, Inc., 1726 Ringwood Avenue, San Jose, CA 95131, USA
TEL: +1-510-933-8848 FAX: +1-510-933-8849

Test Procedure of Radiated Restricted Band Edge

1. The EUT is placed on a turntable, which is 1.5 m above ground plane.
2. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.
3. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.
4. EUT is set 3 m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emissions.
5. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
6. Each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
7. The unit was tested with its standard battery.
8. Spectrum Setting

(1) Measurement Type(Peak, G.5 in KDB 789033 v02r01):

- RBW = 1 MHz
- VBW ≥ 3 MHz
- Detector = Peak
- Sweep Time = auto
- Trace mode = Max hold
- Allow sweeps to continue until the trace stabilizes.
- Note that if the transmission is not continuous, the time required for the trace to stabilize will increase by a factor of approximately 1/x, where x is the duty cycle.

(2) Measurement Type(Average, G.6.d in KDB 789033 v02r01):

- RBW = 1 MHz
- VBW(Duty cycle ≥ 98 percent) = VBW ≤ RBW/100(i.e., 10 kHz) but not less than 10 Hz.
- VBW(Duty cycle is < 98 percent) = VBW ≥ 1/T, where T is the minimum transmission duration.
- The analyzer is set to linear detector mode.
- Detector = Peak.
- Sweep time = auto.
- Trace mode = Max hold.
- Allow max hold to run for at least 50 traces if the transmitted signal is continuous or has at least 98 percent duty cycle. For lower duty cycles, increase the minimum number of traces by a factor of 1/x, where x is the duty cycle.

9. Total = Reading Value + Antenna Factor(A.F) + Cable Loss(C.L) - Amp Gain(G)

Hyundai C-Tech, Inc. dba HCT America, Inc., 1726 Ringwood Avenue, San Jose, CA 95131, USA
TEL: +1-510-933-8848 FAX: +1-510-933-8849

7.7. AC Power line Conducted Emissions

Limit

For an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 µH/50 ohms line impedance stabilization network (LISN).

Frequency Range (MHz)	Limits (dBµV)	
	Quasi-peak	Average
0.15 to 0.50	66 to 56*	56 to 46*
0.50 to 5	56	46
5 to 30	60	50

*Decreases with the logarithm of the frequency.

Compliance with this provision shall be based on the measurement of the radio frequency voltage between each power line (LINE and NEUTRAL) and ground at the power terminals.

Test Configuration

See test photographs attached in Annex A for the actual connections between EUT and support equipment.

Test Procedure

1. The EUT is placed on a wooden table 80 cm above the reference ground plane.
2. The EUT is connected via LISN to a test power supply.
3. The measurement results are obtained as described below:
4. Detectors : Quasi Peak and Average Detector.

Sample Calculation

Quasi-peak(Final Result) = Reading Value + Correction Factor

7.8. Worst case configuration and mode

Radiated test

1. All modes of operation were investigated and the worst case configuration results are reported.
   - Mode: Stand alone, Changing mode
   - Worst case: Changing mode
2. EUT Axis
   - Radiated Spurious Emissions: Z
   - Radiated Restricted Band Edge: Z
3. All packet length of operation were investigated and the test results are worst case in highest packet length.
   (Worst case: 37 Byte)

Conducted test

1. The EUT was configured with packet length of highest power.
   (Packet length of highest power: 37 Byte)

Hyundai C-Tech, Inc. dba HCT America, Inc., 1726 Ringwood Avenue, San Jose, CA 95131, USA
TEL: +1-510-933-8848 FAX: +1-510-933-8849

8. SUMMARY TEST OF RESULTS

Test Description	FCC Part Section(s)	IC Part Section(s)	Test Limit	Test Condition	Test Result
6 dB Bandwidth	§15.247(a)(2)	RSS-247, 5.2.(a)	> 500 kHz	Conducted	PASS
Occupied Bandwidth	N/A	RSS-GEN, 6.7	N/A		PASS
Conducted Maximum Peak Output Power	§15.247(b)(3)	RSS-247, 5.4.(d)	< 1 Watt		N/A
Power Spectral Density	§15.247(e)	RSS-247, 5.2.(b)	< 8 dBm / 3 kHz Band		PASS
Band Edge (Out of Band Emissions)	§15.247(d)	RSS-247, 5.5	Conducted > 20 dBc		PASS
AC Power line Conducted Emissions	§15.207	RSS-GEN, 8.8	cf. Section 7.7		PASS
Radiated Spurious Emissions	§15.247(d), 15.205, 15.209	RSS-GEN, 8.9	cf. Section 7.6	Radiated	PASS
Radiated Restricted Band Edge	§15.247(d), 15.205, 15.209	RSS-GEN, 8.9 RSS-GEN, 8.10	cf. Section 7.6		PASS
Receiver Spurious Emissions	N/A	RSS-GEN, 7.3	cf. Section 7.8		PASS

9. TEST RESULT

9.1 DUTY CYCLE

T_{on} (ms)	T_{total} (ms)	Duty Cycle	Duty Cycle Factor (dB)
1	1	1	0

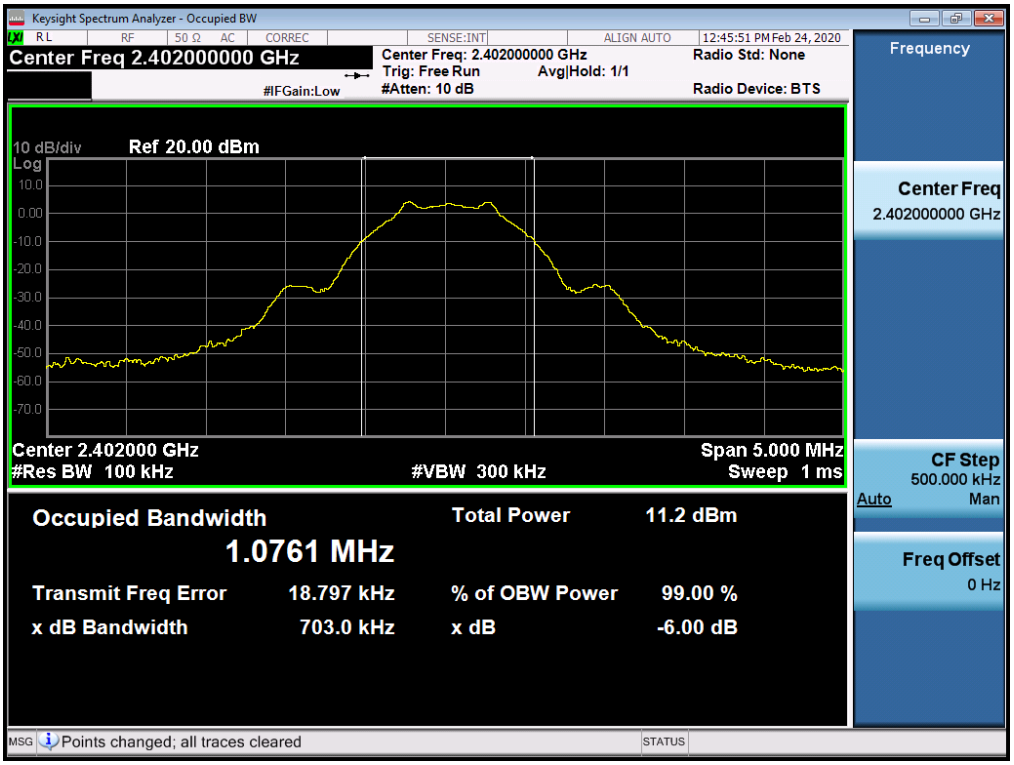
9.2 6 dB BANDWIDTH MEASUREMENT

Channel	6 dB Bandwidth (kHz)	Limit (kHz)
	Result	
0	702.97	> 500
19	699.73	
39	722.00	

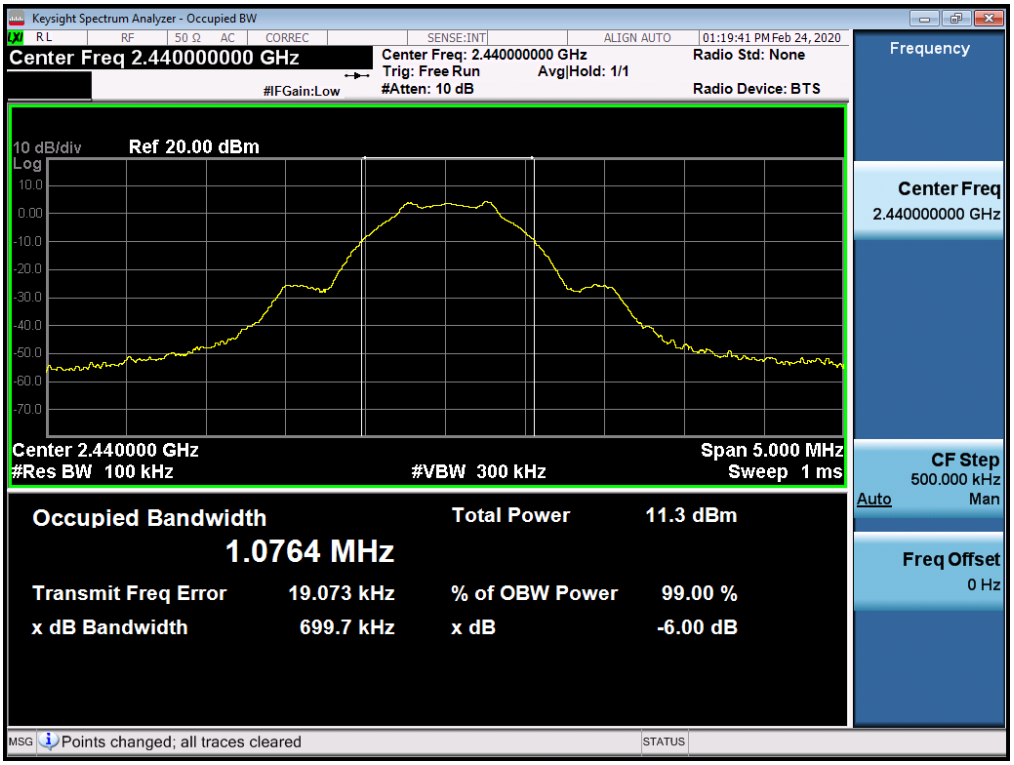
Hyundai C-Tech, Inc. dba HCT America, Inc., 1726 Ringwood Avenue, San Jose, CA 95131, USA
TEL: +1-510-933-8848 FAX: +1-510-933-8849

▣ Test Plots

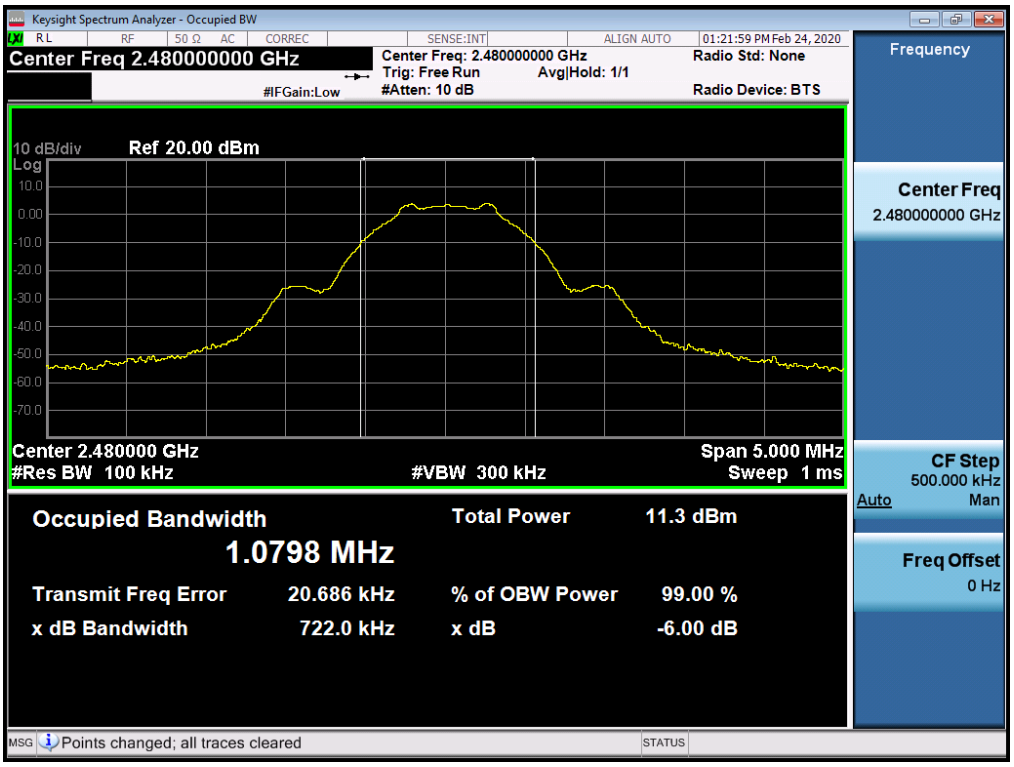
6 dB Bandwidth plot (Low-CH 0)



6 dB Bandwidth plot (Mid-CH 19)



6 dB Bandwidth plot (High-CH 39)



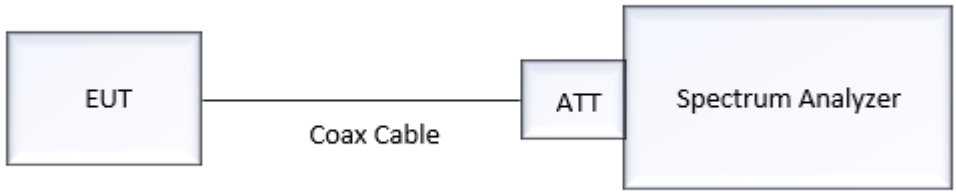
Hyundai C-Tech, Inc. dba HCT America, Inc., 1726 Ringwood Avenue, San Jose, CA 95131, USA
TEL: +1-510-933-8848 FAX: +1-510-933-8849

9.3 99% BANDWIDTH

Limit, RSS-Gen(Issue 5) Section 6.7

The 99 % bandwidth is used to determine the conducted power limits.

▣ TEST CONFIGURATION



▣ TEST PROCEDURE

The transmitter output is connected to the spectrum analyzer.

RBW = 1% ~ 5% of the occupied bandwidth

VBW ≒ 3 x RBW

Detector = Peak

Trace mode = max hold

Sweep = auto couple

Allow the trace to stabilize

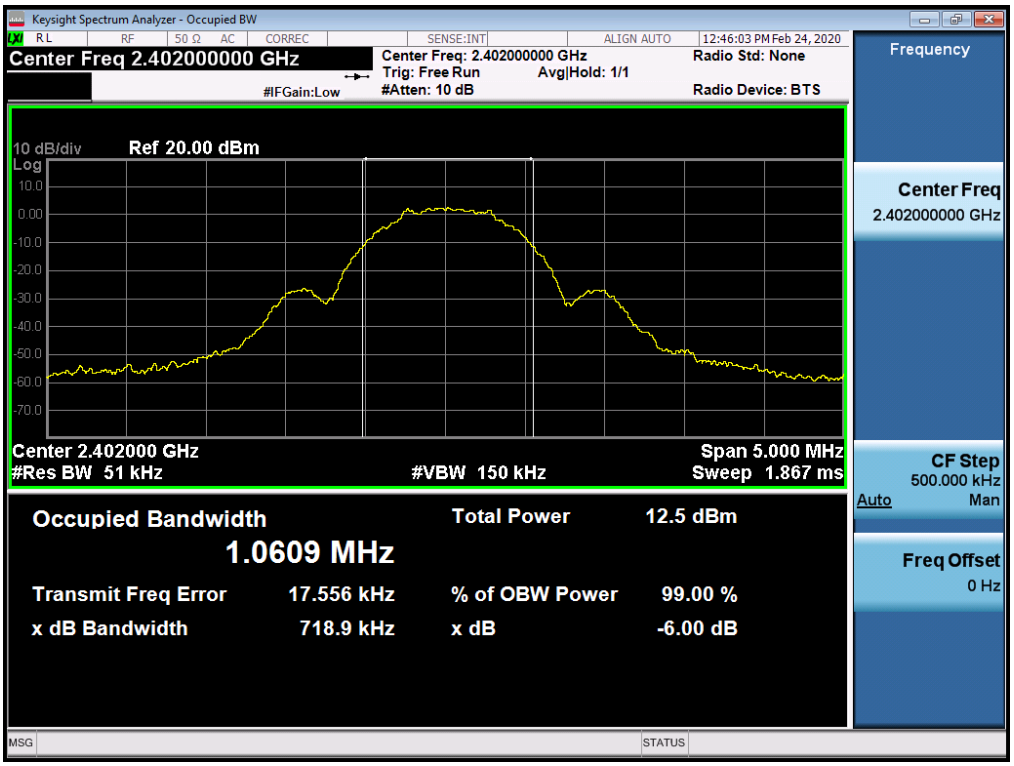
Note : We tested OBW using the automatic bandwidth measurement capability of a spectrum analyzer.

▣ TEST RESULTS

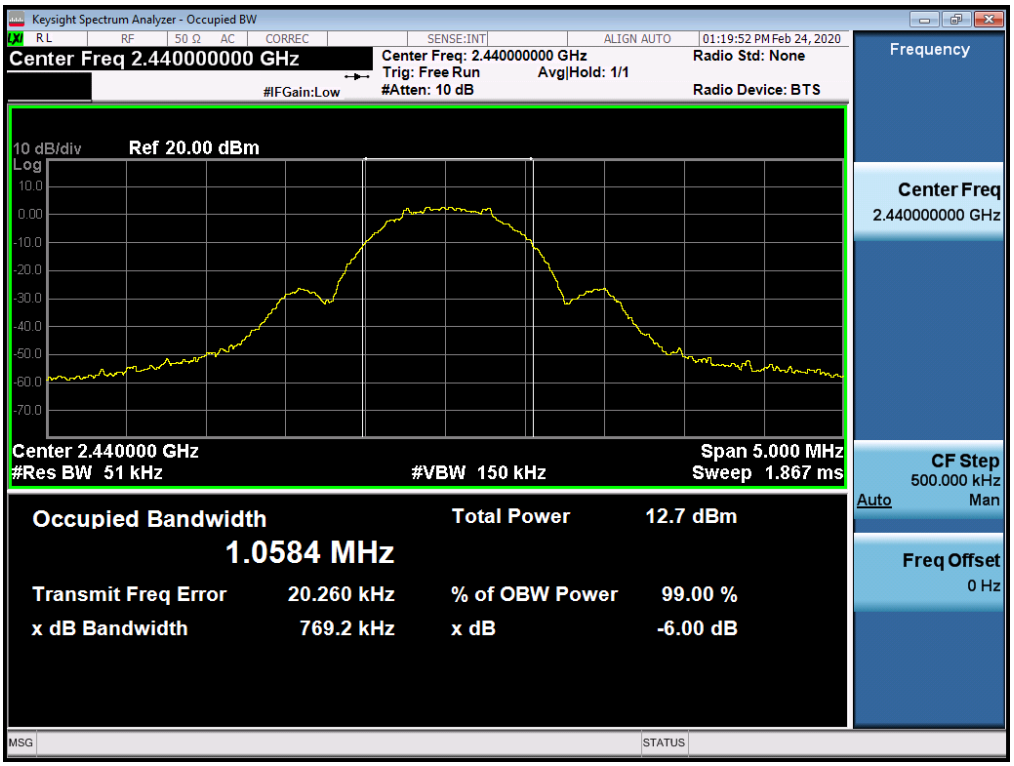
LE Mode		Measured Bandwidth (kHz)
Frequency [MHz]	Channel No.	Result
2402	0	1060.9
2440	19	1058.4
2480	39	1056.8

▣ RESULT PLOTS

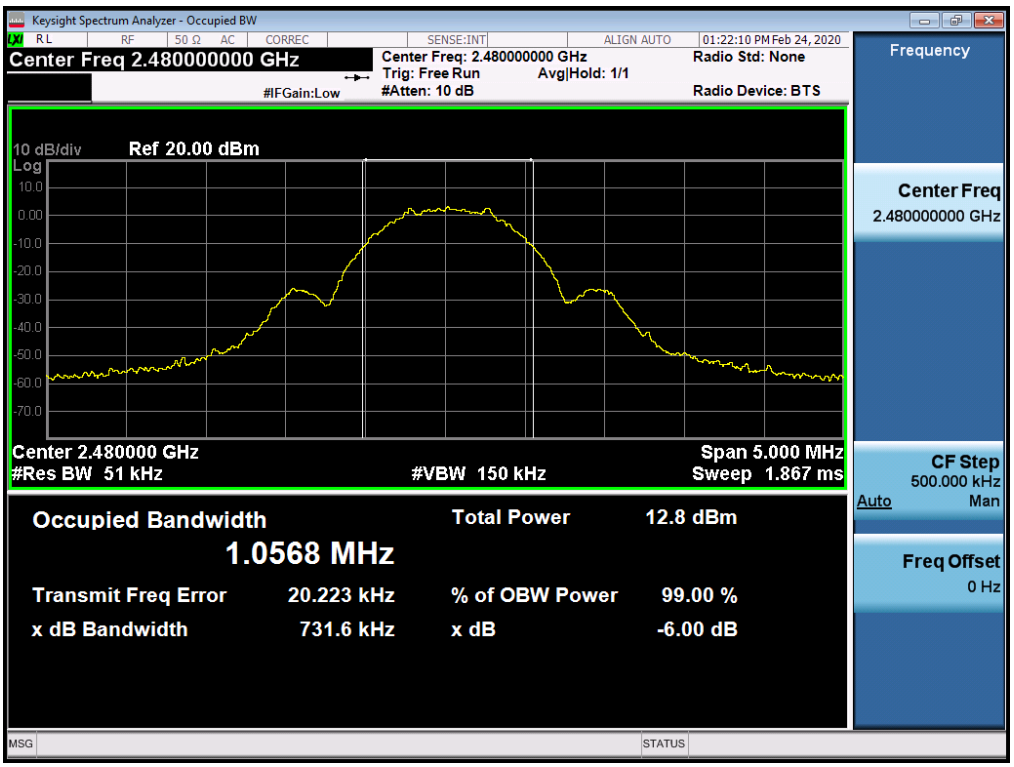
99% Bandwidth plot (Low-CH 0)



99% Bandwidth plot (Mid-CH 19)



99% Bandwidth plot (High-CH 39)



9.4 OUTPUT POWER

Peak Power

LE Mode		Measured Power(dBm)	Limit (dBm)
Frequency[MHz]	Channel No.	Result	
2402	0	4.32	30
2440	19	4.41	30
2480	39	4.49	30

Average Power

LE Mode		Measured Power(dBm) + Duty Cycle Factor(dB)	Limit (dBm)
Frequency[MHz]	Channel No.	Result	
2402	0	4.23	30
2440	19	4.23	30
2480	39	4.29	30

Note :

1. Spectrum reading values are not plot data.

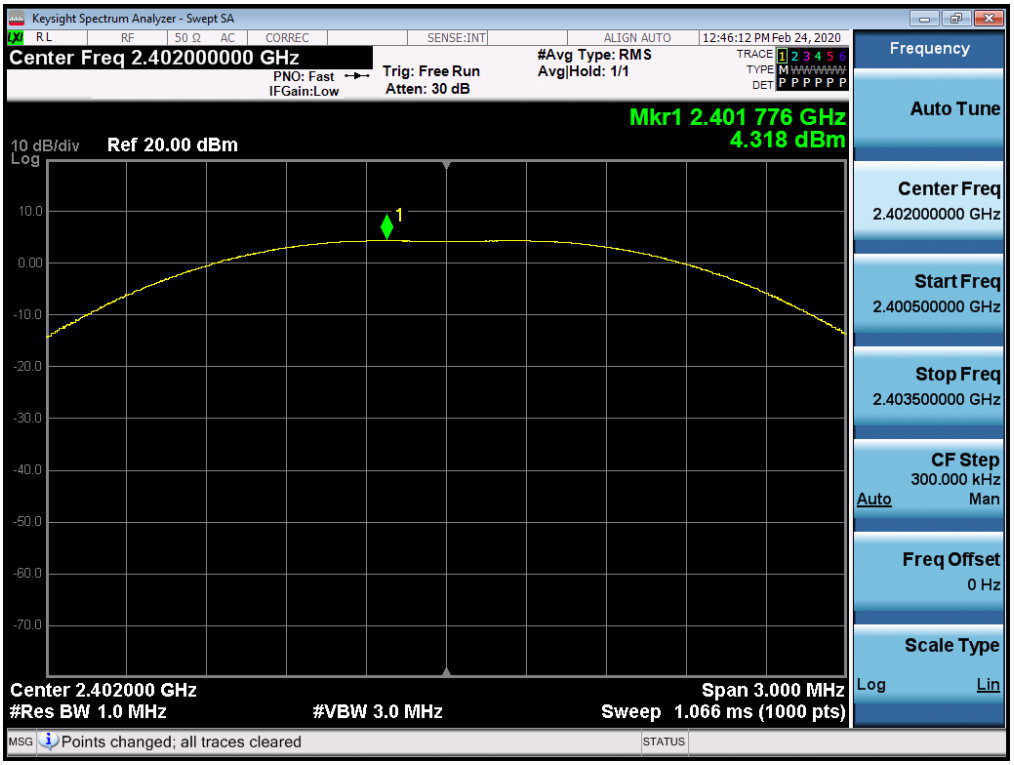
   The power results in plot is already including the actual values of loss for the attenuator and cable combination.

2. Spectrum offset = Attenuator loss + Cable loss

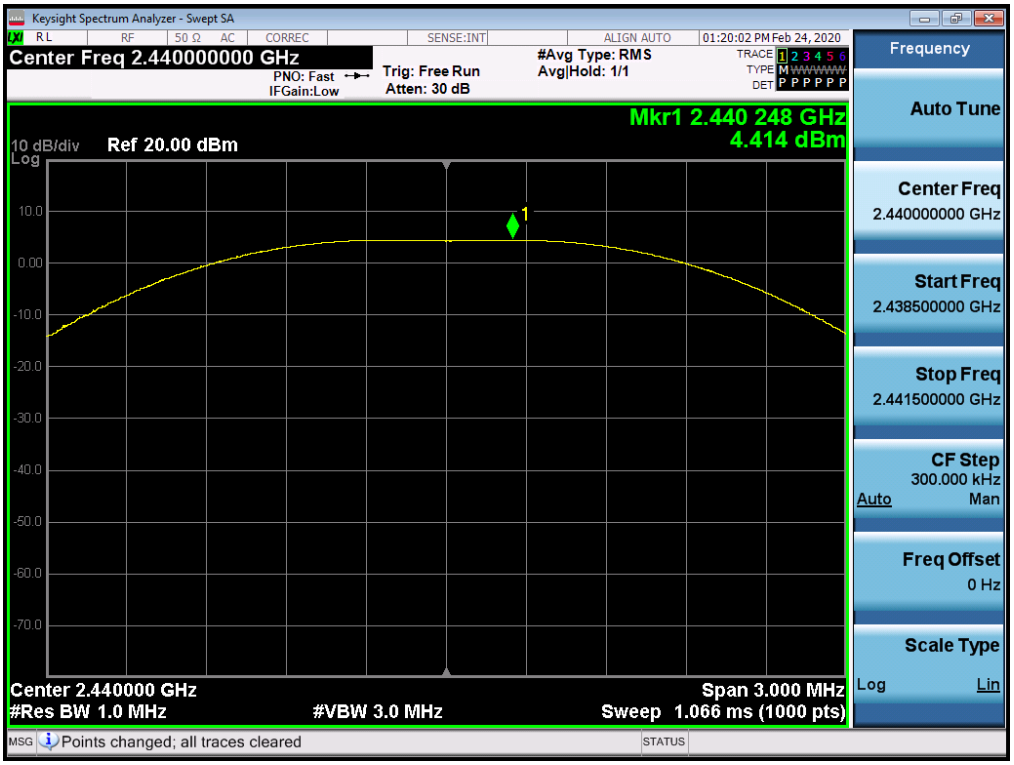
▣ Test Plots

Peak Power

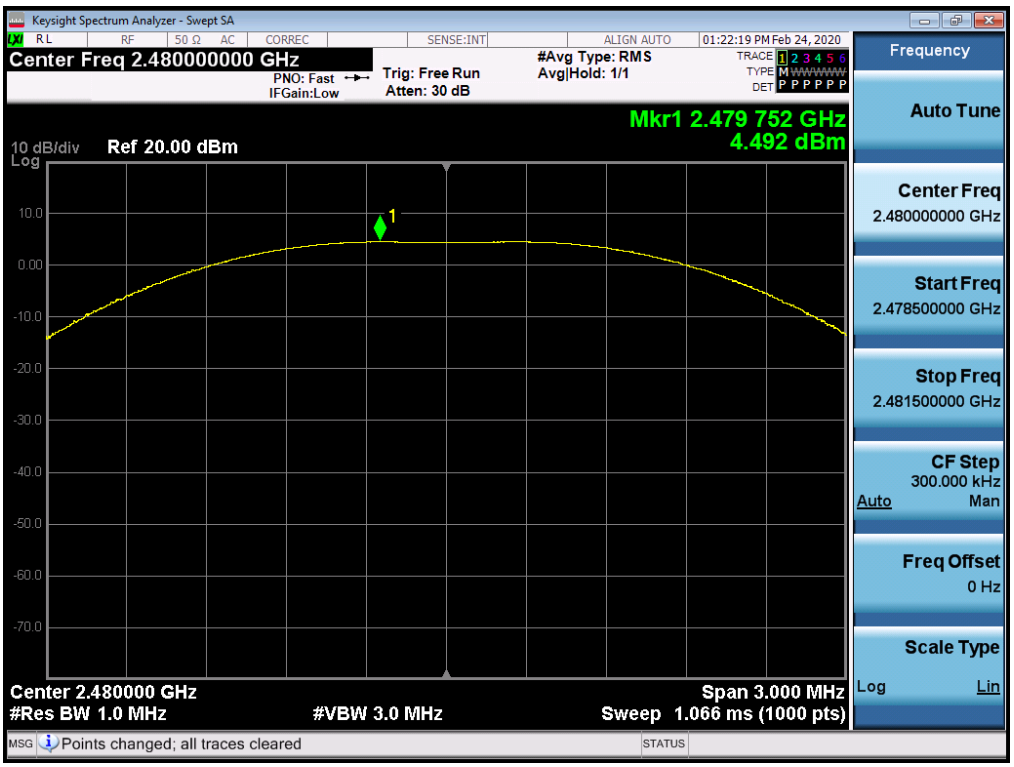
Conducted Output Power (Low-CH 0)



Conducted Output Power (Mid-CH 19)

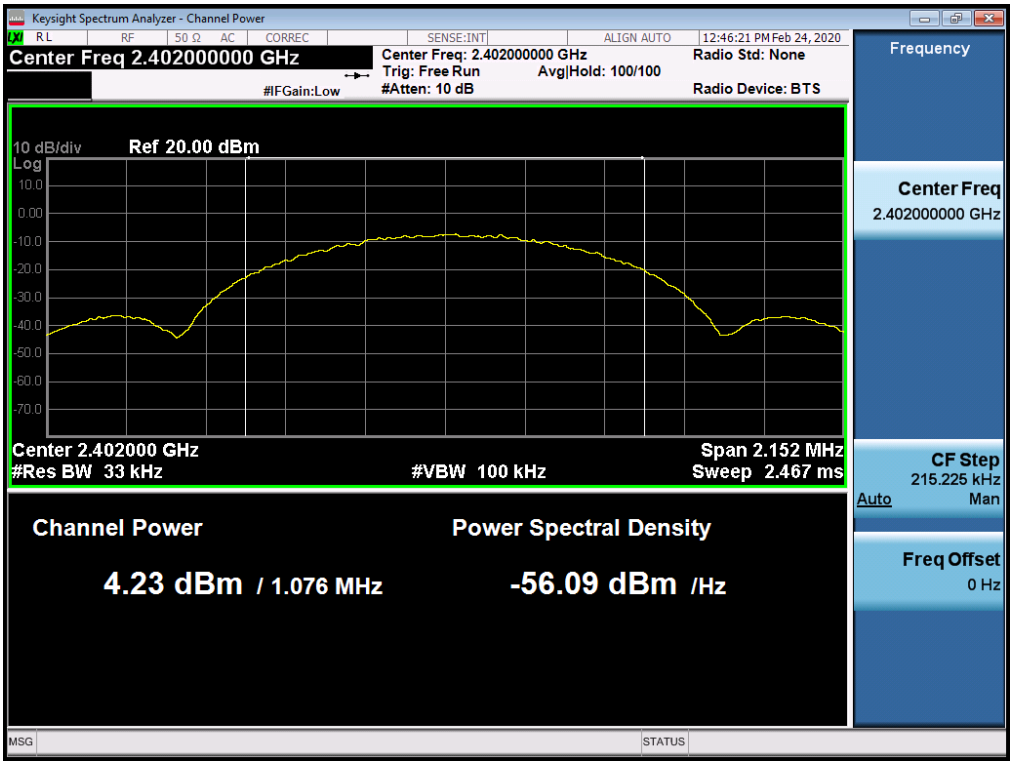


Conducted Output Power (High-CH 39)

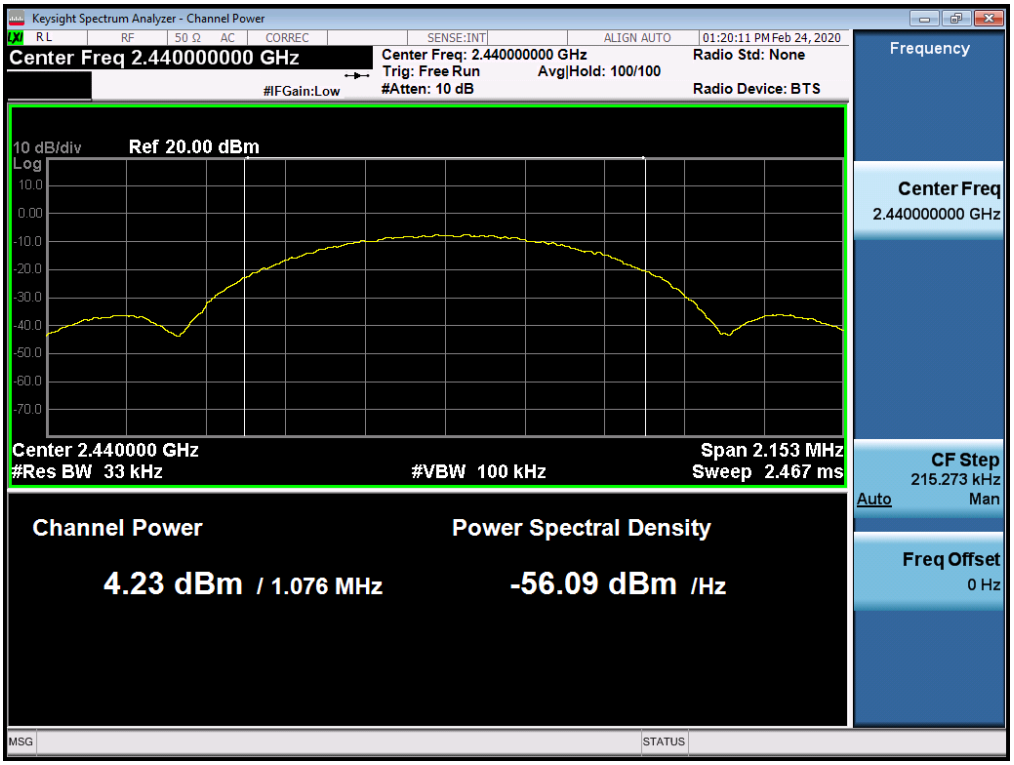


Average Power

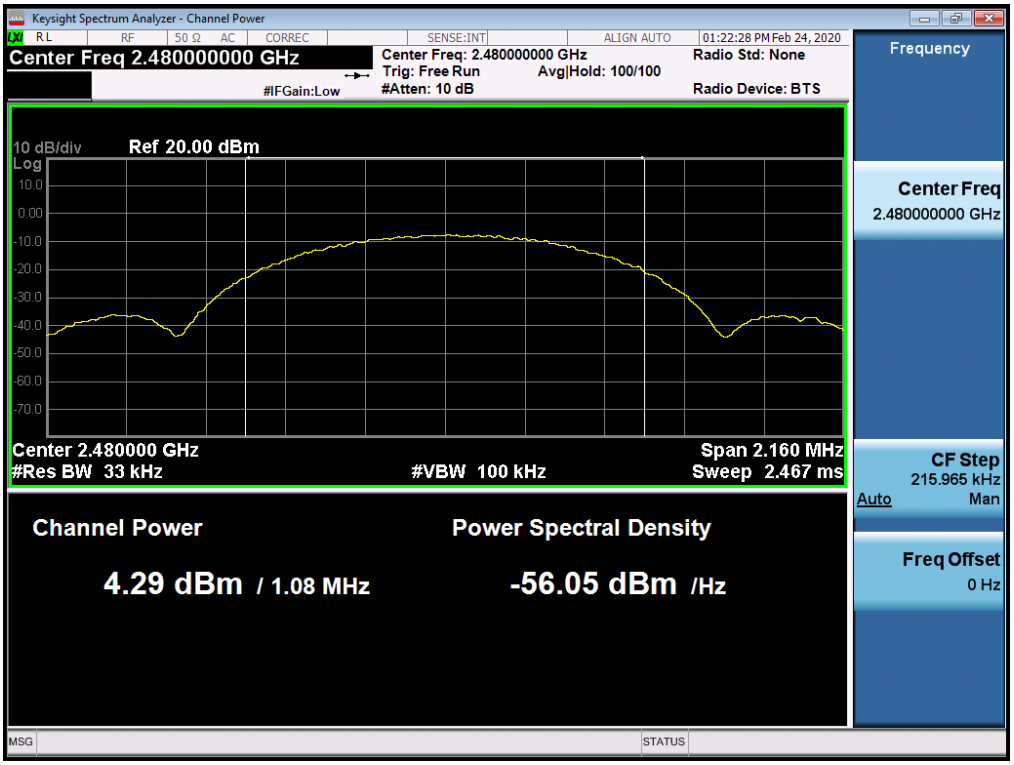
Conducted Output Power (Low-CH 0)



Conducted Output Power (Mid-CH 19)



Conducted Output Power (High-CH 39)



9.5 POWER SPECTRAL DENSITY

Frequency (MHz)	Channel No.	PSD (dBm/3kHz)	
		Result (dBm/3kHz)	Limit (dBm/3kHz)
2402	0	-7.55	8.000
2440	19	-7.65	8.000
2480	39	-6.82	8.000

Note :

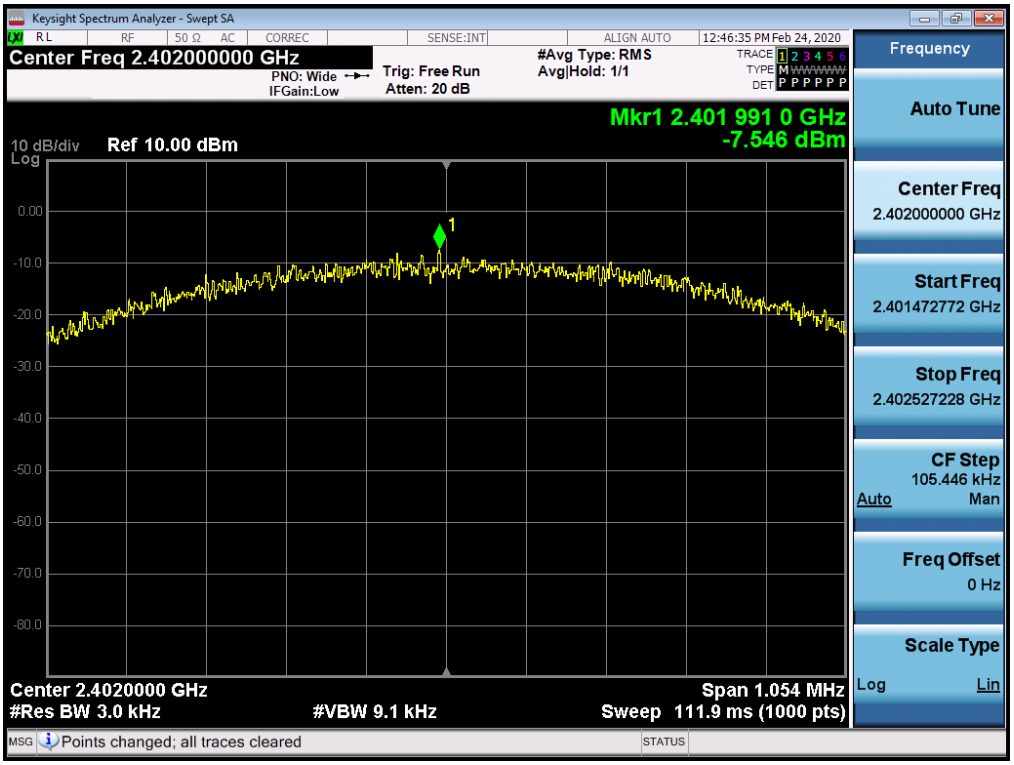
1. Spectrum reading values are not plot data.

   The PSD results in plot is already including the actual values of loss for the attenuator and cable combination.

2. Spectrum offset = Attenuator loss + Cable loss

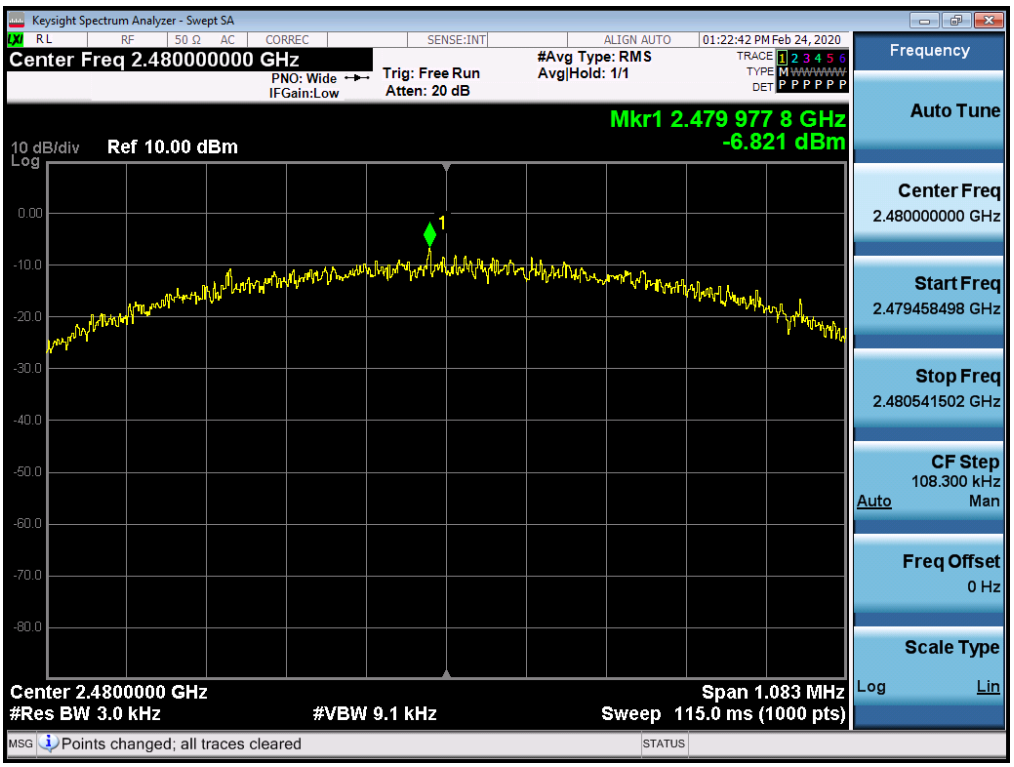
▣ Test Plots

Power Spectral Density (Low-CH 0)



Power Spectral Density (Mid-CH 19)

Power Spectral Density (High-CH 39)



9.6 CONDUCTED BAND EDGE & SPURIOUS EMISSIONS

▣ TEST RESULTS

Out of Band Emissions at the Band Edge

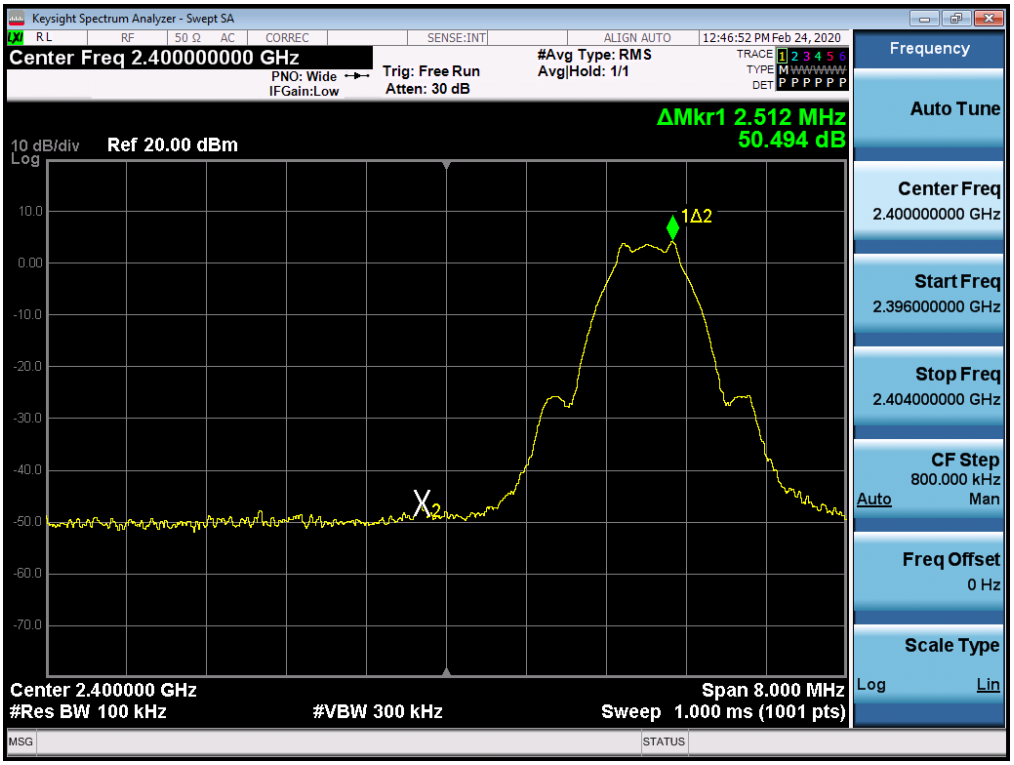
Frequency [MHz]	Channel No.	Position	Test Result		
			Measured Level [dB]	Limit [dBc]	Pass/Fail
2402	0	Lower	50.49	20	Pass
2480	39	Upper	52.65	20	Pass

Conducted Spurious Emissions

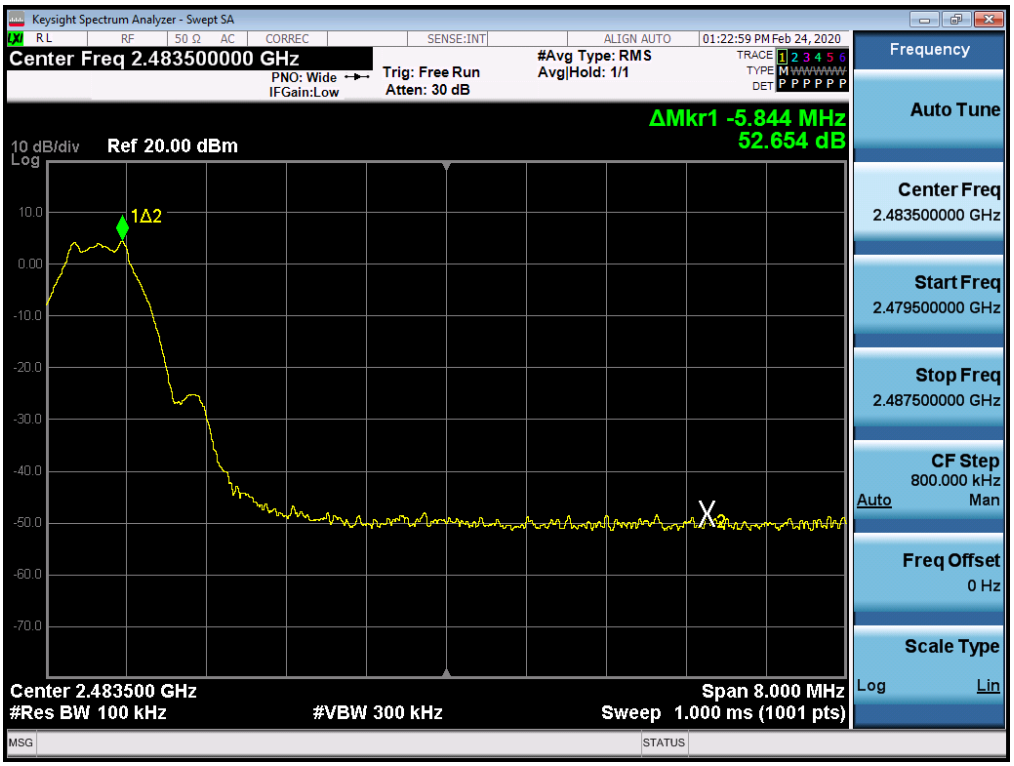
Frequency [MHz]	Channel No.	Position	Test Result		
			Measured Level [dBc]	Limit [dBc]	Pass/Fail
2402	0	Lower	46.16	20	Pass
2440	19	Middle	49.08	20	Pass
2480	39	Upper	48.18	20	Pass

▣ Test Plots (Conducted BandEdge)

Low-CH 0



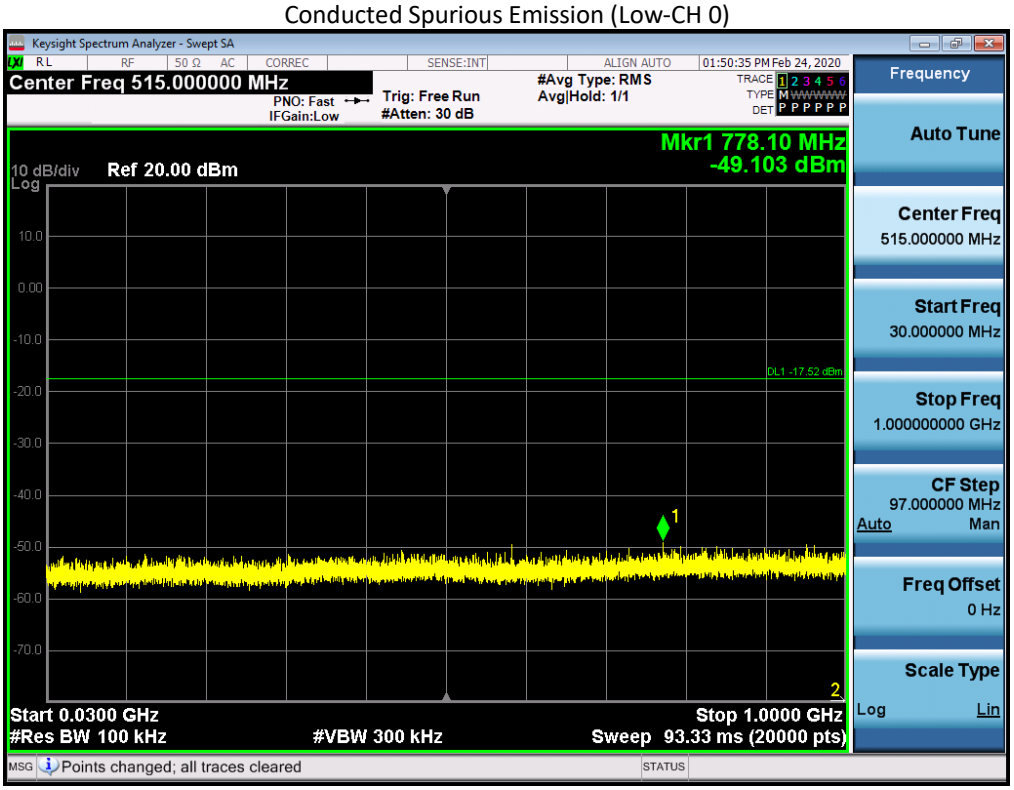
High-CH 39



▣ Test Plots (Conducted Spurious Emission)

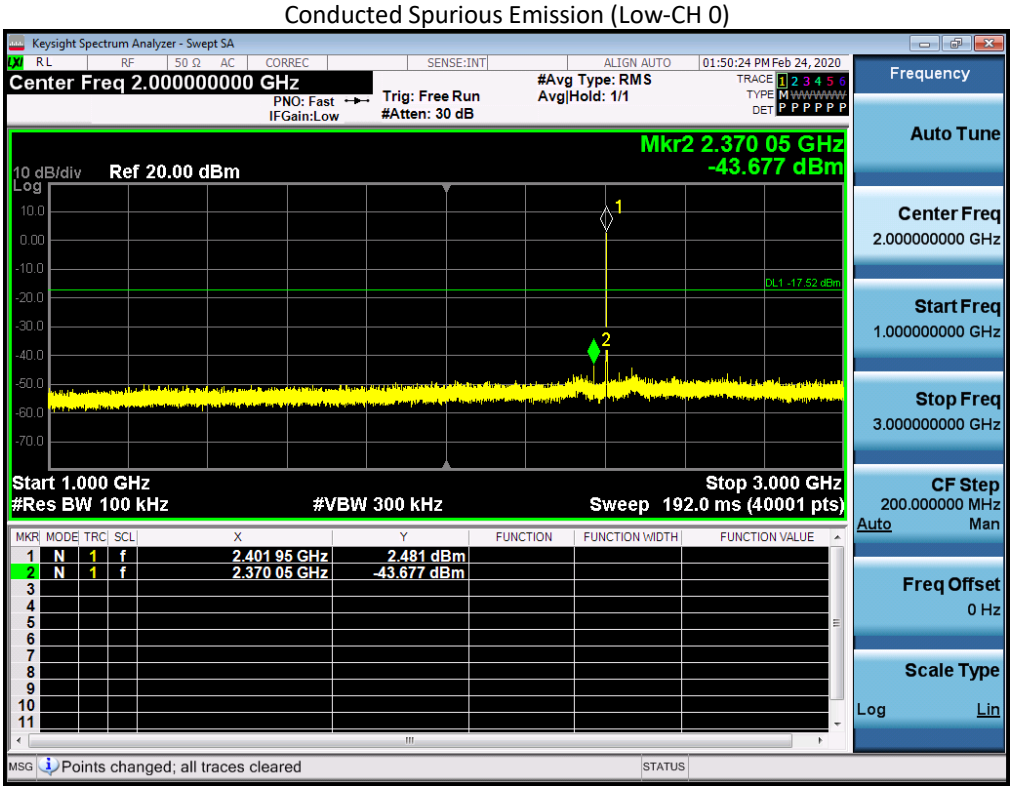
30 MHz ~ 1 GHz

Conducted Spurious Emission (Low-CH 0)



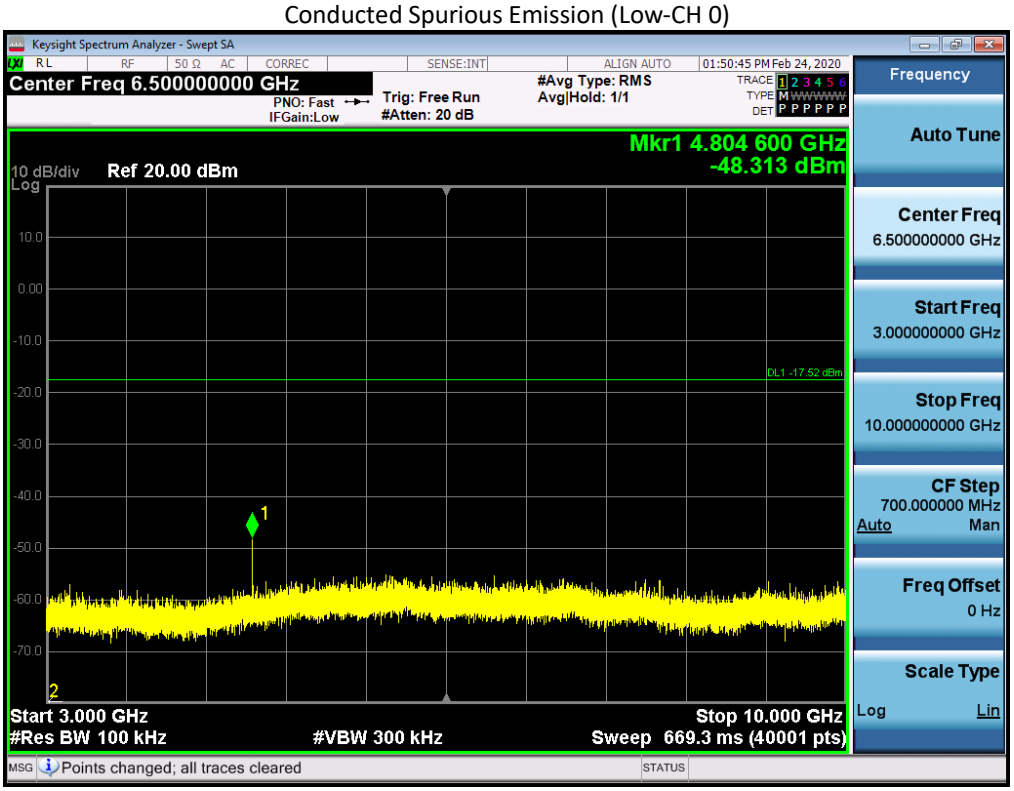
1 GHz ~ 3 GHz

Conducted Spurious Emission (Low-CH 0)



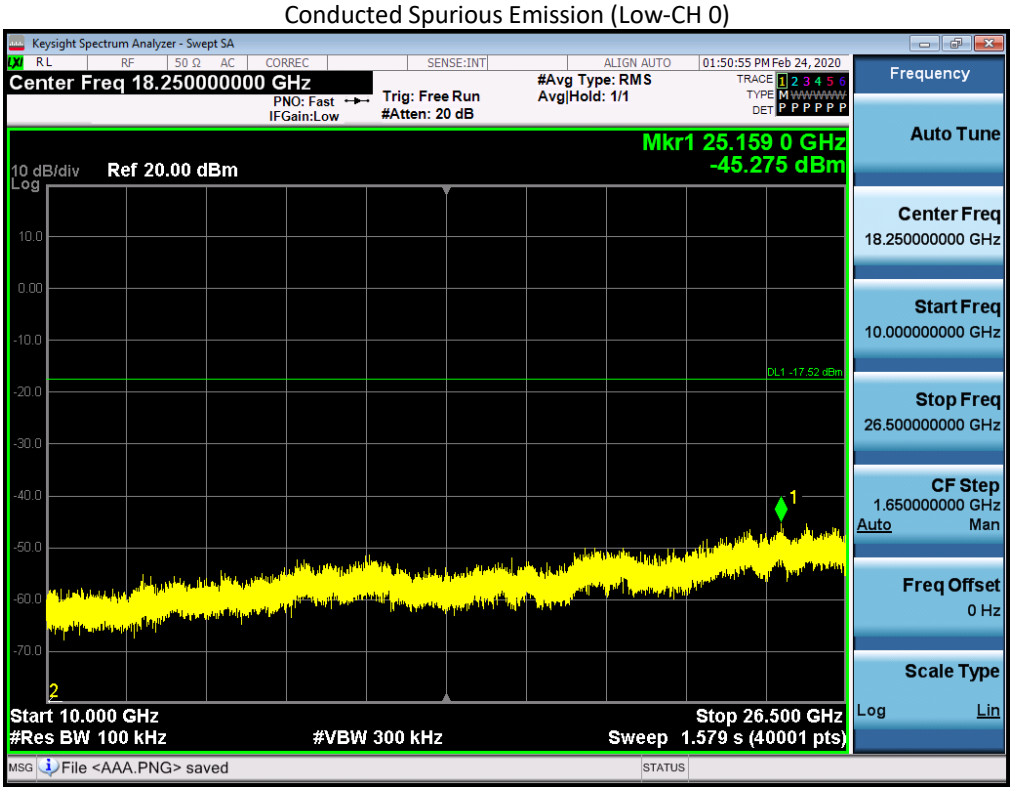
3 GHz ~ 10 GHz

Conducted Spurious Emission (Low-CH 0)



10 GHz ~ 26.5 GHz

Conducted Spurious Emission (Low-CH 0)



9.7 RADIATED SPURIOUS EMISSIONS

9 kHz – 30MHz

CH 0

Frequency [kHz]	ANT. POL [H/V]	Reading [dBuV]	※A.F.+C.L. [dB]	Total [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Measurement Type
0.036	H	16.1	20.8	36.9	116.5	79.6	QP
0.028	H	-6.3	20.9	14.6	118.7	104	QP
0.036	V	6.2	20.8	27	116.5	89.5	QP
0.069	V	6.4	20.1	26.5	110.8	84.3	QP

Notes:

1. The measurement distance is 3 meters.
2. Distance extrapolation factor = 40 log (specific distance / test distance) (dB)
3. Limit line = specific Limits (dBuV) + Distance extrapolation factor
4. Corrected reading: Antenna Factor + Cable loss + Read Level
5. The other Frequencies are attenuated more than 20 dB below the permissible limits.
   In order to simplify the report, attached worst-case mode result.

Frequency Range : Below 1 GHz

CH 0

Frequency [MHz]	ANT. POL [H/V]	Reading [dBuV]	※A.F.+C.L. [dB]	Total [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Measurement Type
37.239	V	24.3	-14	10.3	40	29.7	QP
953.003	H	23.4	-4	19.4	46	26.6	QP

CH 19

Frequency [MHz]	ANT. POL [H/V]	Reading [dBuV]	※A.F.+C.L. [dB]	Total [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Measurement Type
957.959	V	23.5	-4	19.5	46	26.5	QP
955.957	H	23.5	-4	19.5	46	26.5	QP

CH 39

Frequency [MHz]	ANT. POL [H/V]	Reading [dBuV]	※A.F.+C.L. [dB]	Total [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Measurement Type
33.661	V	24.4	-11.4	13	40	27	QP
949.656	H	23.4	-4.1	19.3	46	26.7	QP

Notes:

1. Corrected reading: Antenna Factor + Cable loss + Read Level

Hyundai C-Tech, Inc. dba HCT America, Inc., 1726 Ringwood Avenue, San Jose, CA 95131, USA
TEL: +1-510-933-8848 FAX: +1-510-933-8849

Frequency Range : Above 1 GHz

Operation Mode: CH 0

Frequency MHz	Polarization	Reading dB(uV)			Level dB(uV/m)		Limit dB(uV/m)		Margin dB	
		AV	PK	Factor	AV	PK	AV	PK	AV	PK
4804.266	H	45.5	53.5	-0.2	45.3	53.3	54	74	8.7	20.7
4804.065	V	44.4	52.1	-0.2	44.2	51.9	54	74	9.8	22.1
9607.37	V	40.0	49.7	7.0	47.0	56.7	54	74	7.0	17.3
9607.237	H	39.7	49.6	7.0	46.7	56.6	54	74	7.3	17.4
24020.25	V	36.1	50.3	3.9	40.0	54.2	54	74	14.0	19.8
24020.36	H	35.8	48.9	3.9	39.7	52.8	54	74	14.3	21.2

Operation Mode: CH 19

Frequency MHz	Polarization	Reading dB(uV)			Level dB(uV/m)		Limit dB(uV/m)		Margin dB	
		AV	PK	Factor	AV	PK	AV	PK	AV	PK
4880.034	H	45.1	53.0	-0.2	44.9	52.8	54	74	9.1	21.2
4880.034	V	46.1	53.2	-0.2	45.9	53.0	54	74	8.1	21.0
9760.993	V	39.9	50.2	6.5	46.4	56.7	54	74	7.6	17.3
9760.918	H	37.8	48.9	6.5	44.3	55.4	54	74	9.7	18.6

Operation Mode: CH 39

Frequency MHz	Polarization	Reading dB(uV)			Level dB(uV/m)		Limit dB(uV/m)		Margin dB	
		AV	PK	Factor	AV	PK	AV	PK	AV	PK
4959.974	H	46.8	53.5	0.0	46.8	53.5	54	74	7.2	20.5
4960.076	V	46.0	52.9	0.0	46.0	52.9	54	74	8.0	21.1

Notes:

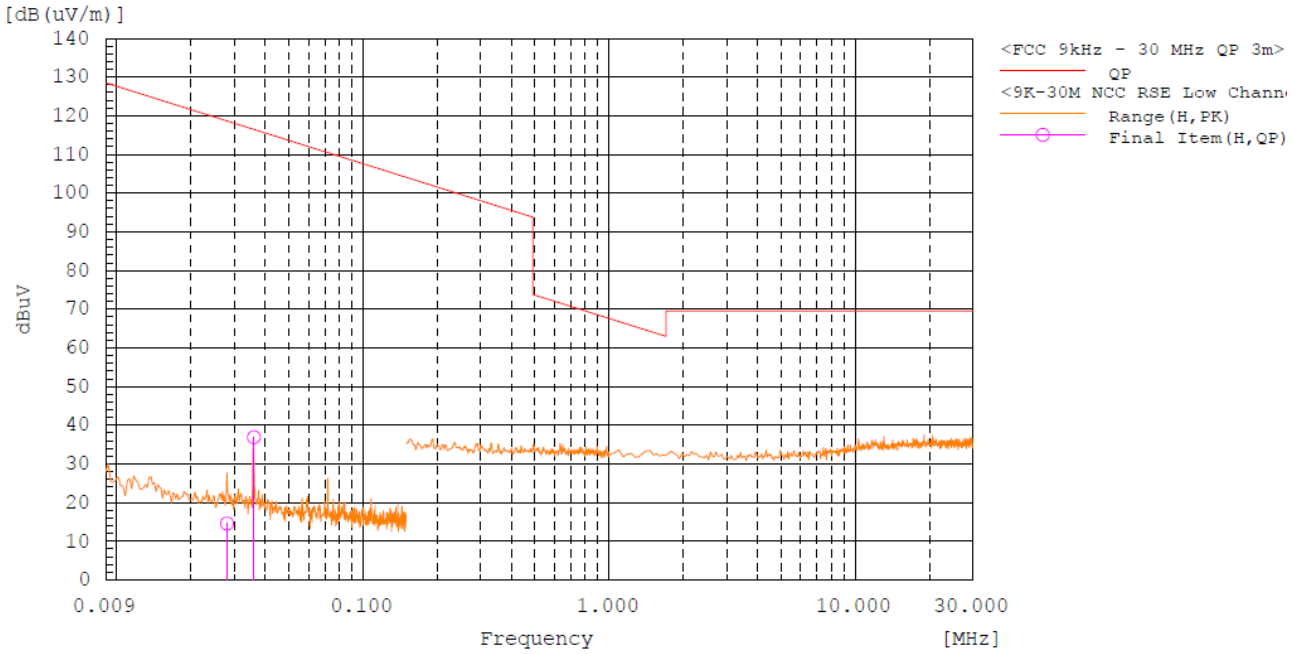
1. Corrected reading: Antenna Factor + Cable loss + Read Level

2. AV Level = Measured Power(dBm) +Duty Cycle Factor(dB)

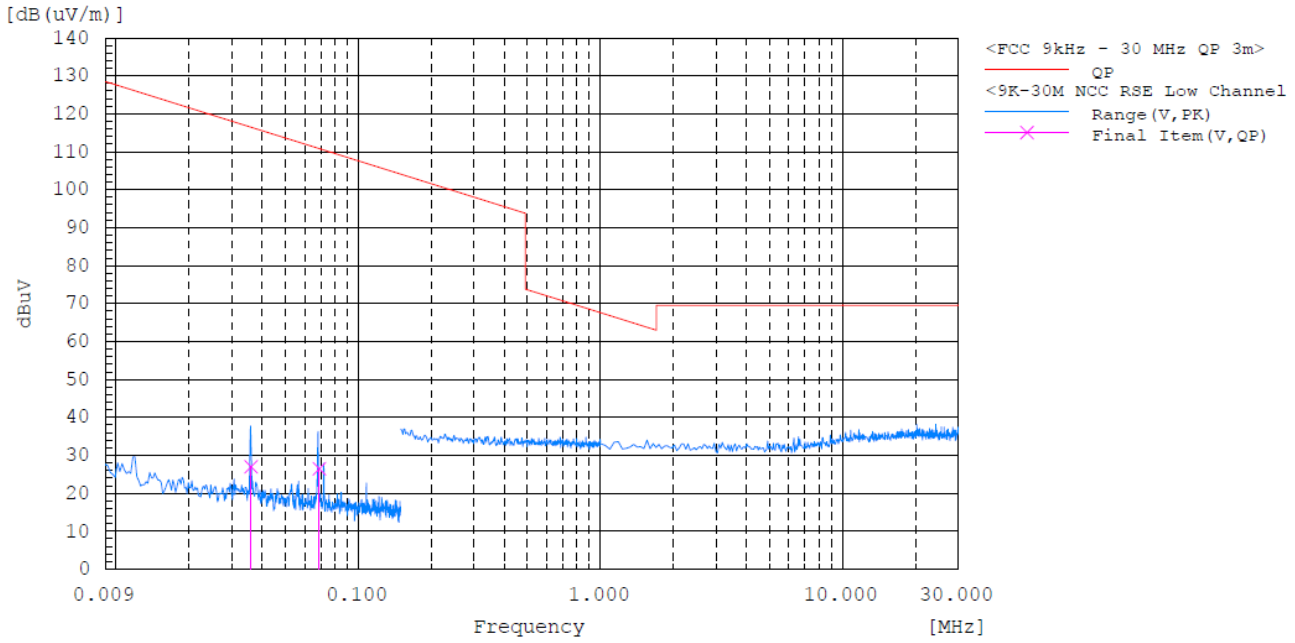
▣ Test Plots

9 kHz – 30MHz

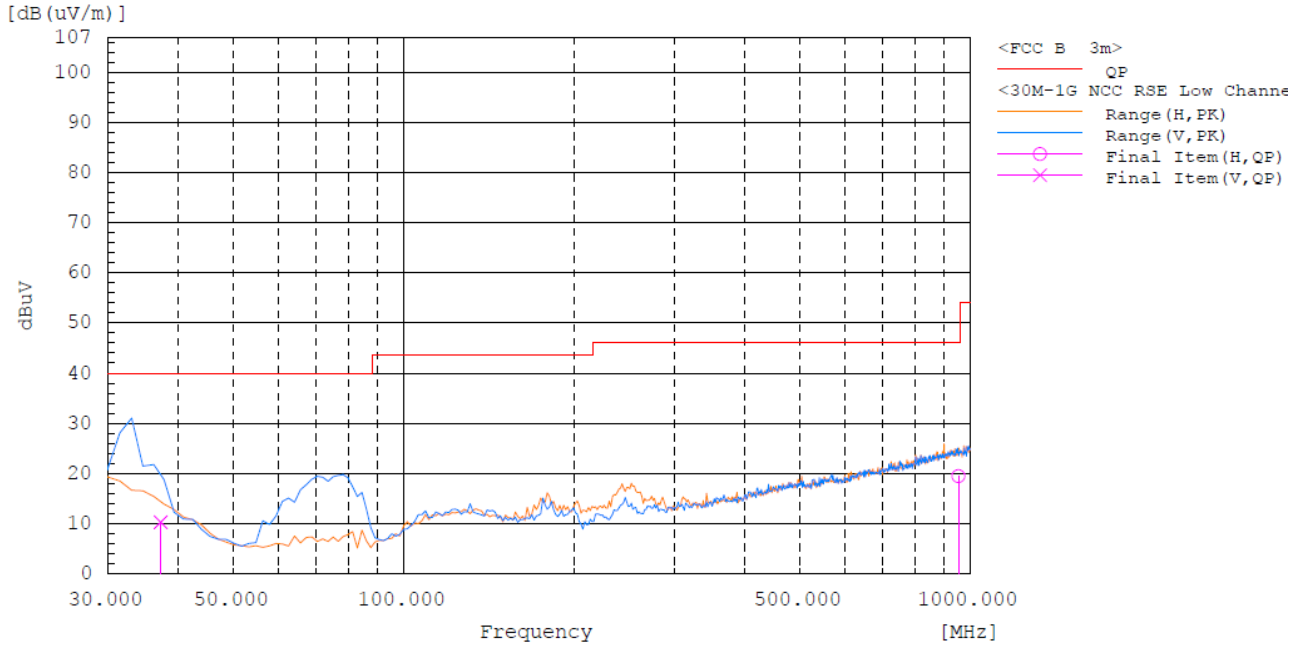
Radiated Spurious Emissions Horizontal plot



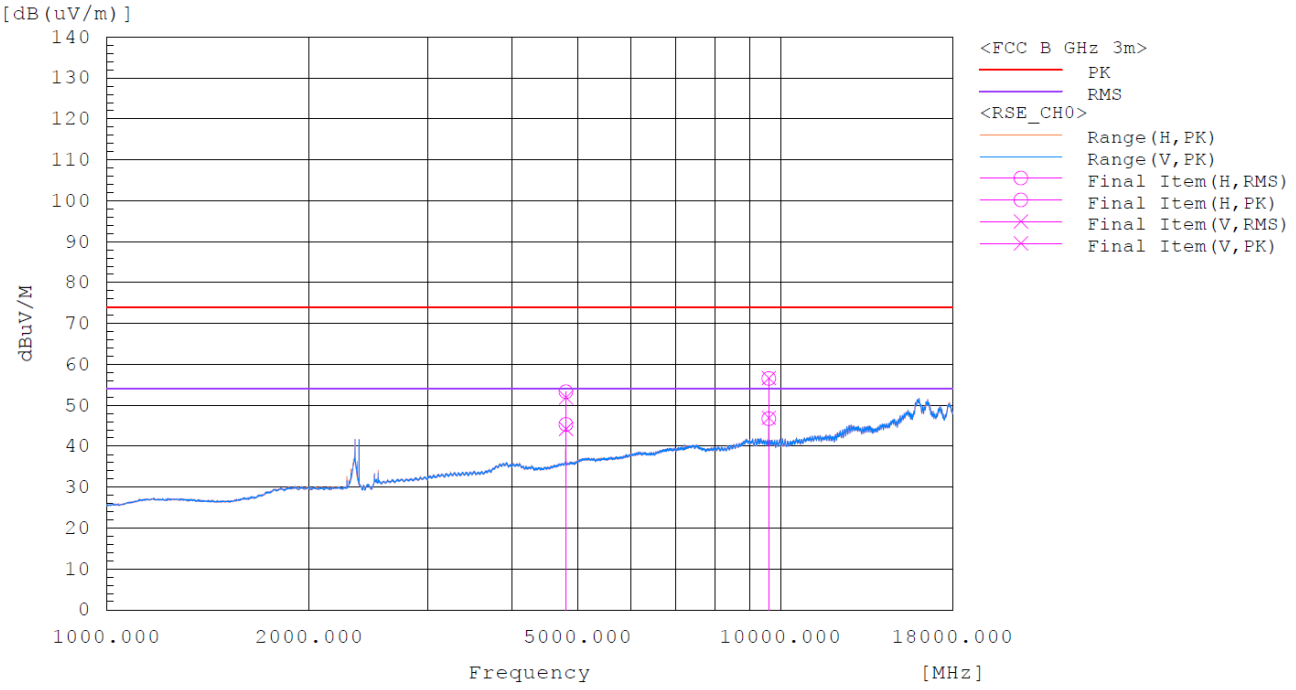
Radiated Spurious Emissions Vertical plot



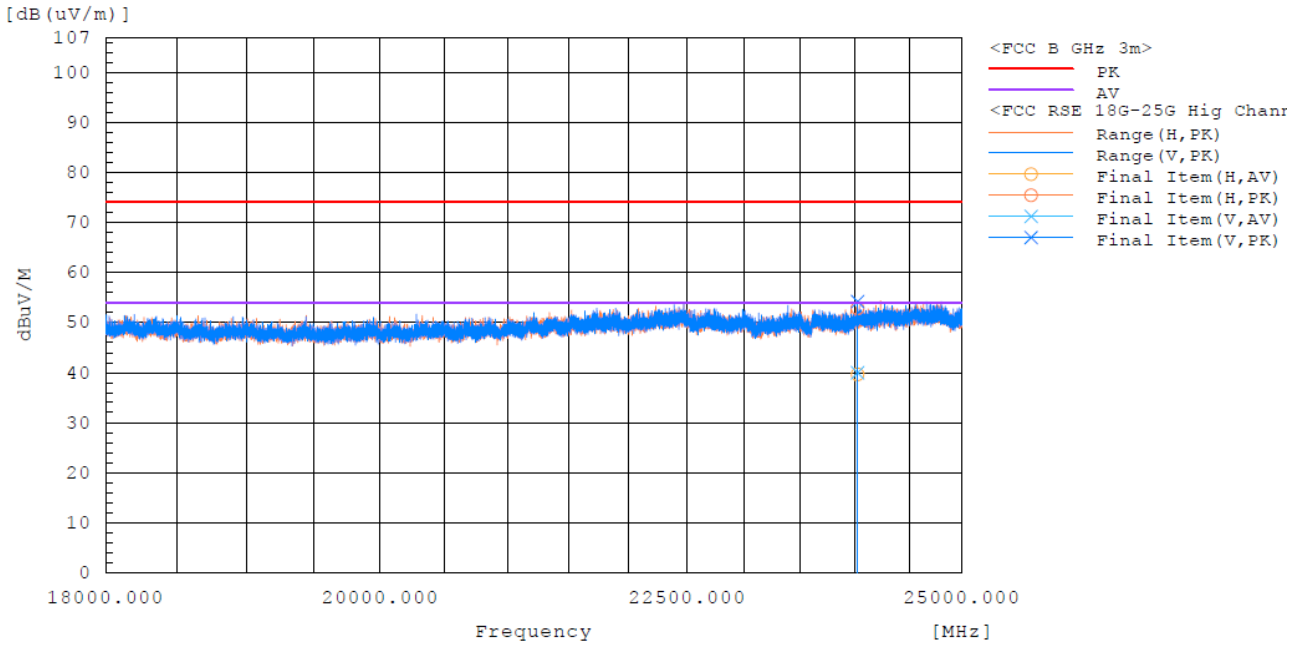
Radiated Spurious Emissions plot Below 1 GHz



Radiated Spurious Emissions plot 1 GHz ~ 18 GHz



Radiated Spurious Emissions plot 18 GHz ~ 25 GHz



Note:

Plot of worst case are only reported.

Hyundai C-Tech, Inc. dba HCT America, Inc., 1726 Ringwood Avenue, San Jose, CA 95131, USA
TEL: +1-510-933-8848 FAX: +1-510-933-8849

9.8 RADIATED RESTRICTED BAND EDGES

Operating Frequency 2402 MHz

Channel No. 0

Frequency MHz	Polarization	Reading dB(uV)			Level dB(uV/m)		Limit dB(uV/m)		Margin dB	
		AV	PK	Factor	AV	PK	AV	PK	AV	PK
2369.952	H	53.2	58.8	-6.3	46.9	52.5	54	74	7.1	21.5
2369.952	V	53.3	58.7	-6.3	47.0	52.4	54	74	7.0	21.6
2338.104	V	52.2	59.9	-6.5	45.7	53.4	54	74	8.3	20.6
2337.93	H	52.4	59.9	-6.5	45.9	53.4	54	74	8.1	20.6

Operating Frequency 2480 MHz

Channel No. 39

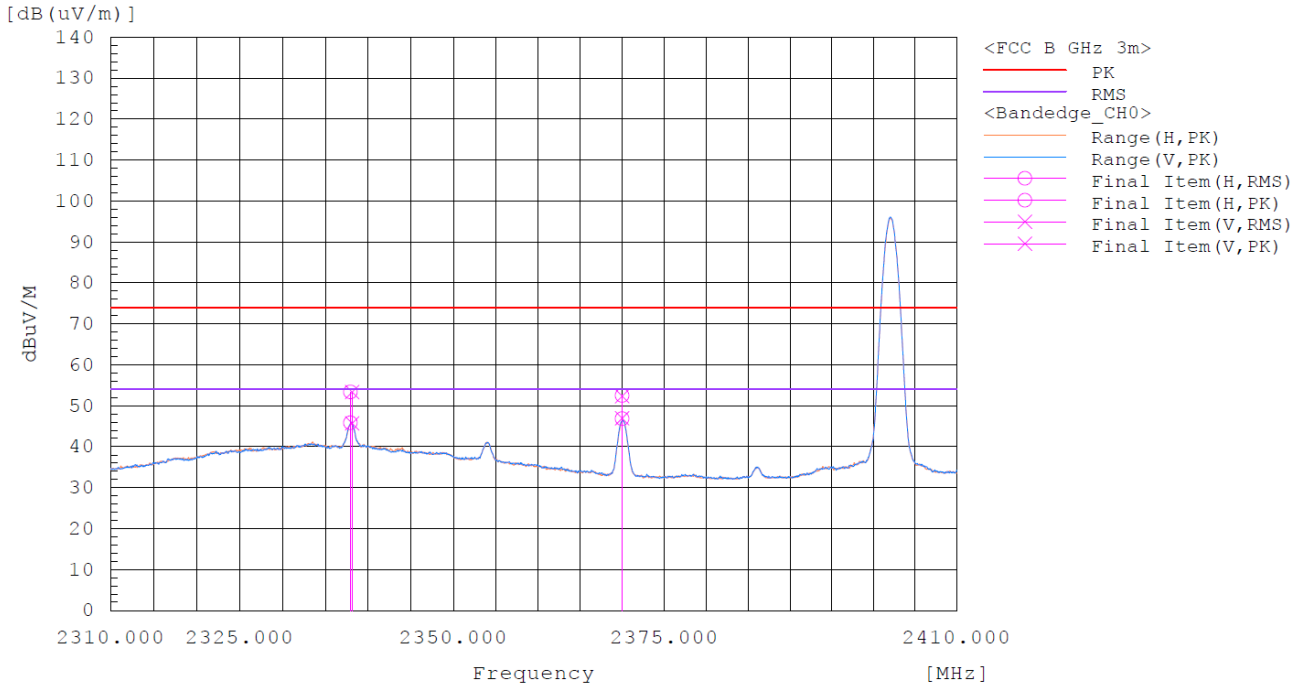
Frequency MHz	Polarization	Reading dB(uV)			Level dB(uV/m)		Limit dB(uV/m)		Margin dB	
		AV	PK	Factor	AV	PK	AV	PK	AV	PK
2483.5	V	39.3	52.8	-5.6	33.7	47.2	54	74	20.3	26.8
2483.5	H	38.3	51.8	-5.6	32.7	46.2	54	74	21.3	27.8

Notes:

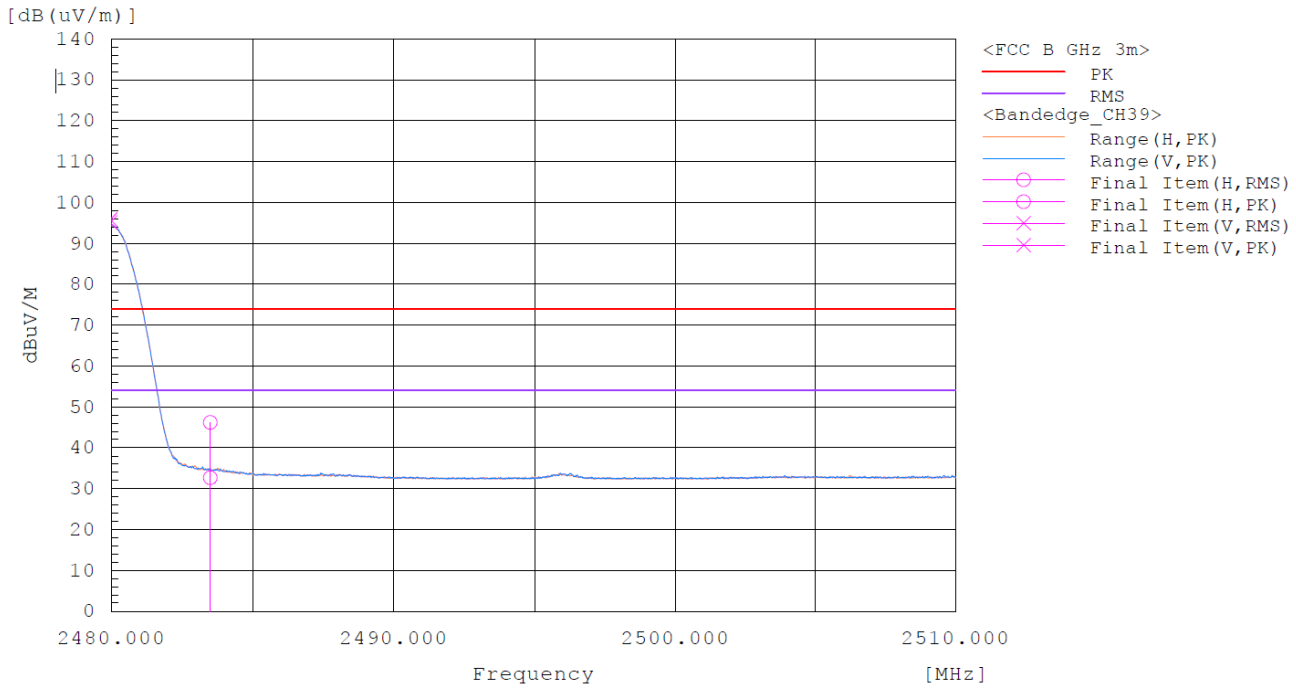
1. Corrected reading: Antenna Factor + Cable loss + Read Level
2. AV Level = Measured Power(dBm) +Duty Cycle Factor(dB)

▣ Test Plots

Radiated Restricted Band Edges plot –(Ch.0)



Radiated Restricted Band Edges plot – (Ch.39)



9.9 RECEIVER SPURIOUS EMISSIONS

Frequency Range : Below 1 GHz

Frequency [MHz]	ANT. POL [H/V]	Reading [dBuV]	※A.F.+C.L. [dB]	Total [dBuV/m]	Limit [dBuV/m]	Margin [dB]	Measurement Type
33.661	V	24.4	-11.4	13	40	27	QP
949.656	H	23.4	-4.1	19.3	46	26.7	QP

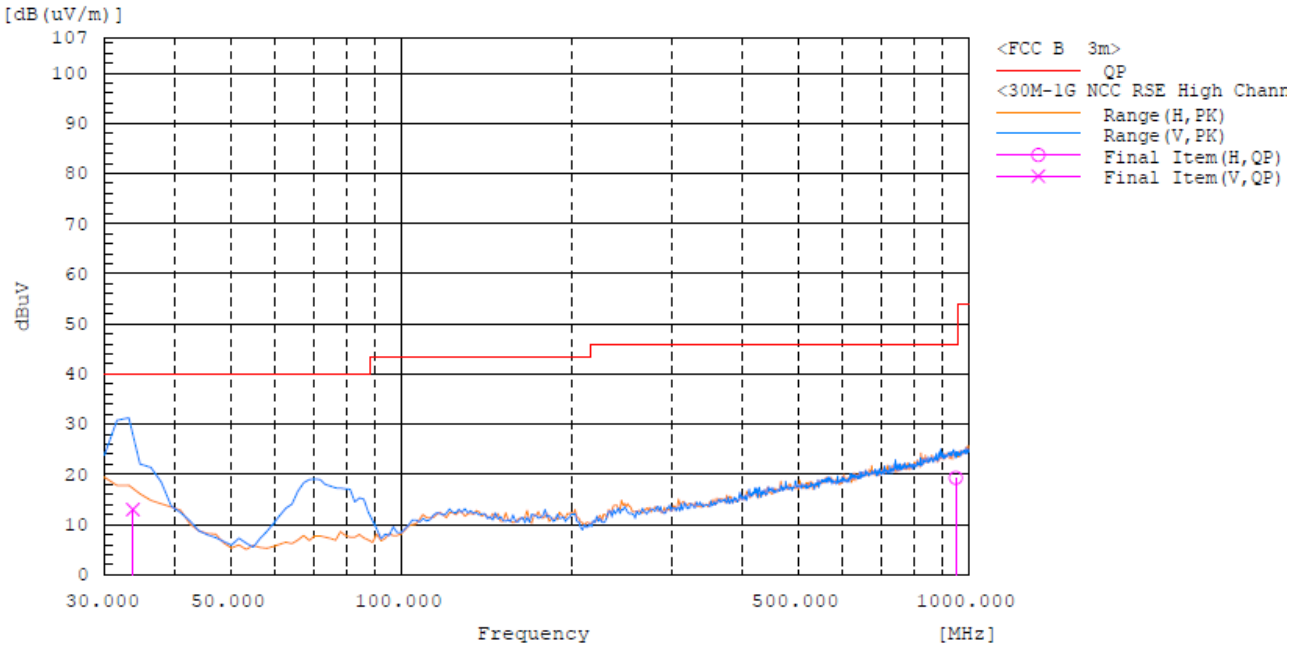
Note:

1. Radiated emissions measured in frequency range from 30 MHz to 1000 MHz were made with an instrument using Quasi peak detector mode.

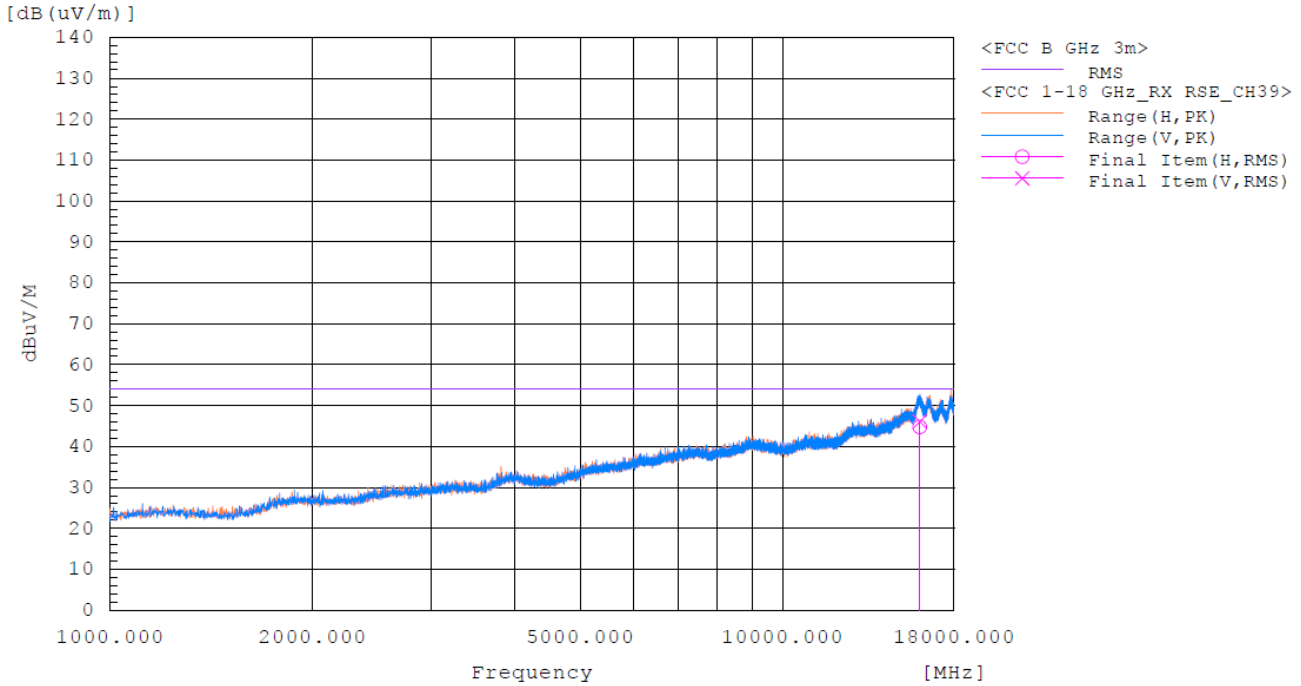
Frequency Range : Above 1 GHz

Frequency MHz	Polarization	Reading dB(uV)		Level dB(uV/m)	Limit dB(uV/m)	Margin dB
		AV	Factor	AV	AV	AV
19517.04	H	41.9	2.8	44.7	54	9.3
19517.39	V	41.5	2.8	44.3	54	9.7
24020.25	V	36.1	3.9	40.0	54	14.0
24020.36	H	35.8	3.9	39.7	54	14.3

Receiver Spurious Emissions plot Below 1 GHz

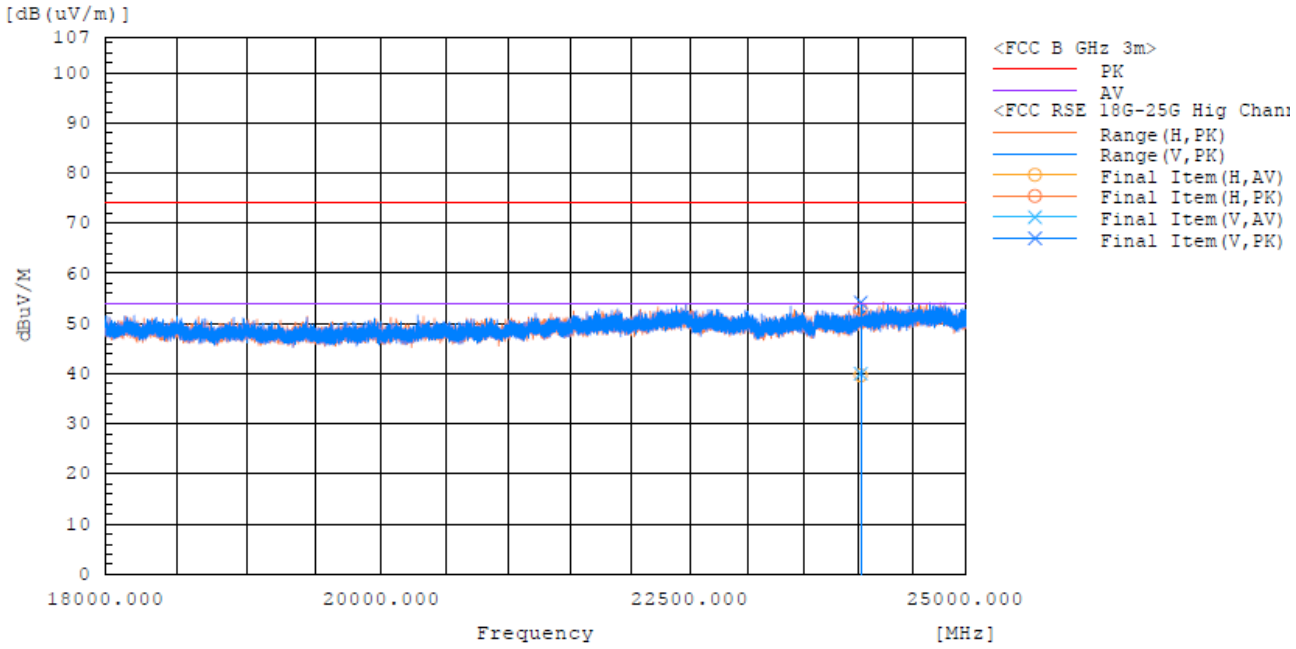


Receiver Spurious Emissions plot 1 GHz ~ 18GHz



Hyundai C-Tech, Inc. dba HCT America, Inc., 1726 Ringwood Avenue, San Jose, CA 95131, USA
TEL: +1-510-933-8848 FAX: +1-510-933-8849

Receiver Spurious Emissions plot 18 GHz ~ 25 GHz

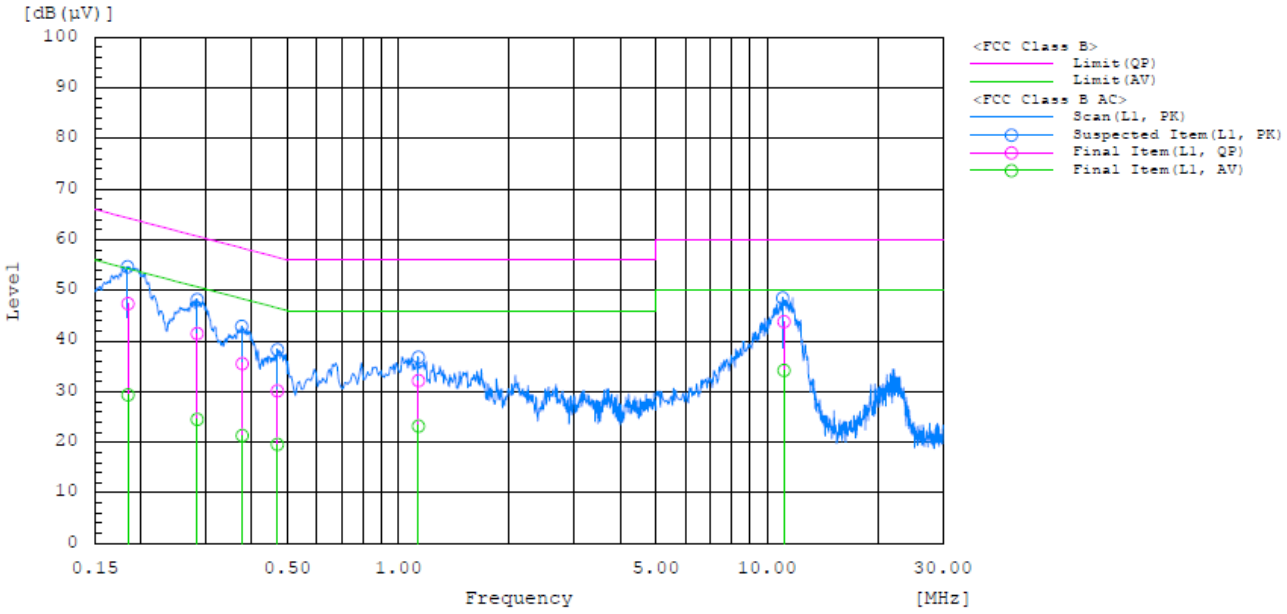


Note:

Plot of worst case are only reported.

9.10 POWERLINE CONDUCTED EMISSIONS

[AC Mains (L1)]

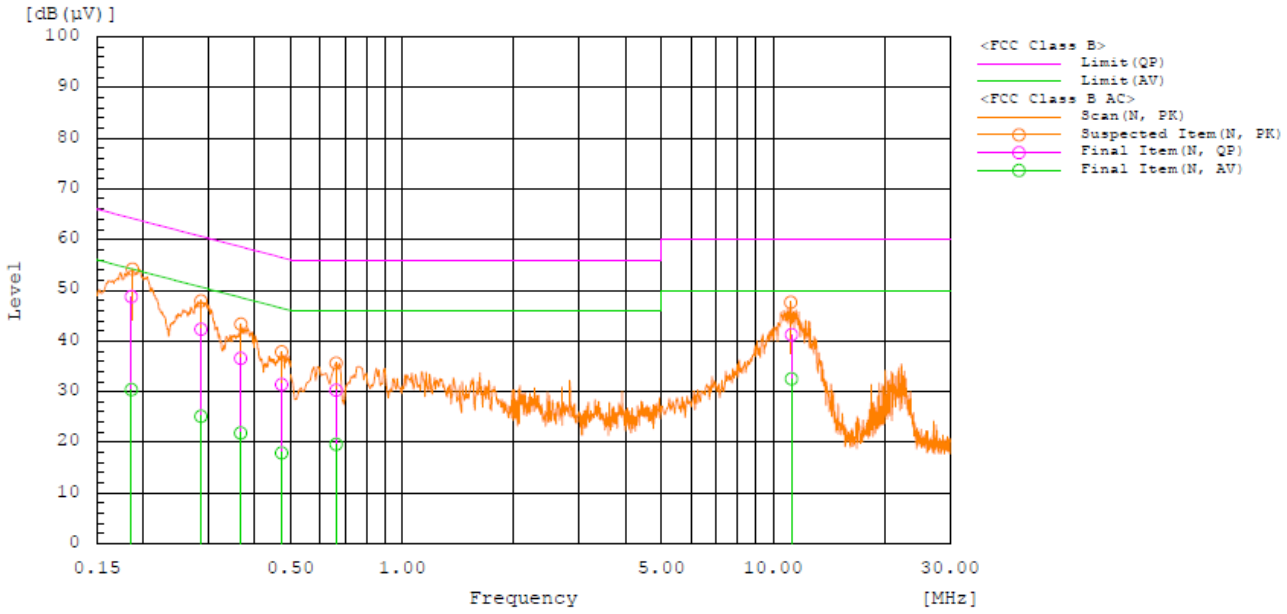


[Final Results]

Frequency MHz	Line	Reading dB(μV)		Corr. dB	Level dB(μV)		Limit dB(μV)		Margin dB	
		QP	CAV		QP	CAV	QP	CAV	QP	CAV
0.184	L1	37.6	19.6	9.8	47.4	29.4	64.3	54.3	16.9	24.9
0.284	L1	31.8	14.8	9.7	41.5	24.5	60.7	50.7	19.2	26.2
0.377	L1	25.8	11.7	9.7	35.5	21.4	58.4	48.4	22.9	27
0.469	L1	20.5	9.9	9.7	30.2	19.6	56.5	46.5	26.3	26.9
1.132	L1	22.4	13.4	9.8	32.2	23.2	56	46	23.8	22.8
11.119	L1	33.7	24.1	10.1	43.8	34.2	60	50	16.2	15.8

Note : Quasi-peak(Final Result) = Reading Value + Correction Factor

[AC Mains (N)]



[Final Results]

Frequency MHz	Line	Reading dB(μV)		Corr. dB	Level dB(μV)		Limit dB(μV)		Margin dB	
		QP	CAV		QP	CAV	QP	CAV	QP	CAV
0.186	N	39.1	20.7	9.7	48.8	30.4	64.2	54.2	15.4	23.8
0.286	N	32.7	15.5	9.7	42.4	25.2	60.6	50.6	18.2	25.4
0.366	N	26.9	12.2	9.7	36.6	21.9	58.6	48.6	22	26.7
0.472	N	21.7	8.2	9.7	31.4	17.9	56.5	46.5	25.1	28.6
0.663	N	20.6	9.9	9.7	30.3	19.6	56	46	25.7	26.4
11.202	N	31.2	22.4	10.1	41.3	32.5	60	50	18.7	17.5

Note : Quasi-peak(Final Result) = Reading Value + Correction Factor

10. LIST OF TEST EQUIPMENT

No.	Instrument	Model No.	Due to Calibration	Manufacture	Serial No.
☒	Signal Analyzer (20 Hz ~ 40.0 GHz)	ESU40	2020-12-20	ROHDE & SCHWARZ	100529
☒	Signal Analyzer (10 Hz ~ 26.5 GHz)	N9020A	2020-11-08	Keysight	MY52091291
☒	BI-LOG Antenna (30 MHz ~ 1 GHz)	JB6	2020-11-29	Sunol	A071116
☒	Fixed Attenuator (20 dB, DC ~ 26.5 GHz)	8493C	2020-12-13	HP	09072
☒	POWER AMP (1 GHz ~ 18 GHz)	PAM-118A	2020-08-22	Com-Power Corporation	18040074
☒	POWER AMP (100 kHz ~ 1.3 GHz)	8447D	2020-10-08	HP	2944
☒	Horn Antenna (1 GHz ~ 18 GHz)	DRH-118	2020-05-24	Sunol	A070516
☒	Loop Antenna (0.009 ~ 30 MHz)	HLA 6121	2020-08-27	TESEQ	43964
☒	Horn Antenna (18 GHz ~ 40 GHz)	DRH-1840	2021-02-20	Sunol	17120
☒	POWER AMP (18 GHz ~ 40 GHz)	CBL184050-45-01	2021-02-04	CERNEX,Inc.	43964
☒	ISM Band Reject filter (2370 ~ 2400 - 2483.5 ~2520 MHz)	WRCJV12	2021-01-18	Wainwright	4
☒	EMI Test Receiver	ESR3	2020-12-20	Rohde & Schwarz	102363
☒	LISN	ENV216	2021-01-19	Rohde & Schwarz	101349

Note:

1. Equipment listed above that calibrated during the testing period was set for test after the calibration.
2. Equipment listed above that has a calibration due date during the testing period, the testing is completed before equipment expiration date

11. ANNEX A TEST SETUP PHOTO

The setup photo will be provided as a separate document

Hyundai C-Tech, Inc. dba HCT America, Inc., 1726 Ringwood Avenue, San Jose, CA 95131, USA
TEL: +1-510-933-8848 FAX: +1-510-933-8849