TEST REPORT

FCC/IC BT Test for ATC31EYAN&ATC31EYKN

Certification

APPLICANT HYUNDAI MOBIS CO., LTD.

REPORT NO. HCT-RF-1909-FI007

DATE OF ISSUE September 06, 2019

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TEST REPORT FCC/IC BT Test for ATC31EYAN& ATC31EYKN	REPORT NO. HCT-RF-1909-FI007 DATE OF ISSUE September 06, 2019 Other Model FCC: ATC30EYAN IC: ATC30EYKN
Applicant	HYUNDAI MOBIS CO., LTD. 203, Teheran-ro, Gangnam-gu, Seoul, 135-977, South Korea
Eut Type FCC Model Name IC Model Name	Car Audio System ATC31EYAN ATC31EYKN
FCC ID IC	TQ8-ATC31EYAN 5074A-ATC31EYKN
Max. RF Output Power	3.957 dBm (2.487 mW)
Modulation type	GFSK(Normal), π/4DQPSK and 8DPSK(EDR)
FCC Classification	FCC Part 15 Spread Spectrum Transmitter
FCC Rule Part(s)	Part 15 subpart C 15.247
IC Rule Part(s)	RSS-247 Issue 2 (February 2017) RSS-Gen Issue 5(April 2018)
	This test results were applied only to the test methods required by the standard. Tested by Se Wook Park
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HCT CO., LTD. Soo Chan Lee SooChan Lee / CEO



REVISION HISTORY

The revision history for this test report is shown in table.

Revision No.	Date of Issue	Description
0	September 06, 2019	Initial Release

The result shown in this test report refer only to the sample(s) tested unless otherwise stated.

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. It is further stated that upon the basis of the measurements made, the equipment tested is capable of operation in accordance with the requirements of the FCC / IC Rules under normal use and maintenance.

According to the Evaluation report, all of the data contained herein is reused from the reference FCC ID : TQ8-ATB31EYAN report.

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1. EUT DESCRIPTION

FCC Model	ATC31EYAN
IC Model	ATC31EYKN
FCC Additional Model	ATC30EYAN
IC Additional Model	ATC30EYKN
EUT Type	Car Audio System
Power Supply	DC 14.4 V
Frequency Range	2402 MHz - 2480 MHz
Max. RF Output Power	3.957 dBm (2.487 mW)
BT Operating Mode	Normal, EDR, AFH
Modulation Type	GFSK(Normal), π/4DQPSK and 8DPSK(EDR)
Modulation Technique	FHSS
Number of Channels	79Channels, Minimum 20 Channels(AFH)
Antenna Specification	Antenna type: Printed Antenna Peak Gain : 0.29 dBi
Date(s) of Tests	July 04, 2019~ September 02, 2019
PMN (Product Marketing Number)	ATC31EYKN
HVIN (Hardware Version Identification Number)	ATC31EYKN
FVIN (Firmware Version Identification Number)	N/A
HMN (Host Marketing Name)	N/A



2. Requirements for Bluetooth transmitter(15.247)

This Bluetooth module has been tested by a Bluetooth Qualification Lab, and we confirm the following:

- 1) This system is hopping pseudo-randomly.
- 2) Each frequency is used equally on the average by each transmitter.
- 3) The receiver input bandwidths that match the hopping channel bandwidths of their corresponding transmitters
- 4) The receiver shifts frequencies in synchronization with the transmitted signals.

• 15.247(g): The system, consisting of both the transmitter and the receiver, must be designed to comply with all of the regulations in this Section 15.247 should the transmitter be presented with a continuous data (or information) stream.

• 15.247(h): The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.

The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.

• RSS-247 5.1 (a): The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

The coordination of frequency hopping systems in any other manner for the express purpose of avoiding the simultaneous occupancy of individual hopping frequencies by multiple transmitters is not permitted.



3. TEST METHODOLOGY

The measurement procedure described in the American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Device (ANSI C63.10-2013, KDB 558074) is used in the measurement of the test device.

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. / 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 3.75 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). To record the final measurements, the analyzer detector function was set to CISPR quasi-peak mode and the bandwidth of the spectrum analyzer was set to 120 kHz for frequencies below 1 GHz or 1 MHz for frequencies above 1 GHz. For average measurements above 1 GHz, the analyzer was set to peak detector with a reduced VBW setting(RBW = 1 MHz, VBW = 1/T Hz, where T = Pulse width).



DESCRIPTION OF TEST MODES

The EUT has been tested under operating condition. Test program used to control the EUT for staying in continuous transmitting and receiving mode is programmed.

4. 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 equipments, which is traceable to recognized national standards.

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

5. FACILITIES AND ACCREDITATIONS

FACILITIES

The SAC(Semi-Anechoic Chamber) and conducted measurement facility used to collect the radiated data are located at the 74, Seoicheon-ro 578beon-gil,

Majang-myeon, Icheon-si, Gyeonggi-do, 17383, Rep. of KOREA.

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

Detailed description of test facility was submitted to the Commission and accepted dated April 02, 2018 (Registration Number: KR0032).

For ISED, test facility was accepted dated February 14, 2019 (CAB identifier: KR0032). **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."



6. 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

According to RSS-GEN(Issue 5) Section 6.8:

The applicant for equipment certification shall provide a list of all antenna types that may be used with the transmitter, where applicable (i.e. for transmitters with detachable antenna), indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna. The test report shall demonstrate the compliance of the transmitter with the limit for maximum equivalent isotropically radiated power (e.i.r.p.) specified in the applicable RSS, when the transmitter is equipped with any antenna type, selected from this list.

For expediting the testing, measurements may be performed using only the antenna with highest gain of each combination of transmitter and antenna type, with the transmitter output power set at the maximum level. However, the transmitter shall comply with the applicable requirements under all operational conditions and when in combination with any type of antenna from the list provided in the test report (and in the notice to be included in the user manual, provided below).

When measurements at the antenna port are used to determine the RF output power, the effective gain of the device's antenna shall be stated, based on a measurement or on data from the antenna's manufacturer.

The test report shall state the RF power, output power setting and spurious emission measurements with each antenna type that is used with the transmitter being tested..



7. 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)	1.82
Radiated Disturbance (9 kHz ~ 30 MHz)	3.40
Radiated Disturbance (30 MHz ~ 1 GHz)	4.80
Radiated Disturbance (1 GHz ~ 18 GHz)	5.70
Radiated Disturbance (18 GHz ~ 40 GHz)	5.05



8. DESCRIPTION OF TESTS

8.1. Conducted Maximum Peak Output Power

<u>Limit</u>

The maximum peak output power of the intentional radiator shall not exceed the following:

- For frequency hopping systems operating in the 2400–2483.5 MHz band employing at least 75 nonoverlapping hopping channels, and all frequency hopping systems in the 5725–5850 MHz band: 1 W. For all other frequency hopping systems in the 2400-2483.5 MHz band: 0.125 W.
- 2. The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi.

Test Configuration



Test Procedure

The transmitter output is connected to the Spectrum Analyzer. The Spectrum Analyzer is set to the peak detector mode. This test is performed with hopping off.

The Spectrum Analyzer is set to (7.8.5 in ANSI 63.10-2013 & Procedure 10(b)(6)(i) in KDB 558074 v05r02)

- 1) Span: approximately 5 times the 20 dB bandwidth, centered on a hopping channel
- 2) RBW > the 20 dB bandwidth of the emission being measured
- 3) VBW \geq RBW
- 4) Sweep = Auto
- 5) Detector = Peak
- 6) Trace = Max hold

Sample Calculation

Output Power = Spectrum Reading Power + Power Splitter loss + Cable loss(2 ea)

= 10 dBm + 6 dB + 1.5 dB = 17.5 dBm



8.2. Conducted Band Edge(Out of Band Emissions)

Limit

According to § 15.247(d), in any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits.

Test Configuration



Test Procedure

This test is performed with hopping off and hopping on.

The Spectrum Analyzer is set to (6.10.4 in ANSI 63.10-2013 & Procedure 8.5 and 8.6 in KDB 558074 v05r02)

- Span: Wide enough to capture the peak level of the emission operating on the channel closest to the band edge, as well as any modulation products which fall outside of the authorized band of operation
- Reference level: As required to keep the signal from exceeding the maximum instrument input mixer level for linear operation. In general, the peak of the spectral envelope shall be more than [10 log (OBW/RBW)] below the reference level.
- 3) Attenuation: Auto (at least 10 dB preferred).
- 4) Sweep time: Coupled.
- 5) RBW: 100 kHz
- 6) VBW: 300 kHz
- 7) Detector: Peak
- 8) Trace: Max hold



8.3. Frequency Separation & 20 dB Bandwidth

Limit

According to § 15.247(a)(1), Frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater.

Test Configuration



Test Procedure(Frequency Separation)

The Channel Separation test is performed with hopping on. And the 20 dB Bandwidth test is performed with hopping off.

The Spectrum Analyzer is set to (7.8.2 in ANSI 63.10-2013 & Procedure 10(b)(6)(iii) in KDB 558074 v05r02)

- 1) Span: Wide enough to capture the peaks of two adjacent channels
- 2) RBW: Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel.
- 3) VBW \geq RBW
- 4) Sweep: Auto
- 5) Detector: Peak
- 6) Trace: Max hold
- 7) All the trace to stabilize.
- 8) Use the marker-delta function to determine the separation between the peaks of the adjacent channels. Compliance of an EUT with the appropriate regulatory limit shall be determined. A plot of the data shall be included in the test report.





Test Procedure (20 dB Bandwidth)

And the 20 dB Bandwidth test is performed with hopping off.

The Spectrum Analyzer is set to (6.9.2 in ANSI 63.10-2013)

- 1) Span: Set between two times and five times the OBW
- 2) RBW: 1% to 5% of the OBW.
- 3) VBW \geq 3*RBW
- 4) Sweep: Auto
- 5) Detector: Peak
- 6) Trace: Max hold
- 7) All the trace to stabilize.





8.4. Number of Hopping Frequencies

Limit

According to \$15.247(a)(1)(iii), Frequency hopping systems operating in the 2400 MHz ~ 2483.5 MHz bands shall use at least 15 hopping frequencies.

Test Configuration



Test Procedure

The Bluetooth frequency hopping function of the EUT was enabled.

The Spectrum Analyzer is set to (7.8.3 in ANSI 63.10-2013 & Procedure 10(b)(4) in KDB 558074 v05r02)

- 1) Span: the frequency band of operation
- 2) RBW: To identify clearly the individual channels, set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller.
- 3) VBW \geq RBW
- 4) Sweep: Auto
- 5) Detector: Peak
- 6) Trace: Max hold
- 7) Allow the trace to stabilize.



8.5. Time of Occupancy

Limit

According to § 15.247(a)(1)(iii), Frequency hopping systems operating in the 2400 MHz ~ 2483.5 MHz bands. The average time of occupancy on any channels shall not greater than 0.4 s within a period 0.4 s multiplied by the number of hopping channels employed.

Test Configuration



Test Procedure

This test is performed with hopping off.

The Spectrum Analyzer is set to (7.8.4 in ANSI 63.10-2013 & Procedure 10(b)(6)(iv) in KDB 558074 v05r02)

- 1) Span: Zero span, centered on a hopping channel
- 2) RBW shall be \leq channel spacing and where possible RBW should be set >> 1 / T, where T is the expected dwell time per channel.
- 3) Sweep = as necessary to capture the entire dwell time per hopping channel
- 4) Detector: Peak
- 5) Trace: Max hold

The marker-delta function was used to determine the dwell time.



Sample Calculation

The following calculation process is not relevant to our measurement results. It is just an example.

* Non-AFH Mode

- DH 5 (GFSK) : 2.890 * (1600/6)/79 * 31.6 = 308.27 (ms)
- 2-DH 5 (π /4DQPSK) : 2.890 * (1600/6)/79 * 31.6 = 308.27 (ms)
- 3-DH 5 (8DPSK) : 2.890 * (1600/6)/79 * 31.6 = 308.27 (ms)

* AFH Mode

- DH 5 (GFSK) : 2.890 * (800/6)/20 * 8.0 = 154.13 (ms)
- 2-DH 5 (π /4DQPSK) : 2.890 * (800/6)/20 * 8.0 = 154.13 (ms)
- 3-DH 5 (8DPSK) : 2.890 * (800/6)/20 * 8.0 = 154.13 (ms)

Note :

DH5 Packet need 5 time slot for transmitting and 1 time slot for receiving.

Then the system makes worst case 1600/6 hops per second with 79 channels. So the system have each channel 3.3755 times per second and so for 31.6 seconds the system have 106.667 times of appearance.

Each tx-time per appearance of DH5 is 2.890 ms. Dwell time = Tx-time * 106.667 = 308.27 (ms)





8.6. Conducted Spurious Emissions

Limit

Conducted > 20 dBc

Test Configuration



Test Procedure

Conducted RF measurements of the transmitter output were made to confirm that the EUT antenna port conducted emissions meet the specified limit and to identify any spurious signals that require further investigation or measurements on the radiated emissions site.

The transmitter output is connected to the spectrum analyzer.

The Spectrum Analyzer is set to (7.8.8 in ANSI 63.10-2013 & Procedure 8.5 and 8.6 in KDB 558074 v05r02)

- 1) Span: 30 MHz to 10 times the operating frequency in GHz.
- 2) RBW: 100 kHz
- 3) VBW: 300 kHz
- 4) Sweep: Coupled
- 5) Detector: Peak

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

This test is performed with hopping off.



Factors for frequency

Freq(MHz)	Factor(dB)
30	7.32
100	7.33
200	7.35
300	7.27
400	7.28
500	7.32
600	7.36
700	7.44
800	7.53
900	7.62
1000	7.68
2000	7.77
2400*	8.04
2500*	8.10
3000	8.21
4000	8.25
5000	8.27
6000	8.40
7000	8.52
8000	8.55
9000	8.60
10000	8.62
11000	8.62
12000	8.80
13000	8.88
14000	8.13
15000	8.32
16000	8.48
17000	8.53
18000	8.62
19000	8.75
20000	8.88
21000	9.06
22000	9.14
23000	9.04
24000	9.26
25000	9.24
26000	9.32

Note : 1. '*' is fundamental frequency range.

2. Factor = Cable loss(2 EA) + Splitter loss(6 dB) + Attenuator(20 dB)



8.7. Radiated Test

<u>Limit</u>

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



Test Configuration

Below 30 MHz







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 and Parallel to the ground plane 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 \geq 3*RBW
- 9. Total = Reading Value + Antenna Factor(A.F) + Cable Loss(C.L) + Distance Factor(D.F)



KDB 414788 OFS and Chamber Correlation Justification

Base on FCC 15.31 (f) (2): measurements may be performed at a distance closer than that specified in the regulations; however, an attempt should be made to avoid making measurements in the near field.

OFS and chamber correlation testing had been performed and chamber measured test result is the worst case test result.

(Worst case: semi-anechoic chamber(10 m chamber))

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. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.

4. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.

- 5. Spectrum Setting
 - (1) Measurement Type(Peak):
 - Measured Frequency Range : 30 MHz 1 GHz
 - Detector = Peak
 - Trace = Maxhold
 - RBW = 100 kHz
 - VBW \geq 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)



Test Procedure of Radiated spurious emissions (Above 1 GHz)

- 1. Radiated test is performed with hopping off.
- 2. The EUT is placed on a turntable, which is 1.5 m above ground plane.
- 3. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.

4. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.

- 5. EUT is set 3.75 m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emissions.
- 6. According to SVSWR requirement in ANSI 63.4-2014, We performed the radiated test at 3.75 m distance from center of turn table. So, we applied the distance factor(reference distance : 3 m).
 *Distance extrapolation factor = 20*log (test distance / specific distance) (dB)
- 7. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
- 8. Each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
- 9. The unit was tested with its standard battery.
- 10. Spectrum Setting
 - (1) Measurement Type(Peak):
 - Measured Frequency Range : 1 GHz 25 GHz
 - Detector = Peak
 - Trace = Maxhold
 - RBW = 1 MHz
 - VBW \geq 3*RBW
 - (2) Measurement Type(Average):
 - We performed using a reduced video BW method was done with the analyzer in linear mode
 - Measured Frequency Range : 1 GHz 25 GHz
 - Detector = Peak
 - Trace = Maxhold
 - RBW = 1 MHz
 - VBW $\geq 1/\tau$ Hz, where τ = pulse width in seconds
 - The actual setting value of VBW = 1 kHz
- 11. Measurement value only up to 6 maximum emissions noted, or would be lesser if no specific emissions from the EUT are recorded (ie: margin > 20 dB from the applicable limit) and considered that's already beyond the background noise floor.
- 12. Total = Reading Value + Antenna Factor(A.F) + Cable Loss(C.L) Amp Gain(G) + Distance

Factor(D.F)



Test Procedure of Radiated Restricted Band Edge

- 1. Radiated test is performed with hopping off.
- 2. The EUT is placed on a turntable, which is 1.5 m above ground plane.
- 3. We have done x, y, z planes in EUT and horizontal and vertical polarization in detecting antenna.

4. The turntable shall be rotated for 360 degrees to determine the position of maximum emission level.

- 5. EUT is set 3.75 m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emissions.
- 6. According to SVSWR requirement in ANSI 63.4-2014, We performed the radiated test at 3.75 m distance from center of turn table. So, we applied the distance factor(reference distance : 3 m).
 *Distance extrapolation factor = 20*log (test distance / specific distance) (dB)
- 7. Each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
- 8. The unit was tested with its standard battery.

9. Spectrum Setting

- (1) Measurement Type(Peak):
 - Detector = Peak
 - Trace = Maxhold
 - RBW = 1 MHz
 - VBW \geq 3*RBW
- (2) Measurement Type(Average):
 - Average value of pulsed emissions
 - Unless otherwise specified, when the radiated emission limits are expressed in terms of the average value of the emission and pulsed operation is employed, the average measurement shall determined from the peak field strength after correcting for the worst-case duty cycle as described in section 9.1.
 - DCCF = 20*log₁₀(Pulse width / Period of the pulse train)
- 10. Total(Measurement Type : Peak)
 - = Reading Value + Antenna Factor(A.F) + Cable Loss(C.L) + Distance Factor(D.F)

Total(Measurement Type : Average)

= Peak Reading Value + Antenna Factor(A.F) + Cable Loss(C.L) + Distance Factor(D.F)



- + Duty Cycle Correction Factor
- 11. Duty Cycle Correction Factor (79 channel hopping)
 - a. Time to cycle through all channels = Δ t= τ [ms] x 79 channels = 229.100 ms, where τ = pulse width
 - b. 100 ms/ Δt [ms] = H \rightarrow Round up to next highest integer, H ' =1
 - c. Worst Case Dwell Time = τ [ms] x H ' = 2.9 ms
 - d. Duty Cycle Correction = 20log (Worst Case Dwell Time/ 100ms) dB = -30.752 dB
- 12. Duty Cycle Correction Factor(AFH mode minimum channel number case 20 channels)
 - a. Time to cycle through all channels = Δ t= τ [ms] x 20 channels = 58.00 ms, where τ = pulse width
 - b. 100 ms/ Δt [ms] = H \rightarrow Round up to next highest integer, H ' = 2
 - c. Worst Case Dwell Time = τ [ms] x H ' = 5.800 ms
 - d. Duty Cycle Correction(AFH) = 20log (Worst Case Dwell Time/ 100ms) dB = -24.7314 dB





8.8. 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 μ H/50 ohms line impedance stabilization network (LISN).

	Limits (dBµV)		
Frequency Range (MHZ)	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.
- 5. The EUT is the device operating below 30 MHz.

- For unterminated the Antenna, the AC line conducted tests are performed with the antenna connected

- For terminated the Antenna, the AC line conducted tests are performed with a dummy load connected to the EUT antenna output terminal.

Sample Calculation

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



8.9. Receiver Spurious Emissions

Limit

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

Note:

Measurements for compliance with the limits in table may be performed at distances other than 3 metres.

Test Configuration

30 MHz - 1 GHz





Above 1 GHz



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 3.75 m away from the receiving antenna, which is varied from 1m to 4m to find out the highest emissions.
- 5. According to SVSWR requirement in ANSI 63.4-2014, We performed the radiated test at 3.75 m distance from center of turn table. So, we applied the distance factor(reference distance : 3 m).
 *Distance extrapolation factor = 20*log (test distance / specific distance) (dB)
- 6. Maximum procedure was performed on the six highest emissions to ensure EUT compliance.
- 7. Each emission was to be maximized by changing the polarization of receiving antenna both horizontal and vertical.
- 8. The unit was tested with its standard battery.
- 9. Spectrum Setting
 - (1) Measurement Type(Peak):
 - Measured Frequency Range : 1 GHz 25 GHz



- Detector = Peak
- Trace = Maxhold
- RBW = 1 MHz
- VBW \geq 3*RBW
- (2) Measurement Type(Average):
 - We performed using a reduced video BW method was done with the analyzer in linear mode
 - Measured Frequency Range : 1 GHz 25 GHz
 - Detector = Peak
 - Trace = Maxhold
 - RBW = 1 MHz
 - VBW $\geq 1/\tau$ Hz, where τ = pulse width in seconds
 - The actual setting value of VBW = 1 kHz
- 10. Measurement value only up to 6 maximum emissions noted, or would be lesser if no specific emissions from the EUT are recorded (ie: margin > 20 dB from the applicable limit) and considered that's already beyond the background noise floor.

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



8.10. 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, Stand alone + external accessories(Keyboard, Charging Doc, Earphone, etc)
- Worstcase : Stand alone
- 2. EUT Axis

- Radiated Spurious Emissions : X

- Radiated Restricted Band Edge : X

3. All data rate of operation were investigated and the test results are worst case in highest datarate of each mode.

- GFSK : DH5
- π/4DQPSK : 2-DH5
- 8DPSK : 3-DH5

4. All position of loop antenna were investigated and the test result is a no critical peak found at all positions.

- Position : Horizontal, Vertical, Parallel to the ground plane
- 5. ATC31EYAN & ATC30EYAN were tested and the worst case results are reported.

(Worst case : ATC31EYAN)

AC Power line Conducted Emissions

1. We don't perform powerline conducted emission test. Because this EUT is used with vehicle.

Conducted test

- 1. The EUT was configured with data rate of highest power.
 - GFSK : DH5
 - π/4DQPSK : 2-DH5
 - 8DPSK : 3-DH5
- 2. AFH & Non-AFH were tested and the worst case results are reported.
- (Worst case : Non-AFH)
- 3. ATC31EYAN & ATC30EYAN were tested and the worst case results are reported.

(Worst case : ATC31EYAN)



9. SUMMARY OF TEST RESULTS

Test Description	FCC Part Section(s)	IC Part Section(s)	Test Limit	Test Condition	Test Result
20 dB Bandwidth	§ 15.247(a)(1)	RSS-247, 5.1	N/A		PASS
Occupied Bandwidth	N/A	RSS-GEN, 6.7	N/A	-	N/A
Conducted Maximum Peak Output Power	§ 15.247(b)(1)	RSS-247, 5.1 b)	< 0.125 W	-	PASS
Carrier Frequency Separation	§ 15.247(a)(1)	RSS-247, 5.1 b)	> 25 kHz or >2/3 of the 20dB BW		PASS
Number of Hopping Frequencies	§ 15.247(a)(1)(iii)	RSS-247, 5.1 d)	≥ 15	Conducted	PASS
Time of Occupancy	§ 15.247(a)(1)(iii)	RSS-247, 5.1 d)	< 400 ms		PASS
Conducted Spurious Emissions	§ 15.247(d)	RSS-247, 5.5	> 20 dB for all out-of band emissions	-	PASS
Band Edge (Out of Band Emissions)	§ 15.247(d)	RSS-247, 5.5	> 20 dB for all out-of band emissions	-	PASS
AC Power line Conducted Emissions	§ 15.207(a)	RSS-GEN, 8.8	cf. Section 8.8	-	N/A
Radiated Spurious Emissions	§ 15.247(d), 15.205, 15.209	RSS-GEN, 8.9	cf. Section 8.7		PASS
Radiated Restricted Band Edge	§ 15.247(d), 15.205, 15.209	RSS-GEN, 8.9 RSS-GEN, 8.10	cf. Section 8.7	Radiated	PASS
Receiver Spurious Emissions	N/A	RSS-GEN, 7	cf. Section 8.9		PASS



10. TEST RESULT

10.1 PEAK POWER

Channel	Frequency	Outpu (Gl	Limit	
	(MHZ)	(dBm)	(mW)	(mvv)
Low	2402	3.612	2.297	
Mid	2441	3.957	2.487	125
High	2480	3.535	2.257	

Channel	Frequency	Outpu (8D	Limit	
	(MHZ)	(dBm)	(mW)	(mvv)
Low	2402	1.189	1.315	
Mid	2441	1.897	1.548	125
High	2480	1.773	1.504	

Channel	Frequency	Outpu (π/4D	Limit	
	(MHZ)	(dBm)	(mW)	(mvv)
Low	2402	0.712	1.178	
Mid	2441	1.454	1.398	125
High	2480	1.385	1.376	

Note:

1. Spectrum reading values are not plot data.

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

2. We apply to the offset in the 2.4 GHz range that was rounded off to the closest tenth dB. Actual value of loss for the splitter and cable combination is 8.07 dB at 2402 MHz and is 8.07 dB at 2480 MHz.

So, 8.07 dB is offset. And the offset gap in the 2.4 GHz range do not affect the conducted peak power final result.



Test Plots (GFSK)

Peak Power (CH.0)



Test Plots (GFSK) Peak Power (CH.39)

Agilent Spectr	um Analyzer - Swept SA		CENCE-INT	ALIG	NAUTO I	04:20:04 PM Aug 14, 2010	
Center Fr	req 2.441000000		Trig: Free Run	#Avg Type: R Avg Hold: 1/1	MS	TRACE 123456 TYPE MULLIN	Frequency
10 dB/div	Ref Offset 8.07 dB Ref 20.00 dBm	IFGain:Low	Atten: 22 dB		Mkr1 2	440 862 GHz 3.957 dBm	Auto Tune
10.0			▲ 1				Center Fred 2.441000000 GH:
-10.0							Start Free 2.438529449 GH
-20.0							Stop Free 2.443470551 GH
-40.0							CF Stej 494.110 kH Auto Ma
-60.0							Freq Offse 0 H
-70.0 Center 2.4	41000 GHz	#)/P	60 MU-			Span 4.941 MHz	
#Res BW	3.0 MHZ	#VBW	50 WHZ	Sw	STATUS	00 ms (1001 pts)	



Test Plots (GFSK) Peak Power (CH.78)



Test Plots (8DPSK) Peak Power (CH.0)

Agilent Spectr	um Analyzer - Swept SA					
Center Fr	req 2.402000000	GHz	SENSE:INT	#Avg Type: RMS	UTO 04:30:04 PM Aug 14, 2019 TRACE 123456	Frequency
		PNO: Fast	Trig: Free Run Atten: 22 dB	Avg Hold: 1/1	DET PPPPP	
10 dB/div	Ref Offset 8.07 dB Ref 20.00 dBm			Mkr	1 2.402 006 7 GHz 1.189 dBm	Auto Tune
10.0			1			Center Freq 2.402000000 GHz
0.00						Start Freq 2.398650000 GHz
-20.0						Stop Freq 2.405350000 GHz
-40.0						CF Step 670.000 kHz Auto Man
-60.0						Freq Offset 0 Hz
Center 2.4	02000 GHz	#VBW	50 MHz	Swee	Span 6.700 MHz	
MSG		# U D U		s	STATUS	



Test Plots (8DPSK)

Peak Power (CH.39)

Agilent Spectrum Analyzer - S	Swept SA				
Center Fred 2 441		SENSE:INT	ALIGNAUTO #Avg Type: RMS	04:30:15 PM Aug 14, 2019 TRACE 1 2 3 4 5 6	Frequency
	PNO: Fas IFGain:Lo	t ↔ Trig:Free Run w Atten:22 dB	Avg Hold: 1/1	TYPE MWWWW DET PPPPP	
Ref Offset	8.07 dB) dBm		Mkr1 2	2.440 993 3 GHz 1.897 dBm	Auto Tulle
10.0					Center Freq
10.0		1			2.441000000 GHz
0.00					Start Freq
-10.0					2.437030000 0112
-20.0					Stop Freq 2.444350000 GHz
-30.0					
-40.0					670.000 kHz Auto Man
-50.0					
-60.0					Freq Offset 0 Hz
-70.0					
Center 2.441000 GH #Res BW 3.0 MHz	z #	/BW 50 MHz	Sweep	Span 6.700 MHz	
MSG			STATU	s	

Test Plots (8DPSK) Peak Power (CH.78)





Test Plots (π/4DQPSK)

Peak Power	(CH 0)	
i eak i uwei	(011.0)	



Test Plots (π/4DQPSK) Peak Power (CH.39)

gilent Spectr	um Analyzer - Swept SA					
Center F	req 2.441000000	GHz PNO: Fast ++- Tr IFGain:Low A	rig: Free Run tten: 22 dB	#Avg Type: RMS Avg Hold: 1/1	04:29:40 PM Aug 14, 2019 TRACE 123456 TYPE MUMUUUUU DET PPPPP	Frequency
0 dB/div	Ref Offset 8.07 dB Ref 20.00 dBm			Mkr1 2	.441 033 90 GHz 1.454 dBm	Auto Tun
10.0			1			Center Fre 2.441000000 GF
0.00						Start Fre 2.437610000 GF
0.0						Stop Fre 2.444390000 GP
0.0						CF Ste 678.000 ki <u>Auto</u> Ma
0.0						Freq Offs 0 H
enter 2.4	441000 GHz				Span 6.780 MHz	
Res BW	3.0 MHz	#VBW 50	MHz	Sweep	1.000 ms (1001 pts)	
sg .				STAT	US	



Test Plots (π/4DQPSK)

Peak F	Power	(CH 78)
I Can I	OWCI	





10.2 BAND EDGES

Without hopping

Outside Frequency Band	GFSK	8DPSK	π/4DQPSK	Limit
Outside Frequency Band	(dB)	(dB)	(dB)	(dBc)
Lower	60.383	56.936	56.428	20
Upper	63.506	60.179	60.082	20

With hopping

Quite de Frequency Dand	GFSK	8DPSK	π/4DQPSK	Limit
Outside Frequency Band	(dB)	(dB)	(dB)	(dBc)
Lower	61.414	57.416	57.276	20
Upper	60.172	59.995	59.813	20

Note :

1. Spectrum reading values are not plot data.

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

2. We apply to the offset in the 2.4 GHz range that was rounded off to the closest tenth dB.

Actual value of loss for the splitter and cable combination is 8.07 dB at 2402 MHz and is 8.07 dB at 2480 MHz.

So, 8.07 dB is offset. And the offset gap in the 2.4 GHz range do not affect the conducted peak power final result.



Test Plots without hopping (GFSK)

Band Edges (CH.0)



Test Plots without hopping (GFSK) Band Edges (CH.78)





Test Plots without hopping (8DPSK)

Band Edges (CH.0)



Test Plots without hopping (8DPSK) Band Edges (CH.78)





Test Plots without hopping (π /4DQPSK)

Band Edges (CH.0)



Test Plots without hopping (π /4DQPSK) Band Edges (CH.78)





Test Plots with hopping (GFSK)

Band Edges (CH.0)



Test Plots with hopping (GFSK)







Test Plots with hopping (8DPSK)

Band Edges (CH.0)



Test Plots with hopping (8DPSK)

Band Edges (CH.78)





Test Plots with hopping (π /4DQPSK)

Band Edges (CH.0)



Test Plots with hopping ($\pi/4DQPSK$)





10.3 FREQUENCY SEPARATION / OCCUPIED BANDWIDTH (99% BW)

99% BW (kHz)						
Channel	GFSK	8DPSK	π/4DQPSK			
CH.0	897.51	1219.5	1211.9			
CH.39	896.44	1217.3	1214.7			
CH.78	901.86	1218.3	1213.2			

20dB BW (kHz)					
Channel	GFSK	8DPSK	π/4DQPSK		
CH.0	981	1340	1355		
CH.39	988	1340	1356		
CH.78	1001	1341	1356		

	Limit		
GFSK	8DPSK	π/4DQPSK	(kHz)
			>25 kHz
998	991	1004	or
			>2/3 of the 20dB BW



Test Plots (GFSK)

Channel Separation



Test Plots (8DPSK) Channel Separation





Test Plots (π/4DQPSK)

Channel Separation





Test Plots (GFSK)

20 dB Bandwidth & Occupied Bandwidth (CH.0)



Test Plots (GFSK)

20 dB Bandwidth & Occupied Bandwidth (CH.39)





Test Plots (GFSK)

20 dB Bandwidth & Occupied Bandwidth (CH.78)



Test Plots (8DPSK)

20 dB Bandwidth & Occupied Bandwidth (CH.0)





Test Plots (8DPSK)

20 dB Bandwidth & Occupied Bandwidth (CH.39)



Test Plots (8DPSK)

20 dB Bandwidth & Occupied Bandwidth (CH.78)





Test Plots (π /4DQPSK)

20 dB Bandwidth & Occupied Bandwidth (CH.0)



Test Plots (π /4DQPSK)

20 dB Bandwidth & Occupied Bandwidth (CH.39)





Test Plots (π/4DQPSK)

20 dB Bandwidth & Occupied Bandwidth (CH.78)







10.4 NUMBER OF HOPPING FREQUENCY

GFSK	8DPSK	π/4DQPSK	Limit	
79	79	79	>15	

Note :

In case of AFH mode, minimum number of hopping channels is 20.



Test Plots (GFSK) Number of Channels (2.4 GHz - 2.441 GHz)



Test Plots (GFSK)

Number of Channels (2.441 GHz - 2.4835 GHz)





Test Plots (8DPSK)

Number of Channels (2.4 GHz - 2.441 GHz)



Test Plots (8DPSK)

Number of Channels (2.441 GHz - 2.4835 GHz)





Test Plots (π/4DQPSK) Number of Channels (2.4 GHz - 2.441 GHz)



Test Plots (π /4DQPSK)

Number of Channels (2.441 GHz - 2.4835 GHz)



10.5 TIME OF OCCUPANCY (DWELL TIME)

	Channel	GFSK	8DPSK	π/4DQPSK
Pulse – Time (ms) –	Low	2.890	2.890	2.890
	Mid	2.890	2.890	2.890
	High	2.885	2.890	2.890

Non-AFH Mode

	Channel	GFSK	8DPSK	π/4DQPSK	Period Time (s)	Limit (ms)
Total of	Low	308.27	308.27	308.27	31.6	
Dwell	Mid	308.27	308.27	308.27	31.6	400
(ms)	High	307.73	308.27	308.27	31.6	

AFH Mode

	Channel	GFSK	8DPSK	π/4DQPSK	Period Time (s)	Limit (ms)
Total of	Low	154.13	154.13	154.13	8.0	
Dwell	Mid	154.13	154.13	154.13	8.0	400
(ms)	High	153.87	154.13	154.13	8.0	

Test Plots (GFSK) Dwell Time (CH.0)

Test Plots (GFSK) Dwell Time (CH.39)

Test Plots (GFSK) Dwell Time (CH.78)

Test Plots (8DPSK) Dwell Time (CH.0)

Test Plots (8DPSK)

Dwell Time (CH.39)

Test Plots (8DPSK) Dwell Time (CH.78)

Test Plots (π/4DQPSK)

Dwell Time (CH.0)

Test Plots (π/4DQPSK) Dwell Time (CH.39)

Test Plots (π/4DQPSK)

10.6 SPURIOUS EMISSIONS

10.6.1 CONDUCTED SPURIOUS EMISSIONS

Test Result : please refer to the plot below.

In order to simplify the report, attached plots were only the worst case channel and data rate.

Test Plots (GFSK)- 30 MHz - 1 GHz

Spurious Emission (CH.39)

Test Plots (GFSK)- 1 GHz – 3 GHz

Spurious Emission (CH.39)

