Report on the Radio Testing

For

Universal Electronics Inc.

on

XR100-UQ

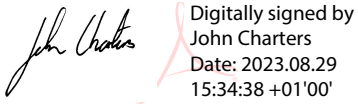
Report no. TRA-061708-47-00B

29th Aug 2023

Report Number: TRA-061708-47-00B
Issue: B

REPORT ON THE RADIO TESTING OF A
Universal Electronics Inc.
XR100-UQ
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.247

TEST DATE: 13th June 2023 to 14th June 2023

Tested by:		Steven Garwell
Written by:		Steven Garwell Radio Test Engineer
Approved by:	 Digitally signed by John Charters Date: 2023.08.29 15:34:38 +01'00'	John Charters Department Manager - Radio
Date:	29th Aug 2023	

1 Revision Record

Issue Number	*Issue Date*	*Revision History*
A	29th Aug 2023	Original
B	29th Aug 2023	General updates and technical corrections throughout document

2 Summary

TEST REPORT NUMBER:	TRA-061708-47-00B
WORKS ORDER NUMBER:	TRA-061708-00
PURPOSE OF TEST:	Certification
TEST SPECIFICATION:	47CFR15.247
EQUIPMENT UNDER TEST (EUT):	XR100-UQ
FCC IDENTIFIER:	MG3-R326810
EUT SERIAL NUMBER(S):	MAC Address: E4:A6:34:04:BB:53 (radiated), MAC Address: E4:A6:34:04:CA:32 (conducted)
AGENT:	Universal Electronics Inc.
AGENT ADDRESS:	15147 North Scottsdale Road Suite H300 Scottsdale AZ 85254
AGENT CONTACT:	Jesse Mendez ☎ 714 918-9701 ✉ jmendez@uei.com
TEST DATE:	13th June 2023 to 14th June 2023
TESTED BY:	Steven Garwell Element

2.1 Test Summary

Test Method and Description		*Requirement Clause 47CFR15*	*Applicable to this equipment*	*Result / Note*
Radiated spurious emissions (restricted bands of operation and cabinet radiation)		15.247 (d)	☒	*PASS*
AC power line conducted emissions		15.207	☐	*Note 1*
Occupied bandwidth		15.247 (a) (2)	☒	*PASS*
Conducted carrier power	Peak	15.247 (b) (3)	☒	*PASS*
	Max.		☐	
Out of band emissions		15.247 (d)	☒	*PASS*
Power spectral density		15.247 (e)	☒	*PASS*
Calculation of duty correction		-	☒	*Note 2*

Specific Note:

1. The EUT is a battery powered device.
2. Client declaration – see appendix A

General Notes:

The results contained in this report relate only to the items tested, in the condition at time of test, and were obtained in the period between the date of initial receipt of samples and the date of issue of the report.

The apparatus was set up and exercised using the configurations, modes of operation and arrangements defined in this report only. Any modifications made are identified in Section 8 of this report.

Particular operating modes, apparatus monitoring methods and performance criteria required by the standards tested to have been performed except where identified in Section 5.2 of this test report (Deviations from Test Standards).

General notes

The decision rule for compliance is not inherent within this specification and compliance is based on the customer requesting a simple acceptance rule based on understanding and acceptance of Elements Measurement Uncertainty values.

3 Contents

4 Introduction

This report TRA-061708-47-00B presents the results of the Radio testing on a Universal Electronics Inc., XR100-UQ to specification 47CFR15 Radio Frequency Devices.

The testing was carried out for Universal Electronics Inc. by Element, at the address detailed below.

☐	Element Hull Unit E South Orbital Trading Park Hedon Road Hull HU9 1NJ UK	☒	Element Skelmersdale Unit 1 Pendle Place Skelmersdale West Lancashire WN8 9PN UK	☐	Element Surrey Hills Unit 15 B Henley Business Park Pirbright Road Normandy Guildford GU3 2DX UK

This report details the configuration of the equipment, the test methods used and any relevant modifications where appropriate.

All test and measurement equipment under the control of the laboratory and requiring calibration is subject to an established programme and procedures to control and maintain measurement standards. The quality management system meets the principles of ISO 9001, and has quality control procedures for monitoring the validity of tests undertaken. Records and sufficient detail are retained to establish an audit trail of calibration records relating to its test results for a defined period. Under control of the established calibration programme, key quantities or values of the test & measurement instrumentation are within specification and comply with the relevant traceable internationally recognised and appropriate standard specifications, which are UKAS calibrated as such where these properties have a significant effect on results. Participation in inter-laboratory comparisons and proficiency testing ensures satisfactory correlation of results conform to Elements own procedures, as well as statistical techniques for analysis of test data providing the appropriate confidence in measurements.

Throughout this report EUT denotes equipment under test.

FCC Site Listing:
The test laboratory is accredited for the above sites under the US-UK MRA,

Designation number(s):

Element Hull	UK2007
Element Skelmersdale	UK2020

The test site requirements of ANSI C63.4-2014 are met up to 1GHz.

The test site SVSWR requirements of CISPR 16-1-4:2010 are met over the frequency range 1 GHz to 18 GHz.

5 Test Specifications

5.1 Normative References

- FCC 47 CFR Ch. I – Part 15 – Radio Frequency Devices.
- ANSI C63.10-2013 – American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.
- ANSI C63.4-2014 – American National Standard for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz.

5.2 Deviations from Test Standards

There were no deviations from the test standard.

6 Glossary of Terms

§	denotes a section reference from the standard, not this document
AC	Alternating Current
ANSI	American National Standards Institute
BW	bandwidth
C	Celsius
CFR	Code of Federal Regulations
CW	Continuous Wave
dB	decibel
dBm	dB relative to 1 milliwatt
DC	Direct Current
DSSS	Direct Sequence Spread Spectrum
EIRP	Equivalent Isotropically Radiated Power
ERP	Effective Radiated Power
EUT	Equipment under Test
FCC	Federal Communications Commission
FHSS	Frequency Hopping Spread Spectrum
Hz	hertz
IC	Industry Canada
ITU	International Telecommunication Union
LBT	Listen before Talk
m	metre
max	maximum
MIMO	Multiple Input and Multiple Output
min	minimum
MRA	Mutual Recognition Agreement
N/A	Not Applicable
PCB	Printed Circuit Board
PDF	Portable Document Format
Pt-mpt	Point-to-multipoint
Pt-pt	Point-to-point
RF	Radio Frequency
RH	Relative Humidity
RMS	Root Mean Square
Rx	receiver
s	second
SVSWR	Site Voltage Standing Wave Ratio
Tx	transmitter
UKAS	United Kingdom Accreditation Service
V	volt
W	watt
Ω	ohm

7 Equipment under Test

7.1 EUT Identification

- Name: XR100-UQ
- Serial Number(s): MAC Address: E4:A6:34:04:BB:53 (radiated),
  MAC Address: E4:A6:34:04:CA:32 (conducted)
- Model Number: XR100
- Software Revision: PTC-UE878NME-CFG-A-DIF
- Build Level / Revision Number: 103.1.0.3

7.2 System Equipment

Equipment listed below forms part of the overall test setup and is required for equipment functionality and/or monitoring during testing. The compliance levels achieved in this report relate only to the EUT and not items given in the following list.

Not Applicable – No support/monitoring equipment required.

7.3 EUT Mode of Operation

The EUT was setup to transmit a permanently modulated carrier with 100% Duty cycle at a power setting of 8. The settings were sent to the EUT via a USB / Serial adaptor from Radio Control Console 4.0.0.0 program provided by the manufacturer. The adaptor was disconnected during test.

7.4 EUT Radio Parameters

7.4.1 General

Frequency of operation:	2402 MHz – 2480 MHz
Modulation type(s):	GFSK
Occupied channel bandwidth(s):	1 MHz
Channel spacing:	2 MHz
ITU emission designator(s):	F1D
Declared output power(s):	+8dBm at the RF port pin
Nominal Supply Voltage:	3.0 Vdc Via 2x AAA Alkaline batteries
Antenna Type & Gain:	PCB trace antenna (dipole configuration); +0.28dBi

7.4.2 Product specific declarations

Multiple antenna configuration(s), e.g. MIMO:	Single
Fixed pt-pt operations (yes/no):	No
Installation manual advice on pt-pt operational restrictions (yes/no):	N/A
Fixed pt-mpt operations (yes/no):	No
Simultaneous tx (yes/no):	N/A

7.5 EUT Description

The EUT is a hand held battery operated infra-red and BLE remote control.

8 Modifications

No modifications were performed during this assessment.

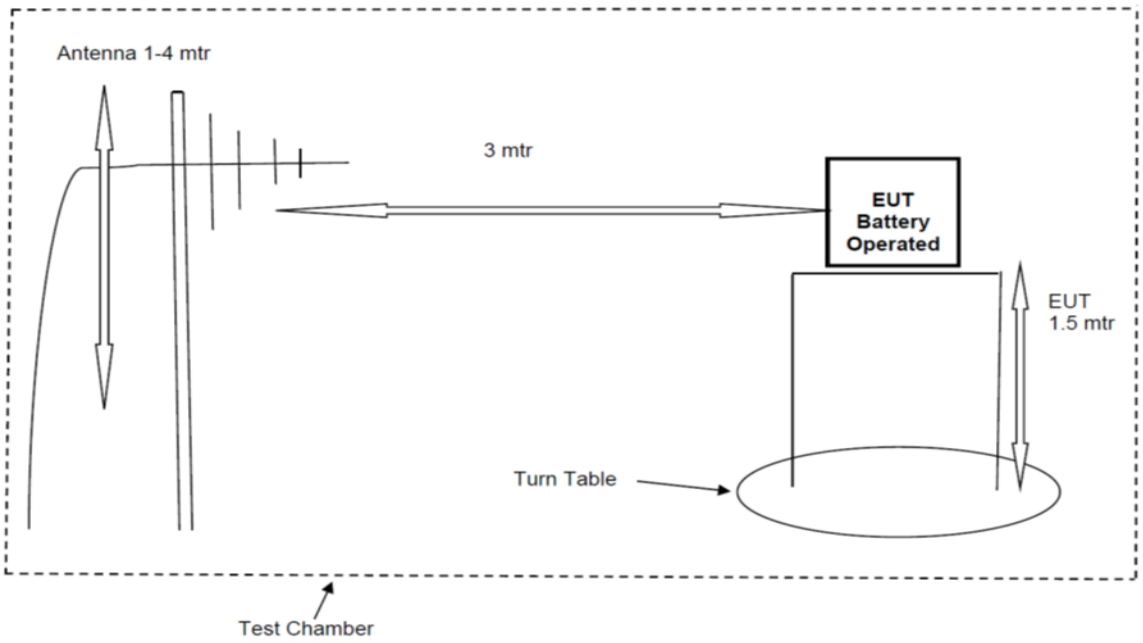
9 EUT Test Setup

9.1 Block Diagram

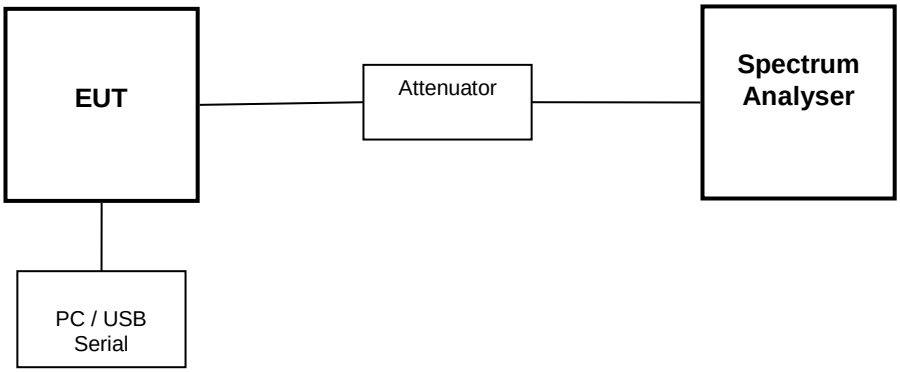
The following diagram shows basic EUT interconnections:

The EUT is a battery powered standalone device

Radiated test setup

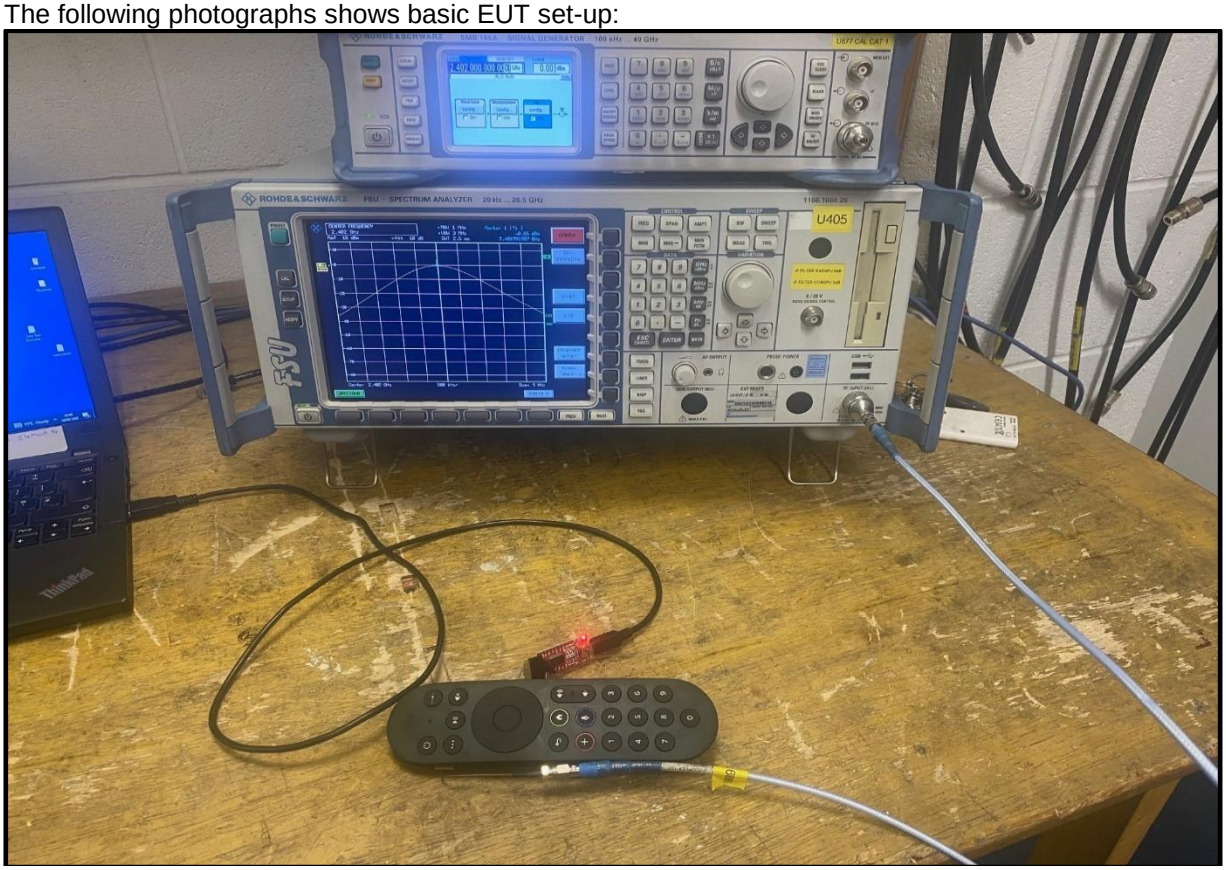


Bench test set-up

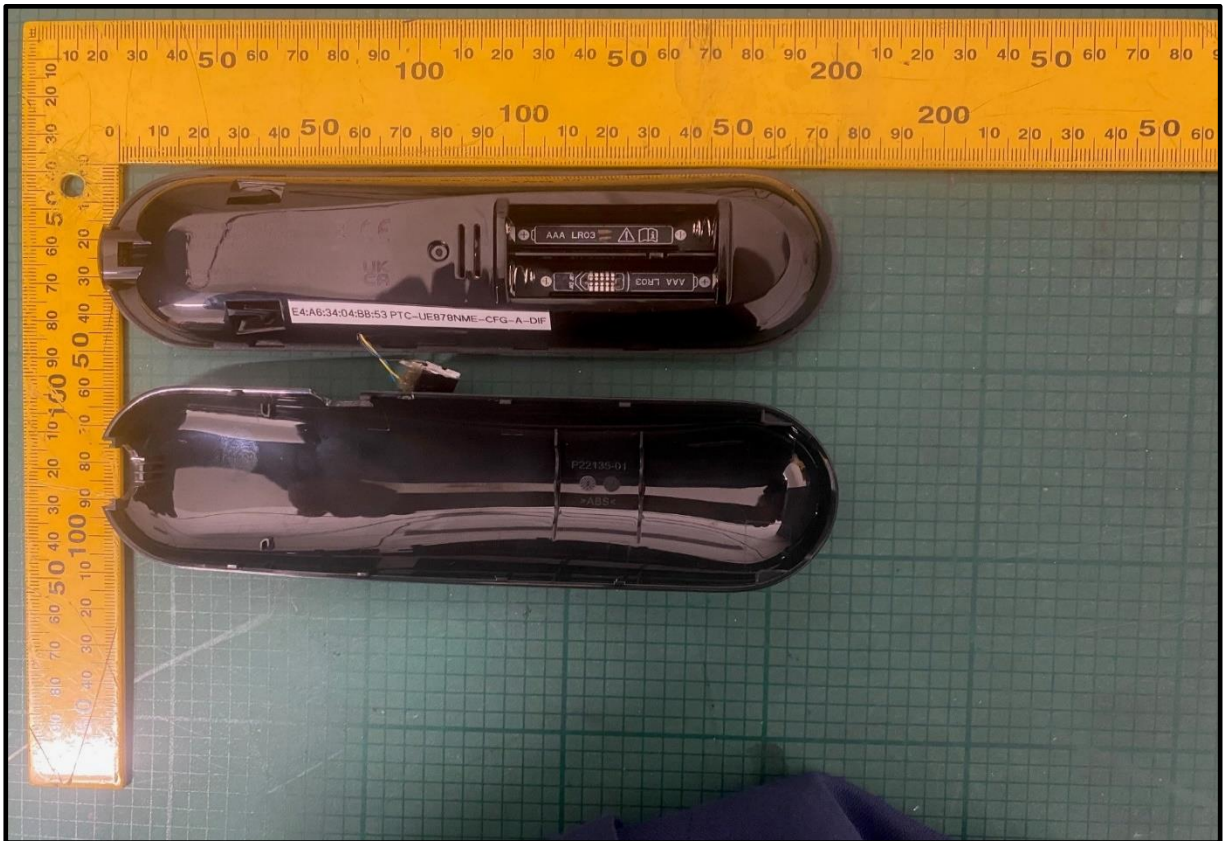


9.2 General Set-up Photographs

The following photographs shows basic EUT set-up:




element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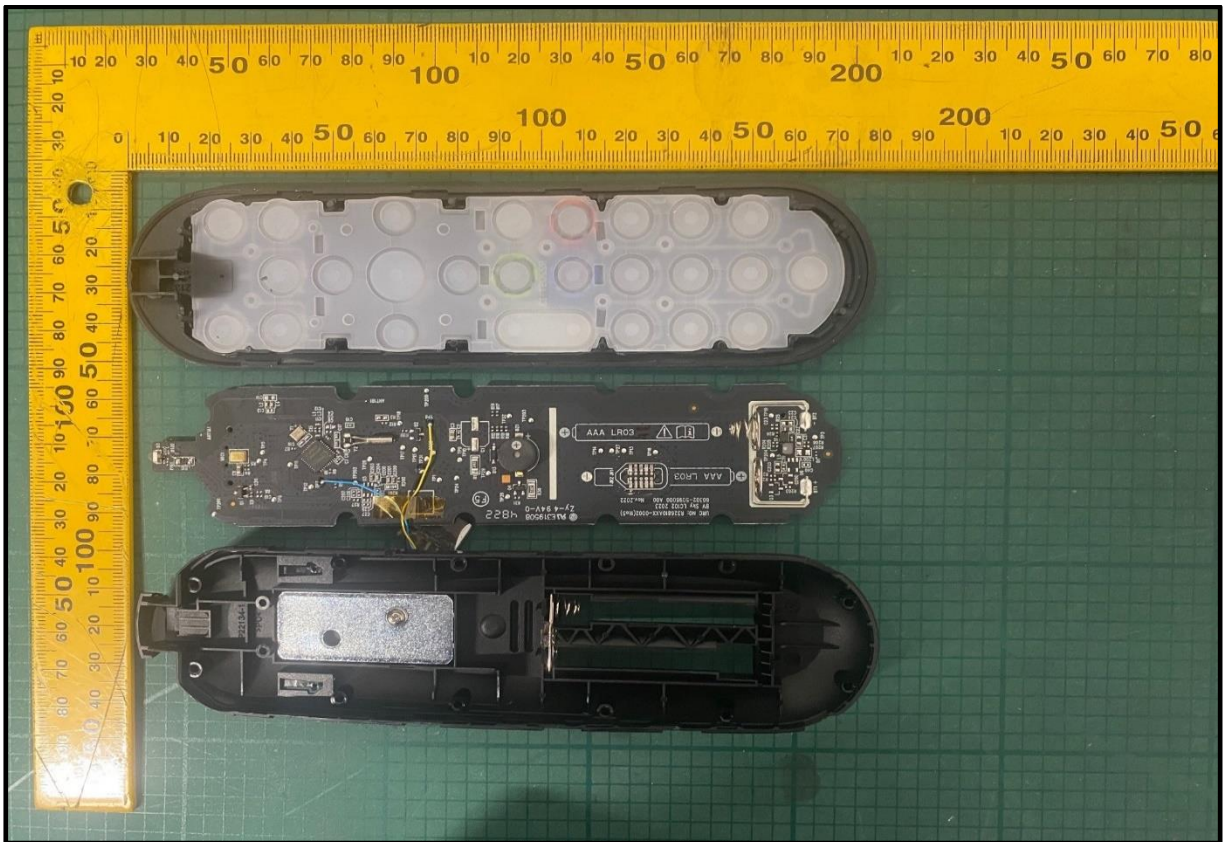
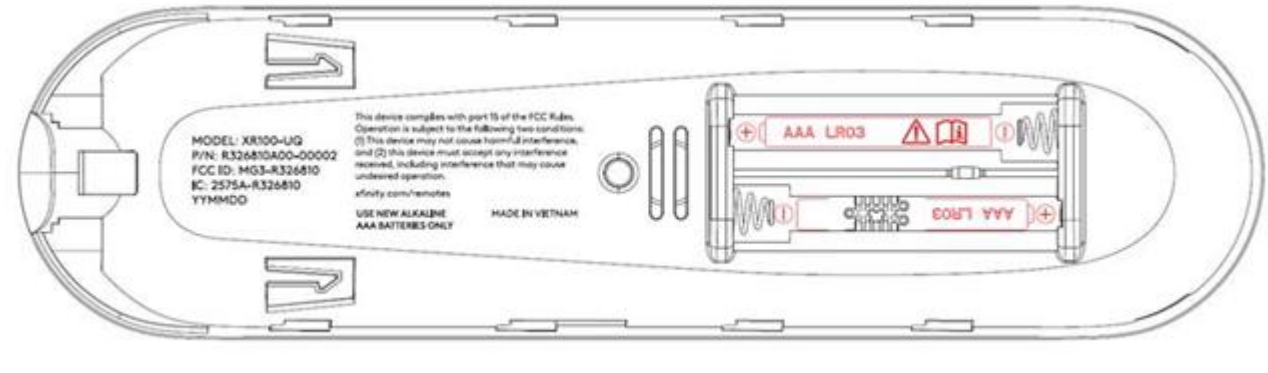
E4:A6:34:04:B8:53 PTC-UE878NME-CFG-A-DIF



Printing



9.3 Measurement software

Where applicable, the following software was used to perform measurements contained within this report.

Element Emissions R5

10 General Technical Parameters

10.1 Normal Conditions

The EUT was tested under the normal environmental conditions of the test laboratory, except where otherwise stated. The normal power source applied was 3.0 Vdc via 2 x AAA Alkaline batteries.

10.2 Varying Test Conditions

There are no specific frequency stability requirements for the type of device. The results contained in this report demonstrate that the occupied bandwidth is contained within the authorised band.

Variation of supply voltage is required to ensure stability of the declared output power. During carrier power testing the following variations were made:

	Category	***Nominal***	***Variation***
☐	Mains	110 Vac +/-2 %	85 % and 115 %
☒	Battery	New battery	N/A

11 Radiated emissions

11.1 Definitions

Spurious emissions
Emissions on a frequency or frequencies, which are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products and frequency conversion products, but exclude out-of-band emissions.

Restricted bands
A frequency band in which intentional radiators are permitted to radiate only spurious emissions but not fundamental signals.

11.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Chamber 01
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Frequencies Measured:	2402 MHz, 2442 MHz & 2480 MHz
Deviations from Standard:	None
Measurement BW:	30 MHz to 1 GHz: 120 kHz; Above 1 GHz: 1 MHz
Measurement Detector:	Up to 1 GHz: quasi-peak; Above 1 GHz: RMS average and Peak

Environmental Conditions (Normal Environment)

Temperature: 23 °C	+15 ºC to +35 ºC (as declared)
Humidity: 59 % RH	20 % RH to 75 % RH (as declared)
Supply: 3.0 Vdc	3.0 Vdc (as declared)

11.3 Test Limit

Unwanted emissions that fall within the restricted frequency bands shall comply with the limits specified:

General Field Strength Limits for License-Exempt Transmitters at Frequencies above 30 MHz

Frequency (MHz)	*Field Strength (µV/m at 3 m)*	*Field Strength (dBµV/m at 3 m)*
30 to 88	100	40.0
88 to 216	150	43.5
216 to 960	200	46.0
Above 960	500	54.0

On frequencies below or equal to 1000 MHz, the limits shown are based on measuring equipment employing a CISPR quasi-peak detector function. On frequencies above 1000 MHz, the radiated emission limits are based on the use of measurement instrumentation employing an average detector function. The limit on peak radio frequency emissions is 20 dB above the maximum permitted average emission limit.

11.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure i, the emissions from the EUT were measured on a spectrum analyzer / EMI receiver.

Radiated electromagnetic emissions from the EUT are checked first by preview scans. Preview scans for all spectrum and modulation characteristics are checked, using a peak detector and where applicable worst-case determined for function, operation, orientation, etc. for both vertical and horizontal polarisations. Pre-scan plots are shown with a peak detector and 100 kHz RBW.

If the EUT connects to auxiliary equipment and is table or floor standing, the configurations prescribed in ANSI C63.10 are followed. Alternatively, a layout closest to normal use (as declared by the provider) is employed, (see EUT setup photographs for more detail).

Emissions between 30 MHz and 1 GHz are measured using calibrated broadband antennas. Emissions above 1 GHz are characterized using standard gain horn antennas. Pre-amplifiers and filters are used where required. Care is taken to ensure that test receiver resolution bandwidth, video bandwidth and detector type(s) meet the regulatory requirements.

For both horizontal and vertical polarizations, the EUT is then rotated through 360 degrees in azimuth until the highest emission is detected. At the previously determined azimuth the test antenna is raised and lowered from 1 to 4 m in height until a maximum emission level is detected, this maximum value is recorded.

Power values measured on the test receiver / analyzer are converted to field strength, FS, in dBµV/m at the regulatory distance, using:

$$FS = PR + CL + AF – PA + DC – CF$$

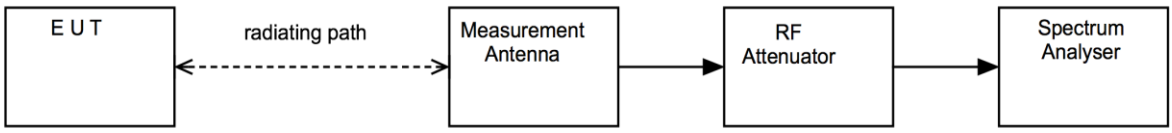
$$Factor = CL + AF – PA$$

Where,

PR is the power recorded on the receiver / spectrum analyzer in dBµV;
CL is the cable loss in dB;
AF is the test antenna factor in dB/m;
PA is the pre-amplifier gain in dB (where used);
DC is the duty correction factor in dB (where used, e.g. harmonics of pulsed fundamental);
CF is the distance factor in dB (where measurement distance different to limit distance);

This field strength value is then compared with the regulatory limit.

Figure i Test Setup

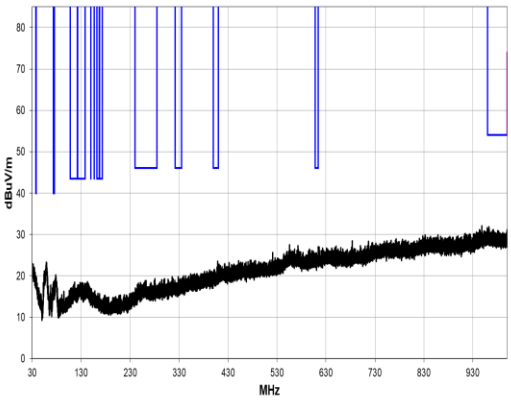


11.5 Test Equipment

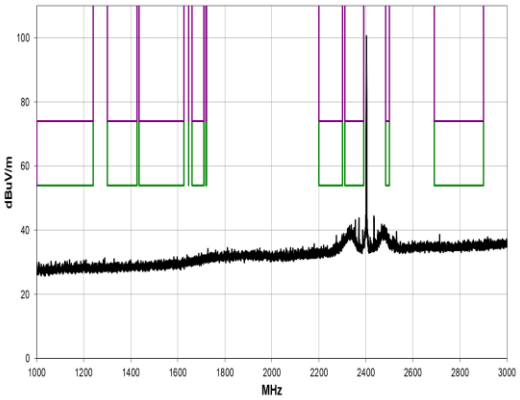
Equipment Description	*Manufacturer*	*Equipment Type*	*Element No*	*Due For Calibration*
Radiated Test Software	Element	Emissions R5	REF9000	Cal not required
Chamber 1	Rainford EMC	ATS	U387	2023-10-24
Spectrum Analyser	R&S	FSU50	U544	2023-11-18
Pre Amp	Agilent	8449B	L572	2023-10-24
Horn Antenna	EMCO	3115	L138	2024-05-23
2.4G Band Stop Filter	BSC	SN 4478	U543	2024-02-08
High Pass Filter	Atlantic Microwave	AFH-07000	U558	2024-02-13
Pre Amp	AMETEK	LNA6901	U711	2024-04-12
Bilog	Chase	CBL611/B	U573	2024-10-14
Horn 18-26GHz (&U330)	Flann	20240-20	L300	2024-06-30

11.6 Test Results

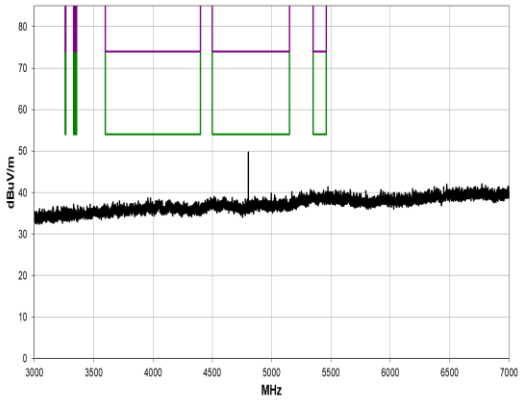
Frequency: 2402 MHz, Power Setting: 8



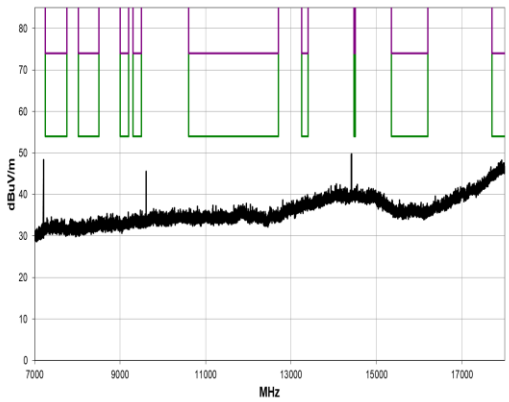
30 MHz to 1 GHz



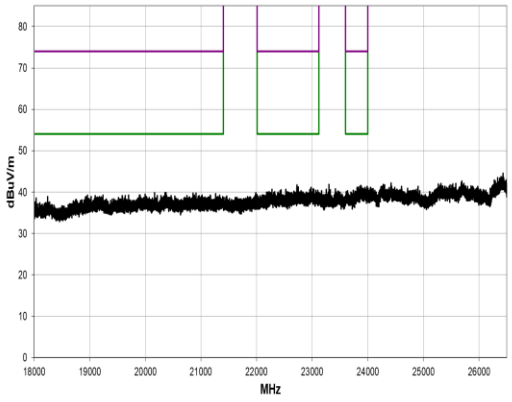
1 GHz to 3 GHz



3 GHz to 7 GHz



7 GHz to 18 GHz



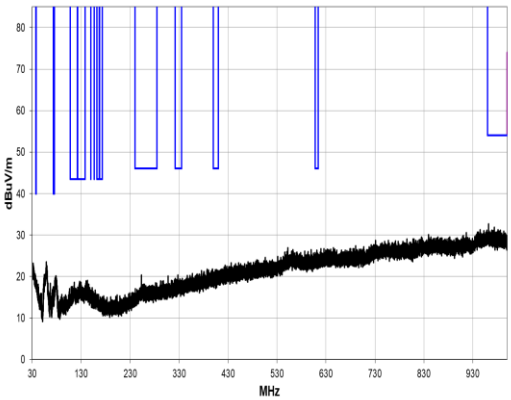
18 GHz to 26.5 GHz

Freq (MHz)	Amplitude (dBuV)	Factor (dB/m)	Antenna Height (meters)	Azimuth (degrees)	Duty Cycle Correction Factor (dB)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)
4804.508	51.5	5.3	1.5	174.2	0.0	0.0	Horz	PK	0.0	56.8	74.0	-17.2
4804.583	47.8	5.3	1.5	69.1	0.0	0.0	Vert	PK	0.0	53.1	74.0	-20.9
4803.442	42.8	5.3	1.5	174.2	-17.3	0.0	Horz	AV	0.0	30.8	54.0	-23.2
4803.400	36.2	5.3	1.5	69.1	-17.3	0.0	Vert	AV	0.0	24.2	54.0	-29.8

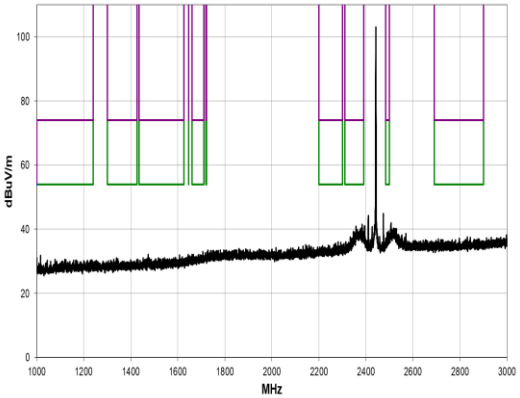
Note: Duty cycle correction factor derived from protocol – see appendix A

Tx duty cycle: 1.360/10 = 13.6%
Corresponding duty cycle correction factor is 20 * Log_{10}(0.360) = -17.32 dB.

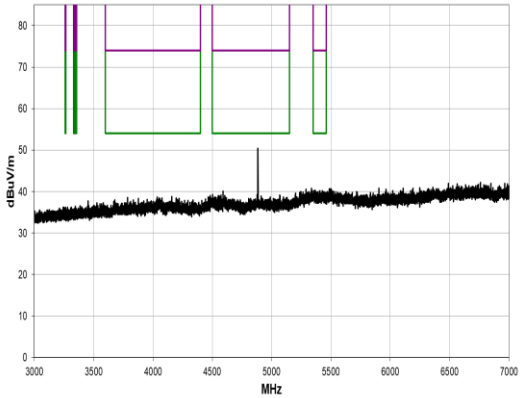
Frequency: 2442 MHz, Power Setting: 8



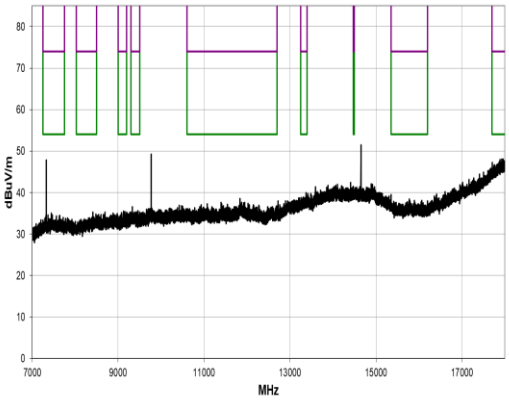
30 MHz to 1 GHz



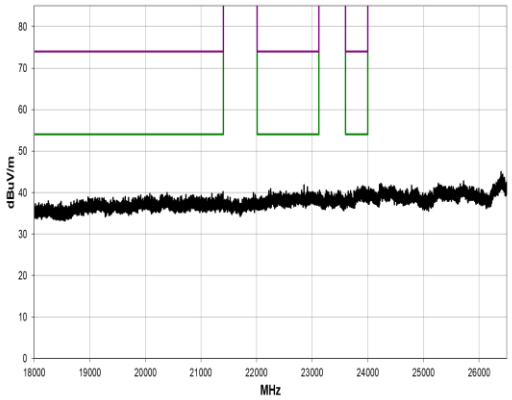
1 GHz to 3 GHz



3 GHz to 7 GHz



7 GHz to 18 GHz



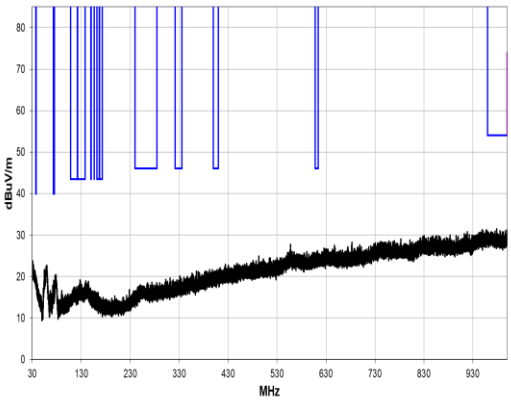
18 GHz to 26.5 GHz

Freq (MHz)	Amplitude (dBuV)	Factor (dB/m)	Antenna Height (meters)	Azimuth (degrees)	Duty Cycle Correction Factor (dB)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)
4884.475	51.0	5.8	1.5	47.2	0.0	0.0	Horz	PK	0.0	56.8	74.0	-17.2
4884.275	47.1	5.8	1.5	316.1	0.0	0.0	Vert	PK	0.0	52.9	74.0	-21.1
4883.517	42.0	5.8	1.5	47.2	-17.3	0.0	Horz	AV	0.0	30.5	54.0	-23.5
4884.583	34.9	5.8	1.5	316.1	-17.3	0.0	Vert	AV	0.0	23.4	54.0	-30.6
7325.208	53.3	10.1	1.5	353.2	0.0	0.0	Horz	PK	-9.5	53.9	74.0	-20.1
7326.925	48.8	10.1	1.7	19.0	0.0	0.0	Vert	PK	-9.5	49.4	74.0	-24.6
7325.292	44.5	10.1	1.5	353.2	-17.3	0.0	Horz	AV	-9.5	27.8	54.0	-26.2
7326.717	38.3	10.1	1.7	19.0	-17.3	0.0	Vert	AV	-9.5	21.6	54.0	-32.4

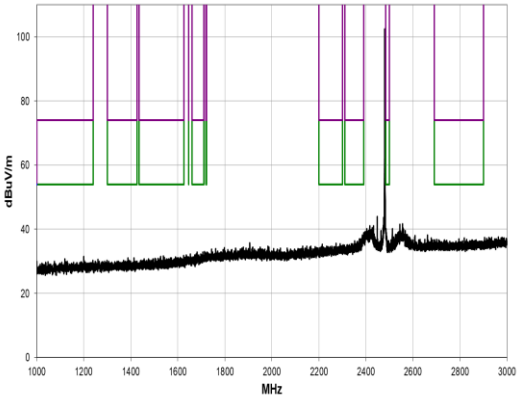
Note: Duty cycle correction factor derived from protocol – see appendix A

Tx duty cycle: 1.360/10 = 13.6%
Corresponding duty cycle correction factor is 20 * Log_{10}(0.360) = -17.32 dB.

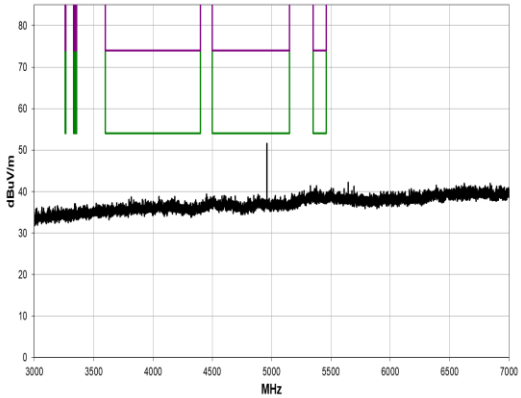
Frequency: 2480 MHz, Power Setting: 8



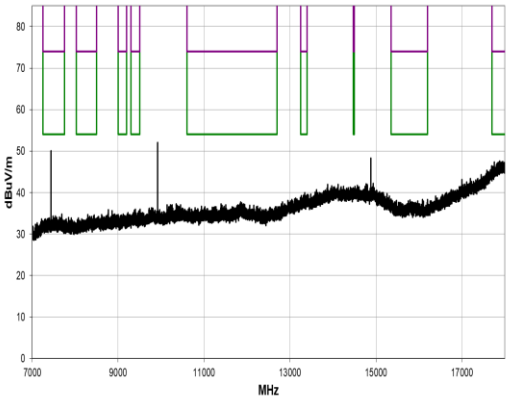
30 MHz to 1 GHz



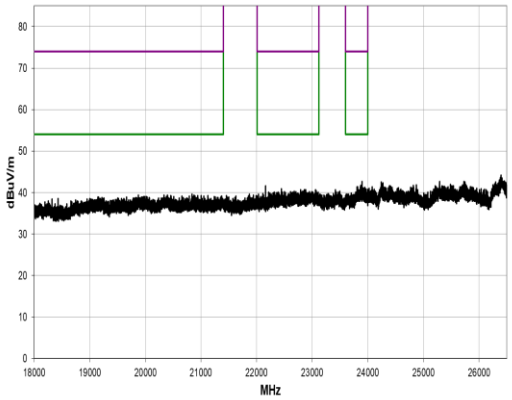
1 GHz to 3 GHz



3 GHz to 7 GHz



7 GHz to 18 GHz



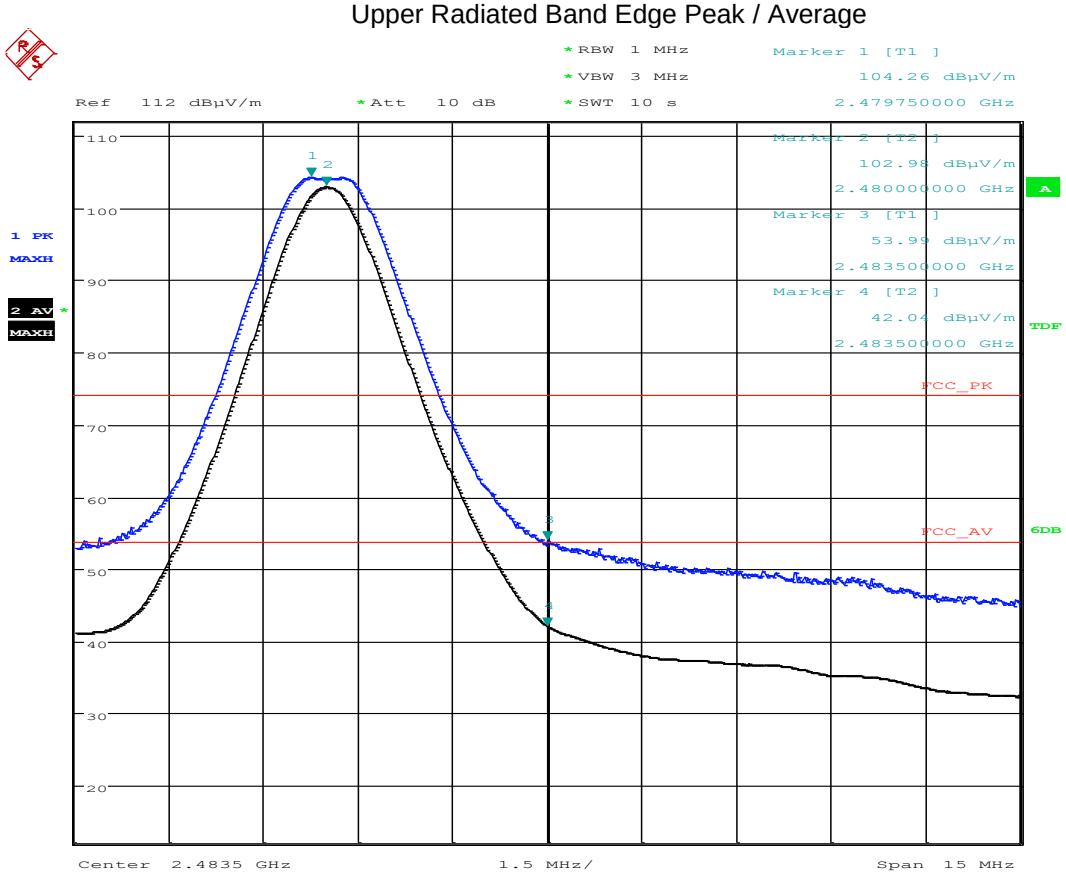
18 GHz to 26.5 GHz

Freq (MHz)	Amplitude (dBuV)	Factor (dB/m)	Antenna Height (meters)	Azimuth (degrees)	Duty Cycle Correction Factor (dB)	External Attenuation (dB)	Polarity/ Transducer Type	Detector	Distance Adjustment (dB)	Adjusted (dBuV/m)	Spec. Limit (dBuV/m)	Compared to Spec. (dB)
4959.658	52.0	6.1	1.7	339.9	0.0	0.0	Horz	PK	0.0	58.1	74.0	-15.9
4960.375	49.4	6.1	1.7	178.9	0.0	0.0	Vert	PK	0.0	55.5	74.0	-18.5
4960.450	43.8	6.1	1.7	339.9	-17.3	0.0	Horz	AV	0.0	32.6	54.0	-21.4
4960.358	39.8	6.1	1.7	178.9	-17.3	0.0	Vert	AV	0.0	28.6	54.0	-25.4
7440.692	55.1	9.8	1.5	353.2	0.0	0.0	Horz	PK	-9.5	55.4	74.0	-18.6
7439.200	51.2	9.8	1.5	25.9	0.0	0.0	Vert	PK	-9.5	51.5	74.0	-22.5
7440.750	46.9	9.8	1.5	353.2	-17.3	0.0	Horz	AV	-9.5	29.9	54.0	-24.1
7440.817	41.2	9.8	1.5	25.9	-17.3	0.0	Vert	AV	-9.5	24.2	54.0	-29.8

Note: Duty cycle correction factor derived from protocol – see appendix A

Tx duty cycle: 1.360/10 = 13.6%
Corresponding duty cycle correction factor is 20 * Log_{10}(0.360) = -17.32 dB

Upper Radiated Band Edge Peak / Average



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12 Occupied Bandwidth

12.1 Definition

The emission bandwidth (x dB) is defined as the frequency range between two points, one above and one below the carrier frequency, at which the spectral density of the emission is attenuated x dB below the maximum in-band spectral density of the modulated signal.

The 99% emission bandwidth is defined as the frequency range between two points, one above and the other below the carrier frequency, within which 99% of the total transmitted power of the fundamental transmitted emission is contained.

12.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	6 dB Bandwidth: ANSI C63.10-2013, Clause 11.8
EUT Frequencies Measured:	2402 MHz, 2442 MHz & 2480 MHz
EUT Channel Bandwidths:	1 MHz
EUT Test Modulations:	GFSK
Deviations From Standard:	None
Measurement BW:	100 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	300 kHz
Measurement Span: (requirement 2 to 5 times OBW)	3 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 25 °C	+15 ºC to +35 ºC (as declared)
Humidity: 46 % RH	20 % RH to 75 % RH (as declared)

12.3 Test Limit

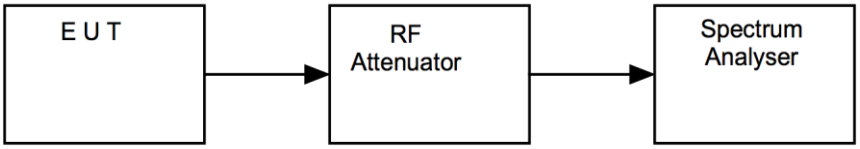
The minimum -6 dB bandwidth shall be at least 500 kHz.

12.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure iii, the bandwidth of the EUT was measured on a spectrum analyser.

The measurements were performed with EUT set at its maximum duty. All modulation schemes, data rates and power settings were used to observe the worst-case configuration in each bandwidth.

Figure iii Test Setup

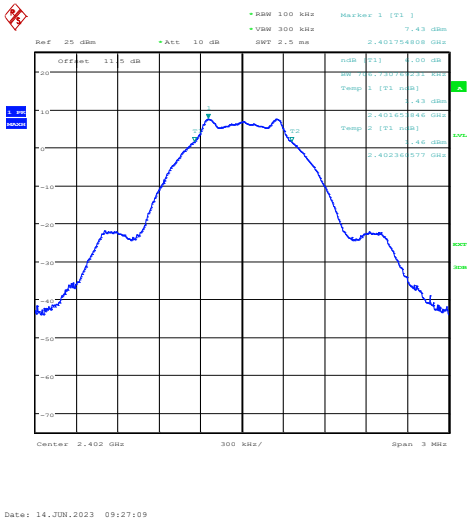


12.5 Test Equipment

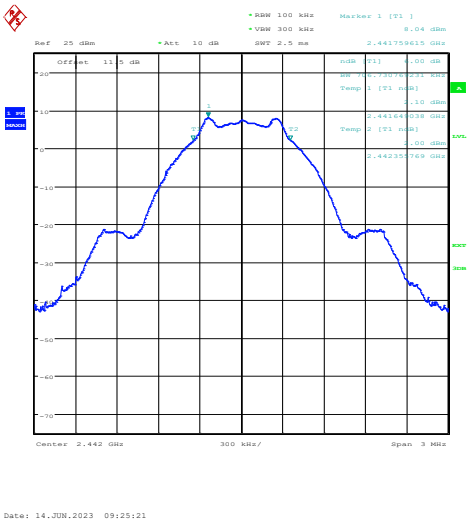
Equipment Type	*Manufacturer*	*Equipment Description*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSU26	U405	2024-05-22
Attenuator	AtlanTecRF Microwave	10dB SMA Attenuator	U633	Cal In use

12.6 Test Results

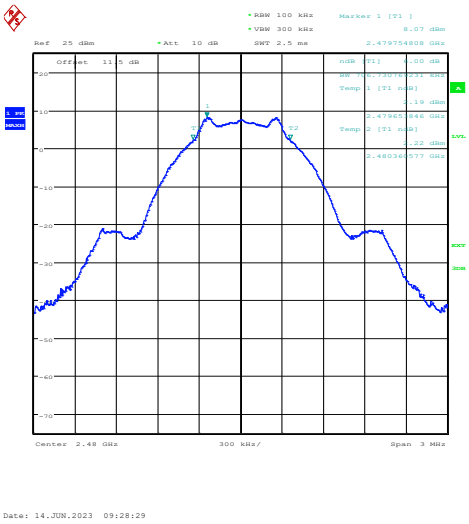
Bandwidth Type: 6 dB; Modulation: GFSK; Data rate: 1 Mbps; Power setting: 8				
Frequency (MHz)	***F_L (MHz)***	***F_H (MHz)***	***Bandwidth (kHz)***	***Result***
2402	2401.653846	2402.360577	706.731	PASS
2442	2441.649038	2442.355769	706.731	PASS
2480	2479.653846	2480.360577	706.731	PASS



2402 MHz



2442 MHz



2480 MHz

13 Maximum peak conducted output power

13.1 Definition

The maximum peak conducted output power is defined as the maximum power level measured with a peak detector using a filter with width and shape of which is sufficient to accept the signal bandwidth.

The effective isotropic radiated power (EIRP) is defined as the product of the power supplied to the antenna and the antenna gain in a given direction relative to an isotropic antenna.

13.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.9.1
EUT Frequencies Measured:	2402 MHz, 2442 MHz & 2480 MHz
EUT Channel Bandwidths:	1 MHz
Deviations From Standard:	None
Measurement BW:	2 MHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	10 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 25 °C	+15 ºC to +35 ºC (as declared)
Humidity: 47 % RH	20 % RH to 75 % RH (as declared)

13.3 Test Limit

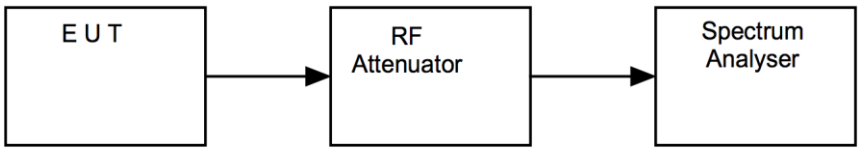
For systems employing digital modulation techniques operating in the bands 902 to 928 MHz, 2400 to 2483.5 MHz and 5725 to 5850 MHz, the maximum peak conducted output power shall not exceed 1 W.

13.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure iv, the resolution bandwidth of the spectrum analyser was increased above the EUT occupied bandwidth and the peak emission data noted.

The measurements were performed with EUT set at its maximum duty. All modulation schemes, data rates and power settings were used to observe the worst-case configuration in each bandwidth.

Figure iv Test Setup



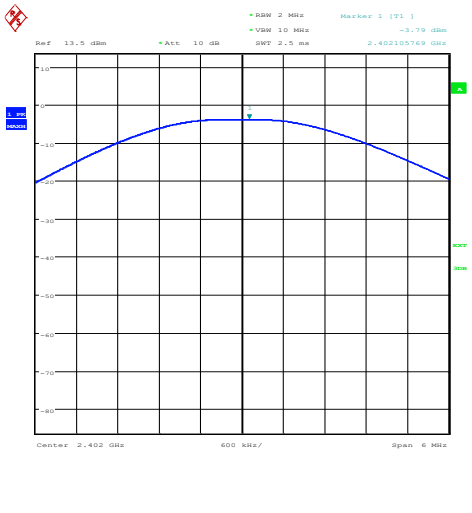
13.5 Test Equipment

Equipment Type	*Manufacturer*	*Equipment Description*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSU26	U405	2024-05-22
Attenuator	AtlanTecRF Microwave	10dB SMA Attenuator	U633	Cal In use

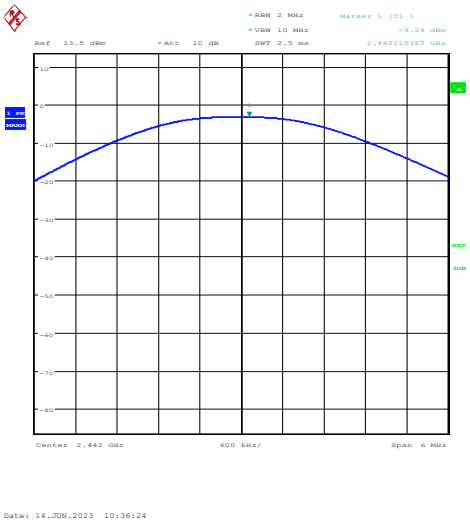
13.6 Test Results

Modulation: GFSK; Data rate: 1 Mbps; Power setting: 8						
Frequency (MHz)	*Conducted Level (dBm)*	*Cable Loss (dB)*	*Maximum peak conducted output power*			*Result*
			(dBm)	*(mW)*	*(W)*	
2402	-3.79	11.50	7.71	5.90	0.00590	PASS
2442	-3.24	11.51	8.27	6.71	0.00671	PASS
2480	-3.24	11.52	8.28	6.73	0.00673	PASS

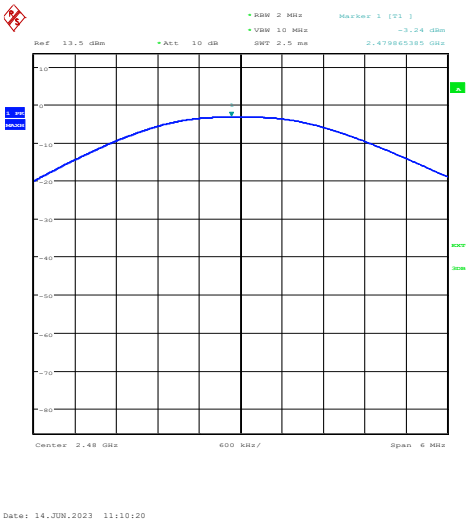
Cable loss includes SMA pigtail and balun PCBA which has a cable loss of 1.0dB, this is associated with the temporary antenna connector provided for test



2402 MHz



2442 MHz



2480 MHz

14 Out-of-band and conducted spurious emissions

14.1 Definition

Out-of-band emission.
Emission on a frequency or frequencies immediately outside the necessary bandwidth that results from the modulation process but excluding spurious emissions.

Spurious emission.
Emission on a frequency or frequencies that are outside the necessary bandwidth and the level of which may be reduced without affecting the corresponding transmission of information. Spurious emissions include harmonic emissions, parasitic emissions, intermodulation products, and frequency conversion products, but exclude out-of-band emissions.

14.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.11
EUT Frequencies Measured:	2402 MHz, 2442 MHz & 2480 MHz
EUT Channel Bandwidths:	1 MHz
Deviations From Standard:	None
Measurement BW:	100 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	300 kHz
Measurement Detector:	Peak
Measurement Range:	9 kHz to 25 GHz

Environmental Conditions (Normal Environment)

Temperature: 25 °C	+15 ºC to +35 ºC (as declared)
Humidity: 46 % RH	20 % RH to 75 % RH (as declared)

14.3 Test Limit

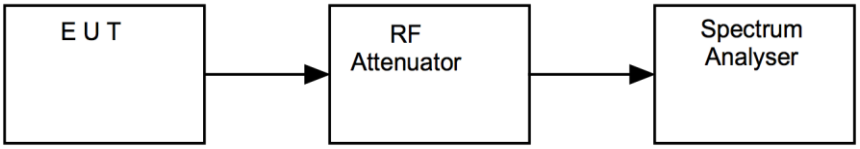
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in FCC 47CFR15.209(a).

14.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure v, the emissions from the EUT were measured on a spectrum analyser.

The measurements were performed with EUT set at its maximum duty. All modulation schemes, data rates and power settings were used to observe the worst case configuration in each bandwidth.

Figure v Test Setup

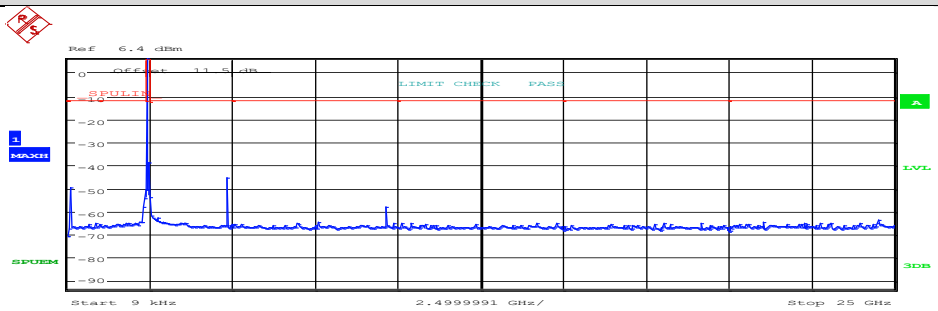


14.5 Test Equipment

Equipment Type	*Manufacturer*	*Equipment Description*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSU26	U405	2024-05-22
Attenuator	AtlanTecRF Microwave	10dB SMA Attenuator	U633	Cal In use

14.6 Test Results

BLE 1M; Frequency: 2402 MHz; Bandwidth: 1 MHz; Modulation: GFSK; Power setting: 8



Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	Δ Limit [dB]
9.000 k	150.000 k	1.00 k	9.000000 k	-77.52	-65.23
150.000 k	30.000 M	10.00 k	191.790000 k	-70.96	-58.67
30.000 M	1.000 G	100.00 k	87.553333 M	-49.58	-37.29
1.000 G	2.400 G	100.00 k	2.370180 G	-51.09	-38.80
2.400 G	2.483 G	2.00 M	2.402104 G	7.69	-22.31
2.483 G	5.000 G	100.00 k	4.803713 G	-45.54	-33.25
5.000 G	10.000 G	100.00 k	9.609000 G	-58.01	-45.72
10.000 G	15.000 G	100.00 k	10.085000 G	-65.29	-53.00
15.000 G	20.000 G	100.00 k	18.010000 G	-65.29	-53.00
20.000 G	25.000 G	100.00 k	24.527500 G	-64.00	-51.71

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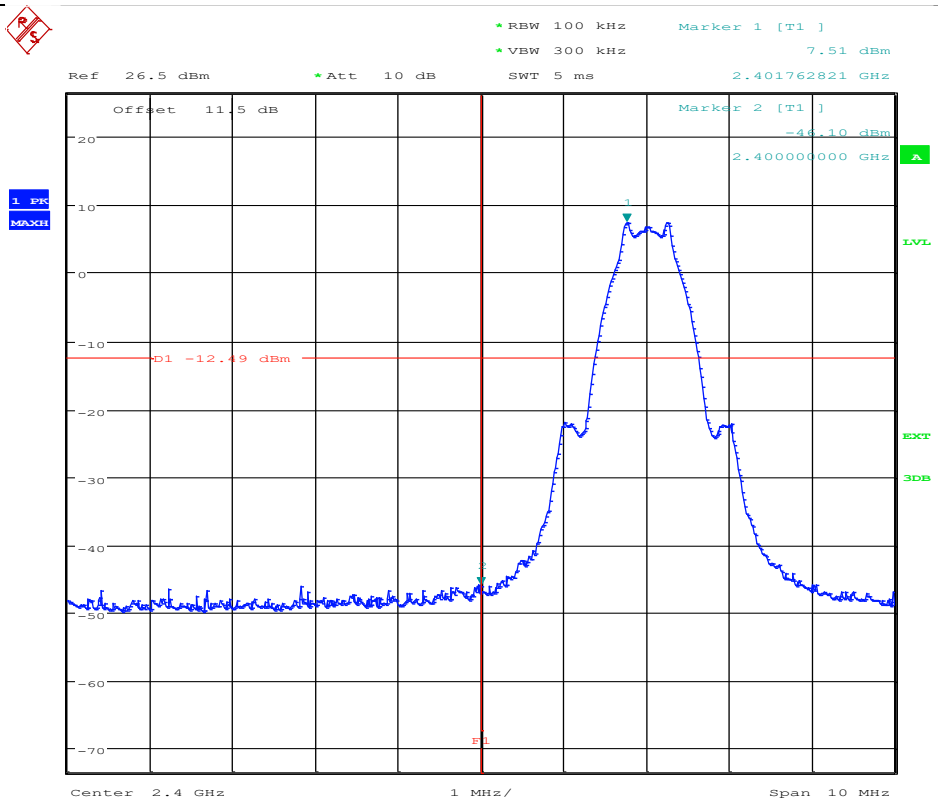

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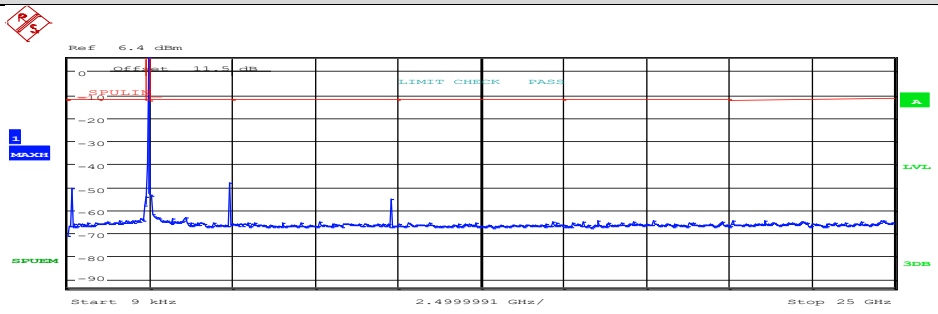
BLE 1M; Frequency: 2442 MHz; Bandwidth: 1 MHz; Modulation: GFSK; Power setting: 8



Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	Δ Limit [dB]
9.000 k	150.000 k	1.00 k	9.000000 k	−76.56	−64.74
150.000 k	30.000 M	10.00 k	188.805000 k	−71.40	−59.58
30.000 M	1.000 G	100.00 k	128.034667 M	−50.75	−38.93
1.000 G	2.400 G	100.00 k	2.380960 G	−54.30	−42.48
2.400 G	2.483 G	2.00 M	2.442159 G	8.17	−21.83
2.483 G	5.000 G	100.00 k	4.883738 G	−48.12	−36.30
5.000 G	10.000 G	100.00 k	9.769000 G	−55.45	−43.63
10.000 G	15.000 G	100.00 k	14.651000 G	−65.26	−53.44
15.000 G	20.000 G	100.00 k	17.703750 G	−64.86	−53.04
20.000 G	25.000 G	100.00 k	20.102500 G	−64.62	−52.80

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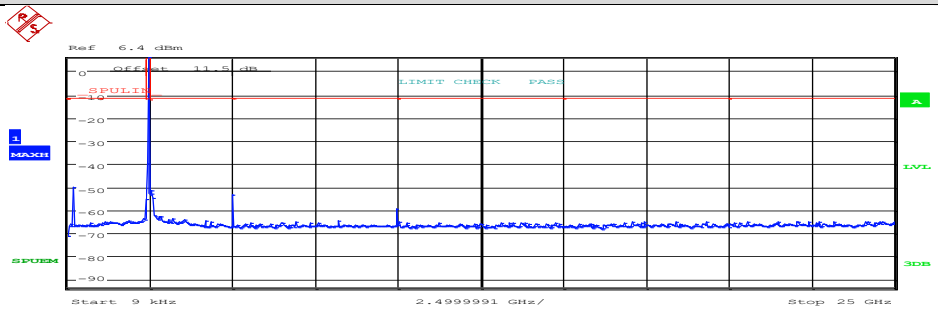
BLE 1M; Frequency: 2480 MHz; Bandwidth: 1 MHz; Modulation: GFSK; Power setting: 8



Start [Hz]	Stop [Hz]	RBW [Hz]	Freq [Hz]	PwrAbs [dBm]	Δ Limit [dB]
9.000 k	150.000 k	1.00 k	9.2225962 k	-77.24	-65.52
150.000 k	30.000 M	10.00 k	164.925000 k	-71.40	-59.68
30.000 M	1.000 G	100.00 k	170.844000 M	-50.17	-38.45
1.000 G	2.400 G	100.00 k	2.399440 G	-55.32	-43.60
2.400 G	2.483 G	2.00 M	2.479717 G	8.27	-21.73
2.483 G	5.000 G	100.00 k	2.511936 G	-51.72	-40.00
5.000 G	10.000 G	100.00 k	9.919500 G	-59.37	-47.65
10.000 G	15.000 G	100.00 k	10.030000 G	-65.39	-53.67
15.000 G	20.000 G	100.00 k	17.061250 G	-65.08	-53.36
20.000 G	25.000 G	100.00 k	22.717500 G	-65.01	-53.29

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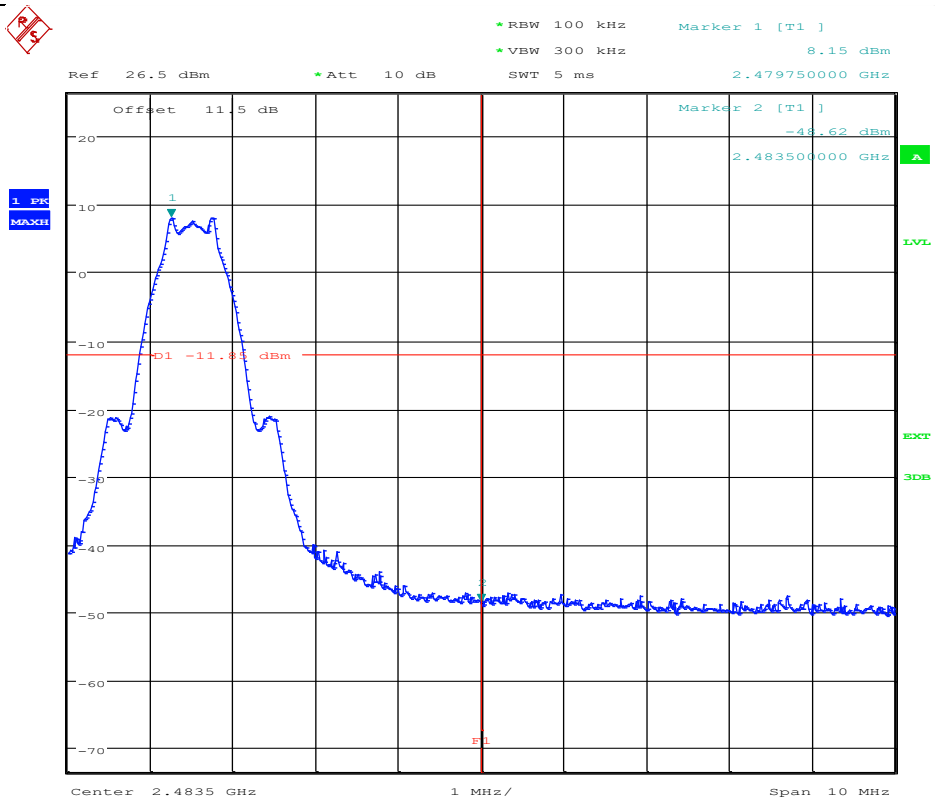

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15 Power spectral density

15.1 Definition

The power per unit bandwidth.

15.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.10
EUT Frequencies Measured:	2402 MHz, 2442 MHz & 2480 MHz
EUT Channel Bandwidths:	1 MHz
Deviations From Standard:	None
Measurement BW:	3 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	10 kHz
Measurement Span: (requirement 1.5 times Channel BW)	1.1 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 25 °C	+15 ºC to +35 ºC (as declared)
Humidity: 45 % RH	20 % RH to 75 % RH (as declared)

15.3 Test Limit

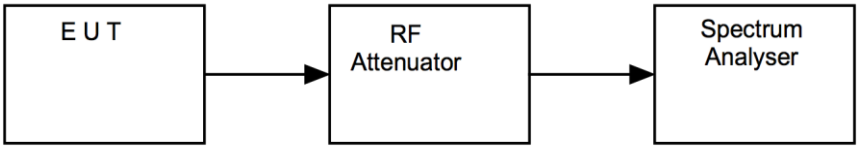
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

15.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure vi, the peak emission of the EUT was measured on a spectrum analyser, with path losses taken into account.

The measurements were performed with EUT set at its maximum duty. All modulation schemes, data rates and power settings were used to observe the worst case configuration in each bandwidth.

Figure vi Test Setup



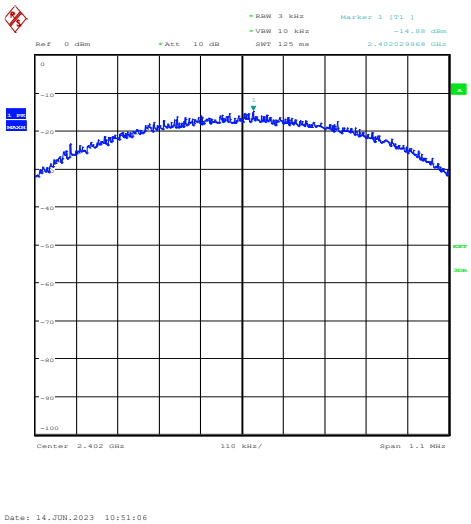
15.5 Test Equipment

Equipment Type	*Manufacturer*	*Equipment Description*	*Element No*	*Due For Calibration*
Spectrum Analyser	R&S	FSU26	U405	2024-05-22
Attenuator	AtlanTecRF Microwave	10dB SMA Attenuator	U633	Cal In use

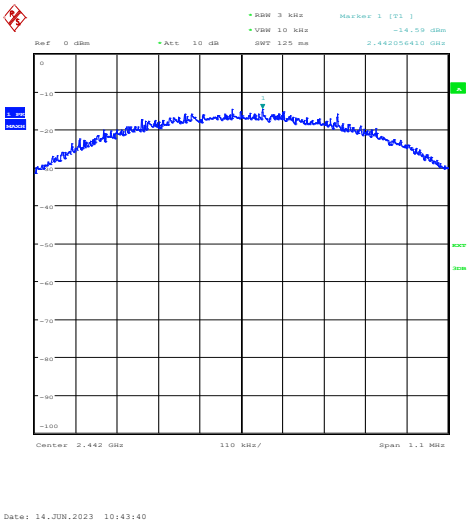
15.6 Test Results

Modulation: GFSK; Data rate: 1 Mbps; Power setting: 8				
Channel Frequency (MHz)	***Analyzer Level (dBm)***	***Cable loss (dB)***	***Power (dBm)***	***Result***
2402	-14.88	11.50	-3.38	PASS
2442	-14.59	11.51	-3.08	PASS
2480	-14.66	11.52	-3.14	PASS

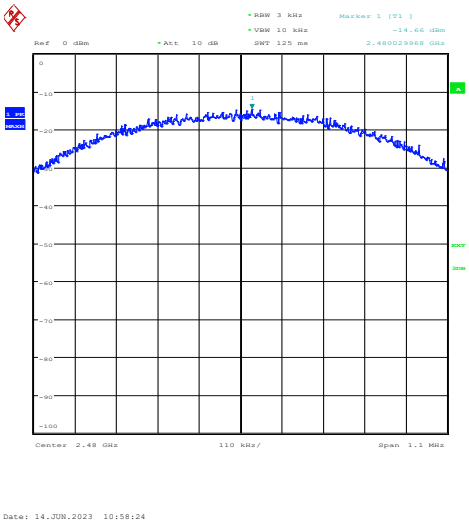
Cable loss includes SMA pigtail and balun PCBA which has a cable loss of 1.0dB, this is associated with the temporary antenna connector provided for test



2402 MHz



2442 MHz



2480 MHz

16 Measurement Uncertainty

Radio Testing – General Uncertainty Schedule

All statements of uncertainty are expanded standard uncertainty using a coverage factor of 1.96 to give a 95 % confidence where no required test level exists.

Test/Measurement	Budget Number	MU
Conducted RF Power, Power Spectral Density, Adjacent Channel Power and Spurious emissions		
Absolute RF power (via antenna connecter) Dare RPR3006W Power Head	MU4001	**0.9 dB**
Carrier Power and PSD - Spectrum Analysers	MU4004	**0.9 dB**
Adjacent Channel Power	MU4002	**1.9 dB**
Transmitter conducted spurious emissions	MU4041	**0.9 dB**
Conducted power and spurious emissions 40 GHz to 50 GHz	MU4042	**2.4 dB**
Conducted power and spurious emissions 50 GHz to 75 GHz	MU4043	**2.5 dB**
Conducted power and spurious emissions 75 GHz to 110 GHz	MU4044	**2.4 dB**
Radiated RF Power and Spurious emissions ERP and EIRP		
Effective Radiated Power Reverb Chamber	MU4020	**3.7 dB**
Effective Radiated Power	MU4021	**4.7 dB**
TRP Emissions 30 MHz to 1 GHz using CBL6111 or CBL6112 Bilog Antenna	MU4046	**5.3 dB**
TRP Emissions 1 GHz to 18 GHz using HL050 Log Periodic Antenna	MU4047	**5.1 dB**
TRP Emissions 18 GHz to 26.5 GHz using Standard Gain Horn	MU4048	**2.7 dB**
TRP Emissions 26.5 GHz to 40 GHz using Standard Gain Horn	MU4049	**2.7 dB**
Spurious Emissions Electric and Magnetic Field		
Radiated Spurious Emissions 30 MHz to 1 GHz	MU4037	**4.7 dB**
Radiated Spurious Emissions 1-18 GHz	MU4032	**4.5 dB**
E Field Emissions 18GHz to 26 GHz	MU4024	**3.2 dB**
E Field Emissions 26GHz to 40 GHz	MU4025	**3.3 dB**
E Field Emissions 40GHz to 50 GHz	MU4026	**3.5 dB**
E Field Emissions 50GHz to 75 GHz	MU4027	**3.6 dB**
E Field Emissions 75GHz to 110 GHz	MU4028	**3.6 dB**
Radiated Magnetic Field Emissions	MU4031	**2.3 dB**
Frequency Measurements		
Frequency Deviation	MU4022	**0.316 kHz**
Frequency error using CMTA test set	MU4023	**113.441 Hz**
Frequency error using GPS locked frequency source	MU4045	**0.0413 ppm**
Bandwidth/Spectral Mask Measurements		
Channel Bandwidth	MU4005	**3.87 %**
Transmitter Mask Amplitude	MU4039	**1.3 dB**
Transmitter Mask Frequency	MU4040	**2.59 %**
Time Domain Measurements		
Transmission Time	MU4038	**4.40 %**
Dynamic Frequency Selection (DFS) Parameters)		
DFS Analyser - Measurement Time	MU4006	**679 µs**
DFS Generator - Frequency Error	MU4007	**92 Hz**
DFS Threshold Conducted	MU4008	**1.3 dB**
DFS Threshold Radiated	MU4009	**3.2 dB**

Test/Measurement	Budget Number	MU
Receiver Parameters		
EN300328 Receiver Blocking	MU4010	**1.1 dB**
EN301893 Receiver Blocking	MU4011	**1.1 dB**
EN303340 Adjacent Channel Selectivity	MU4012	**1.1 dB**
EN303340 Overloading	MU4013	**1.1 dB**
EN303340 Receiver Blocking	MU4014	**1.1 dB**
EN303340 Receiver Sensitivity	MU4015	**0.9 dB**
EN303372-1 Image Rejection	MU4016	**1.4 dB**
EN303372-1 Receiver Blocking	MU4017	**1.1 dB**
EN303372-2 Adjacent Channel Selectivity	MU4018	**1.1 dB**
EN303372-2 Dynamic Range	MU4019	**0.9 dB**
Receiver Blocking Talk Mode Conducted	MU4033	**1.2 dB**
Receiver Blocking Talk Mode- radiated	MU4034	**3.4 dB**
Rx Blocking, listen mode, blocking level	MU4035	**3.2 dB**
Rx Blocking, listen mode, radiated Threshold Measurement	MU4036	**3.4 dB**
Adjacent Sub Band Selectivity	MU4003	**4.2 dB**

17 RF Exposure

17.1 General SAR test reduction & exclusion guidance

KDB 447498

Section 4.3 General SAR test reduction and exclusion guidance

For Standalone SAR exclusion consideration, when SAR Exclusion Threshold requirement in KDB 447498 is satisfied, standalone SAR evaluation for general population exposure conditions by measurement or numerical simulation is not required.

The SAR Test Exclusion Threshold for frequencies in the range 100 MHz to 6 GHz, and for test separation distance of ≤ 50 mm, is determined as follows.

$$\text{SAR Exclusion Threshold (SARET)} = (NT \times TSD_A) / \sqrt{f_{GHz}}$$

Where,

NT = Numeric Threshold (3.0 for 1-g SAR and 7.5 for 10-g SAR)
TSD_A = Minimum Test separation distance or 50 mm (whichever is lower)
f_{GHz} = Transmit frequency in GHz

Channel Frequency (MHz)	*Maximum Conducted Power (mW)*	*SAR Exclusion Threshold at 5 mm (mW)*	*SAR Evaluation*
2402	5.90	9.68	Not Required
2442	6.71	9.60	Not Required
2480	6.73	9.53	Not Required

Therefore standalone SAR evaluation for general population exposure conditions by measurement or numerical simulation is not required.

18 Appendix A – client declaration

Classification | PRIVATE

TX Duty Cycle BLE 64 kbit/s Voice

GP570, GP870

Application Note

1 Introduction

This Application Note provides an explanation on the transmit duty cycle for a BLE device transmitting compressed voice with a data rate of 64 kbit/s . The transmit duty cycle can be used to calculate the average spurious emissions according section 15.35(C) of The FCC radio certification standard CRF 47 PART 15.

Information in this Application Note is applicable to the following integrated circuits (IC) products: GP570, GP870 [1].

Table of Contents

2 Background

To place a BLE device on the US market it requires FCC certification.

2.1 Applicable Standard

CRF 47 PART 15, Section 15.247 “Operation within the bands 902 - 928 MHz, 2400 - 2483.5 MHz, and 5725 - 5850 MHz”. See ref [4].

The Qorvo BLE device complies with 15.247 (a) (2): Systems using digital modulation techniques may operate in the 902 - 928 MHz, 2400 - 2483.5 MHz, and 5725 - 5850 MHz bands. The minimum 6 dB bandwidth shall be at least 500 kHz.

For spurious emissions 15.247 is pointing towards 15.205 “Restricted bands of operation” and towards 15.209 “Radiated emission limits, general requirements”.

Please notice that 15.209 (d) mentions: “Radiated emission limits in these three bands are based on measurements employing an average detector.” Averaging can be done by choosing a narrow video bandwidth setting on the spectrum analyzer or by averaging multiple traces.

2.2 Duty Cycle Correction Spurious Emission According Section 15.35(c)

Section 15.35 (c) mentions: "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 measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds. As an alternative (provided the transmitter operates for longer than 0.1 seconds) or in cases where the pulse train exceeds 0.1 seconds, the measured field strength shall be determined from the average absolute voltage during a 0.1 second interval during which the field strength is at its maximum value. The exact method of calculating the average field strength shall be submitted with any application for certification or shall be retained in the measurement data file for equipment subject to Supplier's Declaration of Conformity."

Details on applying duty cycle correction can be found in ref [6], in the "Frequently Asked Questions" section at "Question 3" , "Answer 3 c)". This answer explains that duty cycle correction of average spurious emissions for protocol limited devices is allowed under the condition that the average spurious emissions are measured with a continuous wave signal.
Quote;
"Taking a RMS average measurement while EUT is transmitting continuously, i.e., greater than 98%, and correcting for operational duty cycle – When greater than 98% duty cycle is achieved for testing purposes, applying average measurement techniques (e.g., average detector / reduced VBW) then adjusting for the protocol limited duty factor to determine the average emission is acceptable."

3 Duty Cycle 64 kbit/s Compressed Voice Streaming

The 64 kbit/s compressed voice streaming is for most applications the transmit scenario that has the highest TX duty cycle, so producing the highest average TX spurious emission.

3.1 Calculation

For sending **64 kbit/s compressed voice** on a 10 ms connection interval and using the 1 Mbit/s PHY on short packets (BT v4.0 compliant)

- Payload size: 20 bytes
- Packet size: 41 bytes
- Connection Interval: 10 ms
- Number of packets per connection interval: 4
- Throughput: 4 * 8 * 20 /10 = 64 kbit/s
- Transmit time: 4 * 8 * (41) = 1312 µs
  (1 bit takes 1 µs transmit at 1 Mbit/s; 20 bytes payload in a 41 bytes packet)
- Calculated Duty cycle is 1312 µs / 10 ms = 1312/10000 = 0.13

3.2 Measurement Result

3.2.1 Test Setup

Figure 1 shows the test setup to measure the duty cycle of voice transmission over BLE. Attenuator is added at the master side to suppress transmission levels from the GP570 master. BLE remote control is being emulated by GP570 slave.

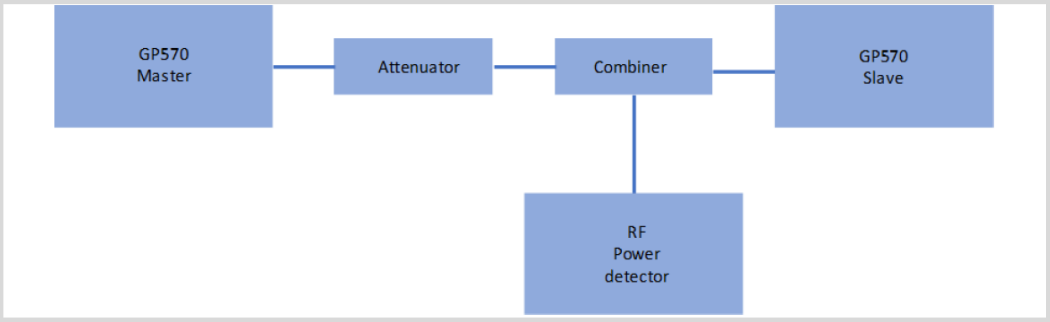


Figure 1 : Test Setup

3.2.2 Test results

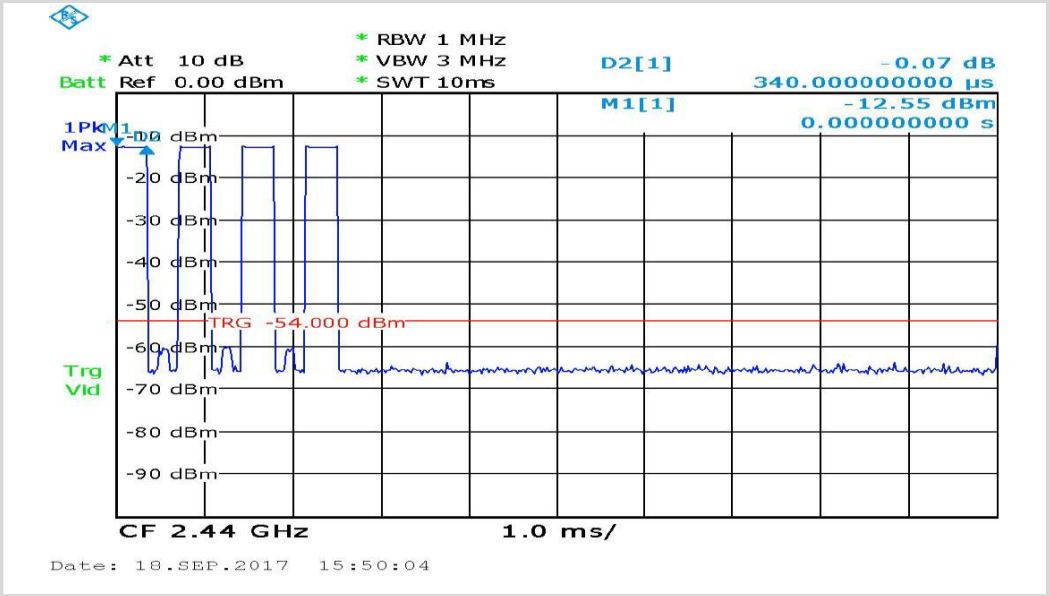


Figure 2 : Spectrum Analyzer Capture of Compressed Voice Transmission over BLE for 10 ms Sweep Time

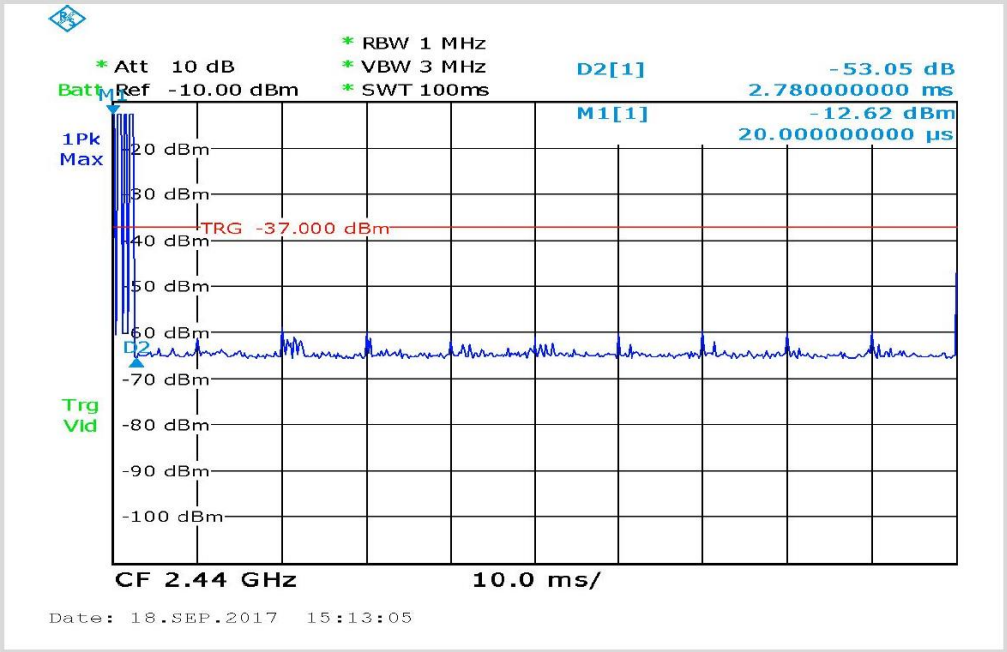


Figure 3 :Spectrum Analyzer Capture of Compressed Voice Transmission over BLE for 100 ms Sweep Time

In Figure 2 and in Figure 3 low level packets are sent by the master, and 4 high level packets containing voice data are sent by the slave.
Figure 2 shows there are 4 voice packets transmitted of 340 µs length each.

Total TX duration: 4 * 340 µs= 1360 µs; the difference between the calculated 1312 µs and the measured 1360 µs can be explained by TX ramp times of the 4 packets.

Figure 3 shows the same 4 voice packets on a different time scale. The reason we do not see (in Figure 3) a new pulse train each 10 ms is explained by hopping: for the next 10 ms connection interval the device hops to another BLE frequency.

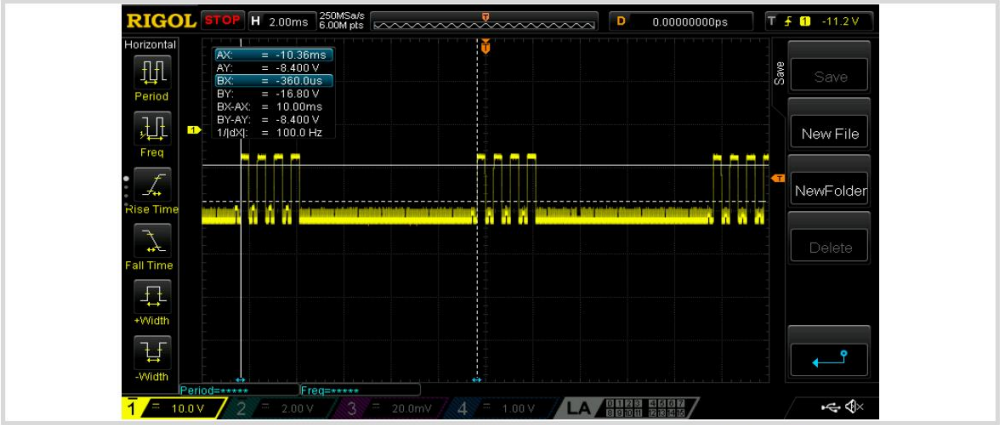


Figure 4 : Oscilloscope Graph of 10 ms Connection Interval

The measurement in Figure 4 is done with a broadband detector, measuring all BLE frequencies. This figure shows that the connection interval is 10 ms (see BX-AX)

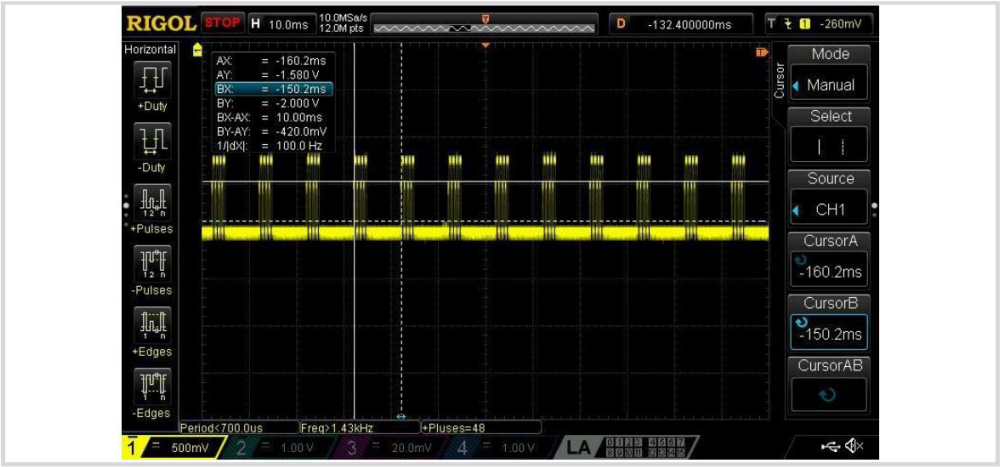


Figure 5 : Oscilloscope Graph 10 ms/div so 120 ms Interval

The measurement in Figure 5 is also done with a broadband detector, measuring all BLE frequencies. This figure shows that the connection interval of 10 ms is repeated during a > 100 ms time period.

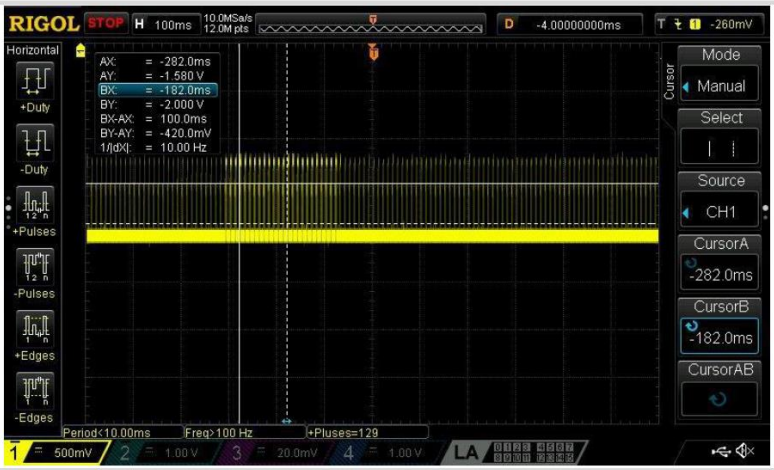


Figure 6 : Oscilloscope Graph 100 ms/div so 1,200 ms Interval

The measurement in Figure 6 is also done with a broadband detector, measuring all BLE frequencies. This figure shows that the connection interval of 10 ms is repeated during a > 1000 ms period.

The period time of 10 ms of the high amplitude voice pulses and the pulse duration of 4 * 0.34 ms can be used to calculate the duty cycle for compressed voice transmission. The pattern repeats over the duration of a voice call and is representative for the max duty cycle in a 100 ms time slot.

TX Duty cycle: 1.360/10 = 13.6 %
Corresponding FCC duty cycle correction factor is 20 * $Log_{10}(0.1360)$ = -17.32 dB.

It is also possible to calculate the max duty cycle for an individual BLE channel.
The BLE standard requires a minimum number of used channels of 2, see 4.5.8.1 Channel Classification in ref [5]. The pulses or the TX power will be equally spread over the 2 channels, so the max duty cycle per individual channel will be -17.32 – 6 = -23.32 dB. FCC will limit the correction factor to -20 dB.

Summary:

- Max TX duty cycle all channels combined: 13.6 %, corresponding correction factor -17. 3 dB
- Max TX duty cycle per channel: ½ * 13.6 %, corresponding correction factor -23. 3 dB, limited by FCC to -20 dB. (minimum # channels is 2)

3.3 Out of Range

Before a BLE slave is allowed to transmit, it must receive the master first. This applies for every individual connection event.

If the master is not hearing the slave, it must close the current connection event and retry in the next connection event.

If the BLE slave (remote control) is not receiving an ACK's from the master, it will retransmit the not ACK-ed packet. However, per specification connection events must close after receiving 2 subsequent packets with a CRC error. So, if missing 2 subsequent ACKs the slave will close the connection event. Means instead of

many packets per connection event you will see typically max 2 packets per connection event when going out of range. TX duty cycle normally reduces when going out of range.

References

[1] GP570 Data Sheet; Qorvo document GP_P008_UM_13489
GP870 Data Sheet; Qorvo document GP_P008_UM_12059
[2] GP570 User Manual; Qorvo document GP_P008_UM_10929
GP870 User Manual; Qorvo document GP_P008_UM_12313
[3] FCC Certification Guide; GP_P905_UM_13440; Qorvo document GP_P905_ GP_P905_UM_13440
[4] Electronic Code of Federal Regulations: eCRF Title 47, Part 15 – Radio Frequency Devices.
[5] BLEUTOOTH SPECIFICATION Version 4.2 [Vol 6, Part B], Link Layer specification.
[6] FCC Publication Number FCC 558074 D01 15.247 Meas Guidance v05r02.pdf

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Document History

Version	Date	Section	Changes
0.10	14 Sept 2017	all	Initial Release.
0.20	15 Sept. 2017		Added measurement results
0.30	18 Sept. 2017		Corrected figure 2, added figure 3, updated text. No change in calculations or duty cycle.
0.40	19 Sept 2017		Added figure 5 and figure 6 to further clarify max duty cycle. Included calculation for duty cycle for minimum number of BLE channels. (paragraph 3.4)
1.00	1 Feb 2018	all	Editorial corrections.
1.01	1 June 2020	3.3 (new)	Added Out of Range information
1.02	10 Feb 2021	2.2	Updated paragraph 2.2 “Duty Cycle Correction Spurious Emission According Section 15.35(c)”