

Report on the Radio Testing
For
Third Millennium Systems Ltd
on
PRX60BLE
Report no. TRA-047608-47-02A
2020-04-03

RF915 7.0



Report Number: TRA-047608-47-02A
Issue: A

REPORT ON THE RADIO TESTING OF A
Third Millennium Systems Ltd
PRX60BLE
WITH RESPECT TO SPECIFICATION
FCC 47CFR 15.247

TEST DATE: 2020-02-13 to 2020-02-26

Written by:

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Radio Test Engineer

Approved by:

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Lab Manager

Date: 2020-04-03

Disclaimers:

- [1] THIS DOCUMENT MAY BE REPRODUCED ONLY IN ITS ENTIRETY AND WITHOUT CHANGE
[2] THE RESULTS CONTAINED IN THIS DOCUMENT RELATE ONLY TO THE ITEM(S) TESTED

1 Revision Record

<i>Issue Number</i>	<i>Issue Date</i>	<i>Revision History</i>
A	2020-04-03	Original

2 Summary

TEST REPORT NUMBER:	TRA-047608-47-02A
WORKS ORDER NUMBER:	TRA-047608-02
PURPOSE OF TEST:	USA: Testing of radio frequency equipment per the relevant authorization procedure of chapter 47 of CFR (code of federal regulations) Part 2, subpart J.
TEST SPECIFICATION:	47CFR15.247
EQUIPMENT UNDER TEST (EUT):	PRX60BLE
FCC IDENTIFIER:	UTJ-RX60BLE
EUT SERIAL NUMBER:	Sample 16
MANUFACTURER/AGENT:	Third Millennium Systems Ltd
ADDRESS:	18/19 Torfaen Business Centre Panteg Way New Inn Pontypool NP4 0LS United Kingdom
CLIENT CONTACT:	Sarah Smith ☎ 01495 751 992 ✉ ssmith@tm-readers.com
ORDER NUMBER:	995445
TEST DATE:	2020-02-13 to 2020-02-26
TESTED BY:	Steven Garwell, Michael Else 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)		15.205	<input checked="" type="checkbox"/>	PASS
AC power line conducted emissions		15.207	<input checked="" type="checkbox"/>	PASS
Occupied bandwidth		15.247(a)(2)	<input checked="" type="checkbox"/>	PASS
Conducted carrier power	Peak	15.247(b)(3)	<input checked="" type="checkbox"/>	PASS
	Max.		<input type="checkbox"/>	
Conducted / radiated RF power out-of-band		15.247(d)	<input checked="" type="checkbox"/>	PASS
Power spectral density, conducted		15.247(e)	<input checked="" type="checkbox"/>	PASS
Calculation of duty correction		15.35(c)	<input type="checkbox"/>	PASS

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).

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4 Introduction

This report TRA-047608-47-02A presents the results of the Radio testing on a Third Millennium Systems Ltd, PRX60BLE to specification 47CFR15 Radio Frequency Devices: Category I Equipment.

The testing was carried out for Third Millennium Systems Ltd by Element, at the address detailed below.

<input type="checkbox"/>	Element Hull Unit E South Orbital Trading Park Hedon Road Hull HU9 1NJ UK	<input checked="" type="checkbox"/>	Element Skelmersdale Unit 1 Pendle Place Skelmersdale West Lancashire WN8 9PN UK
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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:

Element is accredited for the above sites under the US-EU MRA, Designation number UK0009.

IC Registration Number(s):

Element Hull	3483A
Element North West	3930B

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: PRX60BLE
- Serial Number: Sample 16
- Model Number: RX490B
- Software Revision: Not Applicable
- Build Level / Revision Number: Not Applicable

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

7.3.1 Transmission

The mode of operation for transmit tests was as follows:-

The EUT was programmable via customer supplied test cards and was transmitting on the required test frequencies.

7.4 EUT Radio Parameters

7.4.1 General

Frequencies of operation:	2402 MHz to 2480 MHz
Modulation type:	GFSK
Occupied channel bandwidth:	1 MHz
Channel spacing:	2 MHz
Declared output power:	≤10.0 dBm
Nominal Supply Voltage:	12 V _{DC}

7.4.2 Antennas

Type:	TM-BLE ANTENNA (100-*****)
Frequency range:	2402 MHz to 2480 MHz
Connector type:	Integral (PCB trace)

7.5 EUT Description

The EUT is a dc powered door access control reader with RFID and BTLE. This report only covers BTLE.

8 Modifications

No modifications were performed during this assessment.

9 EUT Test Setup

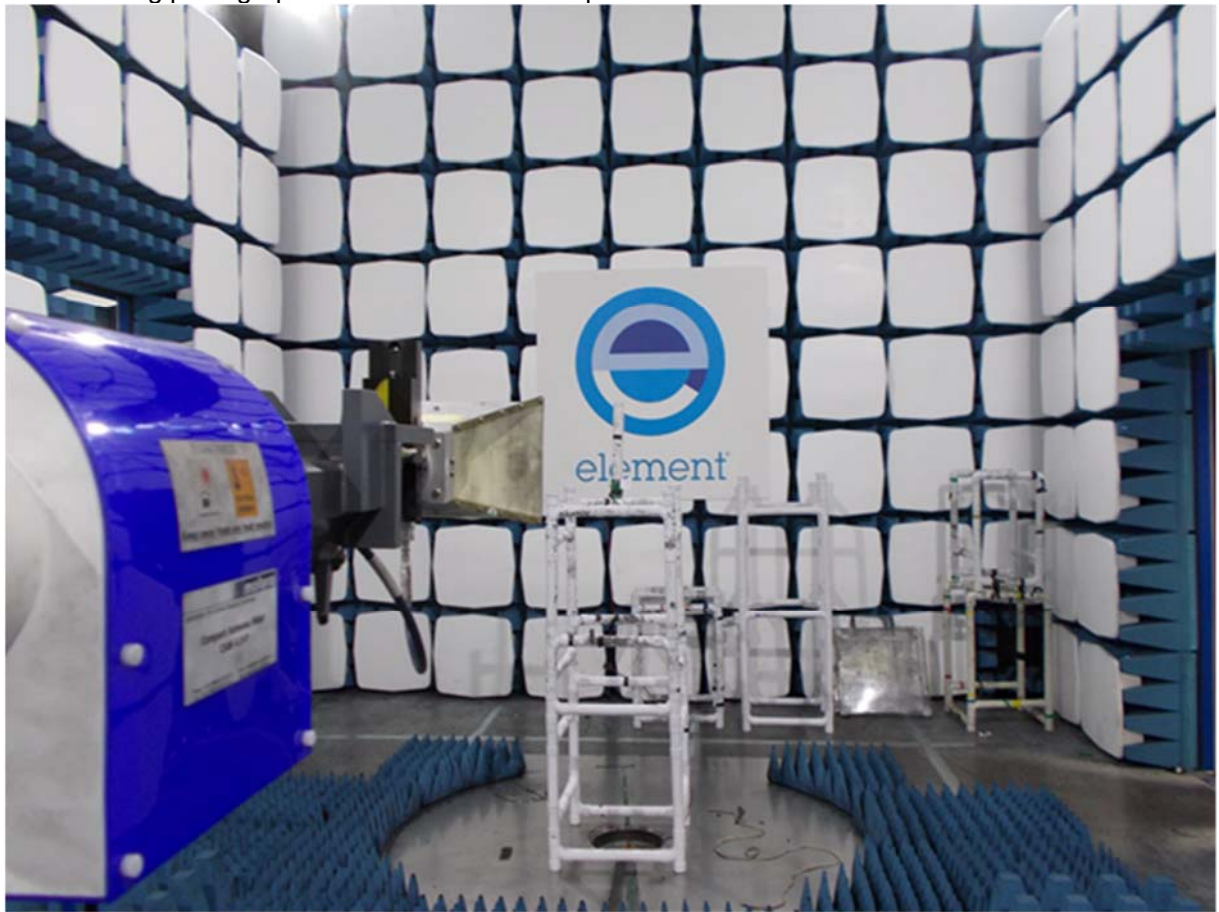
9.1 Block Diagram

The following diagram shows basic EUT interconnections with cable type and cable lengths identified:



9.2 General Set-up Photograph

The following photograph shows basic EUT set-up:



9.3 Measurement software

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

Element Emissions R5 (See Note)
Element Transmitter Bench Test (See Note)
ETS Lindgren EMPower V1.0.4.2

Note:

The version of the Element software used is recorded in the results sheets contained within this report.

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 12 V_{DC} from an external power supply.

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:	Radio chamber SK03
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
EUT Channels Measured:	Low / Mid / High
EUT Channel Bandwidths:	1 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: 21.8 °C	+15 °C to +35 °C (as declared)
Humidity: 31.3 % RH	20 % RH to 75 % RH (as declared)
Supply: 12 V _{DC}	(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 ($\mu\text{V/m}$ at 3 m)
30 to 88	100
88 to 216	150
216 to 960	200
Above 960	500

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:

$$FS = PR + CL + AF - PA + DC - CF$$

$$\text{Factor} = CL + AF - PA$$

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;

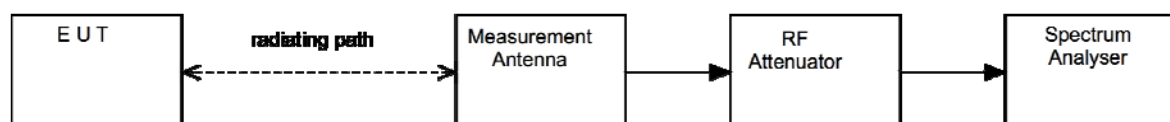
PA is the pre-amplifier gain in dB (where used);

DC is the duty correction factor in dB (where used, e.g. harmonics of pulsed fundamental);

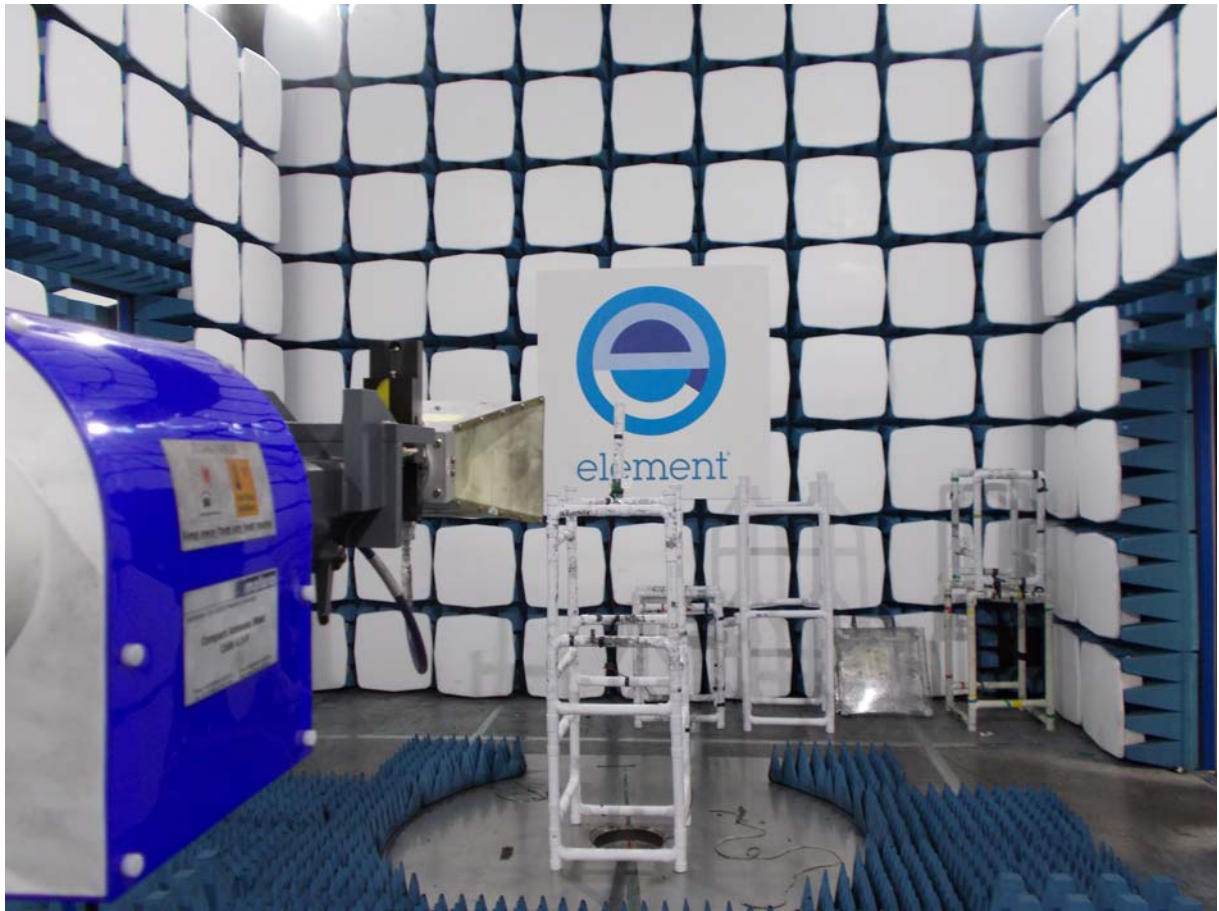
CF is the distance factor in dB (where measurement distance different to limit distance);

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

Figure i Test Setup



11.5 Test Set-up Photograph



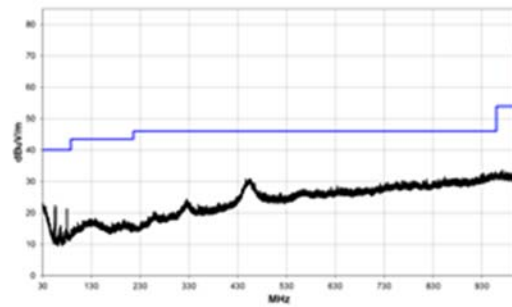
11.6 Test Equipment

<i>Equipment Type</i>	<i>Manufacturer</i>	<i>Equipment Description</i>	<i>Element No</i>	<i>Due For Calibration</i>
CBL611/A	Chase	Bilog	U573	2021-09-19
3115	EMCO	1-18GHz Horn	L139	2021-07-16
6201-69	Watkins Johnson	PreAmp	U372	2020-02-25
8449B	Agilent	Pre Amp	L572	2020-10-15
ATS	Rainford EMC	Radio Chamber - PP	REF940	2021-12-09
20240-20	Flann	Horn 18-26GHz (&U330)	L300	2020-04-24
Spectrum Analyser	Keysight	N9030B	*MY57140717	2020/03/15

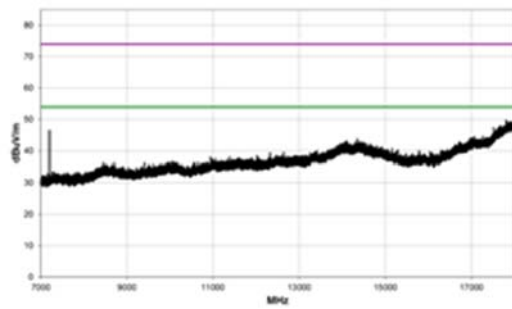
*Loan Analyser

11.7 Test Results

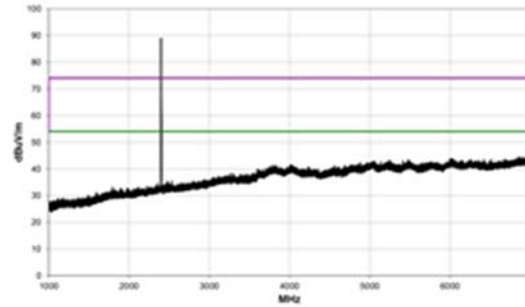
Bottom Channel - 2402 MHz



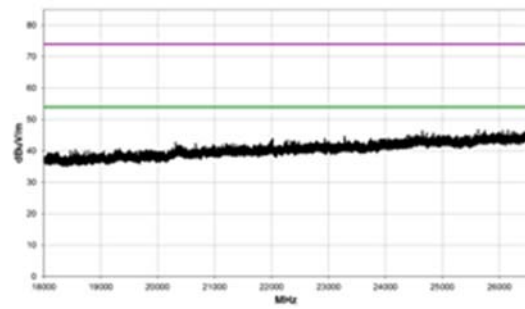
30 MHz to 1 GHz



7 GHz to 18 GHz



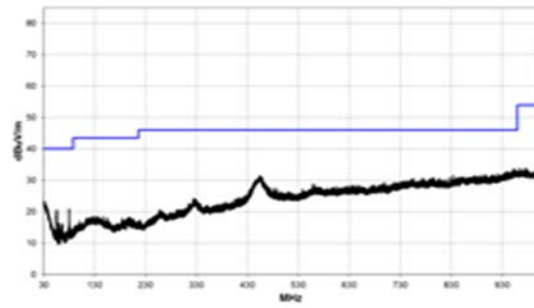
1 GHz to 7 GHz



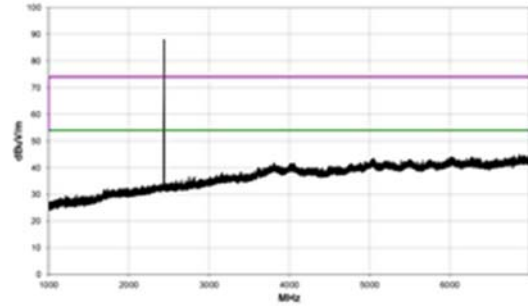
18 GHz to 26.5 GHz

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	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)
7206.492	50.0	7.1	1.5	163.0	0.5	0.0	Vert	AV	-9.5	48.1	54.0	-5.9
7206.467	47.4	7.1	1.5	180.0	0.5	0.0	Horz	AV	-9.5	45.5	54.0	-8.5
7205.175	55.8	7.1	1.5	163.0		0.0	Vert	PK	-9.5	53.4	74.0	-20.6
7205.092	54.1	7.1	1.5	180.0		0.0	Horz	PK	-9.5	51.7	74.0	-22.3

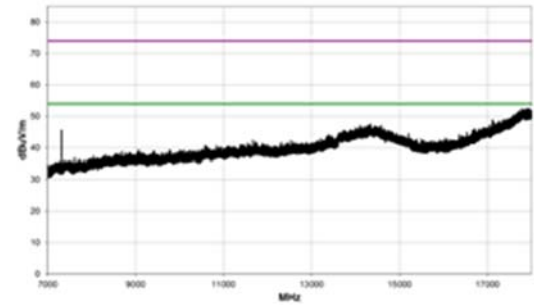
Middle channel - 2440 MHz



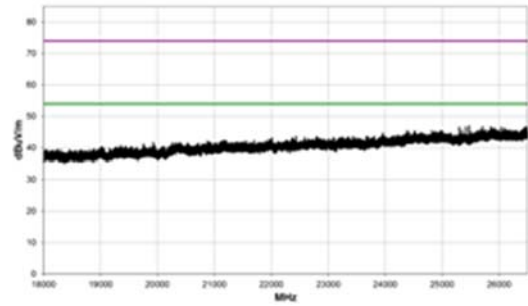
30 MHz to 1 GHz



1 GHz to 7 GHz



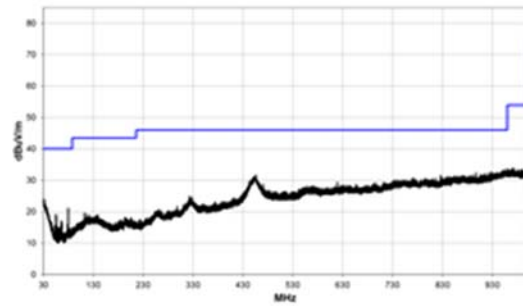
7 GHz to 18 GHz



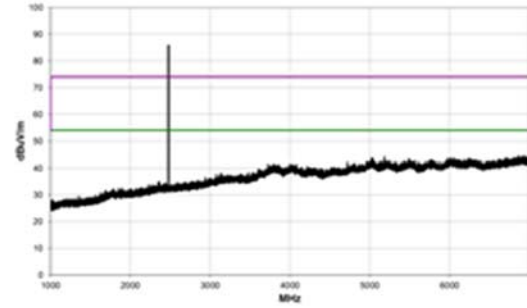
18 GHz to 26.5 GHz

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	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)
7320.283	46.4	7.5	1.5	171.1	0.5	0.0	Horz	AV	-9.5	44.9	54.0	-9.4
7320.275	44.3	7.5	1.55	161.0	0.5	0.0	Vert	AV	-9.5	42.8	54.0	-11.5
7319.058	54.1	7.5	1.5	171.1		0.0	Horz	PK	-9.5	52.1	74.0	-21.9
7318.908	52.8	7.5	1.55	161.0		0.0	Vert	PK	-9.5	50.8	74.0	-23.2

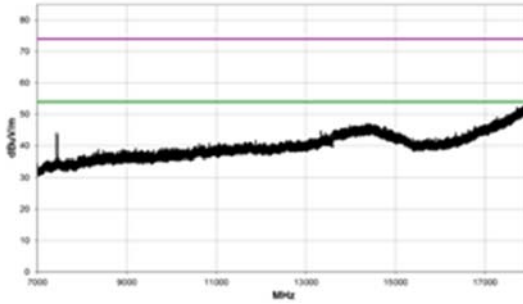
Top channel - 2480 MHz



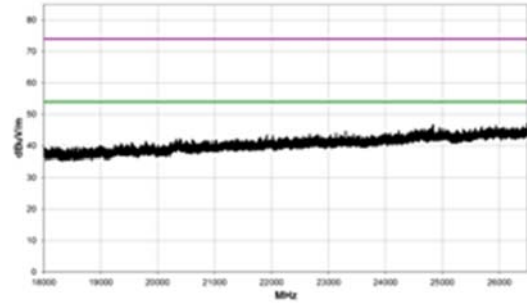
30 MHz to 1 GHz



1 GHz to 7 GHz

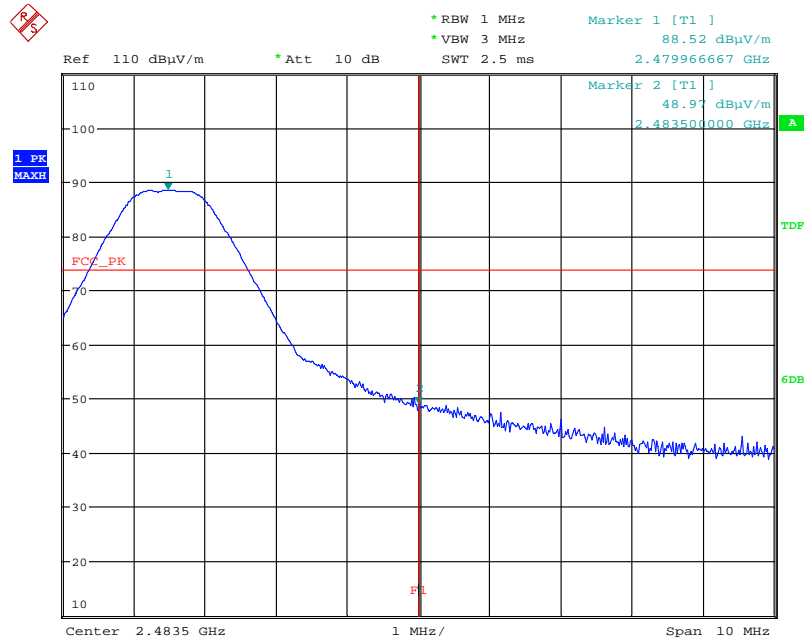


7 GHz to 18 GHz



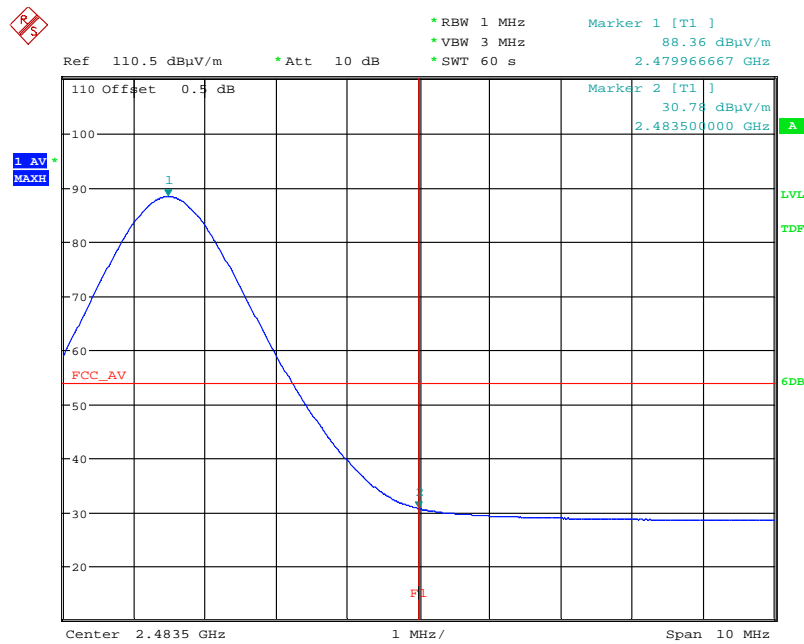
18 GHz to 26.5 GHz

Freq (MHz)	Amplitude (dBuV)	Factor (dB)	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)
7440.250	46.3	7.6	1.49	174.9	0.5	0.0	Horz	AV	-9.5	44.9	54.0	-9.1
7440.325	43.9	7.6	1.26	218.0	0.5	0.0	Vert	AV	-9.5	42.5	54.0	-11.5
7440.533	54.7	7.6	1.49	174.9		0.0	Horz	PK	-9.5	52.8	74.0	-21.2
7439.392	52.5	7.6	1.26	218.0		0.0	Vert	PK	-9.5	50.6	74.0	-23.4



Date: 12.FEB.2020 21:38:02

Upper Band Edge 1 MHz Bandwidth Peak



Date: 13.FEB.2020 15:49:01

Upper Band Edge 1 MHz Bandwidth Average

12 AC power-line conducted emissions

12.1 Definition

Line-to-ground radio-noise voltage that is conducted from all of the EUT current-carrying power input terminals that are directly (or indirectly via separate transformers or power supplies) connected to a public power network.

12.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.2
EUT Channels Measured:	Mid
EUT Channel Bandwidths:	1 MHz
EUT Modulation:	GFSK
Deviations From Standard:	None
Measurement BW:	10 kHz
Measurement Detectors:	Quasi-Peak and Average, RMS

Environmental Conditions (Normal Environment)

Temperature: 23 °C	+15 °C to +35 °C (as declared)
Humidity: 32 % RH	20 % RH to 75 % RH (as declared)
Supply: 12 V _{DC}	(as declared)

12.3 Test Limit

A radio apparatus that is designed to be connected to the public utility (AC) power line shall ensure that the radio frequency voltage, which 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 Table 3.

Table 3 – AC Power Line Conducted Emission Limits

Frequency (MHz)	Conducted limit (dB μ V)	
	Quasi-Peak	Average**
0.15 to 0.5	66 to 56*	56 to 46*
0.5 to 5	56	46
5 to 30	60	50

*The level decreases linearly with the logarithm of the frequency.

**A linear average detector is required.

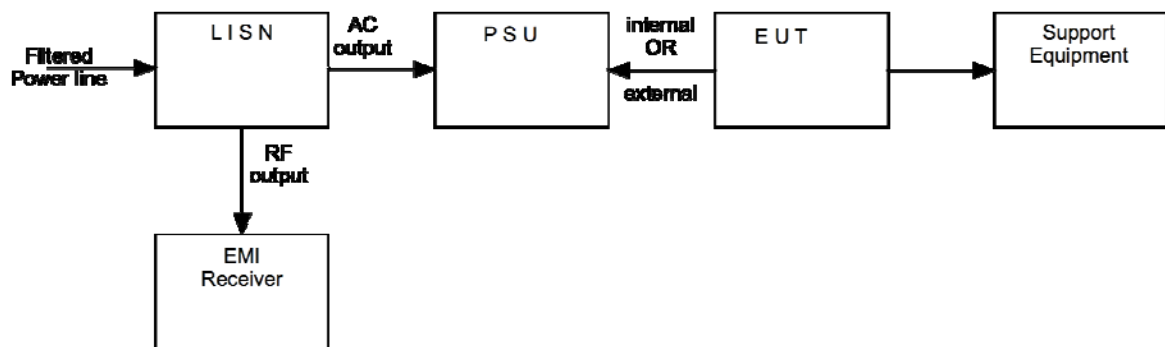
12.4 Test Method

With the EUT setup in a screened room, as per section 9 of this report and connected as per Figure ii, the power line emissions were measured on a spectrum analyzer / EMI receiver.

AC power line conducted emissions from the EUT are checked first by preview scans with peak and average detectors covering both live and neutral lines. A spectrum analyzer is used to determine if any periodic emissions are present.

Formal measurements using the correct detector(s) and bandwidth are made on frequencies identified from the preview scans. Final measurements were performed with EUT set at its maximum duty in transmit and receive modes.

Figure ii Test Setup



12.5 Test Set-up Photograph

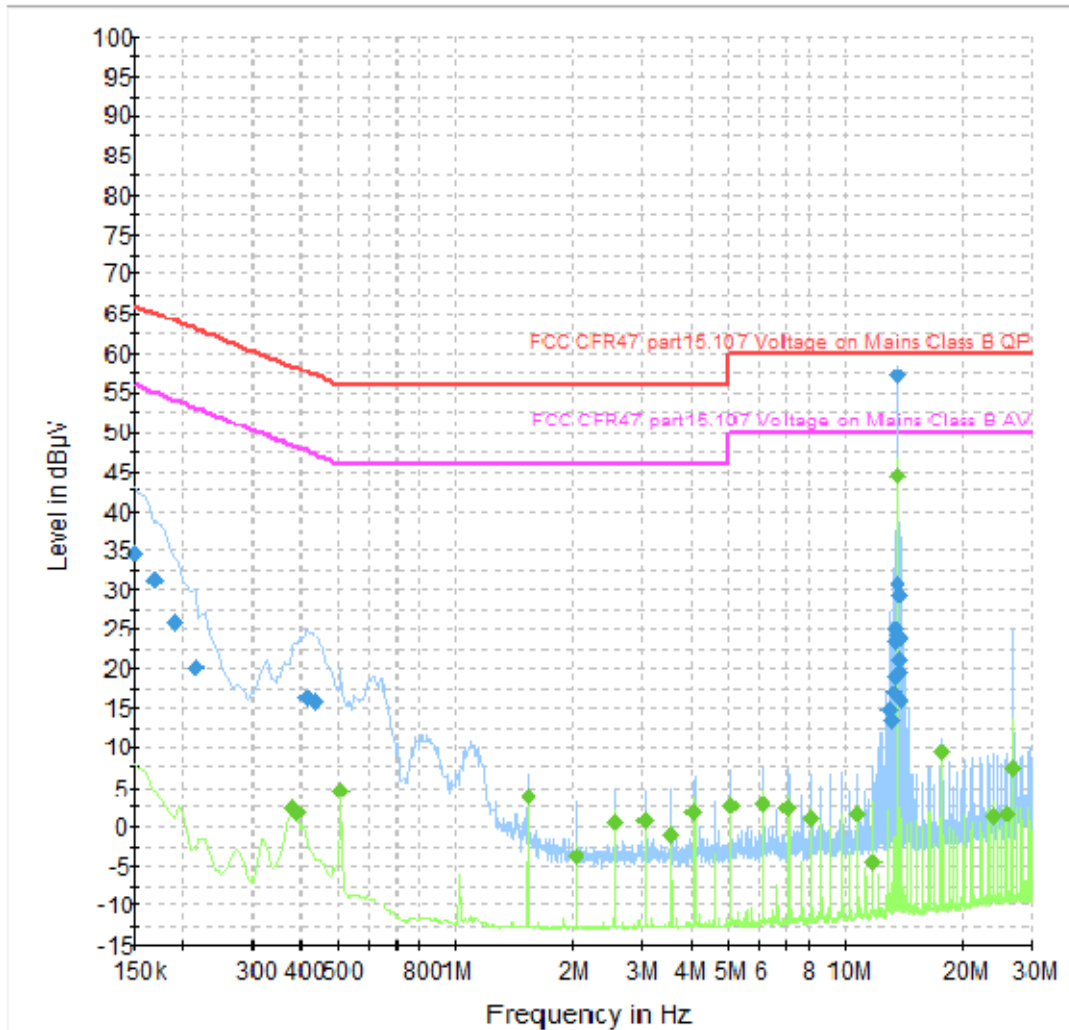


12.6 Test Equipment

<i>Equipment Type</i>	<i>Manufacturer</i>	<i>Equipment Description</i>	<i>Element No</i>	<i>Due For Calibration</i>
ESH3-Z5.831.5	R&S	Lisn	U195	2020-10-04
ESH3-Z2	R&S	Pulse Limiter	U559	2020-10-17
ESHS10	R&S	Receiver	U003	2020-10-23

12.7 Test Results

Conducted emissions on Mains 9kl Iz-30MI Iz C9II IS10 · UII195 · UII559



Final result 1

Frequency (MHz)	QuasiPeak (dBµV)	Meas. Time (ms)	Bandwidth (kHz)	PE	Line	Corr. (dB)	Margin (dB)	Limit (dBµV)
0.150000	34.7	2000.0	10.000	GND	L1	10.0	31.3	66.0
0.170000	31.2	2000.0	10.000	GND	N	10.0	33.7	65.0
0.190000	26.0	2000.0	10.000	GND	N	10.0	38.1	64.0
0.215000	20.2	2000.0	10.000	GND	N	10.0	42.8	63.0
0.415000	16.4	2000.0	10.000	GND	N	10.0	41.2	57.5
0.435000	15.8	2000.0	10.000	GND	L1	10.0	41.4	57.2
12.925000	14.7	2000.0	10.000	GND	L1	10.8	45.3	60.0
13.000000	13.4	2000.0	10.000	GND	L1	10.8	46.6	60.0
13.270000	16.9	2000.0	10.000	GND	L1	10.9	43.1	60.0
13.350000	23.5	2000.0	10.000	GND	N	10.8	36.5	60.0
13.390000	19.0	2000.0	10.000	GND	N	10.8	41.0	60.0
13.425000	25.1	2000.0	10.000	GND	L1	10.9	34.9	60.0
13.475000	24.5	2000.0	10.000	GND	L1	10.9	35.5	60.0
13.520000	30.9	2000.0	10.000	GND	L1	10.9	29.1	60.0
13.560000	57.1	2000.0	10.000	GND	L1	10.9	2.9	60.0
13.615000	29.4	2000.0	10.000	GND	L1	10.9	30.6	60.0
13.685000	19.7	2000.0	10.000	GND	N	10.8	40.3	60.0
13.700000	21.2	2000.0	10.000	GND	L1	10.9	38.8	60.0
13.770000	24.0	2000.0	10.000	GND	L1	10.9	36.0	60.0

Final Result 2

Frequency (MHz)	Average (dB μ V)	Meas. Time (ms)	Bandwidth (kHz)	PE	Line	Corr. (dB)	Margin (dB)	Limit (dB μ V)
0.385000	2.2	2000.0	10.000	GND	N	10.0	46.0	48.2
0.390000	1.9	2000.0	10.000	GND	N	10.0	46.2	48.1
0.510000	4.8	2000.0	10.000	GND	N	10.0	41.2	46.0
1.530000	4.0	2000.0	10.000	GND	N	10.1	42.0	46.0
2.035000	-3.7	2000.0	10.000	GND	L1	10.1	49.7	46.0
2.545000	0.6	2000.0	10.000	GND	L1	10.1	45.4	46.0
3.060000	0.9	2000.0	10.000	GND	N	10.1	45.1	46.0
3.565000	-0.9	2000.0	10.000	GND	L1	10.2	46.9	46.0
4.075000	1.9	2000.0	10.000	GND	L1	10.2	44.1	46.0
5.095000	2.8	2000.0	10.000	GND	N	10.3	47.2	50.0
6.115000	3.0	2000.0	10.000	GND	L1	10.4	47.0	50.0
7.135000	2.4	2000.0	10.000	GND	L1	10.5	47.6	50.0
8.155000	1.0	2000.0	10.000	GND	L1	10.5	49.0	50.0
10.705000	1.6	2000.0	10.000	GND	L1	10.6	48.4	50.0
11.720000	-4.7	2000.0	10.000	GND	L1	10.7	54.7	50.0
13.560000	44.4	2000.0	10.000	GND	L1	10.9	5.6	50.0
17.575000	9.4	2000.0	10.000	GND	L1	11.1	40.6	50.0
23.960000	1.3	2000.0	10.000	GND	L1	11.5	48.7	50.0
26.000000	1.6	2000.0	10.000	GND	L1	11.6	48.4	50.0
27.125000	7.3	2000.0	10.000	GND	N	11.5	42.7	50.0

13 Occupied Bandwidth

13.1 Definition

The emission bandwidth (6 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.

13.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.8
EUT Channels Measured:	Low / Mid / High
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: 24 °C	+15 °C to +35 °C (as declared)
Humidity: 31 % RH	20 % RH to 75 % RH (as declared)
Supply: 12 V _{DC}	(as declared)

13.3 Test Limit

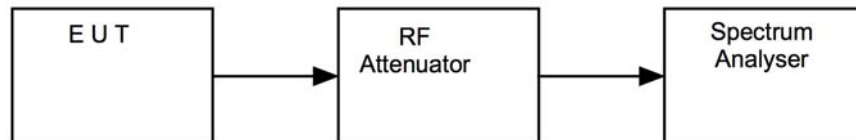
The minimum -6 dB bandwidth shall be at least 500 kHz.

13.4 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

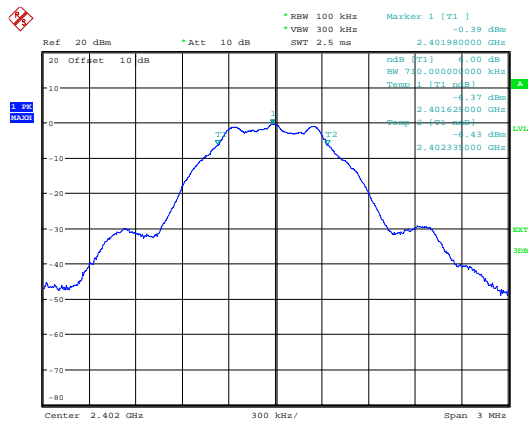


13.5 Test Equipment

<i>Equipment Type</i>	<i>Manufacturer</i>	<i>Equipment Description</i>	<i>Element No</i>	<i>Due For Calibration</i>
FSU46	R&S	Spectrum Analyser	REF910	2020-10-17
Attenuator	AtlanTecRF Microwave	10dB SMA	U633	In Use

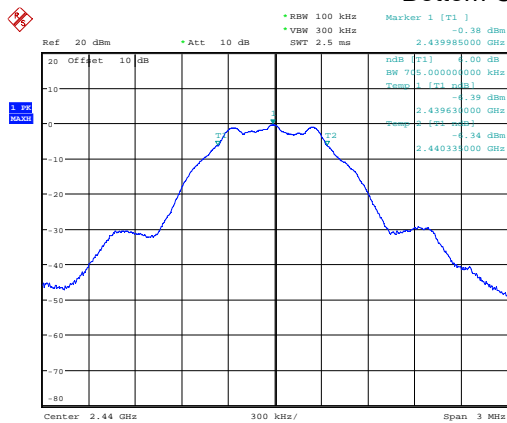
13.6 Test Results

FCC 15.247: 6 dB Bandwidth				
Channel Frequency (MHz)	F_L (MHz)	F_H (MHz)	6dB Bandwidth (kHz)	Result
2402	2401.625	2402.335	710	PASS
2440	2439.630	2440.335	705	PASS
2480	2479.620	2480.330	710	PASS



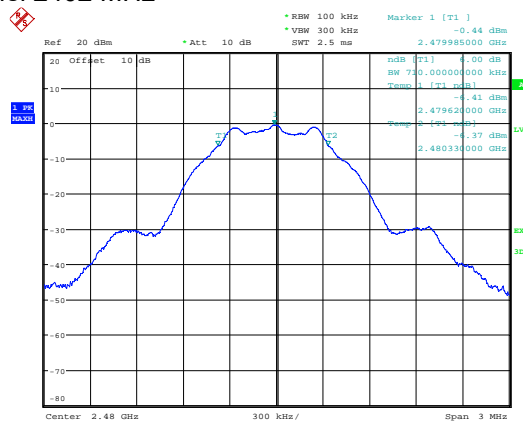
Date: 25.FEB.2020 19:07:33

Bottom Channel 2402 MHz



Date: 25.FEB.2020 19:06:09

Middle channel 2440 MHz



Date: 25.FEB.2020 19:04:22

Top channel 2480 MHz

14 Maximum peak conducted output power

14.1 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 maximum conducted output power is defined as the total transmit power delivered to all antennas and antenna elements averaged across all symbols in the signaling alphabet when the transmitter is operating at its maximum power control level.

14.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.9.1
EUT Channels Measured:	Low / Mid / High
EUT Channel Bandwidths:	1 MHz
Deviations From Standard:	None
Measurement BW:	2 MHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	5 MHz
Measurement Detector:	Peak
Voltage Extreme Environment Test Range:	Mains Power = 85 % and 115 % of Nominal (FCC only requirement); Battery Power = new battery.

Environmental Conditions (Normal Environment)

Temperature: 23 °C	+15 °C to +35 °C (as declared)
Humidity: 32 % RH	20 % RH to 75 % RH (as declared)

14.3 Test Limit

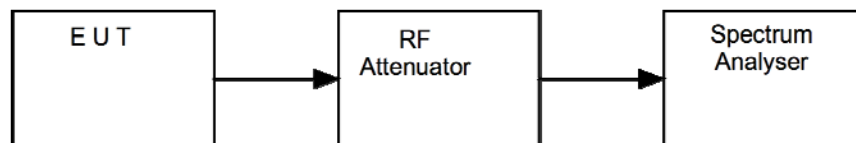
For systems employing digital modulation techniques operating in the bands 902 to 928 MHz, 2400 to 2483.5 MHz and 5725 to 5850 MHz, the maximum peak conducted output power shall not exceed 1 W.

14.4 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



14.5 Test Equipment

<i>Equipment Type</i>	<i>Manufacturer</i>	<i>Equipment Description</i>	<i>Element No</i>	<i>Due For Calibration</i>
FSU46	R&S	Spectrum Analyser	REF910	2020-10-17
Attenuator	AtlanTecRF Microwave	10dB SMA	U633	In Use

14.6 Test Results

<i>Modulation: GFSK; Data rate: 1 Mbps; Power setting: Default</i>					
Channel Frequency (MHz)	Analyzer Level (dBm)	Cable loss (dB)	Power (dBm)	Power (mW)	Result
2402	-9.92	9.90	-0.02	1.00	PASS
2440	-9.90	10.00	0.10	1.02	PASS
2480	-9.96	10.00	0.04	1.01	PASS

The following formula was used to convert field strength (E) in volts/metre to EIRP in watts:

$$\text{EIRP} = (E \times d)^2 / (30)$$

Where d is the measurement distance in metres.

<i>Modulation: GFSK; Data rate: 1 Mbps; Power setting: Default</i>				
Channel Frequency (MHz)	Peak Field Strength (dBμV/m)	Distance (m)	EIRP (mW)	Result
2402	91.2	3	0.395	PASS
2442	89.9	3	0.293	PASS
2480	90.1	3	0.307	PASS

15 Out-of-band and conducted spurious emissions

15.1 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.

15.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.11
EUT Channels Measured:	Low / Mid / High
EUT Channel Bandwidths:	1MHz
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 26.5 GHz

Environmental Conditions (Normal Environment)

Temperature: 23 °C	+15 °C to +35 °C (as declared)
Humidity: 32 % RH	20 % RH to 75 % RH (as declared)
Supply: 12 V _{DC}	(as declared)

15.3 Test Limit

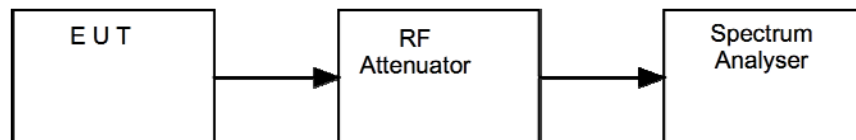
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either 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) / RSS-Gen is not required.

15.4 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

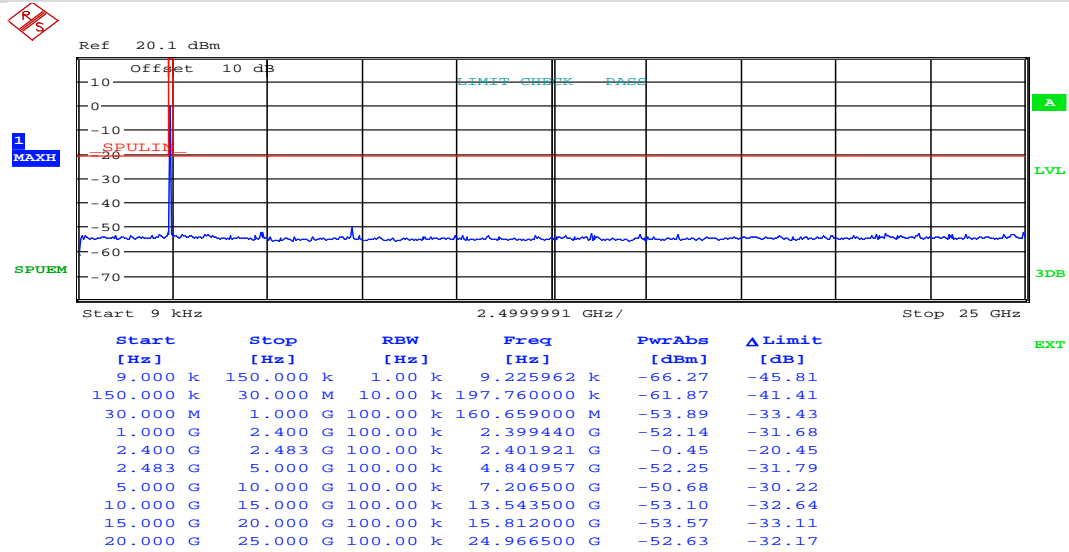


15.5 Test Equipment

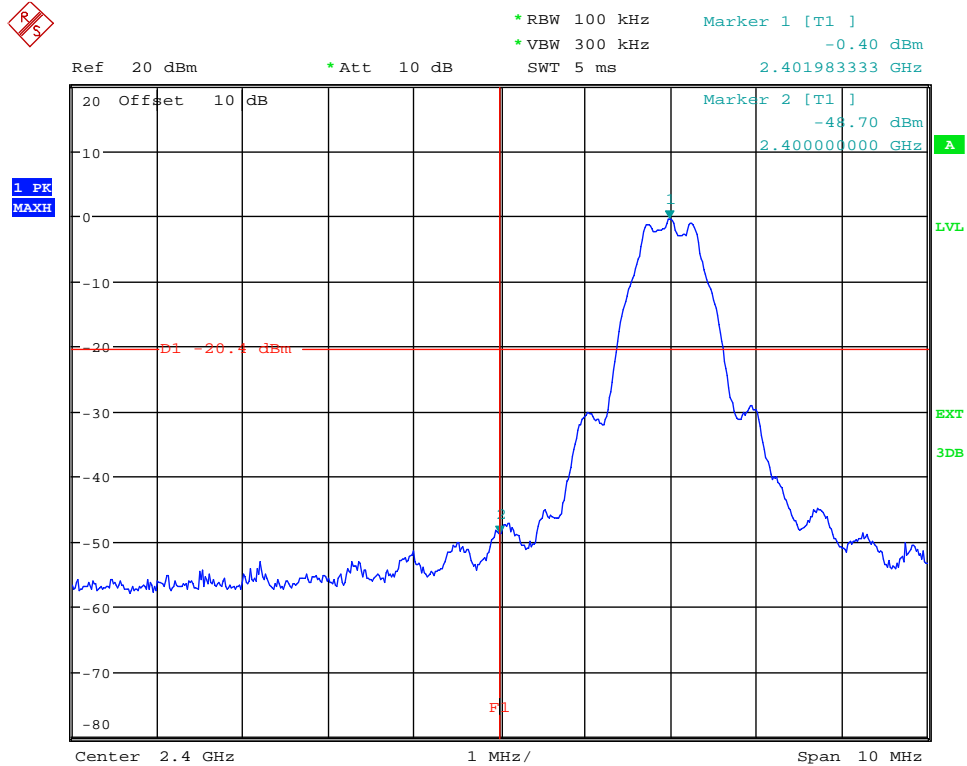
<i>Equipment Type</i>	<i>Manufacturer</i>	<i>Equipment Description</i>	<i>Element No</i>	<i>Due For Calibration</i>
FSU46	R&S	Spectrum Analyser	REF910	2020-10-17
Attenuator	AtlanTecRF Microwave	10dB SMA	U633	In Use

15.6 Test Results

Frequency: 2402 MHz; Bandwidth: 1 MHz; Power setting: Default

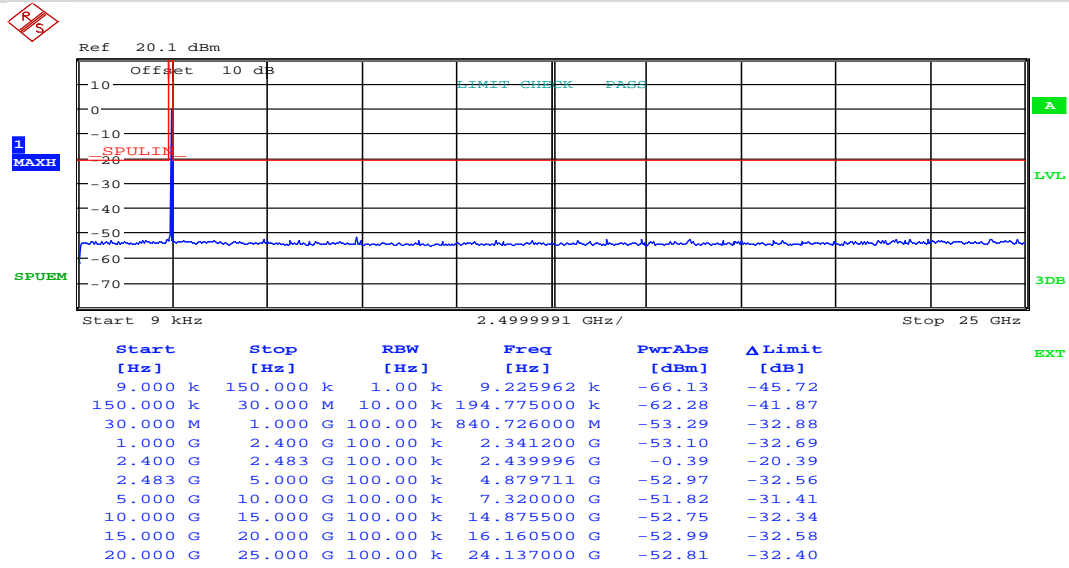


Date: 25.FEB.2020 19:47:32



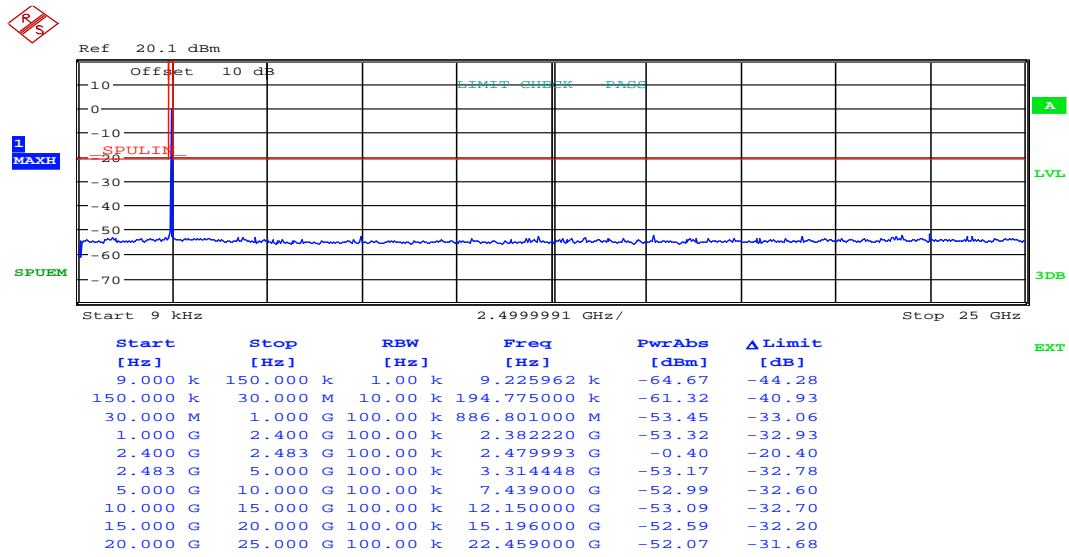
Date: 25.FEB.2020 19:35:41

Frequency: 2440 MHz; Bandwidth: 1 MHz; Power setting: Default

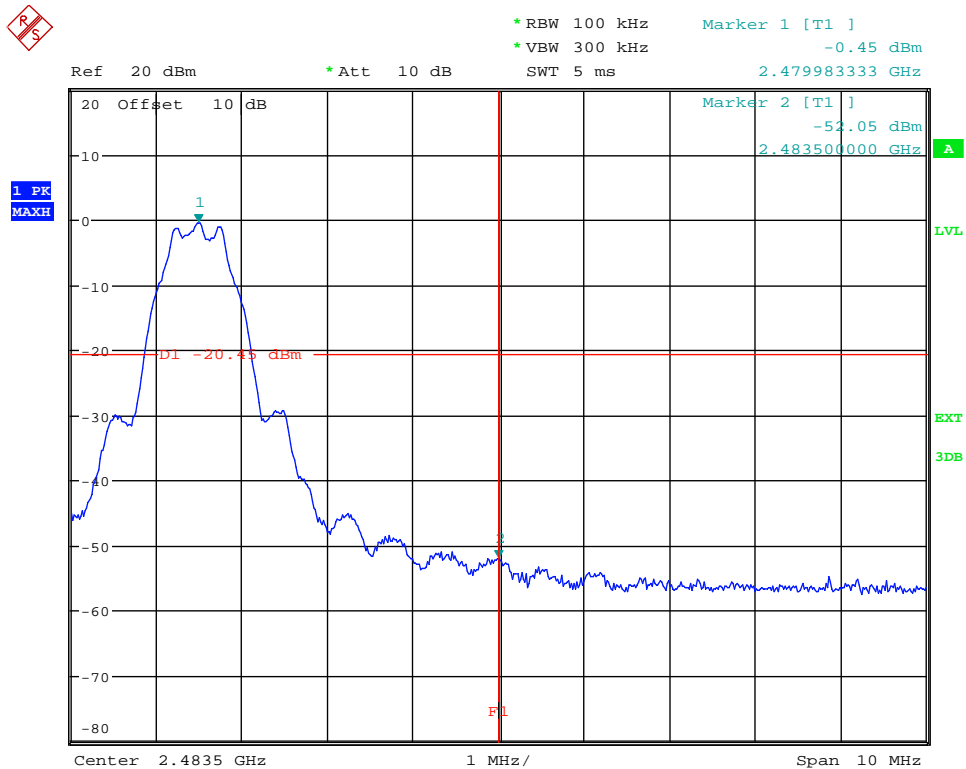


Date: 25.FEB.2020 19:57:09

Frequency: 2480 MHz; Bandwidth: 1 MHz; Power setting: Default



Date: 25.FEB.2020 20:16:32



Date: 25.FEB.2020 19:31:04

16 Power spectral density

16.1 Definition

The power per unit bandwidth.

16.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.10
EUT Channels Measured:	Low / Mid / High
EUT Channel Bandwidths:	1 MHz
Deviations From Standard:	None
Measurement BW:	30 kHz
Spectrum Analyzer Video BW: (requirement at least 3x RBW)	100 kHz
Measurement Span: (requirement 1.5 times Channel BW)	1.1 MHz
Measurement Detector:	Peak

Environmental Conditions (Normal Environment)

Temperature: 23 °C	+15 °C to +35 °C (as declared)
Humidity: 32 % RH	20 % RH to 75 % RH (as declared)
Supply: 12 V _{DC}	(as declared)

16.3 Test Limit

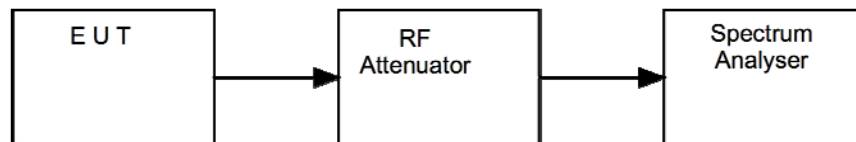
The transmitter power spectral density conducted from the transmitter to the antenna shall not be greater than 8 dBm in any 3 kHz band during any time interval of continuous transmission.

16.4 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

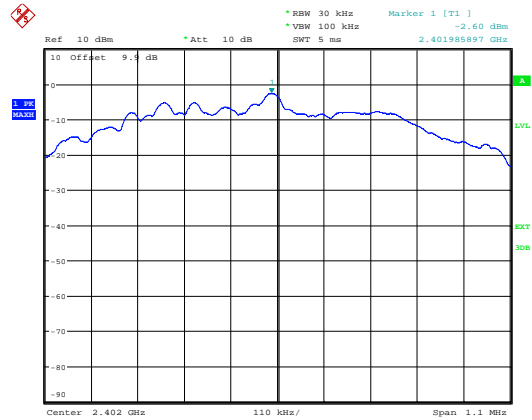


16.5 Test Equipment

<i>Equipment Type</i>	<i>Manufacturer</i>	<i>Equipment Description</i>	<i>Element No</i>	<i>Due For Calibration</i>
FSU46	R&S	Spectrum Analyser	REF910	2020-10-17
Attenuator	AtlanTecRF Microwave	10dB SMA	U633	In Use

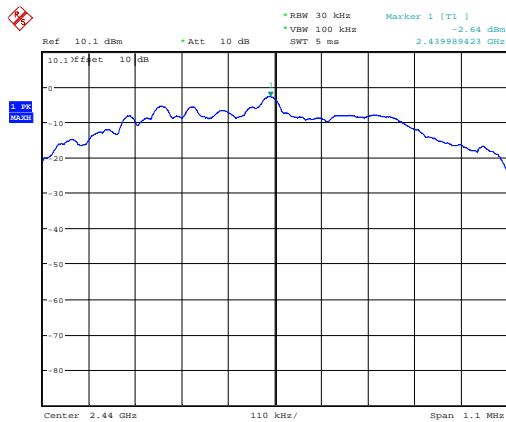
16.6 Test Results

Modulation: GFSK; Data rate: 1 Mbps; Power setting: Default				
Channel Frequency (MHz)	Analyzer Level (dBm)	Cable loss (dB)	Power (dBm)	Result
2402	-12.50	9.90	-2.60	PASS
2440	-12.64	10.00	-2.64	PASS
2480	-12.91	10.00	-2.91	PASS



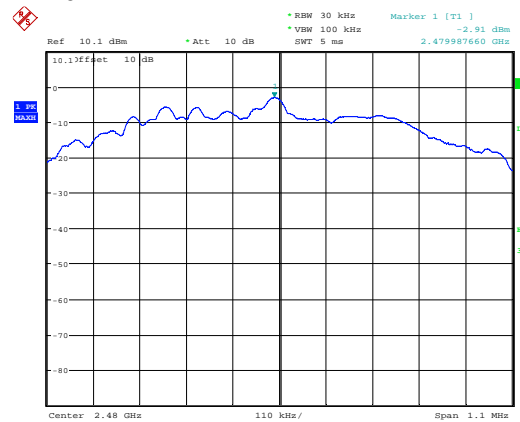
Date: 27.FEB.2020 22:07:48

Bottom channel 2402 MHz



Date: 27.FEB.2020 22:09:17

Middle channel 2440 MHz



Date: 27.FEB.2020 22:10:05

Top channel 2480 MHz

17 Duty Cycle

17.1 Definition

The ratio of the sum of all pulse durations to the total period, during a specified period of operation.

17.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio Laboratory
Test Standard and Clause:	ANSI C63.10-2013, Clause 11.6
EUT Channels Measured:	Mid
Deviations From Standard:	None
Temperature Extreme Environment Test Range:	N/A
Voltage Extreme Environment Test Range:	N/A

Environmental Conditions (Normal Environment)

Temperature: 24 °C	+15 °C to +35 °C (as declared)
Humidity: 31 % RH	20 % RH to 75 % RH (as declared)
Supply: 12 V _{DC}	(as declared)

17.3 Test Limit

N/A.

17.4 Test Method

With the EUT setup as per section 9 of this report and connected as per Figure vii, the duty of the EUT was calculated from the sum of total on and off times over the observation period.

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

[1] Single antenna output devices

Duty was measured at the antenna port / at a distance of 3 m.

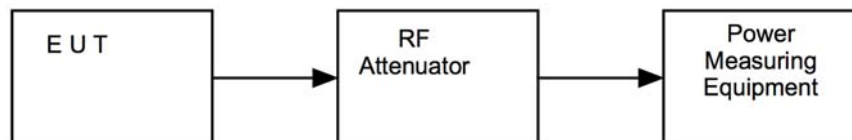
[2] Multiple antenna output devices

Duty was measured as the combination of all ports simultaneously / at a distance of 3 m.

The duty cycle correction factor, DC, shall be added to the measurement results prior to comparing with the emission limit to compute the emission level that would have been measured had the test been performed at 100% duty cycle. The correction factor is computed as:

- 1) If power averaging (rms) mode was used in step f), then the applicable correction factor is $[10 \log (1 / D)]$, where D is the duty cycle.
- 2) If linear voltage averaging mode was used in step f), then the applicable correction factor is $[20 \log (1 / D)]$, where D is the duty cycle.
- 3) If a specific emission is demonstrated to be continuous ($D \geq 98\%$) rather than turning ON and OFF with the transmit cycle, then no duty cycle correction is required for that emission.

Figure vii Test Setup

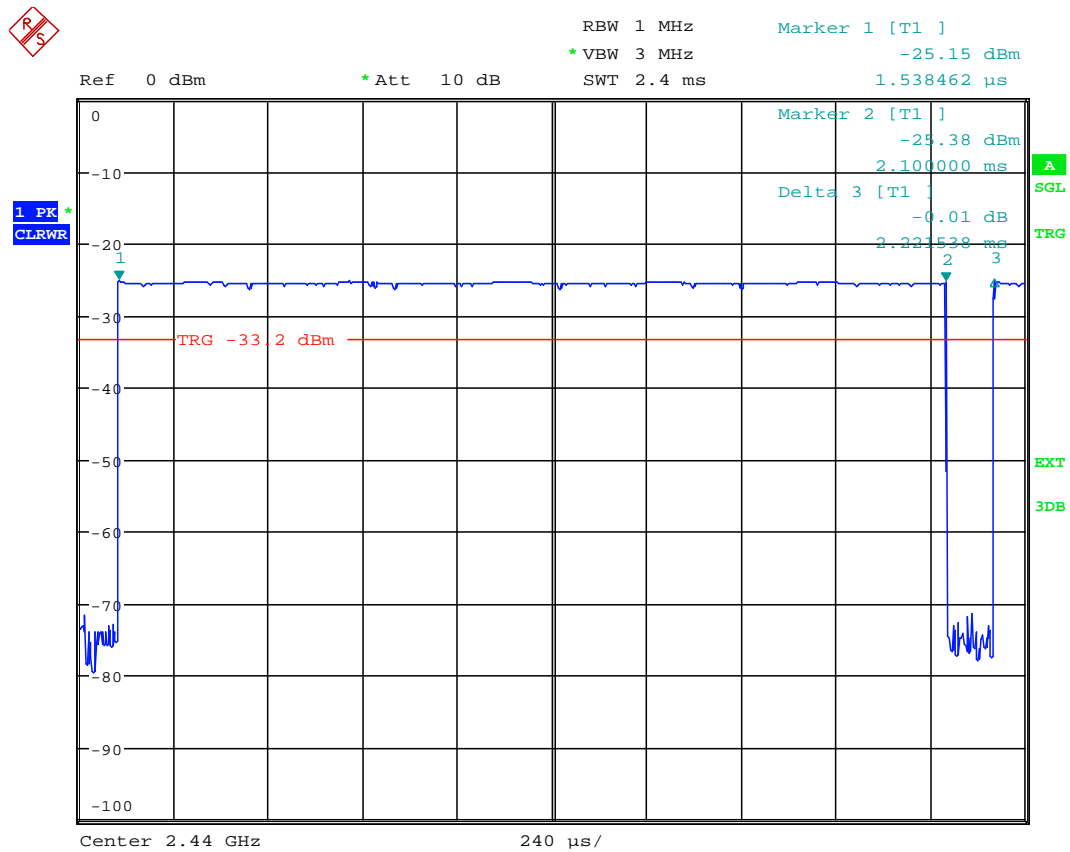


17.5 Test Equipment

Equipment Type	Manufacturer	Equipment Description	Element No	Due For Calibration
FSU46	R&S	Spectrum Analyser	REF910	2020-10-17

17.6 Test Results

BLE1				
Test Environment		TxOn time (ms)	Frame Period (ms)	Calculated Factor (dB)
V _{nominal}	T _{nominal}	2.10	2.22	0.5



Date: 27.FEB.2020 14:55:07

18 Measurement Uncertainty

Calculated Measurement Uncertainties

All statements of uncertainty are expanded standard uncertainty using a coverage factor of 1.96 to give a 95 % confidence:

[1] Radiated spurious emissions

Uncertainty in test result (30 MHz to 1 GHz) = **4.75 dB**

Uncertainty in test result (1 GHz to 18 GHz) = **4.46 dB**

[2] AC power line conducted emissions

Uncertainty in test result = **3.2 dB**

[3] Occupied bandwidth

Uncertainty in test result = **15.58 %**

[4] Conducted carrier power

Uncertainty in test result (Power Meter) = **0.93 dB**

[5] Conducted RF power out-of-band

Uncertainty in test result – up to 8.1 GHz = **3.31 dB**

Uncertainty in test result – 8.1 GHz to 15.3 GHz = **4.43 dB**

[6] Radiated RF power out-of-band

Uncertainty in test result (30 MHz to 1 GHz) = **4.75 dB**

Uncertainty in test result (1 GHz to 18 GHz) = **4.46 dB**

[7] Power spectral density

Uncertainty in test result (Spectrum Analyser) = **3.11 dB**

[8] ERP / EIRP

Uncertainty in test result (Laboratory) = **4.71 dB**

Uncertainty in test result (Pershore OATS) = **4.26 dB**