

Report on the Radio Testing

For

Sepura Limited

on

SC2028

Report no. TRA-059918-45-04B

10th March 2023

Report Number: TRA-059918-45-04B
Issue: B

REPORT ON THE RADIO TESTING OF A
Sepura Limited
SC2028
WITH RESPECT TO SPECIFICATIONS
996369 D04 Module Integration Guide V02 and ISED RSS-GEN Issue 5
(Intermodulation Investigation)

TEST DATE: 2022-12-20

Tested by: D Garvey

Written by: 

D Garvey
Radio Test Engineer

Approved by: D Winstanley
Radio Senior Test Engineer
Date: 10th March 2023

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	25 th January 2023	Original
B	10th March 2023	Update to FCC & ISED ID and serial number

2 Summary

TEST REPORT NUMBER:	TRA-059918-45-04B
WORKS ORDER NUMBER:	TRA-059918-00
PURPOSE OF TEST:	Intermodulation Investigation
TEST SPECIFICATION:	KDB 996369 D04 V02
EQUIPMENT UNDER TEST (EUT):	SC2028
CONTAINS FCC IDENTIFIER:	XX6SC2028M
CONTAINS ISSED IDENTIFIER:	8739A-SC2028M
EUT SERIAL NUMBER:	1PR002244GK93AI
MANUFACTURER/AGENT:	Sepura Limited
ADDRESS:	9000 Cambridge Research Park Beach Drive Waterbeach Cambridge CB25 9TL United Kingdom
CLIENT CONTACT:	James O'Reilly ☎ 01223 876000 ✉ James.OReilly@sepura.com
ORDER NUMBER:	PLC-PO023828-1
TEST DATE:	2022-12-20
TESTED BY:	D Garvey Element

2.1 Test Summary

<i>Test Method and Description</i>	<i>Applicable to this equipment</i>	<i>Result / Note</i>
Radiated Spurious Emissions (Intermodulation Investigation)	☒	Pass

Notes:

Only limited testing was performed to check the intermod emissions.

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-059918-45-04B presents the results of the Radio testing on a Sepura Limited, SC2028 to specification KDB 996369 D04 Module Integration Guide V02 - Modular transmitter integration guide - Guidance for host product manufacturers.

The testing was carried out for Sepura Limited 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
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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:

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 1 GHz.

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.
- ISSED RSS-247, Issue 2, February 2017 – Digital Transmission Systems (DTSSs), Frequency Hopping Systems (FHSSs) and Licence-Exempt Local Area Network (LE-LAN) Devices.
- FCC 47 CFR Ch. I – Part 2 - Code of Federal Regulations, Title 47, Part 2, “Frequency allocations and Radio Telemetry Matters; General Rules and Regulations”
- FCC 47 CFR Ch. I – Part 90 - Code of Federal Regulations, Title 47, Part 90, “Land Mobile Radio Service”
- TIA EIA-603-D Land Mobile FM or PM Communications Equipment Measurement and Performance Standards
- ANSI C63.10-2013 – American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.
- ISSED RSS-Gen, Issue 5, March 2019 – General Requirements for Compliance of Radio Apparatus.
- ISSED RSS-119, Issue 12, May 2015 – Land Mobile and Fixed Equipment Operating in the Frequency Range 27.41-960 MHz
- ANSI C63.10-2013 – American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices.
- ANSI C63.26-2015 - American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services
- 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.
- KDB996369 D04 Module Integration Guide v02 – Modular Transmitter Integration Guide - Guidance for Host Product Manufacturers.
- RSP-100, Issue 12, August 2019 – Certification of Radio Apparatus and Broadcasting Equipment.

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
ACK	Acknowledgement signal
AFH	Adaptive Frequency Hopping
BW	bandwidth
C	Celsius
CCA	Clear Channel Assessment
COT	Channel Occupancy Time
CW	Continuous Wave
dB	decibel
dBm	dB relative to 1 milliwatt
DAA	Detect And Avoid
DC	Direct Current
EIRP	Equivalent Isotropically Radiated Power
EN	European Normative document
EUT	Equipment Under Test
FHSS	Frequency Hopping Spread Spectrum
Hz	hertz
IM	InterModulation
ITU	International Telecommunication Union
LBT	Listen Before Talk
m	metre
max	maximum
min	minimum
N/A	Not Applicable
PCB	Printed Circuit Board
PDF	Portable Document Format
R&TTE	Radio and Telecommunications Terminal Equipment
RE	Radio Equipment
RF	Radio Frequency
RH	Relative Humidity
RMS	Root Mean Square
Rx	receiver
s	second
Tx	transmitter
UKAS	United Kingdom Accreditation Service
V	volt
W	watt
Ω	ohm

7 Equipment Under Test

7.1 EUT Identification

- Name: SC2028
- Serial Number: 1PR002244GK93AI
- Model Number: SC2028
- Software Revision: 181000207367
- Build Level / Revision Number: PLX-2516515-01 H/W mod state 11

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.

Element Laptop
USB programming cable

7.3 EUT Mode of Operation

The unit was connected via the USB lead and scripts, provided by the manufacturer, were sent to the EUT via a terminal program. The unit was put into a mode transmitting a modulated signal on the required frequencies.

7.4 EUT Radio Parameters

Radio description:	2.4 GHz Wi-Fi
Frequency of operation:	2412 MHz to 2472 MHz
Antenna type and gain:	Integral PCB 2.5 dBi
Declared output power:	IEEE 802.11b 19 dBm (max) EIRP
Nominal Supply Voltage:	7.4 Vdc (from rechargeable battery)

Radio description:	BT Classic
Frequency of operation:	2402 MHz to 2480 MHz
Antenna type and gain:	Integral PCB 2.5 dBi
Declared output power:	10 dBm EIRP
Nominal Supply Voltage:	7.4 Vdc (from rechargeable battery)

Radio description:	BT Low Energy
Frequency of operation:	2402 MHz to 2480 MHz
Antenna type and gain:	Integral PCB 2.5 dBi
Declared output power:	9 dBm EIRP
Nominal Supply Voltage:	7.4 Vdc (from rechargeable battery)

Radio Description:	TETRA tested in the SC2028
Frequency of Operation:	806 MHz to 825 MHz & 851 MHz to 869 MHz
Antenna Type and Gain:	$\lambda/4$ Whip 300-00498 >0 dBi
Channel Bandwidth:	25 kHz
Declared Output Power:	35 dBm ERP
Nominal Supply Voltage:	7.4 Vdc (from rechargeable battery)

7.5 EUT Description

The EUT is a TETRA hand held portable radio with BT, BLE, 2.4 GHz WiFi and GNSS. This report only covers intermod testing.

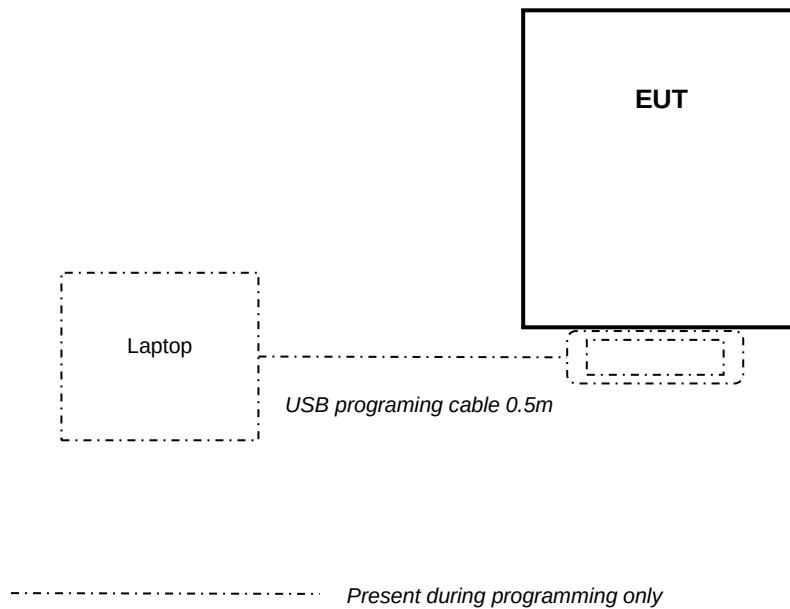
8 Modifications

No modifications were performed during this assessment.

9 EUT Test Setup

9.1 Block Diagram

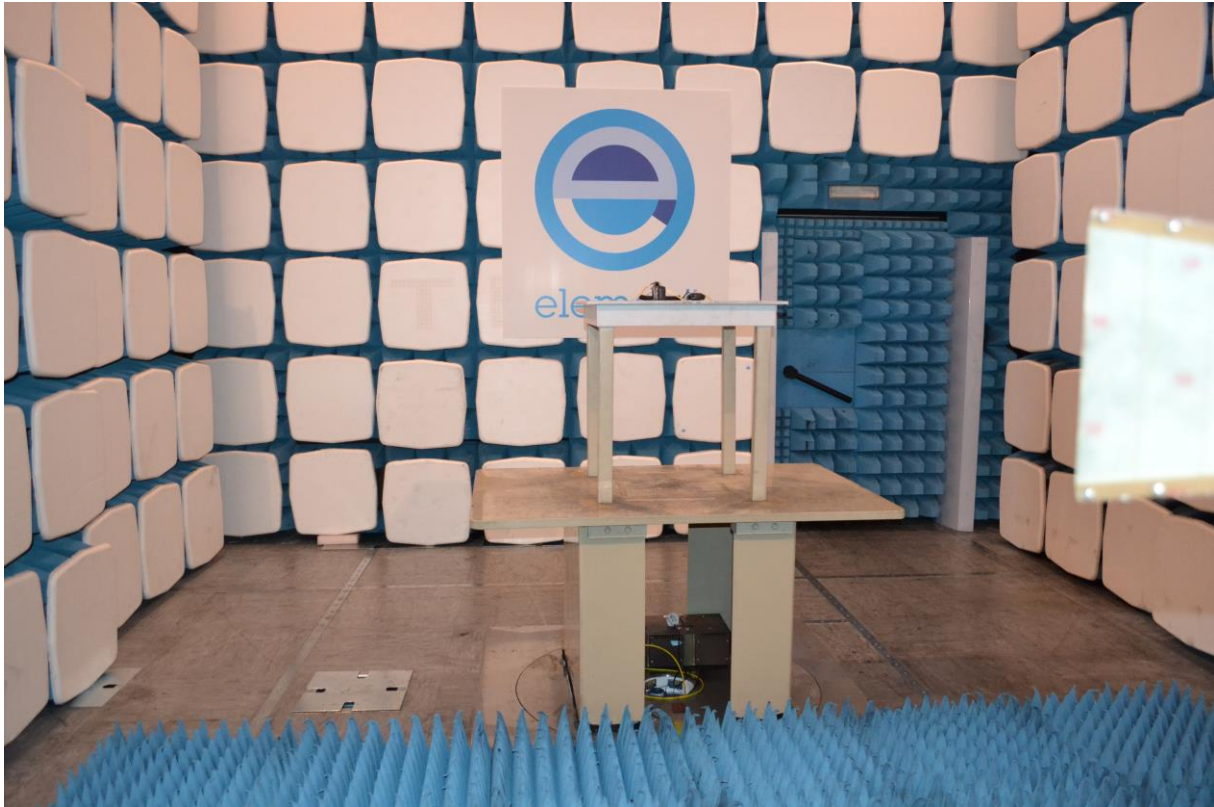
The following diagram shows basic EUT interconnections:



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

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 7.4 Vdc from the lithium polymer rechargeable battery.

11 Transmitter Unwanted Emissions in the Spurious Domain and Intermodulation

11.1 Definitions

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.

11.2 Test Parameters

Test Location:	Element Hull
Test Chamber:	Wireless Lab 2
Test Standard and Clause:	ETSI EG 203 367 V1.1.1 (2016-06), Clause 6.2
Frequencies Measured:	TETRA 815.000 MHz in combinations with 2.4GHz Wi-Fi: 2437 MHz; BT Classic: 2442 MHz; BLE: 2442 MHz & TETRA 860.000 MHz in combinations with 2.4GHz Wi-Fi: 2437 MHz; BT Classic: 2442 MHz; BLE: 2442 MHz
Deviations from Standard:	None
Measurement BW:	100 kHz (30 MHz – 1 GHz); 1 MHz (1 GHz – 26 GHz)
Measurement Detector:	Below 1 GHz: Peak Above 1 GHz: Peak
Test Location:	Element Hull

Environmental Conditions (Normal Environment)

Radiated

Temperature: 21 °C	Standard Requirement: +15 °C to +35 °C
Humidity: 38 %RH	Standard Requirement: 20 %RH to 75 %RH

Test Limits

The power of any emission outside of the authorized operating frequency ranges must be attenuated below the transmitting power (P) by a factor of at least $43 + 10 \log(P)$ dB.

11.3 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 C63.26 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 dB μ V/m at the regulatory distance, using:

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

Where,

PR is the power recorded on the receiver / spectrum analyzer in dB μ V;

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);

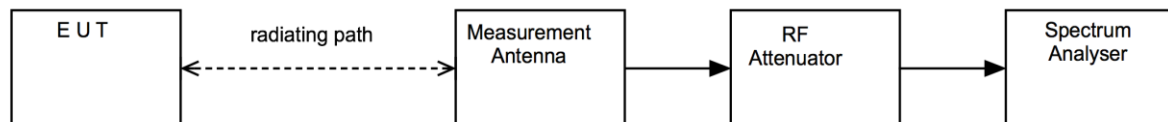
DC is the duty correction factor in dB (where used, e.g. harmonics of pulsed fundamental);

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

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

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

Figure i Test Setup



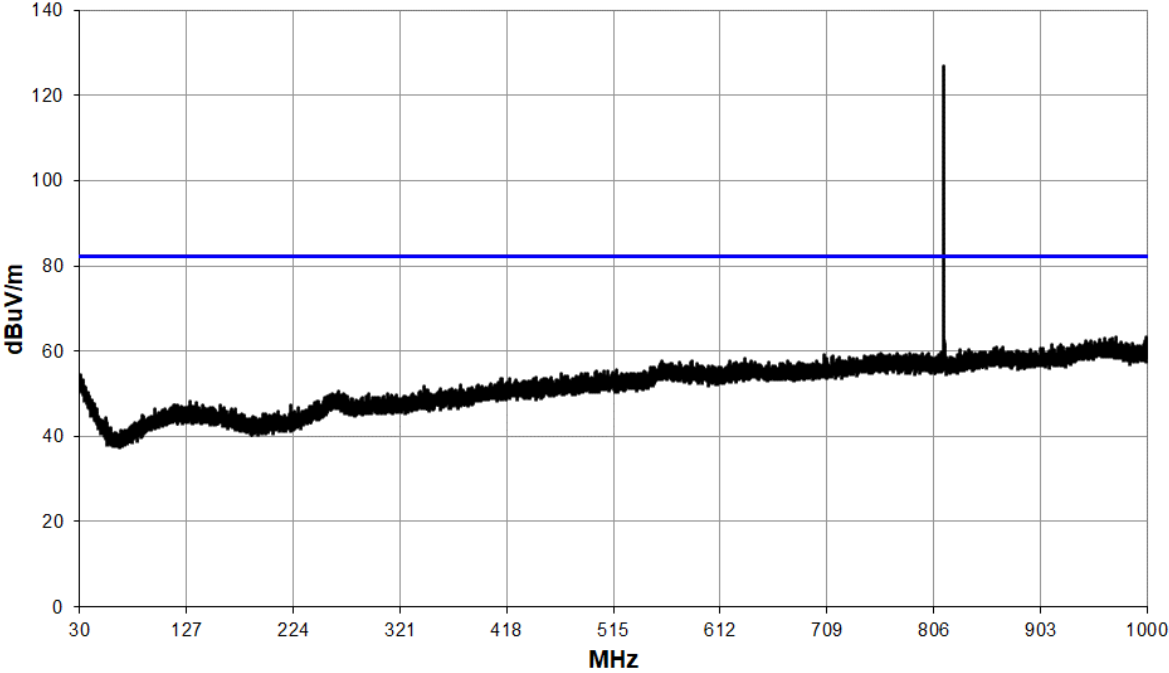
11.4 Test Equipment

<i>Equipment Type</i>	<i>Manufacturer</i>	<i>Equipment Description</i>	<i>Element No</i>	<i>Due For Calibration</i>
Ferrite Lined Chamber	Rainford	Chamber	REF886	2024-06-15
FSU26	R&S	Spectrum Analyser	REF909	2023-08-05
CBL6111D	TESEQ	Bilog Antenna	REF2385	2024-06-24
3115	EMCO	Horn Antenna	RFG129	2024-01-24
LB-62-25-C-SF	A Info Inc	Horn Antenna	REF2244	2024-07-11
LB-180400-25-C-KF	A Info Inc	Horn Antenna	REF2246	2024-09-23
Pre-Amp (9 kHz – 1 GHz)	Sonoma	310	REF2389	2023-09-02
Pre-Amp (1 – 26.5 GHz)	Agilent	8449B	REF913	2023-03-24
Emissions R5	Element	Radiated Test Software	REF9000	Cal Not Required
F-HPC5-730008-S5S5	AtlanTecRF	High Pass Filter	REF2315	Calibrate In Use
VHF-3500+	Mini-Circuits	High Pass Filter	REF2285	Calibrate In Use
4478	BSC	Band Stop Filter	REF2158	Calibrate In Use

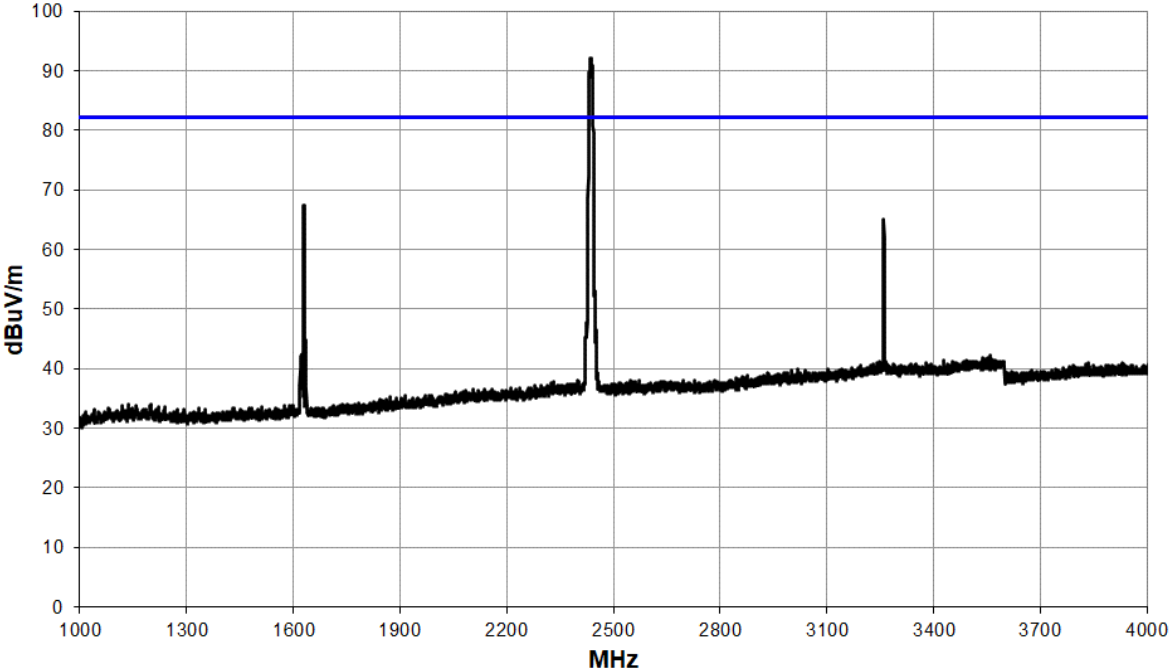
11.5 Test Results

TETRA Frequency: 815.000 MHz; Power Setting: 35 dBm; Modulation: Burst with Wifi Frequency: 2437 MHz; Power Setting: 17 dBm					
Emission	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Result
No Intermodulation emissions were detected within 20 dB of the limit.					

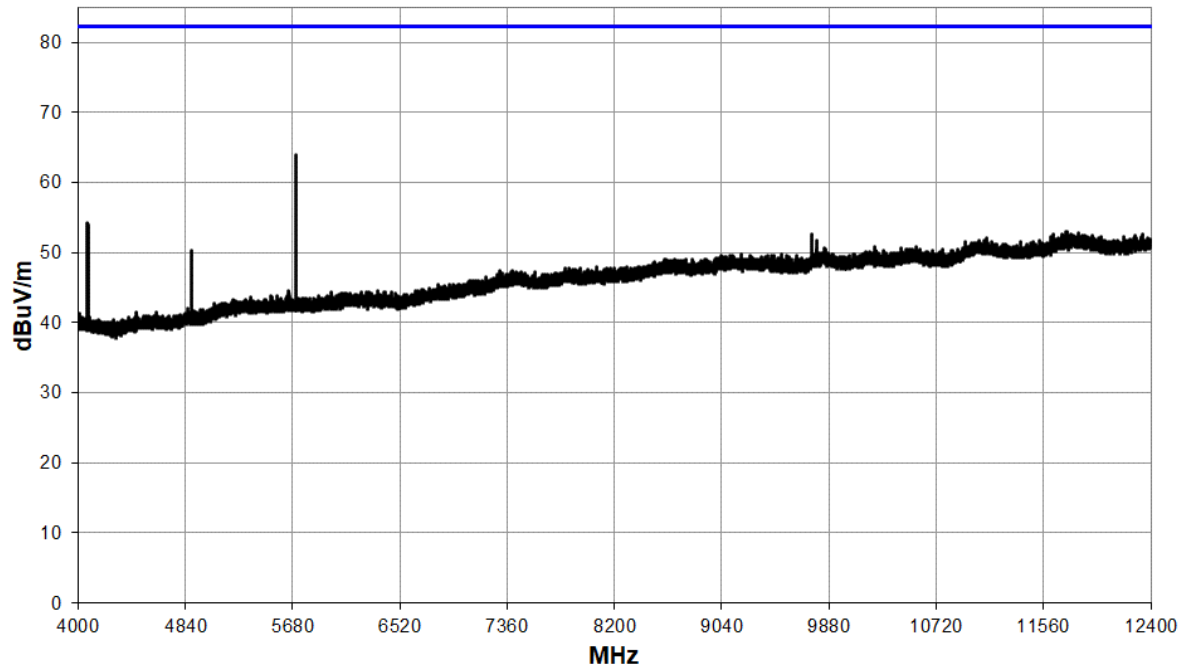
30 MHz to 1 GHz



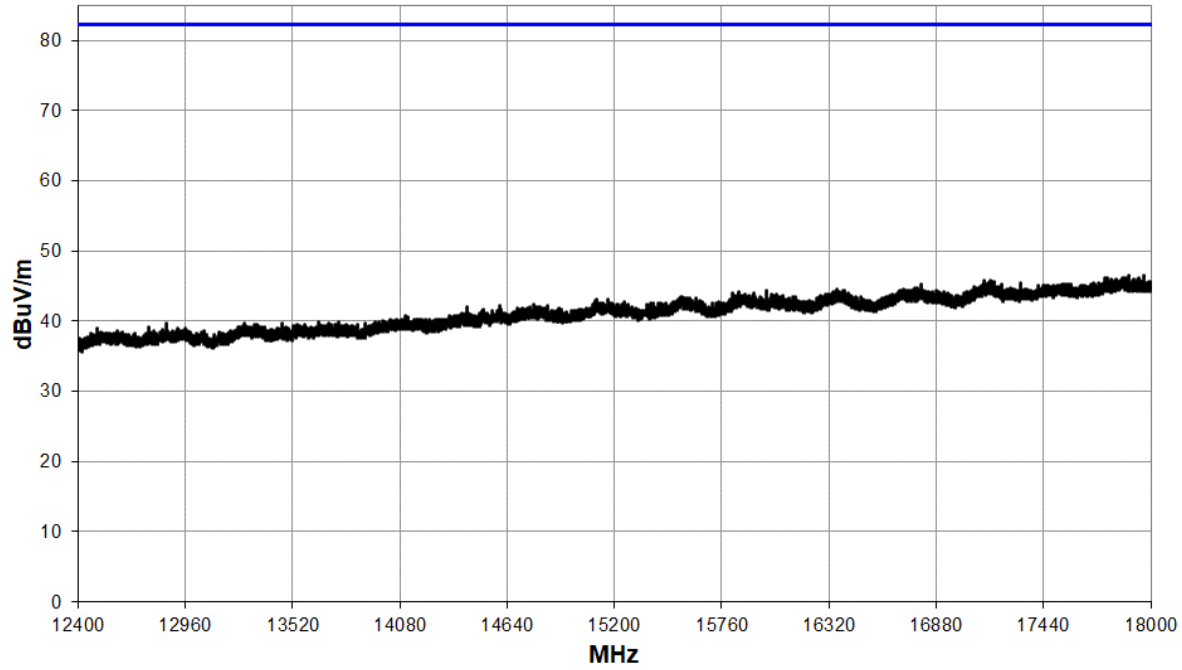
1 GHz to 4 GHz



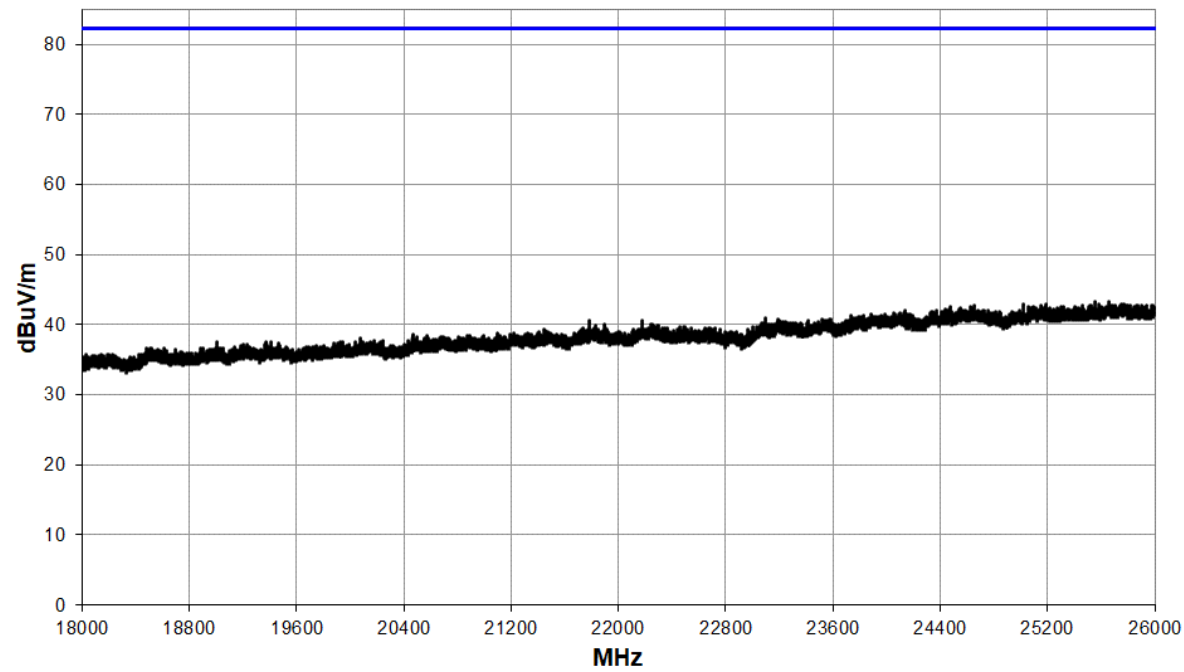
4 GHz to 12.4 GHz



12.4 GHz to 18 GHz

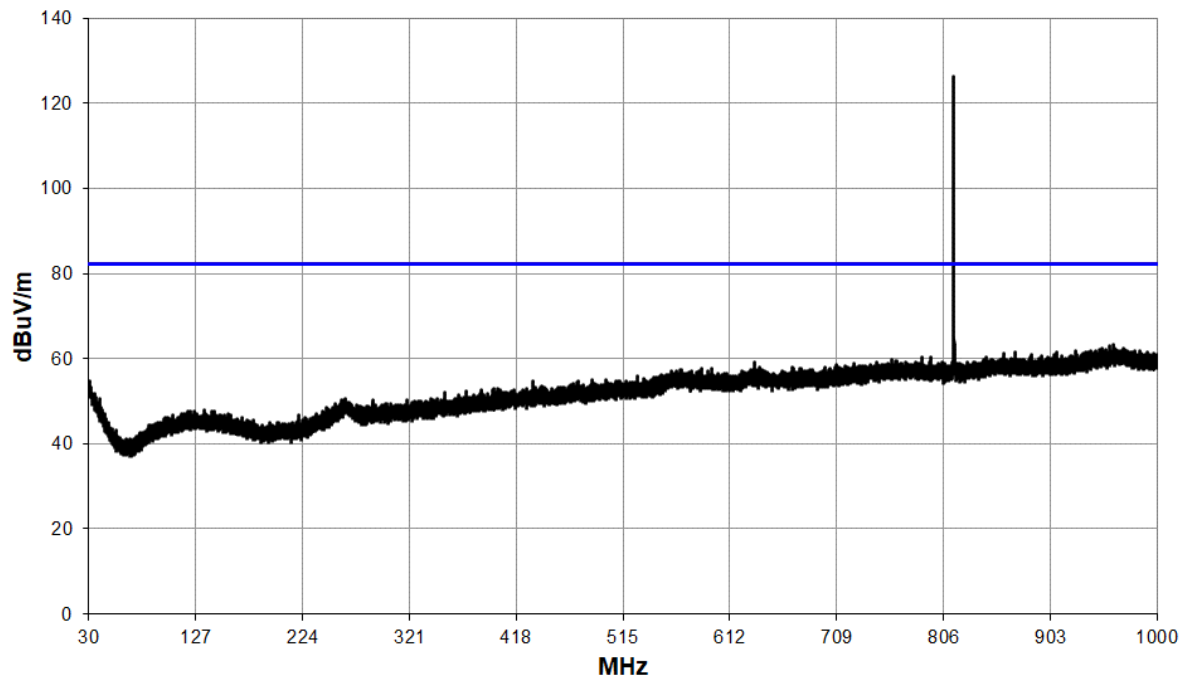


18 GHz to 26 GHz

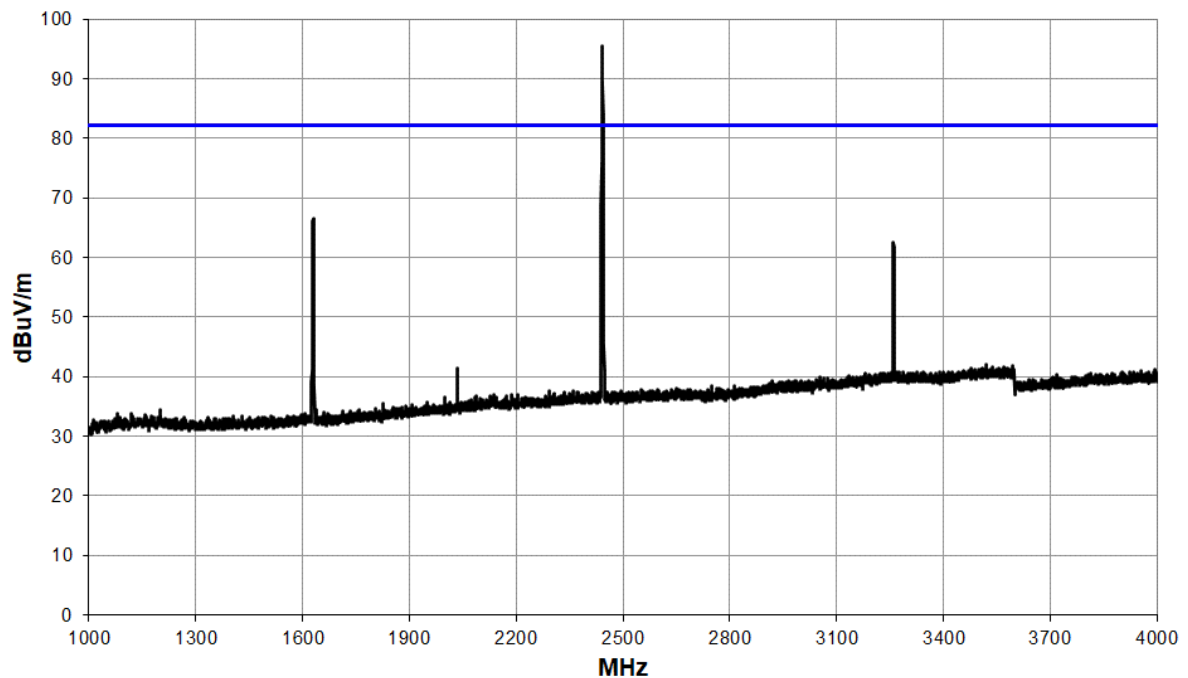


TETRA Frequency: 815.000 MHz; Power Setting: 35 dBm; Modulation: Burst with BT Classic Frequency: 2442 MHz; Power Setting: default					
Emission	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Result
No Intermodulation emissions were detected within 20 dB of the limit.					

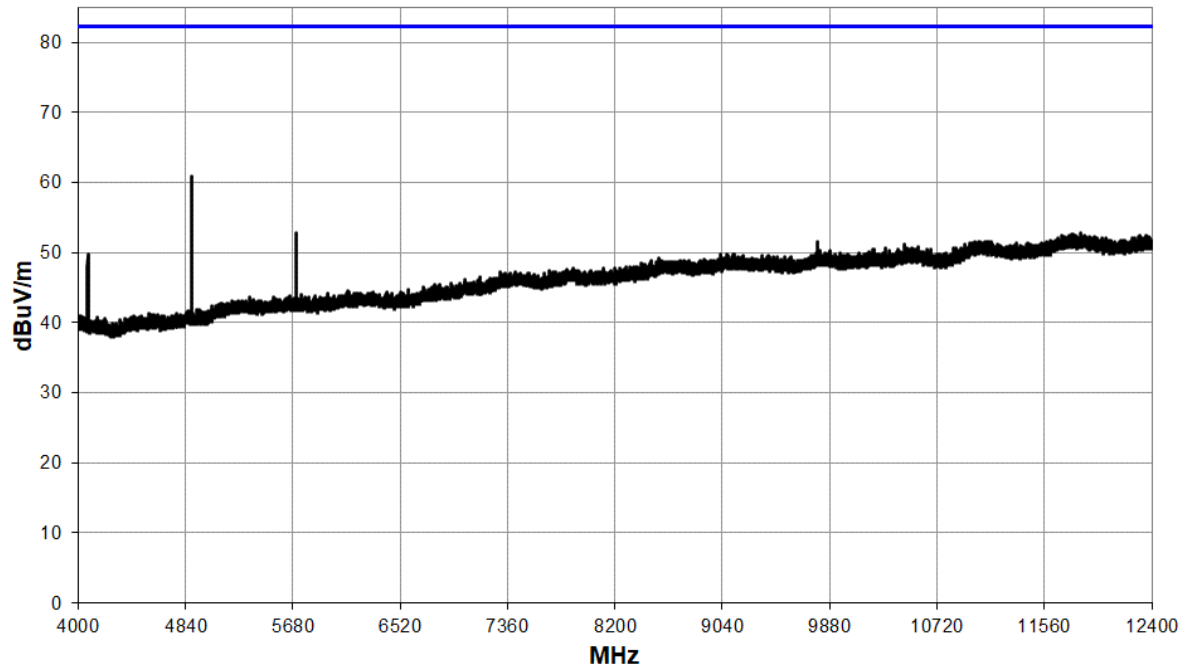
30 MHz to 1 GHz



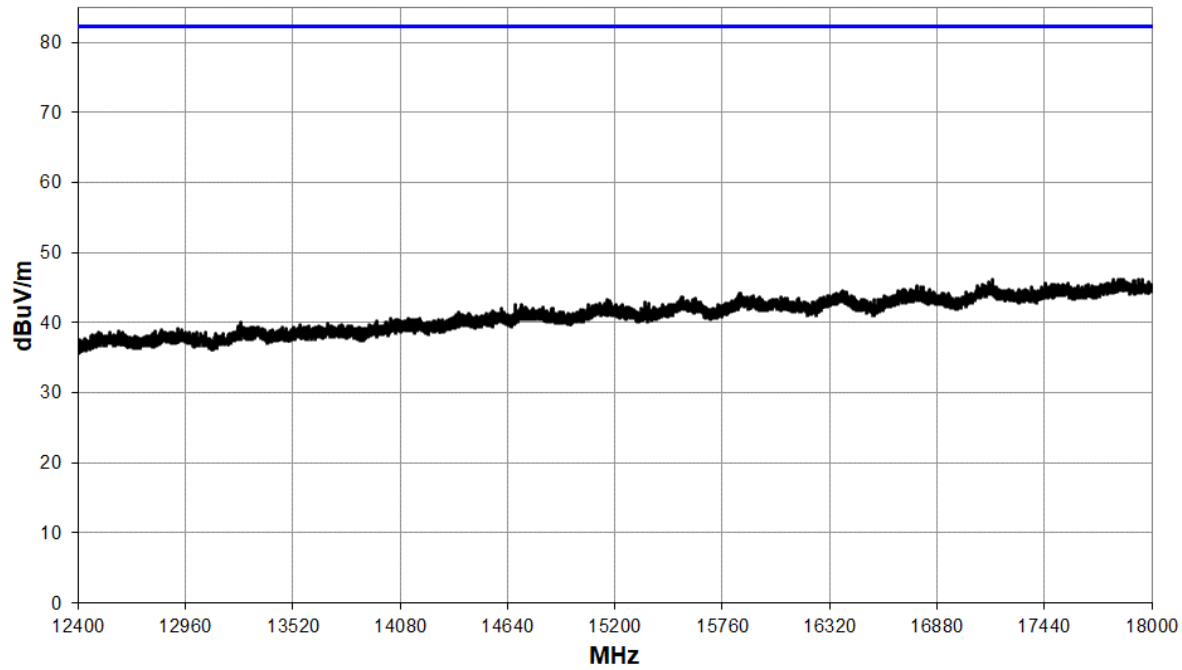
1 GHz to 4 GHz



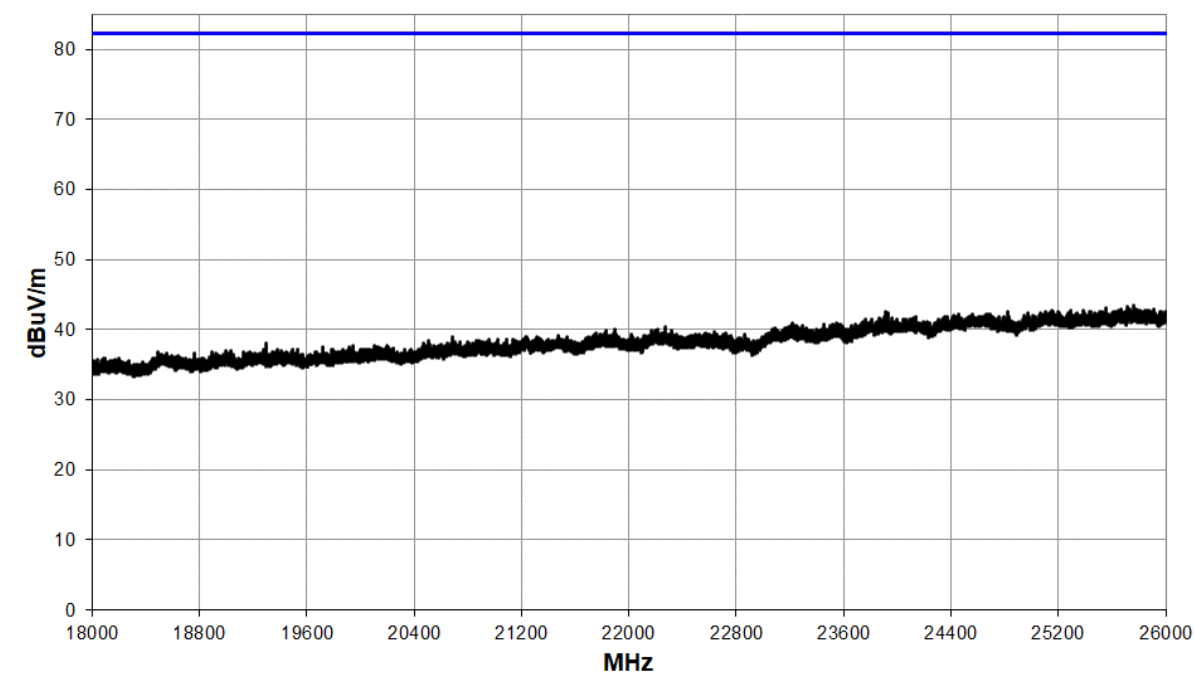
4 GHz to 12.4 GHz



12.4 GHz to 18 GHz

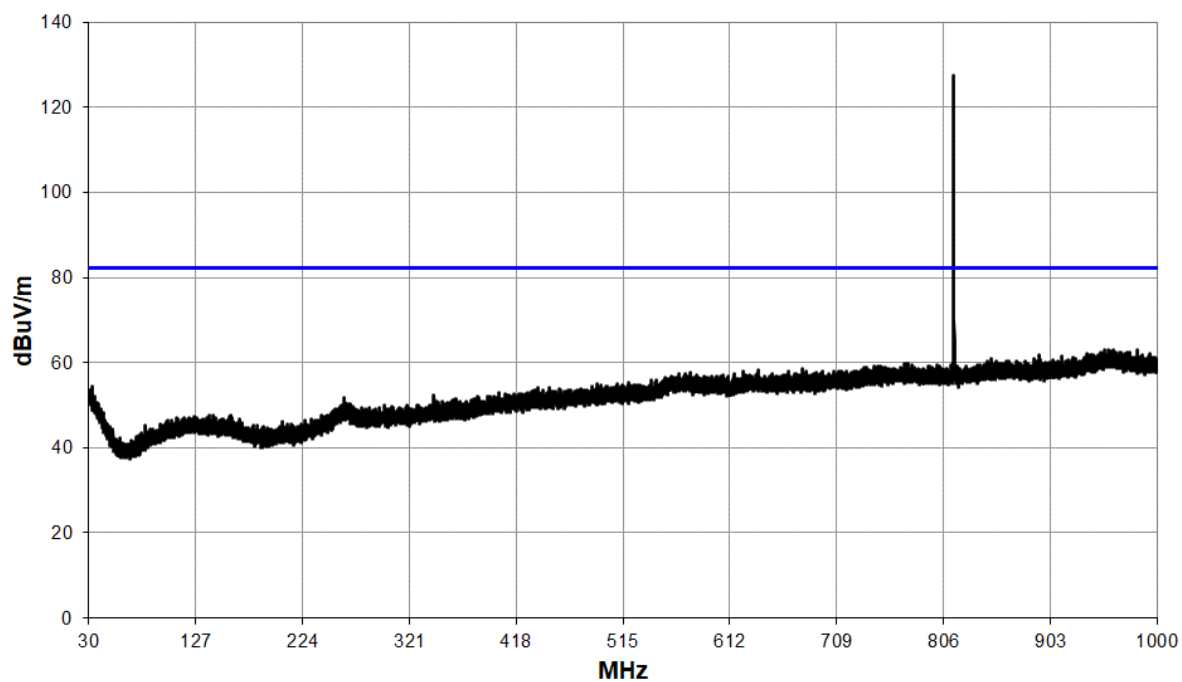


18 GHz to 26 GHz

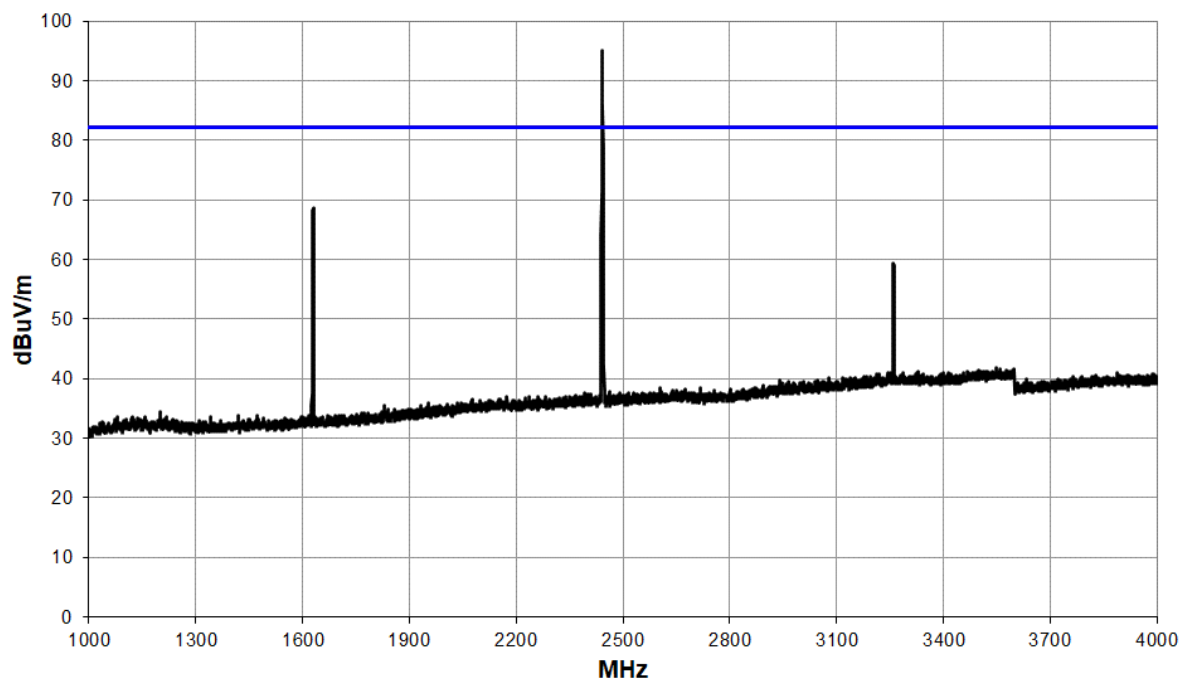


TETRA Frequency: 815.000 MHz; Power Setting: 35 dBm; Modulation: Burst with BLE Frequency: 2442 MHz; Power Setting: default					
Emission	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Result
No Intermodulation emissions were detected within 20 dB of the limit.					

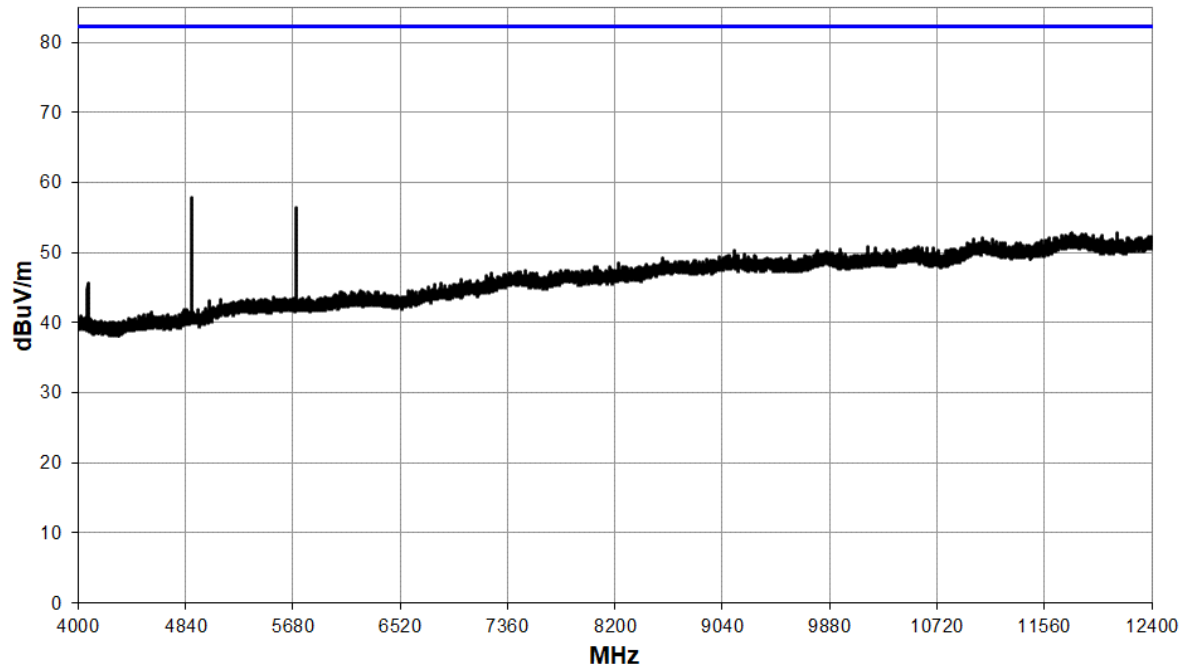
30 MHz to 1 GHz



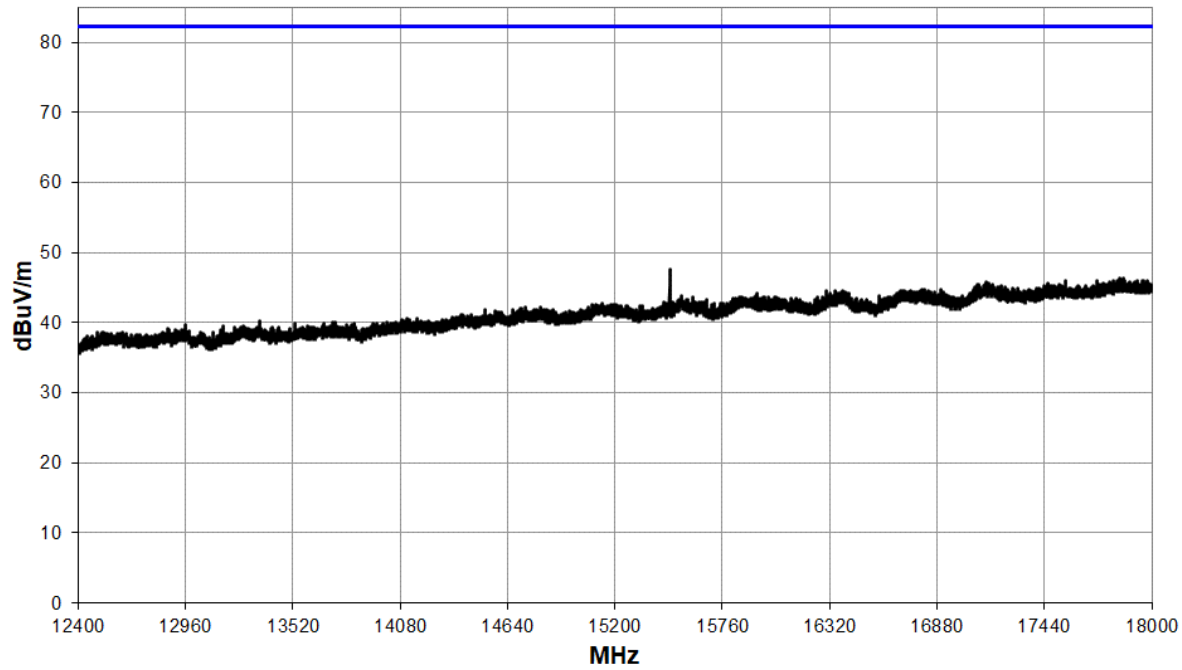
1 GHz to 4 GHz



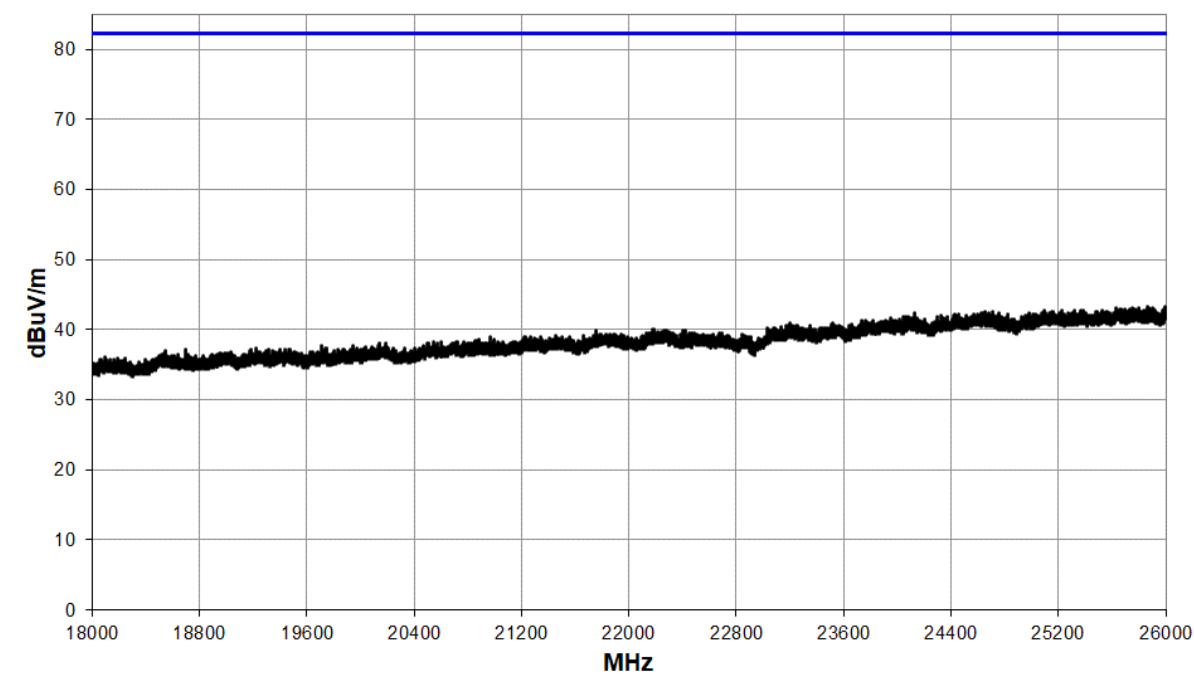
4 GHz to 12.4 GHz



12.4 GHz to 18 GHz

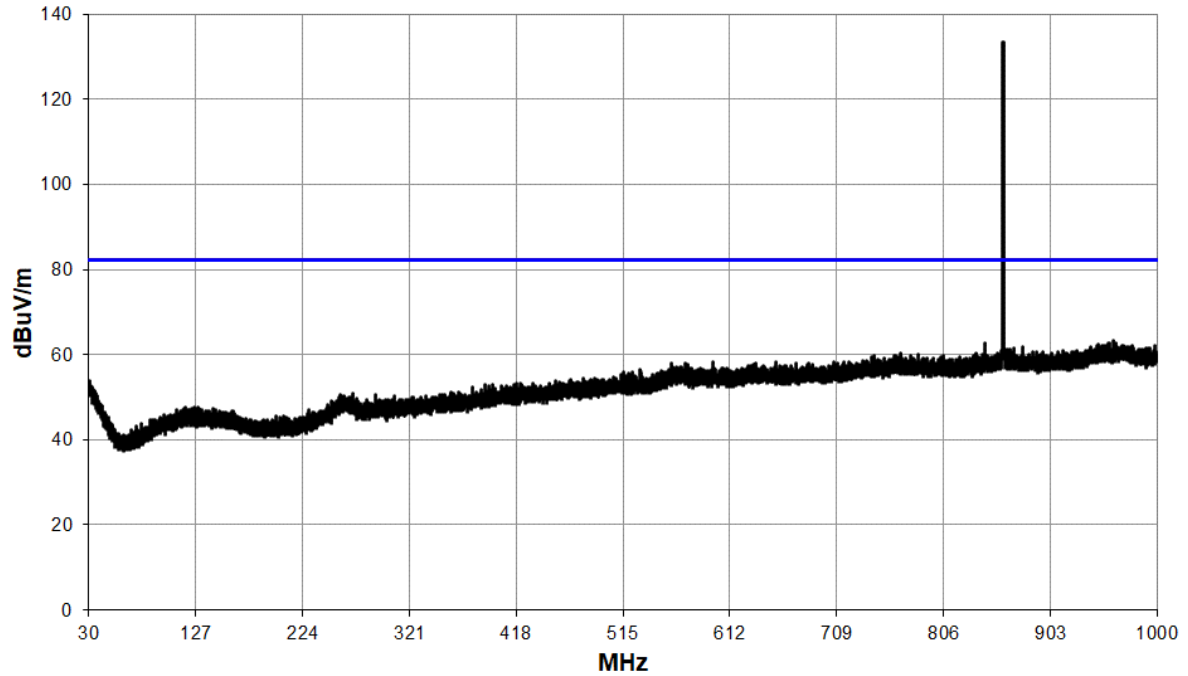


18 GHz to 26 GHz

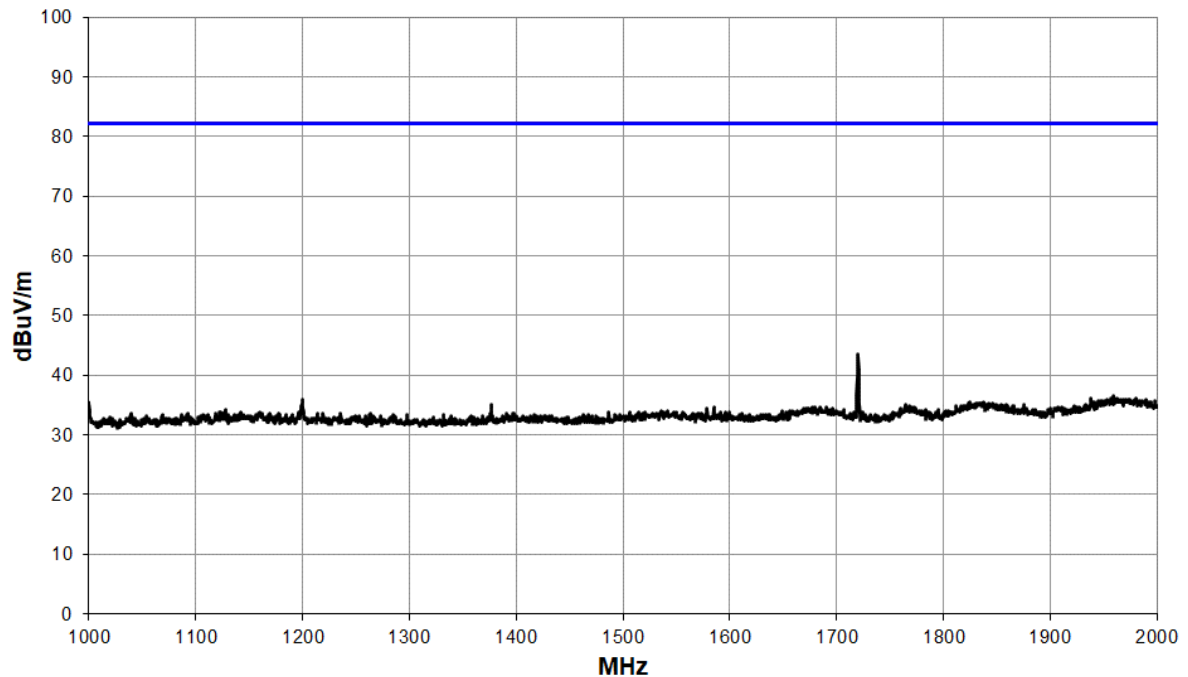


TETRA Frequency: 860.000 MHz; Power Setting: 35 dBm; Modulation: Burst with Wifi Frequency: 2437 MHz; Power Setting: 17 dBm					
Emission	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Result
No Intermodulation emissions were detected within 20 dB of the limit.					

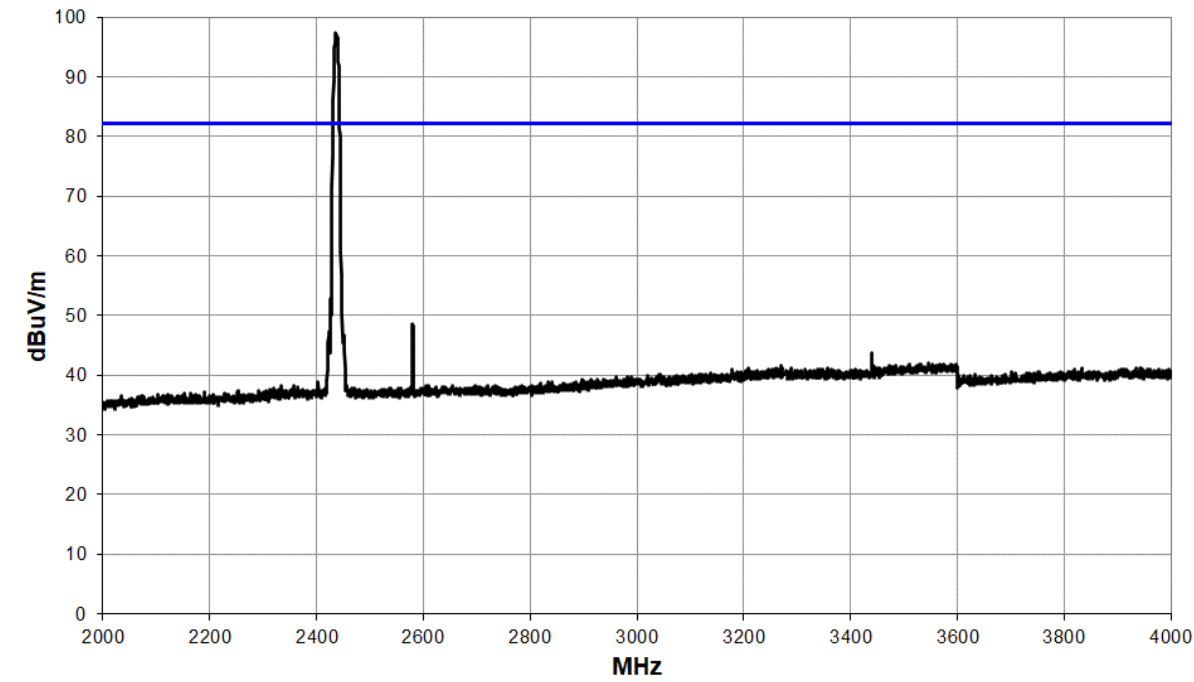
30 MHz to 1 GHz



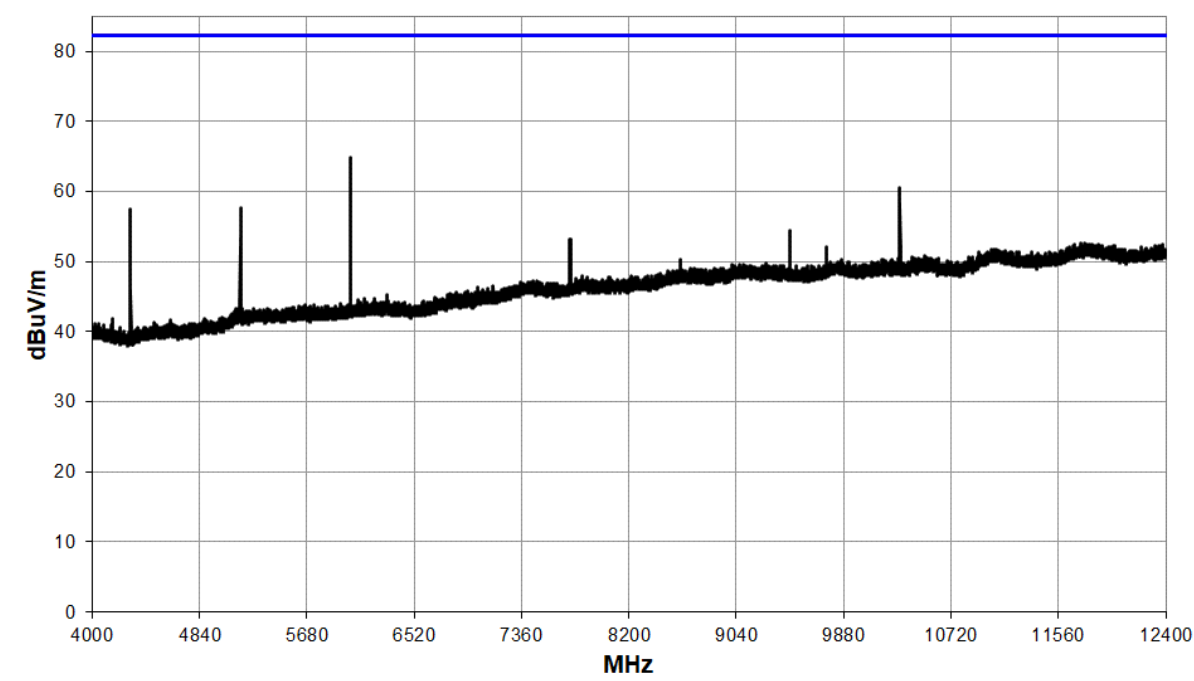
1 GHz to 2 GHz



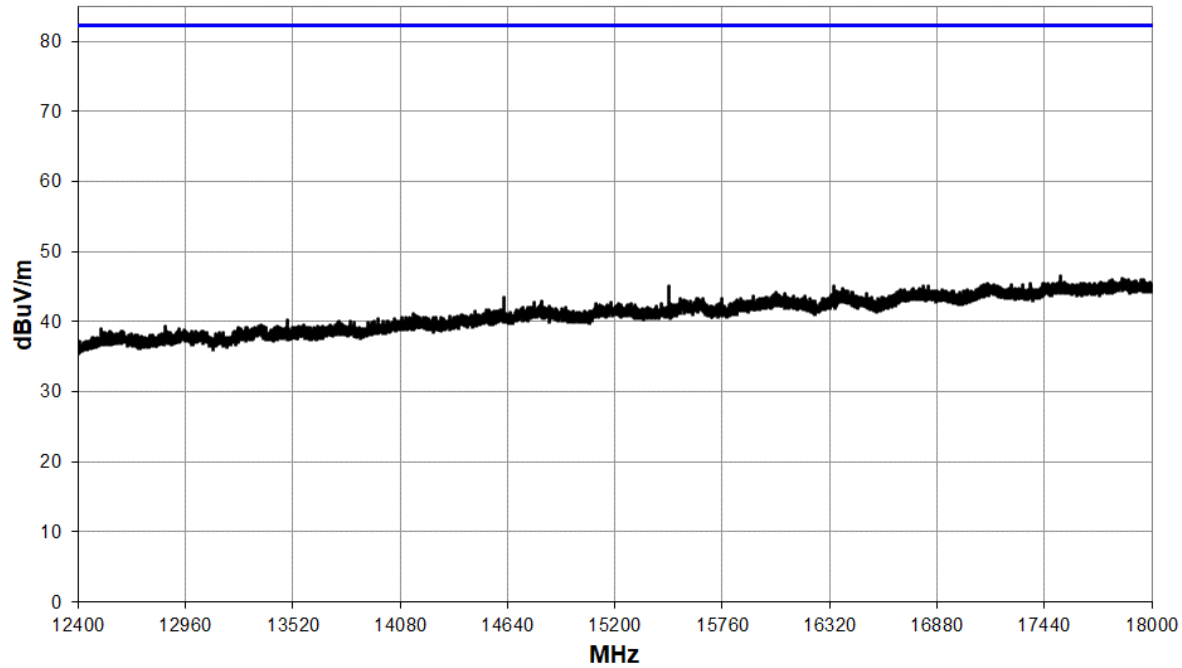
2 GHz to 4 GHz



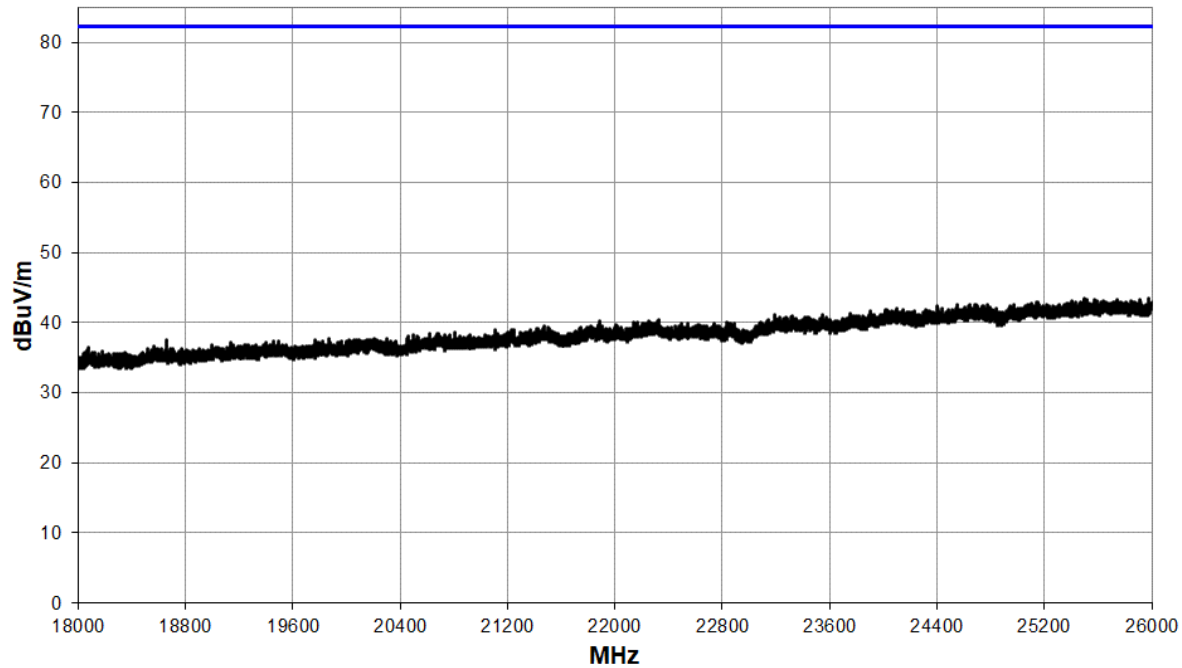
4 GHz to 12.4 GHz



12.4 GHz to 18 GHz

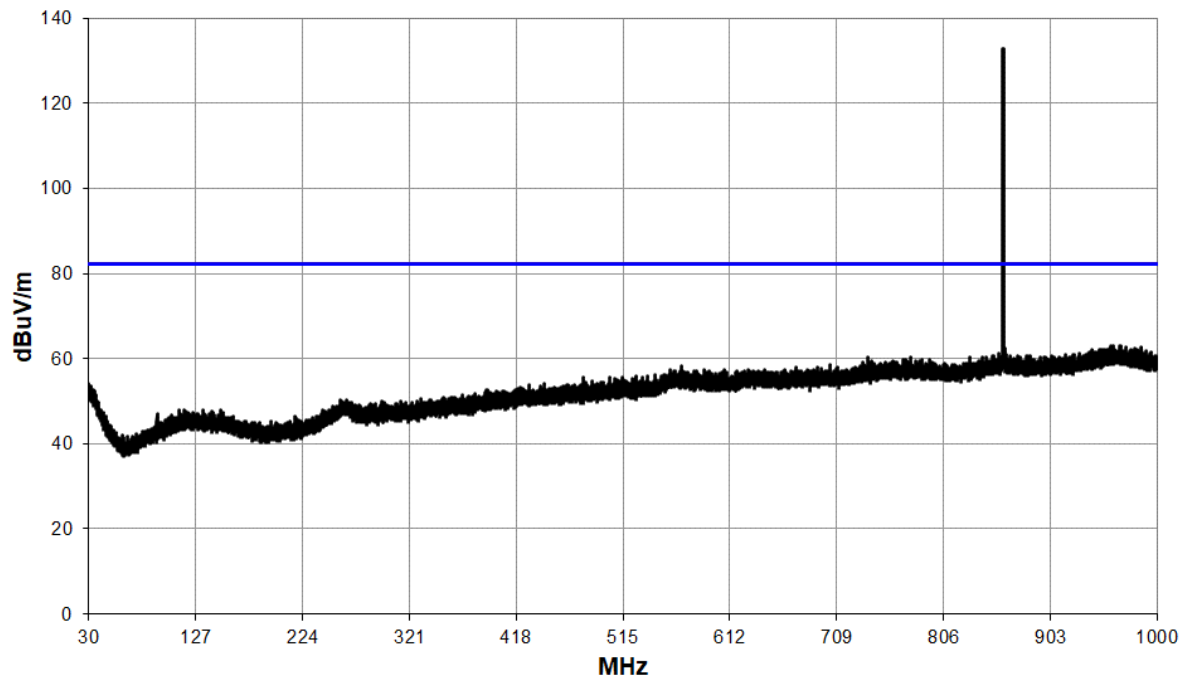


18 GHz to 26 GHz

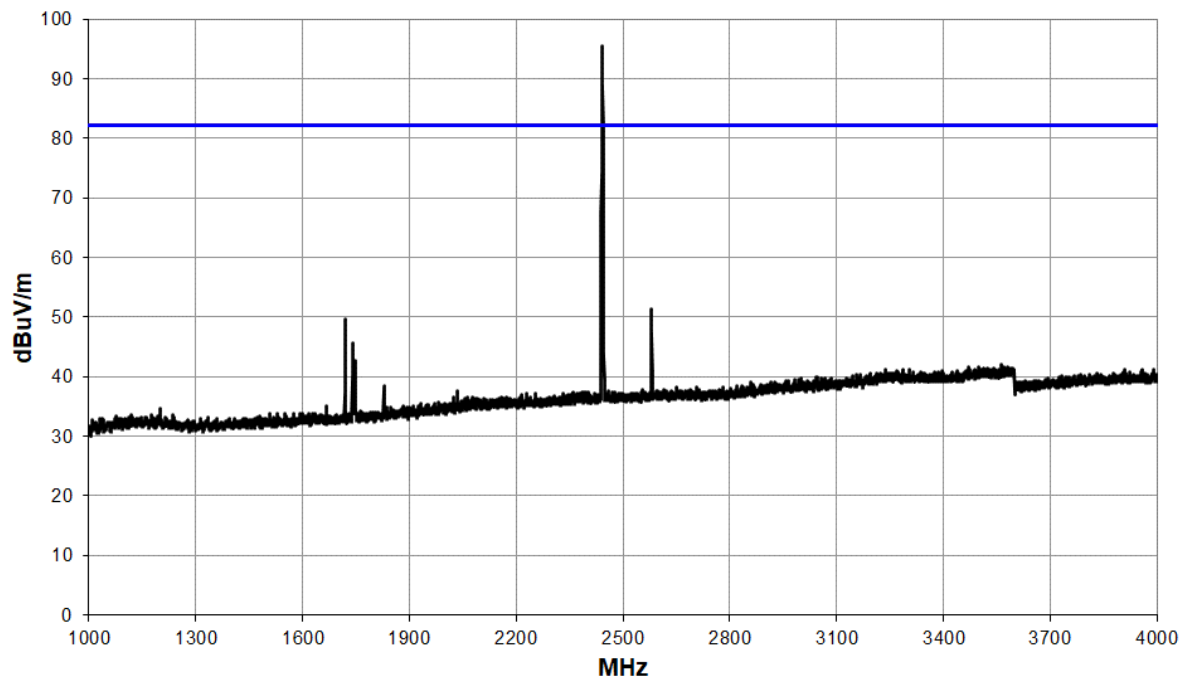


TETRA Frequency: 860.000 MHz; Power Setting: 35 dBm; Modulation: Burst with BT Classic Frequency: 2442 MHz; Power Setting: default					
Emission	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Result
No Intermodulation emissions were detected within 20 dB of the limit.					

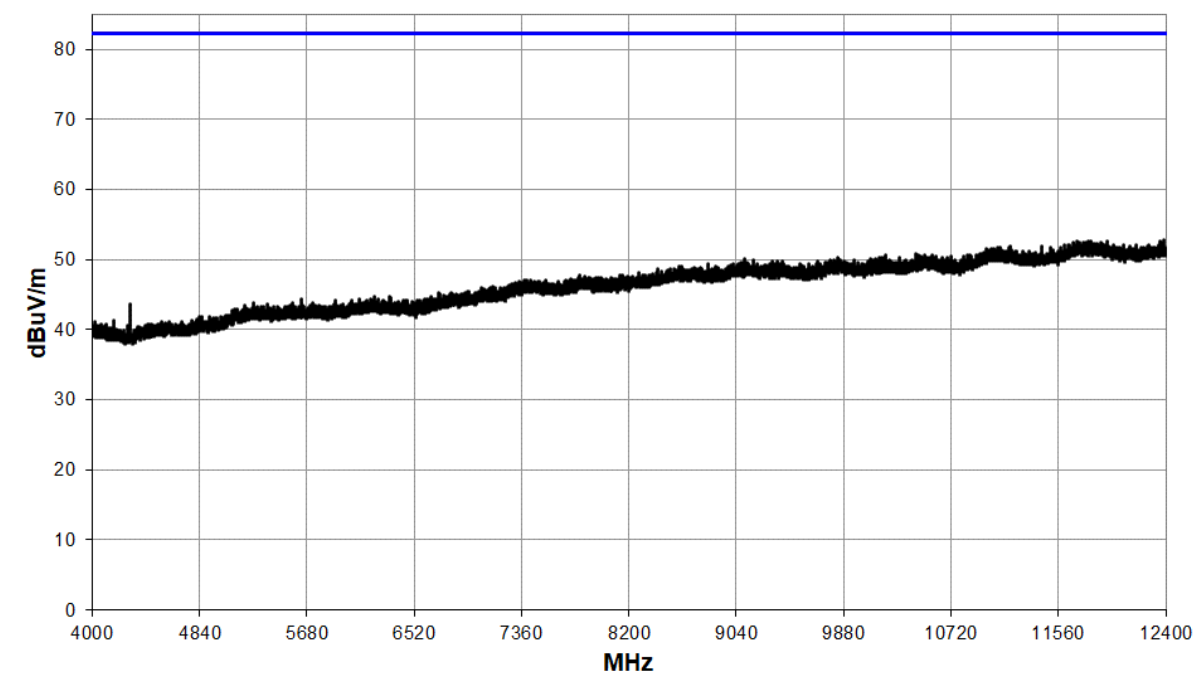
30 MHz to 1 GHz



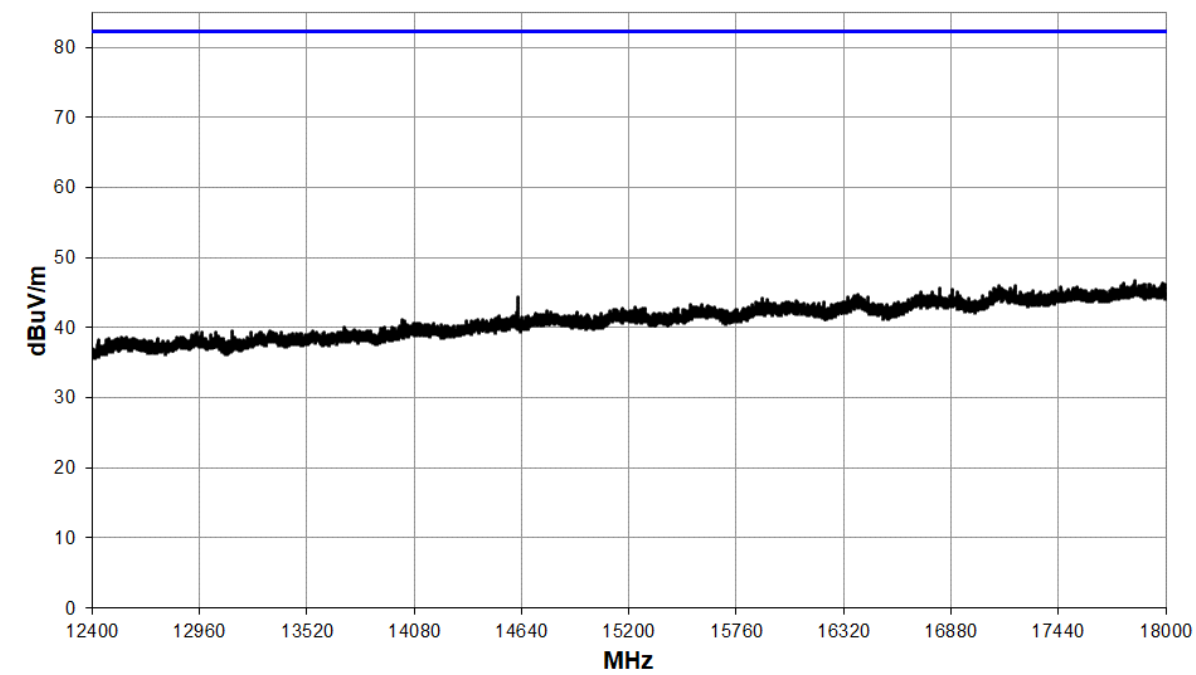
1 GHz to 4 GHz



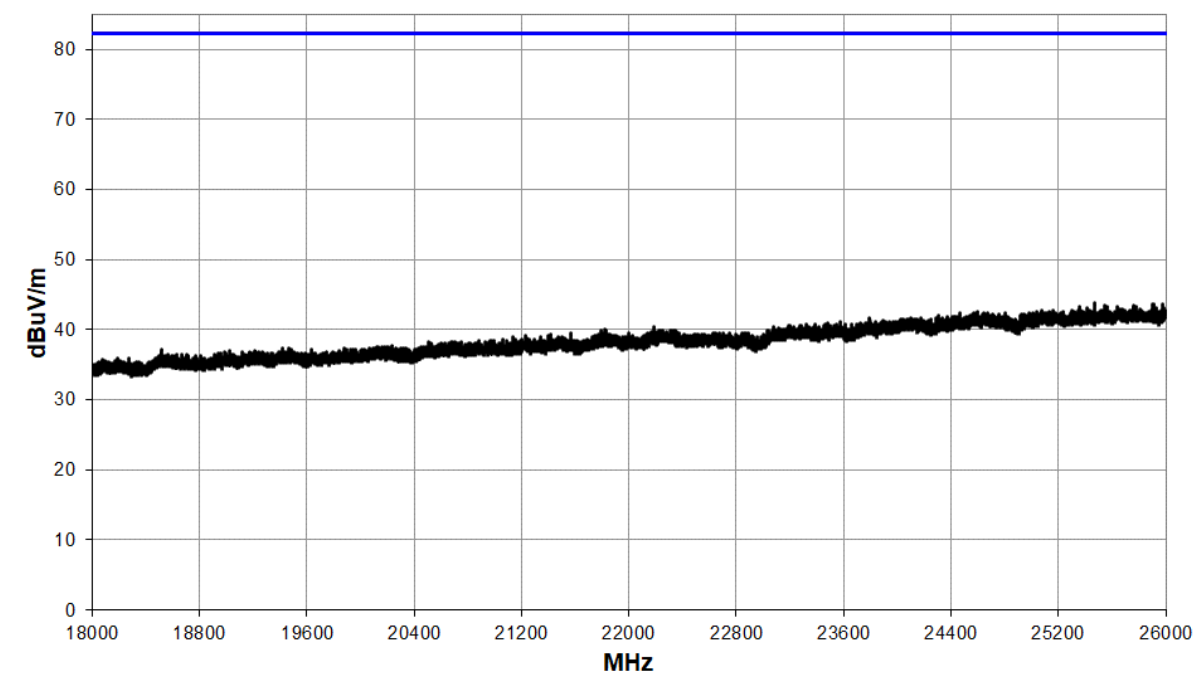
4 GHz to 12.4 GHz



12.4 GHz to 18 GHz

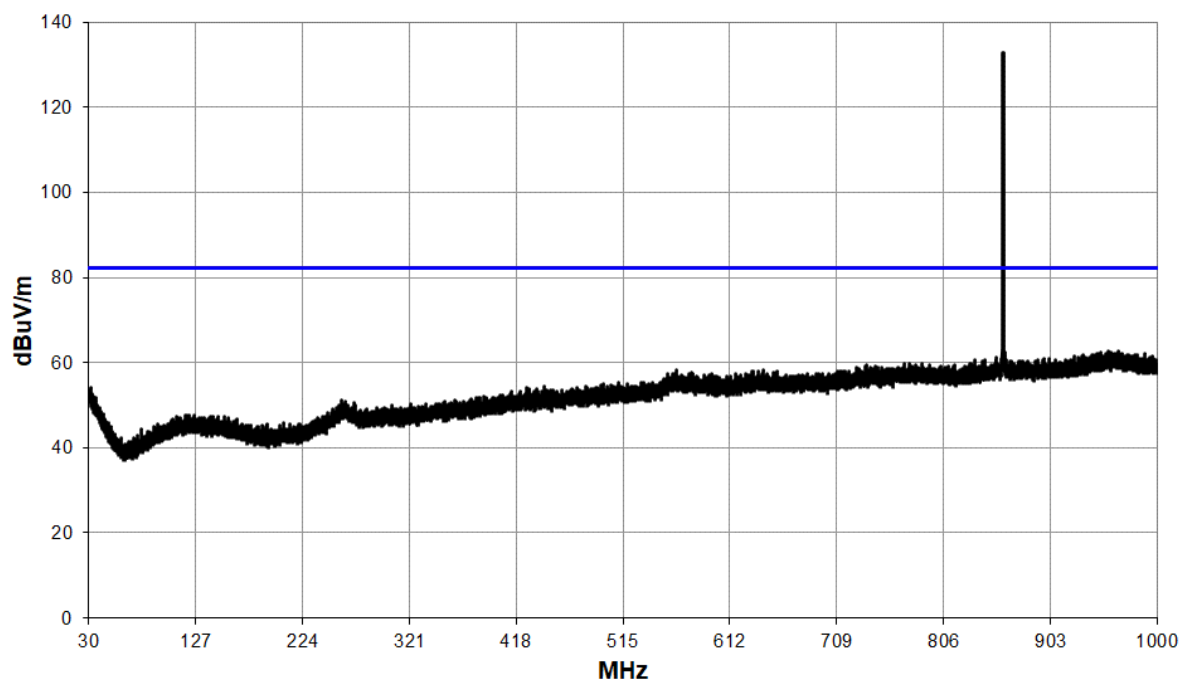


18 GHz to 26 GHz

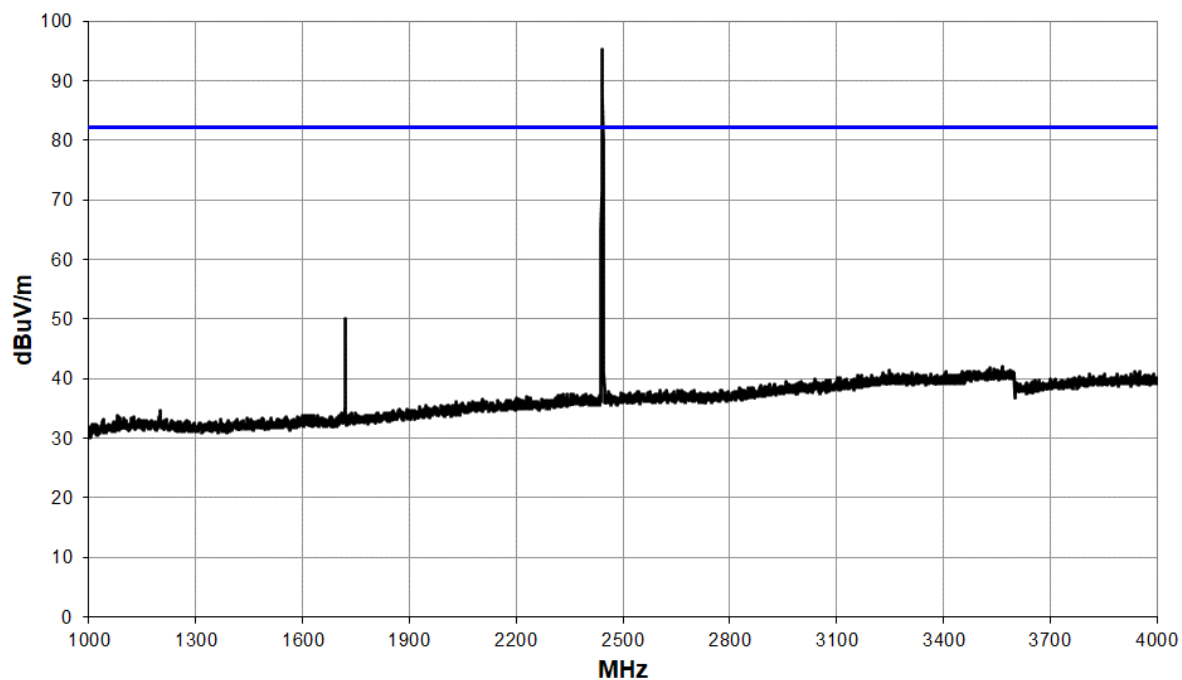


TETRA Frequency: 860.000 MHz; Power Setting: 35 dBm; Modulation: Burst with BLE Frequency: 2442 MHz; Power Setting: default					
Emission	Frequency (MHz)	Level (dBm)	Limit (dBm)	Margin (dB)	Result
No Intermodulation emissions were detected within 20 dB of the limit.					

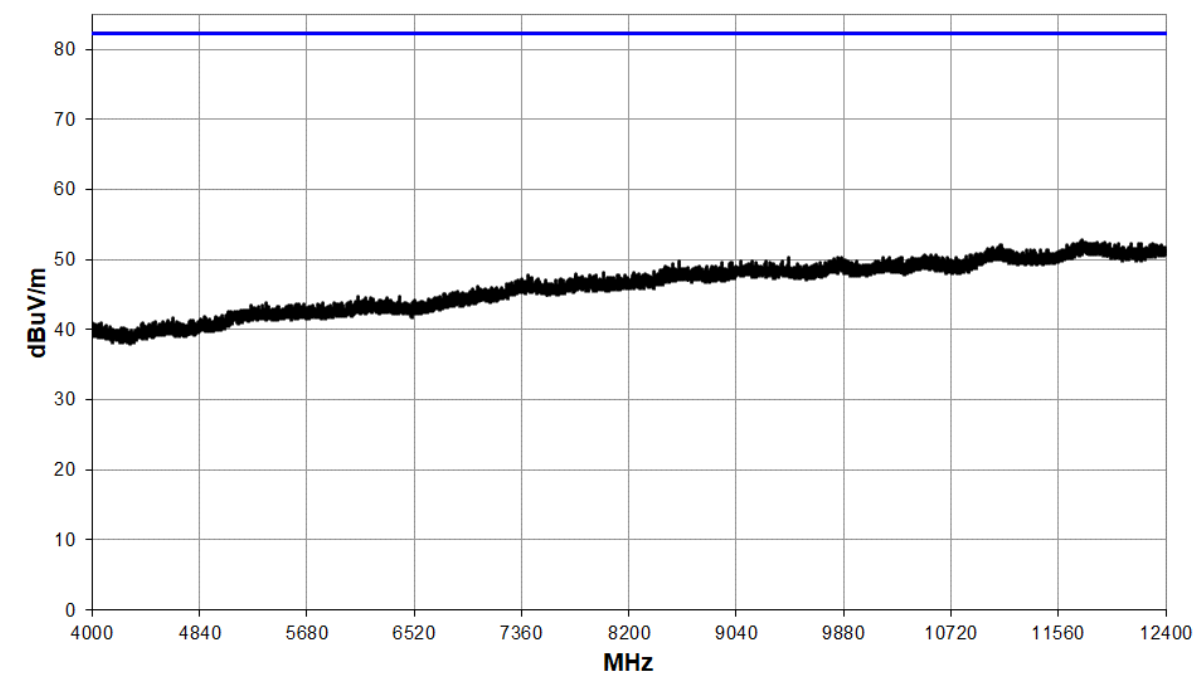
30 MHz to 1 GHz



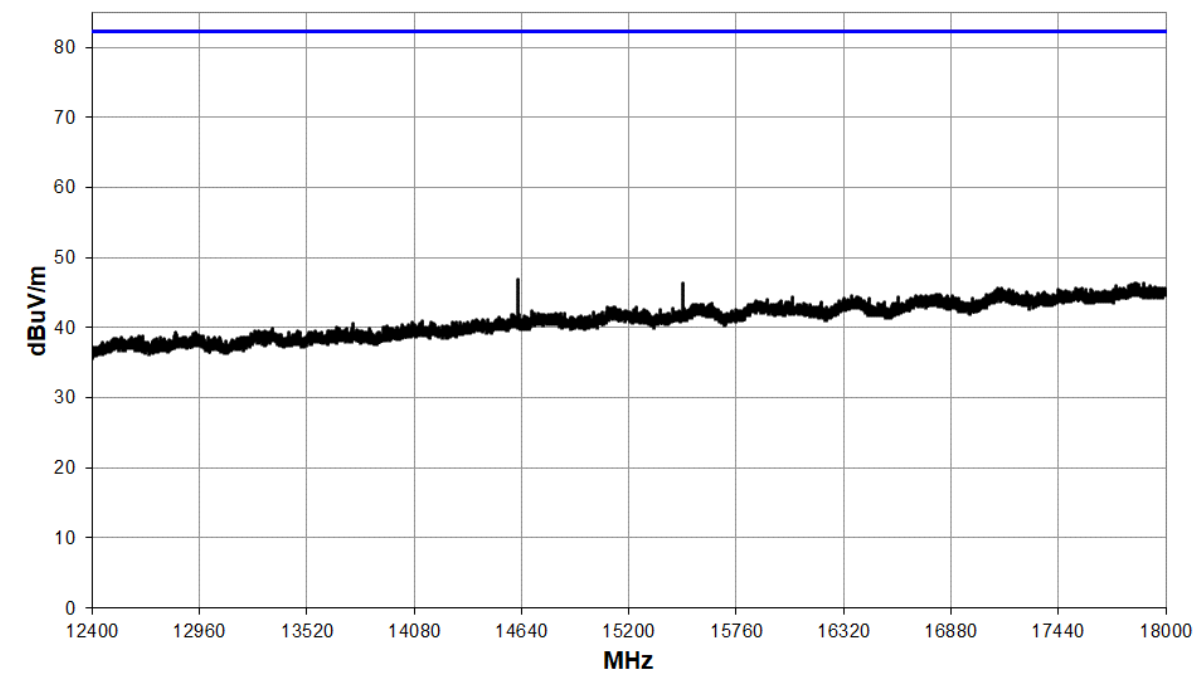
1 GHz to 4 GHz



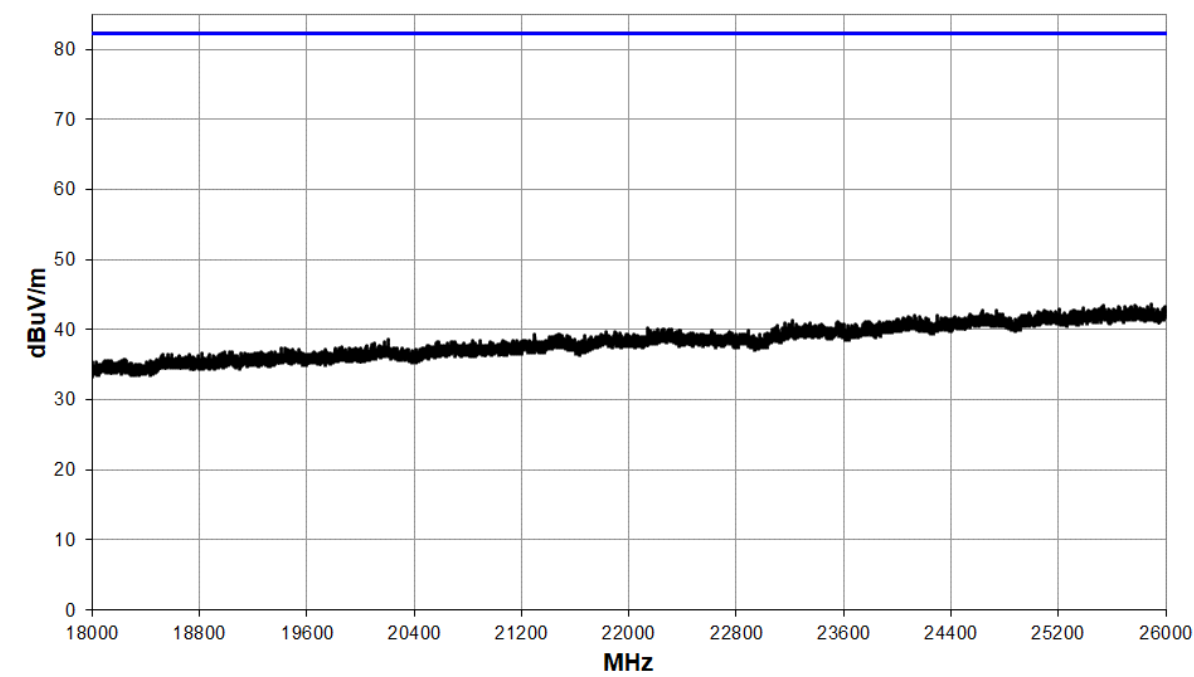
4 GHz to 12.4 GHz



12.4 GHz to 18 GHz



18 GHz to 26 GHz



12 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 connector) 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

13 Customer Declaration

27 July 2022

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Declaration no performance differences of Bluetooth, Wi-Fi and GNSS between SC20 models.

SC20 series radios including the following models but not limited to SC2020, SC2021, SC2024 & SC2028 use the same Bluetooth & Wi-Fi module (LBEE59B1LV-TEMP) along with a new GNSS module (u-blox m10). The electronic implementation/design of these parts in each model of SC20 radios are identical and no performance difference between them. the only difference between each model is the Tetra frequency range.

Signed for and on behalf of Sepura Limited:



James O'Reilly
Conformance engineer

sepura

Dated: 27 July 2022



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