Report on the Intermodulation Testing

For

Microlise Engineering Limited

on

ML10 Tracking Unit

Report no. TRA-027964-14-47-00C

19th August 2016

Report Number: TRA-027964-14-47-00C
Issue: C

REPORT ON THE INTERMODULATION TESTING OF A
Microlise Engineering Limited
ML10 Tracking Unit
WITH RESPECT TO SPECIFICATIONS
47CFR PARTS 15, 22, 24
INTERMODULAITON EMISSIONS INVESTIGATION

TEST DATE: 18/03/2016 to 31/03/2016

Written by: Daniel Winstanley
Daniel Winstanley
Radio Senior Test Engineer

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John Charters
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Date: 19th August 2016

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Company Reg No. 02536659

1 Revision Record

Issue Number	*Issue Date*	*Revision History*
A	21st April 2016	Original
B	8th August 2016	Update of description & Equipment corrections
C	19th August 2016	Update to limit lines

2 Summary

TEST REPORT NUMBER:	TRA-027964-14-47-00C
WORKS ORDER NUMBER	TRA-027964-14
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. Canada: Testing of radio apparatus for TAC (technical acceptance certificate) per subsections 4(2) of the Radiocommunication Act and 21(1) of the Radiocommunication Regulations.
TEST SPECIFICATION(S):	Intermodulation emissions investigation using 47CFR Parts 15, 22, 24
EQUIPMENT UNDER TEST (EUT):	ML10 Tracking Unit
EUT SERIAL NUMBER:	Not applicable
MANUFACTURER/AGENT:	Microlise Engineering Limited
ADDRESS:	Farrington Way Eastwood Nottingham Nottinghamshire NG16 3AG United Kingdom
CLIENT CONTACT:	James Marley ☎ 01773 537006 ✉ james.marley@microlise.com
ORDER NUMBER:	Not Applicable
TEST DATE:	18/03/2016 to 31/03/2016
TESTED BY:	Daniel Winstanley Element

2.1 Test Summary

Test Method and Description	*Requirement Clause*		*Applicable to this equipment*	*Result / Note*
	RSS	*47CFR*		
Intermodulation spurious emissions	Gen, 8.10	Parts 15, 22, 24	☒	*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).

3 Contents

4 Introduction

This report TRA-027964-14-47-00C presents the results of the Radio testing on a Microlise Engineering Limited, ML10 Tracking Unit.

The ML10 contains Pre-approved Radio modules that are able to operate simultaneously.

The Pre-approved Modules are

FCCID	Manufacture	Type
QIPEHS6	Gemalto M2M GmbH	GSM/GPRS/ EDGE/UMTS/HSPA Module
QOQWT32I	Silicon Laboratories Finland Oy	Bluetooth Audio Module
QOQBLE113	Silicon Laboratories Finland Oy	BLE113 Bluetooth smart module

The testing was carried out for Microlise Engineering Limited by Element, at the address(es) detailed below.

☐ Element Hull
Unit E
South Orbital Trading Park
Hedon Road
Hull
HU9 1NJ
UK

☒ Element Skelmersdale
Unit 1
Pendle Place
Skemersdale
West Lancashire
WN8 9PN
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:
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 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

6 Equipment Under Test

6.1 EUT Identification

- Name: ML10 Tracking Unit
- Serial Number: Not applicable
- Model Number: ML 10
- Software Revision: Not Applicable
- Build Level / Revision Number: Not Applicable

6.2 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.

6.3 EUT Mode of Operation

6.3.1 Transmission

The mode of operation for Tx tests was as follows:

Radios were set to transmit permanently in various combinations, the spectrum was checked to determine if any intermodulation products were generated due to multiple radios operating simultaneously. The worst case emission plots are shown in this document other combinations different produce not higher intermodulation products shown in this report.

EUT was operated with worst case modes of operation for each radio device.

6.4 EUT Description

The EUT is a vehicle tracker equipped with GSM, UMTS, GPS and Bluetooth LE and Classic.

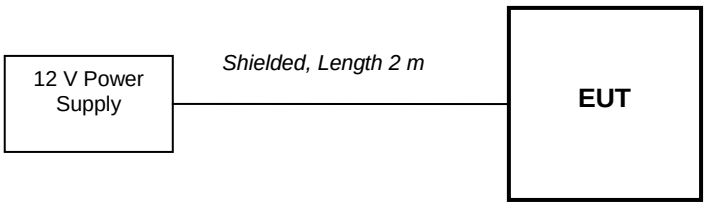
7 Modifications

No modifications were performed during this assessment.

8 EUT Test Setup

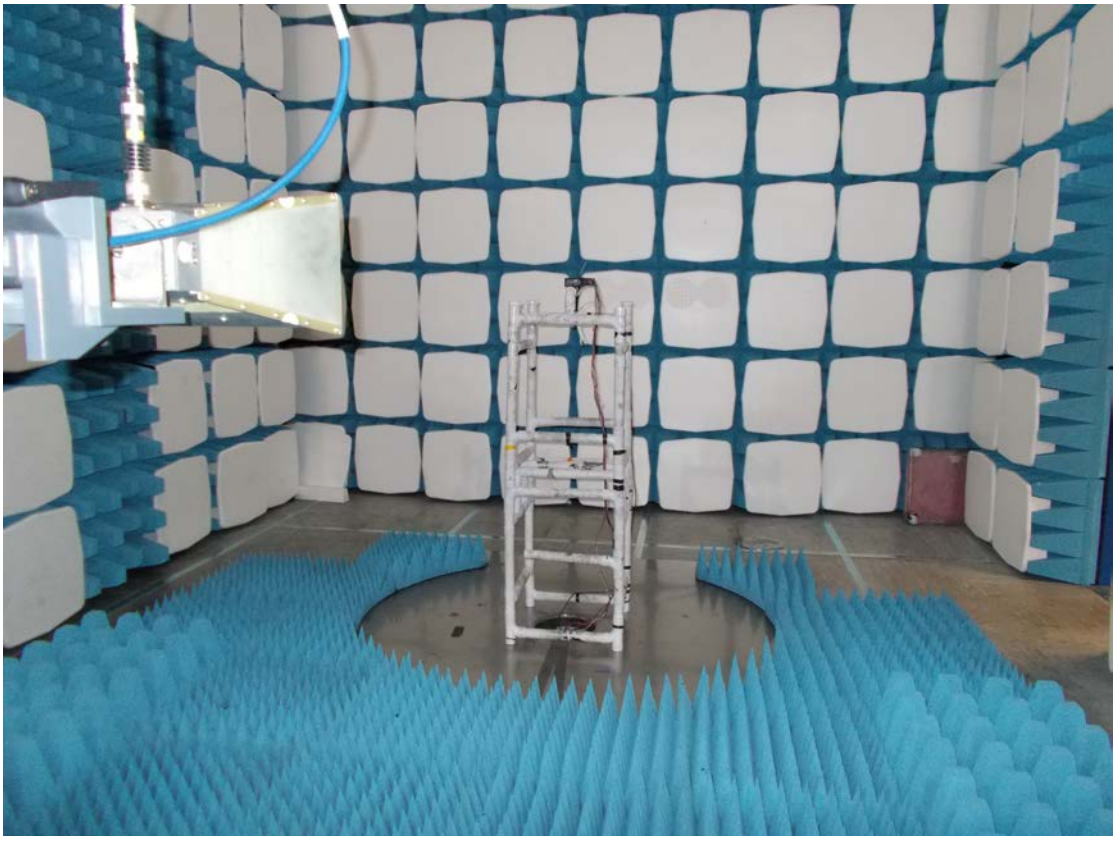
8.1 Block Diagram

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



8.2 General Set-up Photograph

The following photograph shows basic EUT set-up:



9 General Technical Parameters

9.1 Normal Conditions

The ML10 was tested under the normal environmental conditions of the test laboratory, except where otherwise stated. The normal power source applied was approx.12V dc from batteries.

10 Radiated emissions, intermodulation products

10.1 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.

Intermodulation products
Emissions of two or more electromagnetic waves transmitted simultaneously through a nonlinear electronic system.

10.2 Test Parameters

Test Location:	Element Skelmersdale
Test Chamber:	Radio chamber
Test Standard and Clause:	ANSI C63.10-2013, Clause 6.5 and 6.6
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: 28 % RH	20 % RH to 75 % RH (as declared)
Supply: 12 V dc	12 V dc ±10 % (as declared)

10.3 Test Limits

Part 15

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)***
30 to 88	100
88 to 216	150
216 to 960	200
Above 960	500

Part 22 & Part 24

At least 43 + 10 log P dB

$(10\log P_{watts}) - (43+10\log (P_{watts} * 1000)) = LIMIT = -13$ dBm

10.4 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:

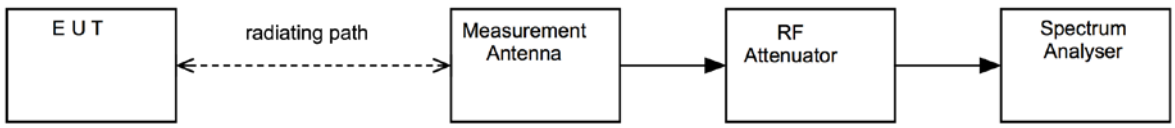
$$FS = PR + CL + AF – PA + DC – CF$$

Where,

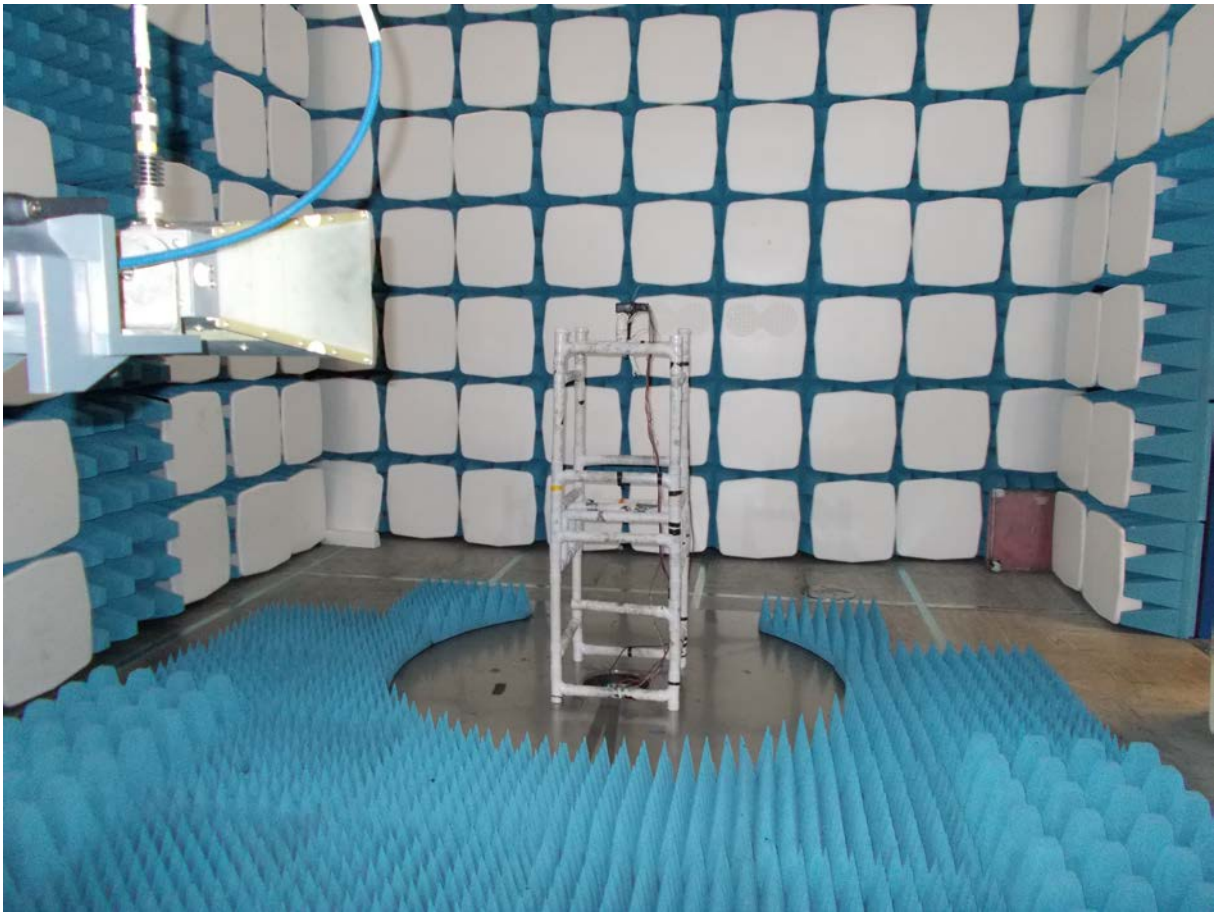
PR is the power recorded on the receiver / spectrum analyzer in dBµV;
CL is the cable loss in dB;
AF is the test antenna factor in dB/m;
PA is the pre-amplifier gain in dB (where used);
DC is the duty correction factor in dB (where used, e.g. harmonics of pulsed fundamental);
CF is the distance factor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

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

Figure i Test Setup



10.5 Test Set-up Photograph



10.6 Test Equipment

Type of Equipment	*Maker/Supplier*	*Model Number*	*Element Number*	*Calibration Due Date*	*Calibration Interval*
Bilog	Chase	CBL611/A	UH191	26/02/2017	24
ESVS10	R&S	ESVS10	L352	07/08/2016	12
Spectrum Analyser	R&S	FSU46	U281	24/04/2016	12
Horn Antenna	EMCO	3115	TRL139	25/09/2017	24
Pre-Amplifier	Agilent	8449B	TRL572	16/02/2017	12

10.7 Test Results; GSM850 – Bluetooth Classic 2402 MHz

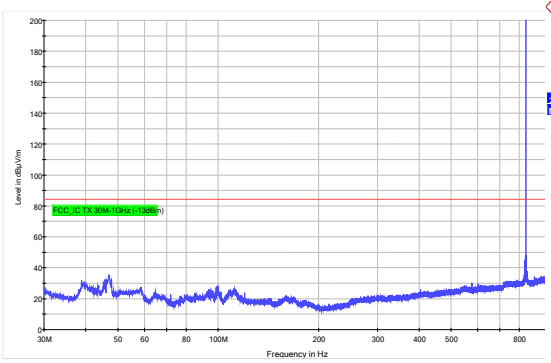


Figure 1 – Intermodulation GSM850 and Bluetooth Classic (30 MHz to 1 GHz); Channel Bottom.

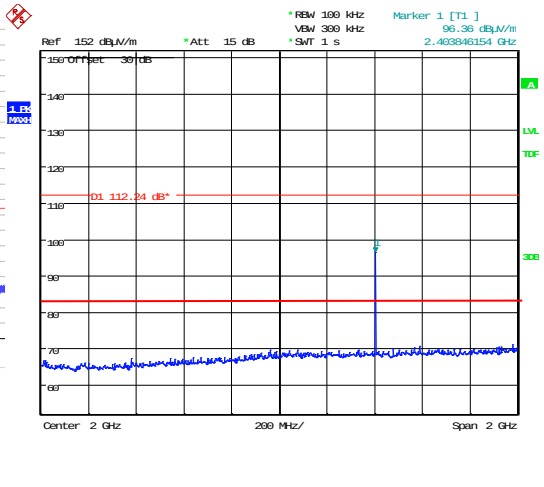


Figure 2 – Intermodulation GSM850 and Bluetooth Classic (1 GHz to 3 GHz); Channel Bottom.

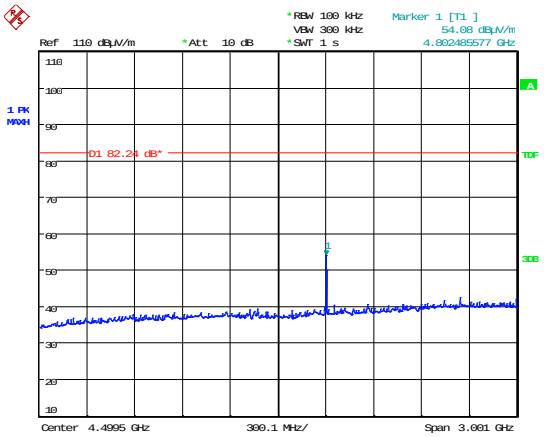


Figure 3 – Intermodulation GSM850 and Bluetooth Classic (3 GHz to 6 GHz); Channel Bottom.

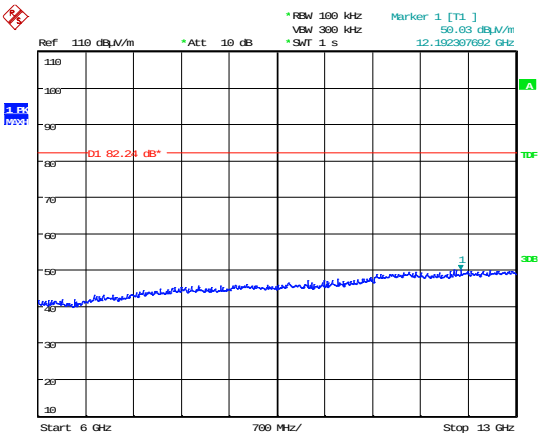


Figure 4 –Intermodulation GSM850 and Bluetooth Classic (6 GHz to 13 GHz); Channel Bottom.

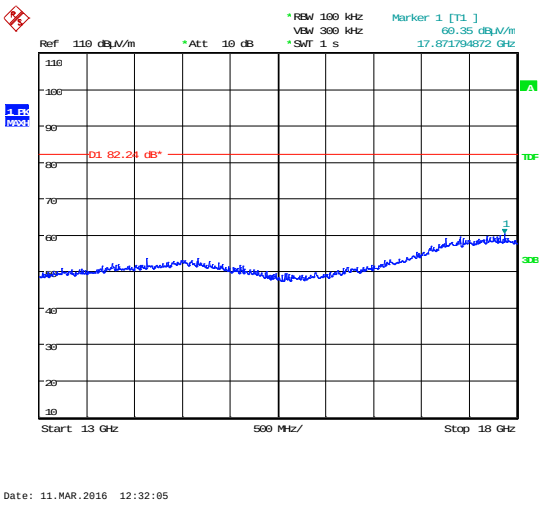


Figure 5 – Intermodulation GSM850 and Bluetooth Classic (13 GHz to 18 GHz); Channel Bottom.

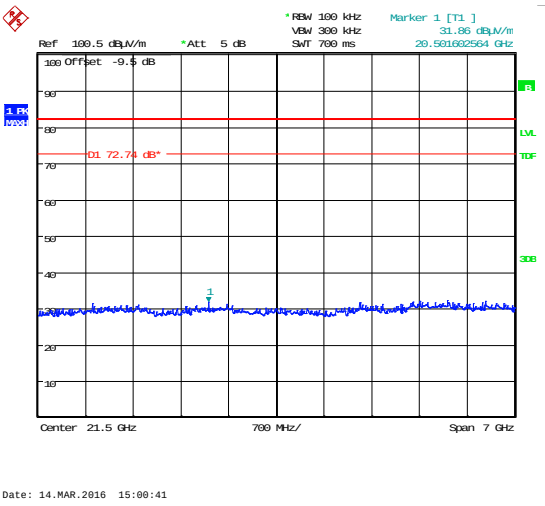


Figure 6 – Intermodulation GSM850 and Bluetooth Classic (18 GHz to 25 GHz); Channel Bottom.

All emissions on graphs are related to either the cellular operation or the Bluetooth Classic operation and are not intermodulation products.

10.8 Test Results; GSM850 – Bluetooth Classic 2480 MHz

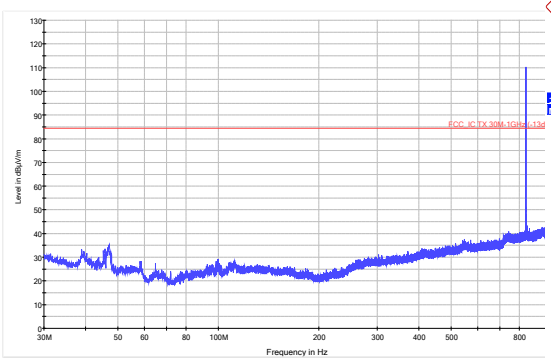


Figure 7 – Intermodulation GSM850 and Bluetooth Classic (30 MHz to 1 GHz); Channel Top.

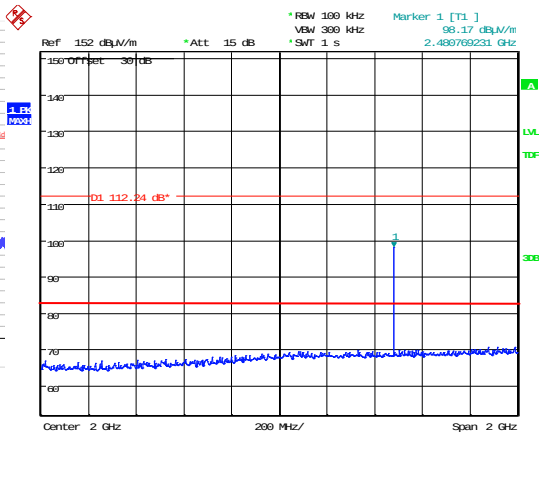


Figure 8 – Intermodulation GSM850 and Bluetooth Classic (1 GHz to 3 GHz); Channel Top.

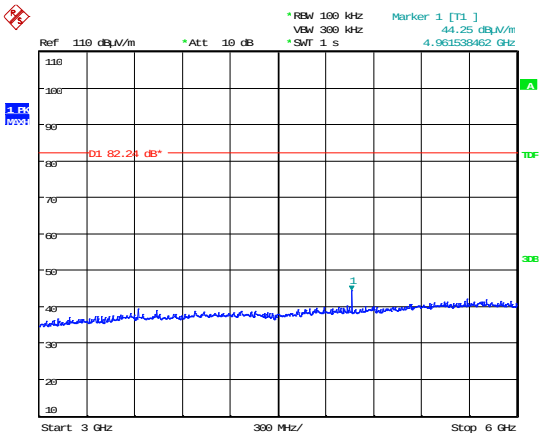


Figure 9 – Intermodulation GSM850 and Bluetooth Classic (3 GHz to 6 GHz); Channel Top.

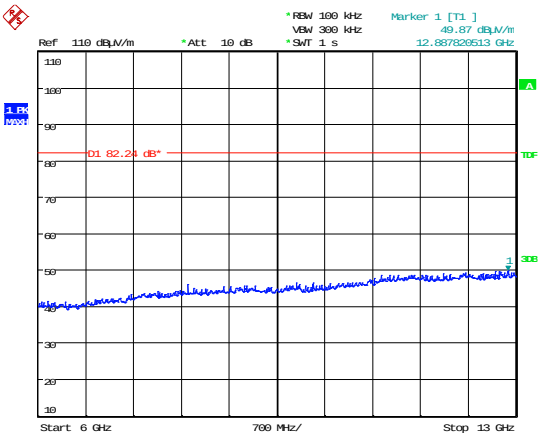


Figure 10 – Intermodulation GSM850 and Bluetooth Classic (6 GHz to 13 GHz); Channel Top.

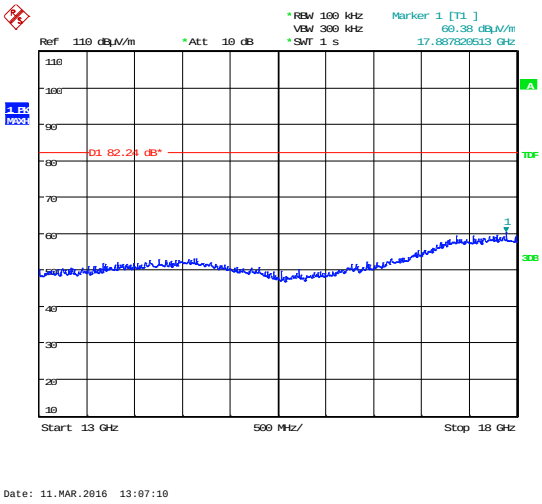


Figure 11 – Intermodulation GSM850 and Bluetooth Classic (13 GHz to 18 GHz); Channel Top.

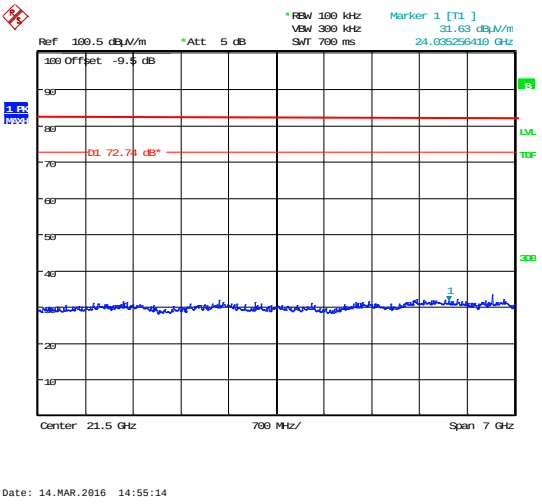


Figure 12 – Intermodulation GSM850 and Bluetooth Classic (18 GHz to 25 GHz); Channel Top.

All emissions on graphs are related to either the cellular operation or the Bluetooth Classic operation and are not intermodulation products.

10.9 Test Results; GSM850 – Bluetooth LE 2402 MHz

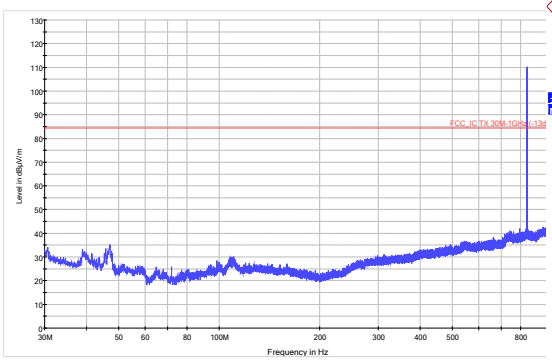
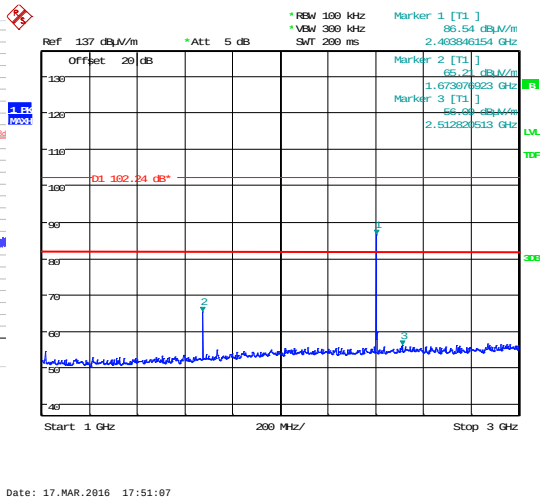


Figure 1 – Intermodulation GSM850 and Bluetooth LE (30 MHz to 1 GHz); Channel Bottom.



Date: 17.MAR.2016 17:51:07

Figure 2 – Intermodulation GSM850 and Bluetooth LE (1 GHz to 3 GHz); Channel Bottom.

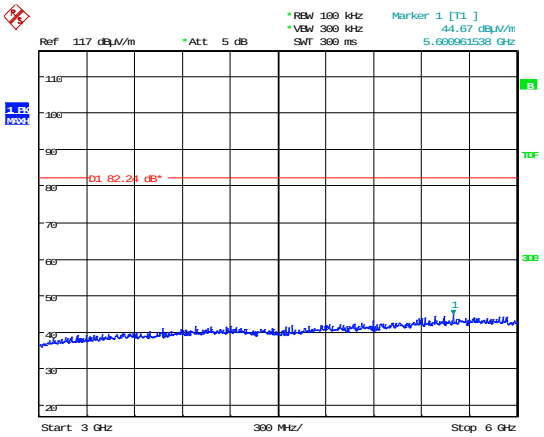


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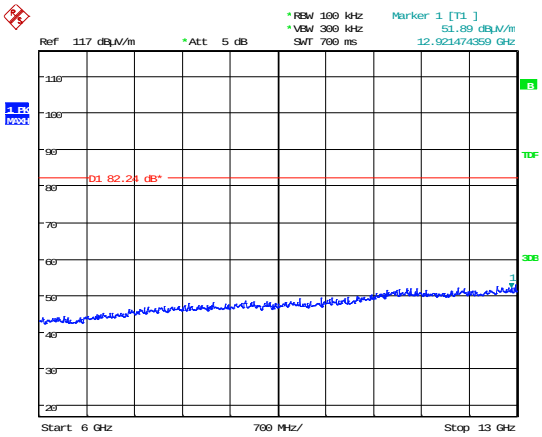
Figure 3 – Intermodulation GSM850 and Bluetooth LE (3 GHz to 6 GHz); Channel Bottom.



Date: 17.MAR.2016 17:37:24

Figure 4 –Intermodulation GSM850 and Bluetooth LE (6 GHz to 13 GHz); Channel Bottom.

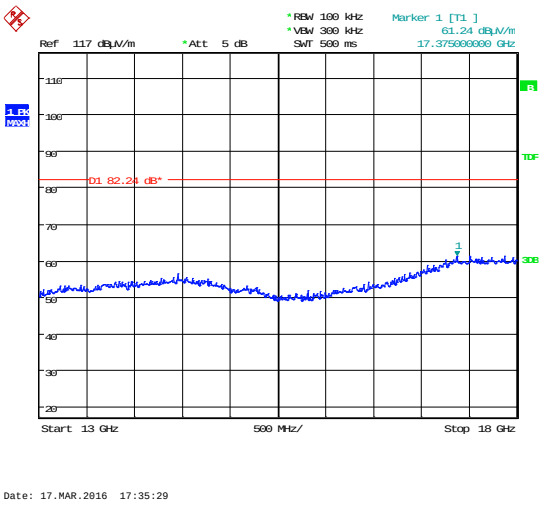


Figure 5 – Intermodulation GSM850 and Bluetooth LE (13 GHz to 18 GHz); Channel Bottom.

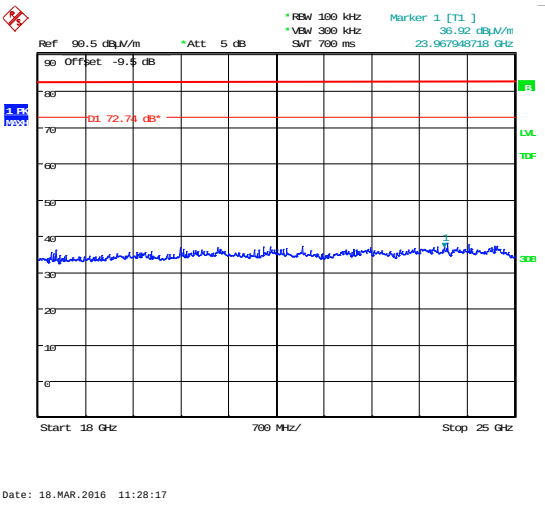


Figure 6 – Intermodulation GSM850 and Bluetooth LE (18 GHz to 25 GHz); Channel Bottom.

All emissions on graphs are related to either the cellular operation or the Bluetooth LE operation and are not intermodulation products.

10.10 Test Results; GSM850 – Bluetooth LE 2480 MHz

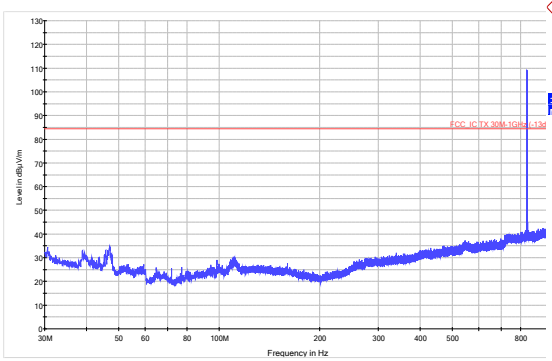


Figure 7 – Intermodulation GSM850 and Bluetooth LE (30 MHz to 1 GHz); Channel Top.

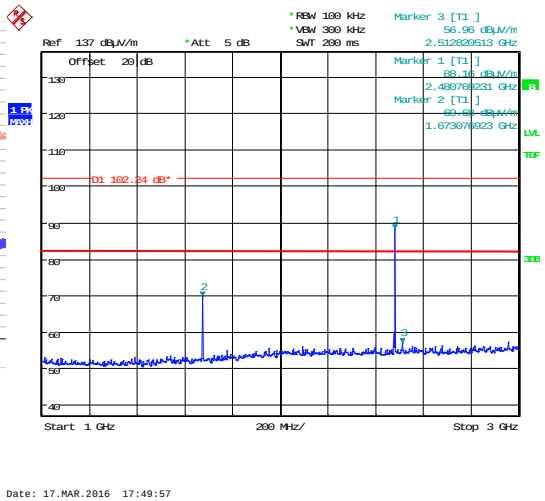


Figure 8 – Intermodulation GSM850 and Bluetooth LE (1 GHz to 3 GHz); Channel Top.

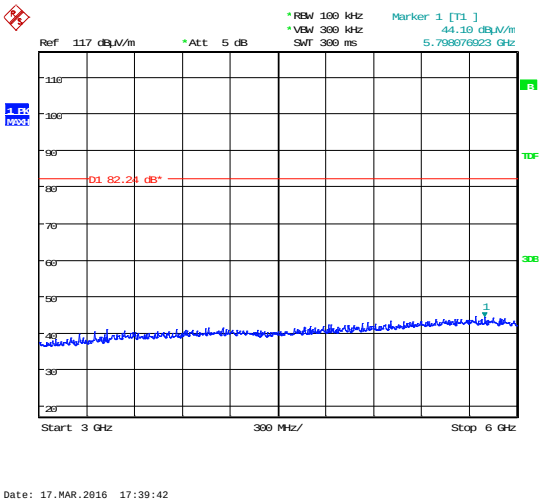


Figure 9 – Intermodulation GSM850 and Bluetooth LE (3 GHz to 6 GHz); Channel Top.

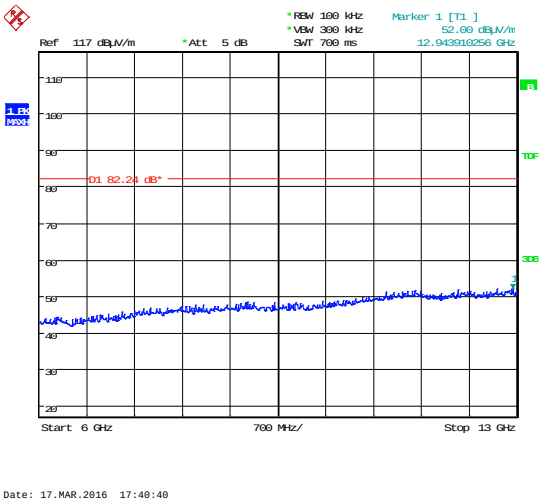


Figure 10 – Intermodulation GSM850 and Bluetooth LE (6 GHz to 13 GHz); Channel Top.

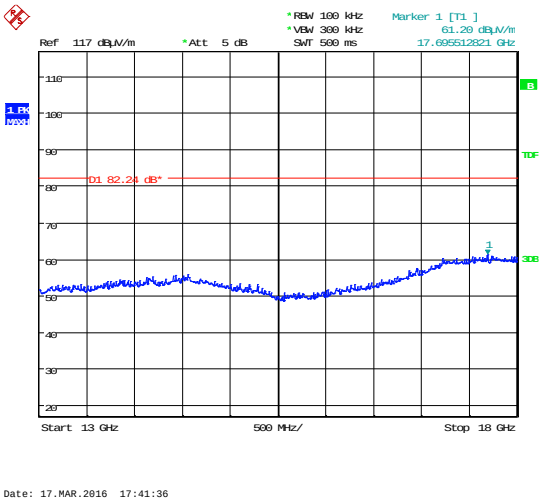


Figure 11 – Intermodulation GSM850 and Bluetooth LE (13 GHz to 18 GHz); Channel Top.

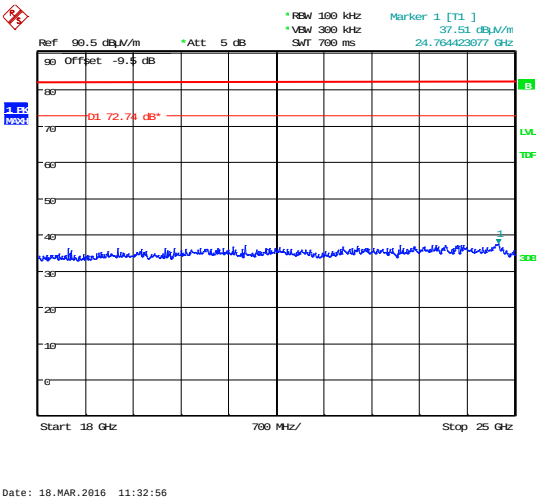


Figure 12 – Intermodulation GSM850 and Bluetooth LE (18 GHz to 25 GHz); Channel Top.

All emissions on graphs are related to either the cellular operation or the Bluetooth LE operation and are not intermodulation products.

10.11 Test Results; GSM1900 – Bluetooth Classic 2402 MHz

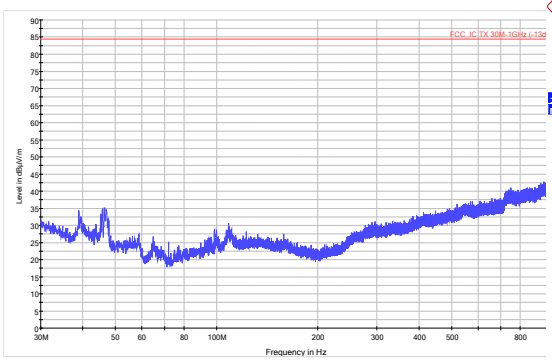


Figure 1 – Intermodulation GSM1900 and Bluetooth Classic (30 MHz to 1 GHz); Channel Bottom.

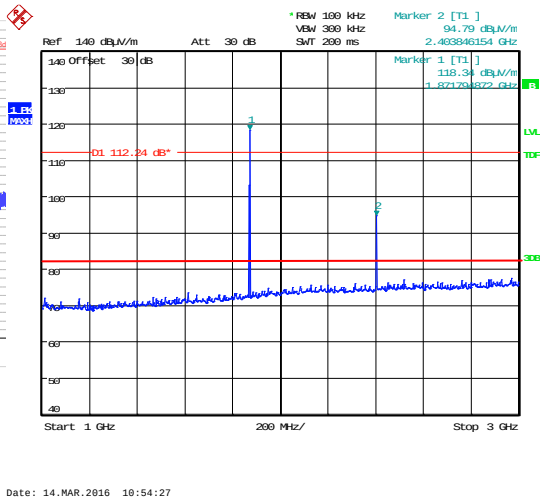


Figure 2 – Intermodulation GSM1900 and Bluetooth Classic (1 GHz to 3 GHz); Channel Bottom.

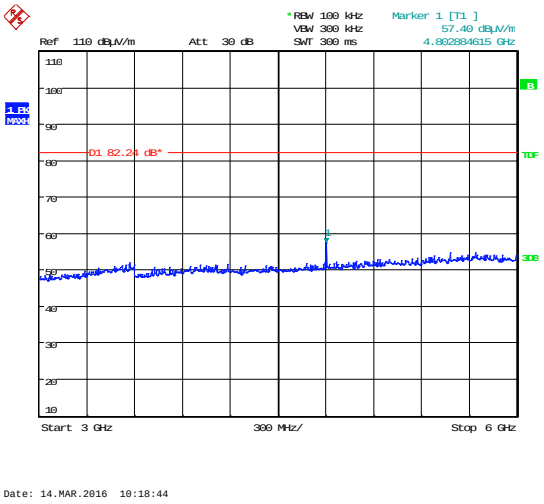


Figure 3 – Intermodulation GSM1900 and Bluetooth Classic (3 GHz to 6 GHz); Channel Bottom.

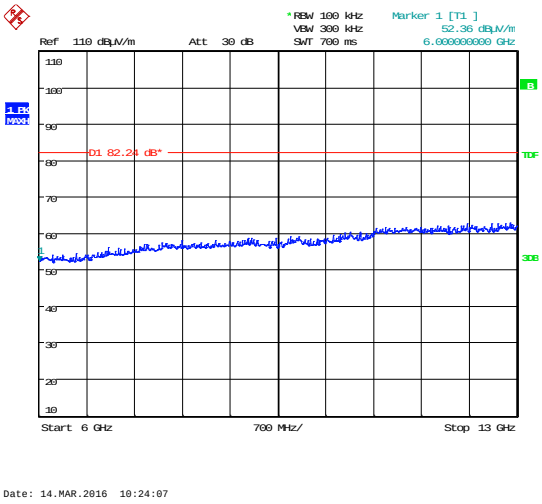


Figure 4 –Intermodulation GSM1900 and Bluetooth Classic (6 GHz to 13 GHz); Channel Bottom.

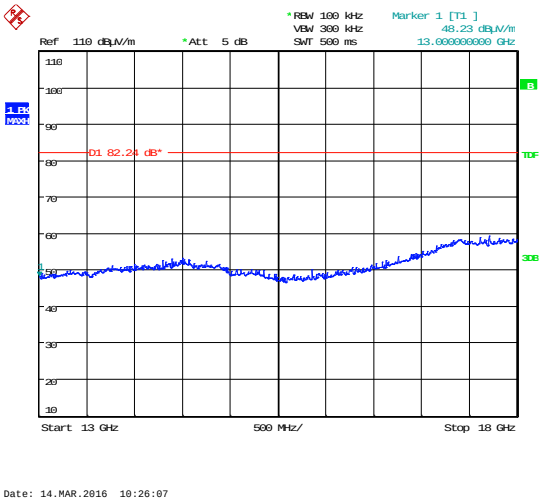


Figure 5 – Intermodulation GSM1900 and Bluetooth Classic (13 GHz to 18 GHz); Channel Bottom.

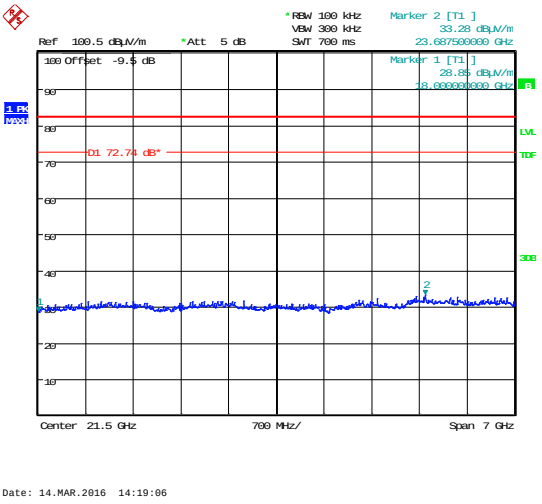


Figure 6 – Intermodulation GSM1900 and Bluetooth Classic (18 GHz to 25 GHz); Channel Bottom.

All emissions on graphs are related to either the cellular operation or the Bluetooth Classic operation and are not intermodulation products.

10.12 Test Results; GSM1900 – Bluetooth Classic 2480 MHz

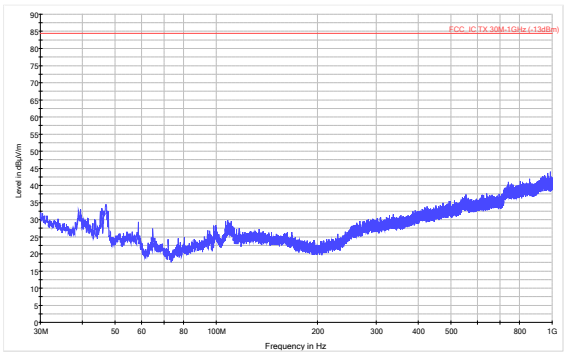


Figure 7 – Intermodulation GSM1900 and Bluetooth Classic (30 MHz to 1 GHz); Channel Top.

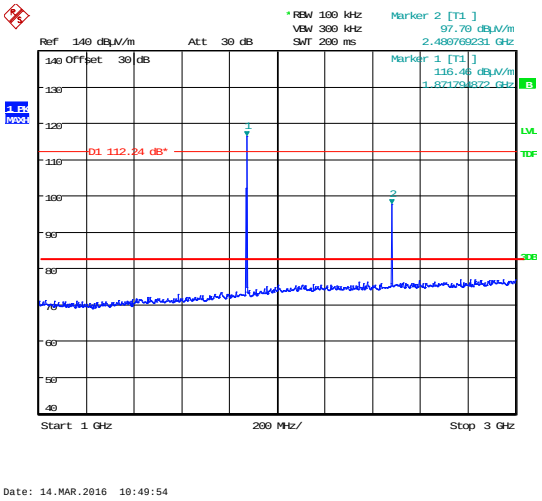


Figure 8 – Intermodulation GSM1900 and Bluetooth Classic (1 GHz to 3 GHz); Channel Top.

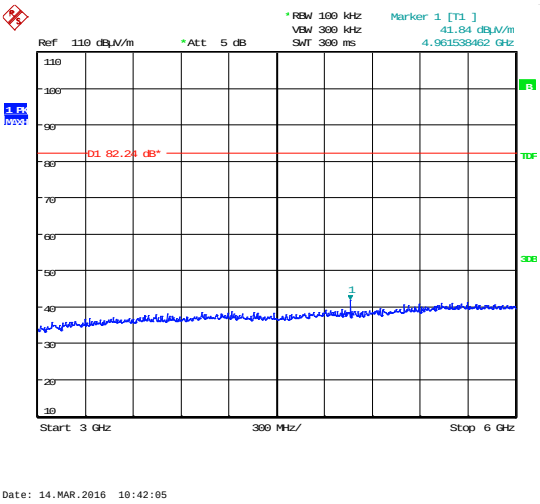


Figure 9 – Intermodulation GSM1900 and Bluetooth Classic (3 GHz to 6 GHz); Channel Top.

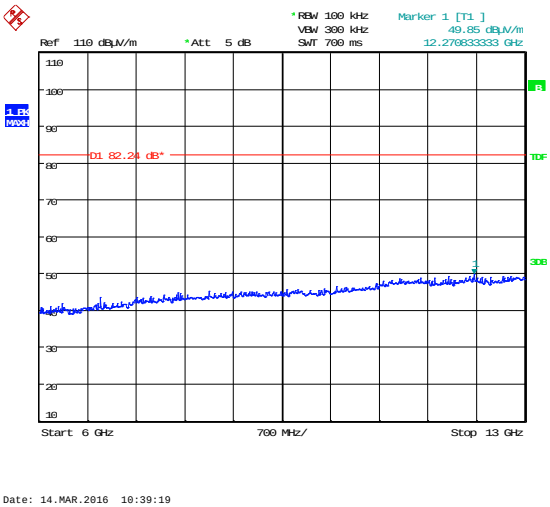


Figure 10 – Intermodulation GSM1900 and Bluetooth Classic (6 GHz to 13 GHz); Channel Top.

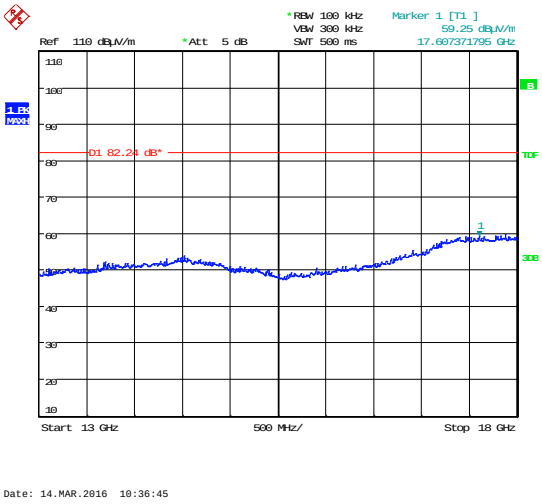


Figure 11 – Intermodulation GSM1900 and Bluetooth Classic (13 GHz to 18 GHz); Channel Top.

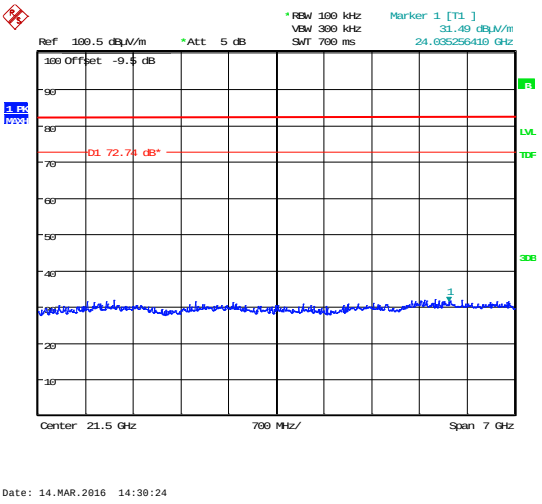


Figure 12 – Intermodulation GSM1900 and Bluetooth Classic (18 GHz to 25 GHz); Channel Top.

All emissions on graphs are related to either the cellular operation or the Bluetooth Classic operation and are not intermodulation products.

10.13 Test Results; GSM1900 – Bluetooth LE 2402 MHz

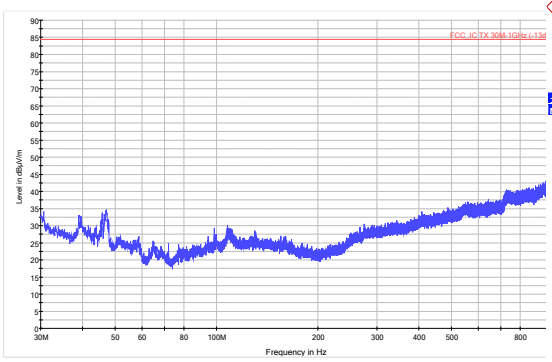


Figure 1 – Intermodulation GSM1900 and Bluetooth LE (30 MHz to 1 GHz); Channel Bottom.

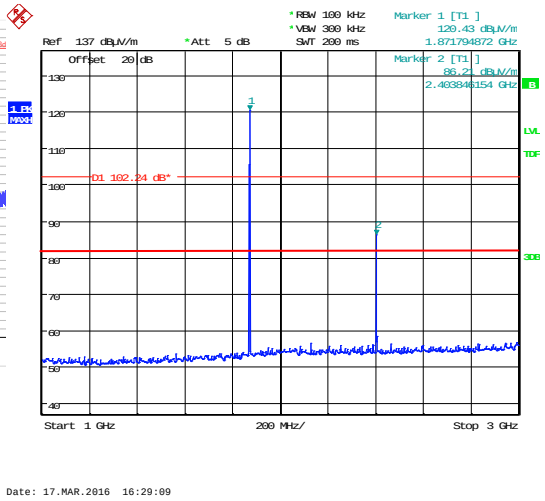


Figure 2 – Intermodulation GSM1900 and Bluetooth LE (1 GHz to 3 GHz); Channel Bottom.

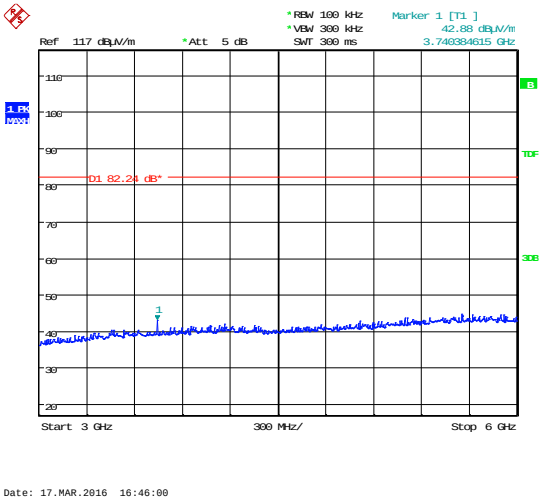


Figure 3 – Intermodulation GSM1900 and Bluetooth LE (3 GHz to 6 GHz); Channel Bottom.

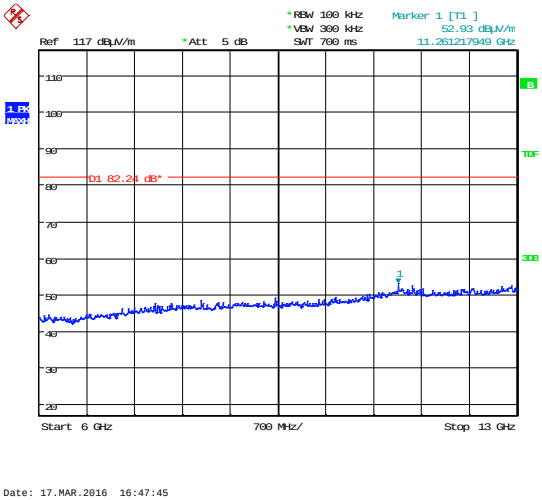


Figure 4 –Intermodulation GSM1900 and Bluetooth LE (6 GHz to 13 GHz); Channel Bottom.

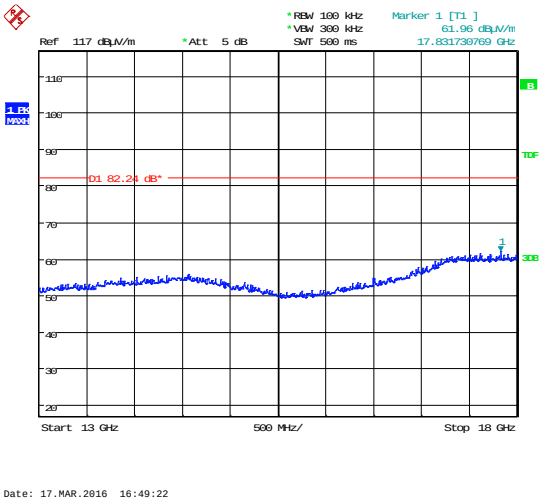


Figure 5 – Intermodulation GSM1900 and Bluetooth LE (13 GHz to 18 GHz); Channel Bottom.

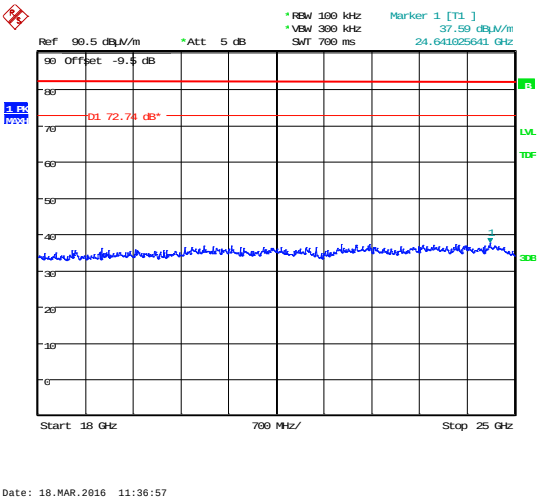


Figure 6 – Intermodulation GSM1900 and Bluetooth LE (18 GHz to 25 GHz); Channel Bottom.

All emissions on graphs are related to either the cellular operation or the Bluetooth LE operation and are not intermodulation products.

10.14 Test Results; GSM1900 – Bluetooth LE 2480 MHz

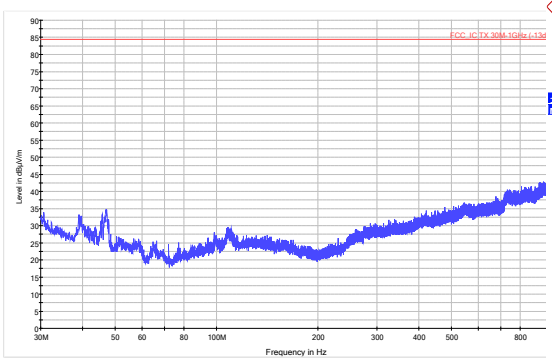


Figure 7 – Intermodulation GSM1900 and Bluetooth LE (30 MHz to 1 GHz); Channel Top.

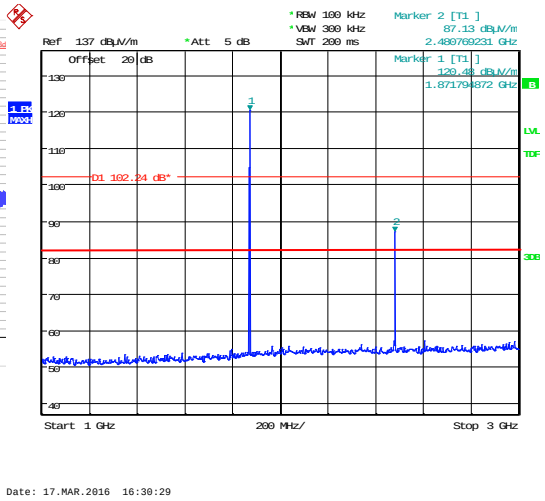


Figure 8 – Intermodulation GSM1900 and Bluetooth LE (1 GHz to 3 GHz); Channel Top.

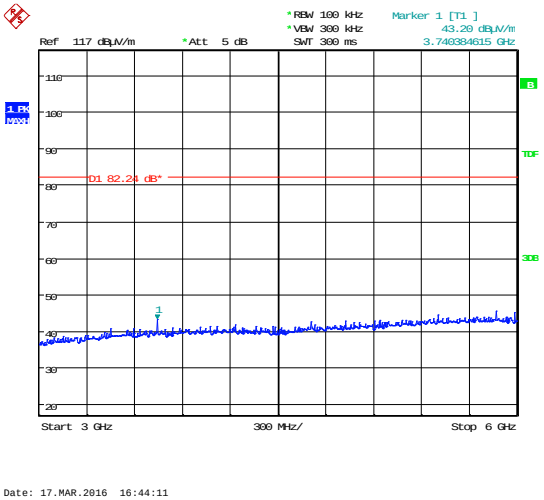


Figure 9 – Intermodulation GSM1900 and Bluetooth LE (3 GHz to 6 GHz); Channel Top.

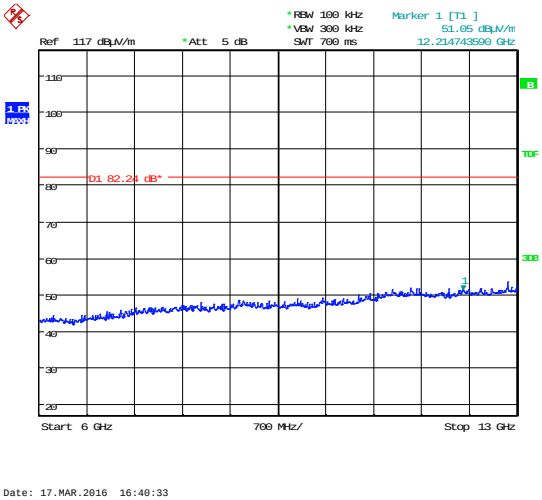


Figure 10 – Intermodulation GSM1900 and Bluetooth LE (6 GHz to 13 GHz); Channel Top.

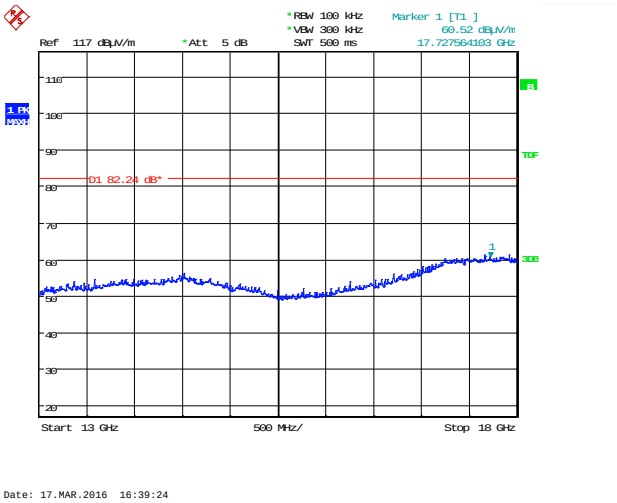


Figure 11 – Intermodulation GSM1900 and Bluetooth LE (13 GHz to 18 GHz); Channel Top.

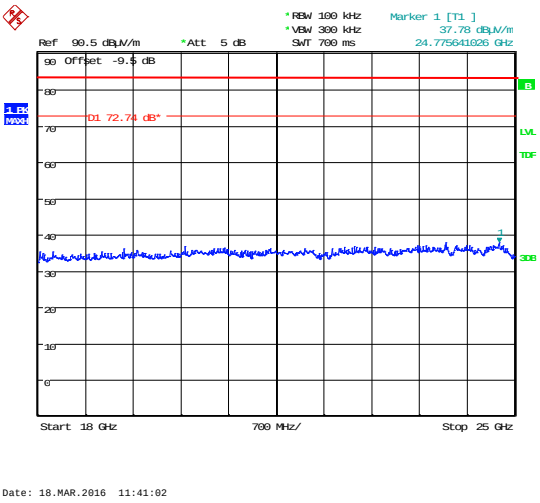


Figure 12 – Intermodulation GSM1900 and Bluetooth LE (18 GHz to 25 GHz); Channel Top.

All emissions on graphs are related to either the cellular operation or the Bluetooth LE operation and are not intermodulation products.

10.15 Test Results; Bluetooth Classic 2402 MHz - Bluetooth LE 2480 MHz

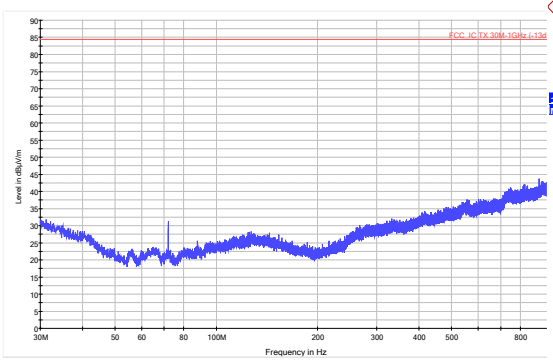


Figure 1 – Intermodulation Top Bluetooth LE and Bottom Classic (30 MHz to 1 GHz).

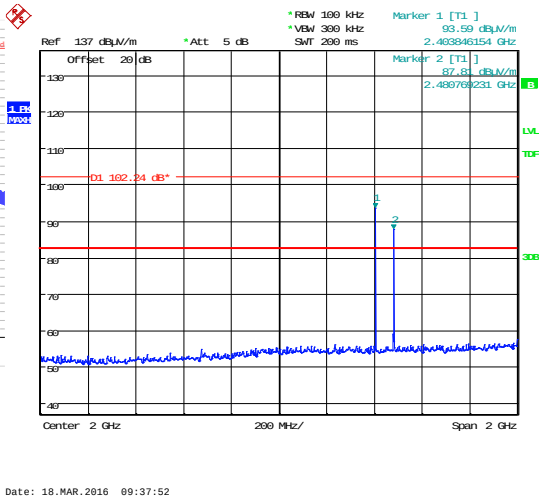


Figure 2 – Intermodulation Top Bluetooth LE and Bottom Classic (1 GHz to 3 GHz).

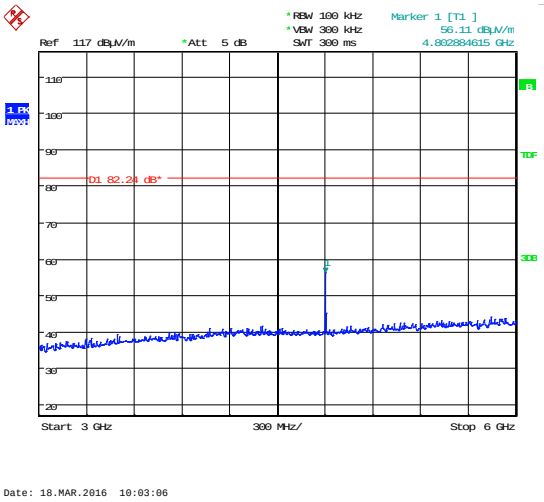


Figure 3 – Intermodulation Top Bluetooth LE and Bottom Classic (3 GHz to 6 GHz).

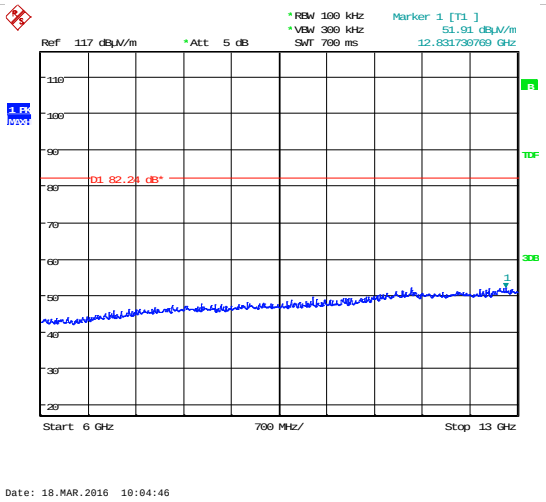


Figure 4 – Intermodulation Top Bluetooth LE and Bottom Classic (6 GHz to 13 GHz).

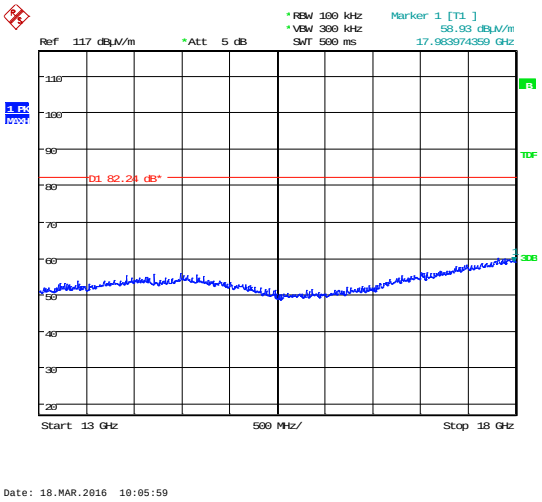


Figure 5 – Intermodulation Top Bluetooth LE and Bottom Classic (13 GHz to 18 GHz).

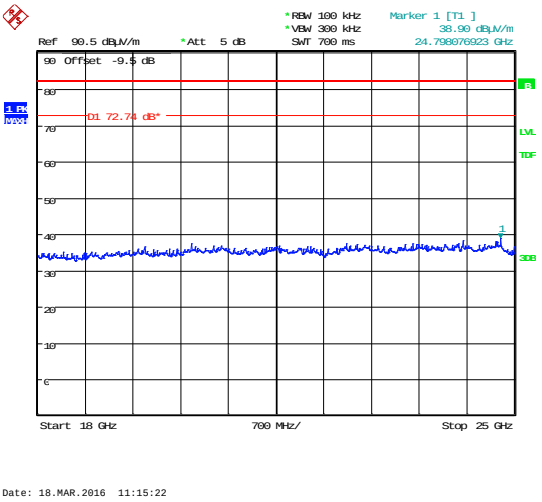


Figure 6 – Intermodulation Top Bluetooth LE and Bottom Classic (18 GHz to 25 GHz).

All emissions on graphs are related to either the Bluetooth LE operation or the Bluetooth Classic operation and are not intermodulation products.

10.16 Test Results; Bluetooth Classic 2480 MHz - Bluetooth LE 2402 MHz

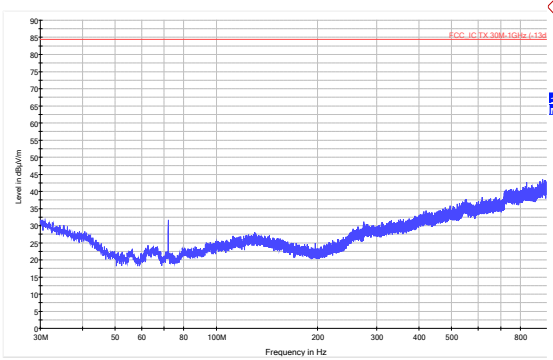


Figure 1 – Intermodulation Bottom Bluetooth LE and Top Classic (30 MHz to 1 GHz).

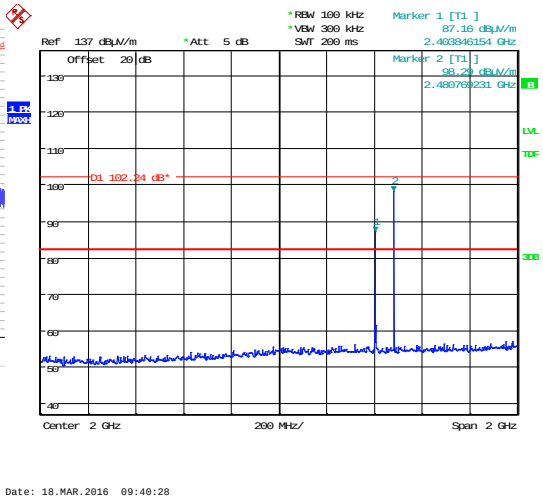


Figure 2 – Intermodulation Bottom Bluetooth LE and Top Classic (1 GHz to 3 GHz).

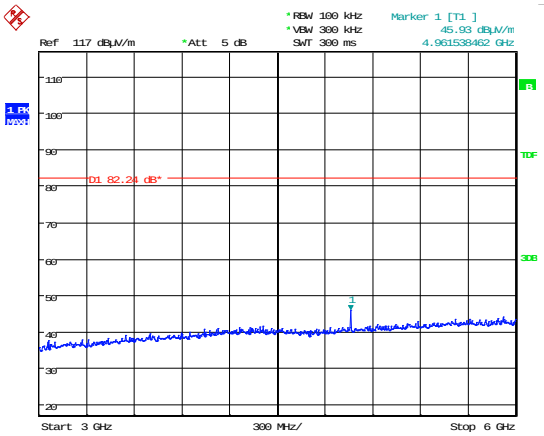


Figure 3 – Intermodulation Bottom Bluetooth LE and Top Classic (3 GHz to 6 GHz).

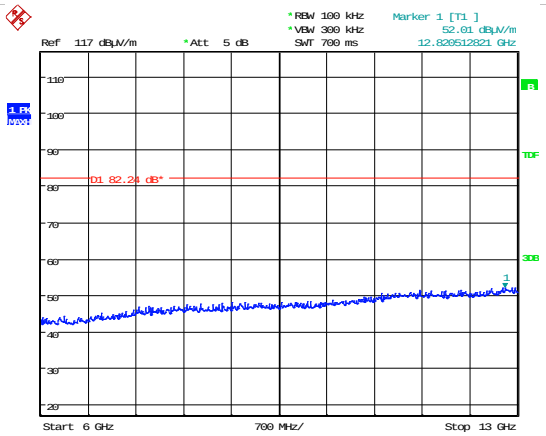


Figure 4 – Intermodulation Bottom Bluetooth LE and Top Classic (6 GHz to 13 GHz).

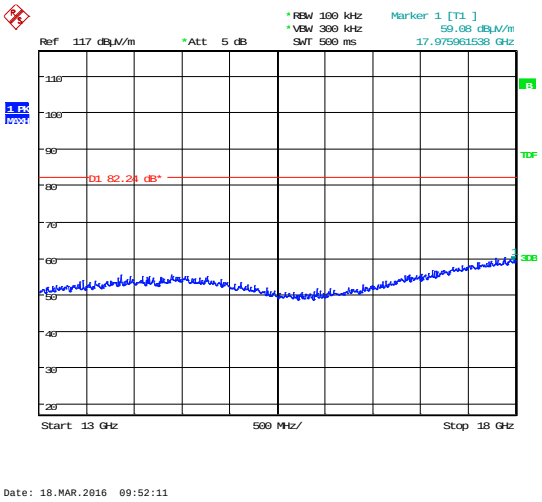


Figure 5 – Intermodulation Bottom Bluetooth LE and Top Classic (13 GHz to 18 GHz).

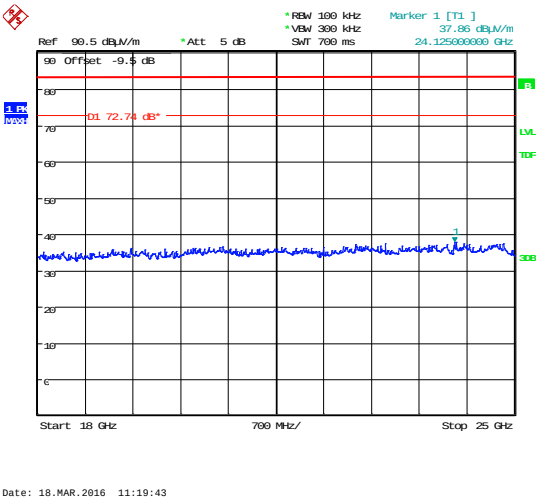


Figure 6 – Intermodulation Bottom Bluetooth LE and Top Classic (18 GHz to 25 GHz).

All emissions on graphs are related to either the Bluetooth LE operation or the Bluetooth Classic operation and are not intermodulation products.

No intermodulation products were found during the investigation.

11 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) = **4.6 dB**
Uncertainty in test result (1 GHz to 18 GHz) = **4.7 dB**