

Radio Testing of the

Masimo

Model: W1 Wrist Worn Device

In accordance with Radio Ordinance of MPT No. 37, 1981 Article 2 Paragraph 1 Item (19) and ARIB STD-T66 V3.7

Masimo
52 Discovery
Irvine, CA 92618



America

Add value.
Inspire trust.

COMMERCIAL-IN-CONFIDENCE

Date: June 2022

Document Number: 72180289B Issue 02 | Version Number: 01

RESPONSIBLE FOR	NAME	DATE	SIGNATURE
Authorized Signatory	Omar Castillo	June 23, 2022	

Signatures in this approval box have checked this document in line with the requirements of TÜV SÜD document control rules.

EXECUTIVE SUMMARY

The EUT in general was confirmed to be in compliance with Radio Ordinance of MPT No. 37, 1981 Article 2 Paragraph 1 Item (19) and ARIB STD-T66 V3.7.



A2LA Cert. No. 2955.13

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ACCREDITATION

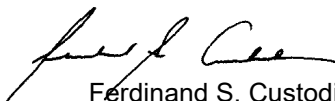
Our A2LA Accreditation does not cover opinions and interpretations and any expressed are outside the scope of our A2LA Accreditation.

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REPORT ON	Radio Testing of the Masimo W1 Wrist Worn Device
TEST REPORT NUMBER	72180289B
TEST REPORT DATE	June 2022
PREPARED FOR	Masimo 52 Discovery Irvine, CA 92618
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APPROVED BY	 Omar Castillo Name Authorized Signatory Title: Senior EMC/Wireless Test Engineer
DATED	June 23, 2022

Revision History

72180289B Masimo W1 Wrist Worn Device					
DATE	OLD REVISION	NEW REVISION	REASON	PAGES AFFECTED	APPROVED BY
06/23/2022	—	Initial Release			Omar Castillo
12/20/2022	Initial Release	Issue 02	Update units from power test results table removing reference to MHz	16	Ferdinand S. Custodio
			Removed RF Exposure section		

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SECTION 1

REPORT SUMMARY

Radio Testing of the
Masimo
W1 Wrist Worn Device



1.1 INTRODUCTION

The information contained in this report is intended to show verification of the Masimo W1 Wrist Worn Device to the requirements of Radio Ordinance of MPT No. 37, 1981 Article 2 Paragraph 1 Item (19) and ARIB STD-T66 V3.7.

Objective	To perform Radio Testing to determine the Equipment Under Test's (EUT's) compliance with the Test Specification, for the series of tests carried out.
Manufacturer	Masimo
EUT	Wrist Worn Device
Trade Name	W1
Model Name	W1
Serial Number(s)	FD00000083
Number of Samples Tested	1
Test Specification/Issue/Date	<ul style="list-style-type: none"> • Radio Ordinance of MPT No. 37, 1981 Article 2 Paragraph 1 Item (19). • ARIB STD-T66 V3.7 Second Generation Low Power Data Communication System/Wireless Lan System ARIB Standard (October 2, 2014 revised). • ARIB RCR STD-38 Radiofrequency-Exposure Protection Version 3.0 July 30, 2019.
Start of Test	May 27, 2022
Finish of Test	June 22, 2022
Name of Engineer(s)	Ferdinand Custodio
Related Document(s)	Telec-T401. Technical Regulations Conformity Certification Of Specified Radio Equipment. Characteristic Test Method For Radio Equipment Used For 2.4 GHz Band Wide-Band Low Power Data Communications System (Radio Station Using 2400 To 2483.5 MHz).



1.2 BRIEF SUMMARY OF RESULTS

A brief summary of the tests carried out in accordance with Radio Ordinance of MPT No. 37, 1981 Article 2 Paragraph 1 Item (19) and ARIB STD-T66 V3.7 are shown below:

Section	Spec Clause	Mode	Test Description	Result	Comments/Base Standard
2.1	3.2(2)	All	Antenna Power	Compliant	
2.2	3.2(3)	All	Allowable Deviation in Antenna Power	Compliant	
2.3	3.2(4)	All	Frequency Tolerance	Compliant	
-	3.2(5)	-	Transmission Rate	N/A	Not Regulated
2.4	3.2(6)	All	Permissible Value of Spurious or Unnecessary Intensity	Compliant	
2.5	3.2(7)	All	Permissible Value of Occupied Frequency Bandwidth	Compliant	
2.5	3.2(8)	All	Spread Bandwidth	Compliant	
2.6	3.2(9)	All	Spreading Factor	Compliant	
-	3.2(10)	OFDM	Number of Carriers	N/A	OFDM System Only
-	3.2(11)	FH System	Dwell Time		For EUT categorized as FH System
2.7	3.3 (1)	All	Limit on Secondary Radiation	Compliant	
2.8	3.6 (2)	All	Antenna Gain	Compliant	
2.9	3.4 (1)	All	Interference Prevention Function	Compliant	
2.10		All	RF Exposure	Compliant	ARIB RCR STD-38

1.3 PRODUCT INFORMATION

1.3.1 Technical Description

The Equipment Under Test (EUT) is a Masimo W1 Wrist Worn Device. The EUT operates standalone, and the internal battery can be charged using a wireless charger.



Equipment Under Test

1.3.2 EUT General Description

EUT Description	Wrist Worn Device
Trade Name	W1
Model Name	W1
Rated Voltage	5 VDC battery powered
Rated RF Power	0.5 mW
Mode Verified	Bluetooth LE 5.0
Capability	IEEE 802.15.1 Bluetooth Low Energy (BLE 5.0)
Primary Unit (EUT)	☐ Production ☐ Pre-Production ☒ Engineering
Manufacturer Declared Temperature Range	0°C to 35°C
Antenna Type	Chip Antenna
Manufacturer	Johanson
Antenna Model	2450AD18A7250, Masimo P/N: 101413
Maximum Antenna Gain	3.0 dBi

1.3.3 Antenna Power

Bluetooth Low Energy (LE)	Frequency Range (MHz)	Antenna Power (dBm)	Output Power (mW)
	2402-2480	-2.92	0.51

1.4 EUT TEST CONFIGURATION

1.4.1 Test Configuration Description

Test Configuration	Description				
Default	<p>Antenna Conducted Port Configuration. A temporary antenna connector was provided for the evaluation. The EUT is connected to a support laptop connected via a FTDI USB cable. The support laptop is running PuTTY which enables configuration of the BLE 5.0 RF module. TX and RX test modes are available. The following settings were used for both 1M and 2M PHY configurations:</p> <table border="1"> <tr> <td>Data Rate</td><td>1Mbit or 2Mbit</td></tr> <tr> <td>Output Power</td><td>Pos8dBm</td></tr> </table>	Data Rate	1Mbit or 2Mbit	Output Power	Pos8dBm
Data Rate	1Mbit or 2Mbit				
Output Power	Pos8dBm				

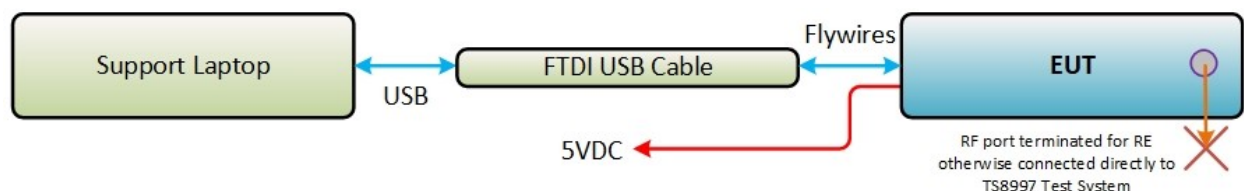
1.4.2 EUT Exercise Software

Firmware used during verification is V0001.

1.4.3 Support Equipment and I/O cables

Manufacturer	Equipment/Cable	Description
HP	Support laptop	Model: Elitebook, S/N:78900672
HP	Support laptop AC Adapter	P/N: 854055-004
-	Laptop to EUT	USB FTDI Cable

1.4.1 Simplified Test Configuration Diagram





1.5 DEVIATIONS FROM THE STANDARD

No deviations from the applicable test standards or test plan were made during testing.

1.6 MODIFICATION RECORD

Description of Modification	Modification Fitted By	Date Modification Fitted
Serial Number: FD00000083		
N/A	-	-

The table above details modifications made to the EUT during the test programme. The modifications incorporated during each test (if relevant) are recorded on the appropriate test pages.

1.7 TEST METHODOLOGY

All measurements contained in this report were conducted with ARIB STD-T66 V3.7 Second Generation Low Power Data Communication System/Wireless LAN System ARIB Standard (October 2, 2014 revised) and Telec-T401. Technical Regulations Conformity Certification of Specified Radio Equipment. Characteristic Test Method For Radio Equipment Used For 2.4 GHz Band Wide-Band Low Power Data Communications System (Radio Station Using 2400 To 2483.5 MHz).

For conducted and radiated emissions (if applicable) the equipment under test (EUT) was configured to measure its highest possible emission level. This level was based on the maximized cable configuration from exploratory testing per ANSI C63.10-2013. The test modes were adapted according to the Operating Instructions provided by the manufacturer/client.

1.8 TEST FACILITY LOCATION

1.8.1 TÜV SÜD America Inc. (Mira Mesa)

10040 Mesa Rim Road, San Diego, CA 92121-2912 (32.901268,-117.177681). Phone: (858) 678-1400 FAX: (858) 546-0364

1.8.2 TÜV SÜD America Inc. (Rancho Bernardo)

16936 Via Del Campo, San Diego, CA 92127-1708 (33.018644,-117.092409). Phone: (858) 678-1400 FAX: (858) 546-0364.

1.9 TEST FACILITY REGISTRATION

1.9.1 FCC – Designation No.: US1146

TÜV SÜD America Inc. (San Diego), is an accredited test facility with the site description report on file and has met all the requirements specified in §2.948 of the FCC rules. The acceptance letter from the FCC is maintained in our files and the Designation is US1146.



1.9.2 Innovation, Science and Economic Development Canada (ISED) Registration No.: 3067A-1 & 22806-1

The 10m Semi-anechoic chamber of TÜV SÜD America Inc. (San Diego Rancho Bernardo) has been registered by Certification and Engineering Bureau of Innovation, Science and Economic Development Canada for radio equipment testing with Registration No. 3067A-1.

The 3m Semi-anechoic chamber of TÜV SÜD America Inc. (San Diego Mira Mesa) has been registered by Certification and Engineering Bureau of Innovation, Science and Economic Development Canada for radio equipment testing with Registration No. 22806-1.

1.9.3 BSMI – Laboratory Code: SL2-IN-E-028R (US0102)

TÜV Product Service Inc. (San Diego) is a recognized EMC testing laboratory by the BSMI under the MRA (Mutual Recognition Arrangement) with the United States. Accreditation includes CNS 13438 up to 6GHz.

1.9.4 NCC (National Communications Commission - US0102)

TÜV SÜD America Inc. (San Diego) is listed as a Foreign Recognized Telecommunication Equipment Testing Laboratory and is accredited to ISO/IEC 17025 (A2LA Certificate No.2955.13) which under APEC TEL MRA Phase 1 was designated as a Conformity Assessment Body competent to perform testing of equipment subject to the Technical Regulations covered under its scope of accreditation including RTTE01, PLMN01 and PLMN08 for TTE type of testing and LP0002 for Low-Power RF Device type of testing.

1.9.5 VCCI – Registration No. A-0280 and A-0281

TÜV SÜD America Inc. (San Diego) is a VCCI registered measurement facility which includes radiated field strength measurement, radiated field strength measurement above 1GHz, mains port interference measurement and telecommunication port interference measurement.

1.9.6 RRA – Identification No. US0102

TÜV SÜD America Inc. (San Diego) is National Radio Research Agency (RRA) recognized laboratory under Phase I of the APEC Tel MRA.

1.9.7 OFCA – U.S. Identification No. US0102

TÜV SÜD America Inc. (San Diego) is recognized by Office of the Communications Authority (OFCA) under Appendix B, Phase I of the APEC Tel MRA.



SECTION 2

TEST DETAILS

Radio Testing of the
Masimo
W1 Wrist Worn Device

2.1 ANTENNA POWER

2.1.1 Specification Reference

Radio Ordinance of MPT No. 37, 1981 Article 2 Paragraph 1 Item (19) and ARIB STD-T66 V3.7 Section 3.2(2)

2.1.2 Standard Applicable

- (a) Given a receiving device that uses a spread spectrum system that is a FH system, a hybrid of a DS system and a FH system, or a hybrid of a FH system and an OFDM system, and uses a frequency band that ranges from above or equal to 2,427MHz and below or equal to 2,470.75MHz, then if the antenna power of the receiving device is modulated by a standard encoding test signal of the same transmission rate as the modulation signal, the mean power for a bandwidth of 1MHz is at most 3mW.
- (b) Given a transmission device that uses a spread spectrum system other than the types listed in (a), if the antenna power of the receiving device is modulated by a standard encoding test signal of the same transmission rate as the modulation signal, the mean power for a bandwidth of 1MHz is at most 10mW.
- (c) Given a transmission device that uses an OFDM system, if the antenna power of the receiving device is modulated by a standard encoding test signal of the same transmission rate as the modulation signal, the mean power for a bandwidth of 1MHz is one of the following:
 - (1) If the transmission device occupies a frequency bandwidth of at most 26MHz, that it be at most 10mW.
 - (2) If the transmission device occupies a frequency bandwidth of over 26MHz but at most 38MHz, that it be at most 5mW.
- (d) For transmission devices that do not fall under the categories indicated by (a), (b), or (c), the antenna power must be at most 10mW under the same circumstances.

2.1.3 Equipment Under Test and Modification State

Serial No: FD00000083 / Default Test Configuration

2.1.4 Date of Test/Initial of test personnel who performed the test

May 27, 2022 / FSC

2.1.5 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

2.1.6 Environmental Conditions (Rancho Bernardo Facility)

Ambient Temperature	21.4 °C
Relative Humidity	25.6 %
ATM Pressure	100.3 kPa

2.1.7 Additional Observations

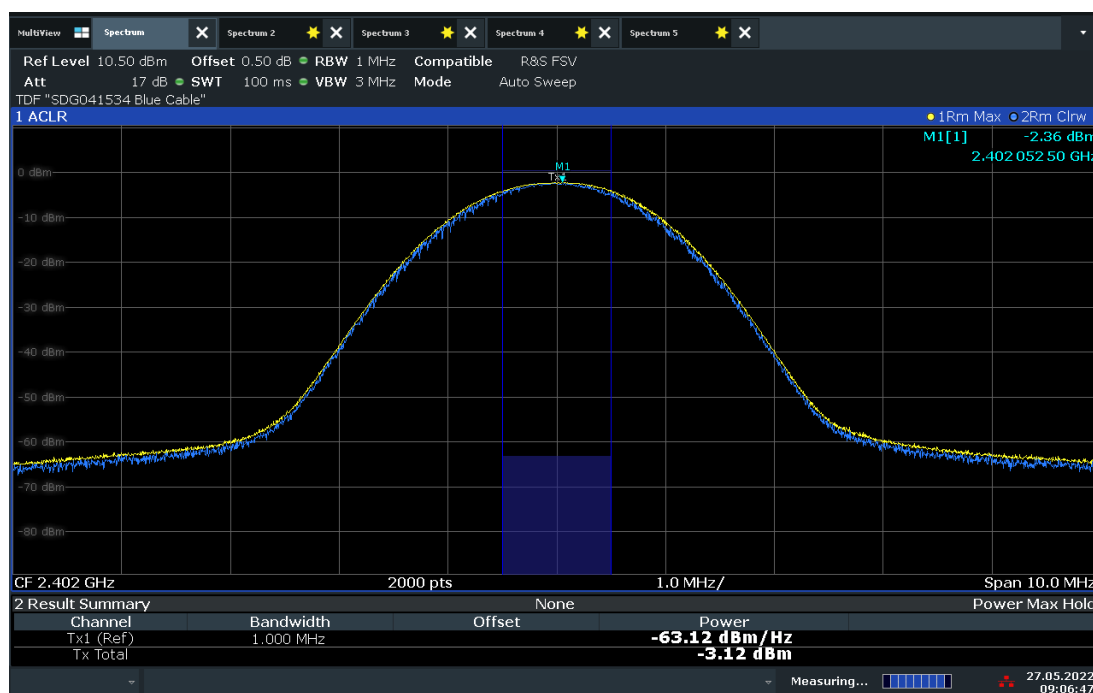
- This is a conducted test through the EUT antenna port.
- The EUT was directly connected to the input of the spectrum analyzer.

- Test performed on Low, Mid and High channels on both 1M and 2M PHY.
- The offset is for the SMA pigtail used.

2.1.8 Test Results

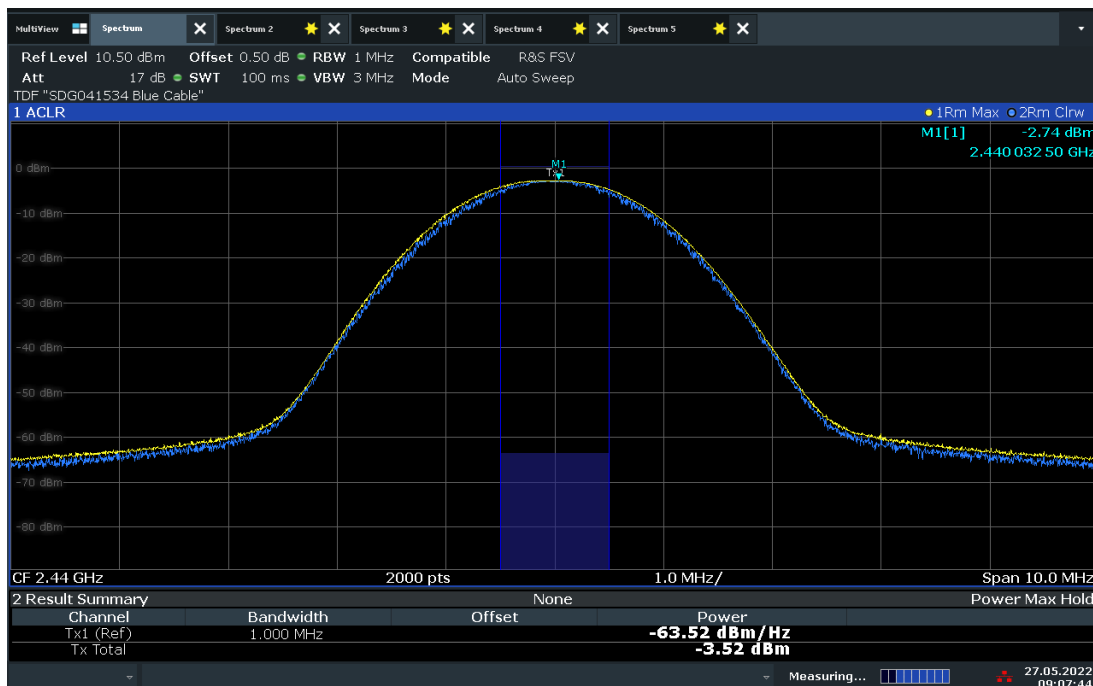
Channels	Mean Antenna Power (dBm)	Mean Antenna Power (mW)	Limit (mW)
Low Channel 1M PHY (2402 MHz)	-3.12	0.49	10
Mid Channel 1M PHY (2440 MHz)	-3.52	0.44	
High Channel 1M PHY (2480 MHz)	-2.92	0.51	
Low Channel 2M PHY (2402 MHz)	-3.60	0.44	
Mid Channel 2M PHY (2440 MHz)	-3.98	0.40	
High Channel 2M PHY (2480 MHz)	-3.53	0.44	
Limit is 10 mW – EUT complies			

2.1.9 Test Plots



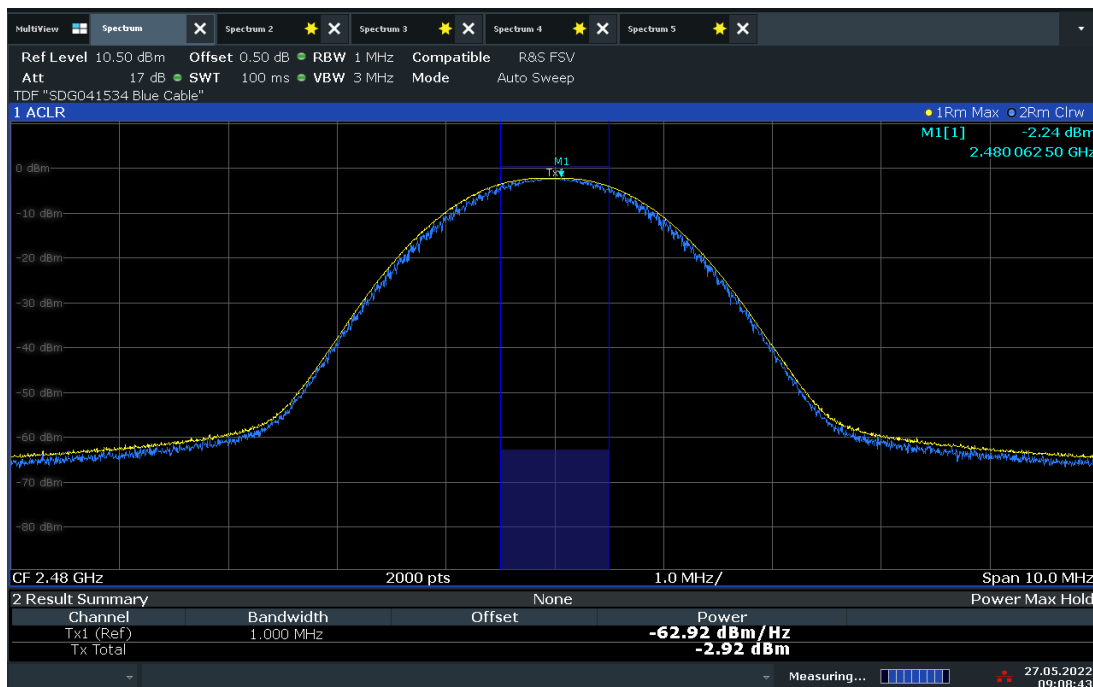
09:06:48 27.05.2022

Low Channel 2402 MHz 1M PHY



09:07:44 27.05.2022

Mid Channel 2440 MHz 1M PHY



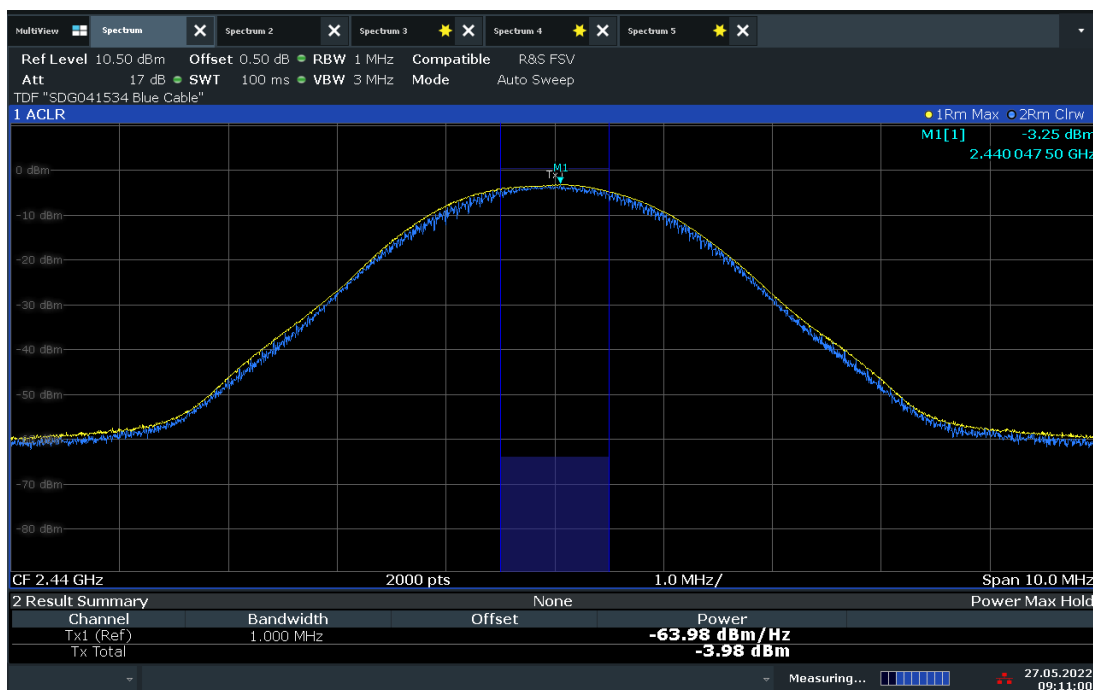
09:08:44 27.05.2022

High Channel 2480 MHz 1M PHY



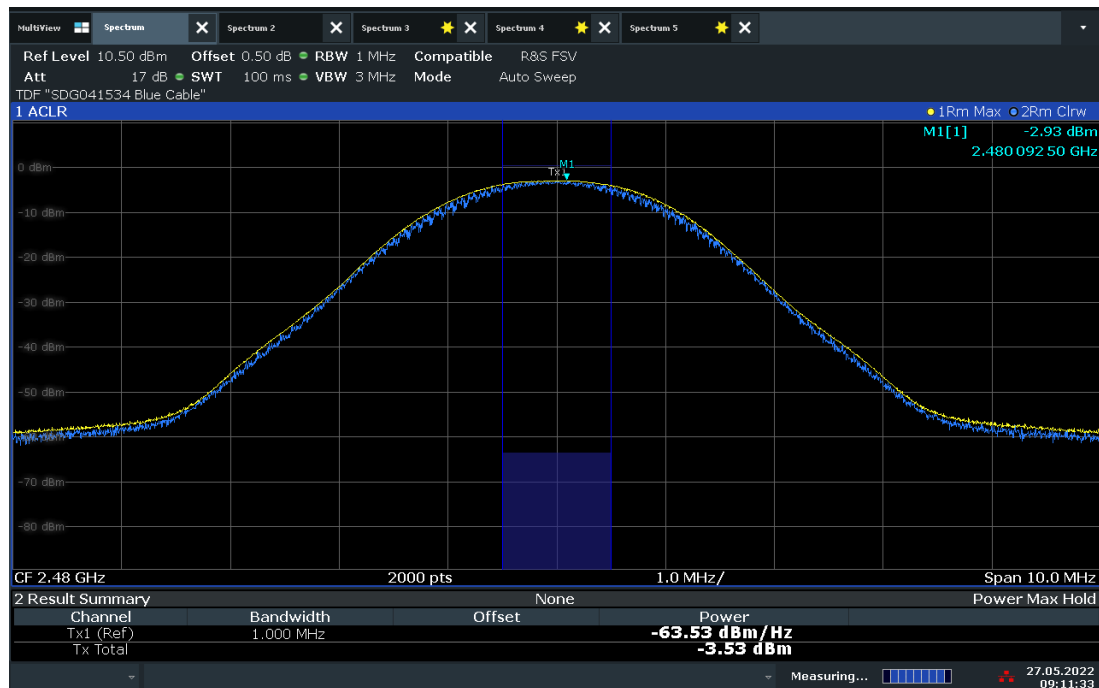
09:10:31 27.05.2022

Low Channel 2402 MHz 2M PHY



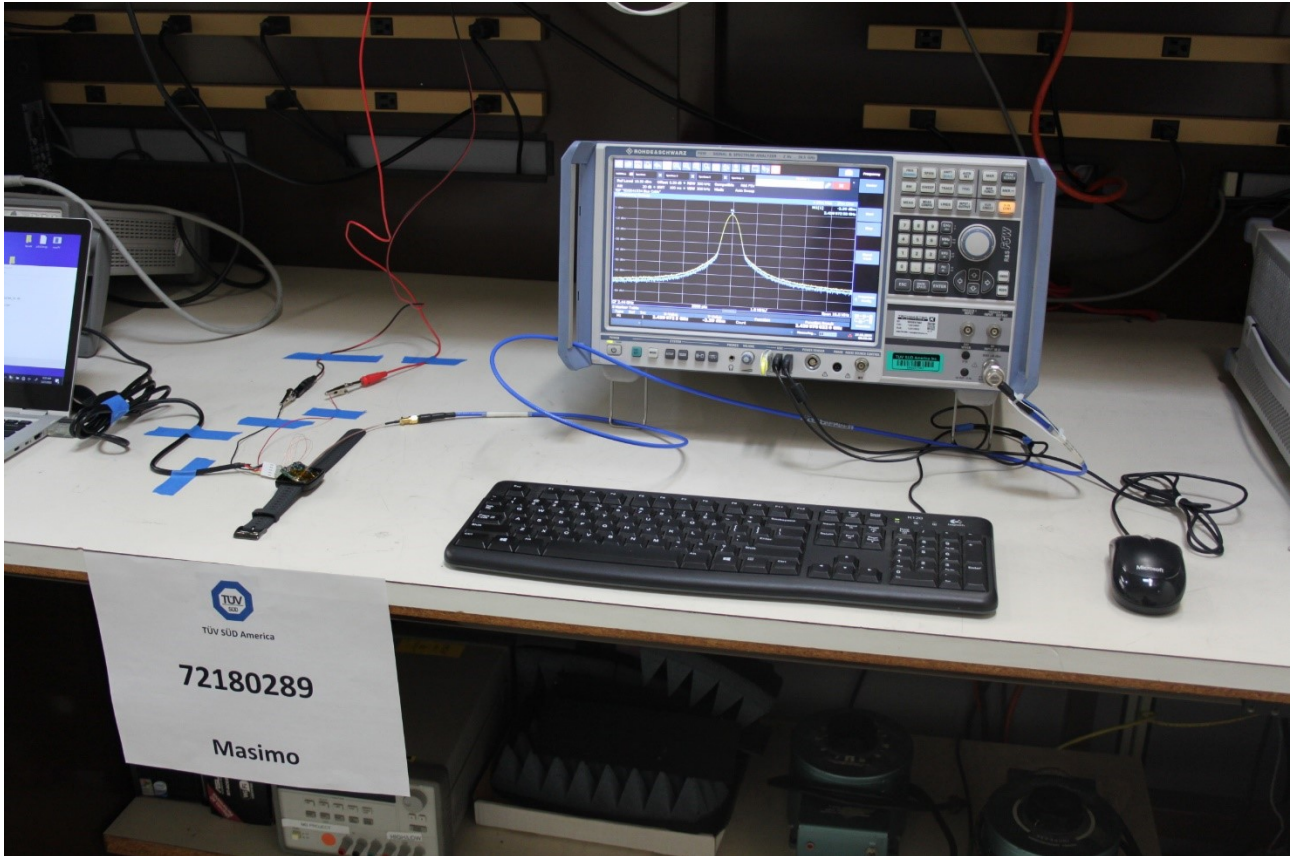
09:11:00 27.05.2022

Mid Channel 2440 MHz 2M PHY



High Channel 2480 MHz 2M PHY

2.1.10 Test Setup Photo



2.2 ALLOWABLE DEVIATIONS IN ANTENNA POWER

2.2.1 Specification Reference

Radio Ordinance of MPT No. 37, 1981 Article 2 Paragraph 1 Item (19) and ARIB STD-T66 V3.7 Section 3.2(3)

2.2.2 Standard Applicable

The upper and lower allowable deviations in antenna power are 20% and -80%, respectively. However, these limits are for maximum rate antenna power. If the antenna power is reduced for communication reasons, there are no regulated upper or lower allowable deviations

2.2.3 Equipment Under Test and Modification State

Serial No: FD00000083 / Default Test Configuration

2.2.4 Date of Test/Initial of test personnel who performed the test

May 27, 2022 / FSC

2.2.5 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

2.2.6 Environmental Conditions (Rancho Bernardo Facility)

Ambient Temperature	21.4 °C
Relative Humidity	25.6 %
ATM Pressure	100.3 kPa

2.2.7 Additional Observations

Worst case measurements from Section 2.1 (1M and 2M PHY) were used.

2.2.8 Test Results

Channels	Rated Power	Measured Power	Transmit power Limit (0.1 to 0.6 mW)
Low Channel (2402 MHz)	0.5 mW (-3.0 dBm)	0.49 mW	Complies
Mid Channel (2440 MHz)		0.44 mW	Complies
High Channel (2480 MHz)		0.51 mW	Complies

2.3 ALLOWABLE DEVIATIONS IN FREQUENCY

2.3.1 Specification Reference

Radio Ordinance of MPT No. 37, 1981 Article 2 Paragraph 1 Item (19) and ARIB STD-T66 V3.7 Section 3.2(4)

2.3.2 Standard Applicable

Deviations must be within $\pm 50 \times 10^{-6}$.

2.3.3 Equipment Under Test and Modification State

Serial No: FD00000083 / Default Test Configuration

2.3.4 Date of Test/Initial of test personnel who performed the test

May 27, 2022 / FSC

2.3.5 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

2.3.6 Environmental Conditions (Rancho Bernardo Facility)

Ambient Temperature	21.4 °C
Relative Humidity	25.6 %
ATM Pressure	100.3 kPa

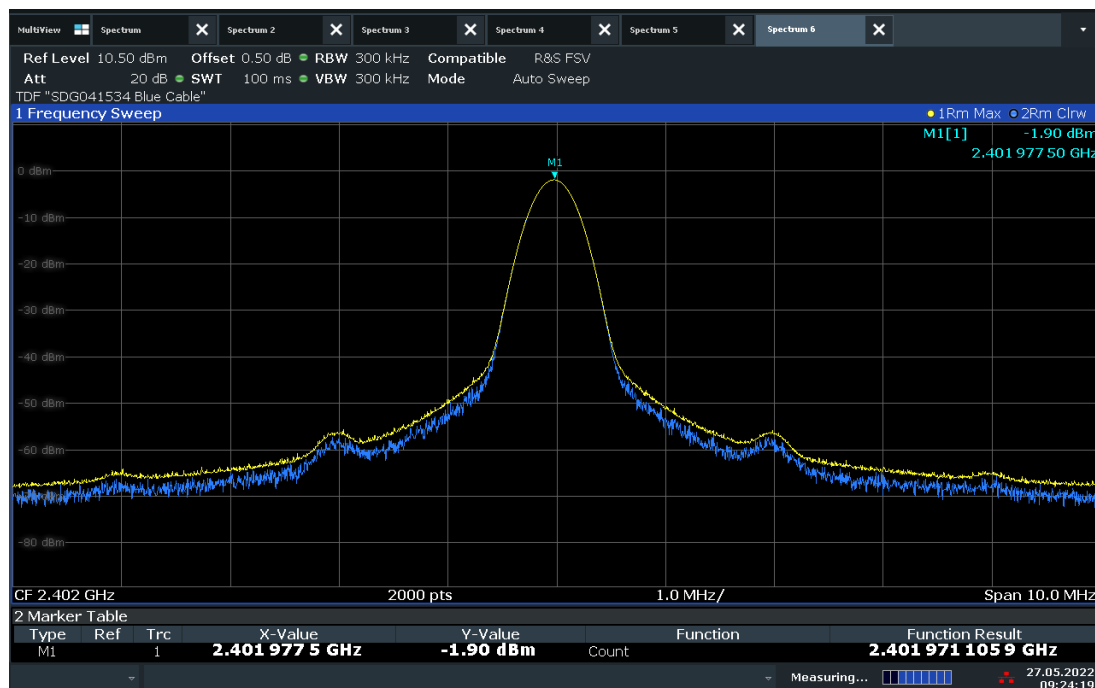
2.3.7 Additional Observations

- CW mode is used for this test.
- The Signal Count function of the Spectrum Analyzer is used for measurement.
- Test setup photo is identical to Section 2.1.10 of this test report.

2.3.8 Test Results

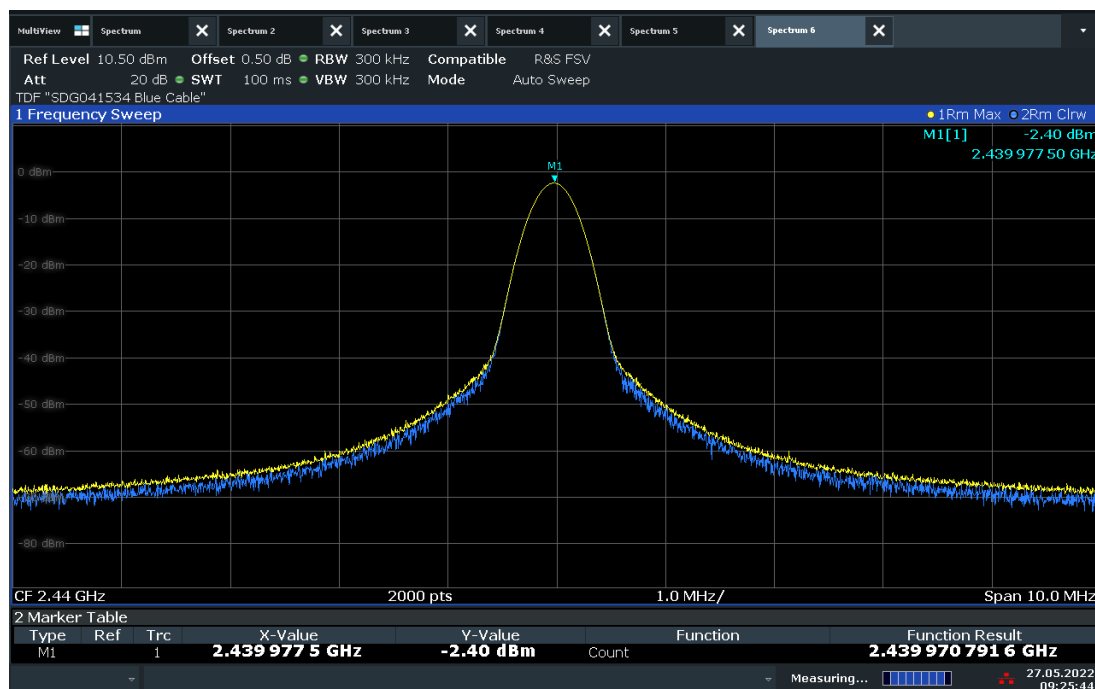
Channel	Max Frequency Deviation (kHz)	Frequency Error (ppm)	Limit (ppm)
Low (2402 MHz)	28.894	12.029	±50
Mid (2440 MHz)	29.208	11.970	±50
High (2480 MHz)	29.598	11.935	±50
EUT Complies with 50ppm requirement			

2.3.9 Test Plots



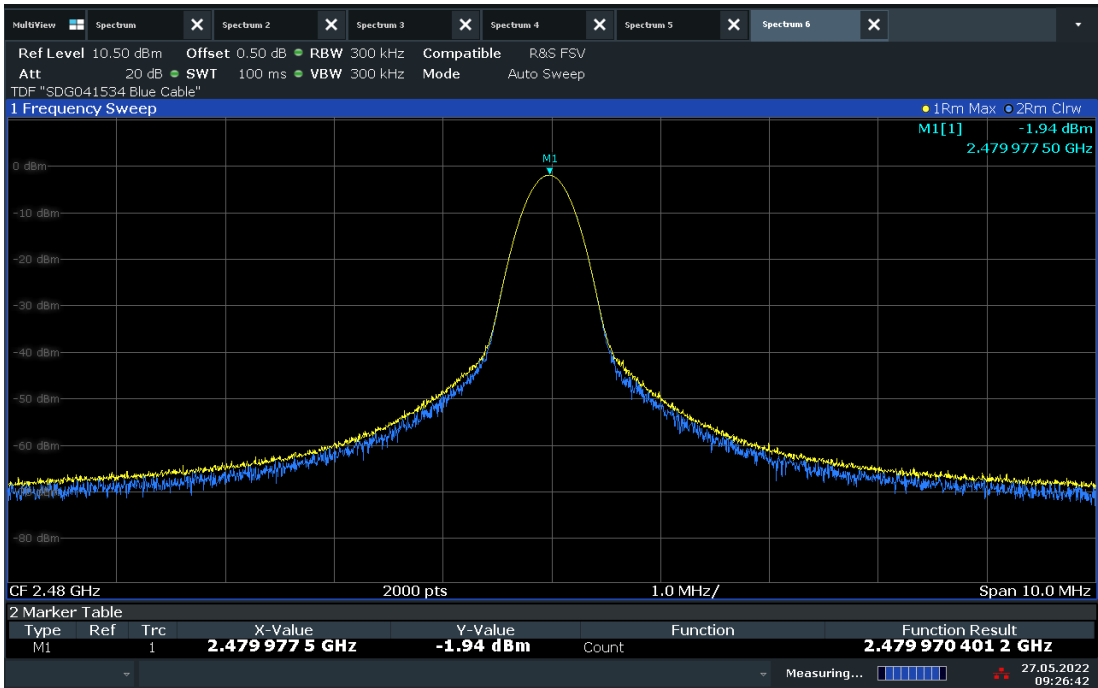
09:24:20 27.05.2022

Low Channel 2402 MHz



09:25:45 27.05.2022

Mid Channel 2440 MHz



09:26:43 27.05.2022

High Channel 2480 MHz

2.4 PERMISSIBLE VALUE OF SPURIOUS OR UNNECESSARY INTENSITY

2.4.1 Specification Reference

Radio Ordinance of MPT No. 37, 1981 Article 2 Paragraph 1 Item (19) and ARIB STD-T66 V3.7 Section 3.2(6)

2.4.2 Standard Applicable

(a) Permissible value applicable starting December 1, 2005 (RE Article 7, Attached table No.3)
The permissible value of unnecessary radiation power is the mean power of unnecessary radiation per frequency supplied to a feeder during modulation, and is regulated as follows:

Frequency band	Permissible value of unnecessary radiation power
Below 2,387MHz or above 2,496.5MHz	Mean power for an arbitrary 1MHz bandwidth is at most 2.5μW
Above or equal to 2,387MHz and below 2,400MHz, or above 2,483.5MHz and below or equal to 2,496.5MHz	Mean power for an arbitrary 1MHz bandwidth is at most 25μW

However, there are transitional measures due to RE Supplementary Provisions (Ordinance from the Ministry of Internal Affairs and Communications, No. 119, August 9, 2005.)

(b) Permissible value based on Radio Equipment Regulations before November 30, 2005

<p>(6) Spurious radiation intensity (RE Article 7) Mean power of spurious radiation per frequency supplied to a feeder is calculated as the mean power of spurious radiation in a 1 MHz bandwidth at a frequency f outside of the frequency band used. The permissible value of this mean power is as follows:</p> <p>(a) $2,387\text{MHz} \leq f < 2,400\text{MHz}$ and $2,483.5\text{MHz} < f \leq 2,496.5\text{MHz}$ at most 25μW (b) $2,387\text{MHz} > f$ and $2,496.5\text{MHz} < f$ at most 2.5μW</p> <p style="text-align: right;">(ARIB STD-T66 version 2.2)</p>

2.4.3 Equipment Under Test and Modification State

Serial No: FD00000083 / Default Test Configuration

2.4.4 Date of Test/Initial of test personnel who performed the test

May 27, 2022 / FSC

2.4.5 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

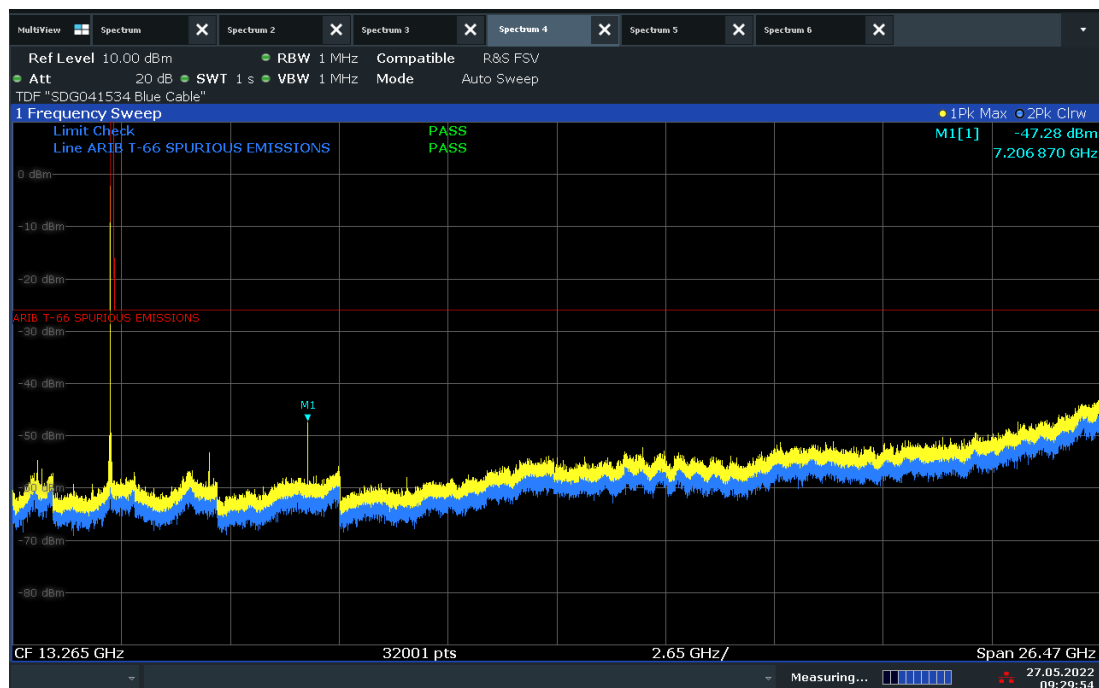
2.4.6 Environmental Conditions (Rancho Bernardo Facility)

Ambient Temperature 21.4 °C
Relative Humidity 25.6 %
ATM Pressure 100.3 kPa

2.4.7 Additional Observations

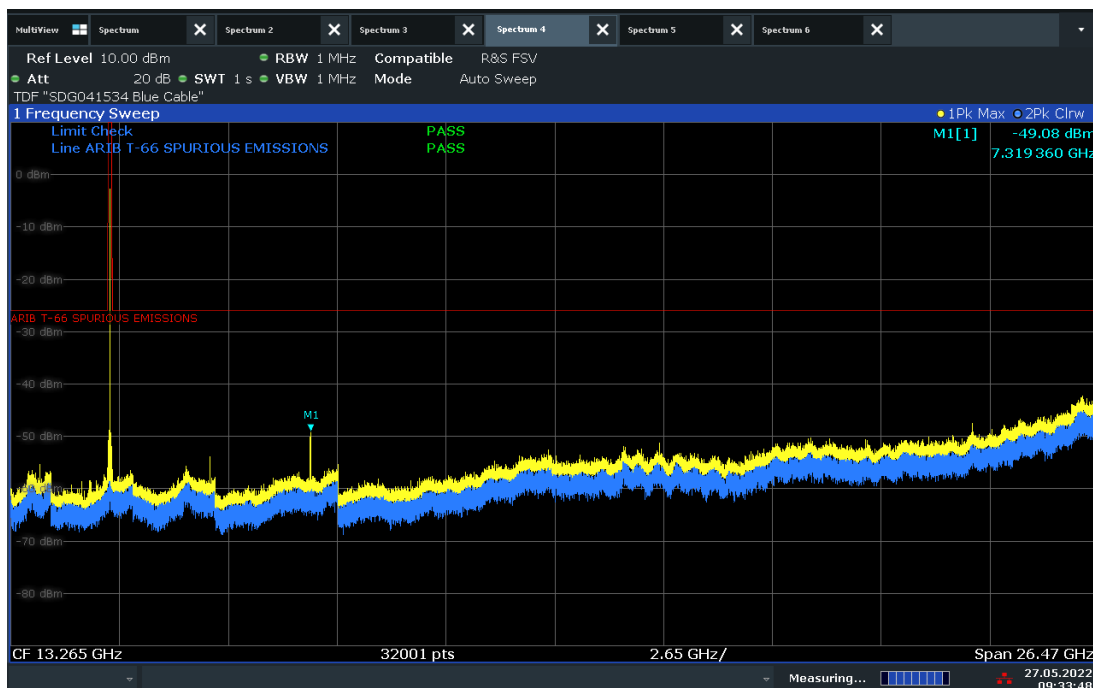
- This is a conducted test.
- All attenuations (SMA pigtail and cable used) were pre-programmed into the test template as TDF (transducer factor).
- The limit was first converted to dBm.
- Spurious emission mask was drawn based on the limit.
- RBW and VBW were set to 1MHz.
- Detector is Peak (worst case).
- Trace is Max Hold
- Test setup photo is identical to Section 2.1.10 of this test report.

2.4.8 Test Results (1M PHY)



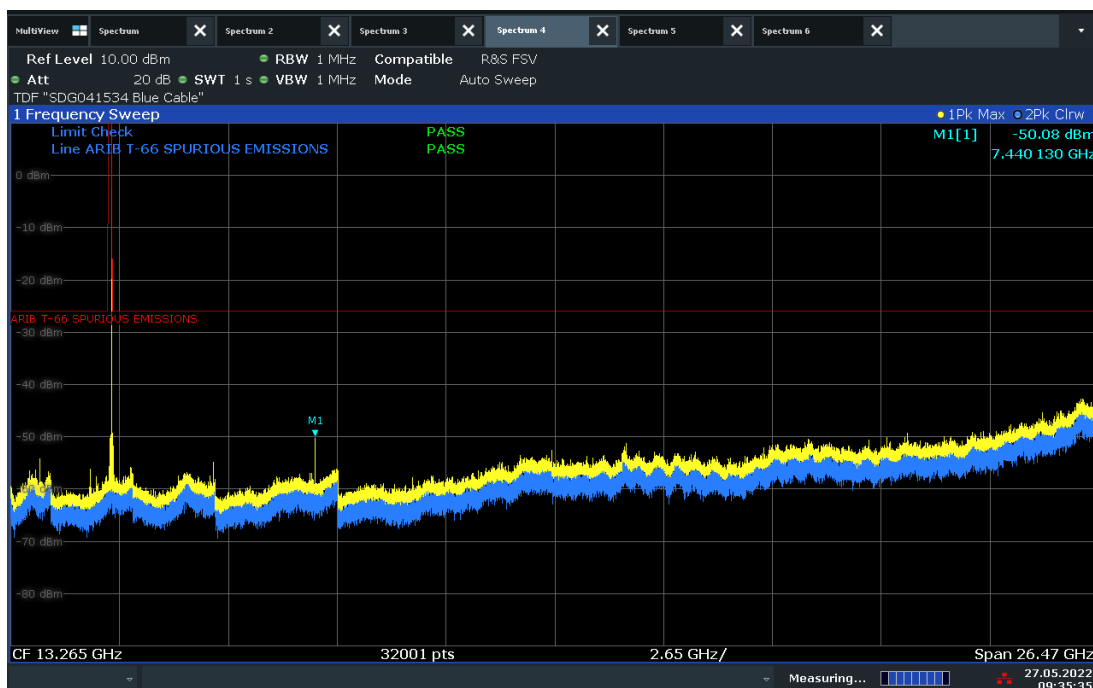
09:29:54 27.05.2022

Low Channel (2402 MHz)



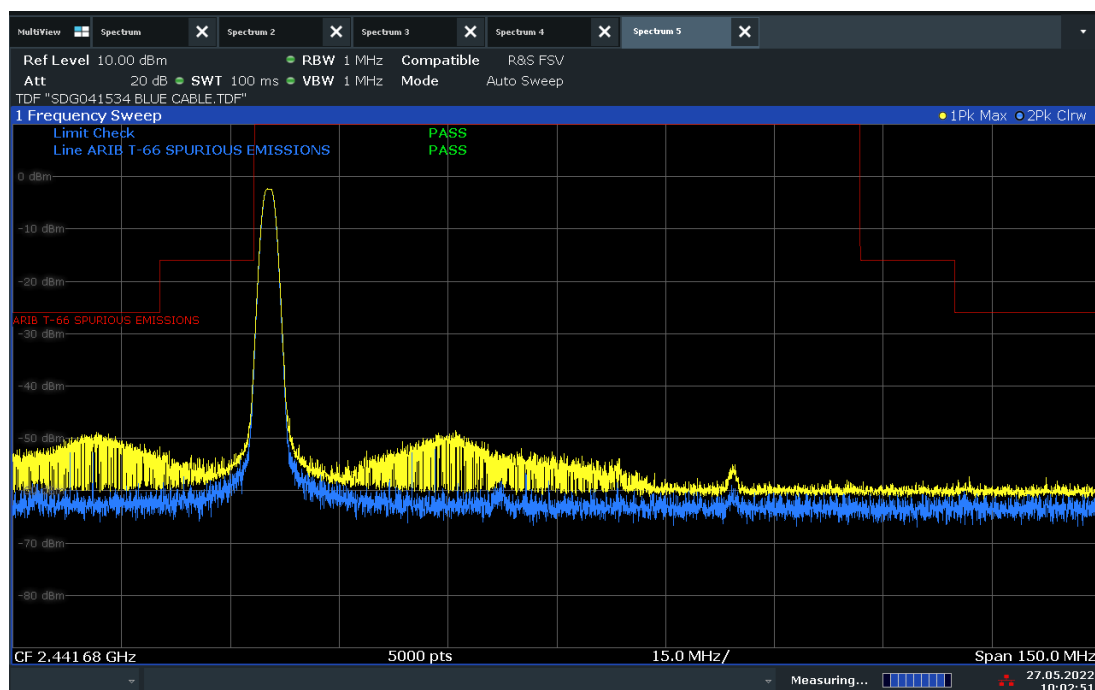
09:33:49 27.05.2022

Mid Channel (2440 MHz)

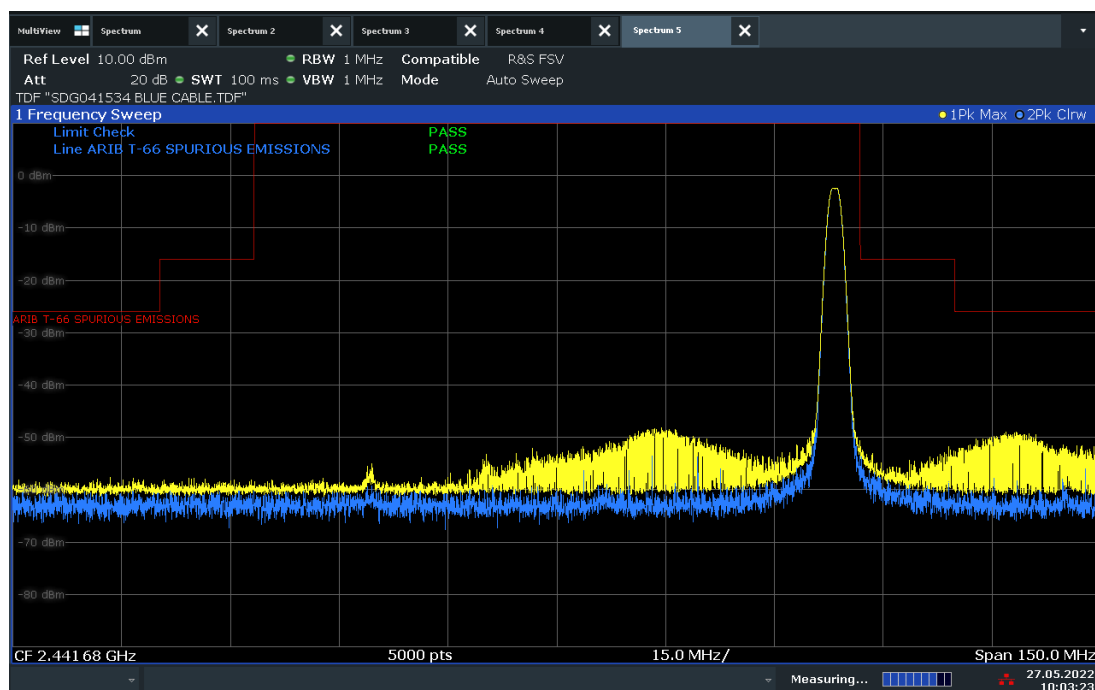


09:35:35 27.05.2022

High Channel (2480 MHz)

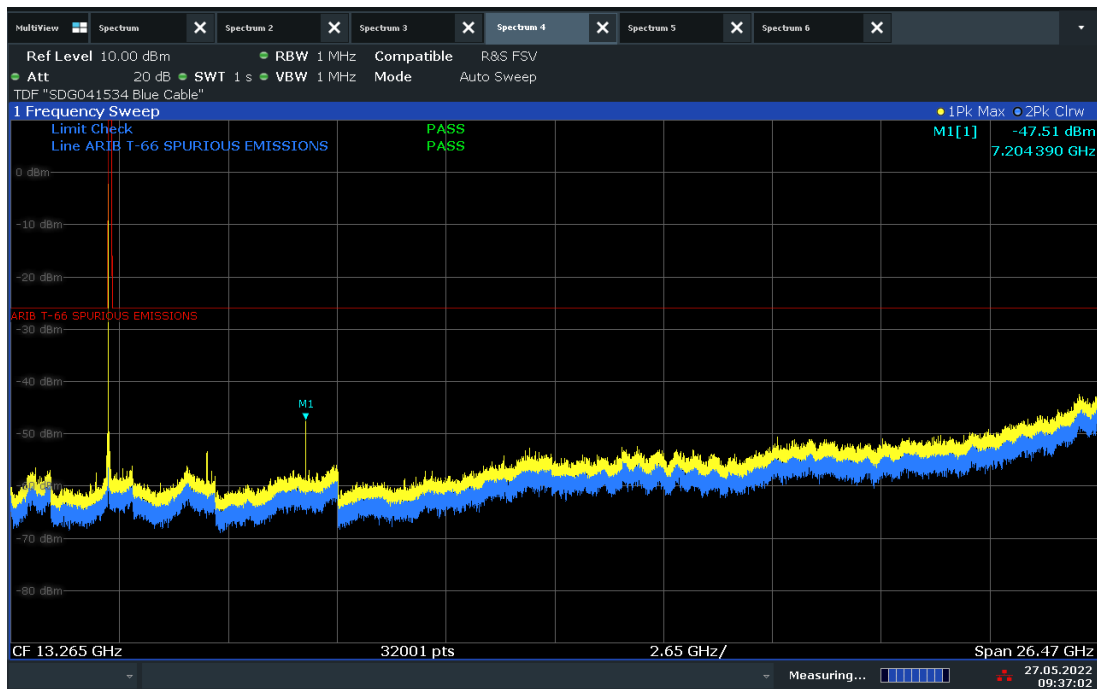


Low Channel Band-Edge Verification



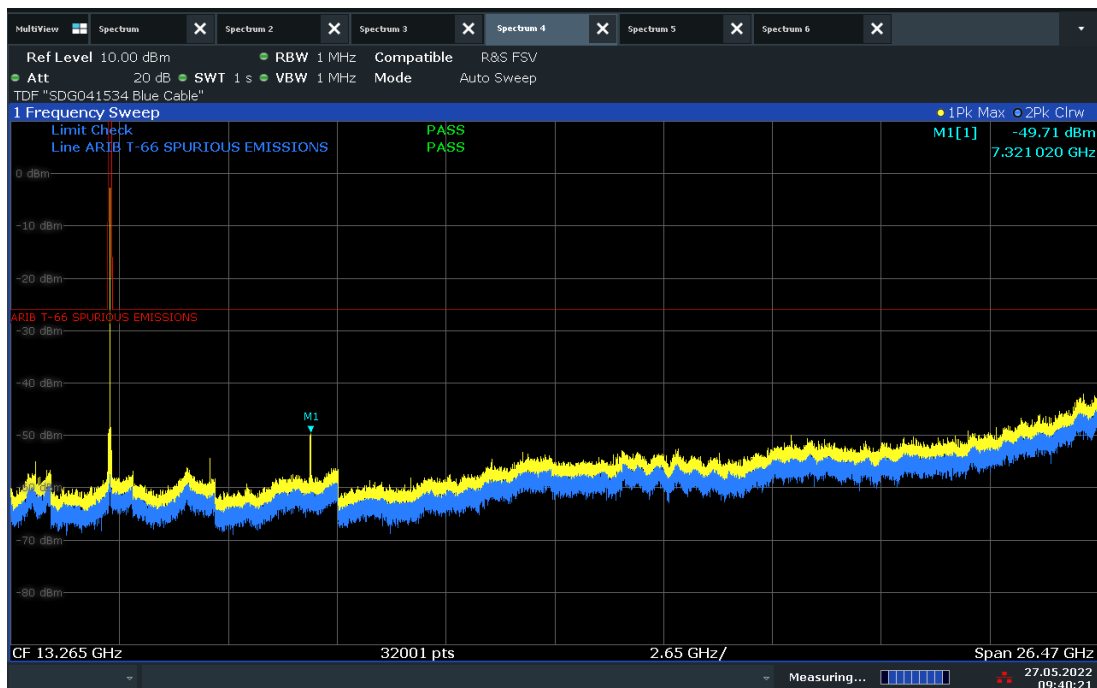
High Channel Band-Edge Verification

2.4.9 Test Results (2M PHY)



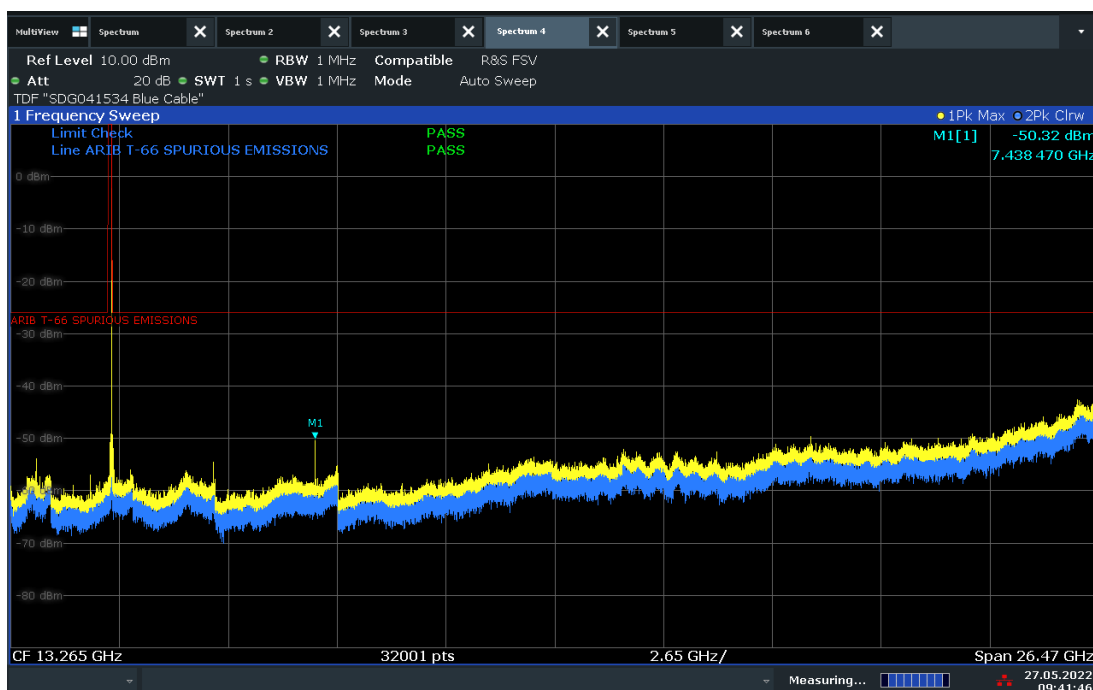
09:37:02 27.05.2022

Low Channel (2402 MHz)



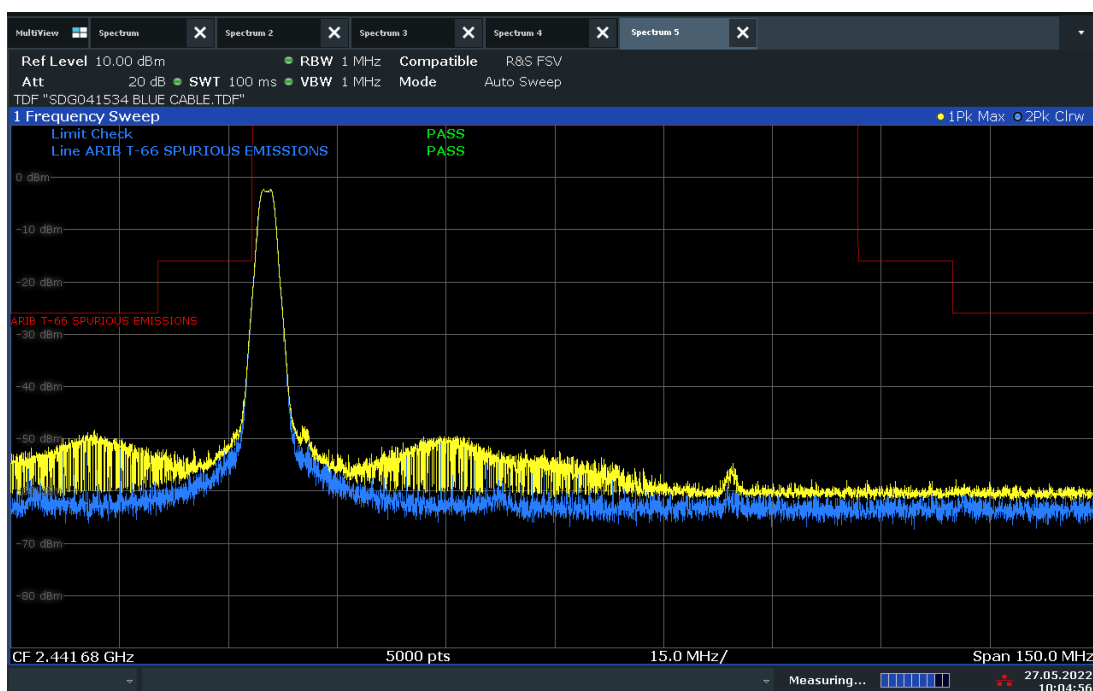
09:40:22 27.05.2022

Mid Channel (2440 MHz)



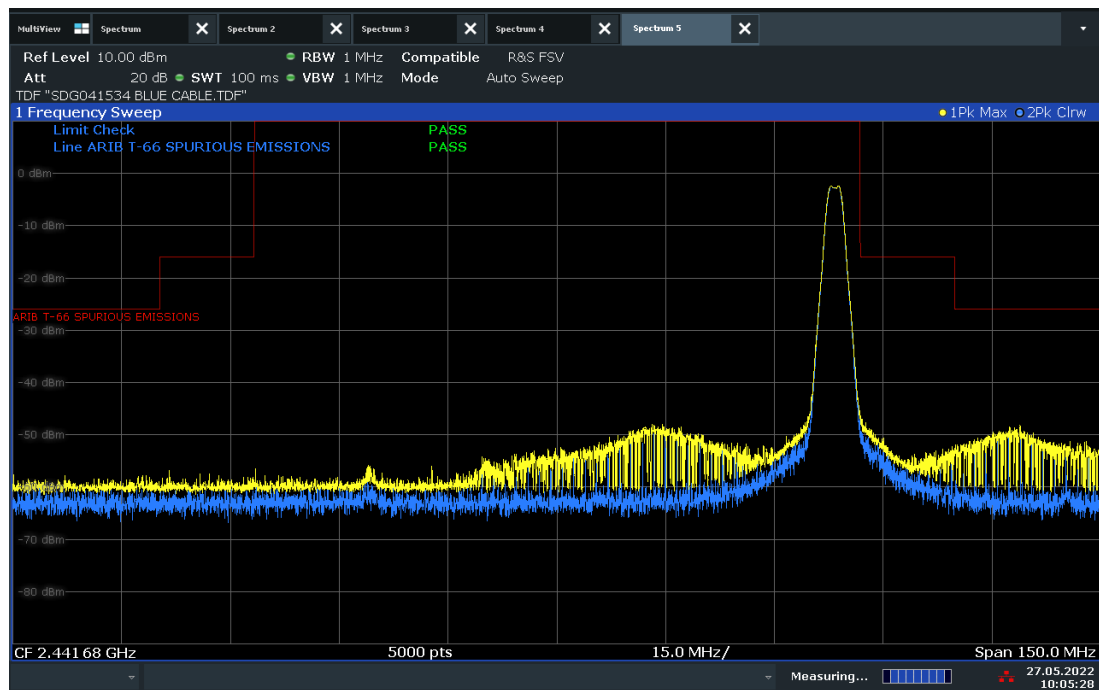
09:41:47 27.05.2022

High Channel (2480 MHz)



10:04:57 27.05.2022

Low Channel Band-Edge Verification



10:05:29 27.05.2022

High Channel Band-Edge Verification



2.5 PERMISSIBLE VALUE OF OCCUPIED FREQUENCY BANDWIDTH AND SPREAD BANDWIDTH

2.5.1 Specification Reference

Radio Ordinance of MPT No. 37, 1981 Article 2 Paragraph 1 Item (19) and ARIB STD-T66 V3.7 Section 3.2(7)(8)

2.5.2 Standard Applicable

Permissible value of occupied frequency bandwidth for transmission devices using a FH system, a DS-FH hybrid system, or a FH-OFDM hybrid system is at most 83.5MHz; for transmission devices using a OFDM system is at most 38MHz; and for transmission devices using any other system the necessary frequency bandwidth is at most 26MHz. Necessary frequency bandwidth is the smallest bandwidth necessary to occupy in order to ensure the required data transmission rate and quality for the system used under specific conditions for a given radiation type.

For spread spectrum systems, the spread bandwidth must be at least 500kHz. Spread bandwidth is a bandwidth whose upper and lower limits are set such that the average radiations emitted at frequencies above the upper limit and below the lower limit are each equal to 5% of the total mean power radiated. The same definition is used henceforth.

2.5.3 Equipment Under Test and Modification State

Serial No: FD00000083 / Default Test Configuration

2.5.4 Date of Test/Initial of test personnel who performed the test

May 27, 2022 / FSC

2.5.5 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

2.5.6 Environmental Conditions (Rancho Bernardo Facility)

Ambient Temperature	21.4 °C
Relative Humidity	25.6 %
ATM Pressure	100.3 kPa

2.5.7 Additional Observations

- This is a conducted test.
- Span is wide enough to capture the channel transmission.
- RBW and VBW were set to 300 kHz
- Detector is Positive Peak.
- Trace is set to Max Hold.
- Channel Bandwidth measurement function of the spectrum analyzer was used for this test.

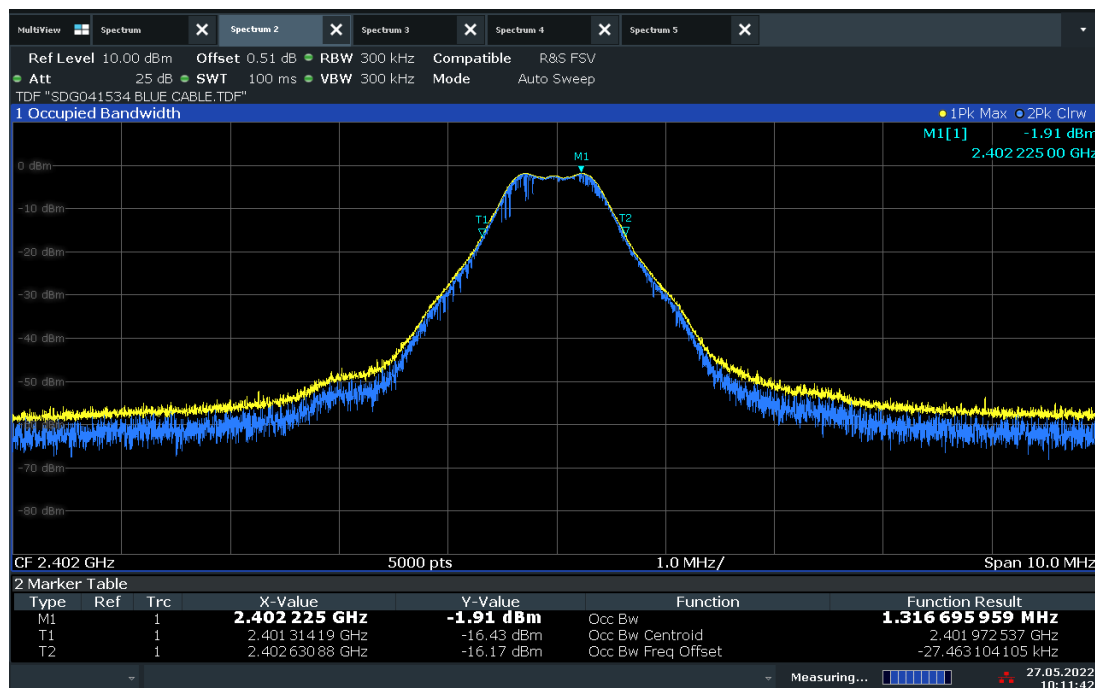
- The % Power Bandwidth setting in the spectrum analyzer was set to 99% for OBW measurements.
- The % Power Bandwidth setting in the spectrum analyzer was set to 90% for Spreading Bandwidth measurements.
- Test setup photo is identical to Section 2.1.10 of this test report.

2.5.8 Test Results

Mode	Channel	Occupied Bandwidth (MHz)	Limit for Occupied Bandwidth	Spreading Bandwidth (MHz)	Limit for Spreading Bandwidth
1MHz BW	37 (2402 MHz)	1.317	$\leq 26\text{MHz}$	0.863	>500 kHz
	18 (2440 MHz)	1.334		0.868	
	39 (2480 MHz)	1.337		0.870	

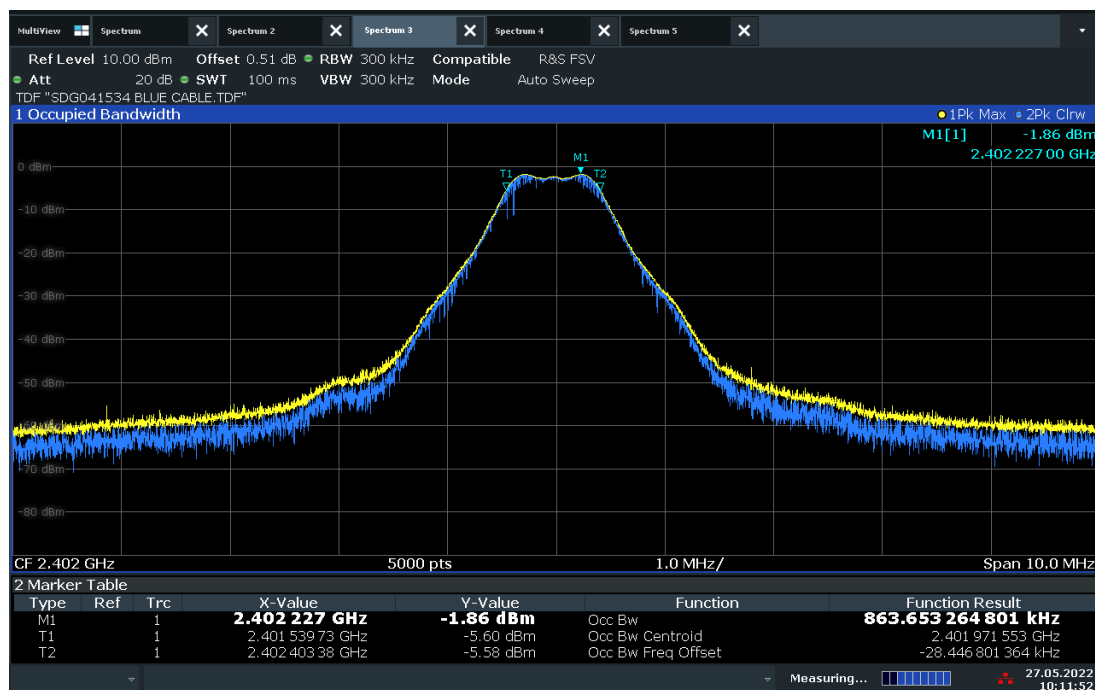
Mode	Channel	Occupied Bandwidth (MHz)	Limit for Occupied Bandwidth	Spreading Bandwidth (MHz)	Limit for Spreading Bandwidth
2MHz BW	37 (2402 MHz)	2.178	$\leq 26\text{MHz}$	1.384	>500 kHz
	18 (2440 MHz)	2.183		1.392	
	39 (2480 MHz)	2.188		1.395	

2.5.9 Test Plots (1MHz BW)



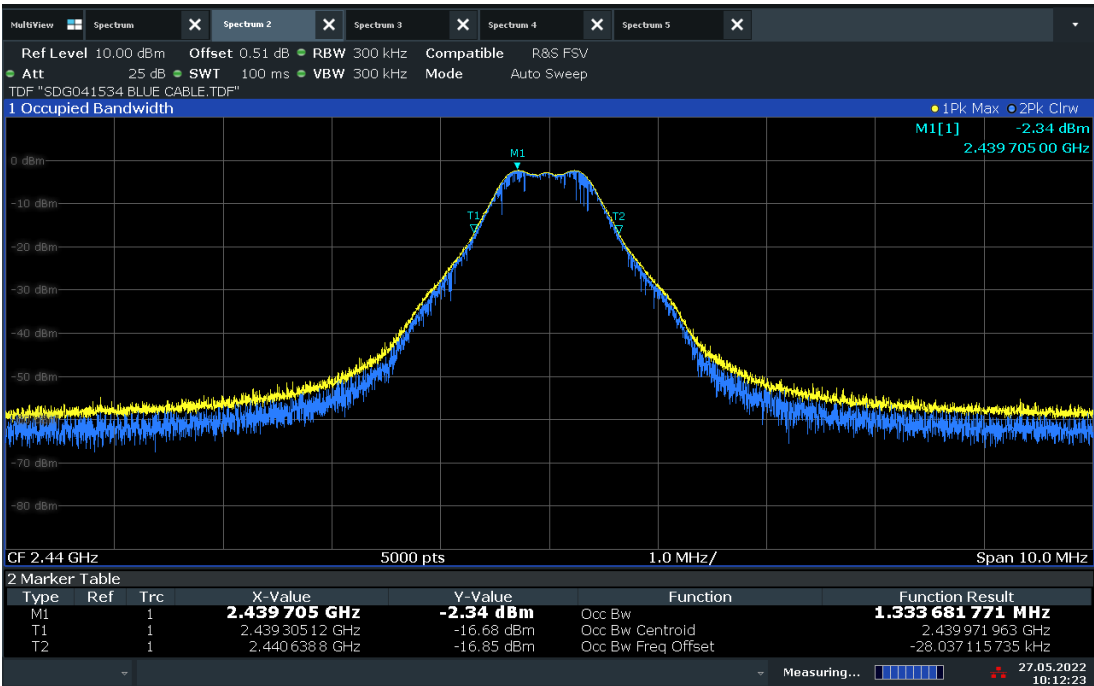
10:11:42 27.05.2022

Low Channel (2402 MHz) OBW



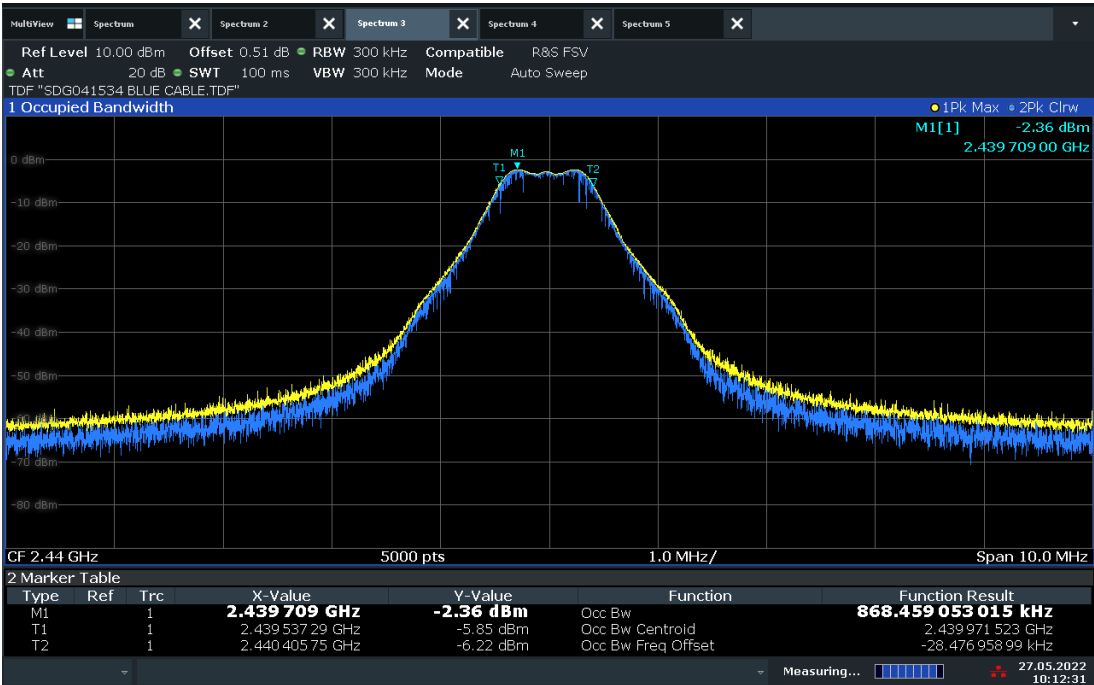
10:11:52 27.05.2022

Low Channel (2402 MHz) Spreading Bandwidth



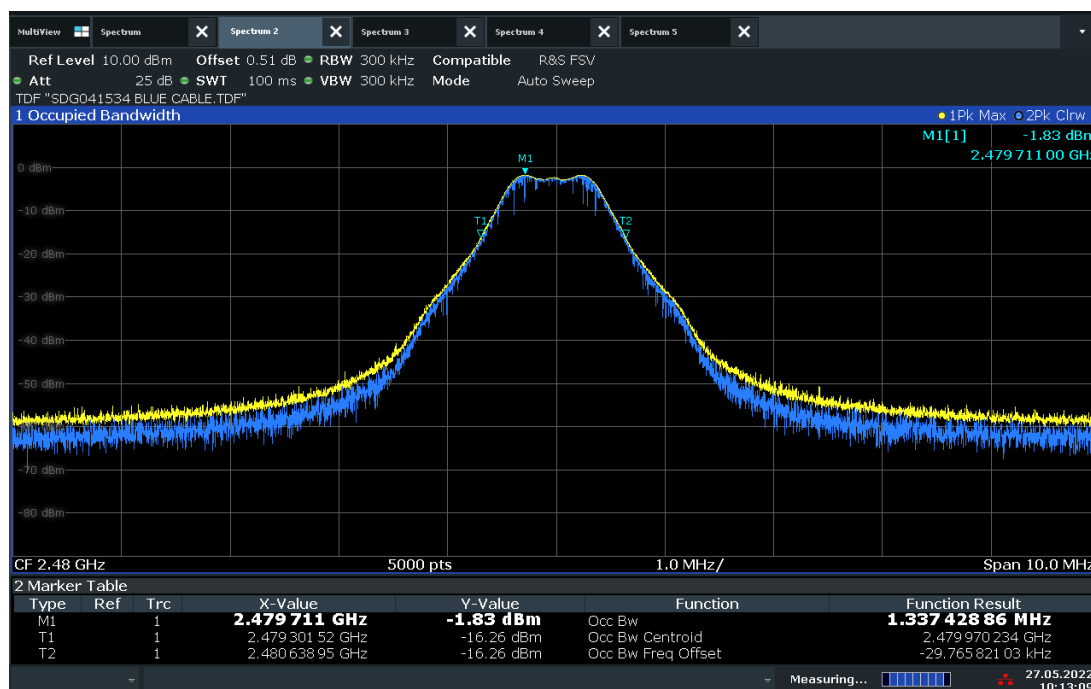
10:12:24 27.05.2022

Mid Channel (2440 MHz) OBW



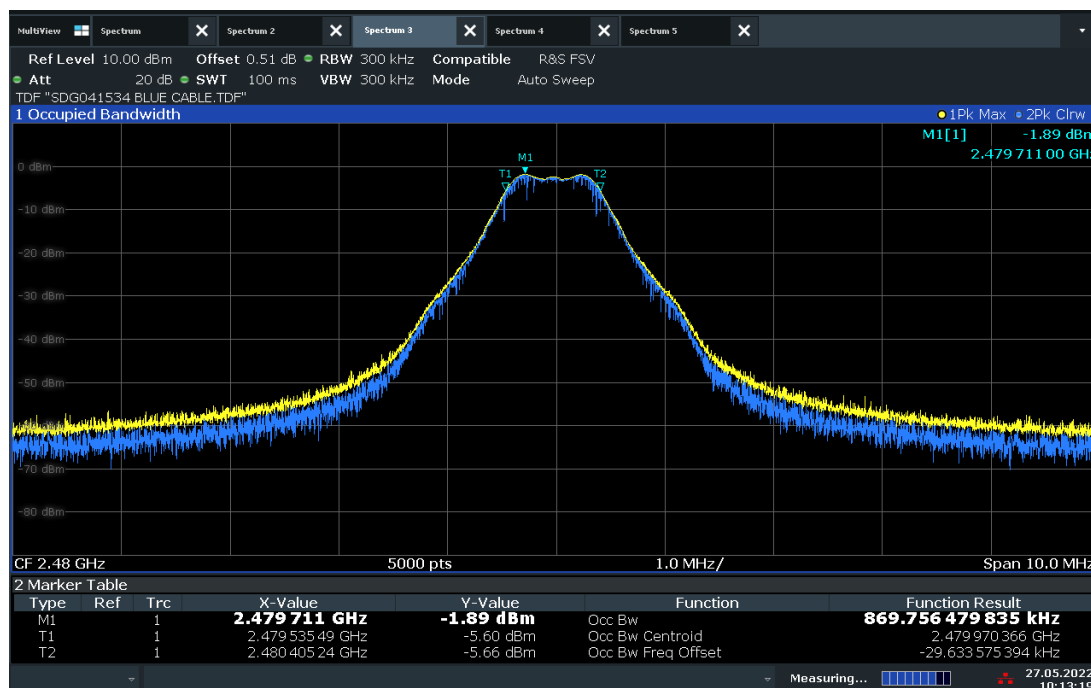
10:12:32 27.05.2022

Mid Channel (2440 MHz) Spreading Bandwidth



10:13:10 27.05.2022

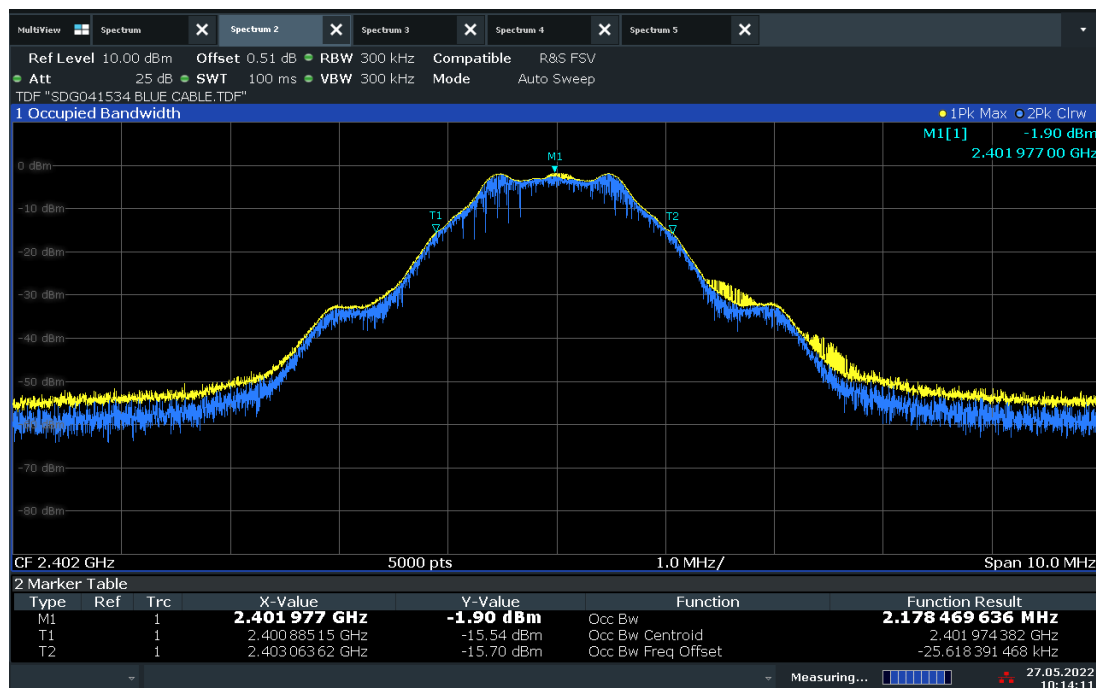
High Channel (2480 MHz) OBW



10:13:20 27.05.2022

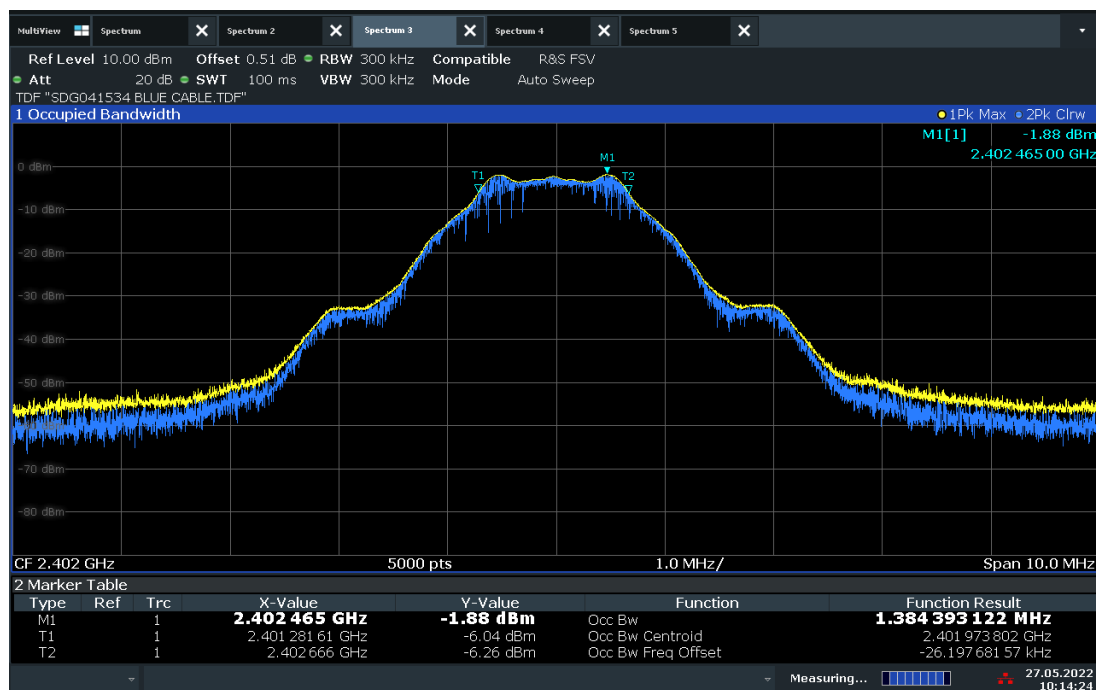
High Channel (2480 MHz) Spreading Bandwidth

2.5.10 Test Plots (2MHz BW)



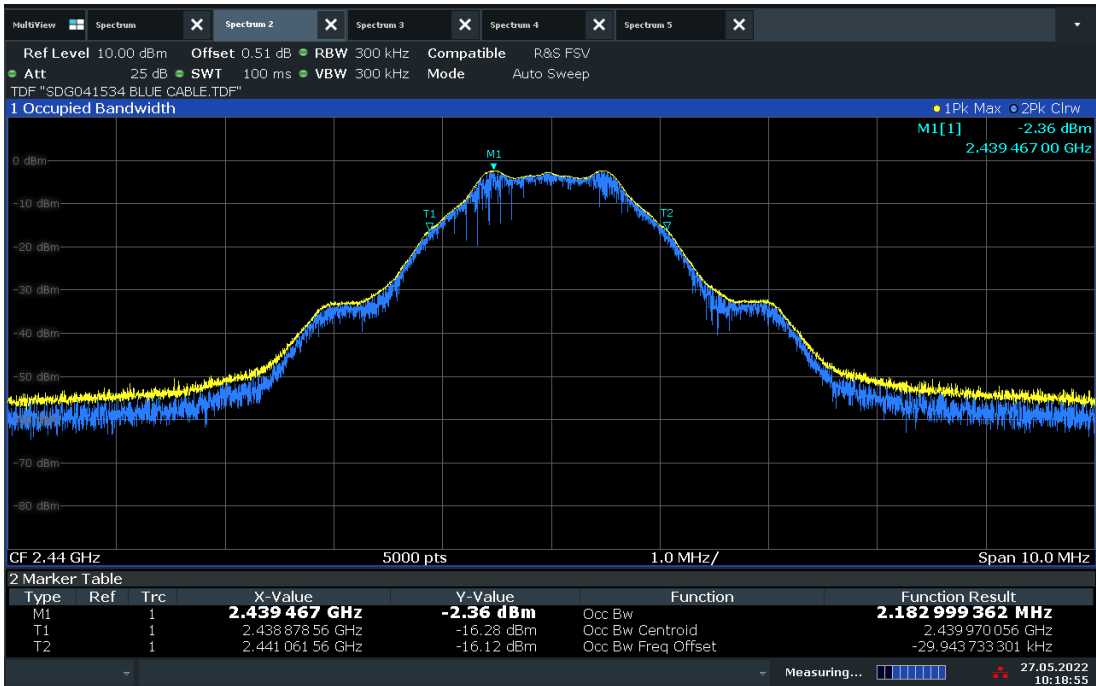
10:14:12 27.05.2022

Low Channel (2402 MHz) OBW



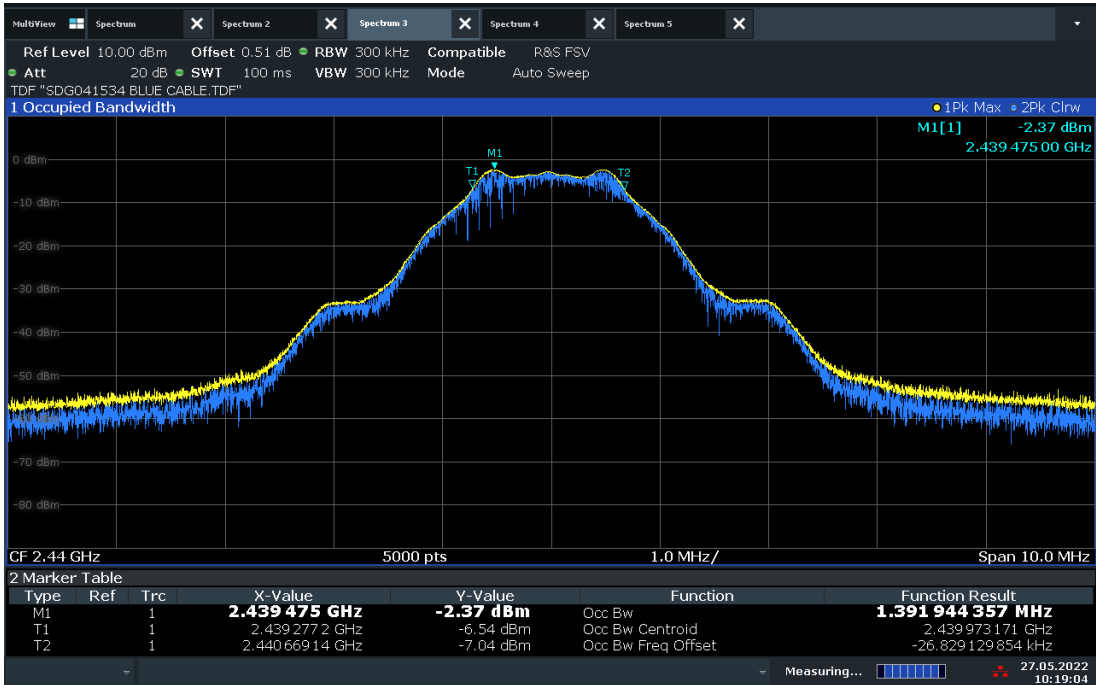
10:14:25 27.05.2022

Low Channel (2402 MHz) Spreading Bandwidth



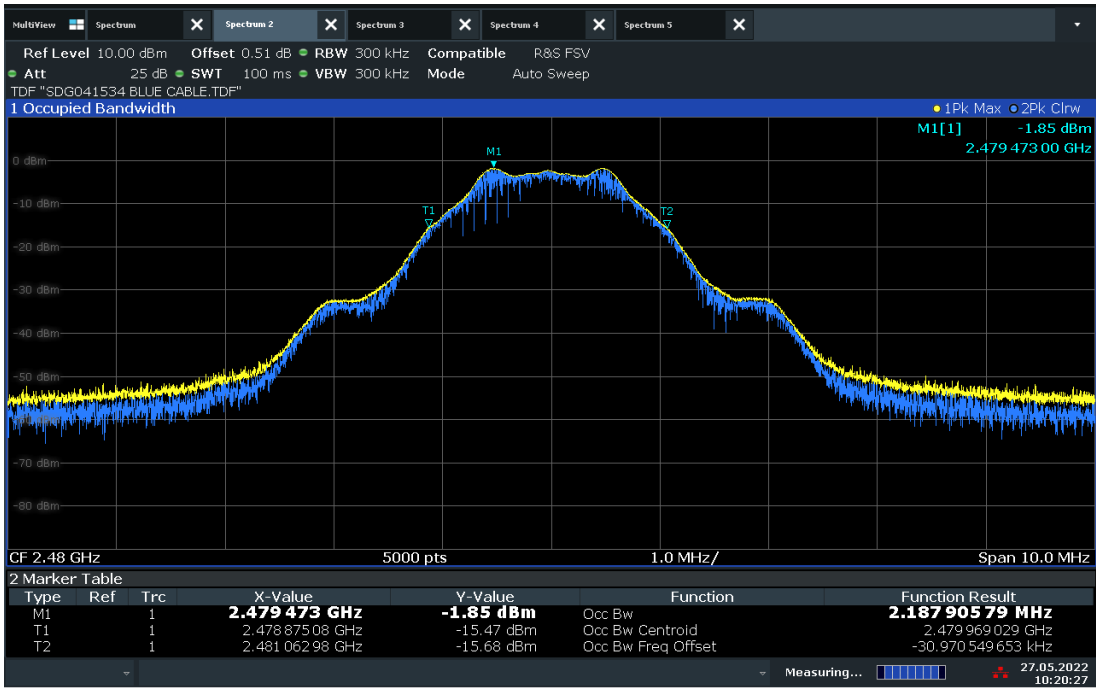
10:18:55 27.05.2022

Mid Channel (2440 MHz) OBW



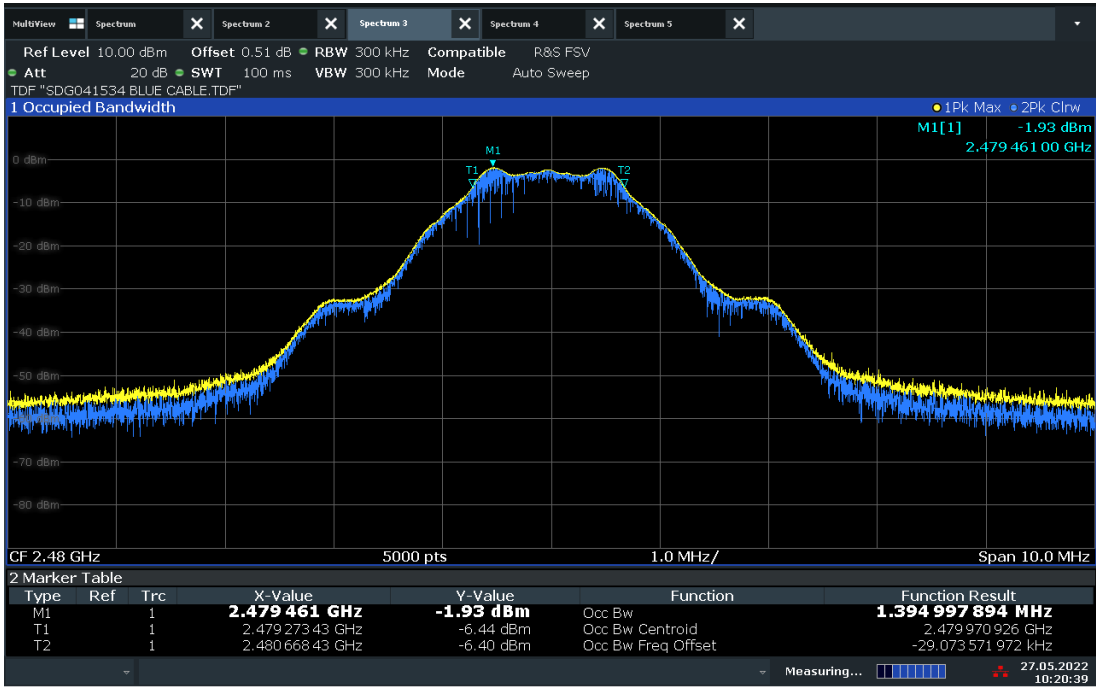
10:19:04 27.05.2022

Mid Channel (2440 MHz) Spreading Bandwidth



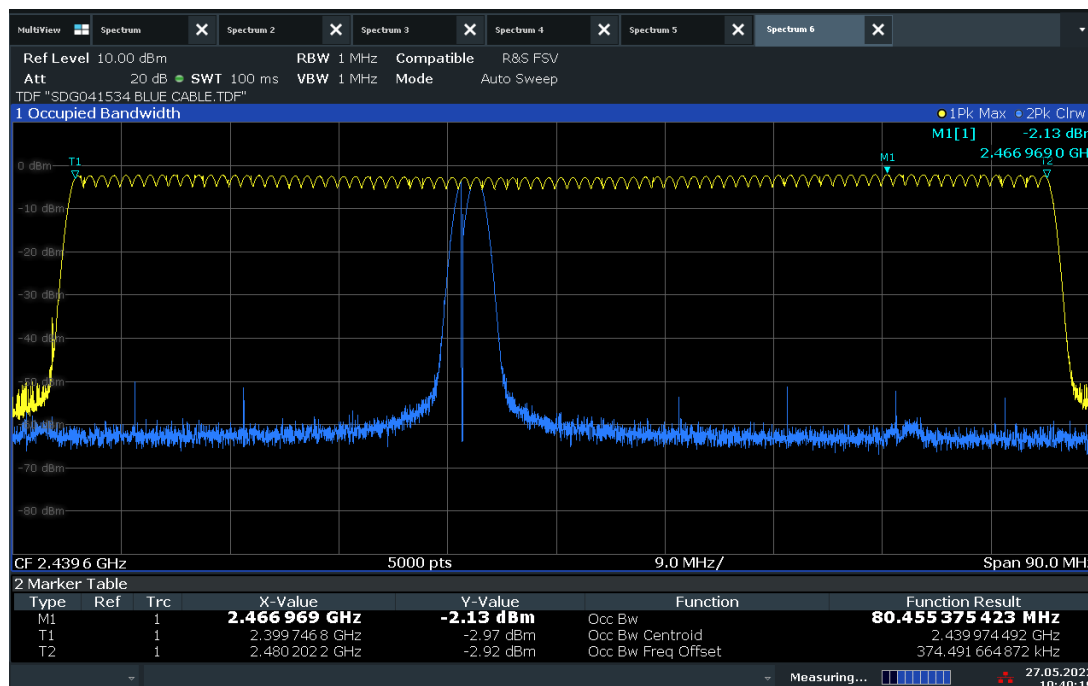
10:20:27 27.05.2022

High Channel (2480 MHz) OBW



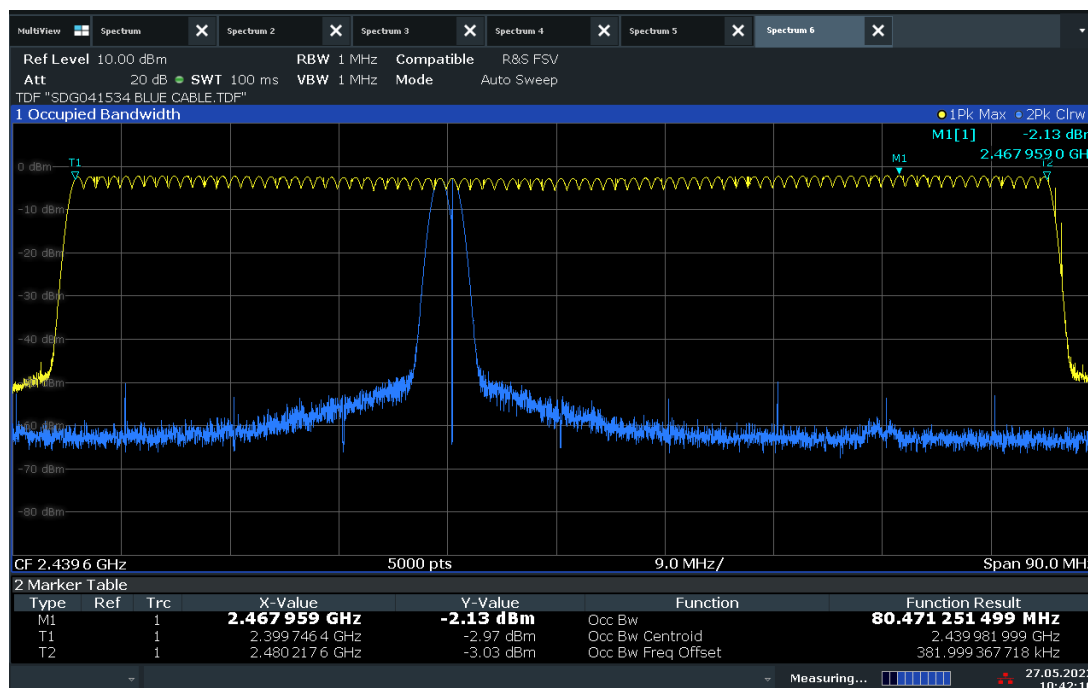
10:20:40 27.05.2022

High Channel (2480 MHz) Spreading Bandwidth



10:40:20 27.05.2022

1M PHY Spreading bandwidth assuming BLE in natural hopping mode covering its frequency range



10:42:11 27.05.2022

2M PHY Spreading bandwidth assuming BLE in natural hopping mode covering its frequency range

2.6 SPREADING FACTOR

2.6.1 Specification Reference

Radio Ordinance of MPT No. 37, 1981 Article 2 Paragraph 1 Item (19) and ARIB STD-T66 V3.7 Section 3.2(9)

2.6.2 Standard Applicable

For spread spectrum systems, the spreading factor must be at least 5. Spreading factor is the value obtained by dividing the spread bandwidth by a frequency equal to the transmission rate of the modulating signal. The same definition is used henceforth.

2.6.3 Equipment Under Test and Modification State

Serial No: FD00000083 / Default Test Configuration

2.6.4 Date of Test/Initial of test personnel who performed the test

May 27, 2022 / FSC

2.6.5 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

2.6.6 Environmental Conditions (Rancho Bernardo Facility)

Ambient Temperature	21.4 °C
Relative Humidity	25.6 %
ATM Pressure	100.3 kPa

2.6.7 Additional Observations

- Spread Bandwidth is from Section 2.5.10 (BLE in FH mode) of this test report.
- The standard Symbol rate of Bluetooth LE was used for this calculation where the wireless technology of the EUT (physical layer) is based.

2.6.8 Results

Mode	Symbol Rate (Msym/s)	Spread Bandwidth (MHz)	Spreading Factor (Spread BW/ Transmission Rate Frequency)	Limit	Compliance
BLE in hopping mode	1.000	80.455	80.455	>5	Complies
	2.000	80.471	40.235		Complies

2.7 LIMIT ON SECONDARY RADIATION

2.7.1 Specification Reference

Radio Ordinance of MPT No. 37, 1981 Article 2 Paragraph 1 Item (19) and ARIB STD-T66 V3.7 Clause 3.3(1)

2.7.2 Standard Applicable

The limit at which secondary radiation will not hinder the function of other radio equipment is, if a fictional antenna circuit with the same electrical constant as the receiving antenna were to be used in calculations, at most 4nW if using a frequency below 1GHz and at most 20nW if using a frequency above or equal to 1GHz.

2.7.3 Equipment Under Test and Modification State

Serial No: FD00000083 / Default Test Configuration

2.7.4 Date of Test/Initial of test personnel who performed the test

May 27, 2022 / FSC

2.7.5 Test Equipment Used

The major items of test equipment used for the above tests are identified in Section 3.1.

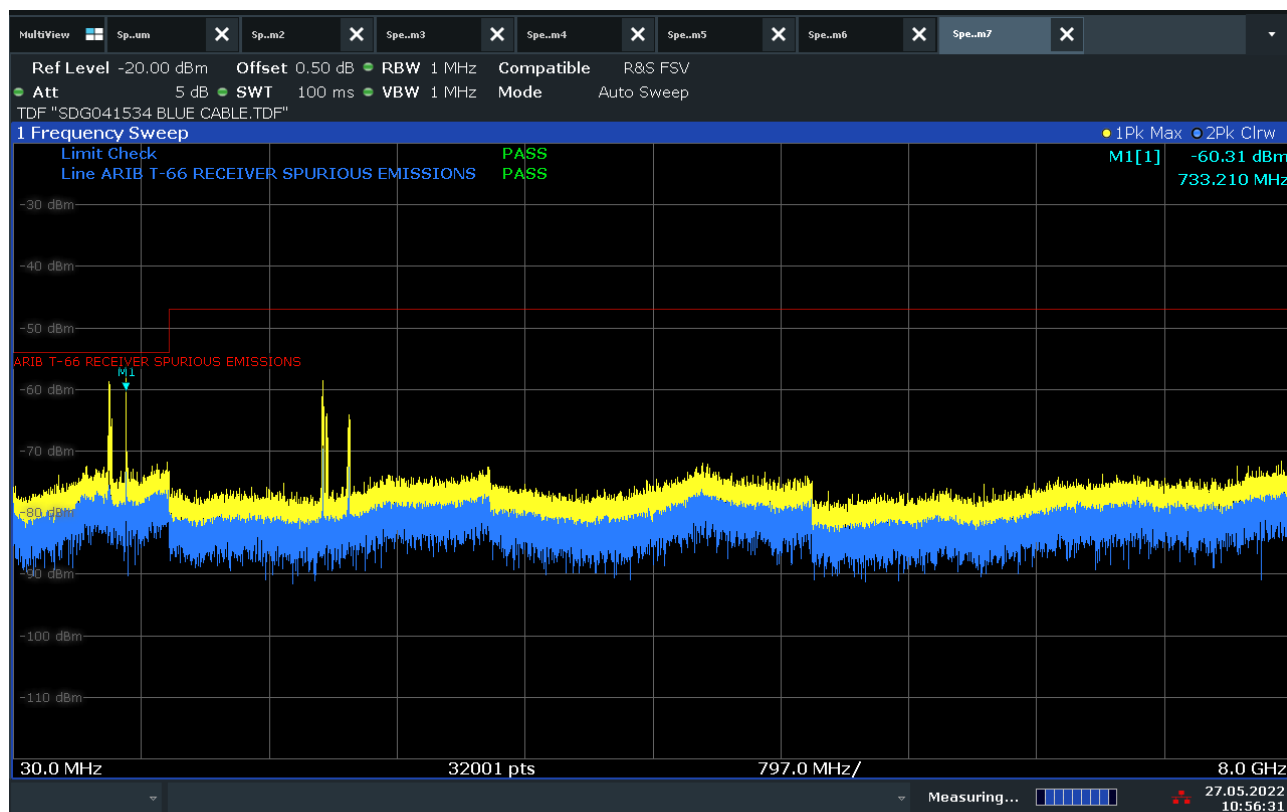
2.7.6 Environmental Conditions (Rancho Bernardo Facility)

Ambient Temperature	21.4 °C
Relative Humidity	25.6 %
ATM Pressure	100.3 kPa

2.7.7 Additional Observations

- This is a conducted test performed for reference only. EUT is a transceiver that doesn't have a separate receiver function. However, the tool used can configure the EUT in RX mode. The EUT is placed in this mode during verification.
- The limit was first converted to dBm.
- TDF (transducer factor) was used for losses between the antenna port and the spectrum analyser.
- The 0.5 dB offset is for the EUT RF port pigtail.
- Spurious emission mask was drawn based on the limit.
- RBW and VBW were set to 1MHz.
- Detector is Peak.
- Trace is Max Hold.
- Test setup photo is identical to Section 2.1.10 of this test report.

2.7.8 Test Results



10:56:32 27.05.2022

EUT in Receive mode – **EUT Complies**

2.8 ANTENNA GAIN

2.8.1 Specification Reference

Radio Ordinance of MPT No. 37, 1981 Article 2 Paragraph 1 Item (19) and ARIB STD-T66 V3.7 Clause 3.6(2)

2.8.2 Standard Applicable

The absolute gain of transmitting antennas must be at most 12.14dB. However, if the equivalent isotropic radiated power is at most the value obtained by applying antenna power with an absolute gain of 12.14dB and the mean of 10mW, the loss may be compensated with the gain of the transmitting antenna. (When using a spread spectrum system or using an OFDM system when the occupied frequency bandwidth is at most 26MHz, the mean power over 1MHz of bandwidth is 10mW. If using an OFDM system when the occupied frequency bandwidth is over 26MHz and at most 38MHz, the mean power is 5mW. However, if using a FH system, DS-FH hybrid system, or hybrid system involving an OFDM system and using frequencies above or equal to 2,427MHz and below or equal to 2,470.75MHz, the mean power over 1MHz of bandwidth is 3mW.)

Equivalent isotropic radiated power is equivalent isotropic radiated power within a bandwidth of 1MHz if using a spread spectrum system or an OFDM system.

(b) The half-power beam width (angle between the two points at which the radiation power is halved) of the transmitting antenna's horizontal and vertical airplanes may not exceed the value calculated by the following formula:

$$360 / A \text{ [degrees]}$$

Here, the constant A is the equivalent isotropic radiated power divided by the value calculated by applying a mean antenna power of 10mW to an antenna with an absolute gain of 2.14dB. If the value is less than 1, it will be rounded up to 1. (When using a spread spectrum system or using an OFDM system when the occupied frequency bandwidth is at most 26MHz, the mean power over 1MHz of bandwidth is 10mW. If using an OFDM system when the occupied frequency bandwidth is over 26MHz and at most 38MHz, the mean power is 5mW. However, if using a FH system, DS-FH hybrid system, or hybrid system involving an OFDM system and using frequencies above or equal to 2,427MHz and below or equal to 2,470.75MHz, the mean power over 1MHz of bandwidth is 3mW.)

Equivalent isotropic radiated power is equivalent isotropic radiated power within a bandwidth of 1MHz if using a spread spectrum system or an OFDM system.

2.8.3 Equipment Under Test and Modification State

Serial No: FD00000083 / Calculation Only

2.8.4 Date and initial of test personnel who performed the calculation

March 27, 2022 / FSC

2.8.5 Additional Observations

- Maximum conducted power (worst channel): -2.92 dBm/MHz (data from section 2.1.8)
- Limit for 10mW/MHz as maximum conducted power: 12.14 dB
- Calculation:

-2.92 dBm/MHz + 3.0 dBi = 0.08 dBm/MHz EIRP (Complies with 22.14 dBm/MHz limit)

2.8.6 Verification Results

Antenna	Type	Requirement	Antenna Gain	Result
BT/WiFi and UWB Mini Antenna, Single-feed, Corner Mount	SMD	<12.14	3.0 dBi	Complies

Refer to attached data sheet showing peak antenna gain of the antenna. Only relevant pages related to BLE operation are presented.

High Frequency Ceramic Solutions

BT/WiFi and UWB Mini Antenna, Single-feed, Corner Mount

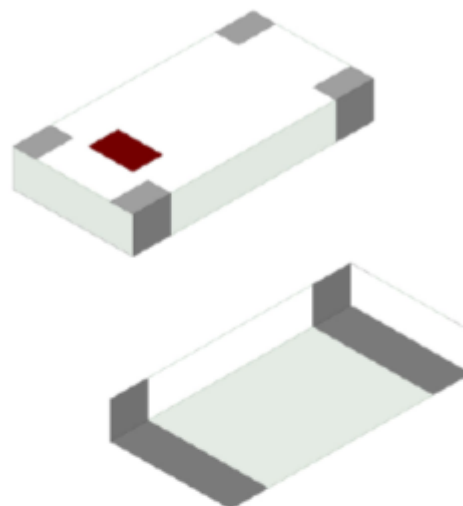
P/N 2450AD18A7250

Detail Specification: 1/21/2021

Page 1 of 6

General Specifications

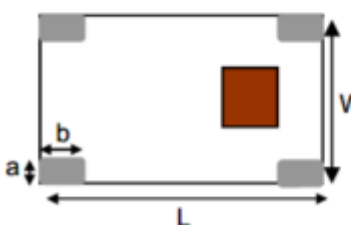
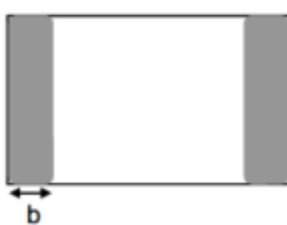
Part Number	2450AD18A7250	
Frequency (MHz)	2400 - 2480	6000 - 8500
Peak Gain (dBi typ.)	+3.0 (YZ-cut)	+5.5 (YZ-cut)
Average Gain (dBi typ.)	+0.4 (YZ-cut)	+1.0 (YZ-cut)
Return Loss (dB)	6.5 min.	6.5 min.
Radiation Efficiency % ¹	78	87
Reel Quantity	3000	
Operating Temp.	-40°C to +85°C	
Power Capacity (W)	3 max. (CW)	
Recommended Storage Conditions and Period for unused T&R Product	+5°C to +35°C Humidity 45 - 75% RH 18 months max.	



Part Number Explanation

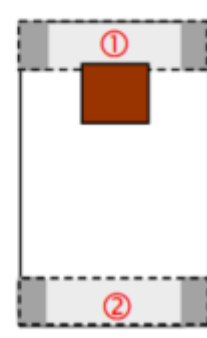
P/N Suffix	Packing Style	Bulk (loose)	Suffix = S	E.g. 2450AD18A7250S
		T & R	Suffix = E	E.g. 2450AD18A7250E
		100% Tin	Suffix = E or S	E.g. 2450AD18A7250(E or S)
	Evaluation Board	2450AD18A7250-EB1SMA (Pre-tuned with SMA connectors)		

Mechanical Dimensions

	In	mm	
L	0.126 ± 0.008	3.20 ± 0.20	 <Side view>
W	0.063 ± 0.008	1.60 ± 0.20	
T	0.020 ± 0.004	0.50 ± 0.10	
a	0.012 +0.004/+0.008	0.30 +0.1/-0.2	
b	0.020 ± 0.004	0.50 ± 0.10	
 <Top view>			 <Bottom view>

Terminal Configuration

No.	Function
1	Feed Point
2	NC



High Frequency Ceramic Solutions

BT/WiFi and UWB Mini Antenna, Single-feed, Corner Mount

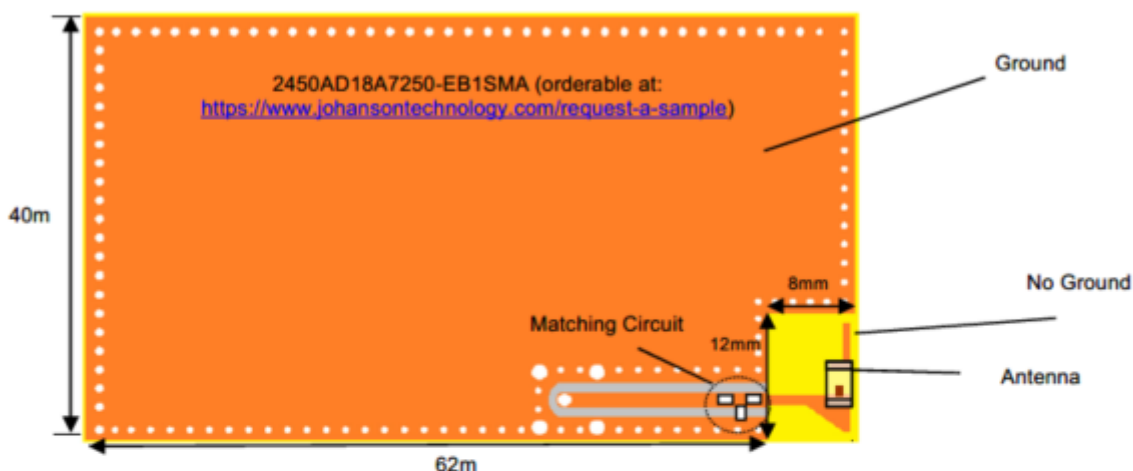
P/N 2450AD18A7250

Detail Specification: 1/21/2021

Page 3 of 6

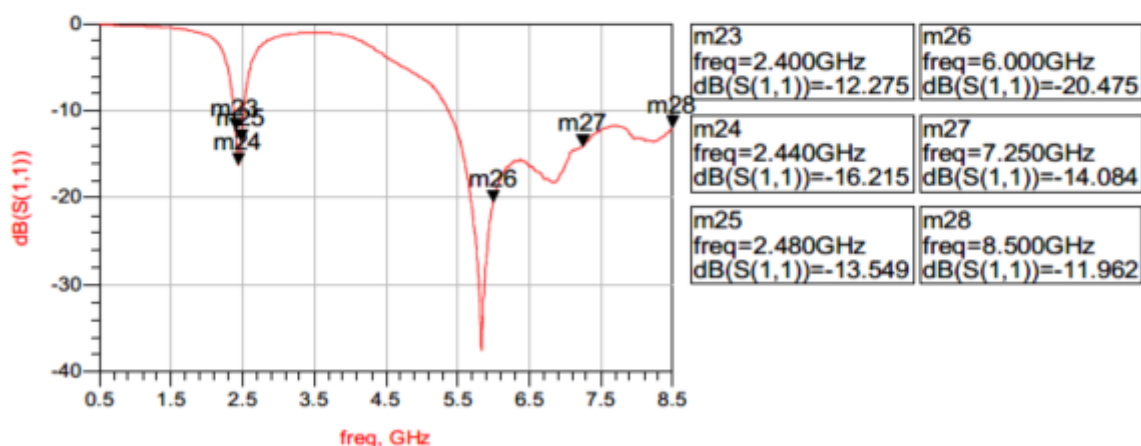
Johanson Technology Evaluation Board Mounting Configuration

❖ Test Board-Top View (Unit in mm)



Typical Electrical Characteristics (T=25°C)

Antenna Return Loss with Matching Circuits On Johanson EVB



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Ver 1.1

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High Frequency Ceramic Solutions

BT/WiFi and UWB Mini Antenna, Single-feed, Corner Mount

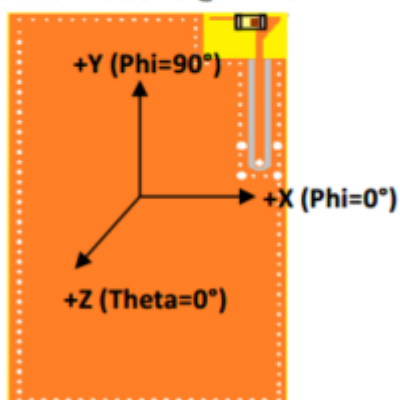
P/N 2450AD18A7250

Detail Specification: 1/21/2021

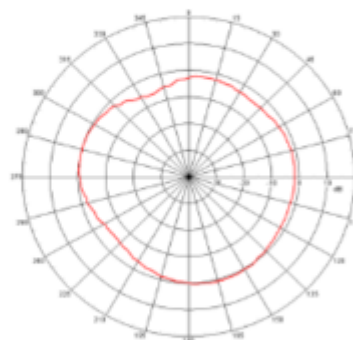
Page 4 of 6

Typical Radiation Patterns

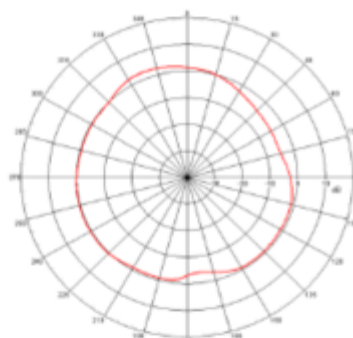
❖ Radiation Patterns @ 2.44GHz



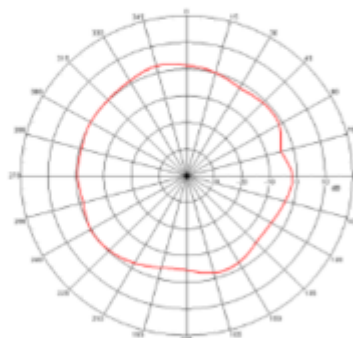
XY-Plane



YZ-Plane



XZ-Plane



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Ver 1.1

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2.9 INTERFERENCE PREVENTION FUNCTION

2.9.1 Specification Reference

Radio Ordinance of MPT No. 37, 1981 Article 2 Paragraph 1 Item (19) ARIB STD-T66 V3.7 Clause 3.4(1)

2.9.2 Requirement

The interference prevention requirement is a requirement that client devices should send an identification code to the master device in order to identify itself as a valid or authorized client.

It must be demonstrated with either a photograph or a screen capture that the device which needs to be certified transmits a MAC address (in the case of BT+EDR, BLE, Wi-Fi or ZigBee devices) consisting of 48 bits.

2.9.3 Equipment Under Test

Serial No: FD00000083

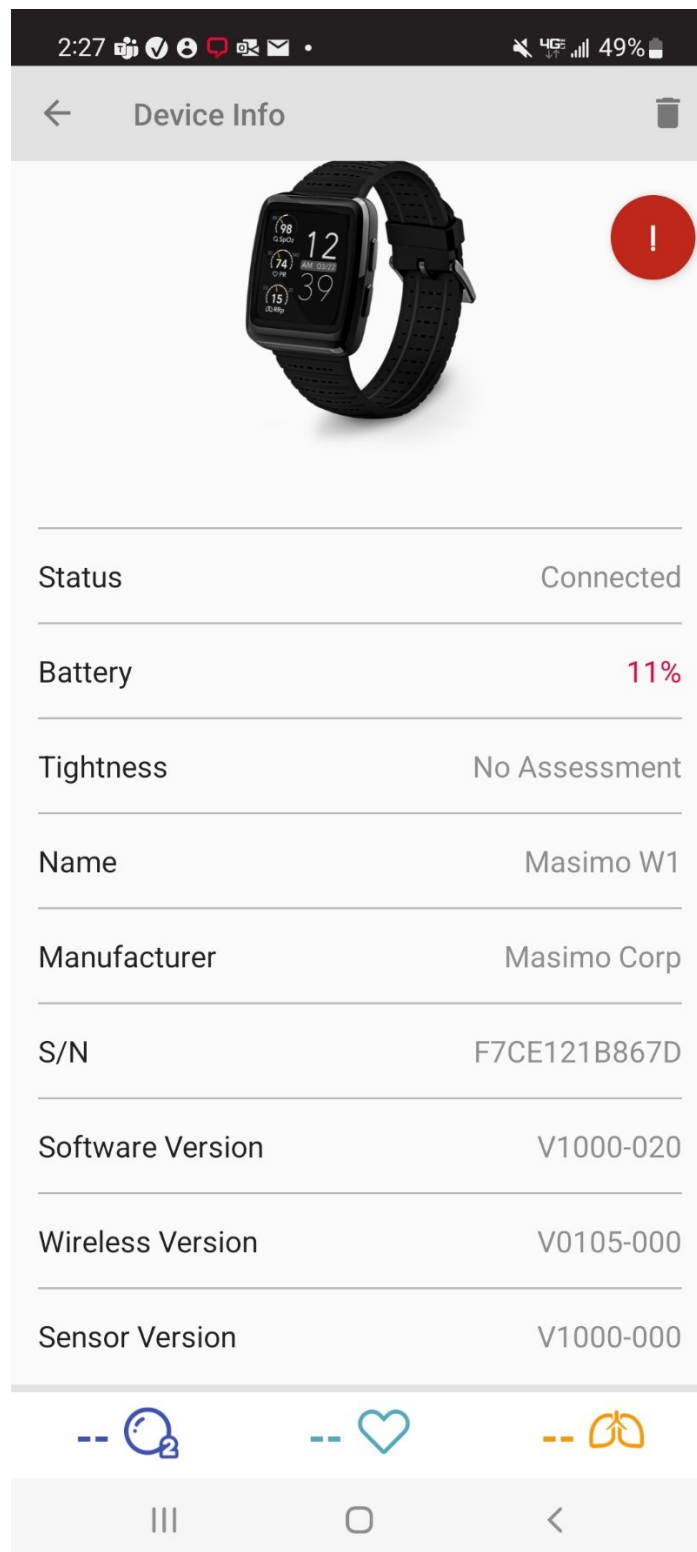
2.9.4 Date of Test/Initial of test personnel who performed the test

June 22, 2021/FSC

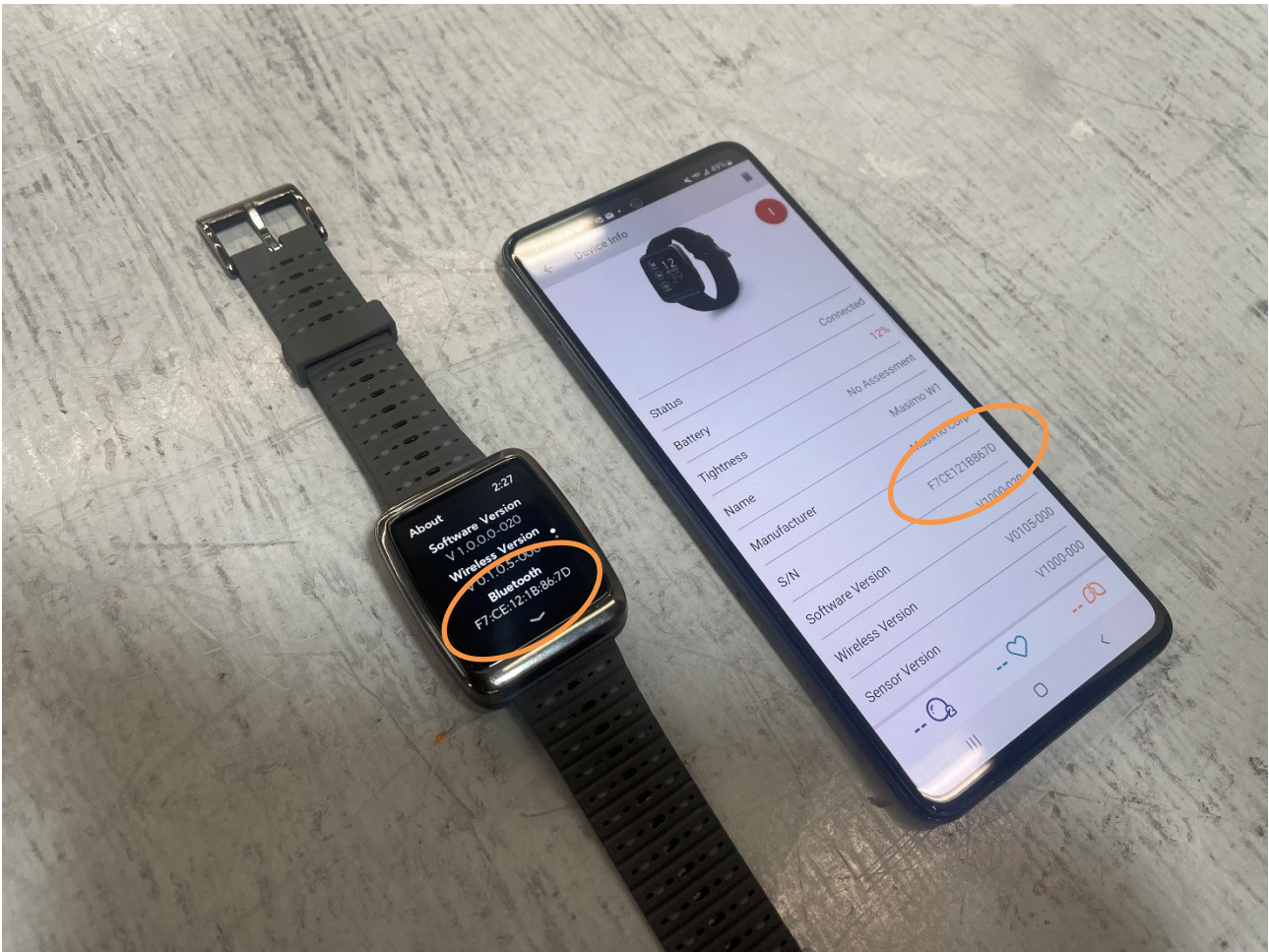
2.9.5 Test Results

Using a support smartphone as the Master Device, the EUT is connectd via BLE using the manufacturer provided app. Once connected, the BLE MAC address of the EUT is displayed as SN in the app. EUT **complies** with this requirement.

2.9.6 Verification Screenshot



2.9.7 Verification Test Setup Photo



Note: EUT BLE MAC address and the Master Device app SN matches



SECTION 3

TEST EQUIPMENT USED



3.1 Test Equipment Used

List of absolute measuring and other principal items of test equipment.

ID Number (SDGE/SDRB)	Test Equipment	Type	Serial Number	Manufacturer	Cal Date	Cal Due Date
Conducted Port Setup						
7582	Signal/Spectrum Analyzer	FSW26	101614	Rohde & Schwarz	12/21/22	12/21/22
Miscellaneous						
11312	Mini Environmental Quality Meter	850027	CF099-56010- 340	Sper Scientific	07/19/21	07/19/22

3.2 Measurement Uncertainty

Calculation of Measurement Uncertainty per CISPR 16-4-2:2011 with Corr. 1

Antenna Port Conducted Measurements						
	Input Quantity (Contribution) X_i	Value	Prob. Dist.	Divisor	$u_i(x)$	$u_i(x)^2$
1	Receiver reading	0.10 dB	Normal, k=1	1.000	0.10	0.01
2	Cable attenuation	1.00 dB	Normal, k=2	2.000	0.50	0.25
3	Receiver sinewave accuracy	0.08 dB	Normal, k=2	2.000	0.04	0.00
4	Receiver pulse amplitude	0.00 dB	Rectangular	1.732	0.00	0.00
5	Receiver pulse repetition rate	0.00 dB	Rectangular	1.732	0.00	0.00
6	Noise floor proximity	0.00 dB	Rectangular	1.732	0.00	0.00
7	Frequency interpolation	0.10 dB	Rectangular	1.732	0.06	0.00
8	Mismatch	0.07 dB	U-shaped	1.414	0.05	0.00
Combined standard uncertainty			Normal	0.52 dB		
Expanded uncertainty			Normal, k=2	1.03 dB		



SECTION 4

ACCREDITATION, DISCLAIMERS AND COPYRIGHT



4.1 Accreditation, Disclaimers and Copyright

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