EMC & RF Test Report

As per

RSS-247 Issue 2:2017
&
FCC Part 15 Subpart C 15.247

Unlicensed Intentional Radiators
FHSS System

on the

RM2-900 MRTR
Wireless Radio Module

Issued by: **TÜV SÜD Canada Inc.**
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Testing produced for

See Appendix A for full client & EUT details.

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R-14023, G-20072
C-14498, T-20060

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Report Scope

This report addresses the EMC verification testing and test results of the **Aarcomm Systems Inc. Wireless Radio Module** Model: **RM2-900 MRTR**, and is herein referred to as EUT (Equipment Under Test). The EUT was tested for compliance against the following standards:

RSS-247 Issue 2:2017

FCC Part 15 Subpart C 15.247

Test procedures, results, justifications, and engineering considerations, if any, follow later in this report.

This report does not imply product endorsement by any government, accreditation agency, or TÜV SÜD Canada Inc.

Opinions or interpretations expressed in this report, if any, are outside the scope of TÜV SÜD Canada Inc. accreditations. Any opinions expressed do not necessarily reflect the opinions of TÜV SÜD Canada Inc., unless otherwise stated.

Summary

The results contained in this report relate only to the item(s) tested.

EUT:	**RM2-900 MRTR Wireless Radio Module**
FCC Certification #, FCC ID:	2AAXW900MRM2
Industry Canada Certification #, IC:	11295A-900MRM2
EUT passed all tests performed	Yes
Tests conducted by	Jadon Bull
Report reviewed by	Scott Drysdale

For testing dates, see "Testing Environmental Conditions and Dates".

Test Results Summary

Standard/Method	Description	Class/Limit	Result
FCC 15.203	Antenna Requirement	Unique	Pass See Justification
FCC 15.205 RSS-GEN (Table 6)	Restricted Bands for Intentional Operation	QuasiPeak Average	Pass
FCC 15.207 RSS-GEN (Table 3)	Power Line Conducted Emissions	QuasiPeak Average	Pass
FCC 15.209 RSS-GEN (Table 4)	Spurious Radiated Emissions	QuasiPeak Average	Pass
FCC 15.247(a)(1) RSS 247 5.1	Carrier Frequency Separation	> 25 kHz or 20 dB BW	Pass
FCC 15.247(a)(1) RSS 247 5.1	Number of Hopping Frequencies	> 50	Pass
FCC 15.247(a)(1)(i) RSS 247 5.1 (3)	Time of Occupancy (FHSS)	< 0.4 sec in 20s period	Pass
FCC 15.247(b)2 RSS-247 5.4(d)	Max Output Power (FHSS)	< 1 Watt	Pass
FCC 15.247(b)4 RSS-247 5.4(d)	Antenna Gain	< 6 dBi	Pass See Justifications
FCC 15.247(d) RSS-247 5.5	Antenna Conducted Spurious	< 20 dBc	Pass
Overall Result			**Pass**

If the product as tested or otherwise complies with the specification, the EUT is deemed to comply with the requirement and is deemed a ‘PASS’ grade. If not ‘FAIL’ grade will be issued. Note that ‘PASS’ / ‘FAIL’ grade is independent of any measurement uncertainties. A ‘PASS’ / ‘FAIL’ grade within measurement uncertainty is marked with a ‘*’.

Notes, Justifications, or Deviations

The following notes, justifications for tests not performed or deviations from the above listed specifications apply:

For the Antenna requirement specified in FCC 15.203 (RSS-247 section 5.4(d)), the device's user manual lists three external antennas that are permitted to be used with the module:

- Pulse Electronics NMOSPEC900: 5.4dBi gain
- Pulse Electronics NMOMMRDS: 5.4dBi gain
- Pulse Electronics Q900 LMB: 3.5dBi gain

The Pulse Electronics NMOSPEC900 was used as a worst-case scenario for testing, and has a 5.4 dBi gain, which is less than the 6 dBi gain limit.

For the Restricted Bands of operation, the EUT is designed to only operate between 920.00 – 927.35MHz which lies entirely within 902 – 928 MHz.

The EUT does not coordination transmission with any other FHSS to avoid simultaneous occupation of hopping frequencies.

The EUT output power was set to "44" during testing, as per the client's instructions.

For maximum permissible exposure, this device is designed to operate greater than 20 cm from any personnel during normal operation. No testing is required, however worst-case calculated exposure compliance was shown in the RF Exposure exhibits.

Sample Calculation(s)

Radiated Emission Test

E-Field Level = Received Signal + Antenna Factor + Cable Loss – Pre-Amp Gain
E-Field Level = 50dBµV + 10dB/m + 2dB – 20dB
E-Field Level = 42dBµV/m

Margin = Limit – E-Field Level
Margin = 50dBµV/m – 42dBµV/m
Margin = 8.0 dB (pass)

Power Line Conducted Emission Test

E-Field Level = Received Signal + Attenuation Factor + Cable Loss + LISN Factor
E-Field Level = 50dBµV + 10dB + 2.5dB + 0.5dB
E-Field Level = 63dBµV

Margin = Limit – E-Field Level
Margin = 73dBµV – 63dBµV
Margin = 10.0 dB (pass)

Applicable Standards, Specifications and Methods

ANSI C63.4:2014	Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
ANSI C63.10:2013	American National Standard For Testing Unlicensed Wireless Devices
CFR 47 FCC 15 Subpart C	Code of Federal Regulations – Radio Frequency Devices, Intentional Radiators
FCC KDB 558074: 2019	FCC KDB 558074 Digital Transmission Systems, measurements and procedures
FCC KDB 447498: 2015	RF exposure procedures and equipment authorization policies for mobile and portable devices
ICES-003 Issue 7: 2020	Digital Apparatus - Spectrum Management and Telecommunications Policy Interference-Causing Equipment Standard
RSS-GEN Issue 5: 2018+A1:2019+A2:2021	General Requirements and Information for the Certification of Radio Apparatus
RSS-247 Issue 2: 2017	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices
ISO/IEC 17025:2017	General Requirements for the Competence of Testing and Calibration Laboratories

Document Revision Status

Revision	Date	Description	Initials
000	July 4th, 2023	Initial Release	JB

Definitions and Acronyms

The following definitions and acronyms are applicable in this report.
See also ANSI C63.14.

DTS – Digital Transmission System
LISN – Line Impedance Stabilization Network
NCR – No Calibration Required
NSA – Normalized Site Attenuation
N/A – Not Applicable
RF – Radio Frequency

AE – Auxiliary Equipment. A digital accessory that feeds data into or receives data from another device (host) that in turn, controls its operation.

Antenna Port – Port, other than a broadcast receiver tuner port, for connection of an antenna used for intentional transmission and/or reception of radiated RF energy.

BW – Bandwidth. Unless otherwise stated, this refers to the 6 dB bandwidth.

EMC – Electro-Magnetic Compatibility. The ability of an equipment or system to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances to anything in that environment.

EMI – Electro-Magnetic Immunity. The ability to maintain a specified performance when the equipment is subjected to disturbance (unwanted) signals of specified levels.

EUT – Equipment Under Test. A device or system being evaluated for compliance that is representative of a product to be marketed.

ITE – Information Technology Equipment. Has a primary function of entry, storage, display, retrieval, transmission, processing, switching, or control of data and/or telecommunication messages and which may be equipped with one or more ports typically for information transfer.

Testing Facility

Testing for EMC on the EUT was carried out at TÜV SÜD Canada testing lab near Toronto, Ontario. The testing lab has calibrated 3m semi-anechoic chambers which allow measurements on a EUT that has a maximum width or length of up to 2m and a height of up to 3m. The testing lab also has a calibrated 10m Open Area Test Site (OATS). The chambers are equipped with a turntable that is capable of testing devices up to 5000lb in weight and are equipped with a mast that controls the polarization and height of the antenna. Control of the mast occurs in the control room adjoining the shielded chamber. This facility is capable of testing products that are rated for single phase or 3-phase AC input and DC capability is also available. Radiated emission measurements are performed using a BiLog antenna and a Horn antenna where applicable. Conducted emissions, unless otherwise stated, are performed using a LISN and using the vertical ground plane if applicable.

Calibrations and Accreditations

The 3m semi-anechoic chamber is registered with Federal Communications Commission (FCC, CA6844), Innovation, Science and Economic Development Canada (ISED, 6844A-3) and Voluntary Control Council for Interference (VCCI, R-14023, G-20072, C-14498, and T-20060). This chamber was calibrated for Normalized Site Attenuation (NSA) using test procedures outlined in ANSI C63.4 "Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz". The chamber is lined with ferrite tiles and absorption cones to minimize any undesired reflections. The NSA data is kept on file at TÜV SÜD Canada. For radiated susceptibility testing, a 16 point field calibration has been performed on the chamber. The field uniformity data is kept on file at TÜV SÜD Canada. TÜV SÜD Canada Inc. is accredited to ISO 17025 by A2LA with Testing Certificate #2955.02. The laboratory's current scope of accreditation listing can be found as listed on the A2LA website. All measuring equipment is calibrated on an annual or biennial basis as listed for each respective test.

Testing Environmental Conditions and Dates

Following environmental conditions were recorded in the facility during time of testing

Date	Test	Initials	Temperature (ºC)	Humidity (%)	Pressure (kPa)
05/04/2023	Radiated Emissions	JB	23.6	31.5	101.2
05/08/2023 05/09/2023 05/10/2023	Antenna Conducted Emissions	JB	24.5 25.1 24.5	34.5 20.0 18.4	101.5 101.9 102.3

Detailed Test Results Section

Number of Hopping Frequencies

Purpose

The purpose of this test is to ensure that the RF energy of frequency hopping systems is sufficiently spread over a spectrum and that the radio energy is not overly dense. This limit helps allow for other spread spectrum devices to co-exist in the same frequency spectrum. This also helps prevent corruption of data by ensuring adequate channel separation to distinguish the reception of the intended information.

Limits and method

The limits are as defined in 47 CFR FCC Part 15 Section 15.247(a)(1) and RSS 247 Section 5.1. The test method is a defined in ANSI C63.10.

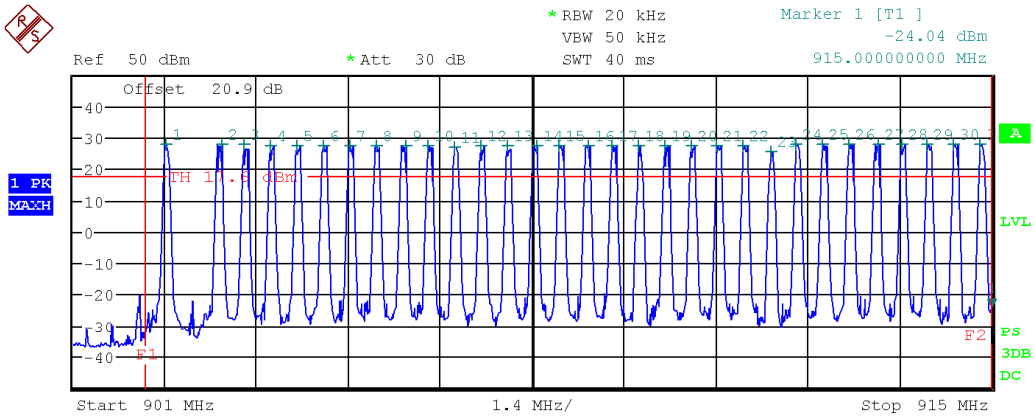
902 to 928 MHz	$P_{max\text{-}pk} \leq 1$ W $N_{ch} \geq 50$	$P_{max\text{-}pk} \leq 0.25$ W $25 \leq N_{ch} \leq 50$
2400 to 2483.5 MHz	$P_{max\text{-}pk} \leq 1$ W $N_{ch} \geq 75$	$P_{max\text{-}pk} \leq 0.125$ W $N_{ch} \geq 15$
5275 to 5850 MHz	$P_{max\text{-}pk} \leq 1$ W $N_{ch} \geq 75$	

Results

The EUT passed the requirements of the number of channels. The number of channels the device occupies is 62, (31+31) channels in the allocation band of 902 to 927.75 MHz.

Graph(s)

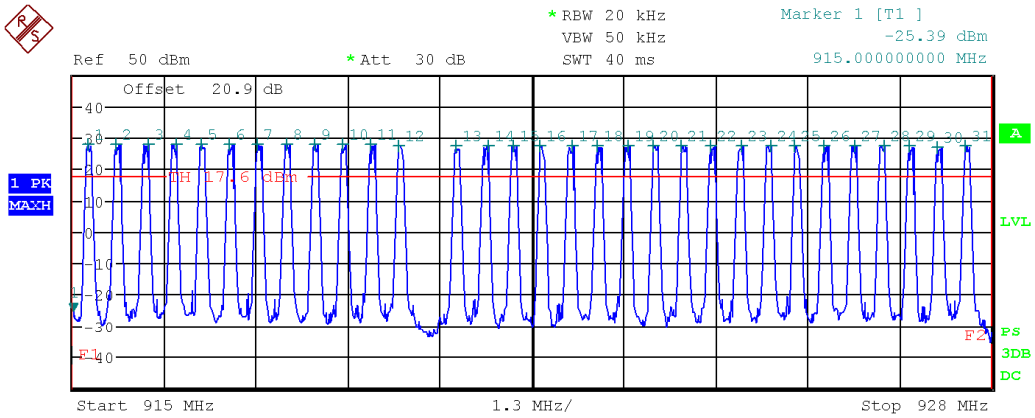
The graphs shown below shows the number of occupied channels during the operation of the device. This is measured by a max hold on the spectrum analyzer and the highest resolution bandwidth that is sufficiently low to exhibit the channel spacing of the signal being measured. This measurement is a peak measurement. Max hold is performed for a duration of not less then 10 minutes, or as sufficient to capture the channels occupied.



#	Frequency	Level
25	912.424000 MHz	27.58 dBm
26	912.827200 MHz	27.72 dBm
27	913.275200 MHz	27.67 dBm
28	913.633600 MHz	27.69 dBm
29	914.025600 MHz	27.74 dBm
30	914.428800 MHz	27.56 dBm
31	914.832000 MHz	27.65 dBm

Date: 10.MAY.2023 17:01:48

Graph 1 of 2 (31 channels)



#	Frequency	Level
25	925.223200 MHz	27.20 dBm
26	925.628800 MHz	27.25 dBm
27	926.076000 MHz	27.21 dBm
28	926.481600 MHz	27.18 dBm
29	926.835200 MHz	27.18 dBm
30	927.230400 MHz	26.99 dBm
31	927.625600 MHz	27.05 dBm

Date: 10.MAY.2023 17:05:47

Graph 2 of 2 (31 more channels)

Note: See 'Appendix B – EUT & Test Setup Photographs' for photos showing the test set-up.

Test Equipment List

Equipment	Model No.	Manufacturer	Last Calibration Date	Next Calibration Date	Asset #
Spectrum Analyzer	ESU 40	Rohde & Schwarz	Feb. 11, 2022	Feb. 11, 2024	GEMC 233
20dB Attenuator (100W)	6N100W-20F	Inmet	NCR	NCR	GEMC 352

Carrier Frequency Separation

Purpose

The purpose of this test is to ensure that the RF energy of frequency hopping systems is sufficiently spread over a spectrum and that the radio energy is not overly dense. This limit helps allow for other spread spectrum devices to co-exist in the same frequency spectrum. This also helps prevent corruption of data by ensuring adequate channel separation to distinguish the reception of the intended information.

Limits and method

The limits are as defined in 47 CFR FCC Part 15 Section 15.247(a)(1) and RSS 247 Section 5.1. The test method is a defined in ANSI C63.10.

902 to 928 MHz	$P_{max\text{-}pk} \leq 1$ W $\Delta f \geq$ MAX {25 kHz, BW_{20dB}} $BW_{20dB} \leq 250$ kHz	$P_{max\text{-}pk} \leq 0.25$ W $\Delta f \geq$ MAX {25 kHz, BW_{20dB}} 250 kHz $\leq BW_{20dB} \leq 500$ kHz
2400 to 2483.5 MHz	$P_{max\text{-}pk} \leq 1$ W $\Delta f \geq$ MAX {25 kHz, BW_{20dB}} Max. BW_{20dB} not specified	$P_{max\text{-}pk} \leq 0.125$ W $\Delta f \geq$ [MAX {25 kHz, $\frac{2}{3}BW_{20dB}$} OR MAX {25 kHz, BW_{20dB}}] Max. BW_{20dB} not specified
5275 to 5850 MHz	$P_{max\text{-}pk} \leq 1$ W $\Delta f \geq$ MAX {25 kHz, BW_{20dB}} $BW_{20dB} \leq 1$ MHz	

Note 1: The greater of the 20 dB BW or 25 kHz. The larges 20 dB BW of the system was measured to be 102.24 kHz for 50 kbps data rate, so a limit of 102.24 kHz applies.

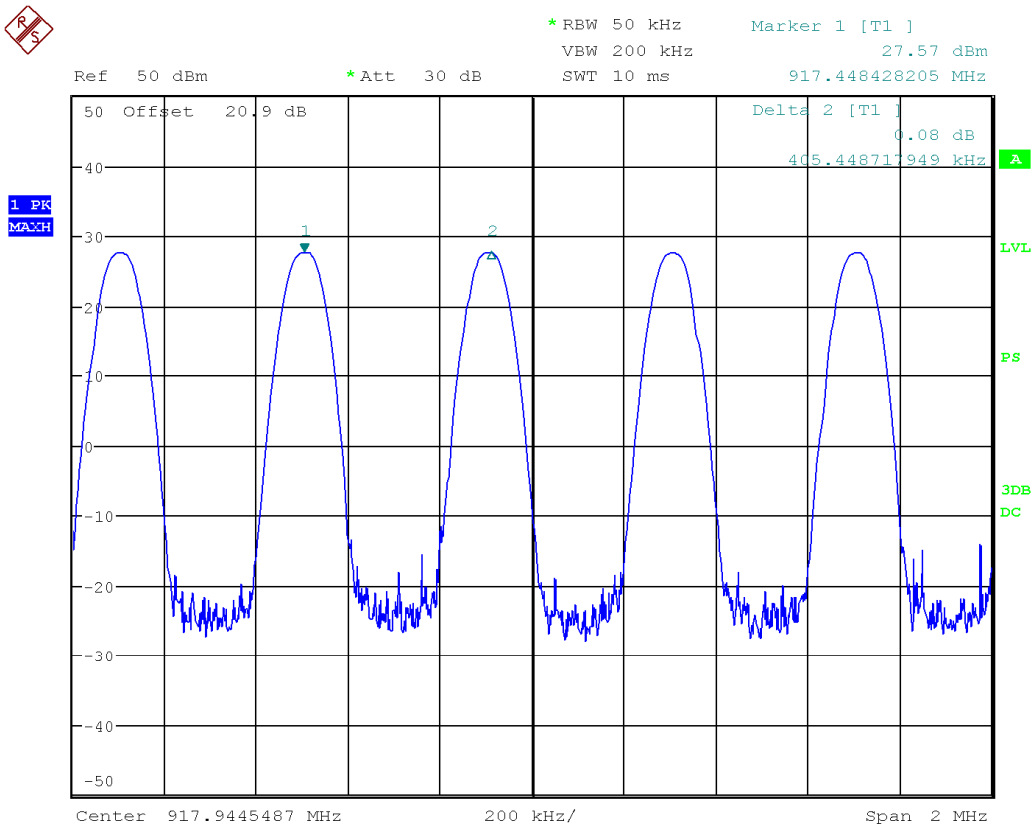
Results

The EUT passed the requirements of channel carrier spacing exceeding the measured 20 dB BW of the EUT. The 20 dB BW measured is 102.244 kHz, and the device had a channel spacing of 405.45 kHz.

Graph(s)

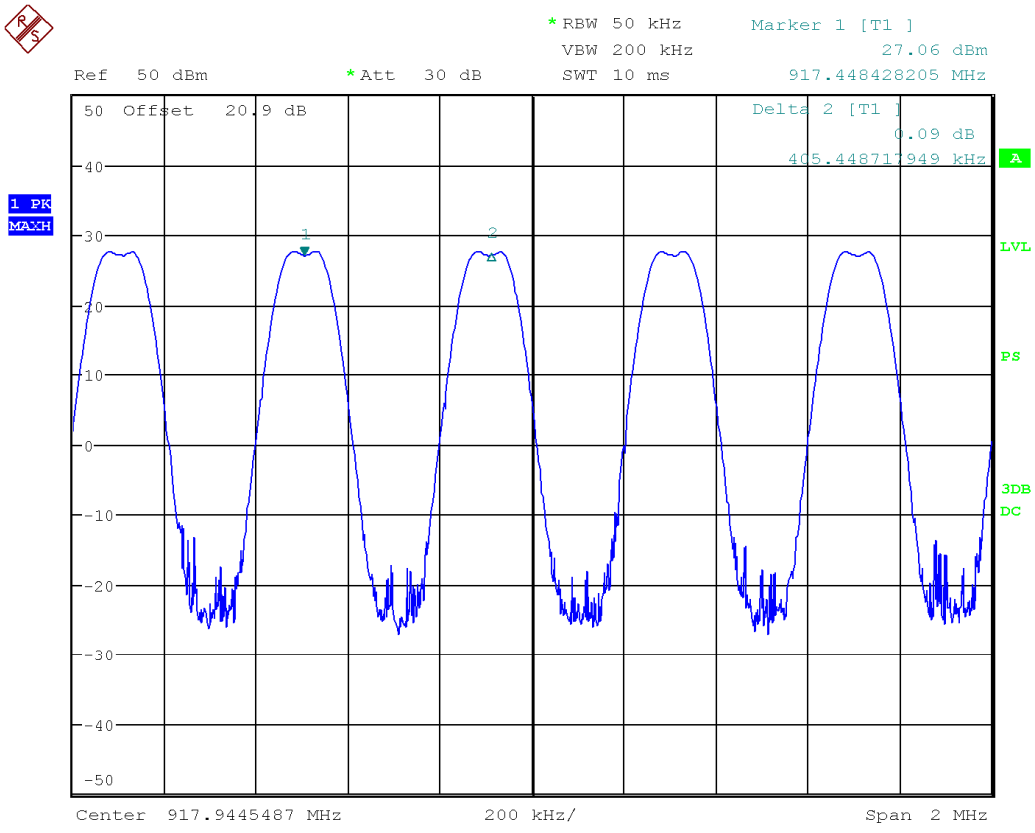
The graphs shown below shows the channel spacing during the operation of the device. This is measured by a max hold on the spectrum analyzer and the highest resolution bandwidth that is sufficiently low to exhibit the channel spacing of the signal being measured. This measurement is a peak measurement. Max hold is performed for a duration of not less than 1 minute, as the device is stepping through its hopping table.

19.2kbps



Channel Separation

50kbps



Date: 10.MAY.2023 18:21:53

Channel Separation

Note: See 'Appendix B – EUT & Test Setup Photographs' for photos showing the test set-up.

Test Equipment List

Equipment	Model No.	Manufacturer	Last Calibration Date	Next Calibration Date	Asset #
Spectrum Analyzer	ESU 40	Rohde & Schwarz	Feb. 11, 2022	Feb. 11, 2024	GEMC 233
20dB Attenuator (100W)	6N100W-20F	Inmet	NCR	NCR	GEMC 352

Time of Occupancy

Purpose

The purpose of this test is to ensure that the RF energy of frequency hopping systems is hopping at a minimum defined rate. This helps ensure sufficient time off to enable other frequency hopping devices to co-operate within this allocated band.

Limits

The limits are as defined in 47 CFR FCC Part 15 Section 15.247(a)(1) and RSS 247 Section 5.1. The test method is a defined in ANSI C63.10.

902 to 928 MHz	$P_{max\text{-}pk} \leq 1$ W $BW_{20dB} \leq 250$ kHz $t_{ch} \leq 0.4$ s for $T = 20$ s	$P_{max\text{-}pk} \leq 0.25$ W 250 kHz $\leq BW_{20dB} \leq 500$ kHz $t_{ch} \leq 0.4$ s for $T = 10$ s
2400 to 2483.5 MHz	$P_{max\text{-}pk} \leq 1$ W $N_{ch} \geq 75$ $t_{ch} \leq 0.4$ s for $T = 0.4\ N_{ch}$ s	$P_{max\text{-}pk} \leq 0.125$ W $N_{ch} \geq 15$ $t_{ch} \leq 0.4$ s for $T = 0.4\ N_{ch}$ s
5275 to 5850 MHz	$P_{max\text{-}pk} \leq 1$ W $t_{ch} \leq 0.4$ s for $T = 30$ s	

Results

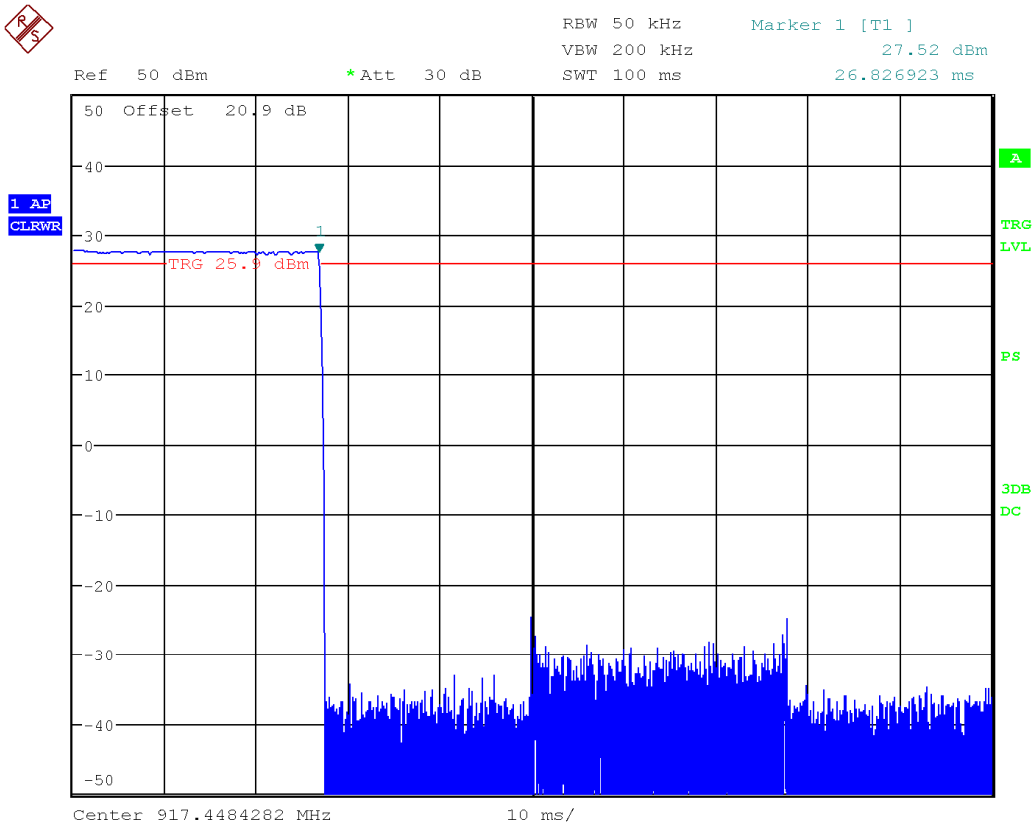
The EUT passed the requirements. There are 62 channels occupied in total. The transmit time per hop is 26.83ms. The repetition rate of the hops is 2.936s. The number of hops within 20 seconds is 7. The average time of occupancy is calculated as follows for the worst-case data rate (19.2kbps):

$$Average\ Time\ of\ Occupancy = Number\ of\ Hops\ within\ 20s * Transmit\ Time\ per\ Hop$$
$$Average\ Time\ of\ Occupancy = 7 * 26.83ms = 187.81ms = 0.19s$$

Therefore, the average time of occupancy is 0.19s, which meets the requirements of <0.4s.

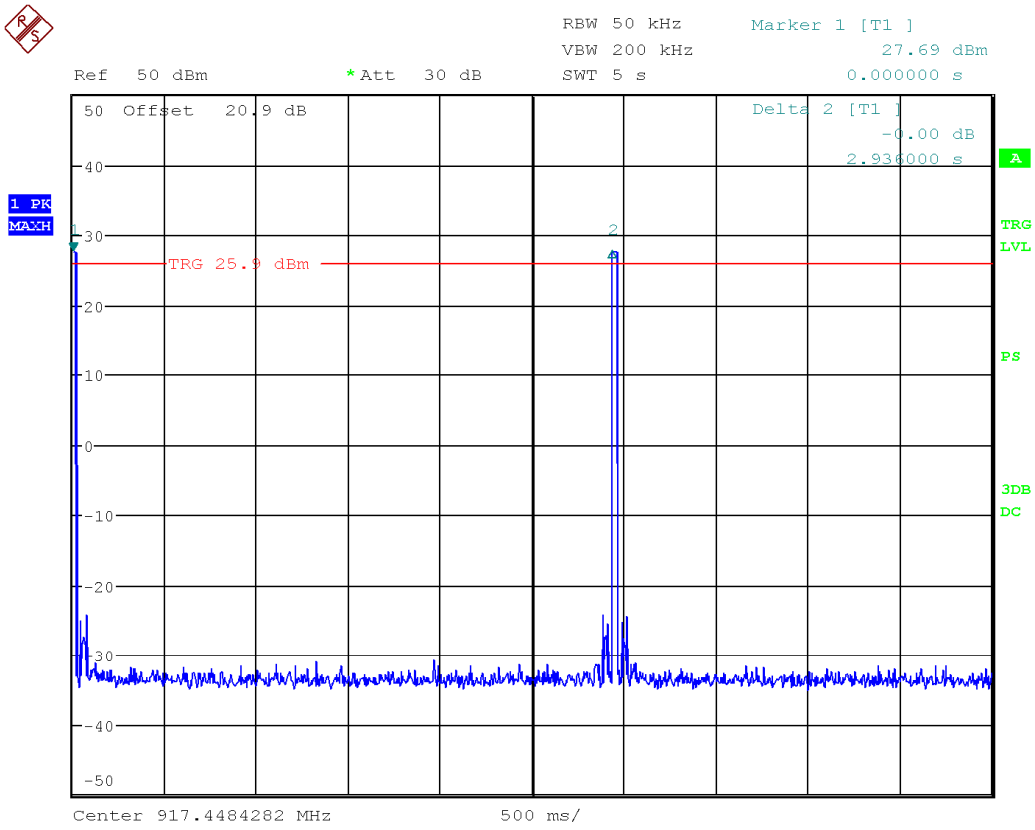
Graph(s)

19.2kbps



Date: 10.MAY.2023 18:27:41

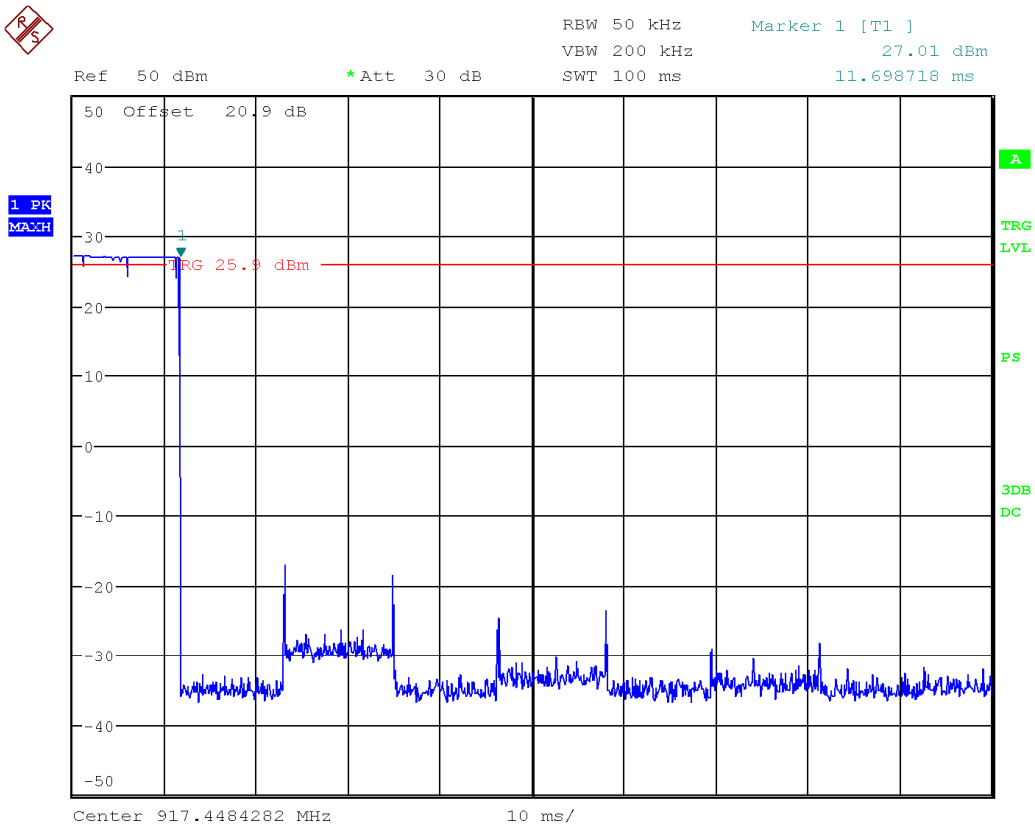
Transmit Time per Hop



Date: 10.MAY.2023 18:31:19

Repetition Rate

50kbps



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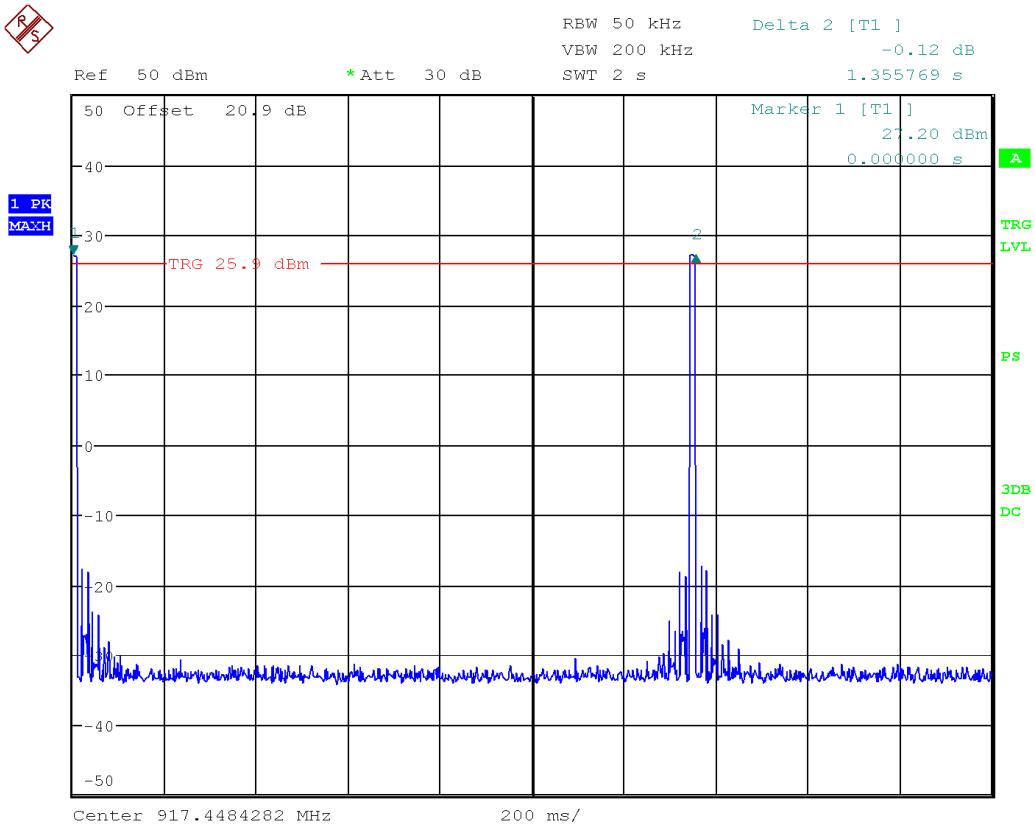
Transmit Time per Hop



Date: 10.MAY.2023 18:34:09

Repetition Rate

Note: See 'Appendix B – EUT & Test Setup Photographs' for photos showing the test set-up.

Test Equipment List

Equipment	Model No.	Manufacturer	Last Calibration Date	Next Calibration Date	Asset #
Spectrum Analyzer	ESU 40	Rohde & Schwarz	Feb. 11, 2022	Feb. 11, 2024	GEMC 233
20dB Attenuator (100W)	6N100W-20F	Inmet	NCR	NCR	GEMC 352

Channel Carrier Bandwidth

Purpose

The purpose of this test is to allow for results that is used to help establish other limits. Although there is not specific limit for this requirement, the derived limits dependant on this information helps allow for other spread spectrum devices to co-exist in the same frequency spectrum. This also helps prevent corruption of data by ensuring adequate channel separation to distinguish the reception of the intended information.

Limits and Methods

The limits are as defined in 47 CFR FCC Part 15 Section 15.247(a)(1) and RSS 247 Section 5.1. The test method is a defined in ANSI C63.10.

902 to 928 MHz	$P_{max\text{-}pk} \leq 1$ W $BW_{20dB} \leq 250$ kHz	$P_{max\text{-}pk} \leq 0.25$ W $250 \text{ kHz} \leq BW_{20dB} \leq 500$ kHz
2400 to 2483.5 MHz	$P_{max\text{-}pk} \leq 1$ W $N_{ch} \geq 75$ Max. BW_{20dB} not specified	$P_{max\text{-}pk} \leq 0.125$ W $N_{ch} \geq 15$ Max. BW_{20dB} not specified
5275 to 5850 MHz	$P_{max\text{-}pk} \leq 1$ W $BW_{20dB} \leq 1$ MHz	

Note: For 2400 to 2483.5 MHz transmitter; there is no specified limit. However, an approximate calculated maximum limit can be obtained by dividing the maximum bandwidth of the frequency allocation by the minimum number of channels. Note that this is a maximum bandwidth, and the measurement is used to calculate other limits.

Results

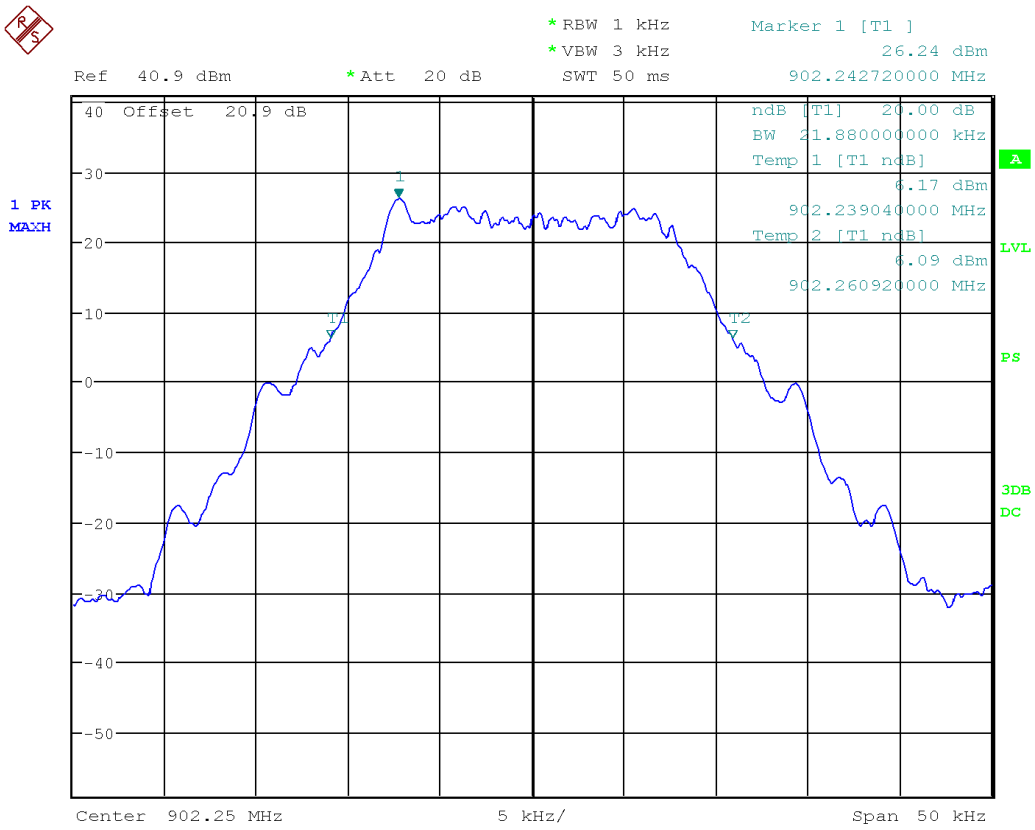
The EUT meets the requirements. The maximum 20 dB BW measured was 102.244 kHz. The maximum 99% BW measured was 95.200 kHz.

Graph(s)

The graphs shown below shows the 20 dB bandwidth during the operation of the device. This is measured by a max hold on the spectrum analyzer and the highest resolution bandwidth that is sufficiently low to exhibit the 20 dB bandwidth of a channel during operation of the EUT. This measurement is a peak measurement. Max hold is performed for a duration of not less than 1 minute. Additionally, the 99% emission bandwidth has been measured.

20dB Bandwidth

19.2kbps



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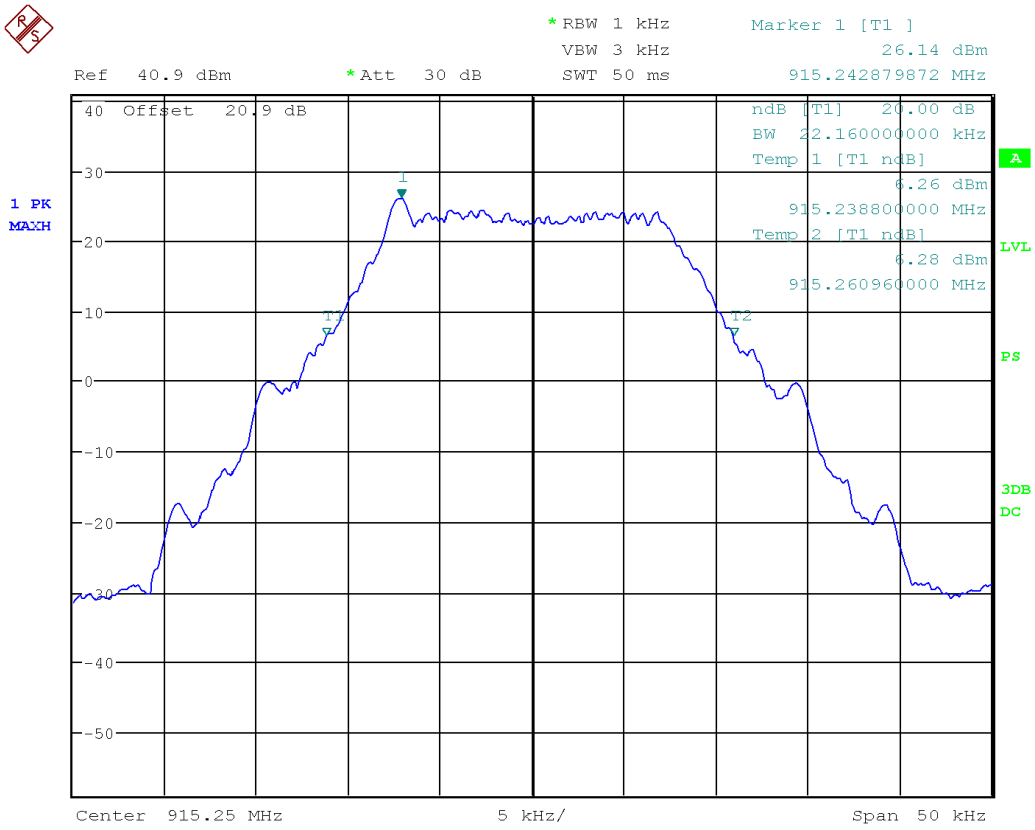
Low Channel



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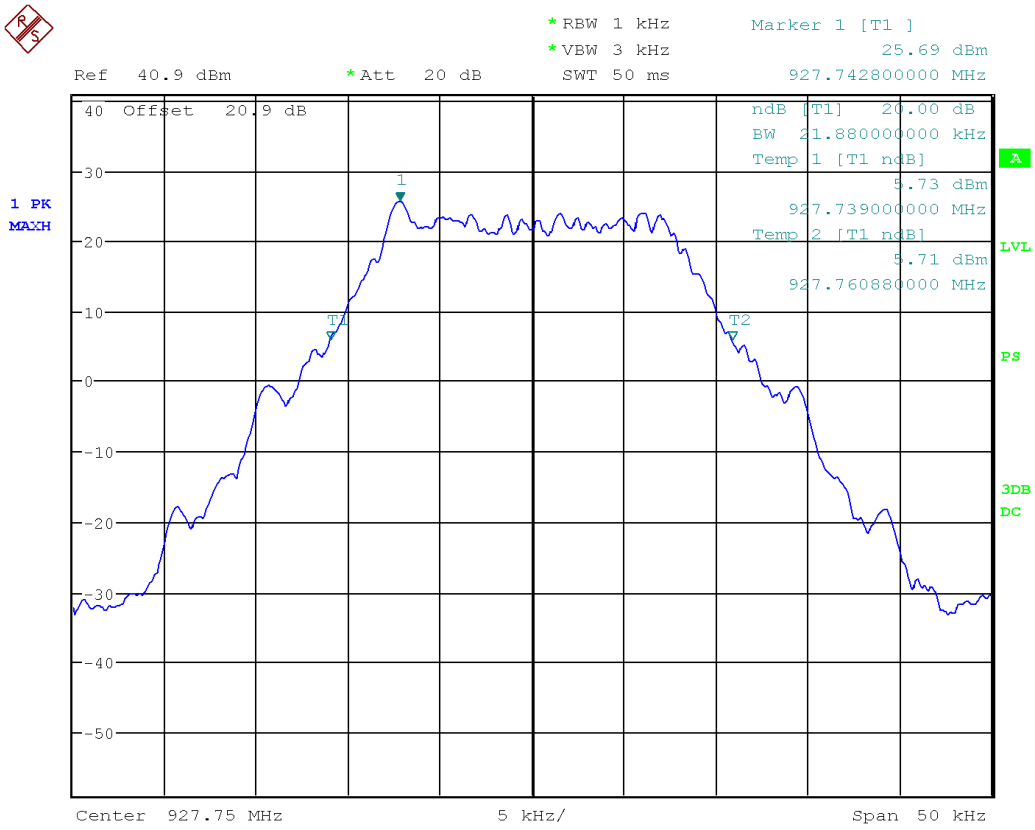
Mid Channel



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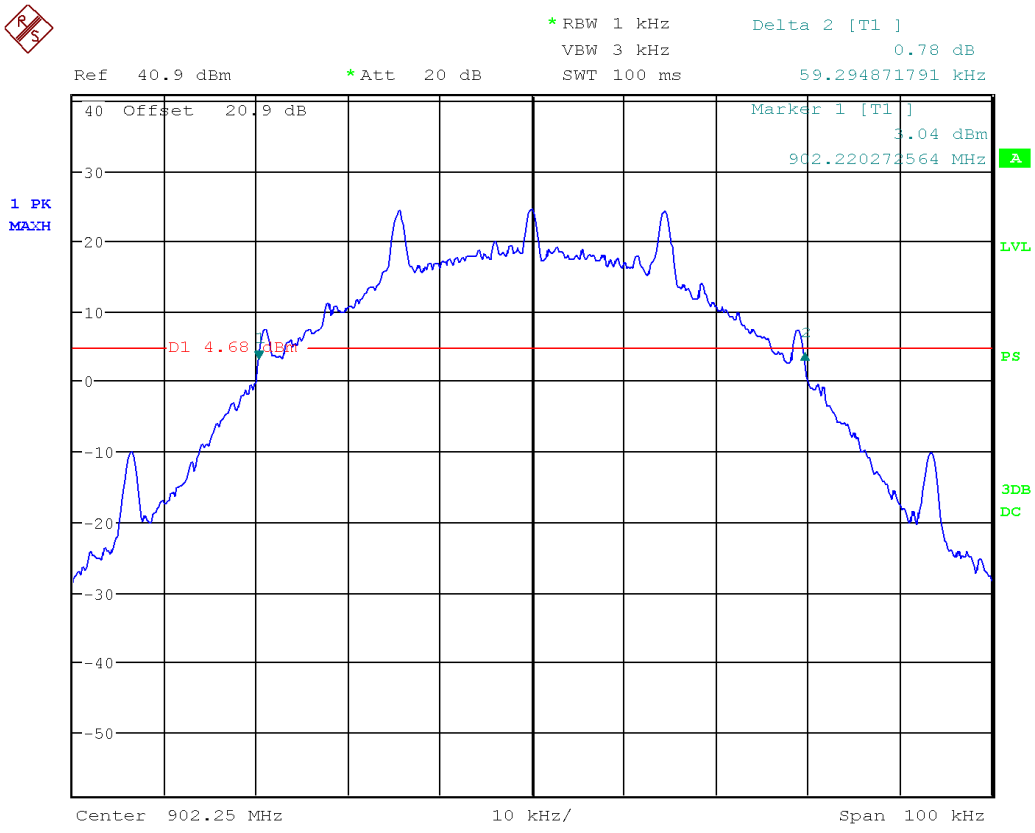
High Channel

28kbps



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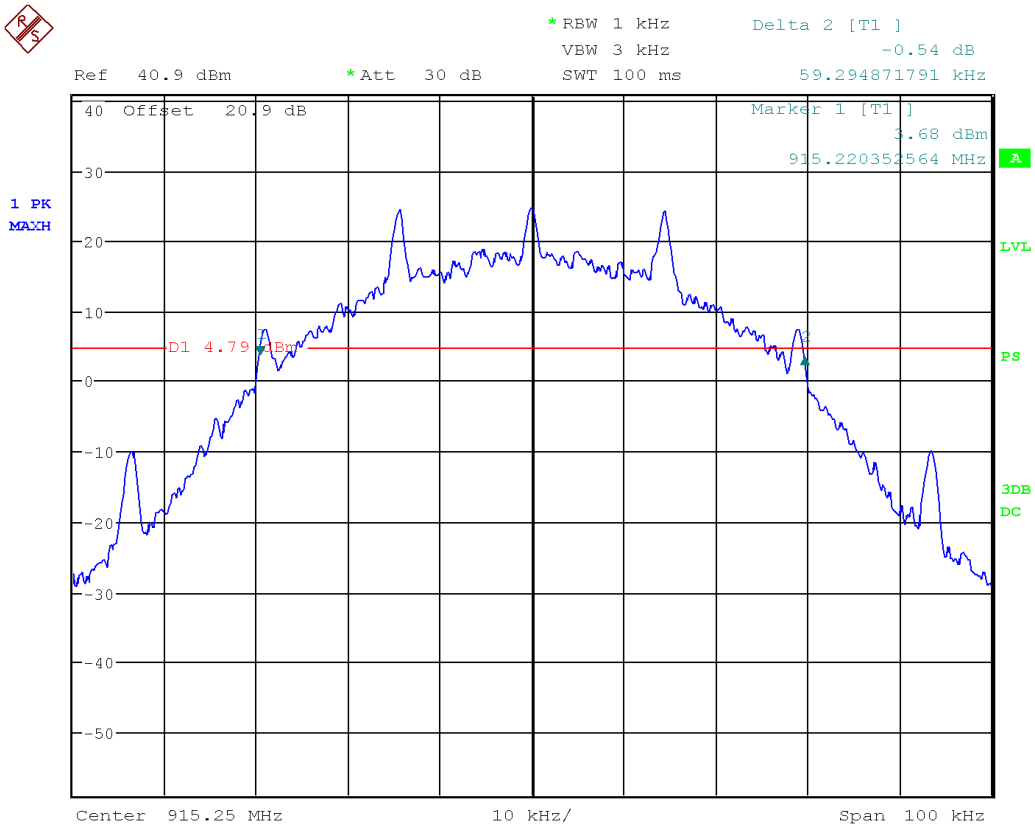
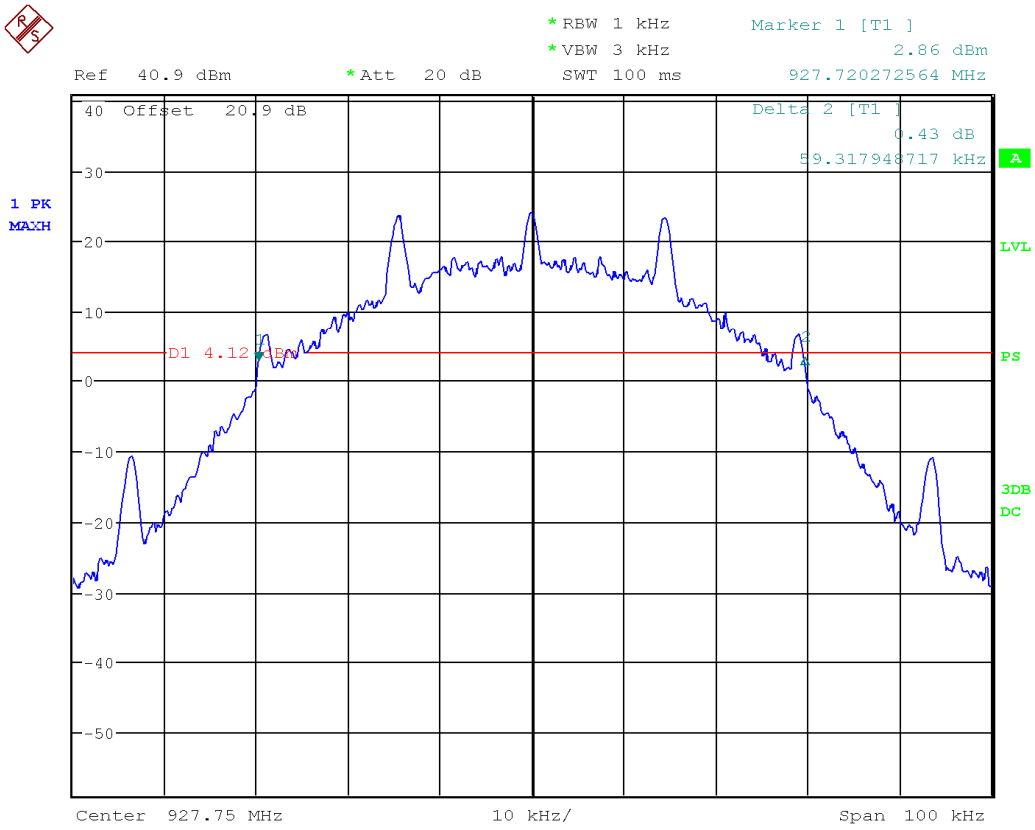
Low Channel



Date: 9.MAY.2023 15:17:05

Mid Channel



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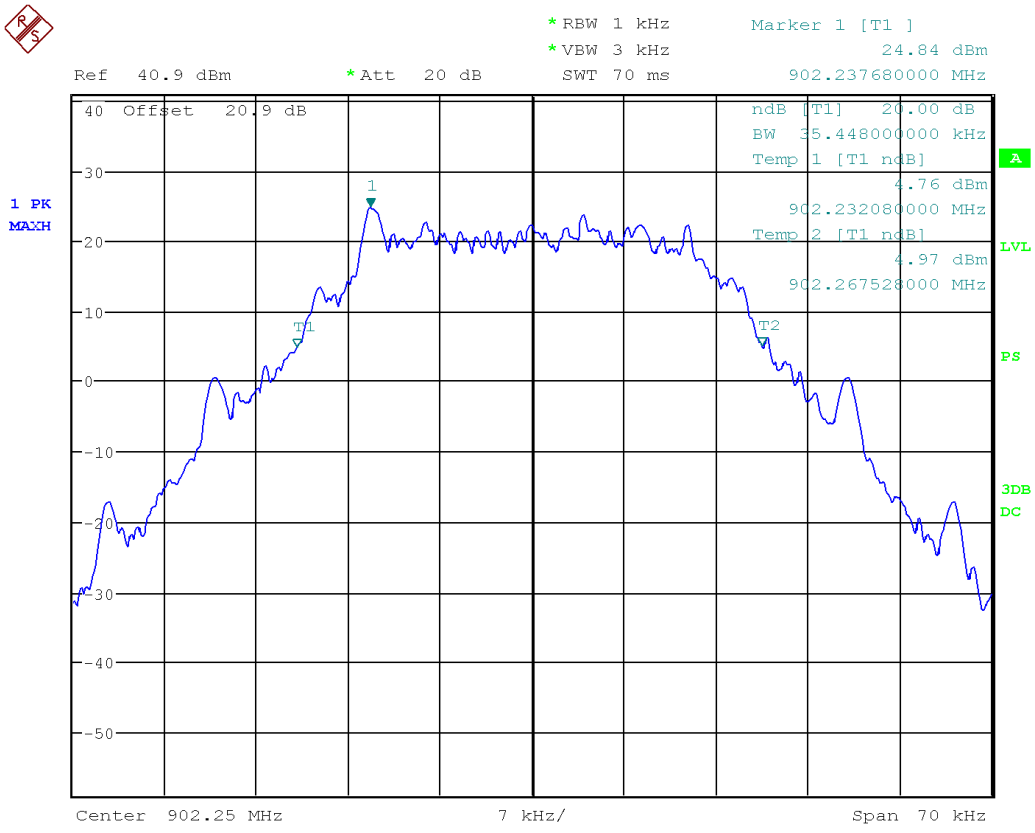
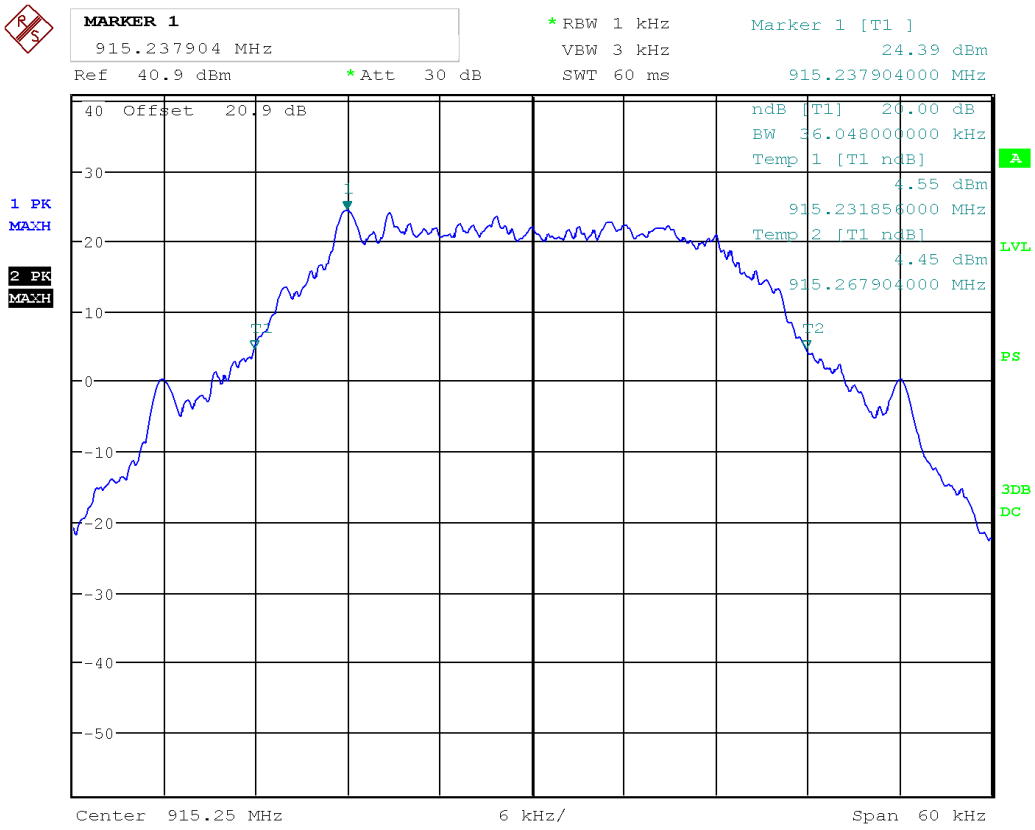
High Channel

32kbps



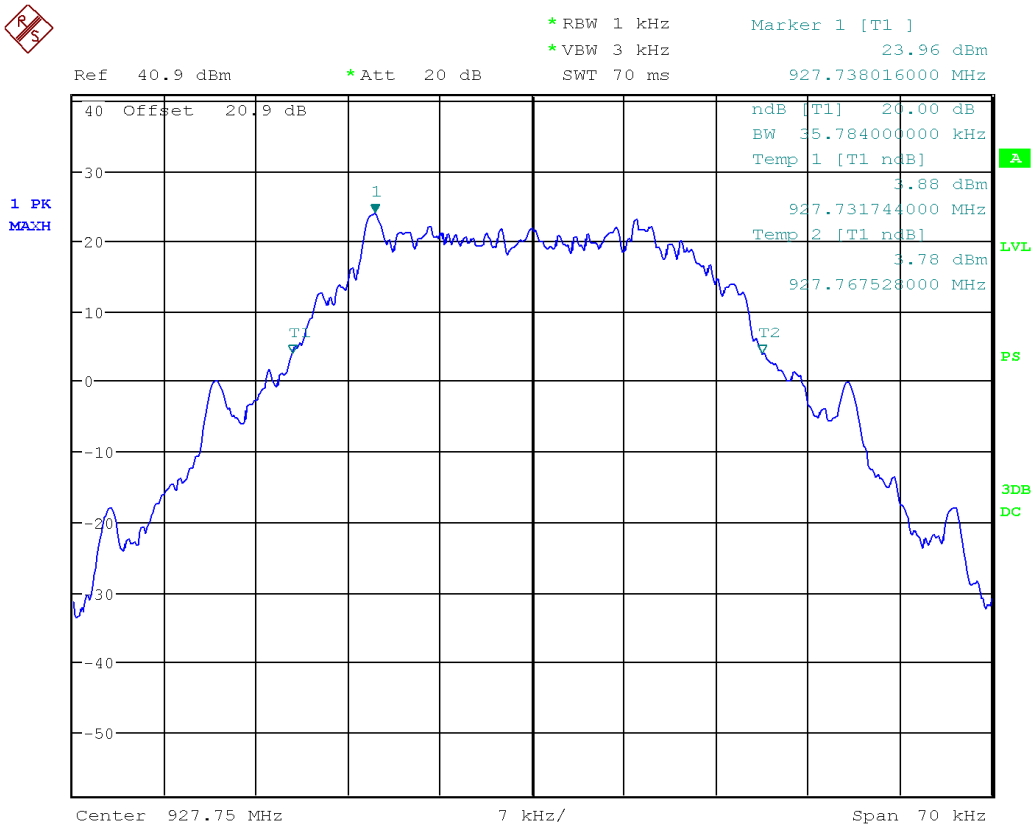
Date: 9.MAY.2023 16:49:40

Low Channel



Date: 9.MAY.2023 15:07:34

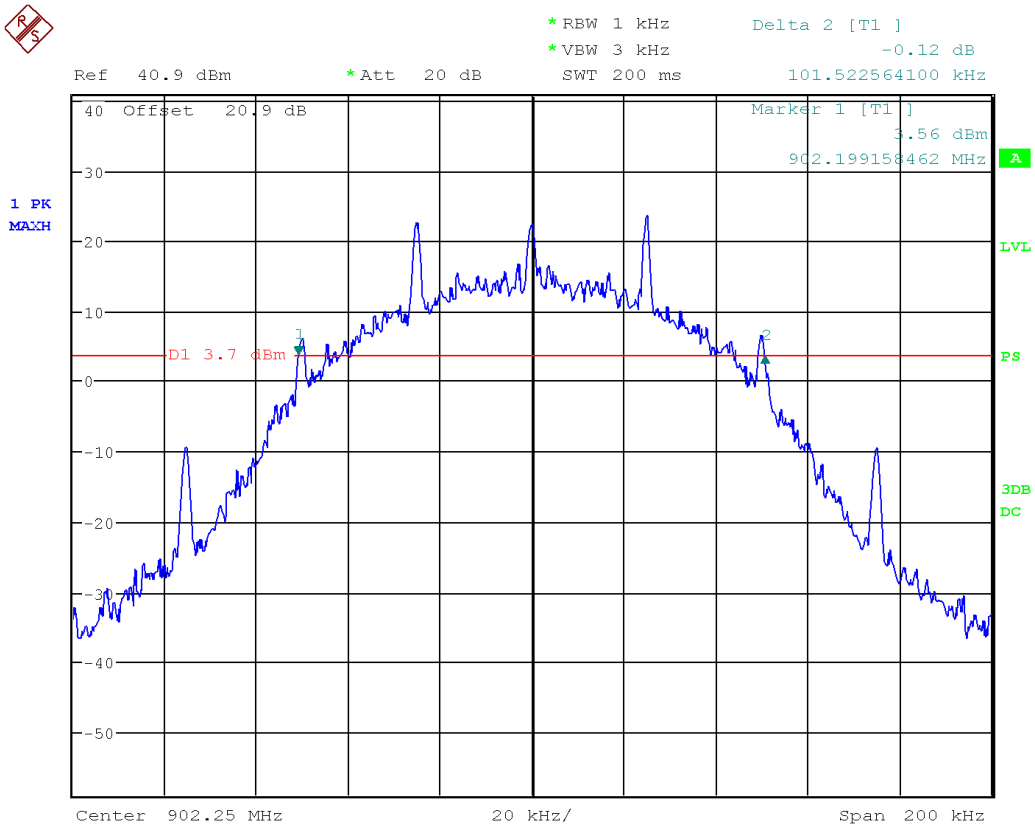
Mid Channel



Date: 9.MAY.2023 16:52:41

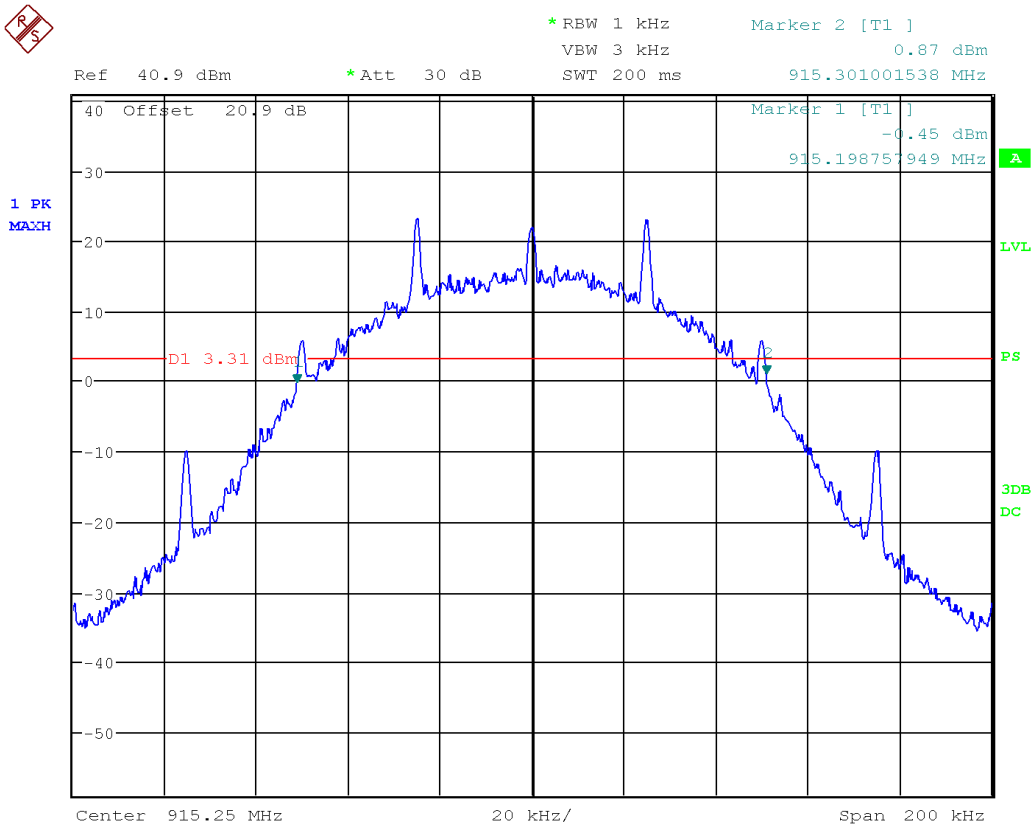
High Channel

50kbps



Date: 9.MAY.2023 17:00:33

Low Channel



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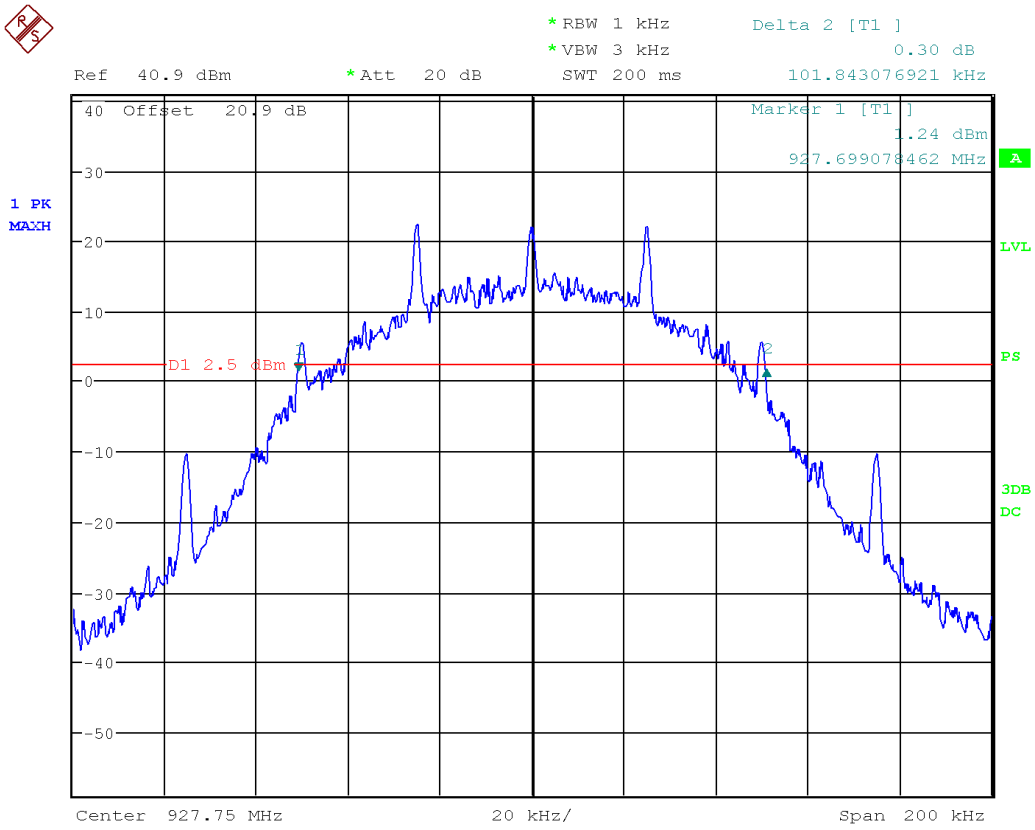
Mid Channel

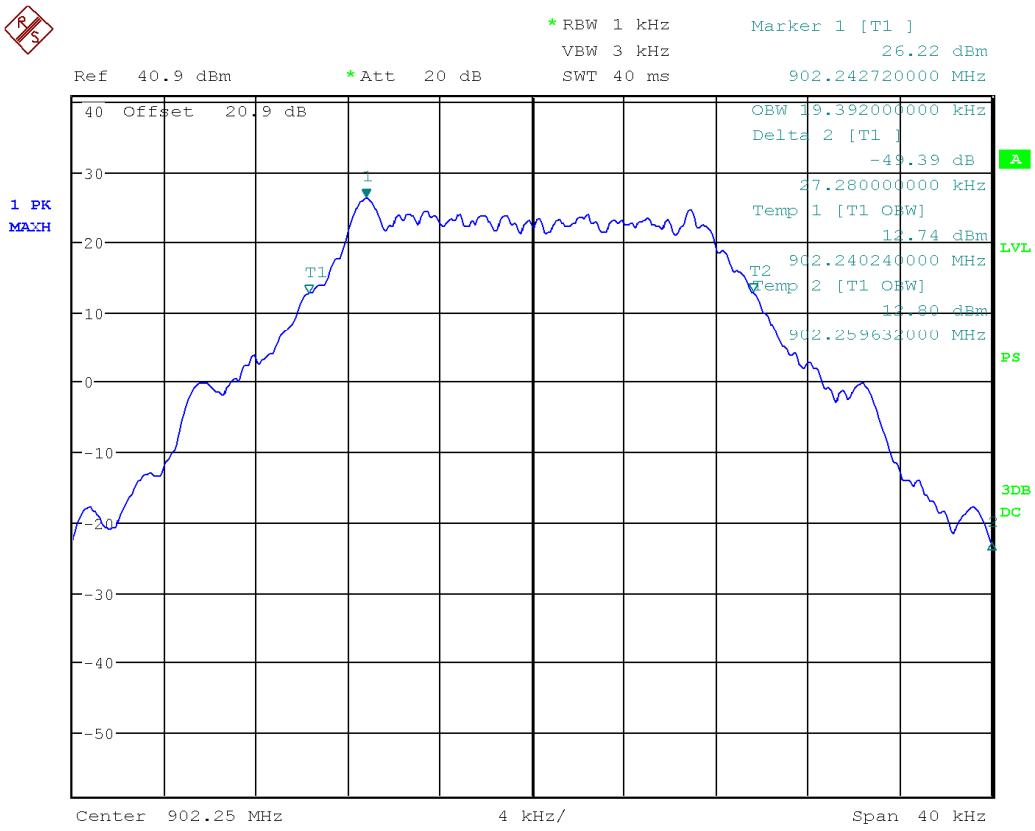


Date: 9.MAY.2023 17:04:33

High Channel

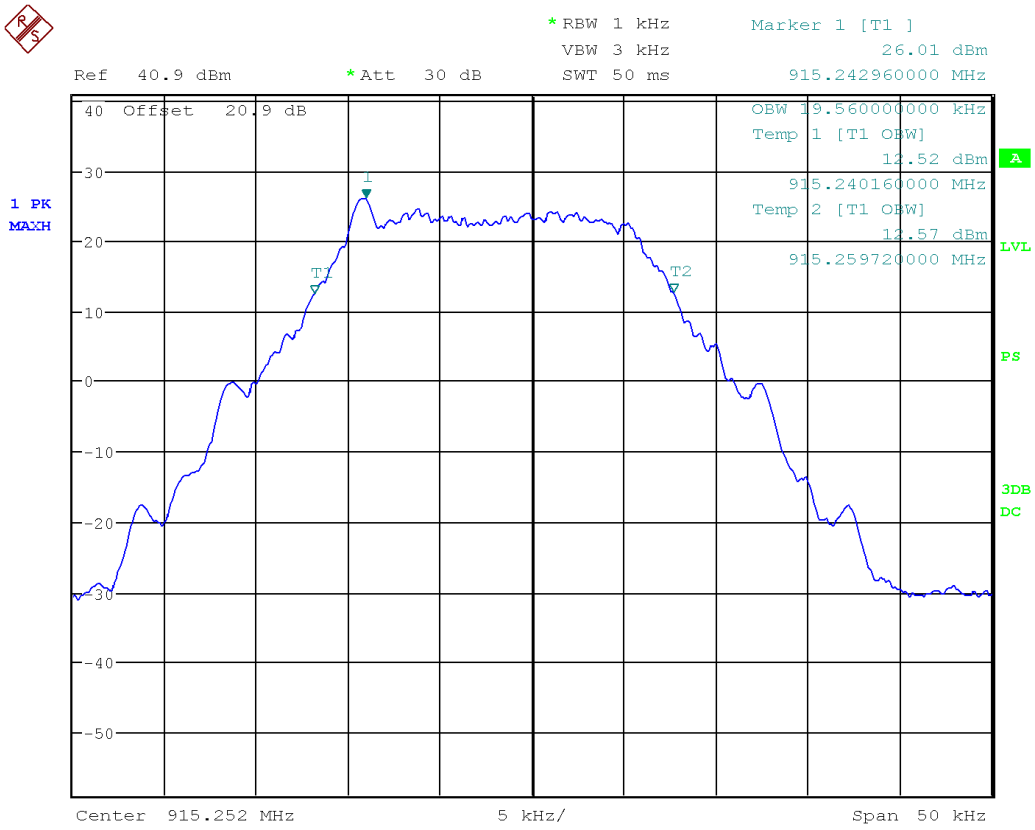
99% Bandwidth

19.2kbps



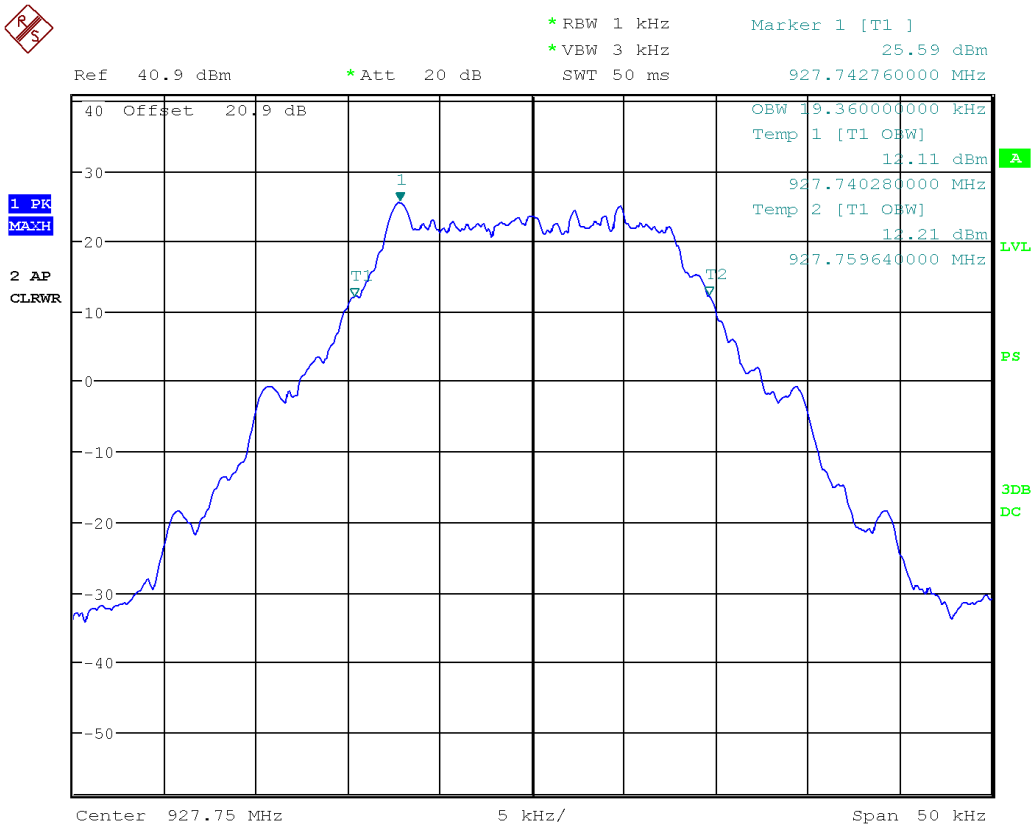
Date: 9.MAY.2023 15:35:06

Low Channel



Date: 9.MAY.2023 14:40:16

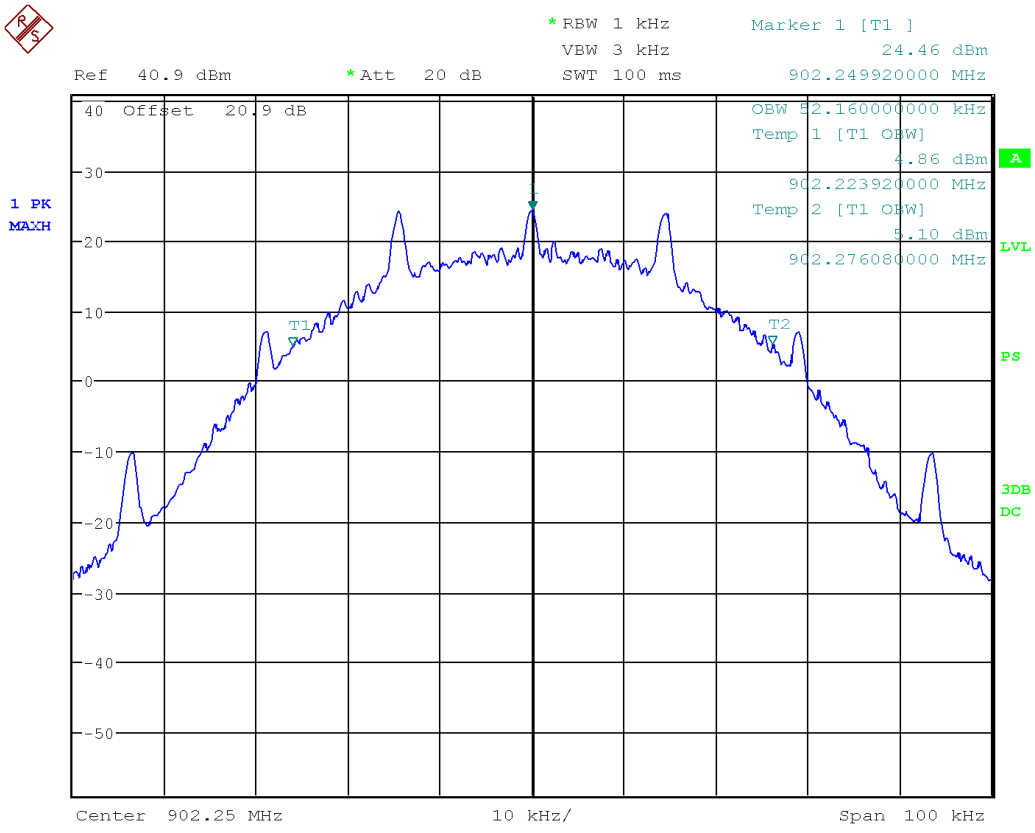
Mid Channel



Date: 9.MAY.2023 16:20:09

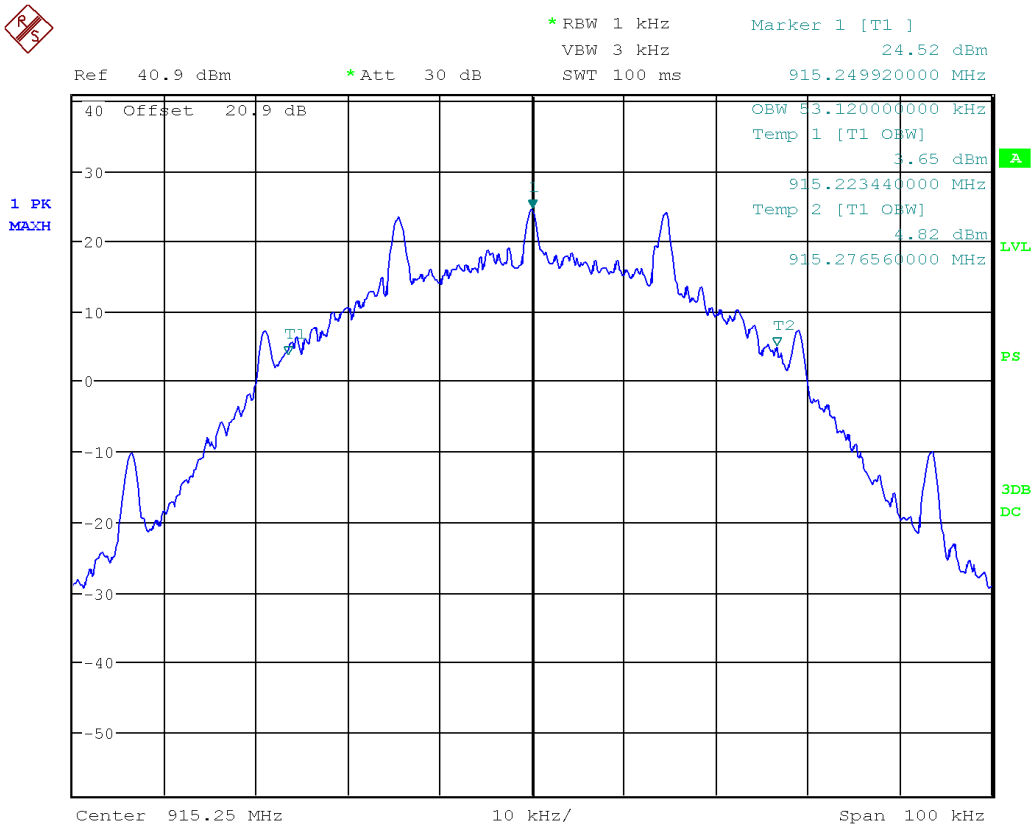
High Channel

28kbps



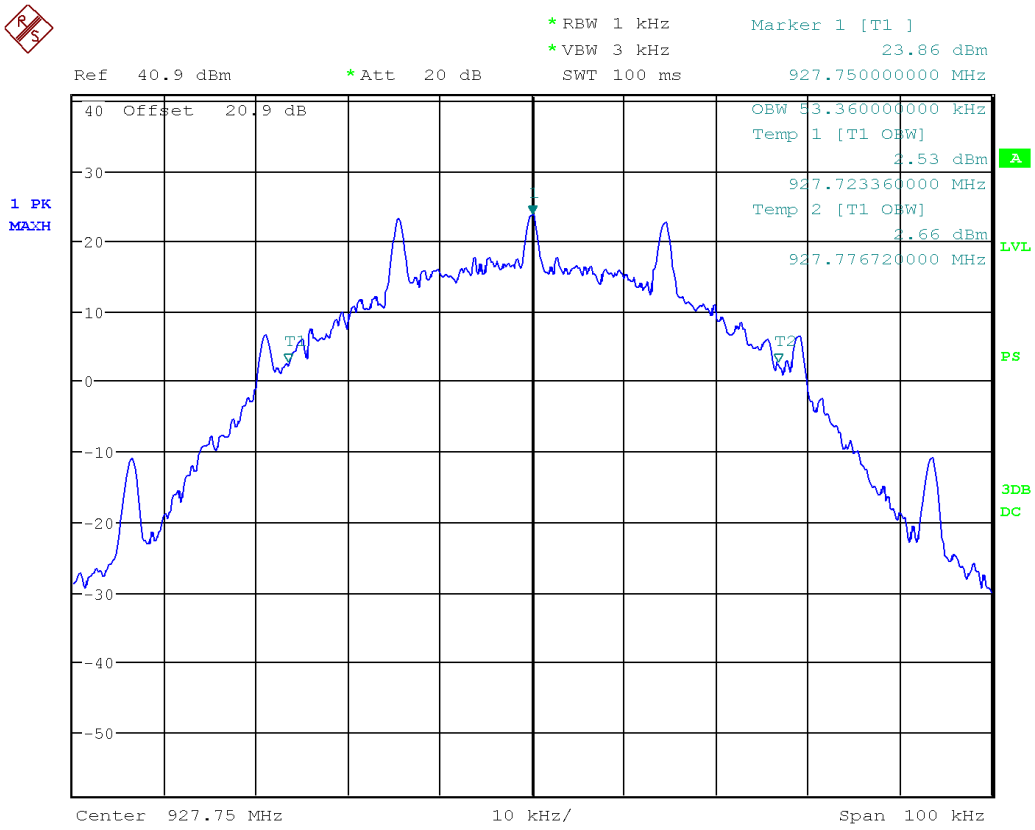
Date: 9.MAY.2023 15:45:17

Low Channel



Date: 9.MAY.2023 15:14:24

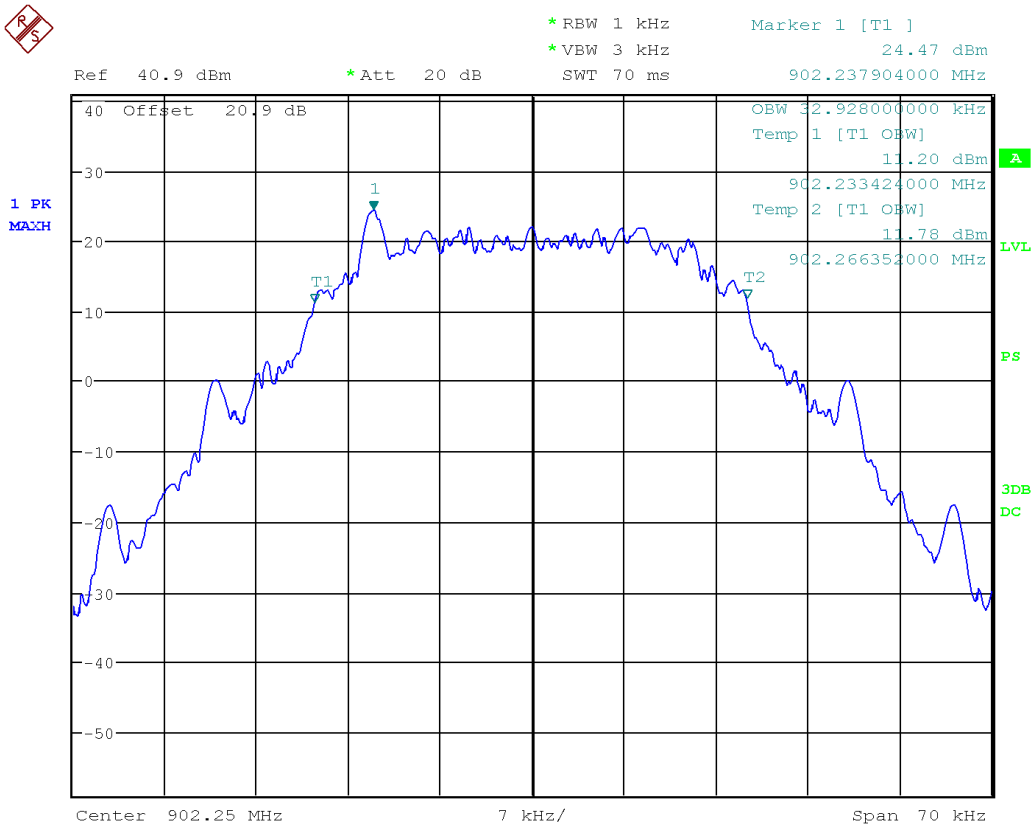
Mid Channel



Date: 9.MAY.2023 16:35:50

High Channel

32kbps



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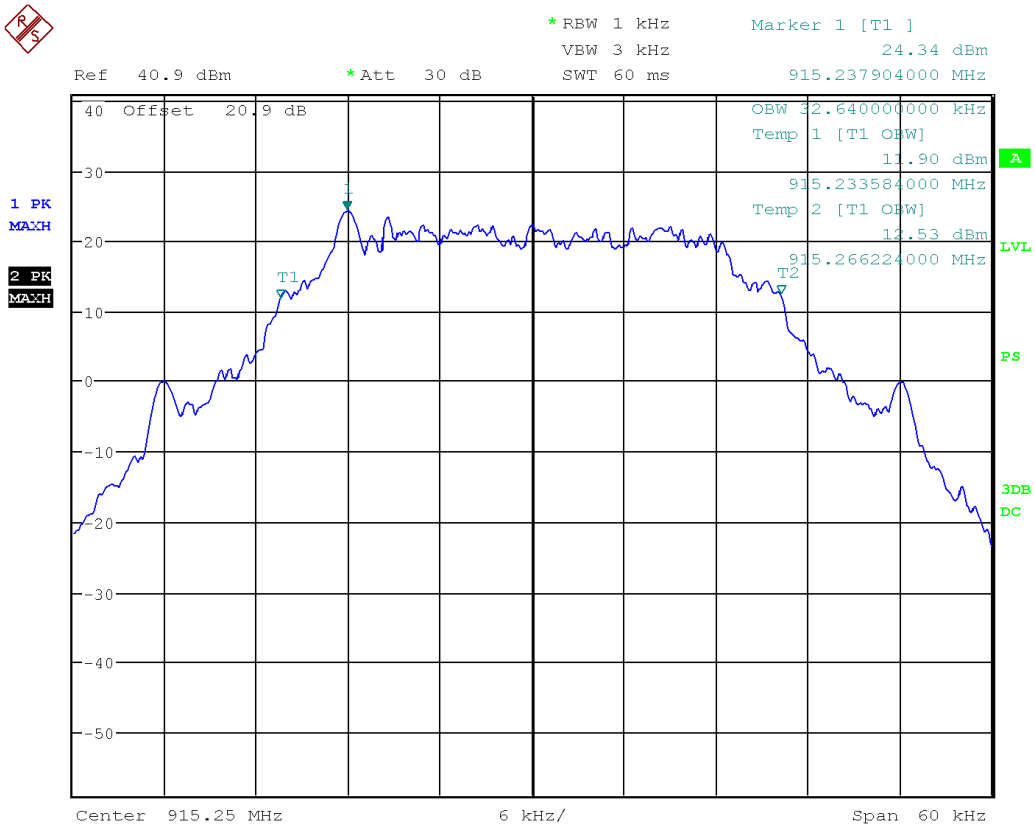
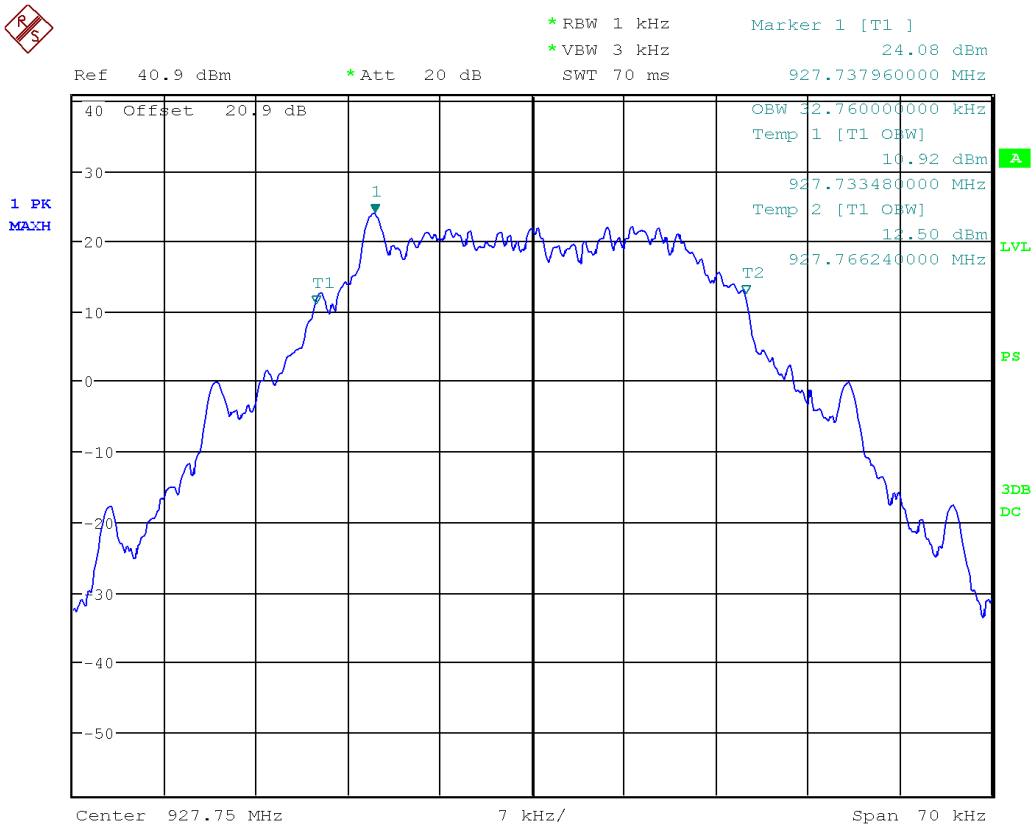
Low Channel



Date: 9.MAY.2023 15:05:59

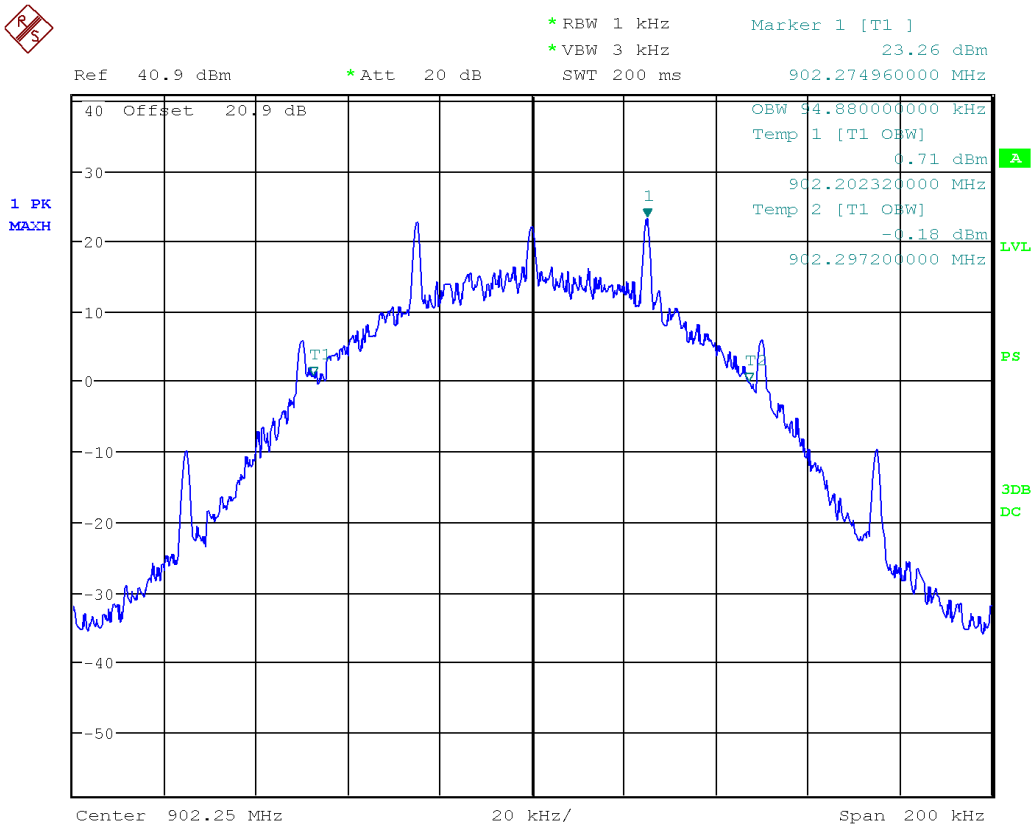
Mid Channel



Date: 9.MAY.2023 16:51:23

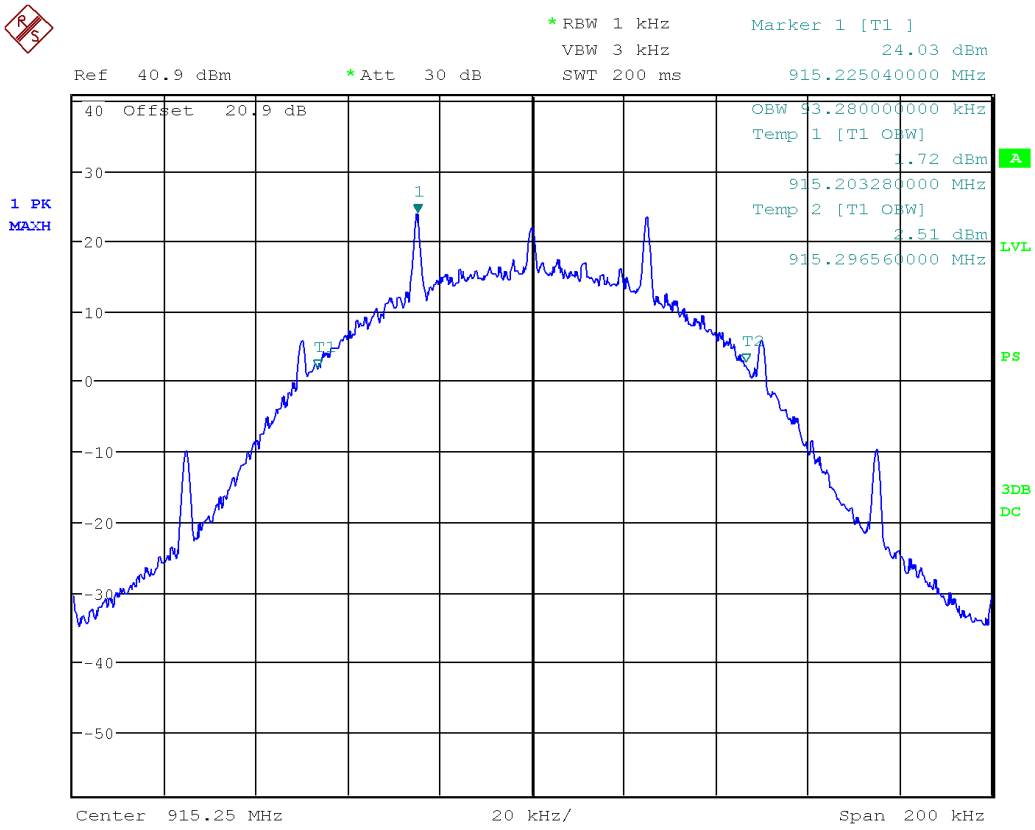
High Channel

50kbps



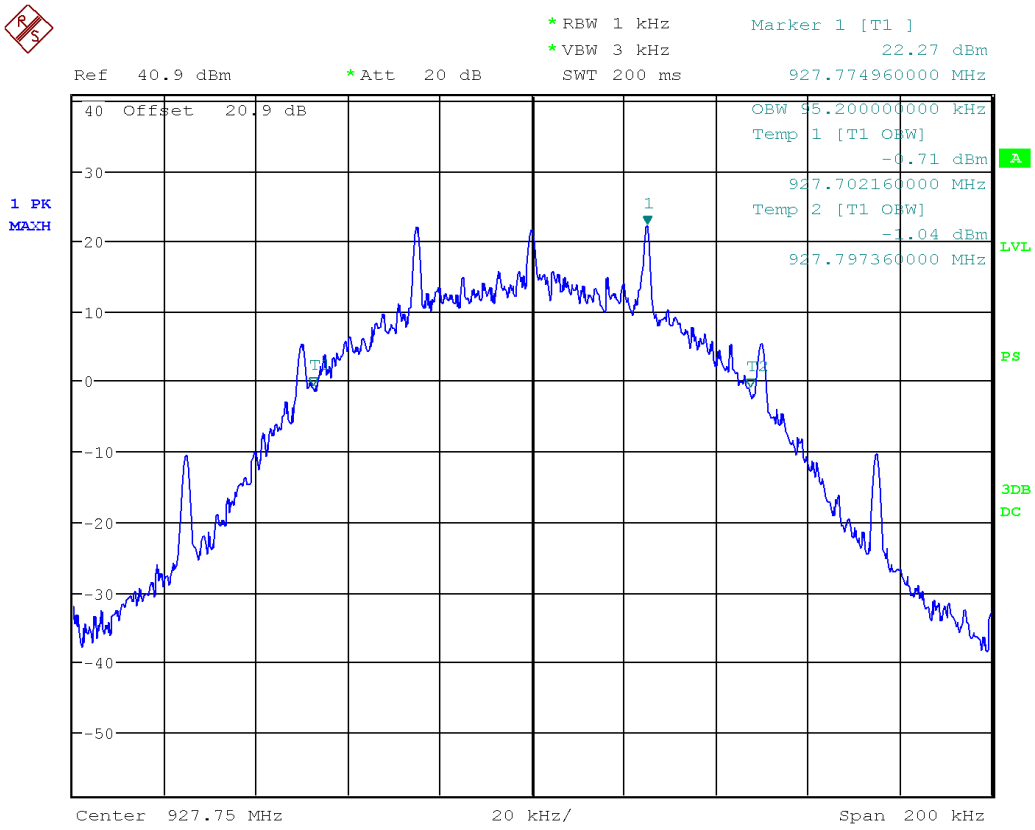
Date: 9.MAY.2023 16:55:14

Low Channel



Date: 9.MAY.2023 14:52:18

Mid Channel



High Channel

Note: See 'Appendix B – EUT & Test Setup Photographs' for photos showing the test set-up.

Measurement(s)

19.2kbps

Channel	Frequency (MHz)	20dB BW (kHz)	99% BW (kHz)
Low	902.25	21.72	19.39
Mid	915.25	22.16	19.60
High	927.75	21.88	19.36

28kbps

Channel	Frequency (MHz)	20dB BW (kHz)	99% BW (kHz)
Low	902.25	59.30	52.40
Mid	915.25	59.30	53.12
High	927.75	59.32	53.36

32kbps

Channel	Frequency (MHz)	20dB BW (kHz)	99% BW (kHz)
Low	902.25	35.45	32.92
Mid	915.25	36.05	32.64
High	927.75	35.78	32.76

50kbps

Channel	Frequency (MHz)	20dB BW (kHz)	99% BW (kHz)
Low	902.25	101.52	94.88
Mid	915.25	102.24	93.12
High	927.75	101.84	95.20

Test Equipment List

Equipment	Model No.	Manufacturer	Last Calibration Date	Next Calibration Date	Asset #
Spectrum Analyzer	ESU 40	Rohde & Schwarz	Feb. 11, 2022	Feb. 11, 2024	GEMC 233
20dB Attenuator (100W)	6N100W-20F	Inmet	NCR	NCR	GEMC 352

Maximum Peak Envelope Conducted Power - FHSS

Purpose

The purpose of this test is to ensure that the maximum power conducted to the radiating element does not exceed the limits specified.

Limits

The limits are as defined in 47 CFR FCC Part 15 Section 15.247(b) and RSS 247 Section 5.4. The test method is a defined in ANSI C63.10.

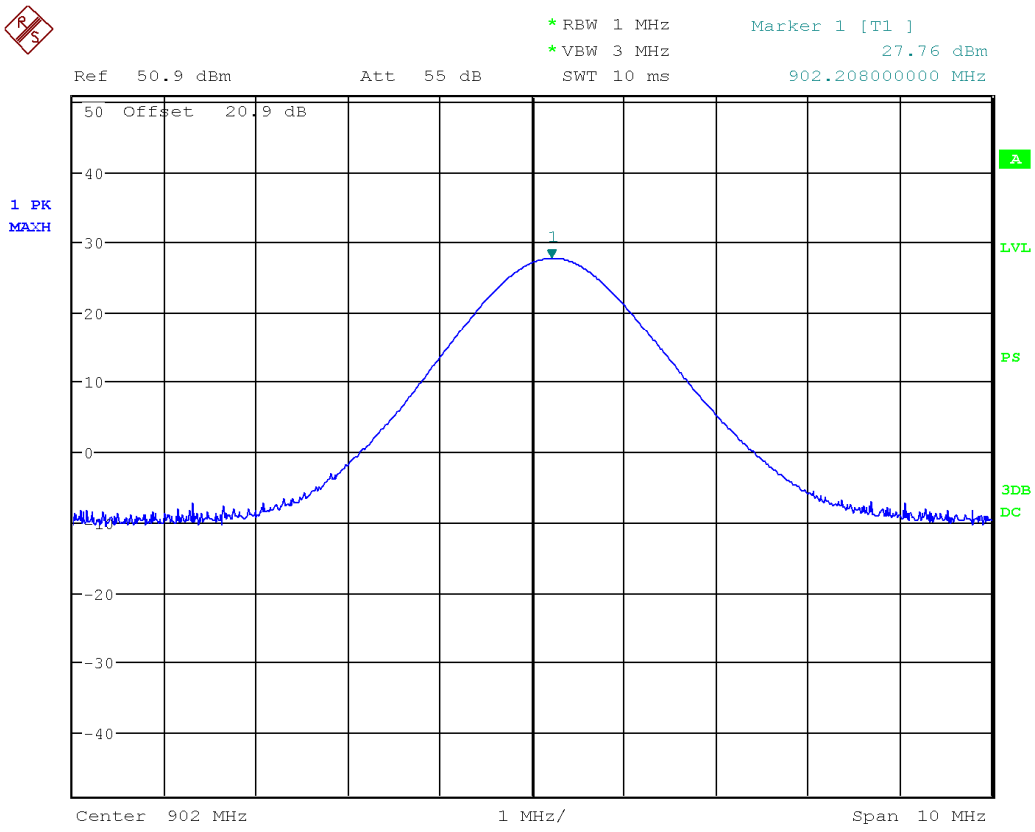
902 to 928 MHz	$N_{ch} \geq 50$ $P_{max\text{-}pk} \leq 1$ W	$25 \leq N_{ch} \leq 50$ $P_{max\text{-}pk} \leq 0.25$ W
2400 to 2483.5 MHz	$N_{ch} \geq 75$ $P_{max\text{-}pk} \leq 1$ W	$N_{ch} \geq 15$ $P_{max\text{-}pk} \leq 0.125$ W
5275 to 5850 MHz	$N_{ch} \geq 75$ $P_{max\text{-}pk} \leq 1$ W	

Results

The EUT passed. The FHSS peak power measured was 27.76 dBm (597.04 mW). The external attenuator and cable loss are accounted for as reference offset in the spectrum analyzer

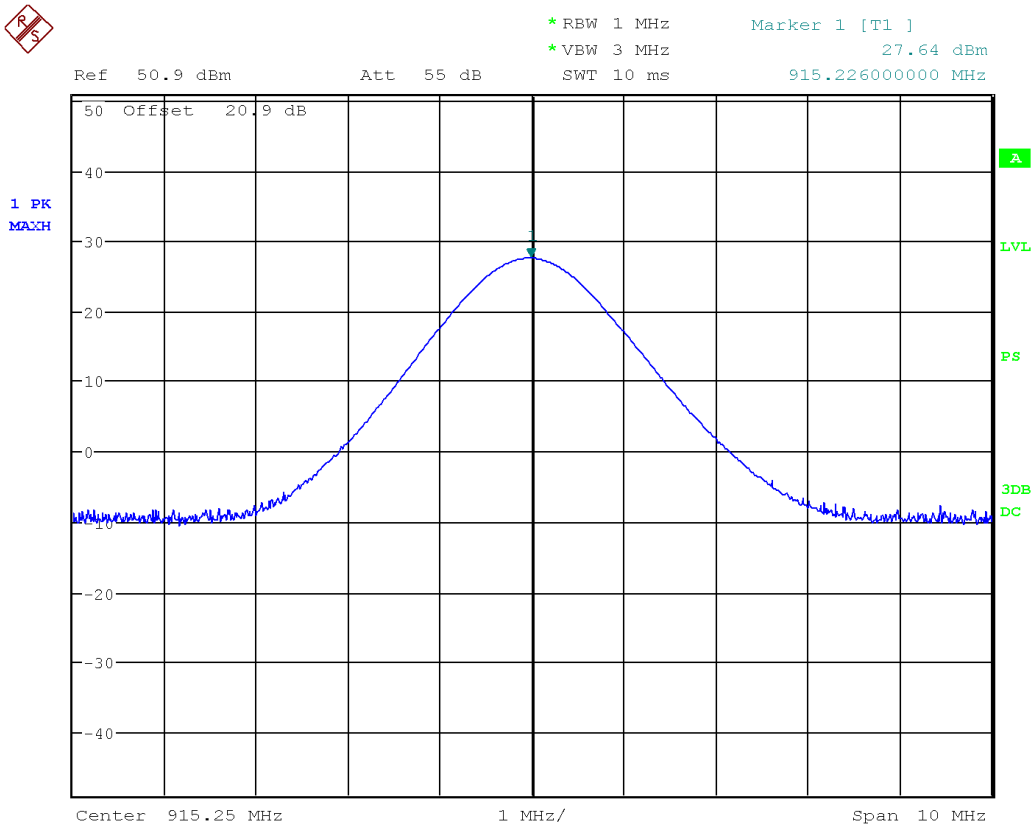
Graph(s)

19.2kbps

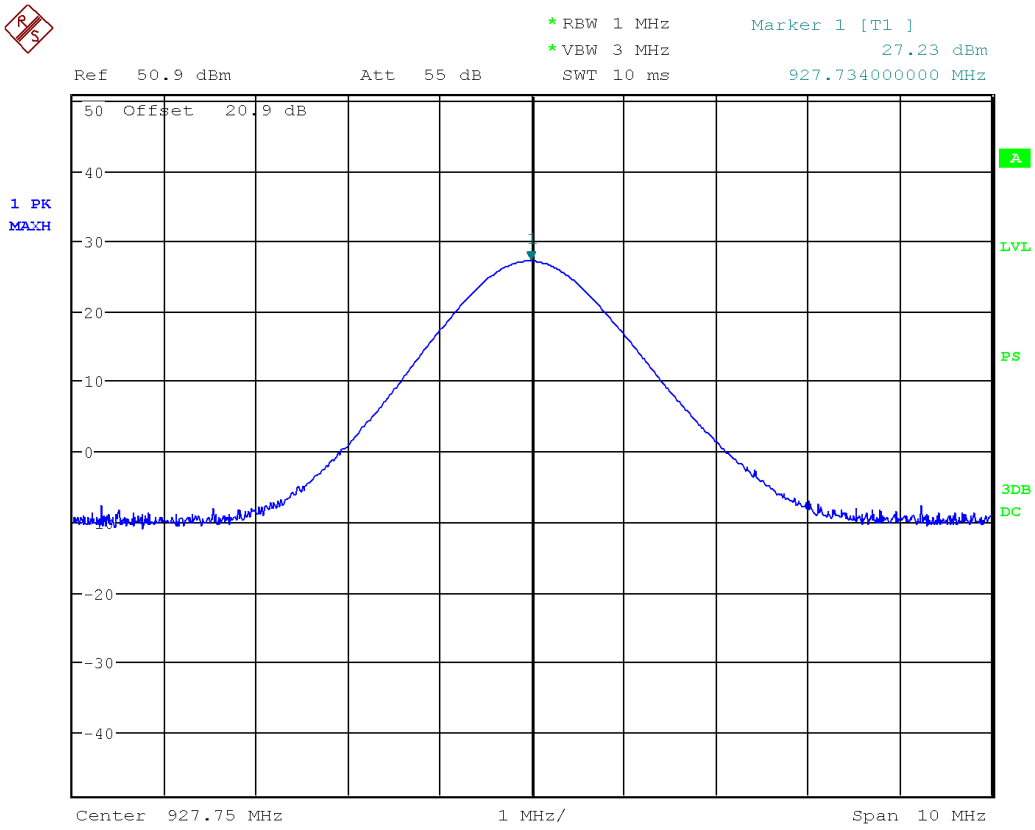


Date: 8.MAY.2023 17:22:56

Low Channel (902 MHz)



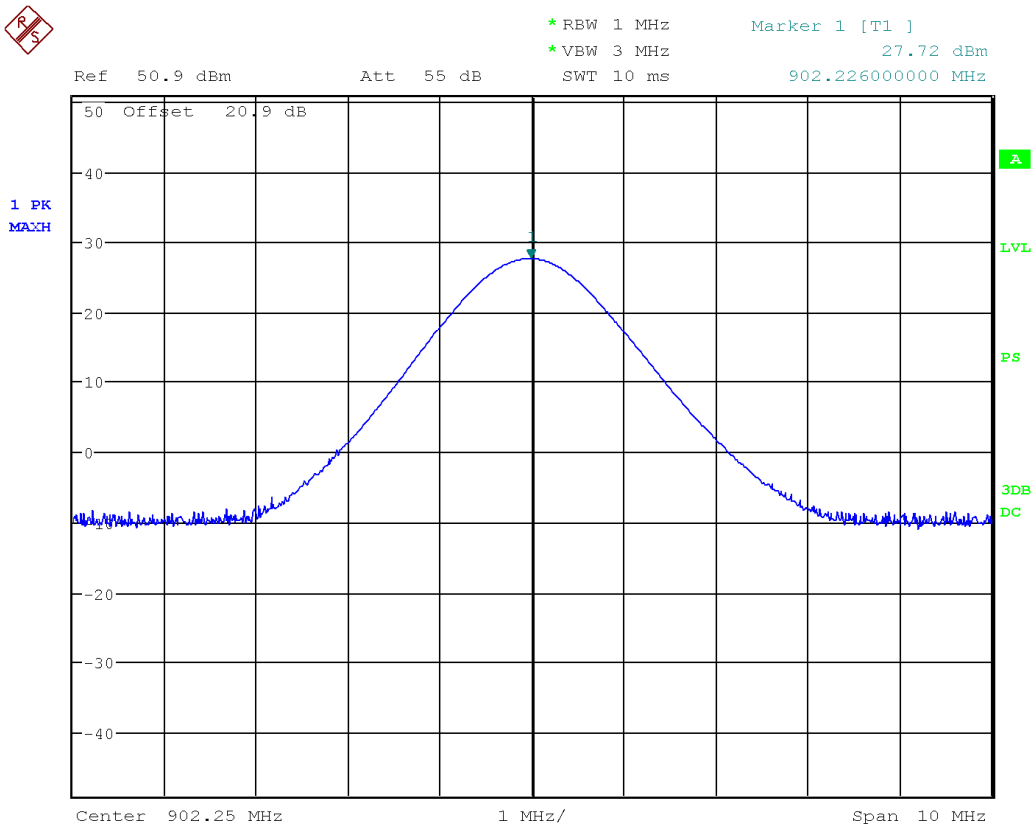
Mid Channel (915 MHz)



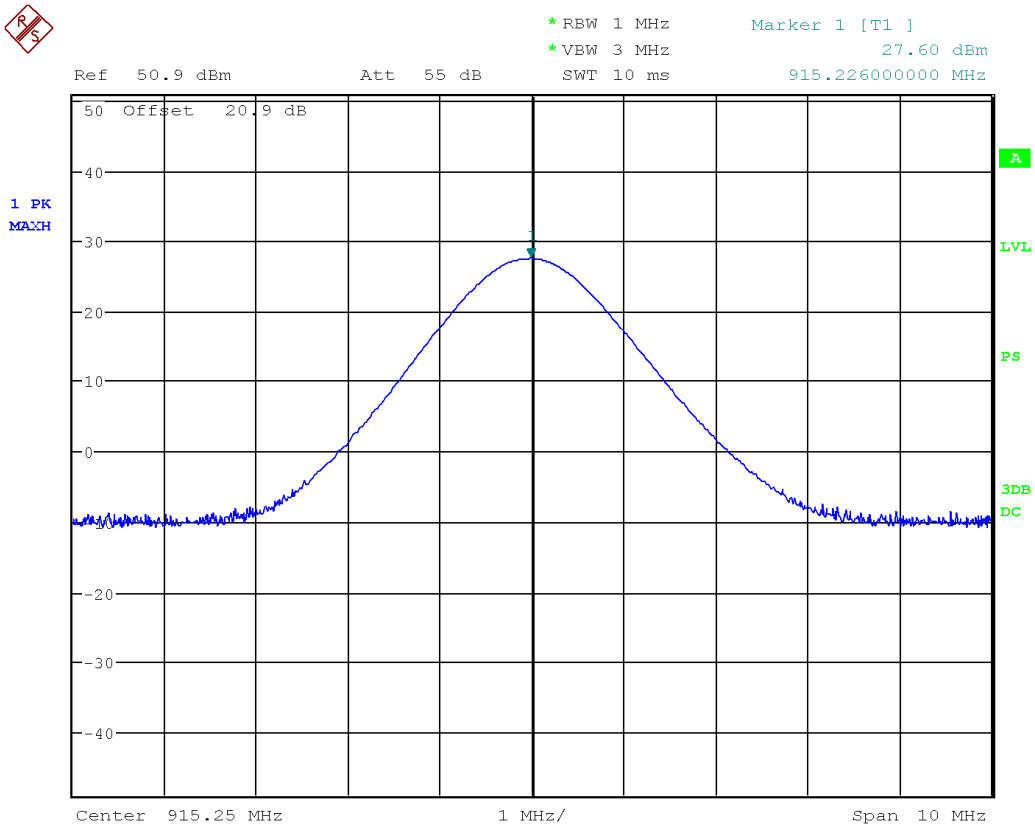
Date: 8.MAY.2023 17:34:00

High Channel (928 MHz)

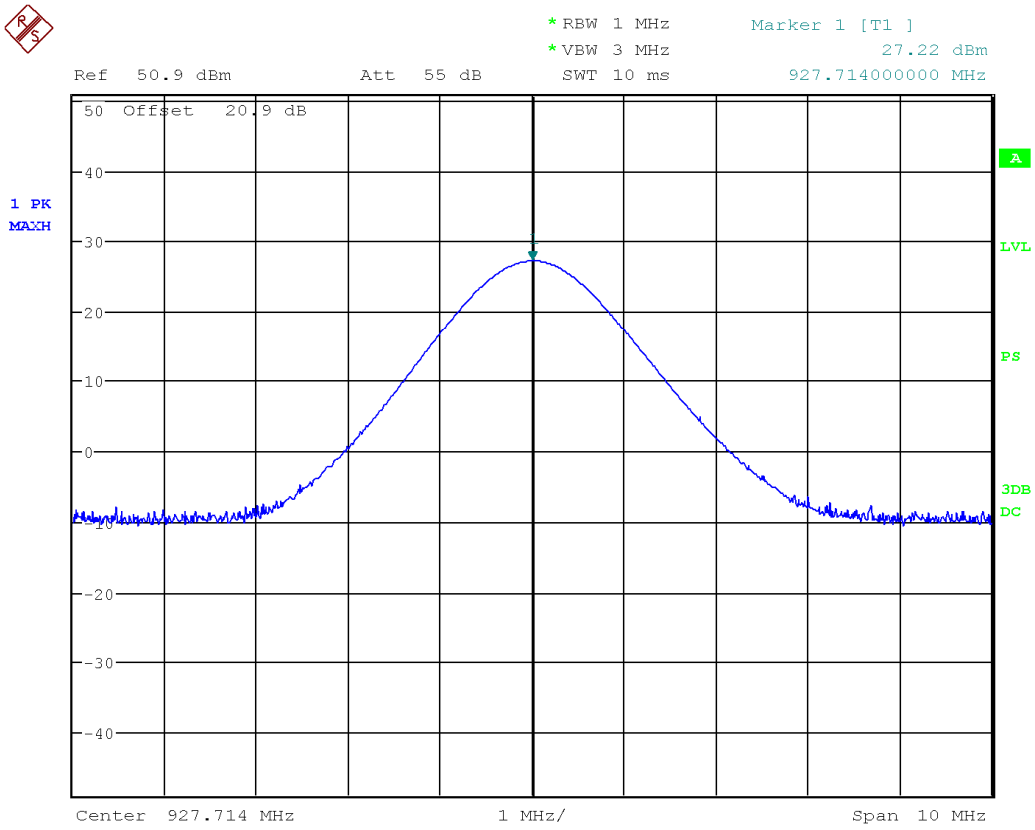
28kbps



Low Channel (902 MHz)

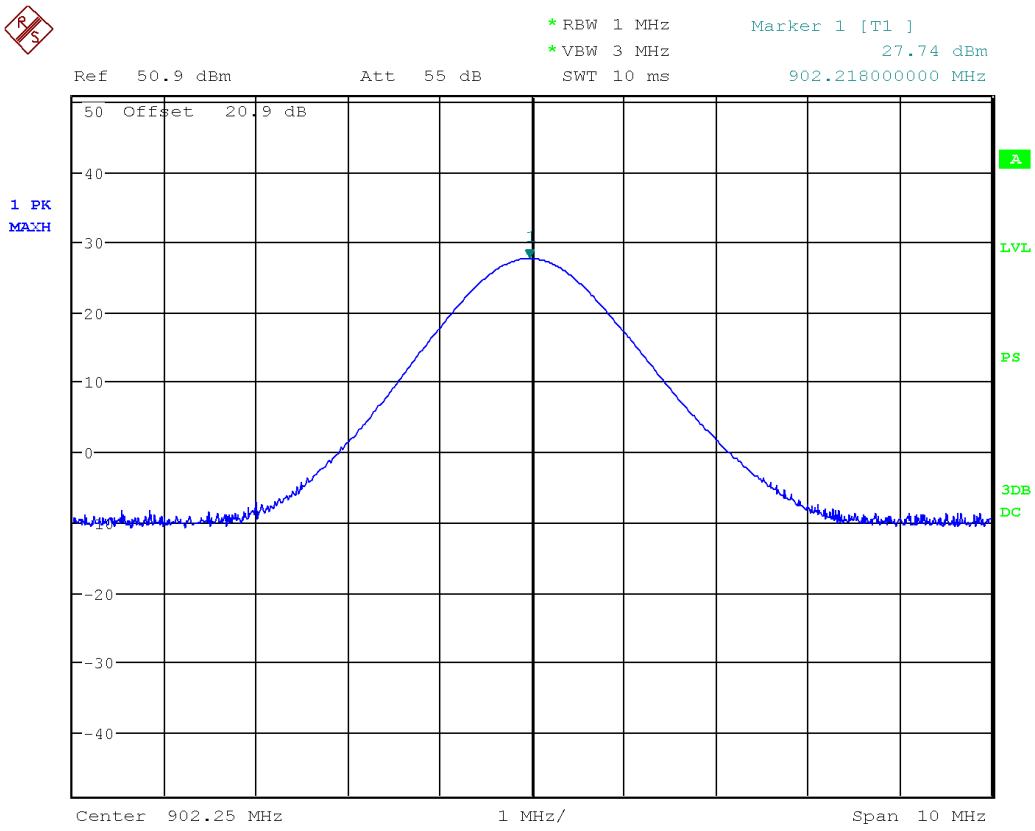


Mid Channel (915 MHz)

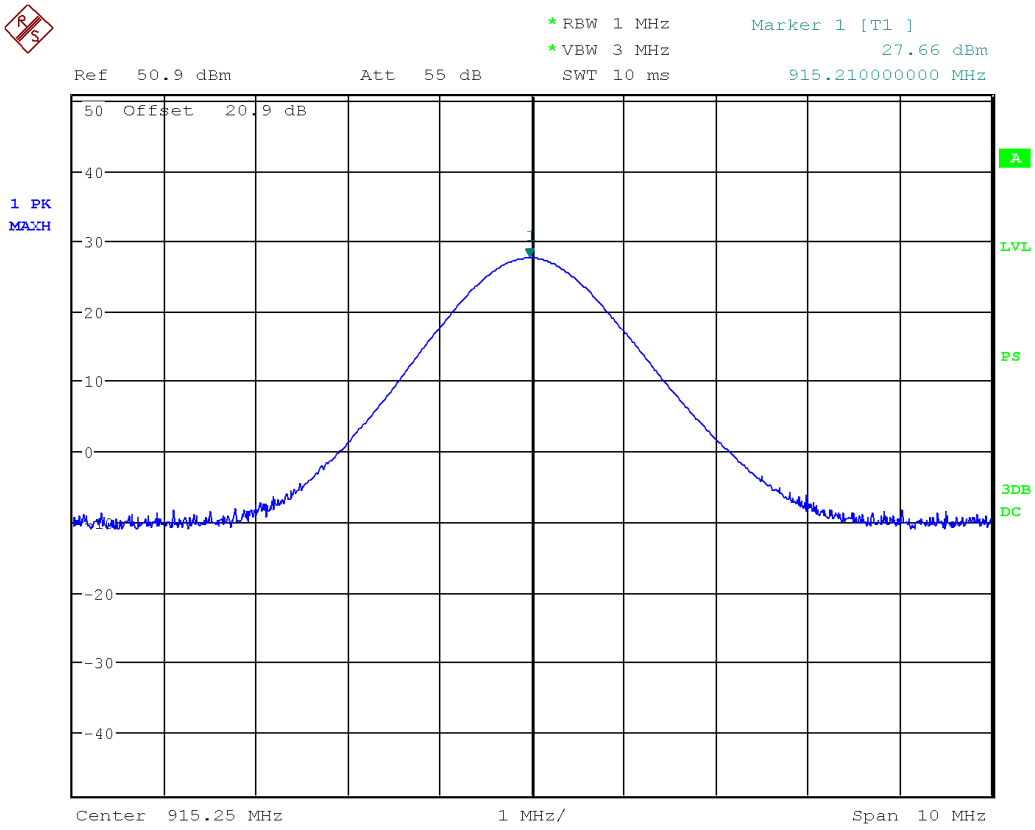


High Channel (928 MHz)

32kbps

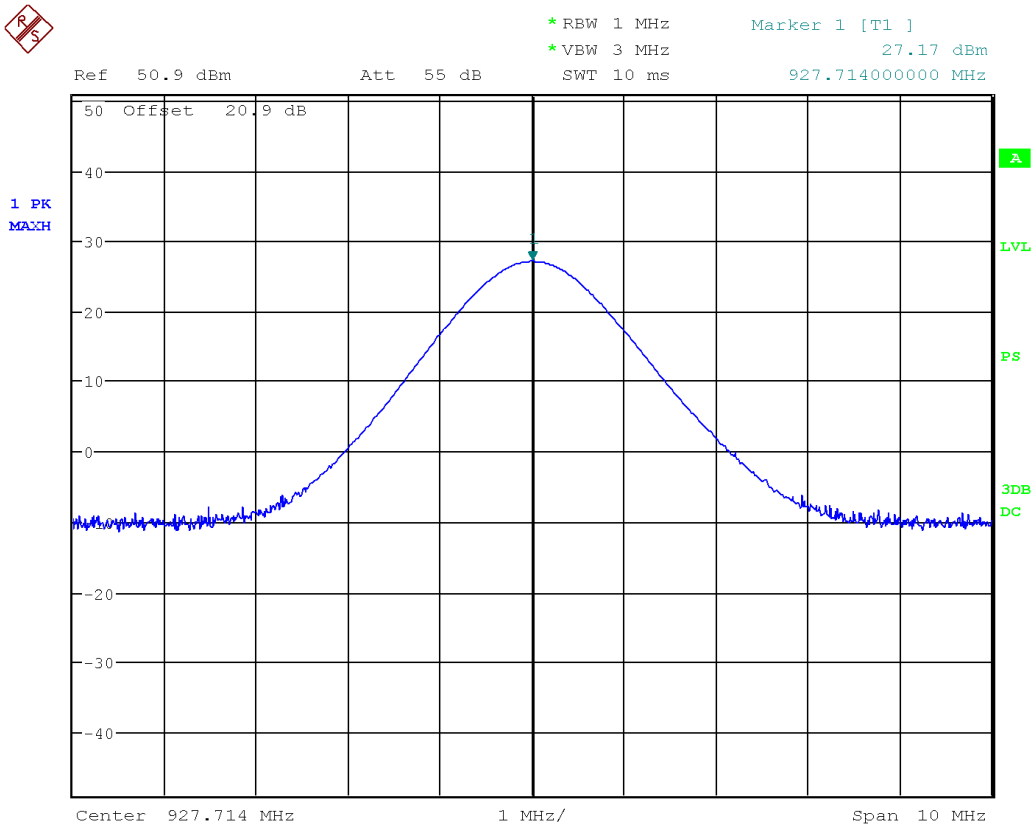


Low Channel (902 MHz)



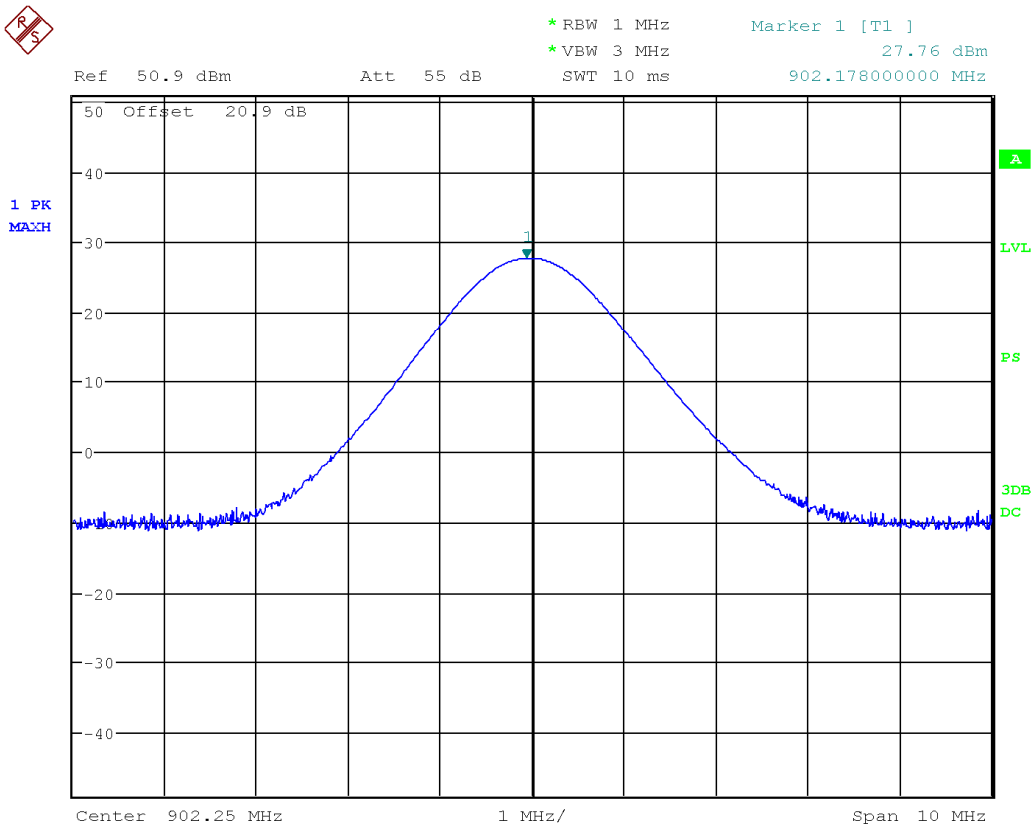
Date: 8.MAY.2023 17:41:10

Mid Channel (915 MHz)

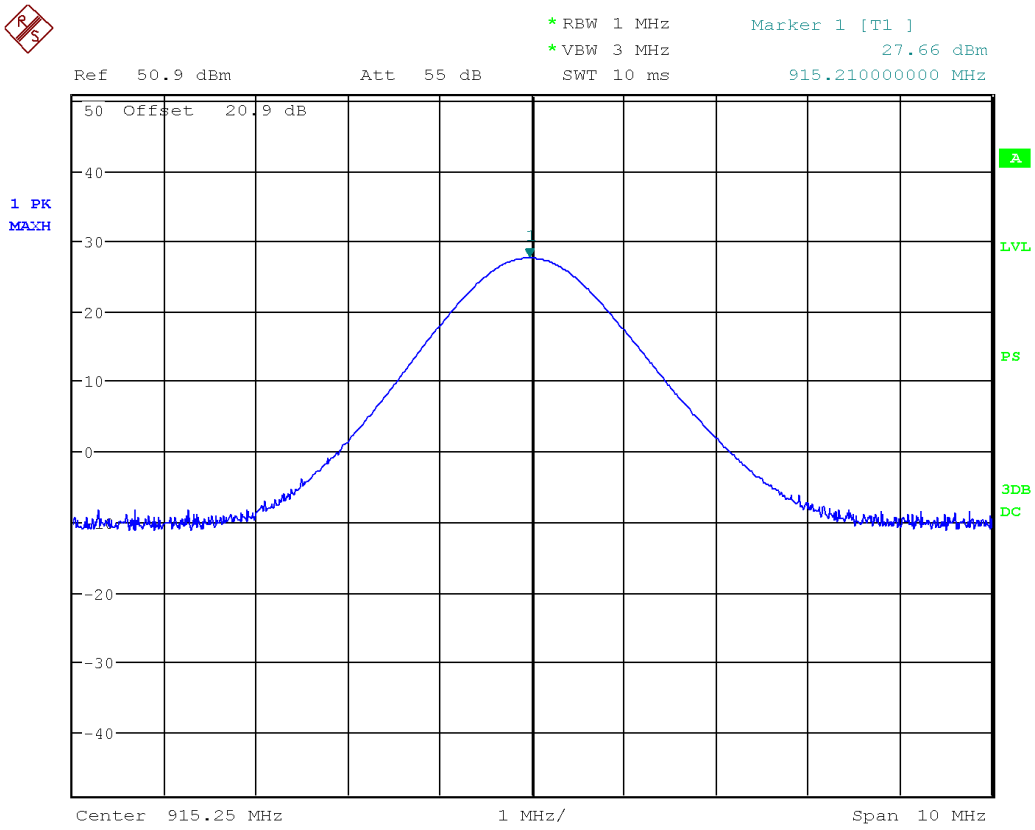


High Channel (928 MHz)

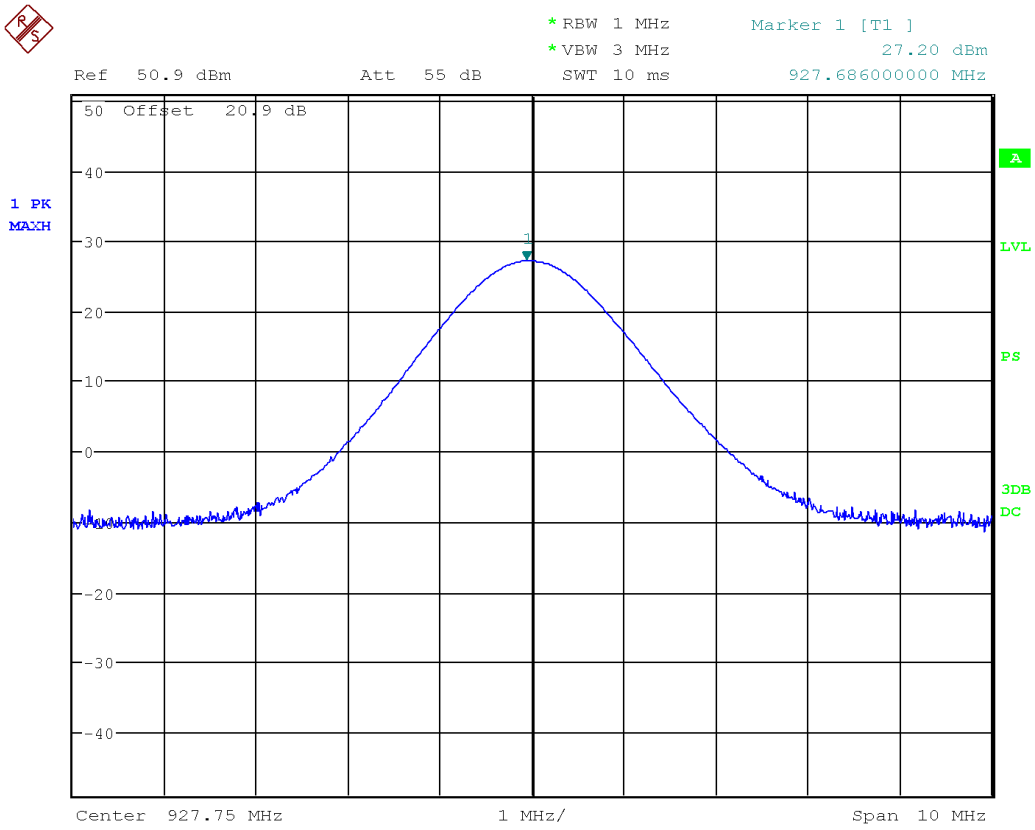
50kbps



Low Channel (902 MHz)



Mid Channel (915 MHz)



High Channel (928 MHz)

Measurement(s)

The graphs shown below shows the peak power output of the device during the antenna conducted measurement during transmit operation of the EUT. The EUT was tested at 4 data rates (19.2, 28, 32, and 50 kbps).

19.2kbps

Channel	Frequency (MHz)	Peak Power (dBm)	Peak Power (mW)
Low	902.25	27.76	597.04
Mid	915.25	27.64	580.76
High	927.75	27.23	528.45

28kbps

Channel	Frequency (MHz)	Peak Power (dBm)	Peak Power (mW)
Low	902.25	27.72	591.56
Mid	915.25	27.60	575.44
High	927.75	27.22	527.23

32kbps

Channel	Frequency (MHz)	Peak Power (dBm)	Peak Power (mW)
Low	902.25	27.74	594.29
Mid	915.25	27.66	583.45
High	927.75	27.17	521.19

50kbps

Channel	Frequency (MHz)	Peak Power (dBm)	Peak Power (mW)
Low	902.25	27.76	597.04
Mid	915.25	27.66	583.45
High	927.75	27.20	524.81

Note: See ‘Appendix B – EUT & Test Setup Photographs’ for photos showing the test set-up.

Test Equipment List

Equipment	Model No.	Manufacturer	Last Calibration Date	Next Calibration Date	Asset #
Spectrum Analyzer	ESU 40	Rohde & Schwarz	Feb. 11, 2022	Feb. 11, 2024	GEMC 233
20dB Attenuator (100W)	6N100W-20F	Inmet	NCR	NCR	GEMC 352

Antenna Spurious Conducted Emissions

Purpose

The purpose of this test is to ensure that the maximum power conducted to the radiating element at frequencies outside of the authorized spectrum does not exceed the limits specified. This ensures that the only the intended signal is delivered to the radiating element.

Limits and Method

The limits are defined in 15.247(d) and RSS-247 5.5. In any 100 kHz band, the peak spurious harmonics emissions must be at least 20 dB below the fundamental. Spurious Conducted emissions are to be evaluated up to the 10^{th} harmonic. This -20 dBc requirement also applies at the 'band edge'.

The method is given in FCC KDB 558074 Section 11 and ANSI C63.10.

Results

The EUT passed. The measurement of Antenna Conducted Spurious Emissions was taken in the worst-case configuration of the EUT, based on the RF Conducted Output Power, which was found to be the 19.2kbps data rate while operating in the low channel of 902MHz, and is presented as a graph for the spectrum.

The -20 dBc requirement is also shown for the lower band edge at 902 MHz in the low band and for the higher band edge at 928 MHz in the high band. Band edge testing was performed with the transmitter in hopping mode and with hopping mode turned off. The Band edge testing was repeated for the lowest and highest data rates.

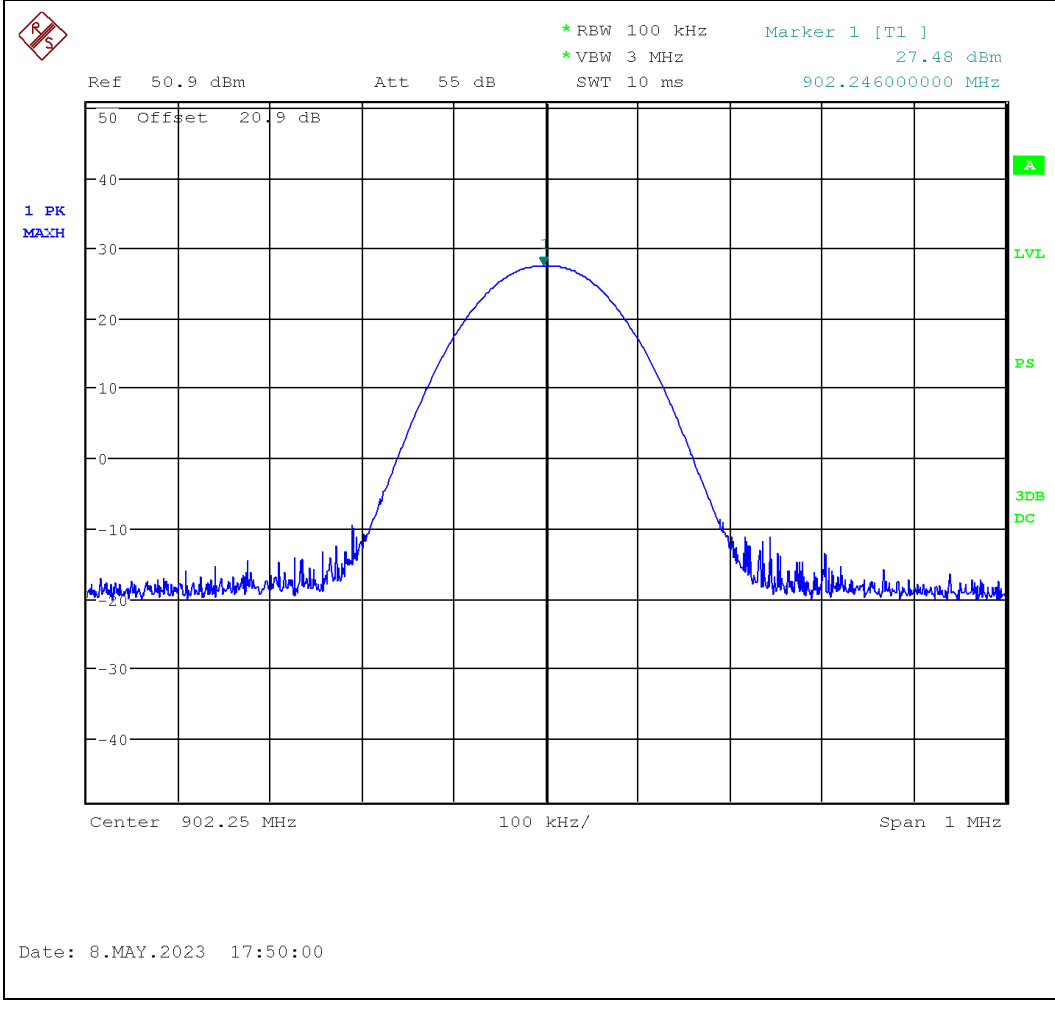
Graphs

The graphs shown below show the power output of the device during the conducted measurement operation of the EUT.

19.2kbps

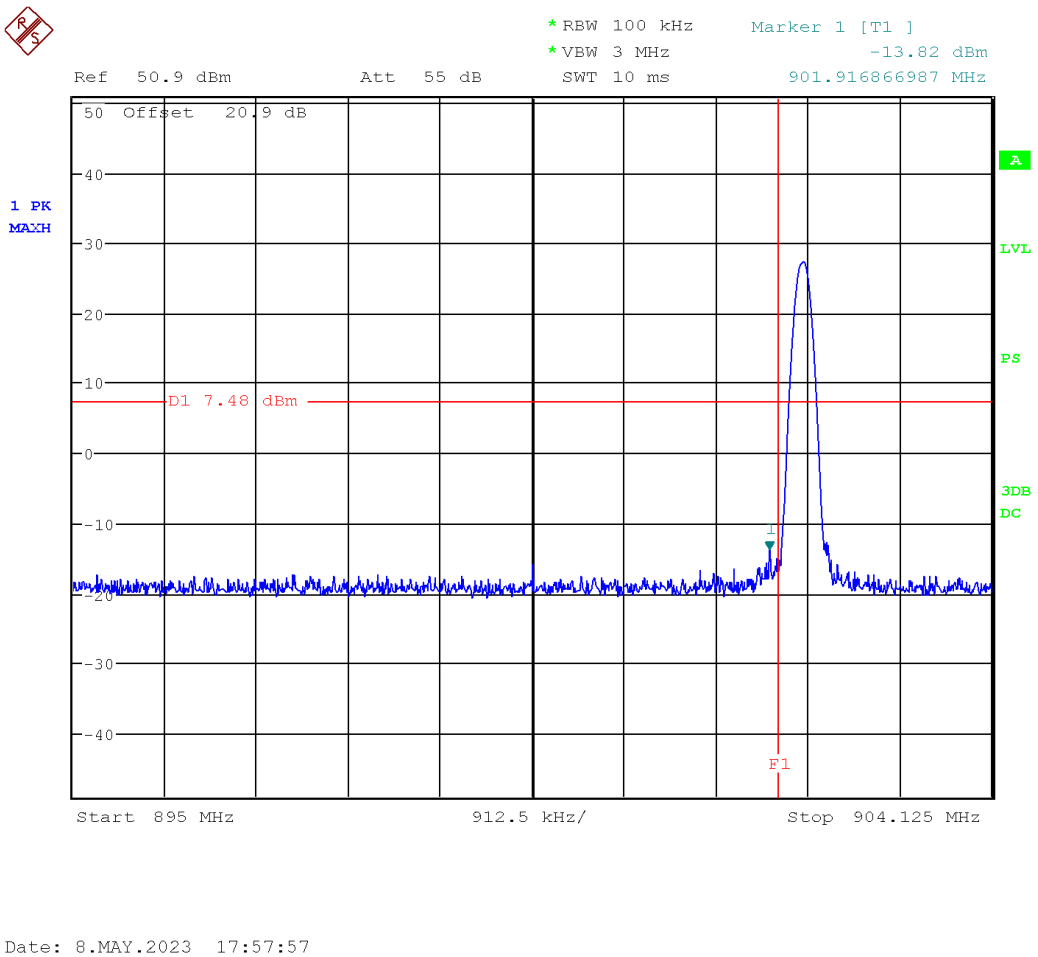
-20dBc – Low Channel

Reference Level: 27.48 dBm



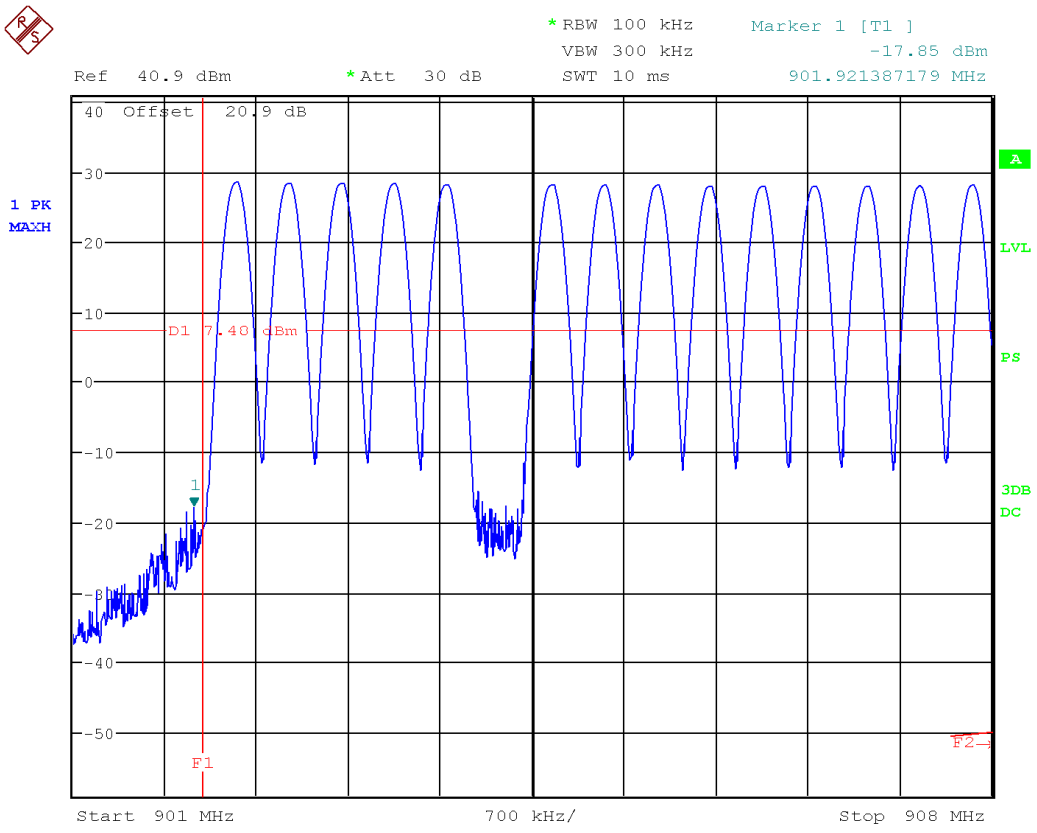
-20dBc – Low Channel

902 MHz Band Edge – Single Channel



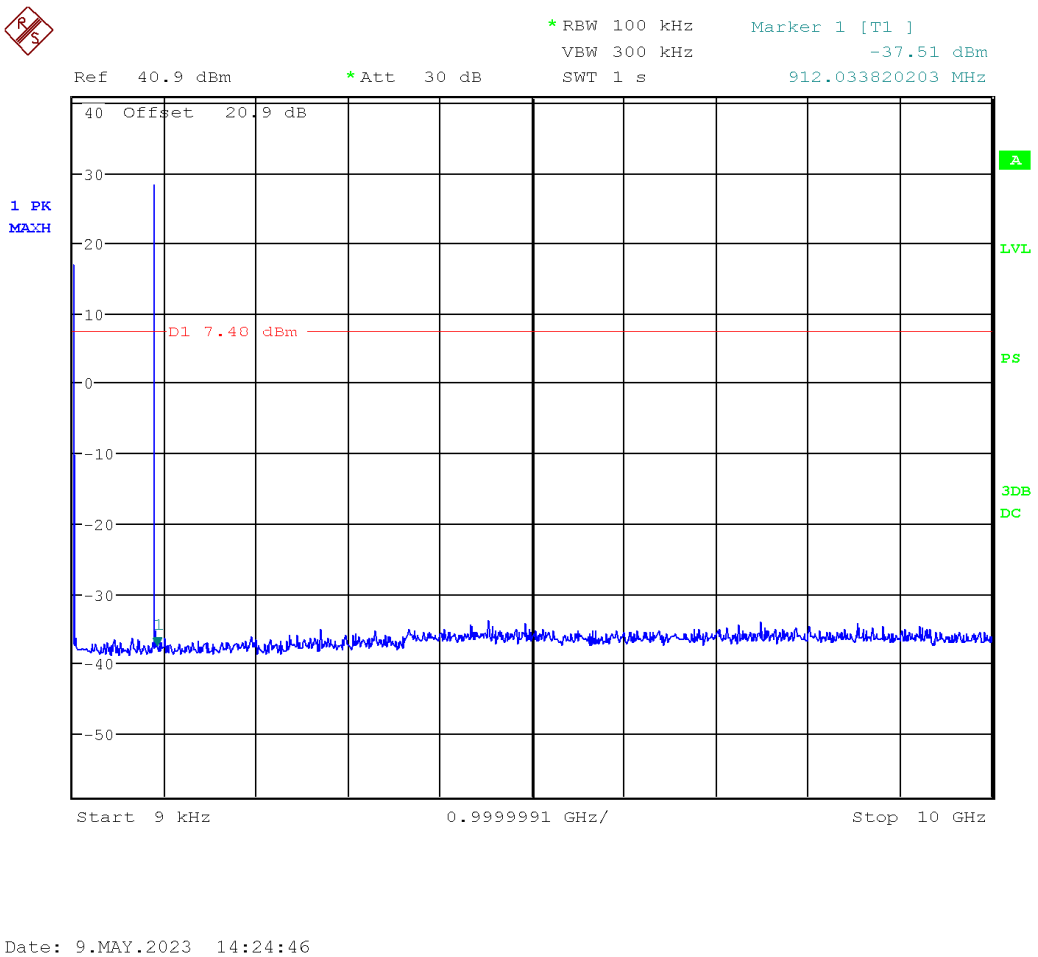
-20dBc – Low Channel

902 MHz Band Edge - Hopping



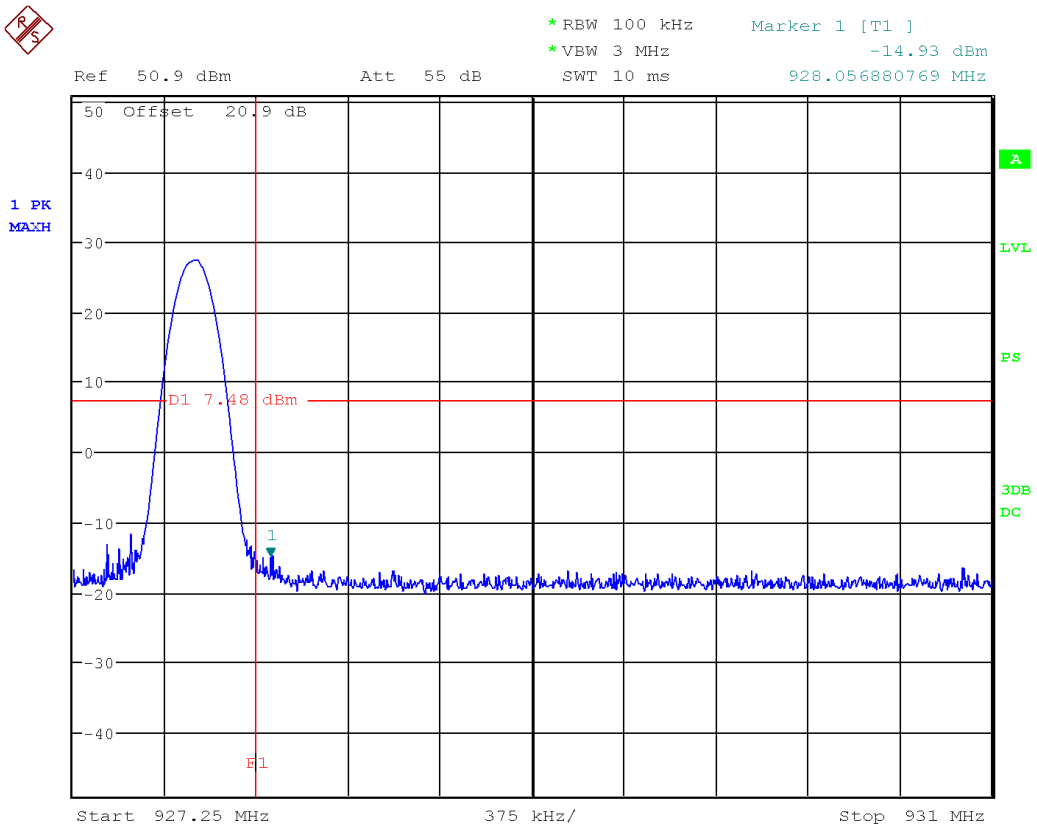
-20dBc – Low Channel

9kHz – 10GHz



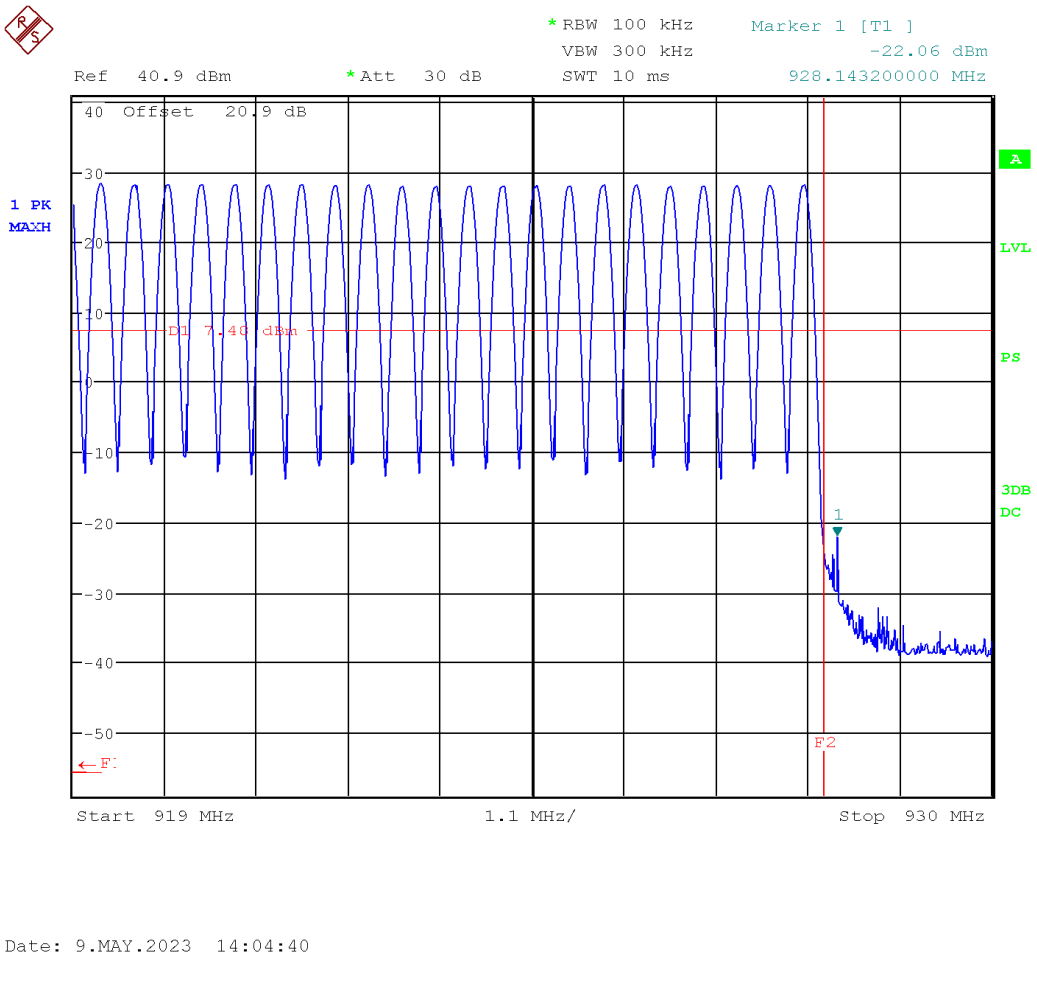
-20dBc – High Channel

928 MHz Band Edge – Single Channel



-20dBc – High Channel

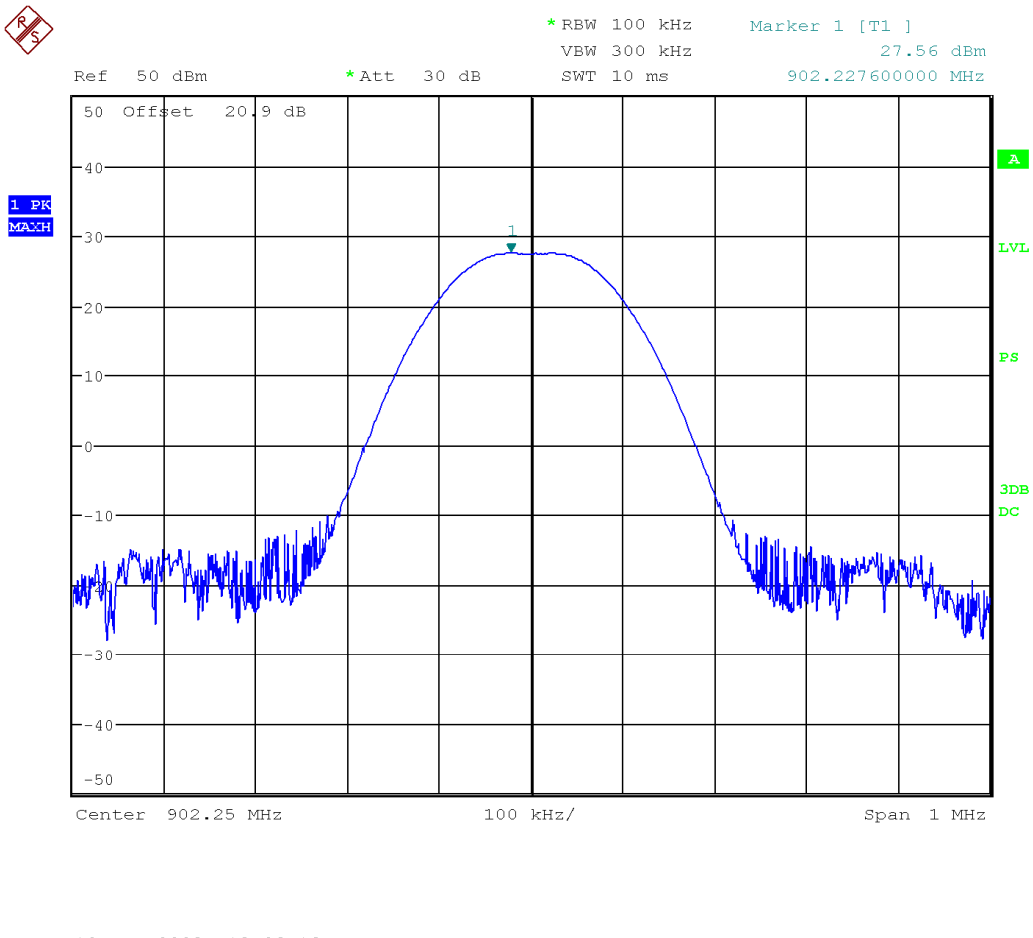
928 MHz Band Edge – Hopping



50kbps

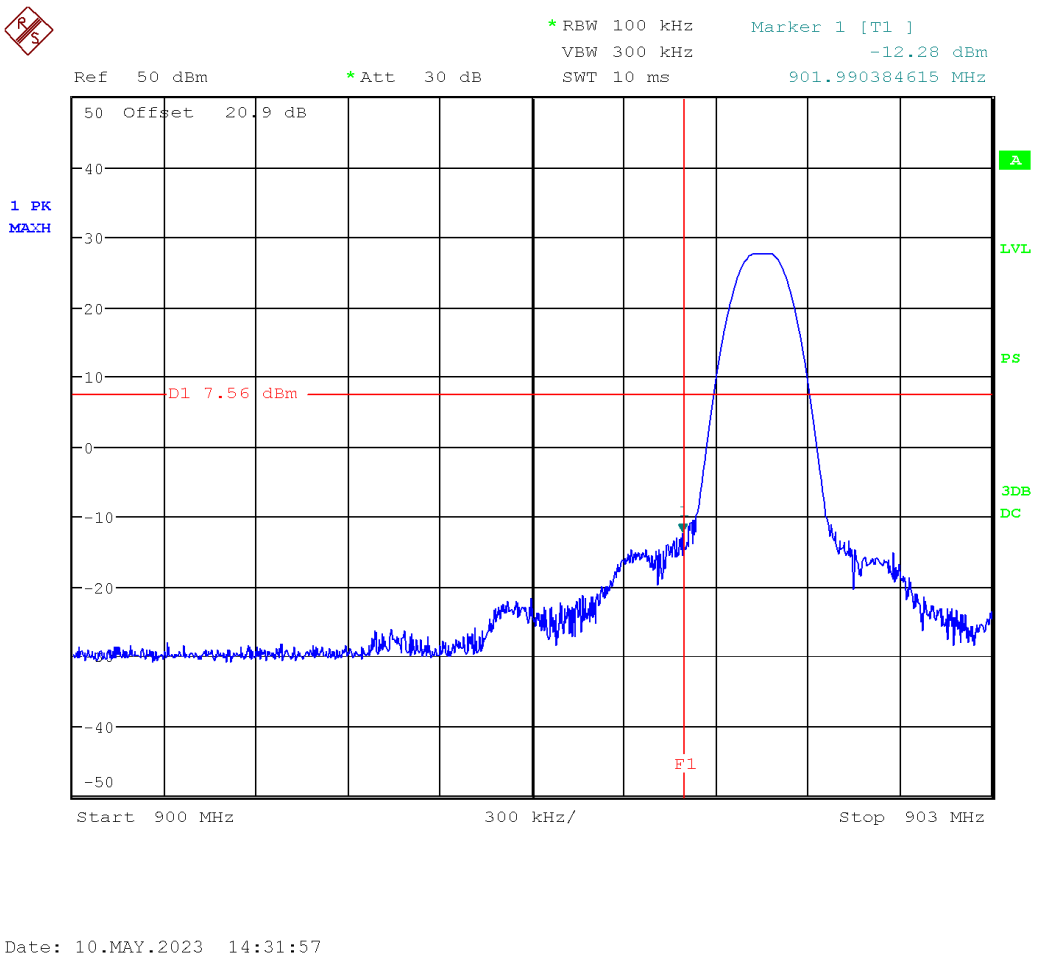
-20dBc – High Channel

Reference Level: 27.56 dBm



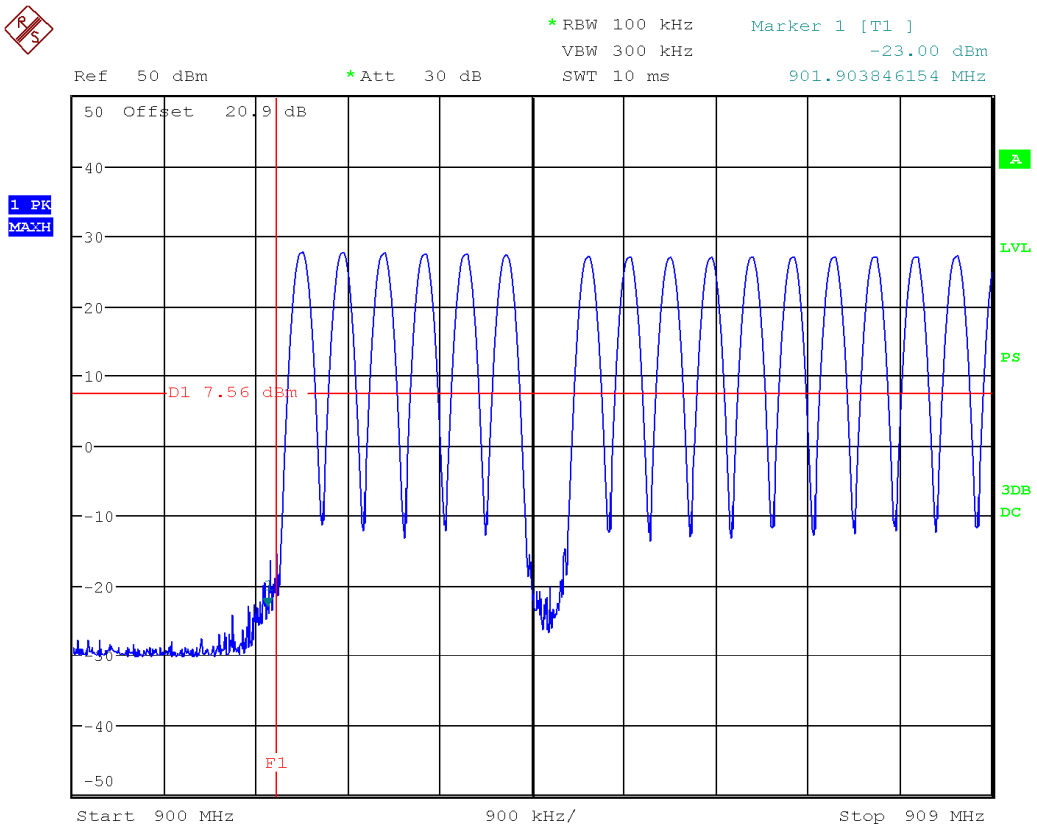
-20dBc – Low Channel

902 MHz Band Edge – Single Channel



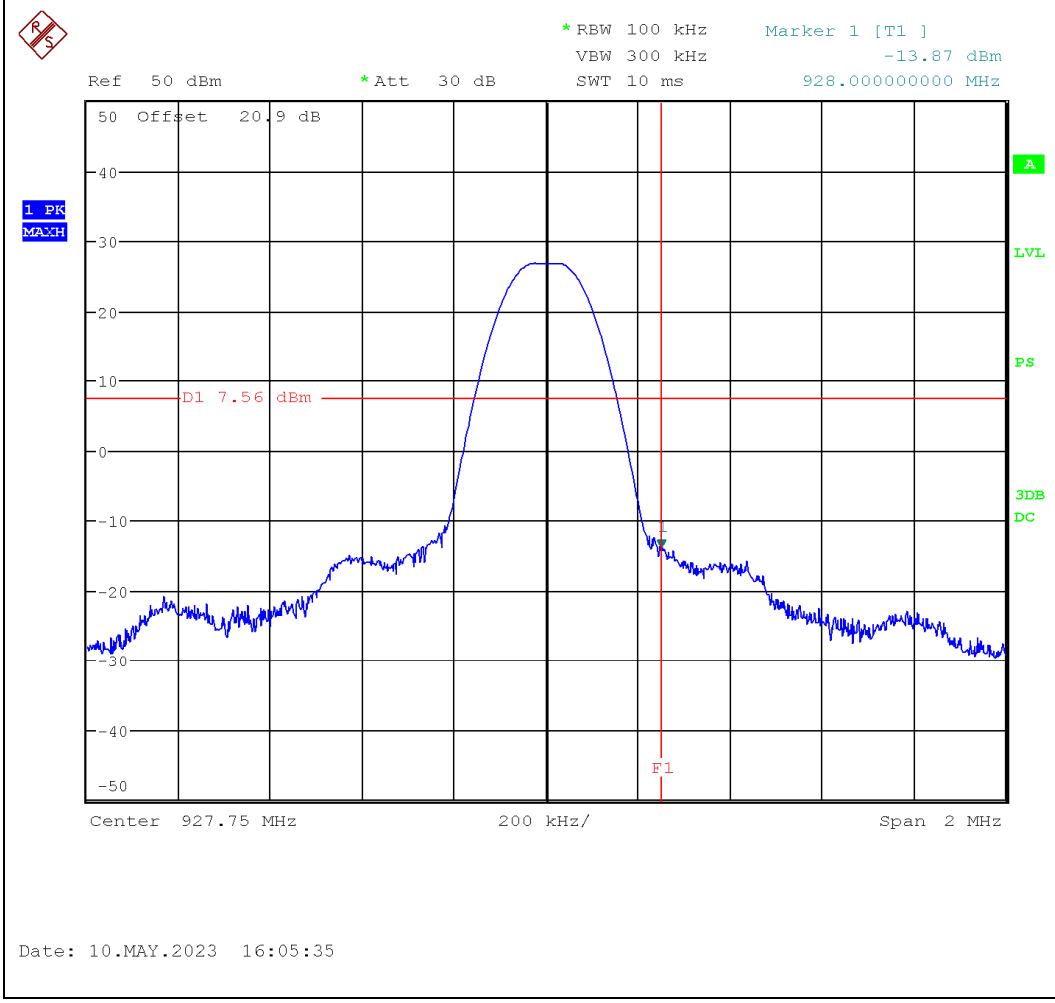
-20dBc – Low Channel

902 MHz Band Edge – Hopping



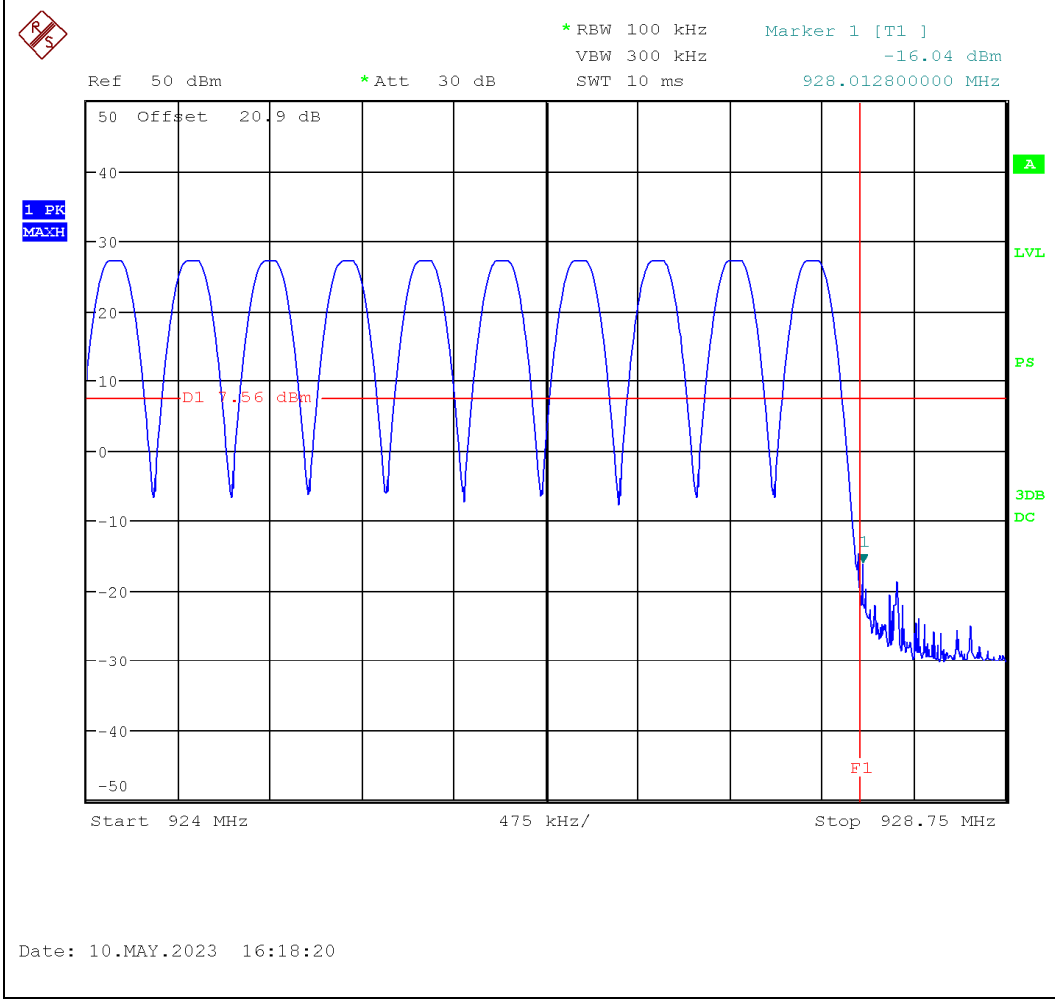
-20dBc – High Channel

928 MHz Band Edge – Single Channel



-20dBc – High Channel

928 MHz Band Edge – Hopping



See 'Appendix B – EUT and Test Setup Photos' for photos showing the test set-up.

Test Equipment List

Equipment	Model No.	Manufacturer	Last Calibration Date	Next Calibration Date	Asset #
Spectrum Analyzer	ESU 40	Rohde & Schwarz	Feb. 11, 2022	Feb. 11, 2024	GEMC 233
20dB Attenuator (100W)	6N100W-20F	Inmet	NCR	NCR	GEMC 352

Transmitter Spurious Radiated Emissions

Purpose

The purpose of this test is to ensure that the RF energy unintentionally emitted from the EUT does not exceed the limits listed below as defined in the applicable test standard, as measured from a receiving antenna. This helps protect broadcast radio services such as television, FM radio, pagers, cellular telephones, emergency services, and so on, from unwanted interference.

Limits and Method

The method is as defined in FCC KDB 558074 Section 12.2 and ANSI C63.10.

The limits, as defined in 15.247(d) for unintentional radiated emissions, apply for those emissions that fall in the restricted bands, as defined in Section 15.205(a). These emissions must comply with the radiated emission limits specified in Section 15.209(a).

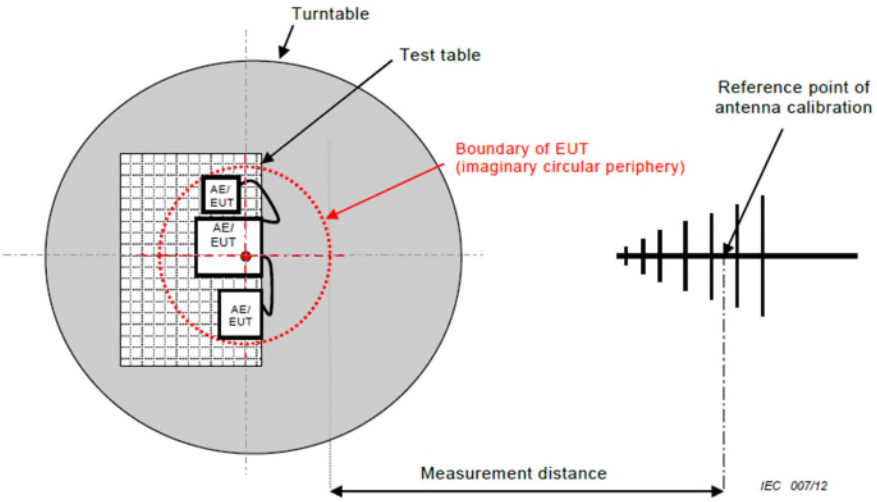
All unintentional emissions must also meet the 'Spurious Conducted Emissions' requirements of -30 dBc or greater. See also 'Antenna Spurious Conducted Emissions' for further details.

Frequency	Field Strength Limit (µV/m)	Field Strength at 3m (dBµV/m)
0.009 MHz – 0.490 MHz	2400/F(kHz) [a] (at 300m)	128.5 to 93.8[a]
0.490 MHz – 1.705 MHz	24000/F(kHz)[a] (at 30m)	73.8 to 63.0[a]
1.705 MHz – 30 MHz	30[a] (at 30m)	69.5[a]
30 MHz – 88 MHz	100[a] (at 3m)	40.0[a]
88 MHz – 216 MHz	150[a] (at 3m)	43.5[a]
216 MHz – 960 MHz	200[a] (at 3m)	46.0[a]
Above 960 MHz	500[a] (at 3m)	54.0[a]
Above 1000 MHz	500[b] (at 3m)	54.0[b]
Above 1000 MHz	5 mV/m[c] (at 3m)	74.0[c]

[a]Limit is with Quasi Peak detector with bandwidths as defined in CISPR-16-1-1
[b]Limit is with 1 MHz measurement bandwidth and using an Average detector
[c]Limit is with 1 MHz measurement bandwidth and using a Peak detector

Based on ANSI C63.4 Section 4.2, if the Peak detector measurements do not exceed the Quasi-Peak limits, where defined, then the EUT is deemed to have passed the requirements.

Typical Radiated Emissions Setup



Measurement Uncertainty

The expanded measurement uncertainty is calculated in accordance with CISPR 16-4-2 and is ±5.67dB for 30MHz – 1GHz and ±4.58dB for 1GHz – 18GHz with a 'k=2' coverage factor and a 95% confidence level.

Preliminary Graphs

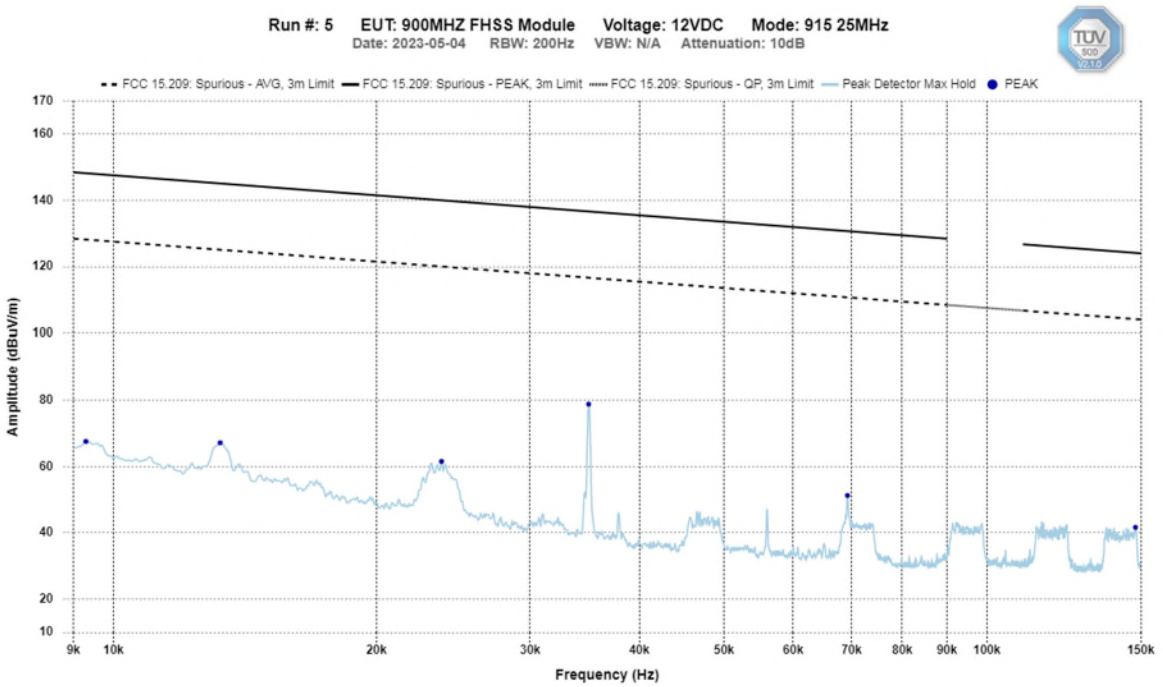
The graphs shown below are maximized peak measurement graphs measured with a resolution bandwidth greater than or equal to the final required detector over a full 0-360°. This peaking process is done as a worst-case measurement and enables the detection of frequencies of concern for final measurement. For final measurements with the appropriate detector, where applicable, please refer to the tables under Final Measurements.

In accordance with FCC Part 15, Subpart A, Section 15.33, the device was scanned to the 10^{th} harmonic (a minimum of 9.28 GHz).

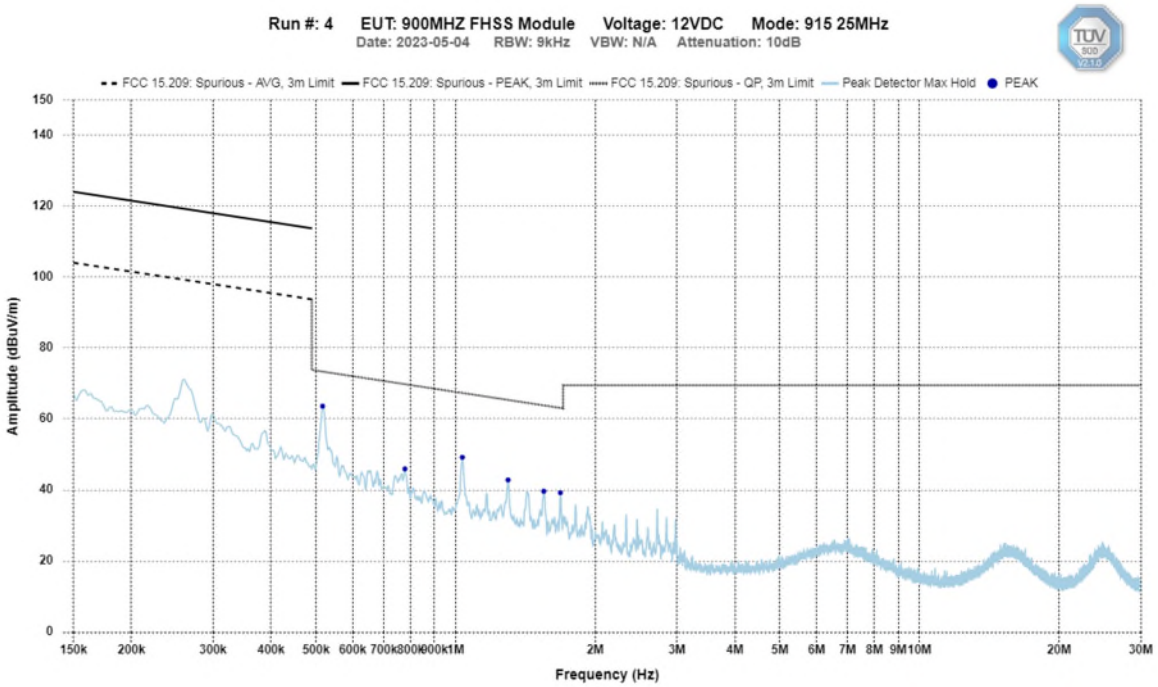
Devices scanned may be scanned at alternate test distances and in accordance with FCC Part 15, Subpart A, Section 15.31, an extrapolation factor of 20 dB/decade was used above 30 MHz and 40 dB/decade below 30 MHz. For example, for 1 meter measurements, an extrapolation factor 9.5 dB from 20 Log (1m / 3m) is applied.

Peak output power for low, middle, and high channels were checked. The worst case was used for the spurious emissions.

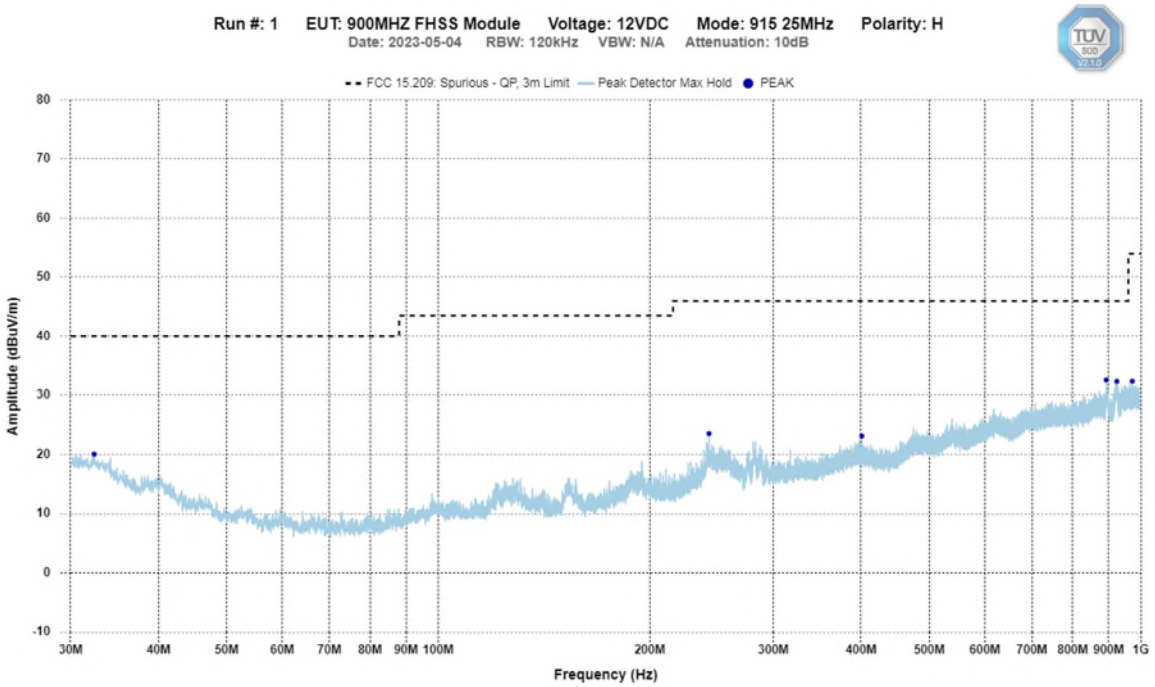
Spurious Emissions



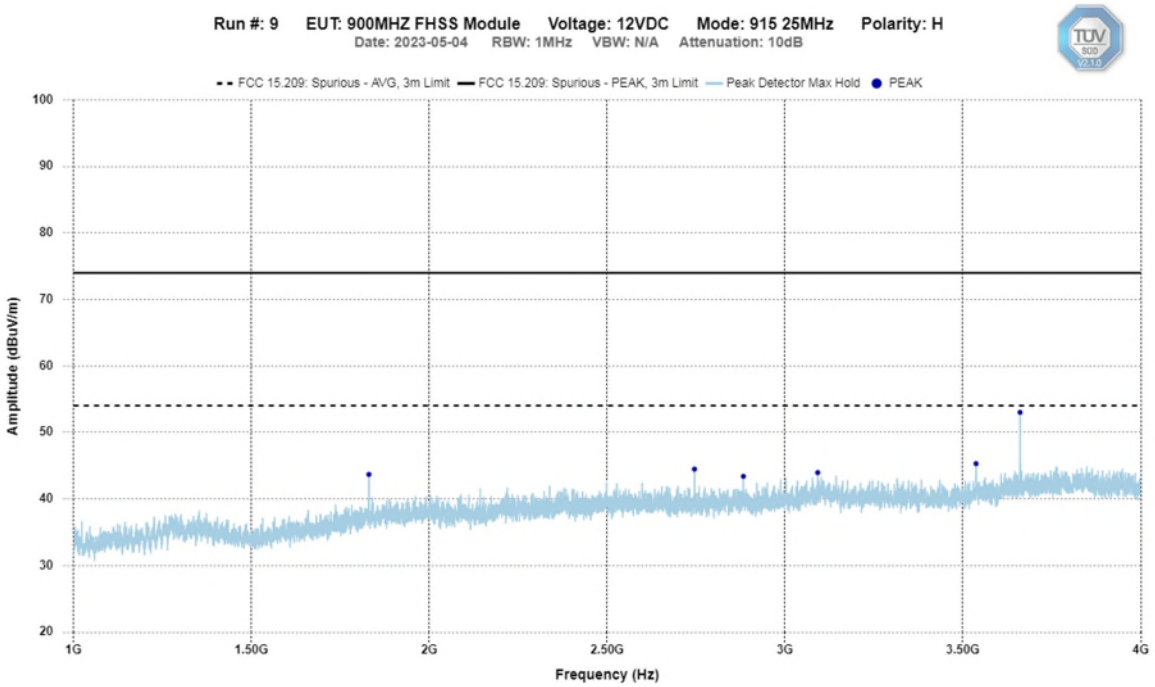
Mid Channel
9 kHz – 150 kHz
Peak Emission Graph



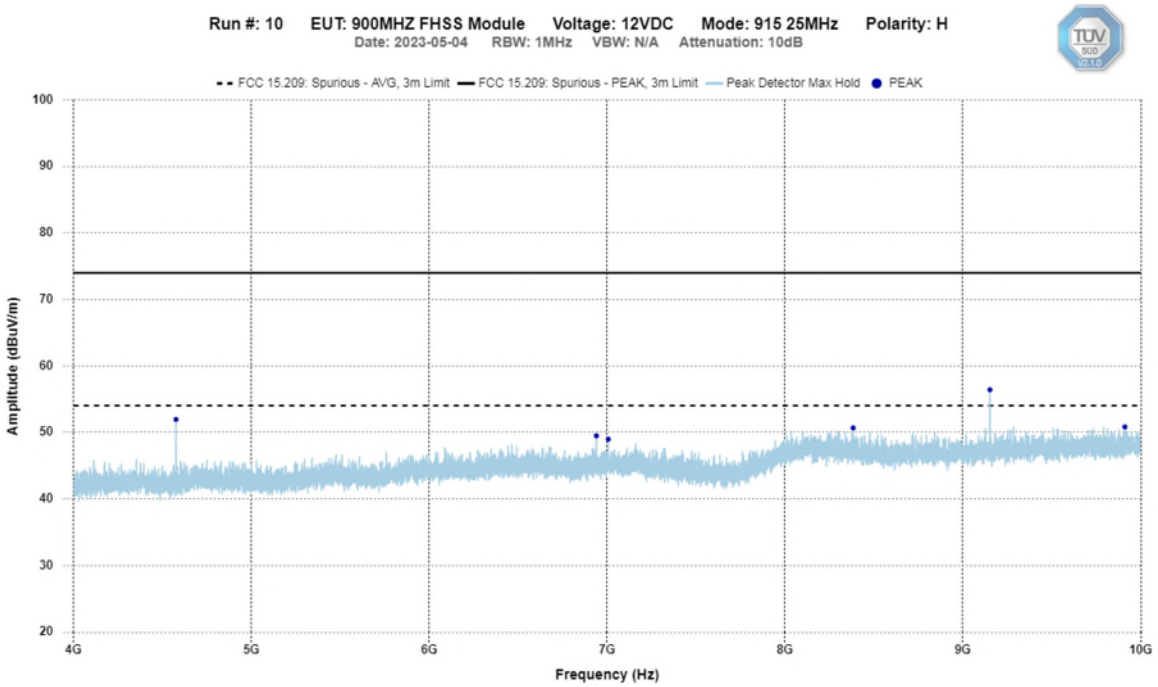
Mid Channel
150 kHz – 30 MHz
Peak Emission Graph



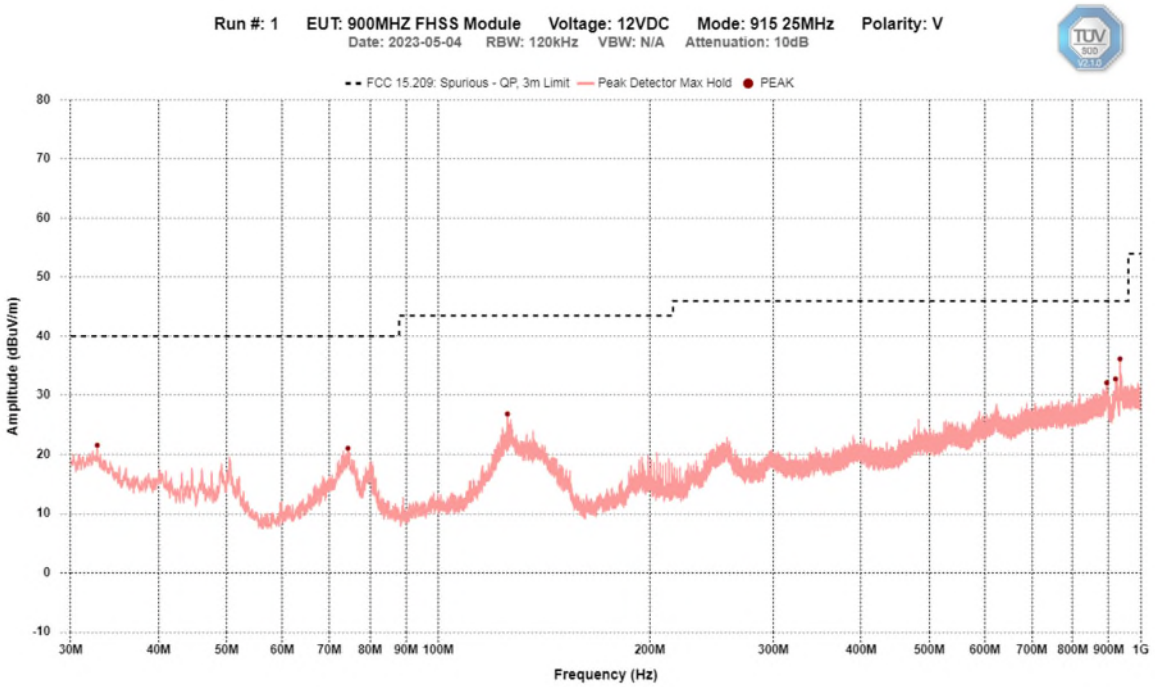
Mid Channel – 30 MHz – 1 GHz
Horizontal - Peak Emission Graph



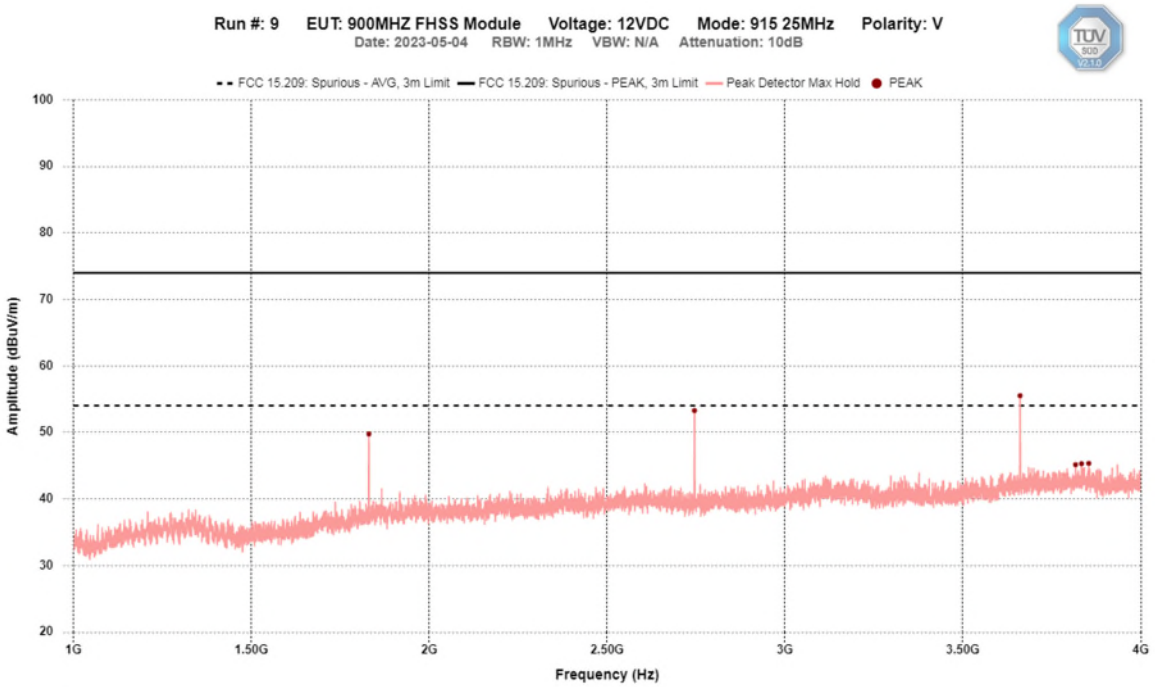
Mid Channel – 1 GHz – 4 GHz
Horizontal - Peak Emission Graph



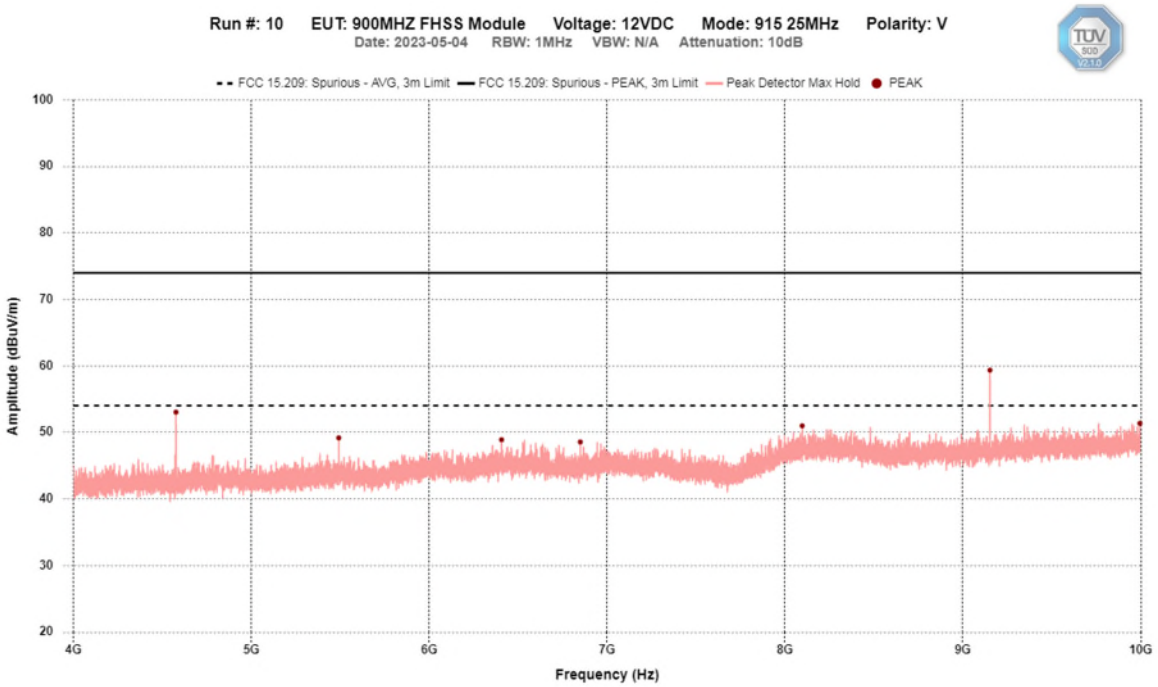
Mid Channel – 4 GHz – 10 GHz
Horizontal - Peak Emission Graph



Mid Channel – 30 MHz – 1 GHz
Vertical - Peak Emission Graph



Mid Channel – 1 GHz – 4 GHz
Vertical - Peak Emission Graph



Mid Channel – 4 GHz – 10 GHz
Vertical - Peak Emission Graph

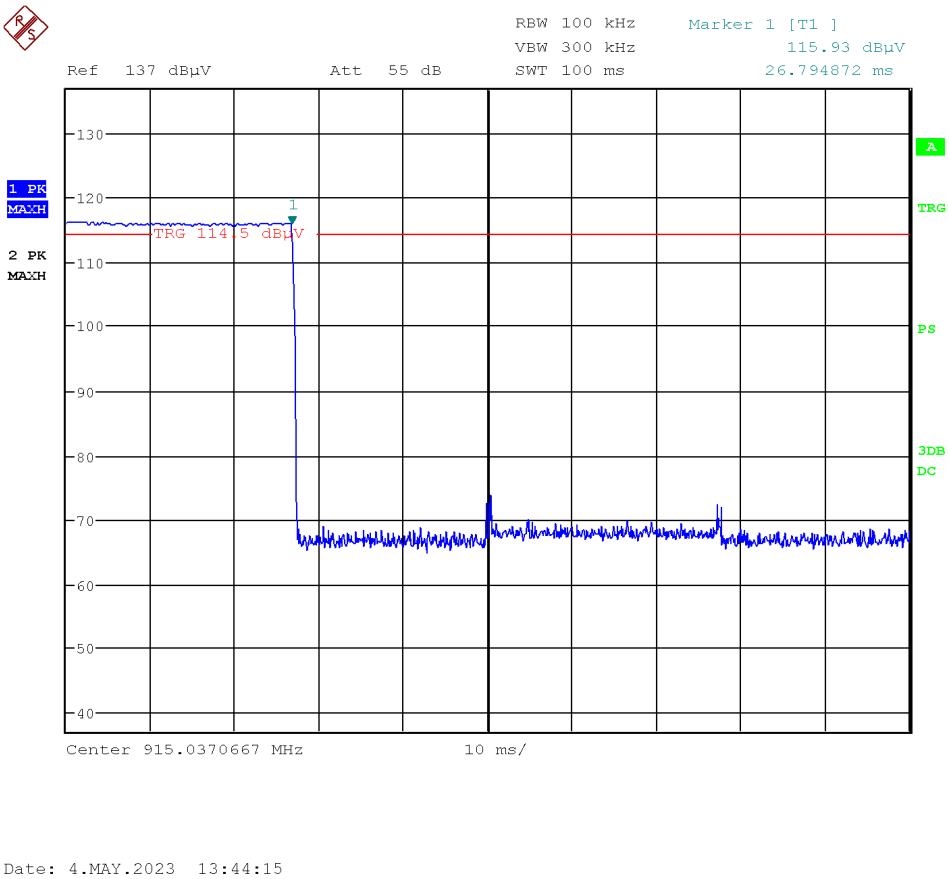
Final Measurements and Results

The EUT passed. Low, middle, and high bands were measured. Final Measurements results are shown for the mid channel as a worst-case scenario.

In accordance with 15.247(d), only frequencies exceeding the 15.209 limit that occur within the bands listed in 15.205 need to be verified with a final detector. Emissions outside the restricted bands were measured for informational purposes.

The measurements were maximized by rotating the turn table over a full 0-360 rotation and the antenna height was varied from 1 m to 4 m.

The Duty Cycle Correction Factor was used to calculate the average value of pulsed emissions as per ANSI C63.10 Clause 7.5. The following graph and sample calculation show how the Duty Cycle Correction Factor is applied to the peak emissions to calculate the average value as recorded in the final measurements table below.



Duty Cycle Measurement

$$Duty\ Cycle\ Correction\ Factor = 20\log\frac{Pulse\ Duration(ms)}{100\ (ms)}$$

$$Duty\ Cycle\ Correction\ Factor = 20\log\frac{26.80\ ms}{100\ ms}$$

$$Duty\ Cycle\ Correction\ Factor = -11.4\ dB$$

$$Average\ Value\ of\ Pulsed\ Emissions = Peak\ Value + Duty\ Cycle\ Correction\ Factor$$

$$Average\ Value\ of\ Pulse\ Emissions\ (3.661GHz) = 53.0\frac{dBuV}{m} - 11.4dB = 41.6\frac{dBuV}{m}$$

Duty Cycle Correction Factor Calculations

EUT Name	900MHZ FHSS Module
Limit	FCC 15.209, Spurious
Power Supply	**12VDC**

Frequency (Hz)	Detector	Correction Factor (dB/m)	Level (dBuV/m)	Duty Cycle Correction Factor (dB)	Corrected AVG Level (dBuV/m)	PEAK Limit (dBuV/m)	AVG Limit (dBuV/m)	PEAK Margin (dB)	AVG Margin (dB)	Test Result
Horizontal										
3.661G	PEAK	4.4	53.0	-11.4	41.6	74.0	54.0	21.0	12.4	Pass
3.537G	PEAK	4.5	45.3	-11.4	33.9	74.0	54.0	28.7	20.1	Pass
2.746G	PEAK	2.2	44.5	-11.4	33.0	74.0	54.0	29.5	21.0	Pass
3.092G	PEAK	4.1	43.9	-11.4	32.5	74.0	54.0	30.1	21.5	Pass
1.831G	PEAK	-1.1	43.7	-11.4	32.2	74.0	54.0	30.3	21.8	Pass
2.883G	PEAK	2.4	43.4	-11.4	31.9	74.0	54.0	30.6	22.1	Pass
9.1525G	PEAK	11.3	56.4	-11.4	44.9	74.0	54.0	17.6	9.1	Pass
4.57625G	PEAK	5.9	51.9	-11.4	40.5	74.0	54.0	22.1	13.5	Pass
8.3835G	PEAK	10.8	50.7	-11.4	39.2	74.0	54.0	23.3	14.8	Pass
6.93975G	PEAK	8.7	49.5	-11.4	38.0	74.0	54.0	24.5	16.0	Pass
7.007G	PEAK	8.7	49.0	-11.4	37.5	74.0	54.0	25.0	16.5	Pass
9.91125G	PEAK	12.6	50.8	-11.4	39.4	74.0	54.0	23.2	14.6	Pass
Vertical										
3.661G	PEAK	4.4	55.5	-11.4	44.1	74.0	54.0	18.5	9.9	Pass
2.74575G	PEAK	2.1	53.3	-11.4	41.8	74.0	54.0	20.7	12.2	Pass
1.8305G	PEAK	-1.0	49.7	-11.4	38.3	74.0	54.0	24.3	15.7	Pass
3.854G	PEAK	5.2	45.3	-11.4	33.9	74.0	54.0	28.7	20.1	Pass
3.83375G	PEAK	5.3	45.3	-11.4	33.9	74.0	54.0	28.7	20.1	Pass
3.817G	PEAK	5.3	45.1	-11.4	33.7	74.0	54.0	28.9	20.3	Pass
9.1525G	PEAK	11.4	59.3	-11.4	47.9	74.0	54.0	14.7	6.1	Pass
4.57625G	PEAK	5.8	53.0	-11.4	41.6	74.0	54.0	21.0	12.4	Pass
9.99525G	PEAK	12.9	51.3	-11.4	39.9	74.0	54.0	22.7	14.1	Pass
8.09725G	PEAK	11.1	51.0	-11.4	39.5	74.0	54.0	23.0	14.5	Pass
5.49175G	PEAK	7.6	49.2	-11.4	37.7	74.0	54.0	24.8	16.3	Pass
6.40675G	PEAK	9.2	48.9	-11.4	37.4	74.0	54.0	25.1	16.6	Pass
6.84975G	PEAK	8.8	48.6	-11.4	37.1	74.0	54.0	25.4	16.9	Pass

Peak and Average Emissions Table

Test Equipment List

Equipment	Model No.	Manufacturer	Last Calibration / Verification Date	Next Calibration / Verification Date	Asset #
Spectrum Analyzer	ESU 40	Rohde & Schwarz	Feb. 11, 2022	Feb. 11, 2024	GEMC 233
BiLog Antenna	3142-C	ETS-Lindgren	Dec. 7, 2022	Dec. 7, 2024	GEMC 8
Horn Antenna 1 – 18 GHz	3117	ETS-Lindgren	Mar. 11, 2022	Mar. 11, 2024	GEMC 340
Band Reject Filter	BRC50722	Micro-Tronics	NCR	NCR	GEMC 186
0.98 GHz High pass filter	8IH40-980/T3750	K & L Microwave	NCR	NCR	GEMC 4256
4GHZ-12GHz High Pass filter	11SH10-4000/T12000-0/0	K & L Microwave	NCR	NCR	GEMC 119
Attenuator 6 dB	612-6-1	Meca Electronics, Inc	NCR	NCR	GEMC 287
Pre-Amp 9 kHz – 1 GHz	CPA9230	Chase	Sept. 16, 2022	Sept 16, 2024	GEMC 301
Pre-Amp 1 – 26.5 GHz	HP 8449B	HP	Mar. 11, 2022	Mar. 11, 2024	GEMC 189
RF Cable <1GHz	LMR-400	LexTec	NCR	NCR	GEMC 274
RF Cable <1GHz	Sucoflex 104A	Huber+Suhner	NCR	NCR	GEMC 271
RF Cable >1GHz	EMC2	MegaPhase	NCR	NCR	GEMC 369
Emissions Software	V2.1.0	TUV SUD Canada, Inc.	NCR	NCR	GEMC 361

Appendix A – EUT Summary

For further details for filing purposes, refer to filing package.

General EUT Description

Client Details	
Organization / Address	AARCOMM Systems Inc.
Contact	Leonard Dueckman
Phone	1.604.889.2677
Email	len.dueckman@aarcomm.com
EUT (Equipment Under Test) Details	
EUT Name	RM2-900 MRTR Wireless Radio Module
EUT Model / SN	RM2-900MRTR
EUT revision	New product
EUT is powered using	Battery
Input voltage range(s) (V)	+7 to 40 VDC
Frequency range(s) (Hz)	902-928 MHz
Rated input current (A)	250 mA @ 24 VDC
Nominal power consumption (W)	2.5W max

Note the EUT is considered to have been received the date of the commencement of the first test, unless otherwise stated. For a close-up picture of the EUT, see 'Appendix B – EUT and Test Setup Photos'.

Appendix B – EUT and Test Setup Photos

Refer to the files separate from this test report