RF Test Report

As per

RSS-137 Issue 2:2009
&
FCC Part 90 Subpart M

Location and Monitoring Service (LMS)
Operation in the 902 -928 MHz Band

on the

MPR 4.1
Model: 802890

Issued by: **TÜV SÜD Canada Inc.**
11 Gordon Collins Dr,
Gormley, ON, L0H 1G0
Canada
Ph: (905) 883-7255

Prepared by

Min Xie,
Sr. EMC/RF Engineer

Reviewed by

Raymond Au,
Project Engineer

Testing produced for

See Appendix A for full client & EUT details.

Innovation, Science and Economic Development Canada
Registration # 6844A-3

Testing Laboratory Certificate #2955.02

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

Registration # CA6844

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Report Scope

This report addresses the EMC verification testing and test results of the Kapsch TrafficCom Canada Inc.'s **MPR 4.1, Model: 802890** and is herein referred to as EUT (Equipment Under Test). The EUT was tested for compliance against the following standards:

RSS-137 Issue 2:2009

FCC Part 90 Subpart M

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

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

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:	MPR 4.1 Model: 802890
FCC Certification #, FCC ID:	JQU802890
ISED Canada Certification #, IC:	2665A-802890
EUT passed all tests performed	Yes
Tests conducted by	Min Xie
Review By	Raymond Au

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

Test Results Summary

Standard/Method	Description	Limit	Result
FCC 90.205 RSS-137 Clause 6.4	Output Power	30 W	Pass
FCC 90.207 RSS-137 Clause 6.2	Types of Modulation	--	Pass See Justifications
FCC 90.209 RSS-137 Clause 6.1.2	Occupied Bandwidth	902 - 904 MHz: 2 MHz 909.75 – 921.75 MHz 12 MHz	Pass
FCC 90.210 (K) RSS-137 Clause 6.5.3	Spurious antenna port conducted emissions	Attenuation By: 55 + 10 $\log_{10}(P_{max})$ dB.	Pass
FCC 90.210 RSS-137 Clause 6.5.3	Spurious radiated emissions	Attenuation By: 55 + 10 $\log_{10}(P_{max})$ dB.	Pass
FCC 90.213 RSS-137 Clause 6.3	Frequency stability	2.5 ppm	Pass
FCC 90.214	Transient Behavior	--	N/A See Justifications
Overall Result			**Pass**

All tests were performed by Min Xie.

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:

The EUT supports the following 6 protocols: KTDM, ATA, SeGo, 6B, 6C, and T21

1. Kapsch Time Division Multiplex (TDM), hereafter referred to as the “KTDM” protocol
2. Super eGo® (SeGo)
3. ISO-18000-6C a.k.a. EPC Class 1 Gen 2, hereafter referred to as the “6C” protocol
4. ISO-10374 a.k.a. American Association of Railroads (AAR) S-918, a.k.a. American Trucking Association (ATA), hereafter referred to as the “ATA” protocol
5. ISO-18000-6B, hereafter referred to as the “6B” protocol
6. State of California Code of Regulation (CALTRAN) Title 21 – hereafter referred to as the “T21” protocol

The EUT only transmits a CW signal in ATA mode and the other five protocols uses Shaped ON-OFF Keying to transmit information. According to FCC 90.207, the EUT have two types of emission:

1. N0N for ATA
2. K1D for the other five protocols

For FCC 90.214, the EUT operates in the 902-928 MHz band, and this requirement is not applicable.

For FCC 90.213, the EUT is a fixed non-multilateration transmitter with an authorized bandwidth that is more than 40 kHz from the band edge and therefore is not subject to frequency tolerance restrictions. The test was performed for information purpose.

For the requirements of FCC 90.210 (K) and FCC 2.1053 Measurements required: Field strength of spurious radiation. Spurious radiated emissions of the EUT was performed at 3 meters. The limit specified in FCC 90.210 (K) is: On any frequency outside the licensee’s sub-band edges, the peak power of any emission shall be attenuated by 55 + 10 log(P) where P is the highest emission (Watts) of the transmitter. For all intents and purposes, the limit is -25 dBm ERP. The 3 meter field strength limit for the EUT is given below:

E(dBµV/m) = EIRP(dBm) + 95.2
Where EIRP = ERP + 2.15
E(dBµV/m) = ERP (dBm) + 97.35
E(dBµV/m) = -25 dBm + 97.35 = 72.35 dBuV

This limit is applicable to all emission at 3 meter measurement distance.

Sample Calculation(s)

Radiated Emission Test

Margin = Limit – (Received Signal + Antenna Factor + Cable Loss – Pre-Amp Gain)
Margin = 50.5dBµV/m – (50dBµV + 10dB/m + 2.5dB – 20dB)
Margin = 8.0 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
ANSI C63.26:2015	American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services
CFR 47 FCC Part 2 Subpart J	Code of Federal Regulations – Equipment Authorization Procedure
CFR 47 FCC Part 90	Code of Federal Regulations – Private Land Mobile Radio Services
FCC KDB 412172	D01 Determining ERP and EIRP v01
RSS 137 Issue 2:2009	Spectrum Management and Telecommunications. Radio Standards Specification, Location and Monitoring Service in the Band 902-928 MHz.
RSS-GEN Issue 5 2018	General Requirements and Information for the Certification of Radio Apparatus
ISO 17025:2017	General Requirements for the Competence of Testing and Calibration Laboratories

Document Revision Status

Revision	Date	Description	Initials
Draft	2022-05-06	DRAFT Release	MX
000	2022-05-31	Initial Release	MX

Definitions and Acronyms

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

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

BW – Bandwidth. Unless otherwise stated, this is 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 with a primary function(s) of entry, storage, display, retrieval, transmission, processing, switching, or control, of data.

LISN – Line Impedance Stabilization Network

NCR – No Calibration Required

RF – Radio Frequency

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)
2022-04-27	Radiated Emissions	MX	22.4	16.8	102
2022-04-28	Antenna Conducted Emissions	MX	22.4	13.3	102.4
2022-04-29	Antenna Conducted Emissions	MX	22.2	14.1	102.3
2022-05-02	Frequency Stability	MX	22.4	16.8	102

Detailed Test Results Section

Output Power and Antenna Heights

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 defined in FCC Part 90.205 (l) and RSS 137 Clause 6.4 as per the following paragraph:

902-928 MHz. LMS systems operating pursuant to subpart M of this part in the 902-927.25 MHz band will be authorized a maximum of 30 watts ERP. LMS equipment operating in the 927.25-928 MHz band will be authorized a maximum of 300 watts ERP. ERP must be measured as peak envelope power. Antenna heights will be as specified in §90.353(h).

Results

The EUT passed.

The EUT supports the following 6 protocols: KTDM, ATA, SeGo, 6B, 6C, and T21. Each protocol has its own frequency channels and frequency ranges. Where a protocol has more than one channel, the Low, middle and high channels were measured. The table below gives the results for each protocol.

The ATA, 6B, and 6C protocols operate in both sub-bands allocated for non-multilateral LMS transmitters. Output power for both sub-bands were measured.

Antenna selection varies by application. RF cable loss and fixed attenuations (added inline or manually set inside the unit under control of a commanding reader) is used to compensate for antenna gain so that the ERP is 30 watts or less. See page Tuning Procedure for further details.

Guidance for antenna height requirement and restrictions on setting the conducted output power to meet ERP are given in User Manual.

Table(s)

ATA – 902 – 904 MHz Sub-Band			
Channel	Frequency (MHz)	Power (dBm)	Power (W)
Low Channel	902.50	33.42	2.20
Mid Channel	903.00	34.10	2.57
High Channel	903.50	34.08	2.56
ATA – 909.75 – 921.75 MHz Sub-Band			
Channel	Frequency (MHz)	Power (dBm)	Power (W)
Low Channel	910.00	34.06	2.55
Mid Channel	915.00	33.66	2.33
High Channel	921.50	33.94	2.48

KTDM			
Channel	Frequency (MHz)	Power (dBm)	Power (W)
Channel	915.75	34.24	2.65

SeGO			
Channel	Frequency (MHz)	Power (dBm)	Power (W)
Low Channel	911.00	34.07	2.55
Mid Channel	915.00	34.09	2.54
High Channel	920.00	33.76	2.38

6B – 902 – 904 MHz Sub-Band			
Channel	Frequency (MHz)	Power (dBm)	Power (W)
Channel	903.00	34.14	2.59
6B - 909.75 to 921.75 MHz Sub-Band			
Channel	Frequency (MHz)	Power (dBm)	Power (W)
Low Channel	910.50	34.28	2.68
Mid Channel	915.00	34.24	2.65
High Channel	920.50	34.01	2.52

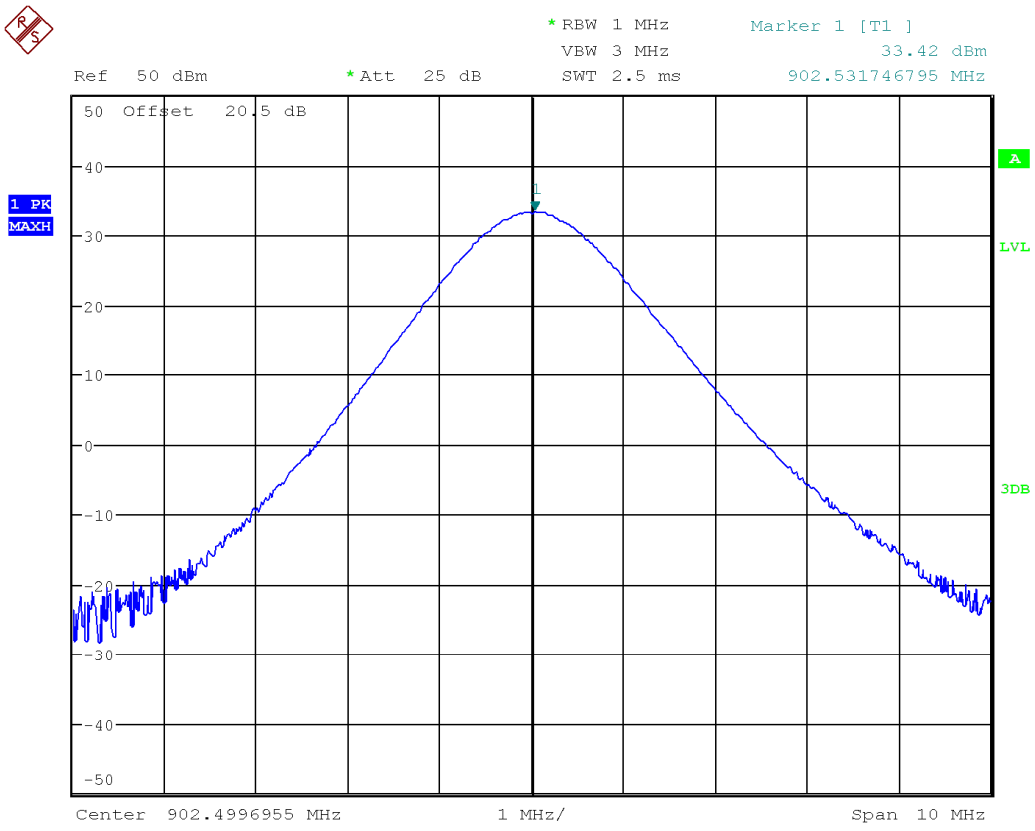
6C – 902 – 904 MHz Sub-Band			
Channel	Frequency (MHz)	Power (dBm)	Power (W)
Channel	903.00	33.97	2.49
6C – 909.75 to 921.75 MHz Sub-Band			
Channel	Frequency (MHz)	Power (dBm)	Power (W)
Low Channel	910.50	34.23	2.65
Mid Channel	915.00	33.92	2.47
High Channel	920.50	33.74	2.36

T21			
Channel	Frequency (MHz)	Power (dBm)	Power (W)
Channel	915.75	33.84	2.42

Graph(s)

The graphs below show the Peak Power during the operation of the device. Measurements were performed using a spectrum analyzer with a Peak detector of 1 MHz RBW / 3 MHz VBW. This measurement is a peak measurement. Max hold is performed for a duration of not less than 1 minute.

ATA – 902 – 904 MHz Sub-Band
Low Channel



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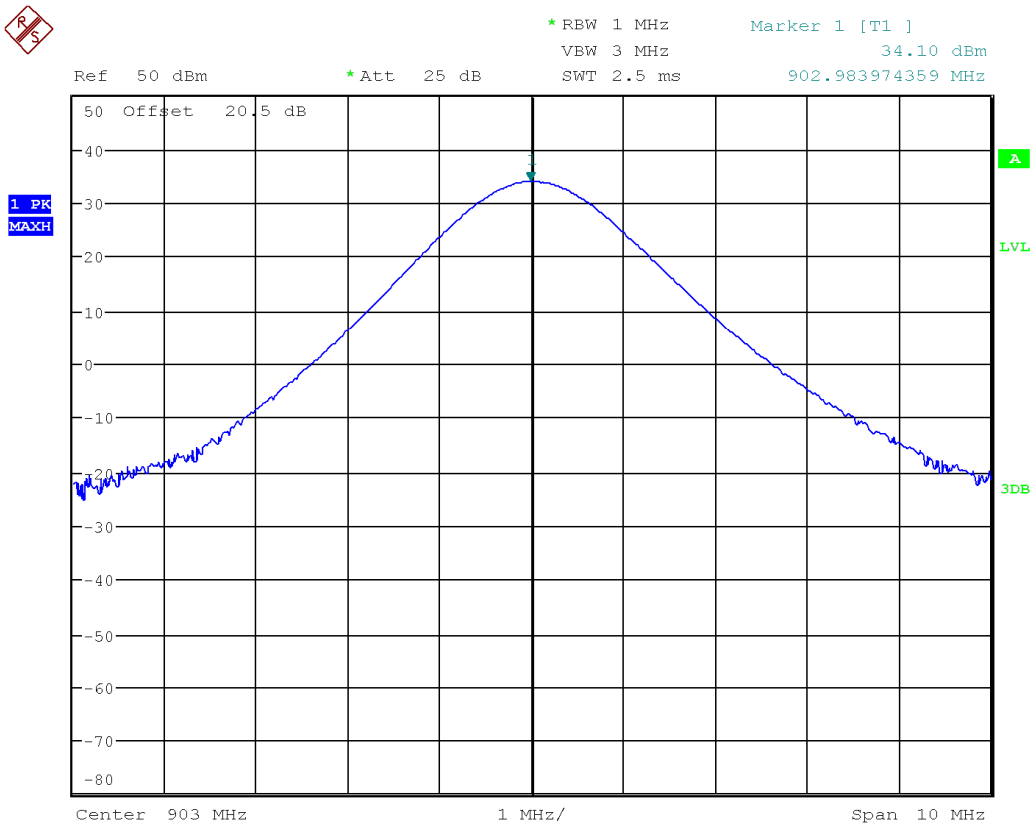
ATA – 902 – 904 MHz Sub-Band
Mid Channel



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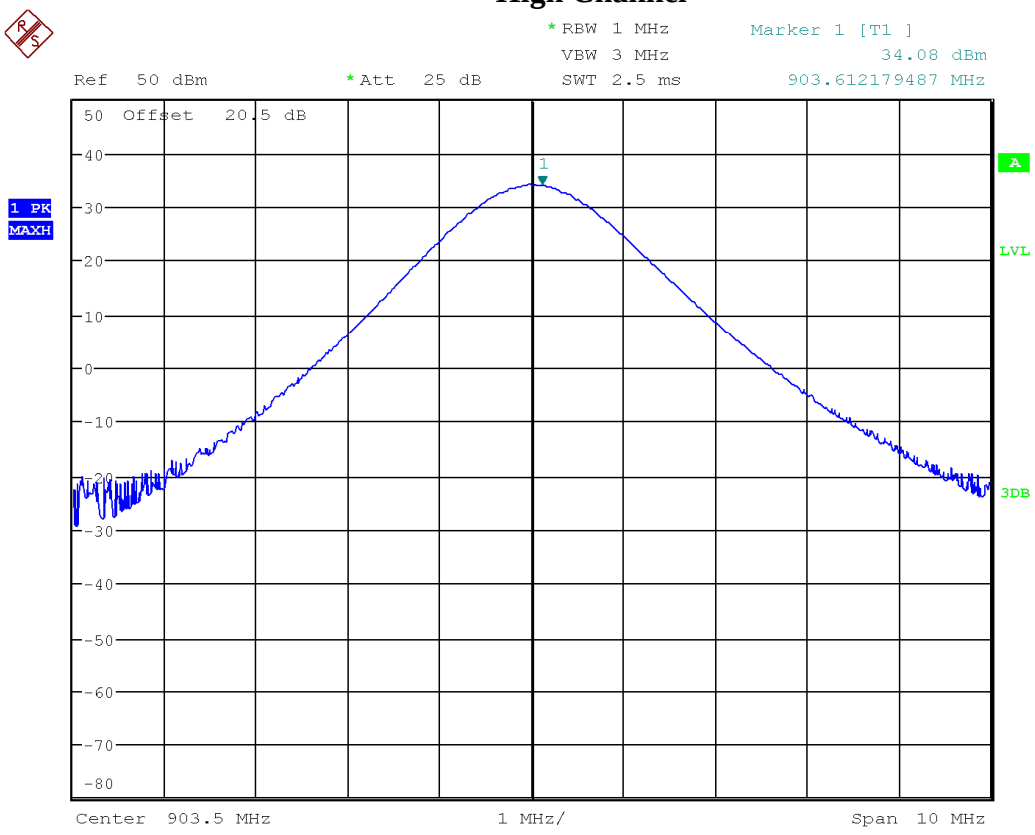
ATA – 902 – 904 MHz Sub-Band
High Channel



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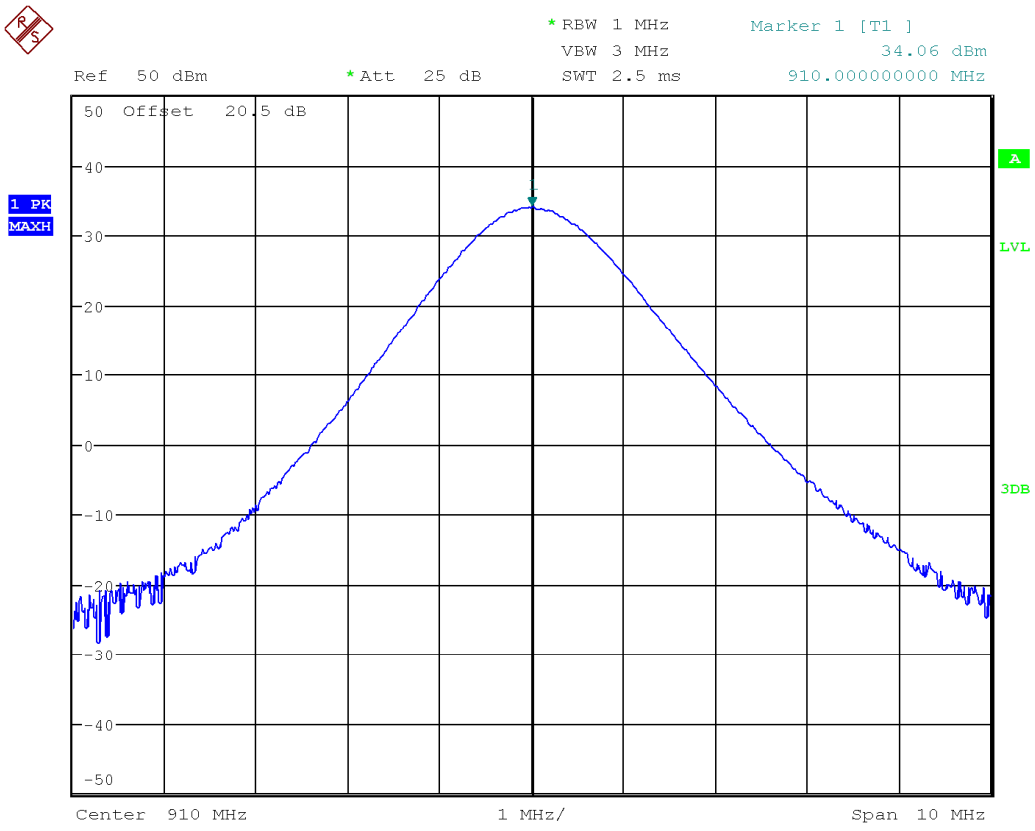
ATA – 909.75 – 921.75 MHz Sub-Band
Low Channel



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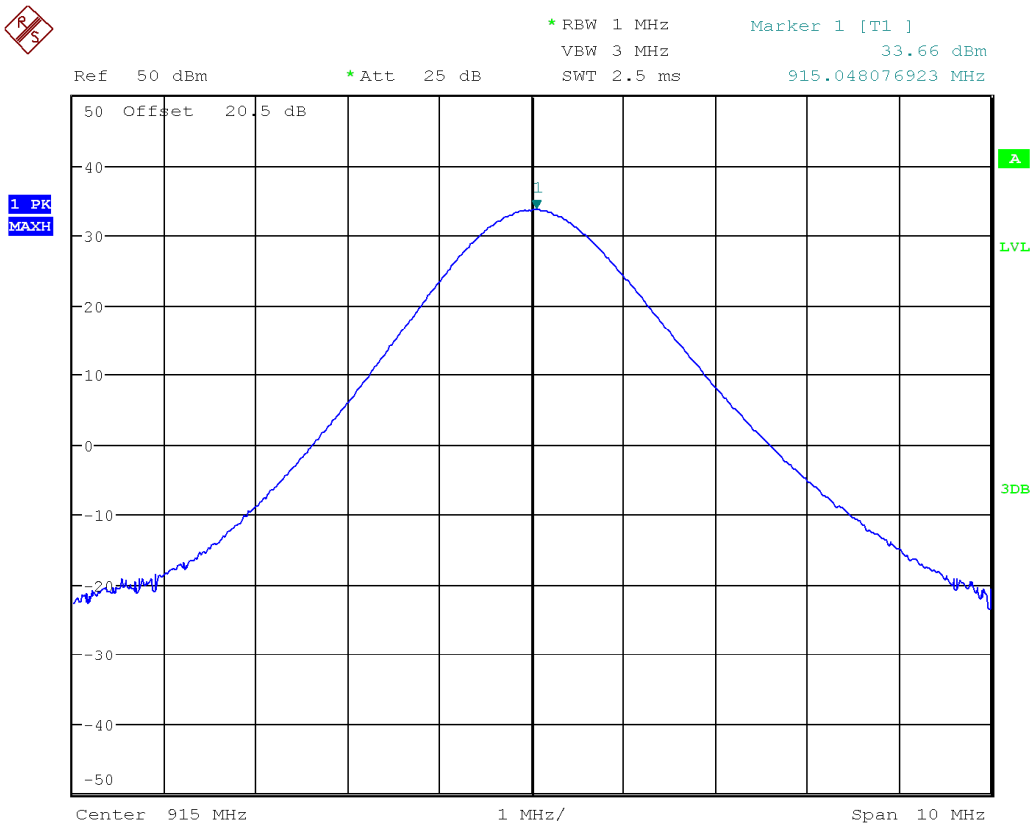
ATA – 909.75 – 921.75 MHz Sub-Band
Mid Channel



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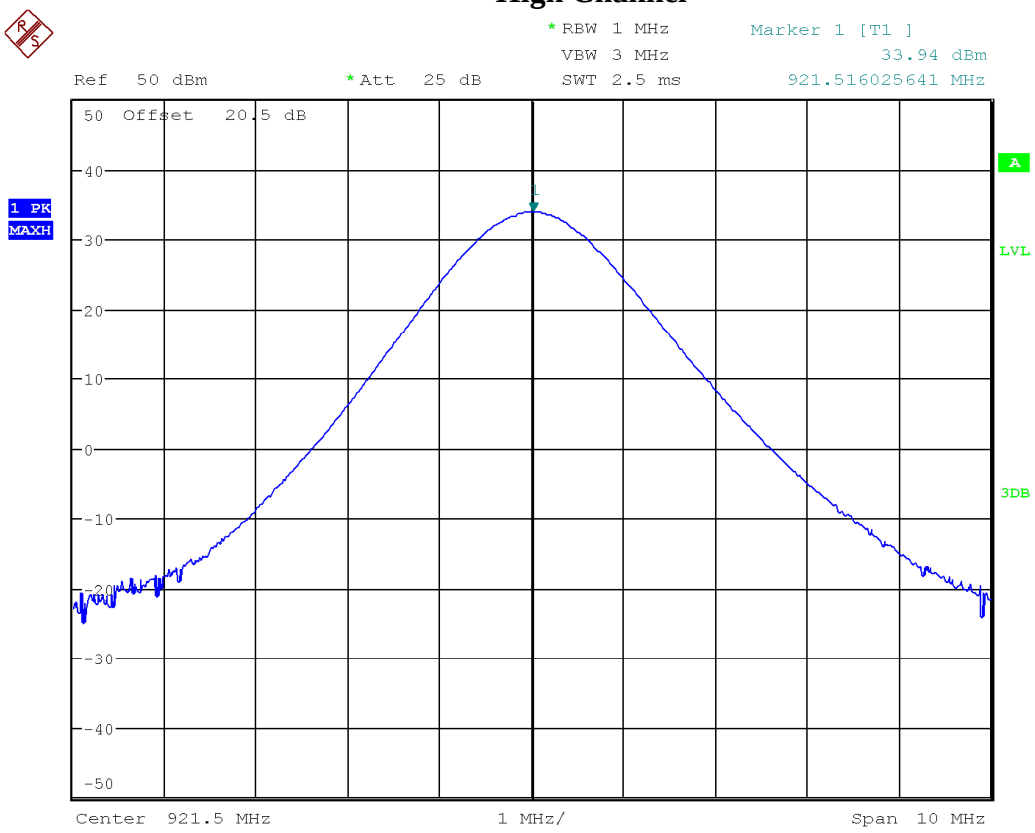
ATA – 909.75 – 921.75 MHz Sub-Band
High Channel



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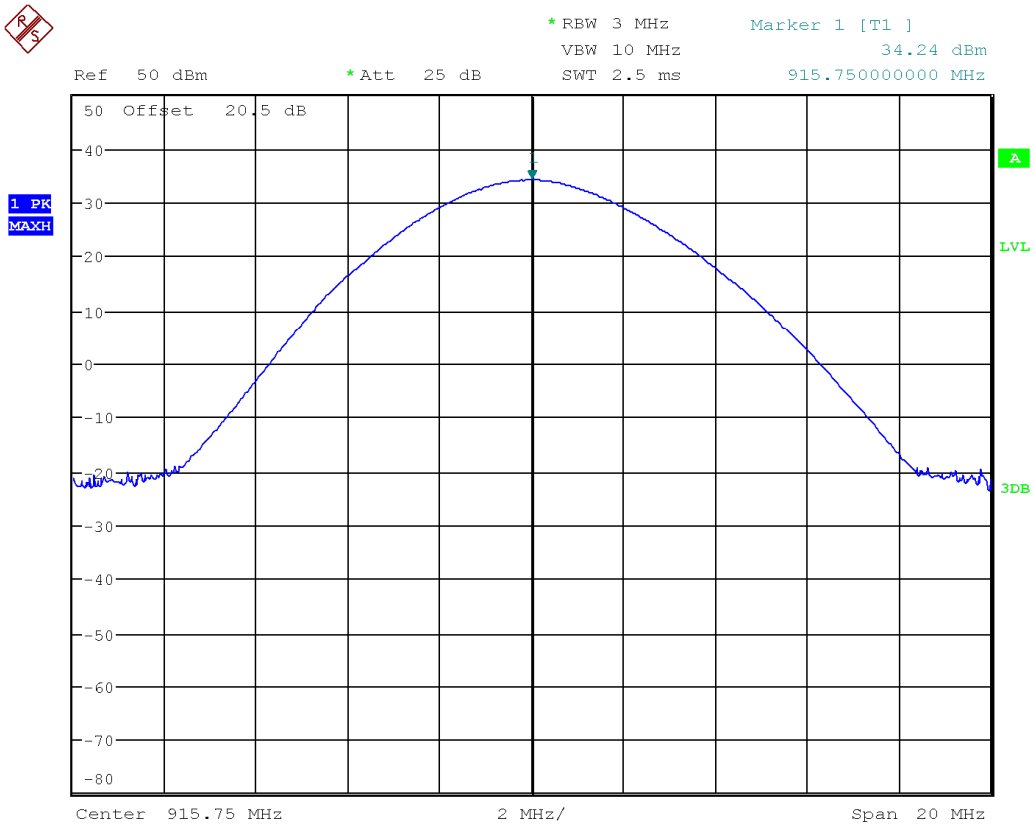
KTDM



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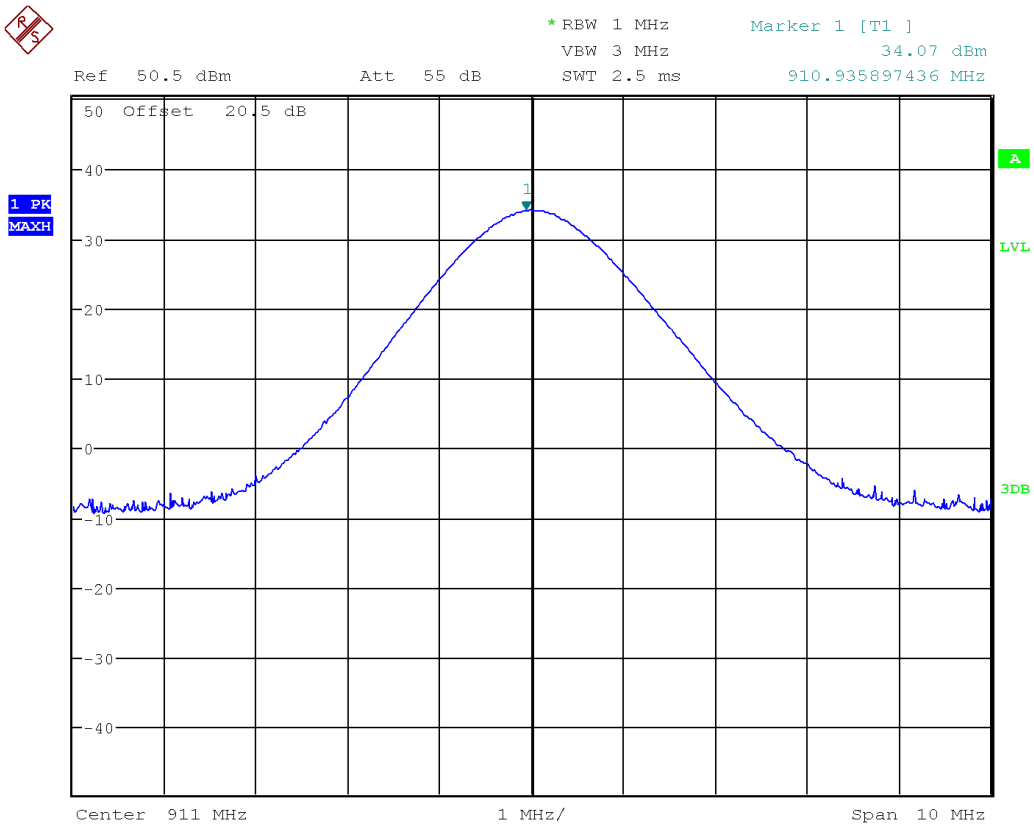
SeGO – 909.75 – 921.75 MHz Sub-Band
Low Channel



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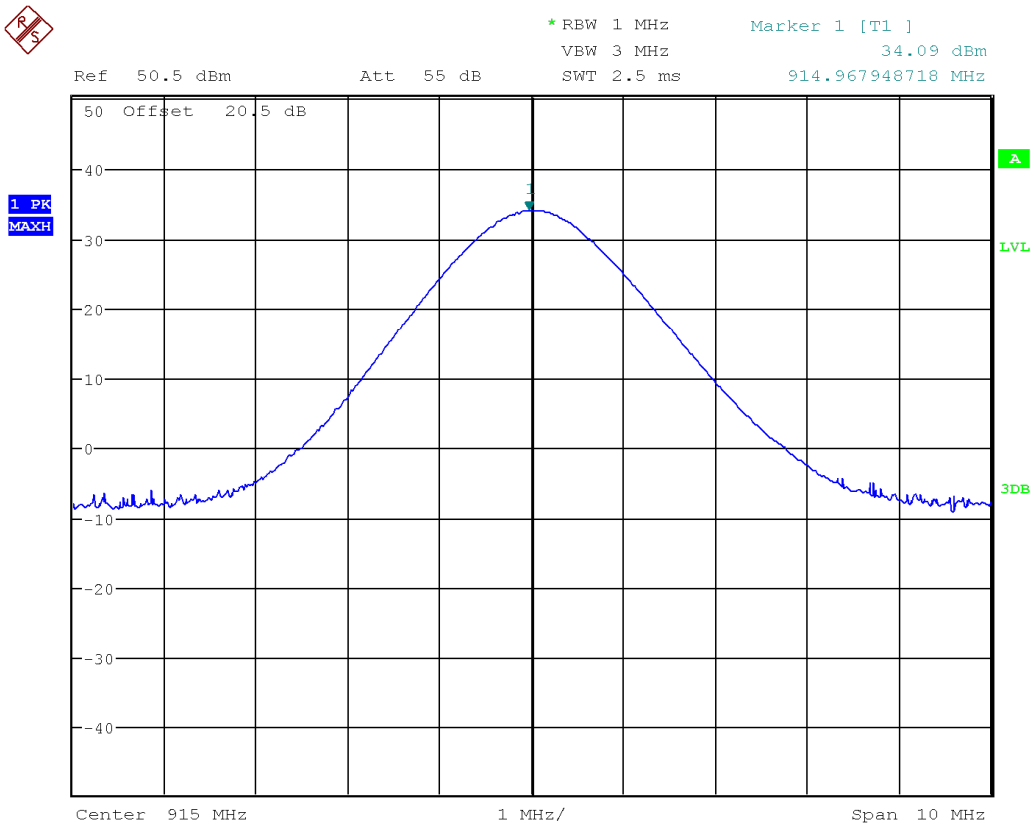
SeGO – 909.75 – 921.75 MHz Sub-Band
Mid Channel



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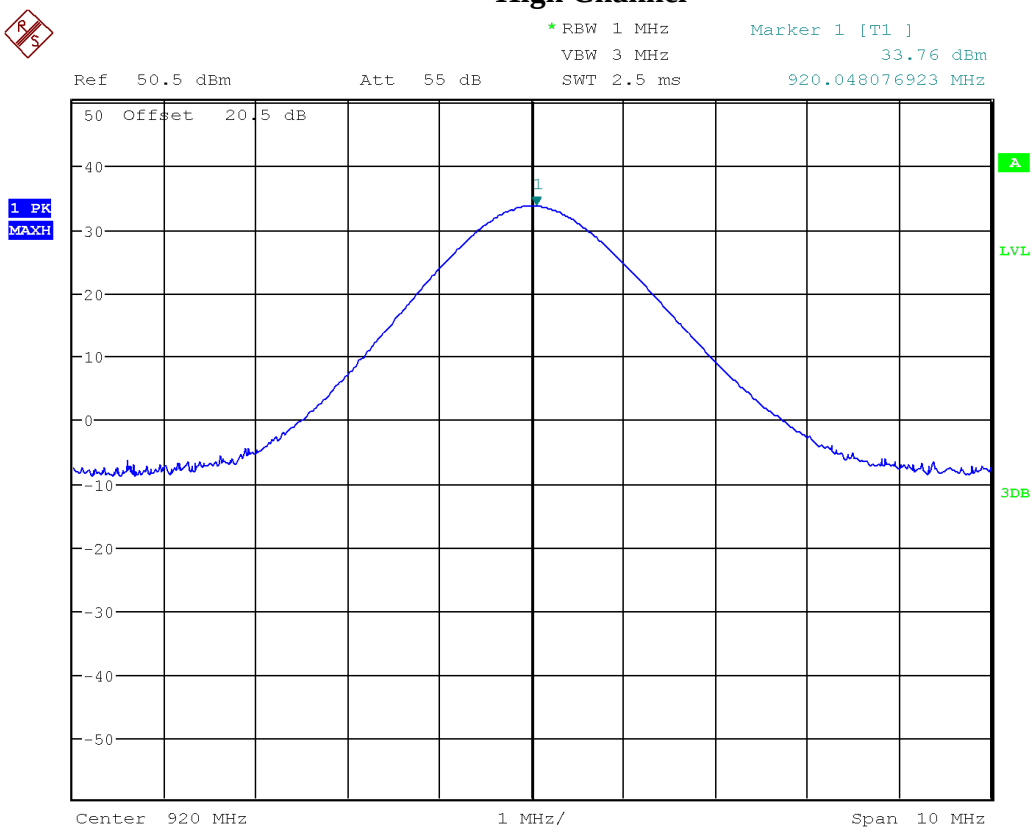
SeGO – 909.75 – 921.75 MHz Sub-Band
High Channel



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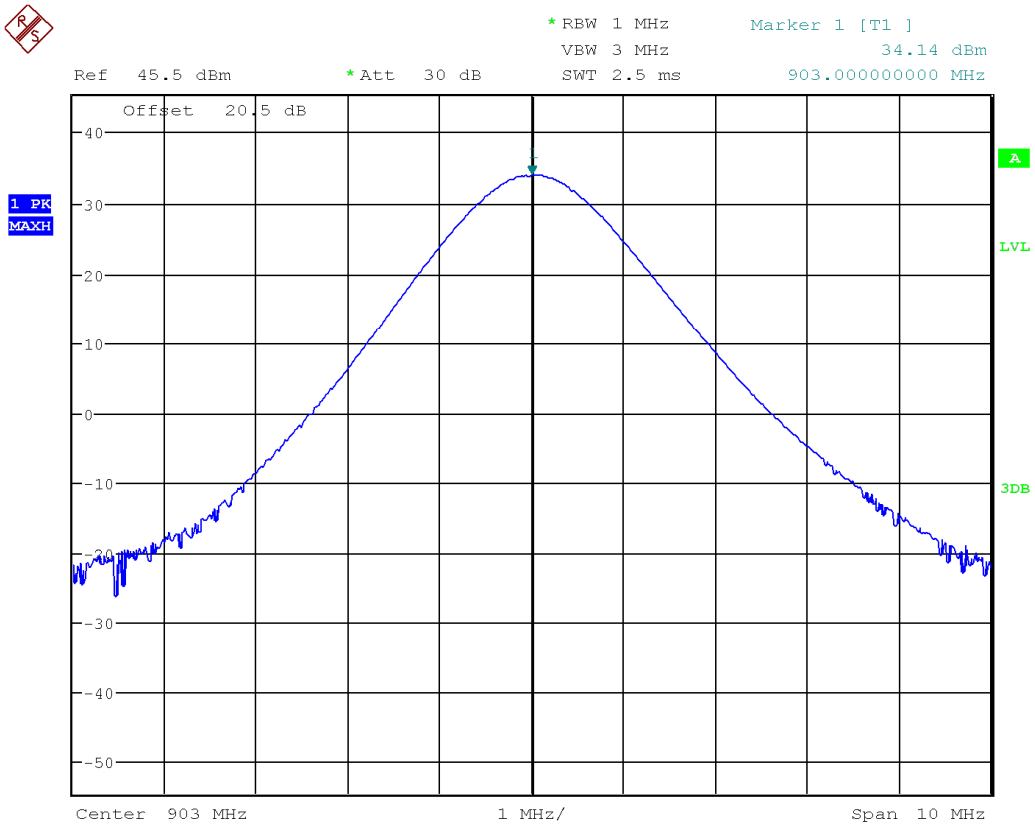
6B – 902 – 904 MHz Sub-Band



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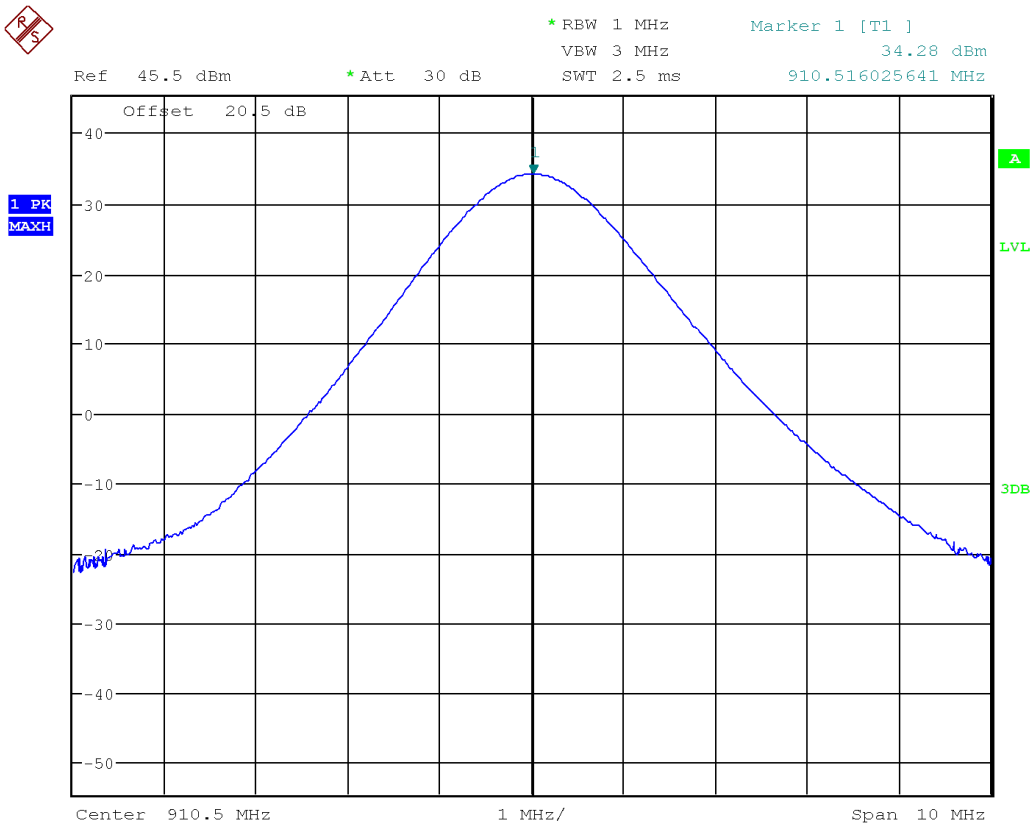
6B – 909.75 – 921.75 MHz Sub-Band
Low Channel



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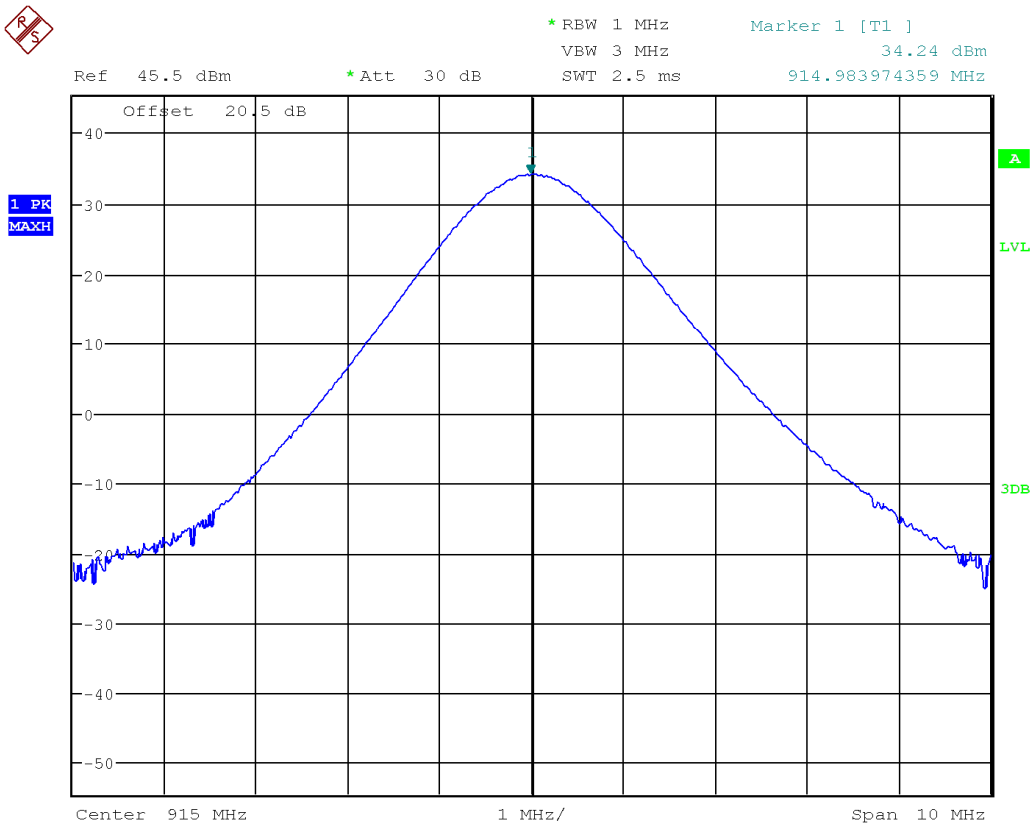
6B – 909.75 – 921.75 MHz Sub-Band
Mid Channel



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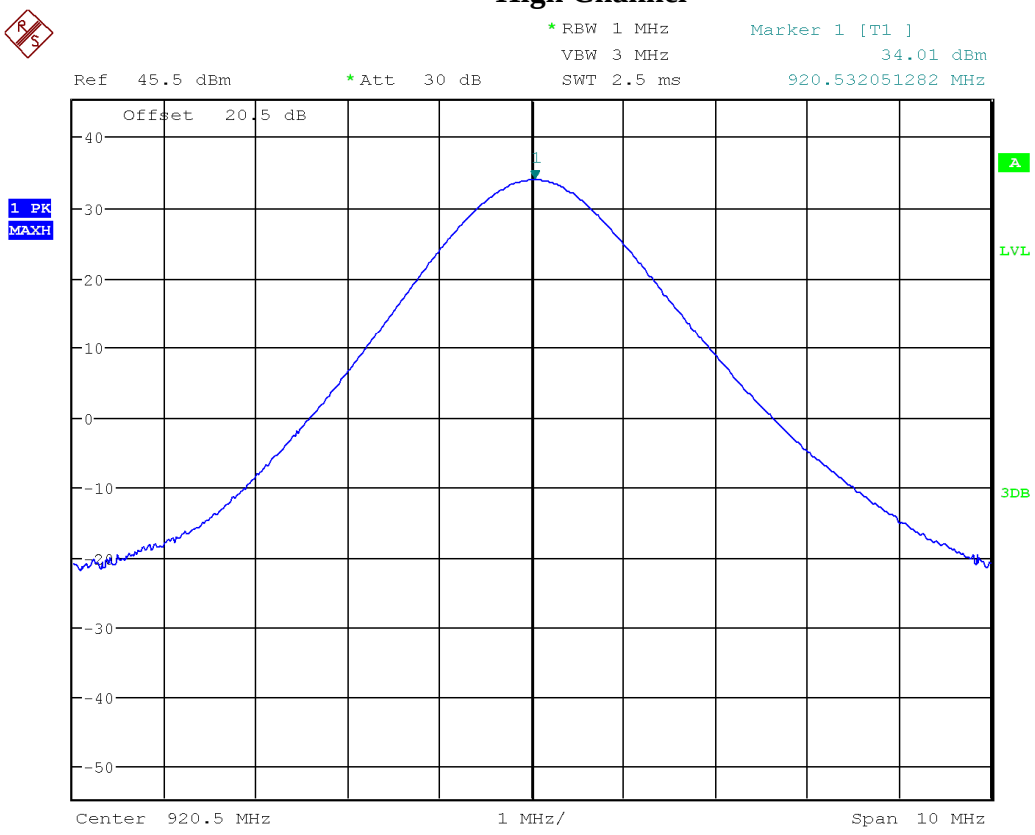
6B – 909.75 – 921.75 MHz Sub-Band
High Channel



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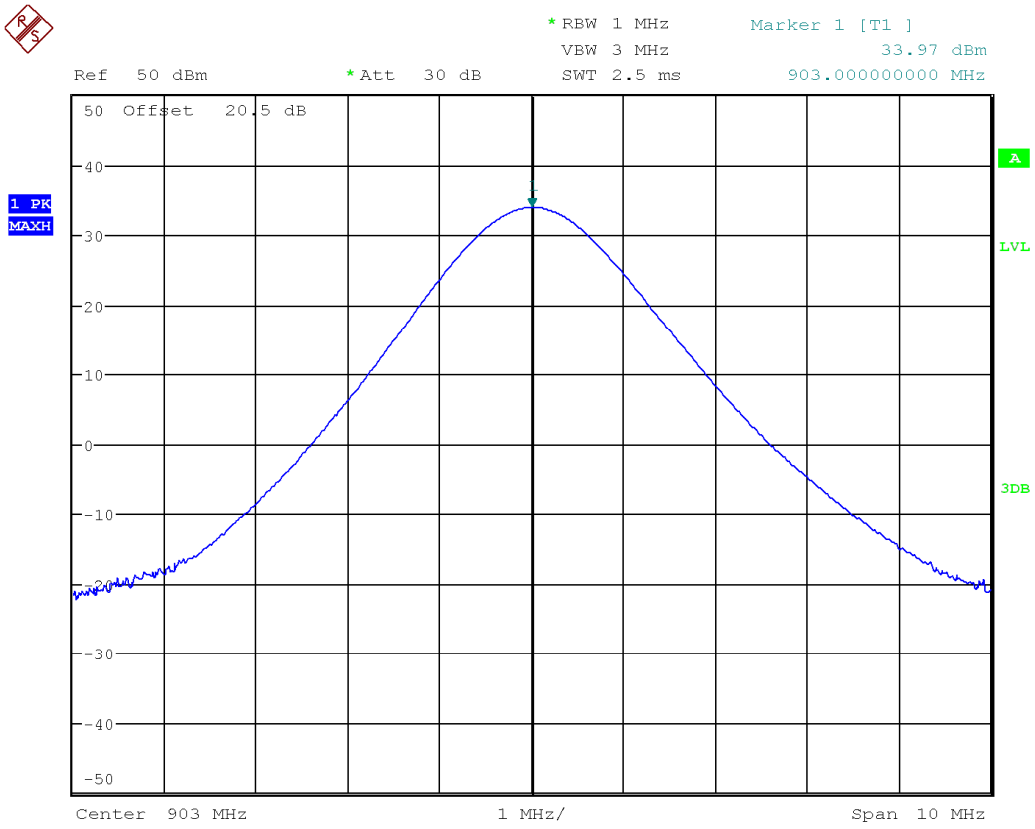
6C – 902 – 904 MHz Sub-Band



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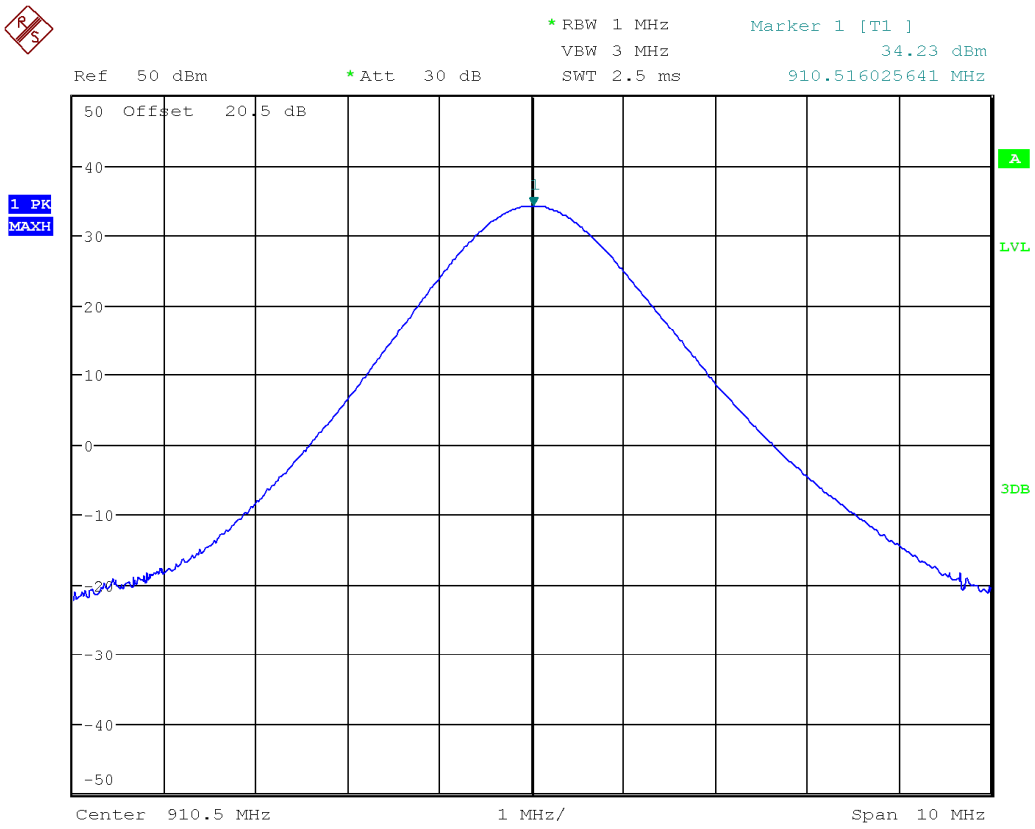
6C – 909.75 – 921.75 MHz Sub-Band
Low Channel



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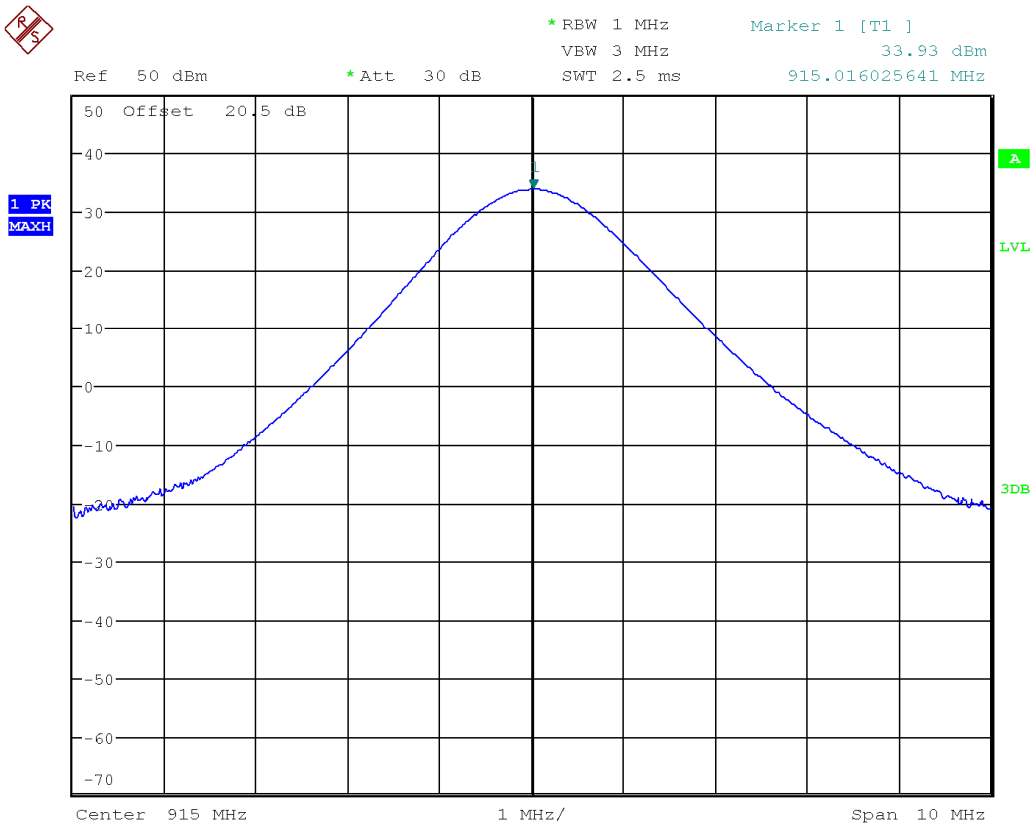
6C – 909.75 – 921.75 MHz Sub-Band
Mid Channel



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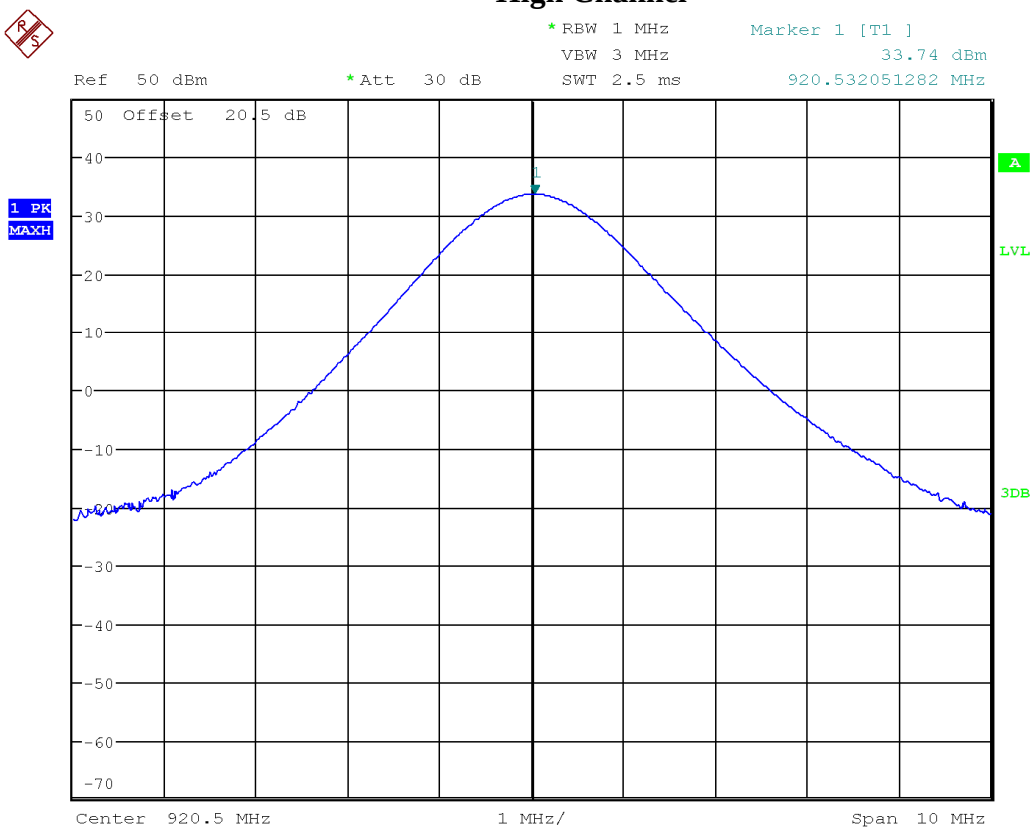
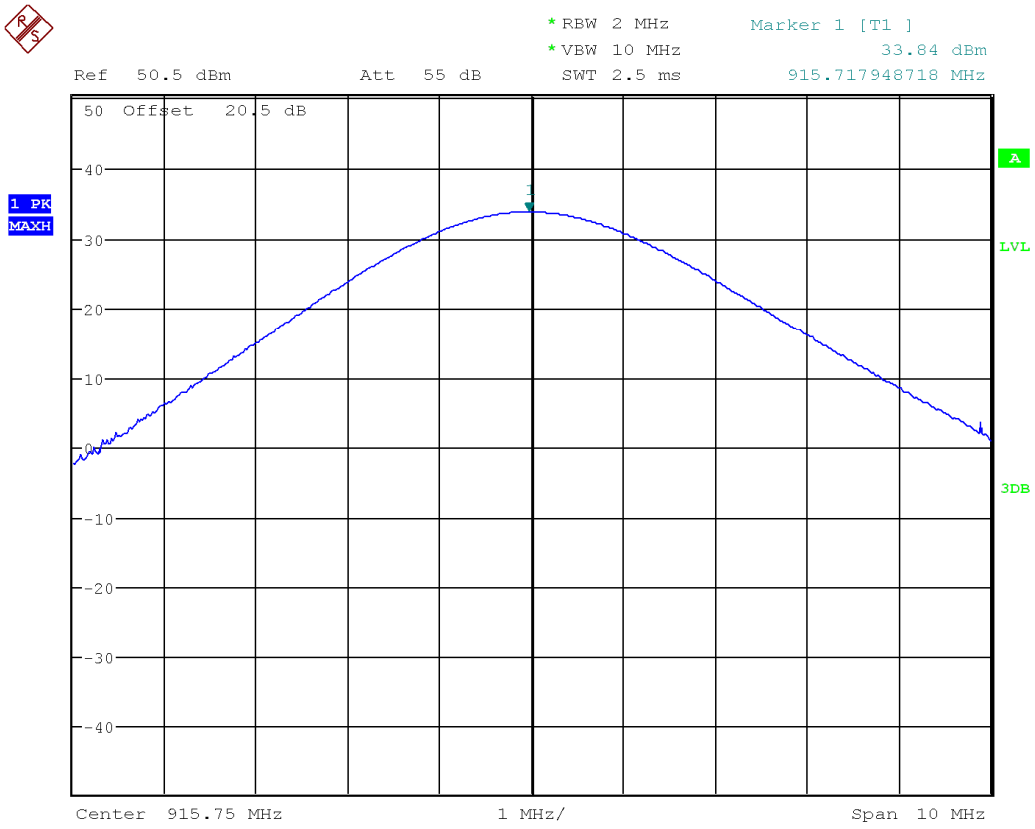
6C – 909.75 – 921.75 MHz Sub-Band
High Channel



Date: 29.APR.2022 12:09:00

T21



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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 #
Signal Analyzer	FSQ 26	Rohde & Schwarz	Nov. 30 2021	Nov. 30, 2023	GEMC 234
10dB Attenuator	6N5W-10	Inmet	NCR	NCR	GEMC 348
10dB Attenuator	18N5W-10	Inmet	NCR	NCR	GEMC 358

Note: GEMC 287 is part of GEMC 8's calibration.

Occupied Bandwidth

Purpose

The purpose of this test is to ensure that the bandwidth occupied exceeds a stated minimum. This helps ensure the utilization of the frequency allocation is sufficiently wide. This also helps prevent corruption of data by ensuring adequate data separation to distinguish the reception of the intended information.

Limits

The Limit is as specified in FCC Part 90.209 and RSS-137 Clause 6.1.2.

The maximum authorized bandwidth shall be 12 MHz for non-multilateration LMS operations in the band 909.75-921.75 MHz and 2 MHz in the band 902.00-904.00 MHz. The maximum authorized bandwidth for multilateration LMS operations shall be 5.75 MHz in the 904.00-909.75 MHz band; 2 MHz in the 919.5-921.75 MHz band; 5.75 MHz in the 921.75-927.25 MHz band and its associated 927.25-927.50 MHz narrowband forward link; and 8.00 MHz if the 919.75-921.75 MHz and 921.75-927.25 MHz bands and their associated 927.25-927.50 MHz and 927.50-927.75 MHz narrowband forward links are aggregated.

Results

The EUT passed. Each of the 6 supported protocol was tested. Where a protocol has more than one channel, the Low, middle, and high channels were measured. The table below gives the results for each protocol.

The ATA, 6B and 6C protocols operate in both non- multilateration LMS sub-bands and the other 2 protocols operate in the 909.75 – 921.75 MHz sub-band.

ATA – 902 – 904 MHz Sub-Band			
Channel	Frequency (MHz)	20 dB BW (kHz)	99% Bandwidth (kHz)
Low Channel	902.5	0.29	6.44
Mid Channel	903.0	0.34	4.94
High Channel	903.5	0.33	5.26
ATA – 909.75 – 921.75 MHz Sub-Band			
Channel	Frequency (MHz)	20 dB BW (kHz)	99% Bandwidth (kHz)
Low Channel	910.0	3.59	12.21
Mid Channel	915.0	4.26	14.62
High Channel	921.5	8.85	14.51

KTDM			
Channel	Frequency (MHz)	20 dB BW (kHz)	99% Bandwidth (kHz)
Channel	915.75	1402.0	2769.2

SeGO			
Channel	Frequency (MHz)	20 dB BW (kHz)	99% Bandwidth (kHz)
Low Channel	911.0	480.76	487.18
Mid Channel	915.0	480.76	477.56
High Channel	920.0	480.77	474.35

6B – 902 – 904 MHz Sub-Band			
Channel	Frequency (MHz)	20 dB BW (kHz)	99% Bandwidth (kHz)
Channel	903.0	250.00	241.59
6B - 909.75 to 921.75 MHz Sub-Band			
Channel	Frequency (MHz)	20 dB BW (kHz)	99% Bandwidth (kHz)
Low Channel	910.5	263.22	259.61
Mid Channel	915.0	269.23	265.63
High Channel	920.5	270.43	262.02

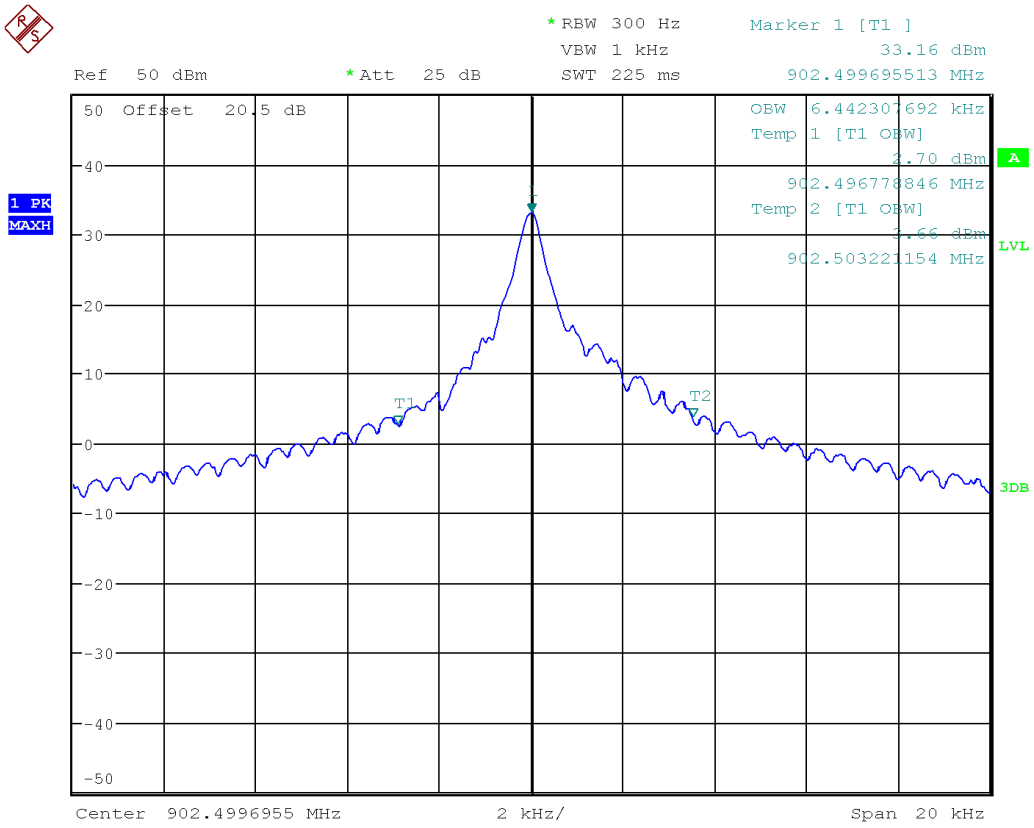
6C – 902 – 904 MHz Sub-Band			
Channel	Frequency (MHz)	20 dB BW (kHz)	99% Bandwidth (kHz)
Channel	903.0	419.87	426.28
6C – 909.75 to 921.75 MHz Sub-Band			
Channel	Frequency (MHz)	20 dB BW (kHz)	99% Bandwidth (kHz)
Low Channel	910.5	419.87	427.88
Mid Channel	915.0	419.87	426.28
High Channel	920.5	419.87	405.45

T21			
Channel	Frequency (MHz)	20 dB BW (kHz)	99% Bandwidth (kHz)
Channel	915.75	737.18	817.3

Graph(s)

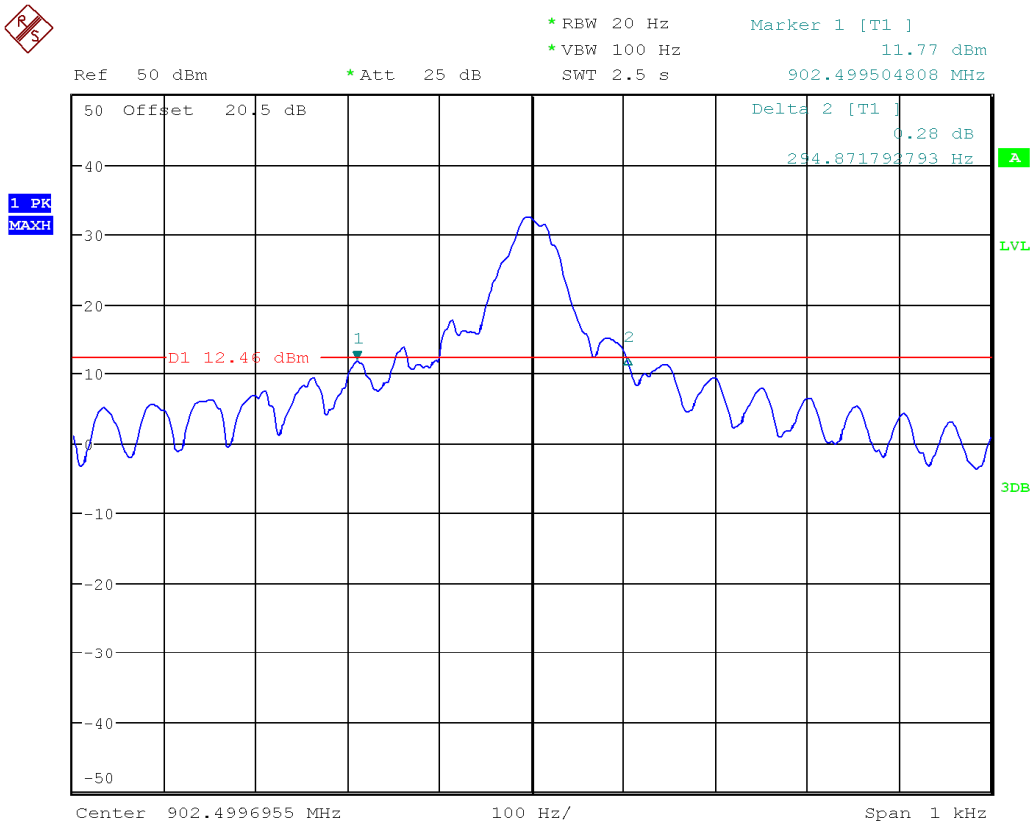
The graphs showed below shows the OBW during the operation of the device. This is measured by a max hold on the spectrum analyzer and the highest resolution bandwidth that is sufficiently low to exhibit the 99% bandwidth of a channel during operation of the EUT. This measurement is a peak measurement.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

ATA – 902 – 904 MHz Sub-Band
Low Channel
99%BW



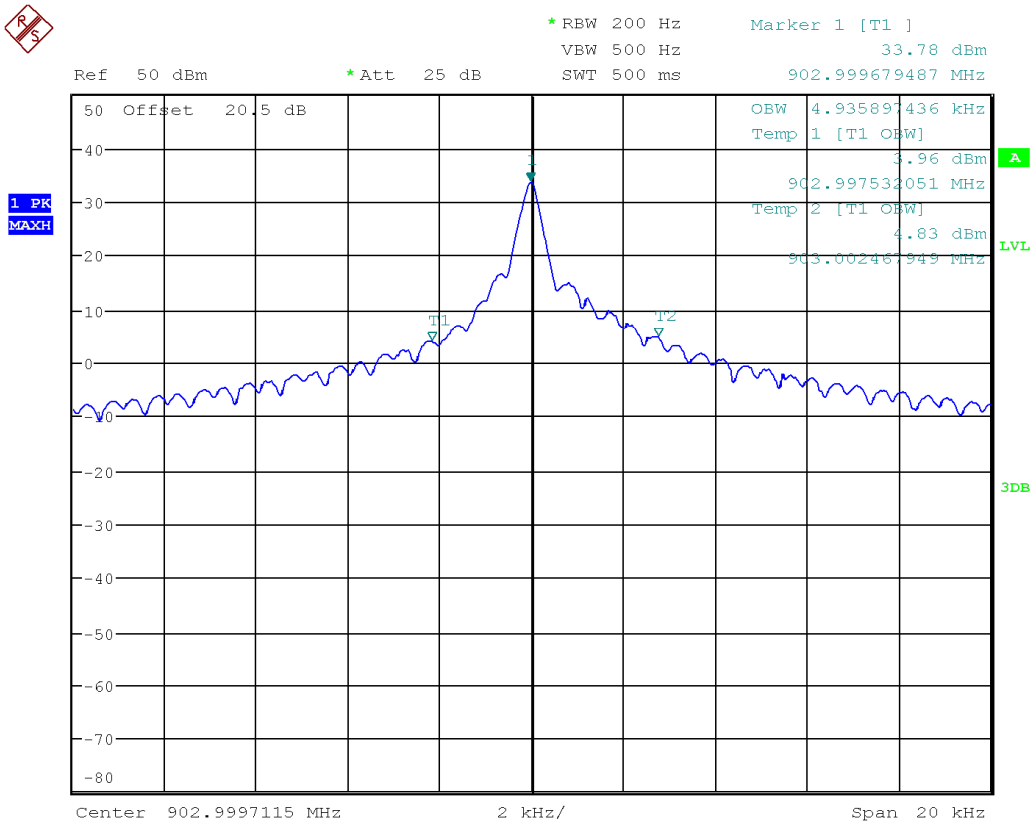
Date: 28.APR.2022 14:01:33

20 dB BW



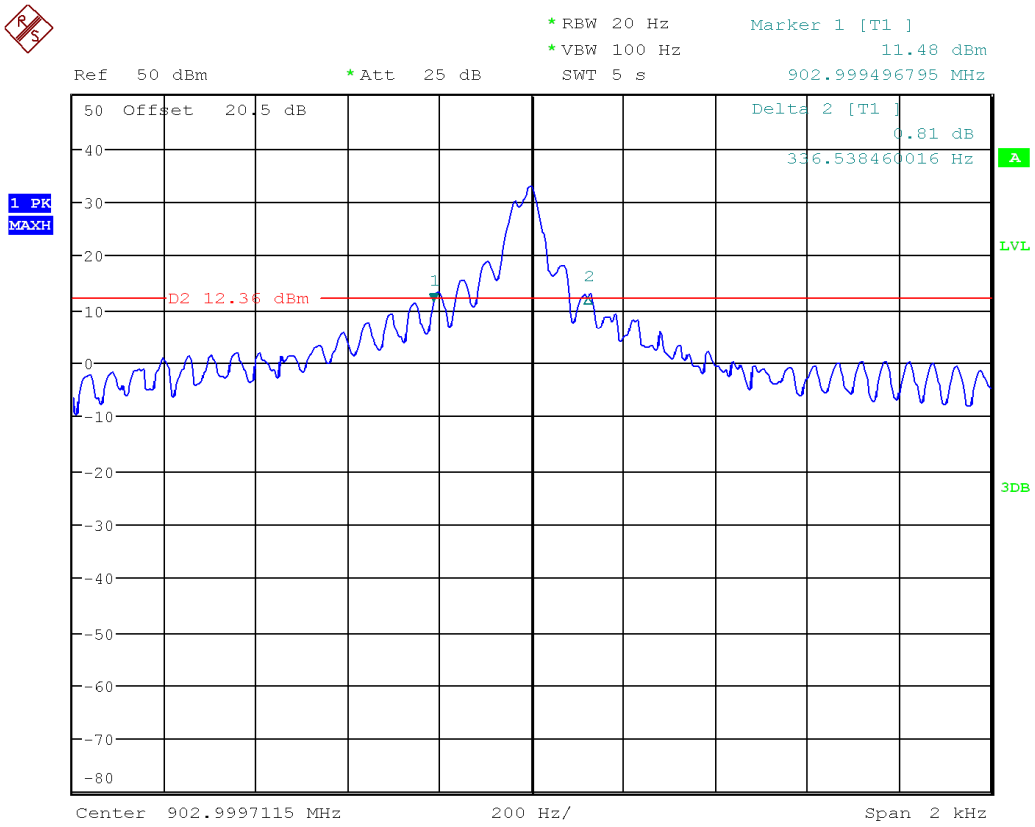
Date: 28.APR.2022 13:58:14

ATA – 902 – 904 MHz Sub-Band
Mid Channel
99% BW



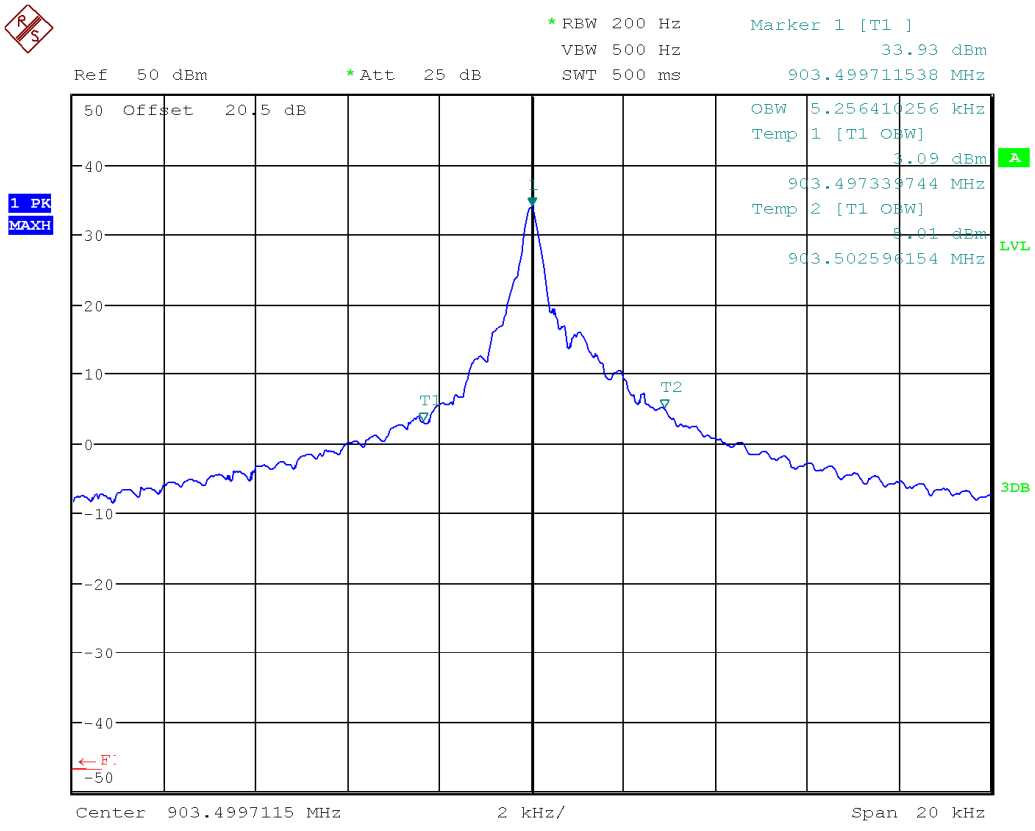
Date: 28.APR.2022 14:36:25

20 dB BW



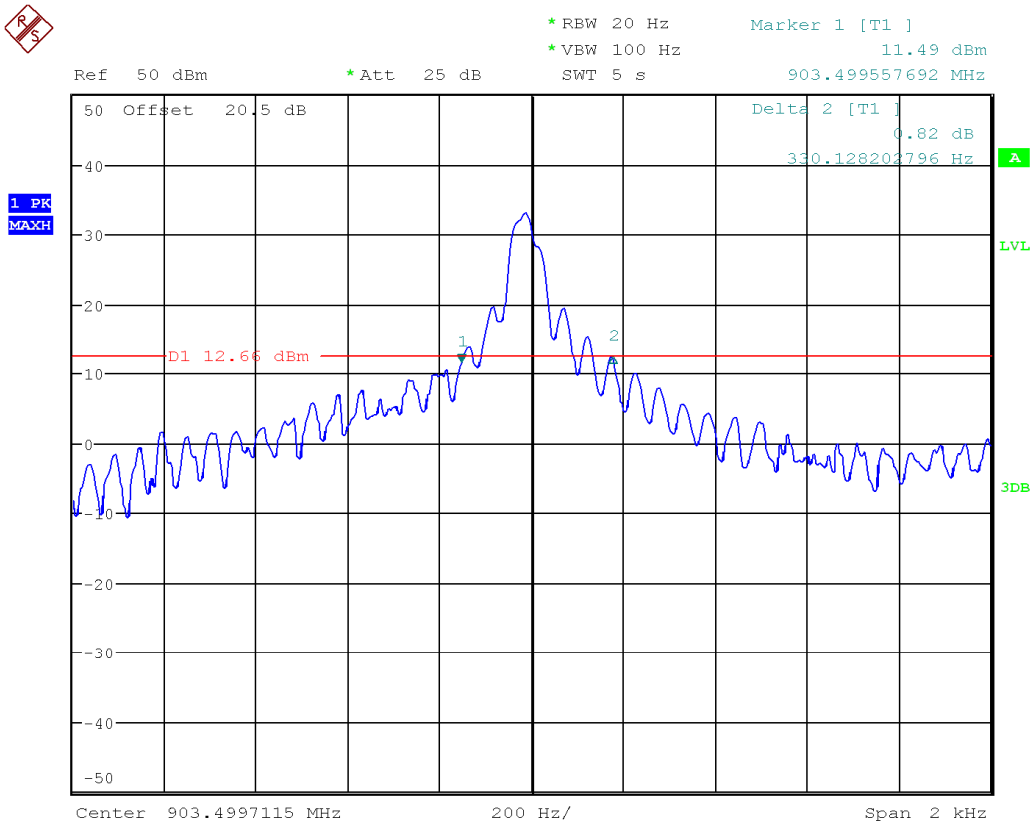
Date: 28.APR.2022 14:40:23

ATA – 902 – 904 MHz Sub-Band
High Channel
99% BW



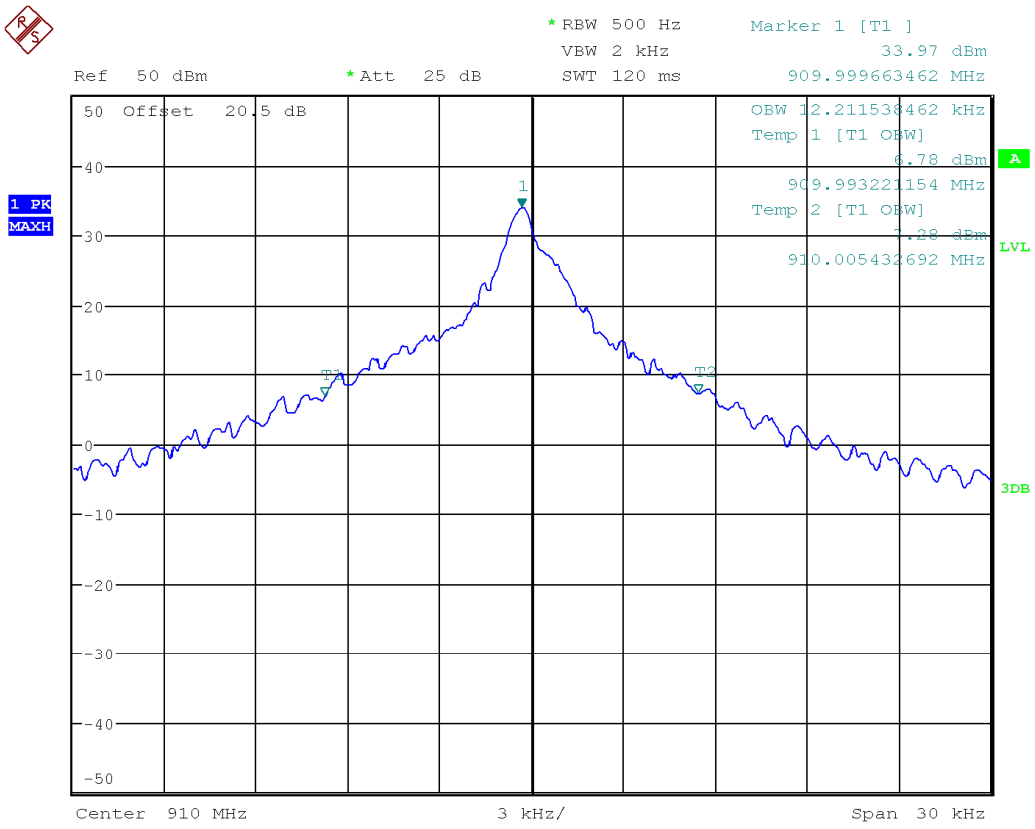
Date: 28.APR.2022 14:21:28

20dB BW



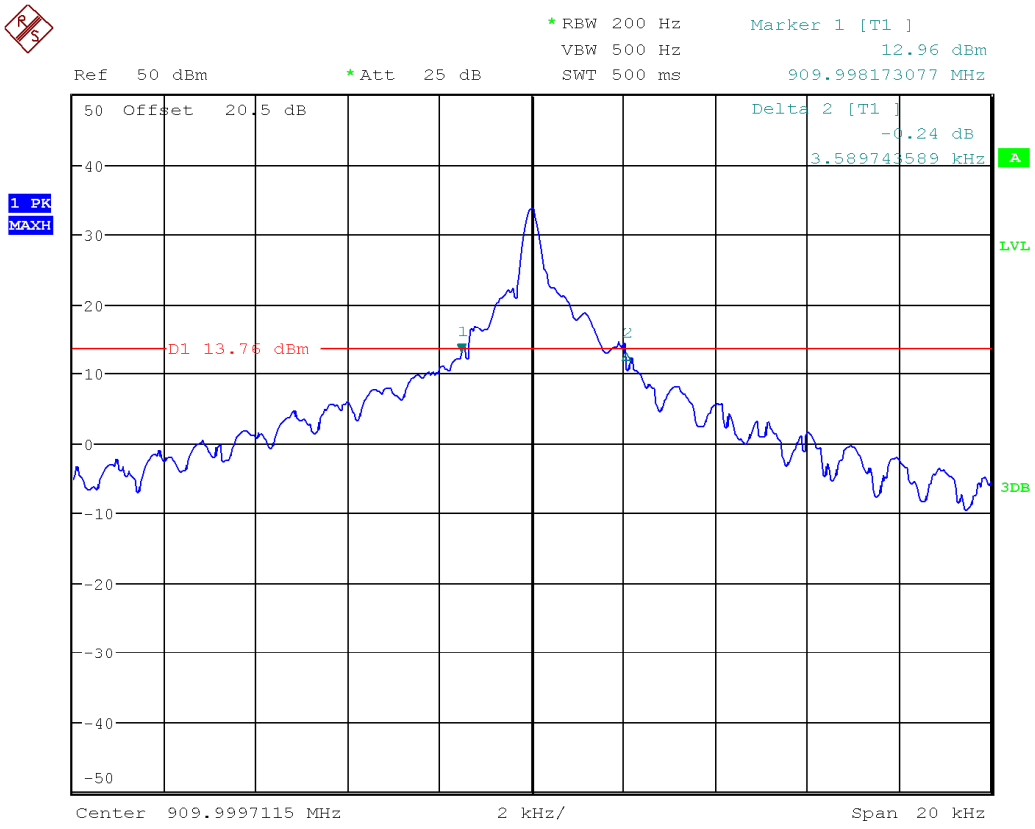
Date: 28.APR.2022 14:24:51

ATA – 909.75 – 921.75 MHz Sub-Band
Low Channel
99% BW



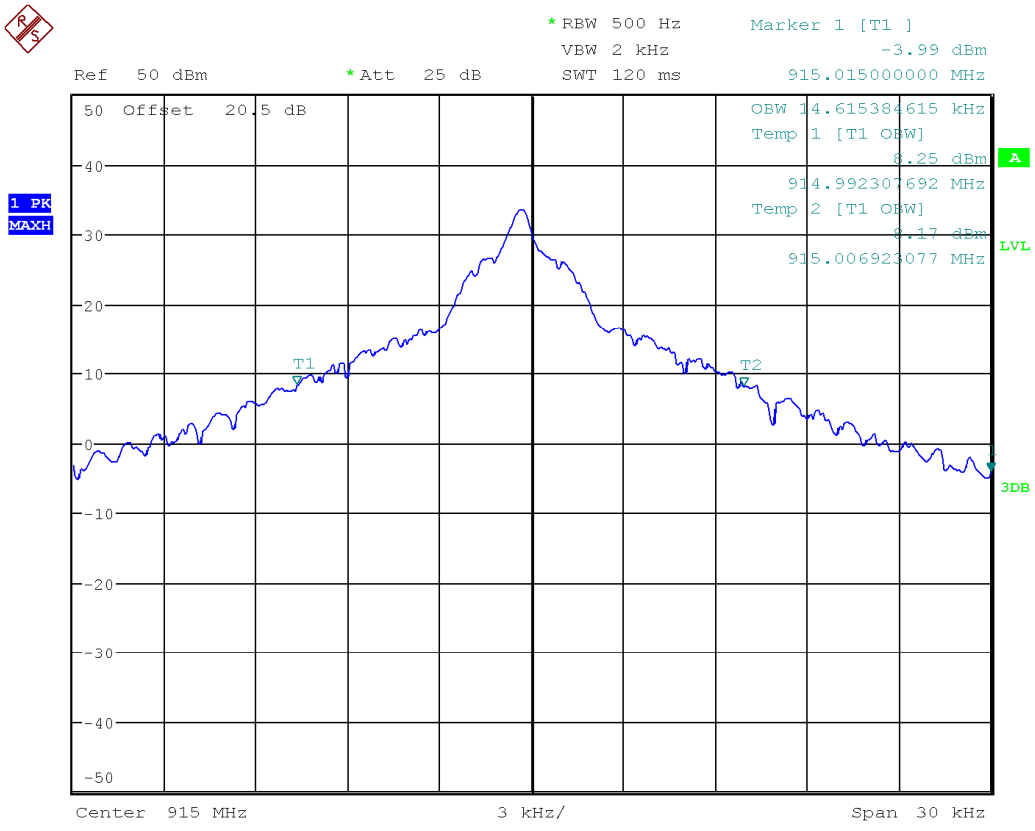
Date: 28.APR.2022 11:29:44

20dB BW



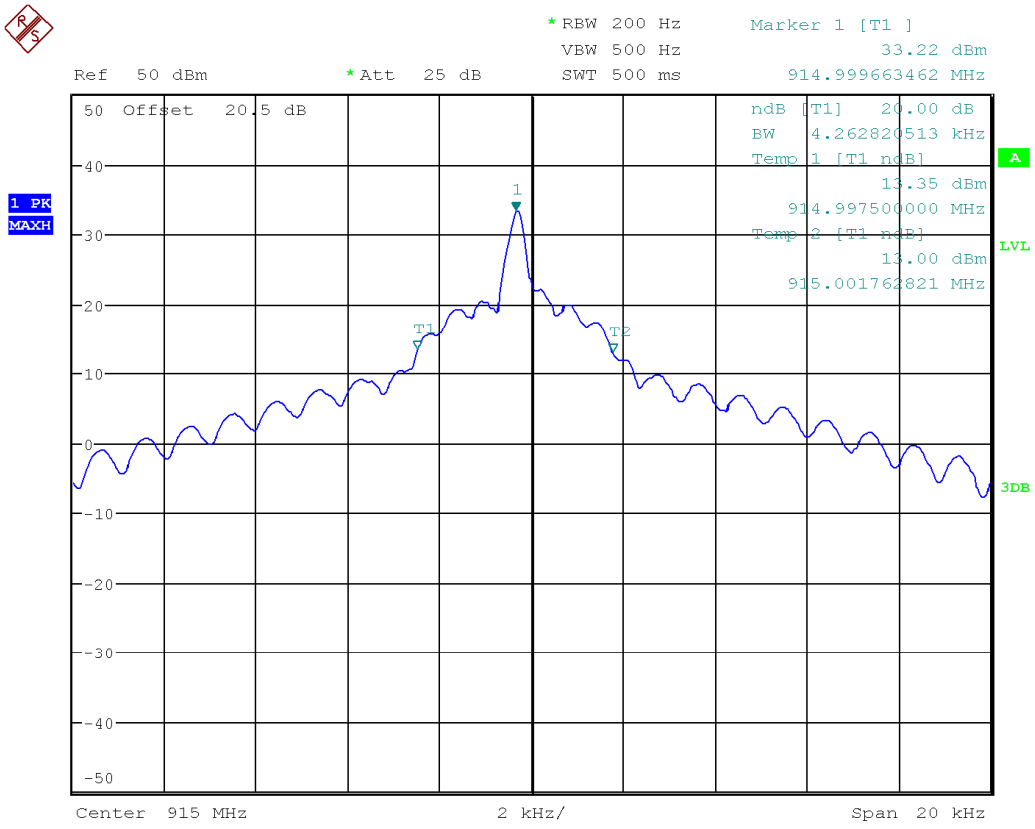
Date: 28.APR.2022 12:08:07

ATA – 909.75 – 921.75 MHz Sub-Band
Mid Channel
99% BW



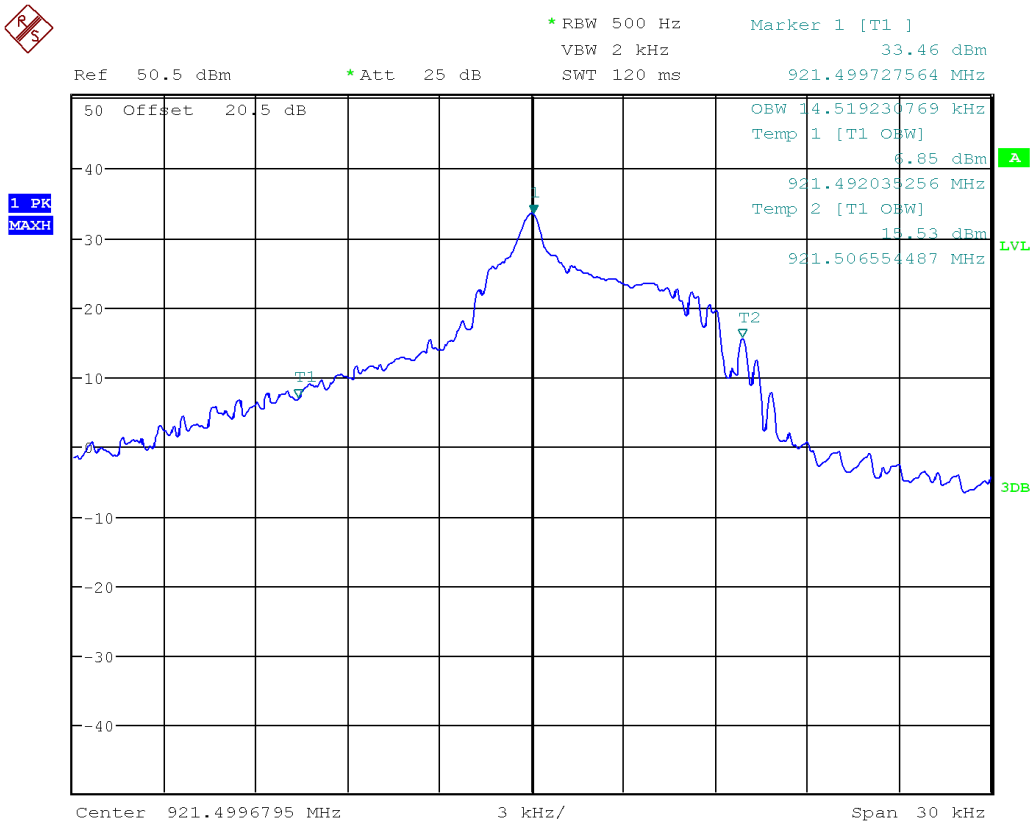
Date: 28.APR.2022 12:42:55

20dB BW



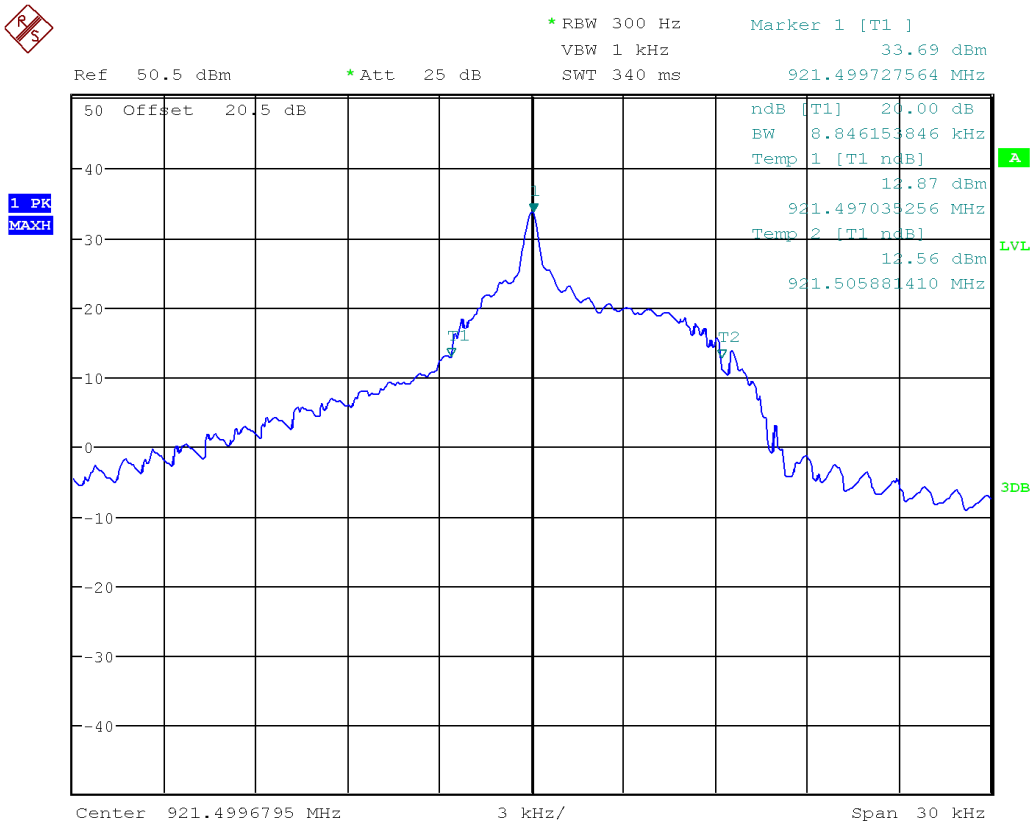
Date: 28.APR.2022 13:31:33

ATA – 909.75 – 921.75 MHz Sub-Band
High Channel
99% BW



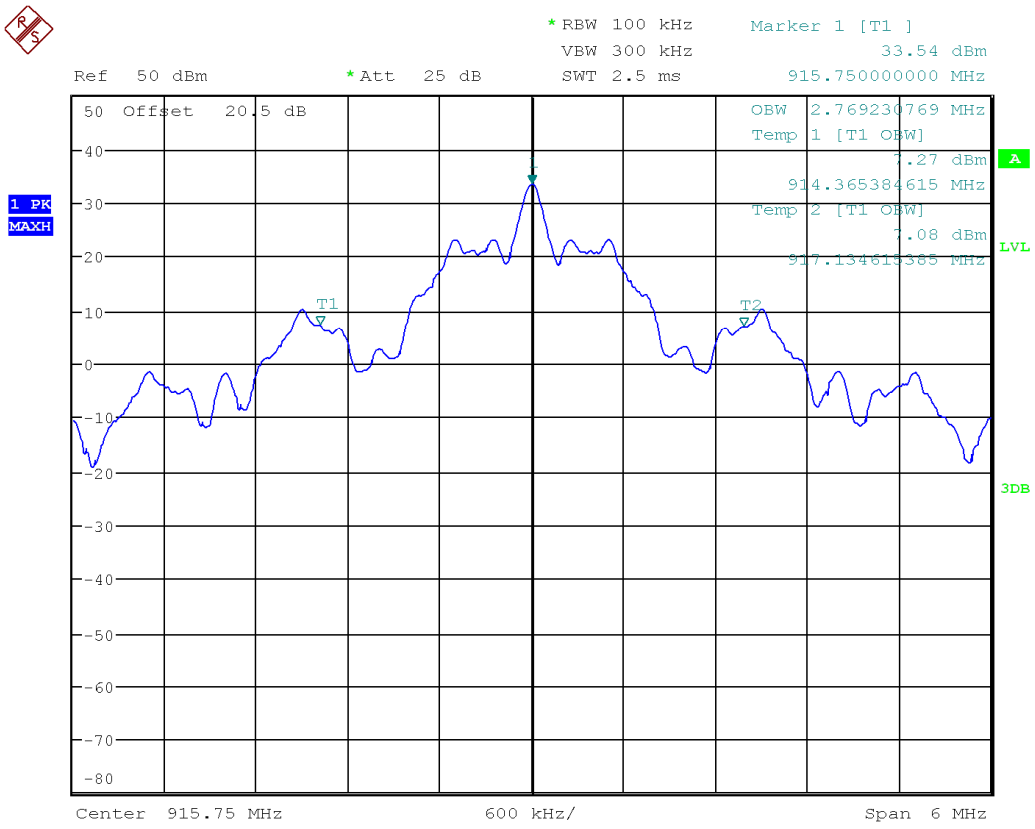
Date: 28.APR.2022 10:35:40

20dB BW



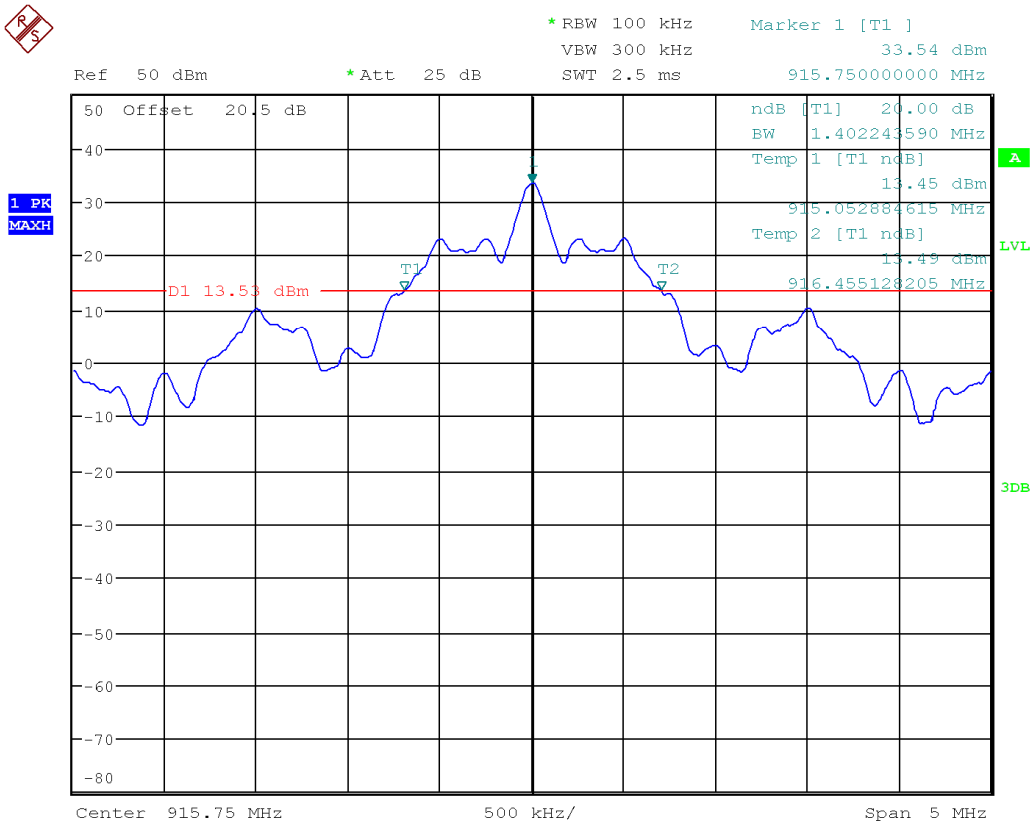
Date: 28.APR.2022 10:45:31

KTDM
99% BW



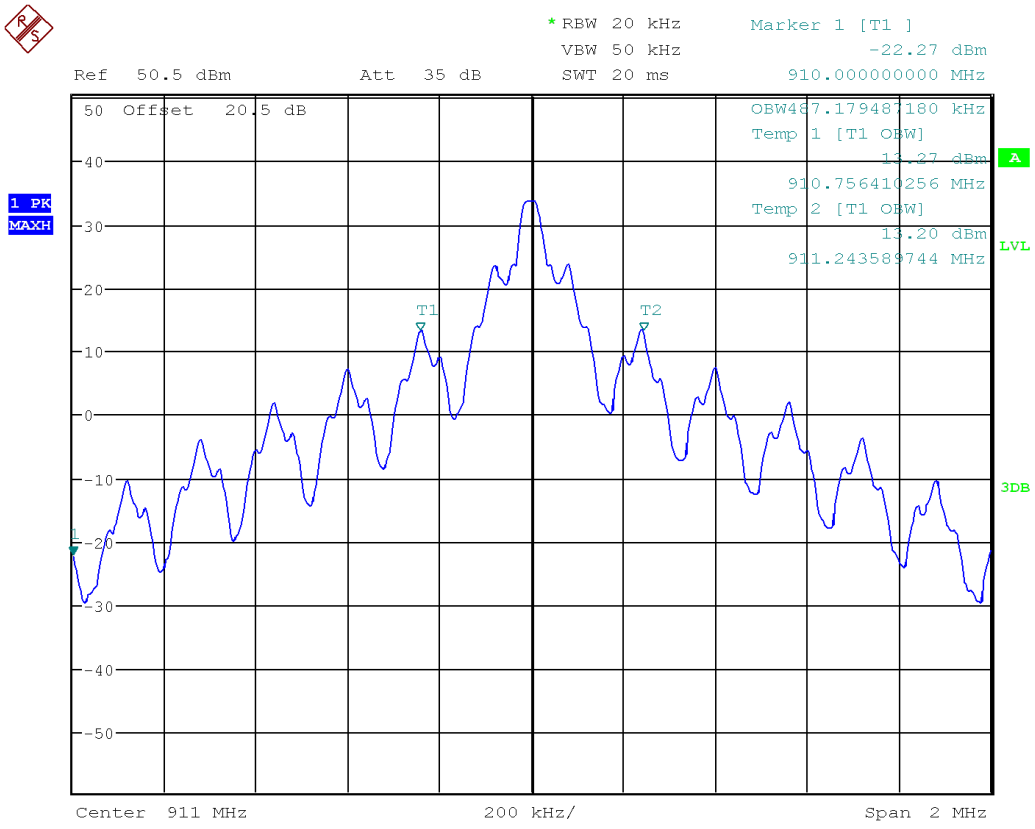
Date: 28.APR.2022 14:55:50

20dB BW



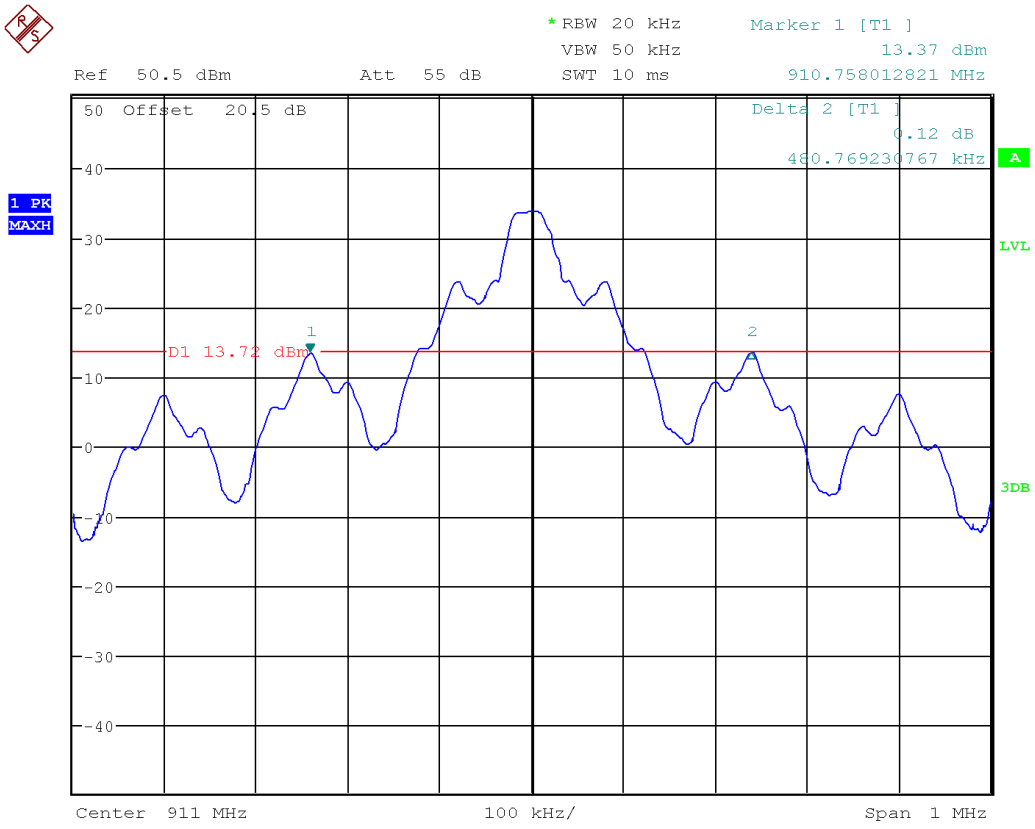
Date: 28.APR.2022 14:52:56

SeGO – 909.75 – 921.75 MHz Sub-Band
Low Channel
99% BW



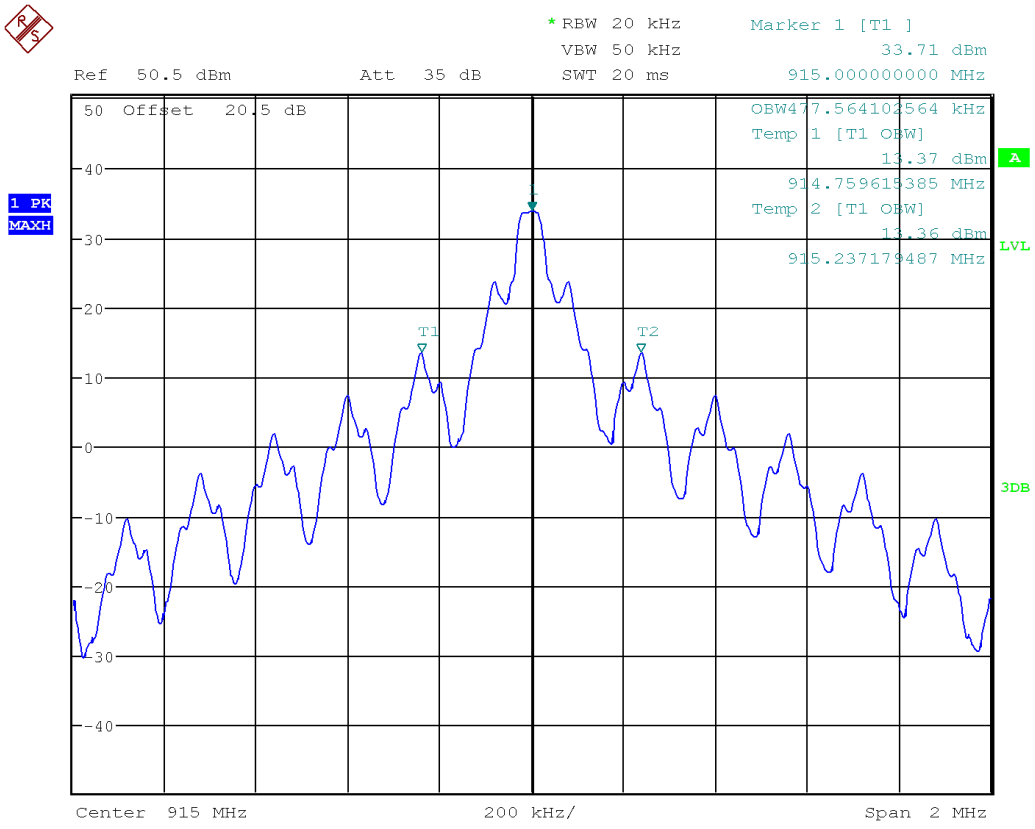
Date: 28.APR.2022 16:06:43

20dB BW



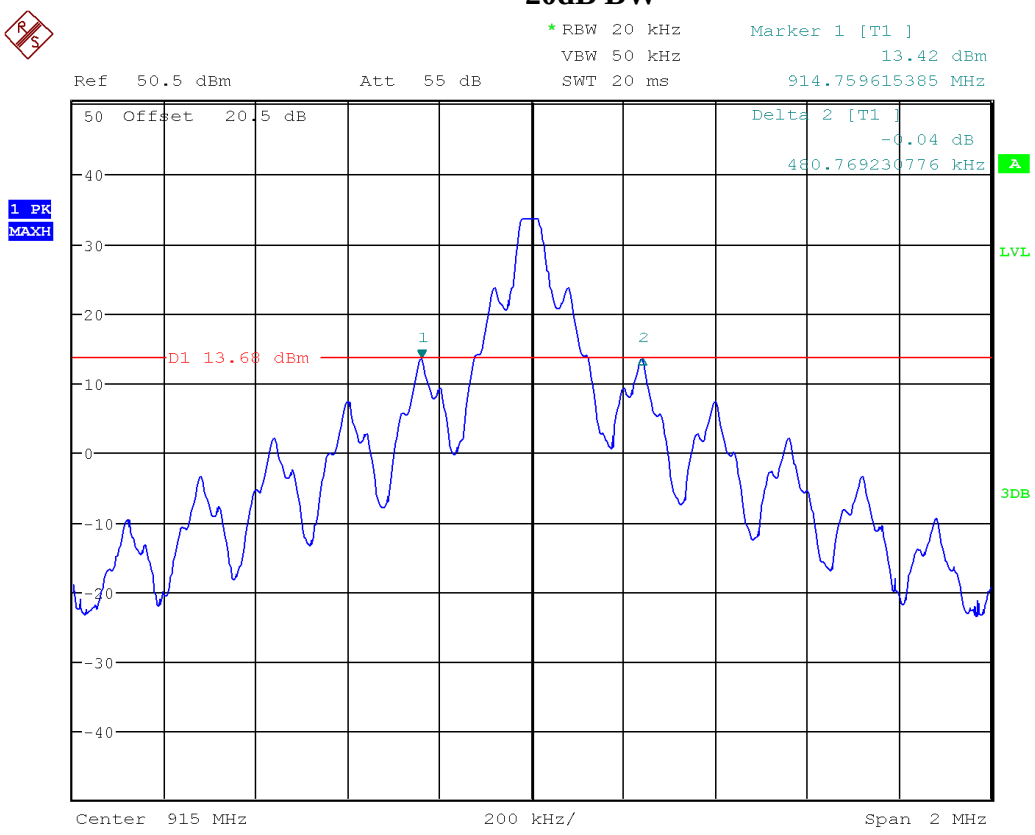
Date: 28.APR.2022 15:56:10

SeGO – 909.75 – 921.75 MHz Sub-Band
Mid Channel
99% BW



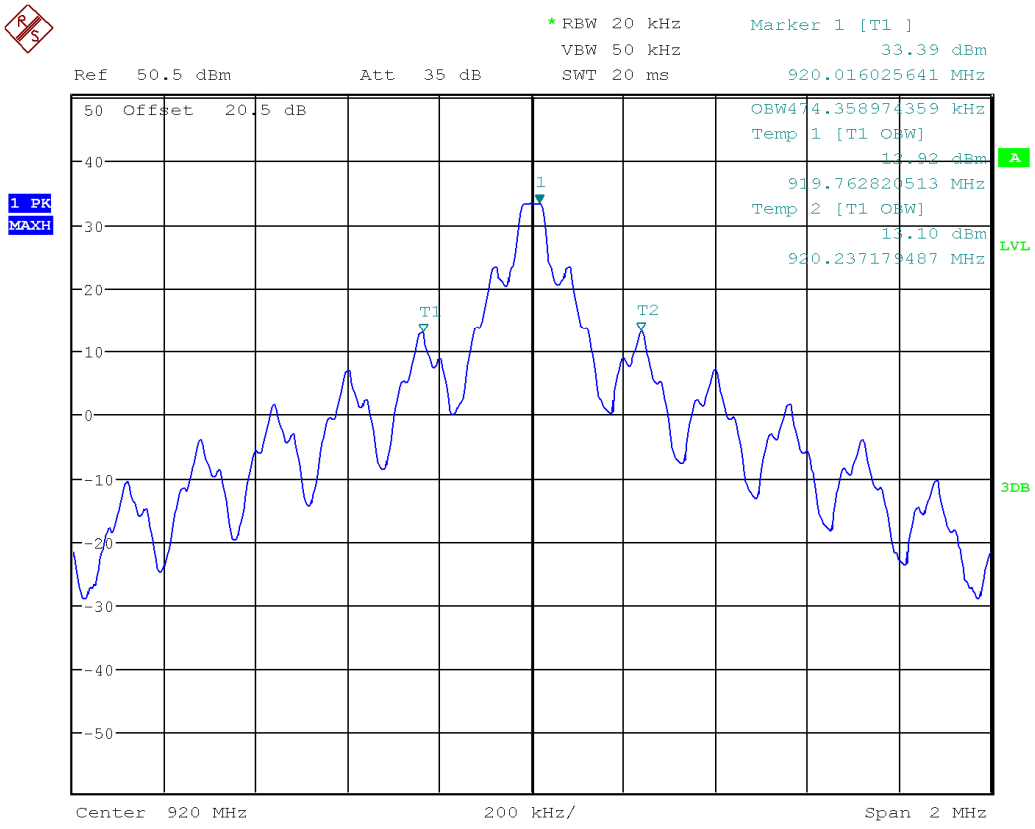
Date: 28.APR.2022 15:48:05

20dB BW



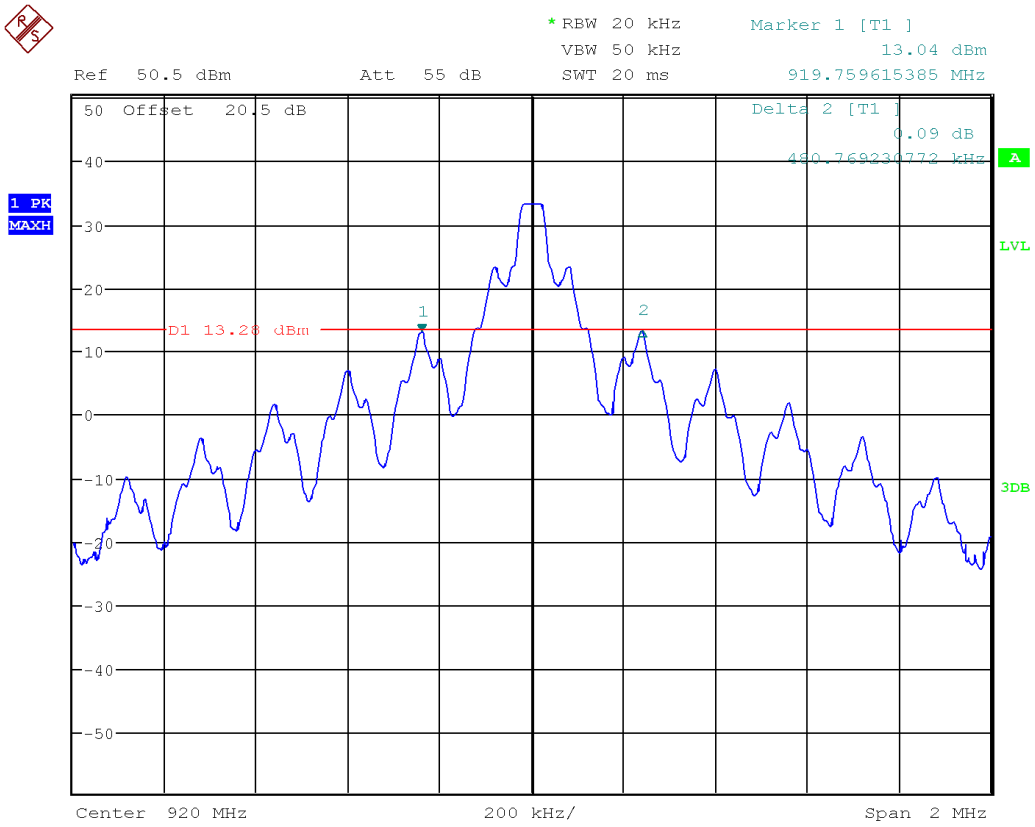
Date: 28.APR.2022 15:49:57

SeGO – 909.75 – 921.75 MHz Sub-Band
High Channel
99% BW



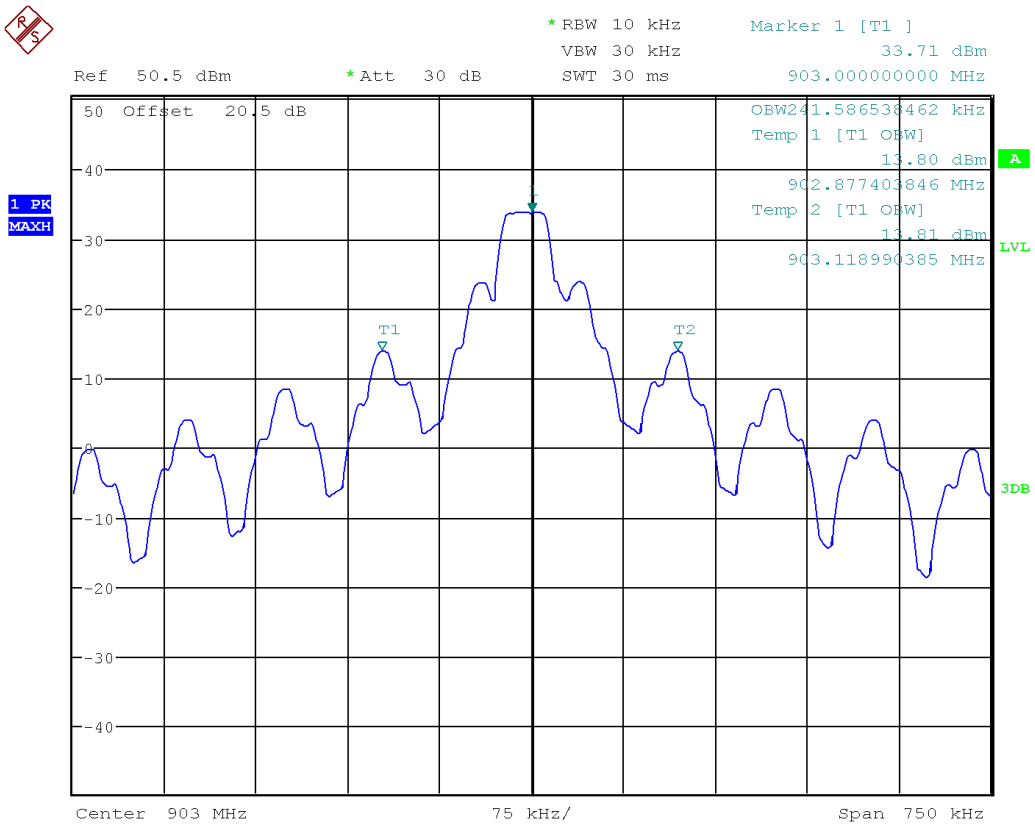
Date: 28.APR.2022 16:14:22

20dB BW



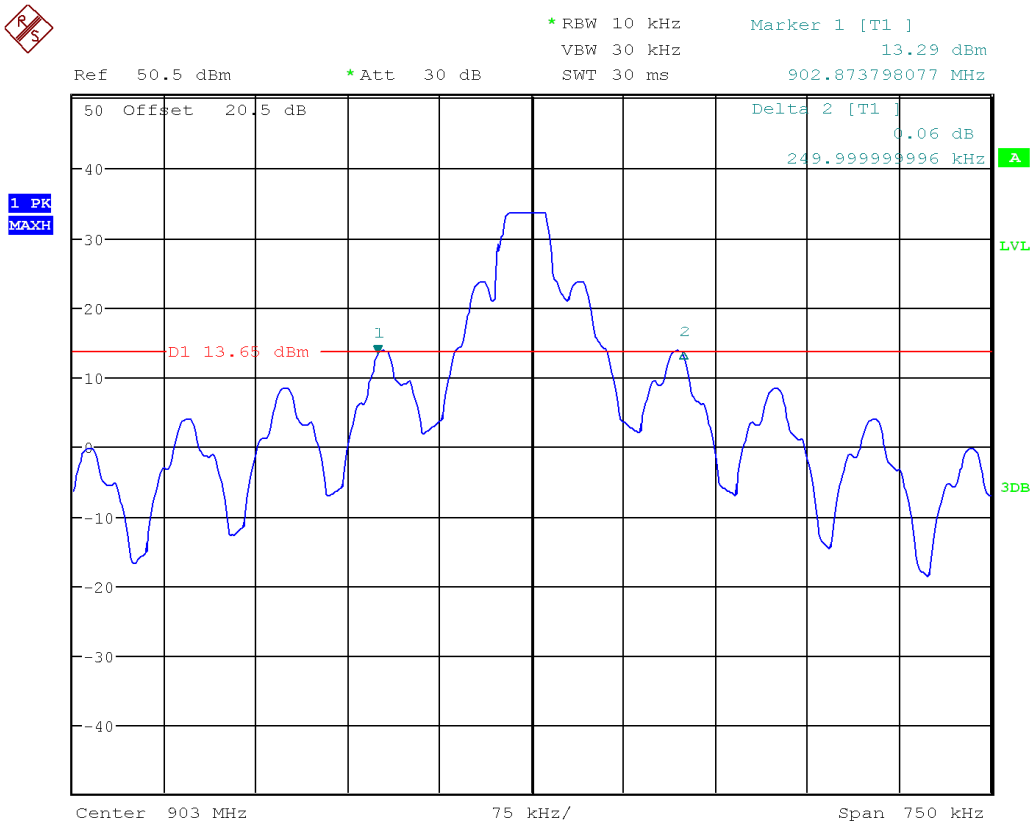
Date: 28.APR.2022 16:15:59

6B – 902 – 904 MHz Sub-Band
99% BW



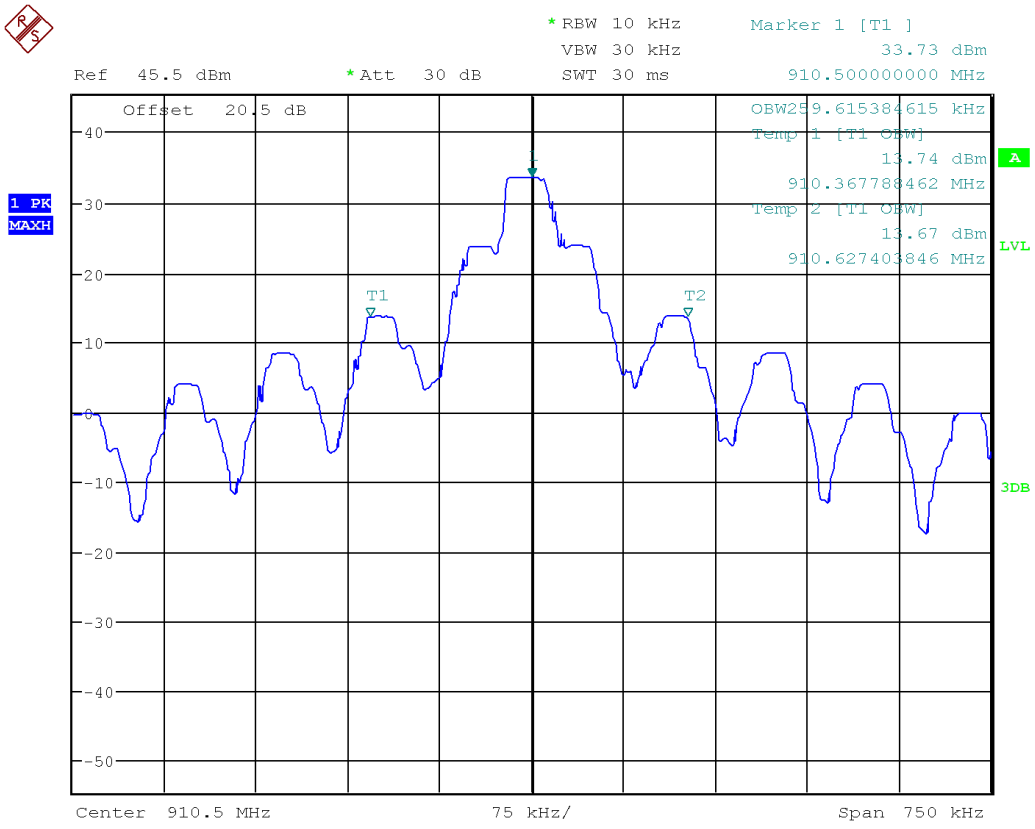
Date: 29.APR.2022 10:01:13

20dB BW



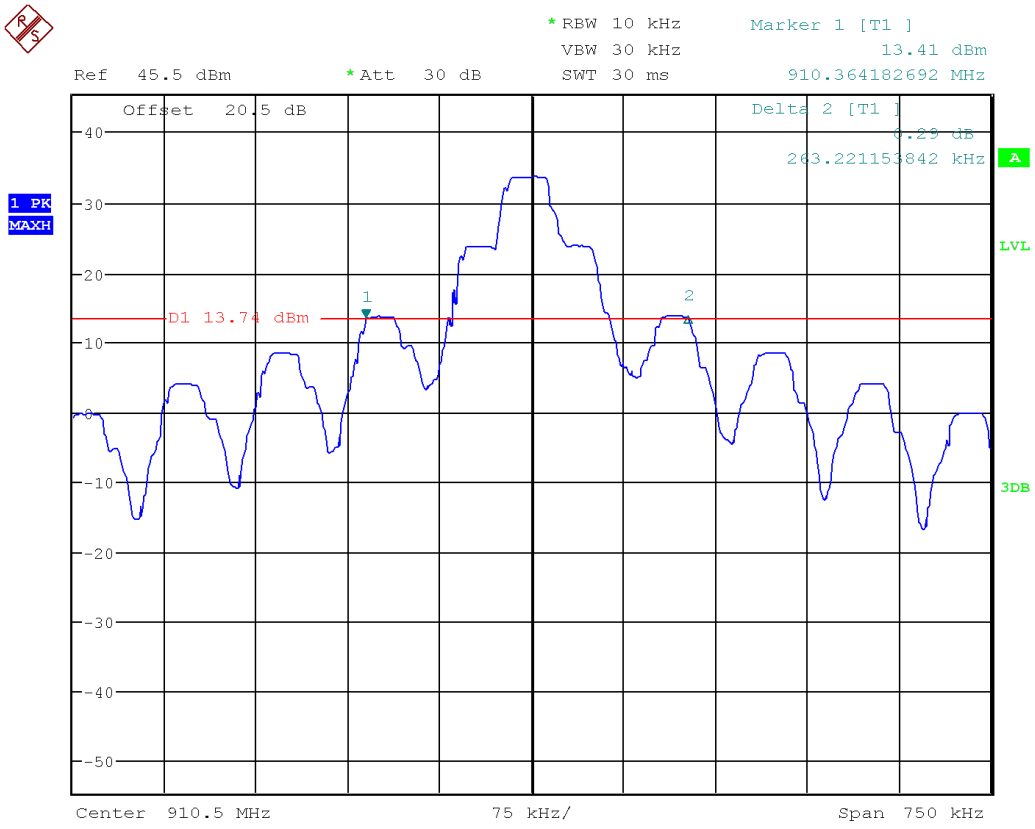
Date: 29.APR.2022 10:04:36

6B – 909.75 – 921.75 MHz Sub-Band
Low Channel
99% BW



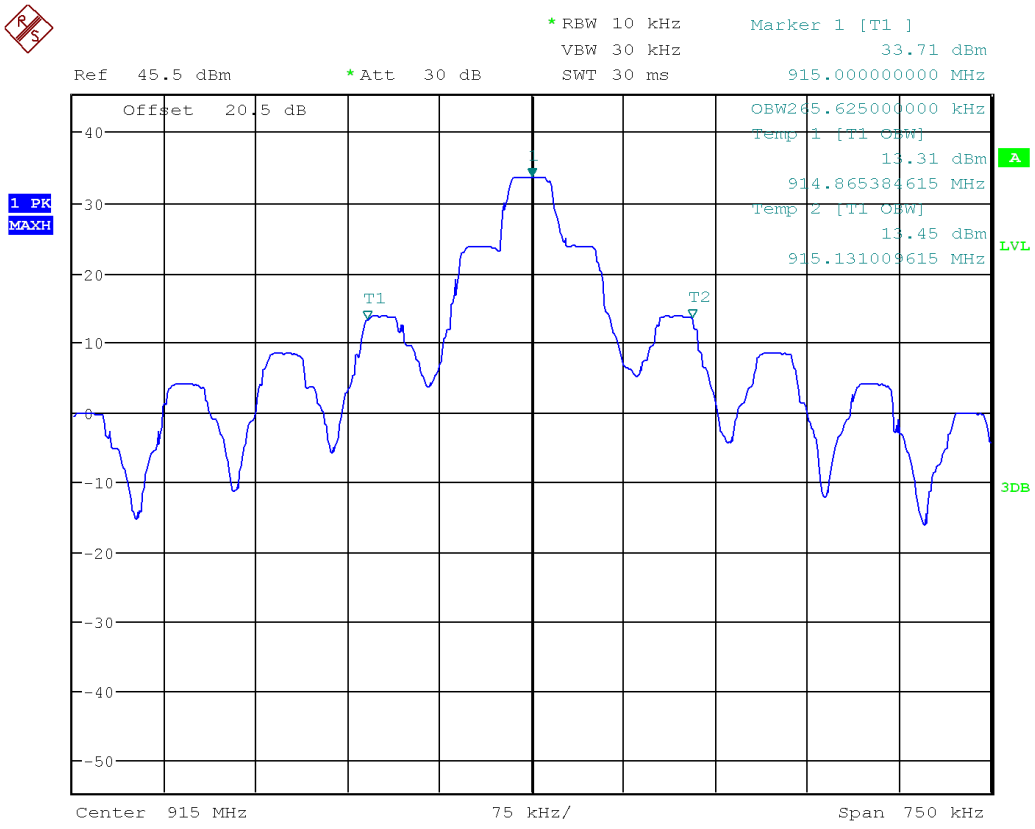
Date: 29.APR.2022 10:17:03

20dB BW



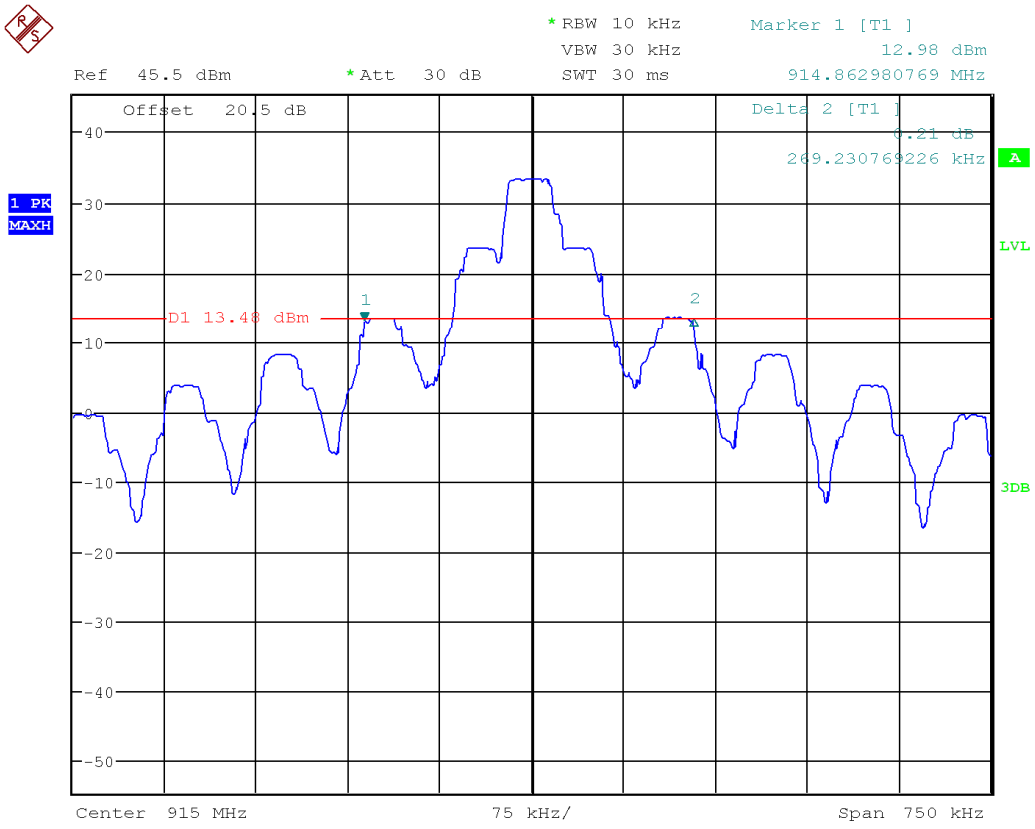
Date: 29.APR.2022 10:22:24

6B – 909.75 – 921.75 MHz Sub-Band
Mid Channel
99% BW



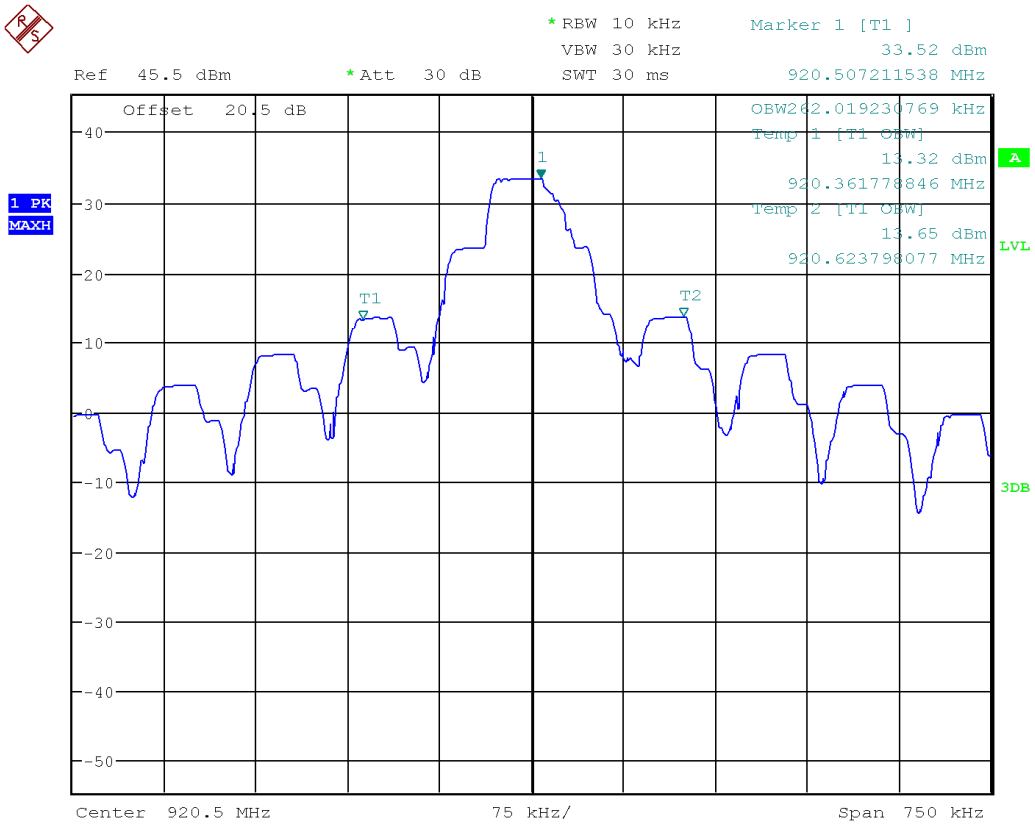
Date: 29.APR.2022 10:30:37

20dB BW



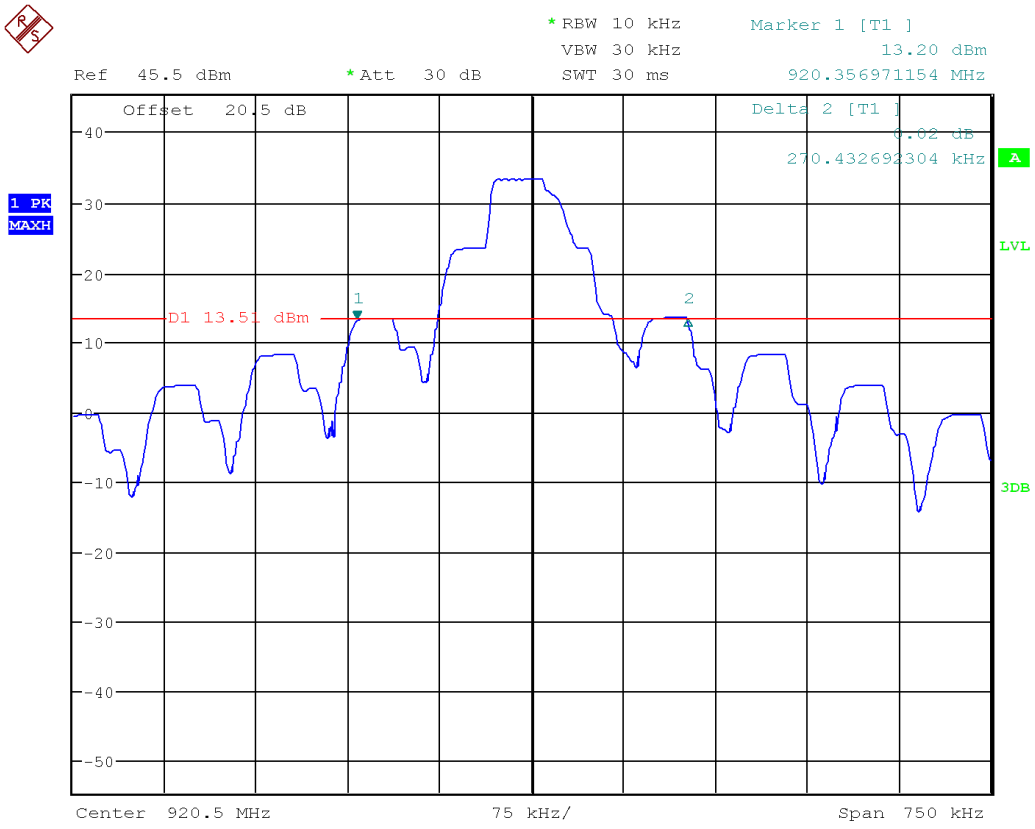
Date: 29.APR.2022 10:27:40

6B – 909.75 – 921.75 MHz Sub-Band
High Channel
99% BW



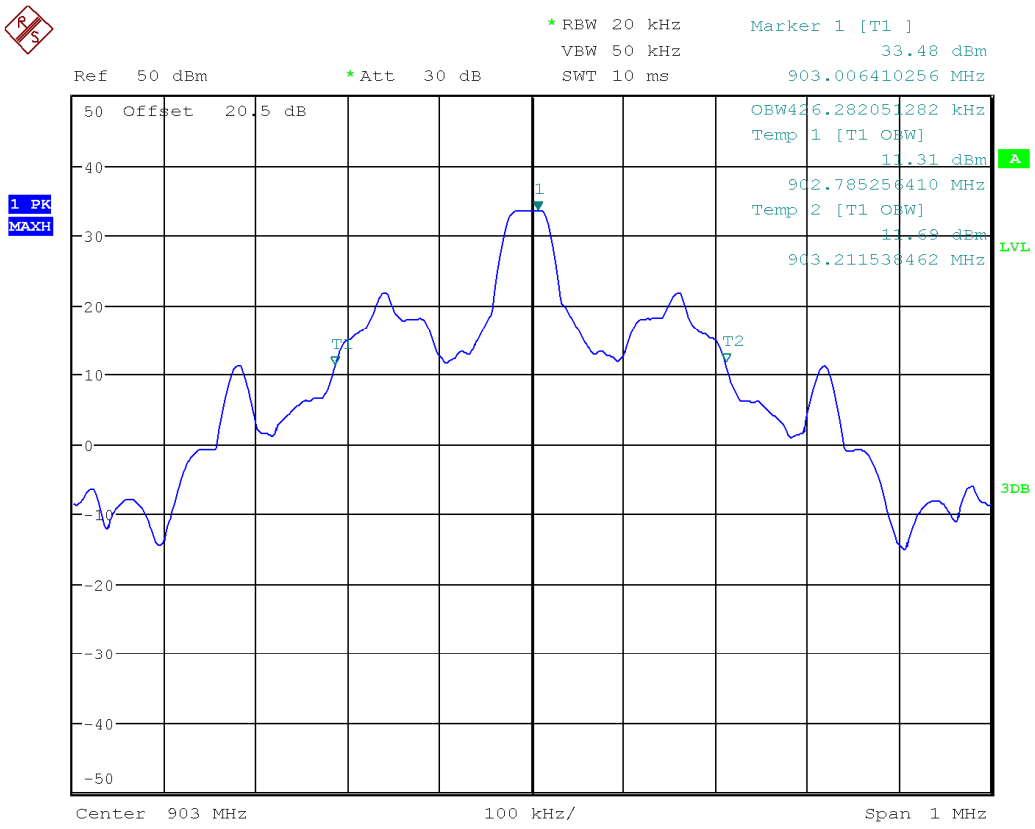
Date: 29.APR.2022 10:36:08

20dB BW



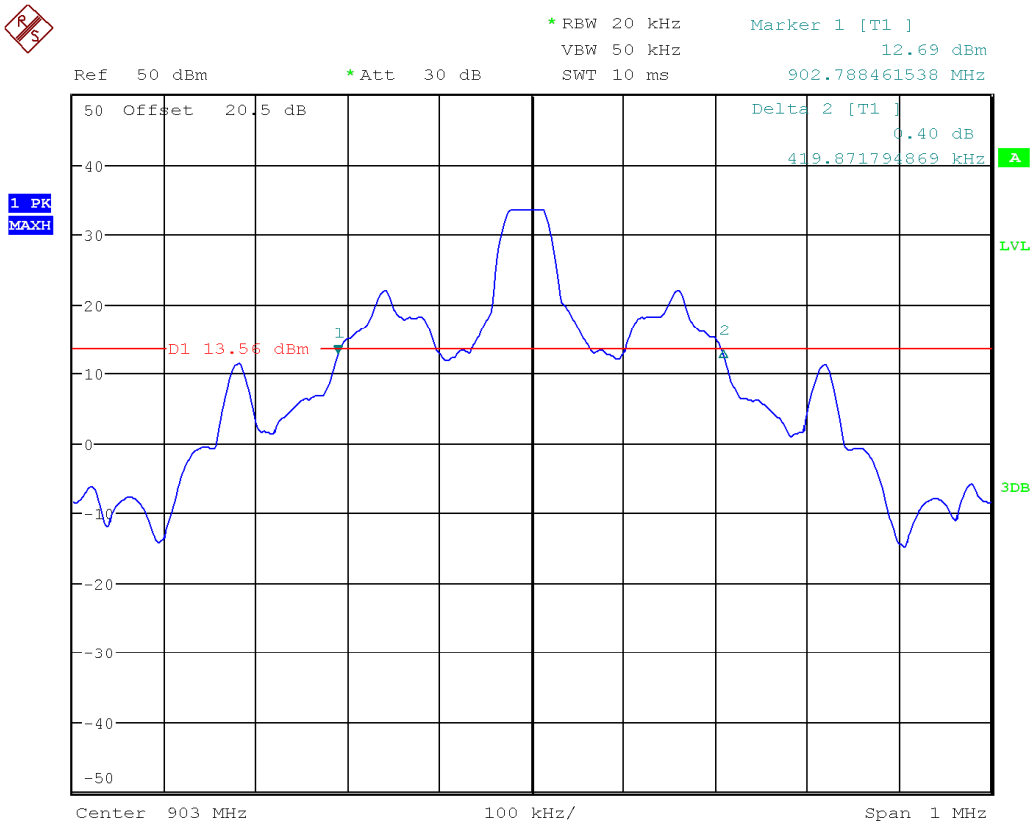
Date: 29.APR.2022 10:39:17

6C – 902 – 904 MHz Sub-Band
99% BW



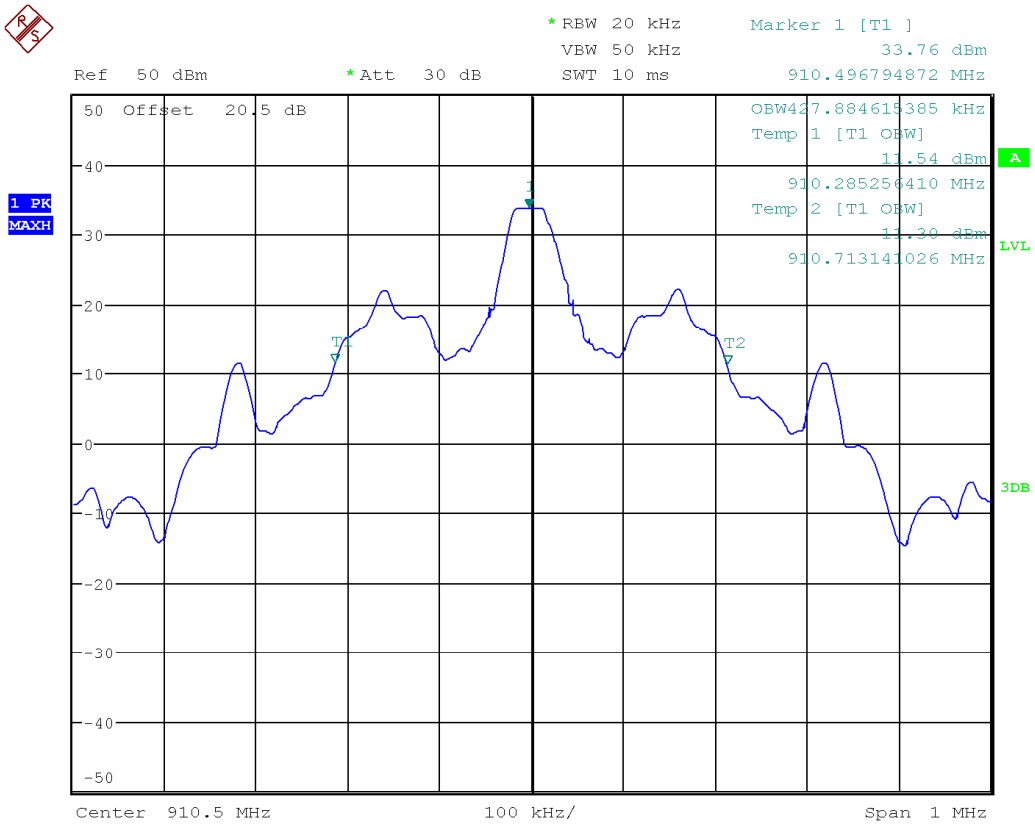
Date: 29.APR.2022 11:19:30

20dB BW



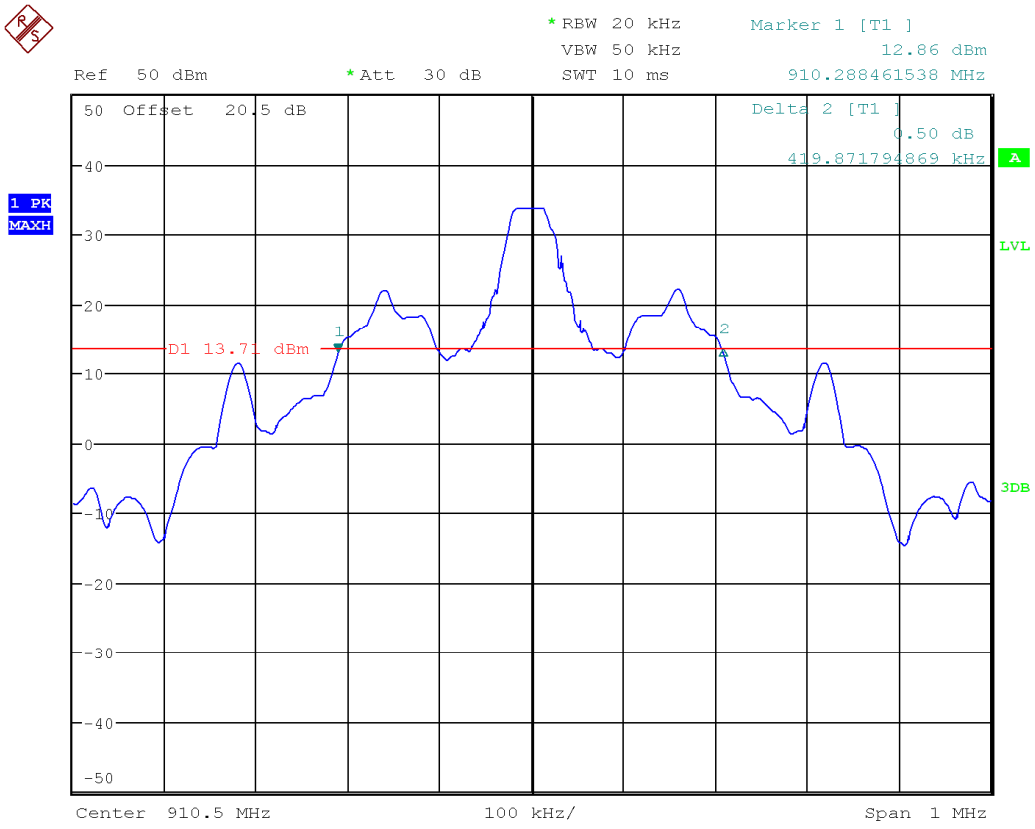
Date: 29.APR.2022 11:17:51

6C – 909.75 – 921.75 MHz Sub-Band
Low Channel
99% BW



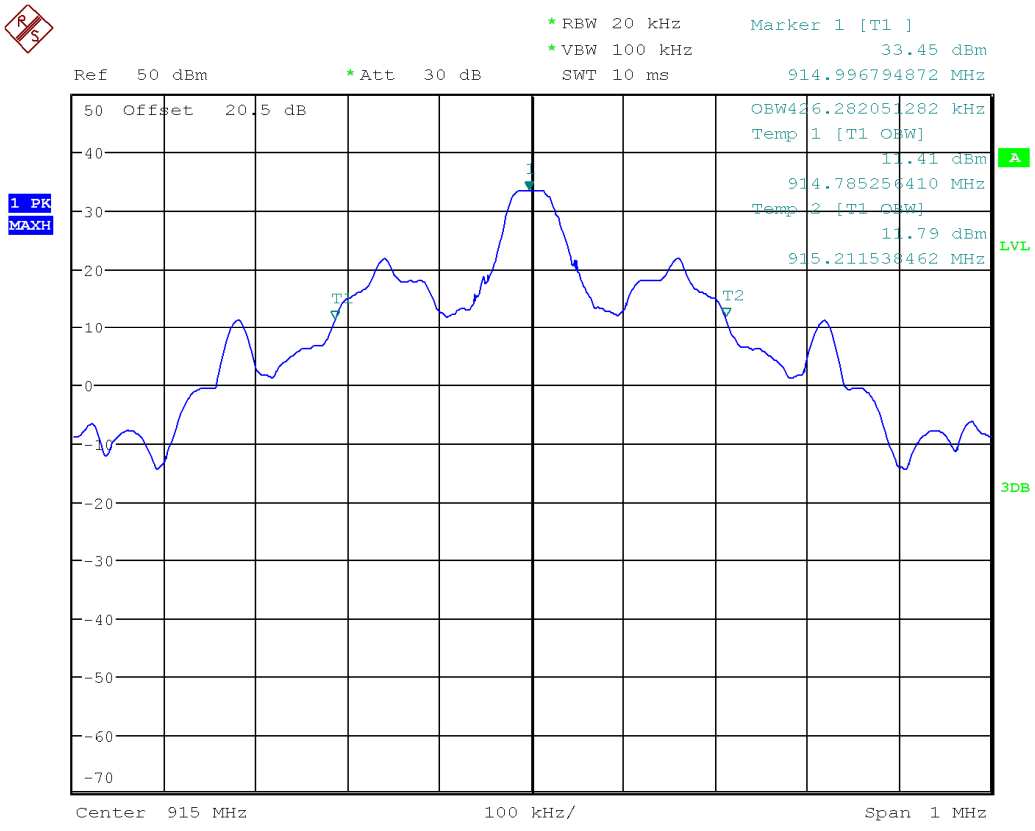
Date: 29.APR.2022 11:36:29

20dB BW



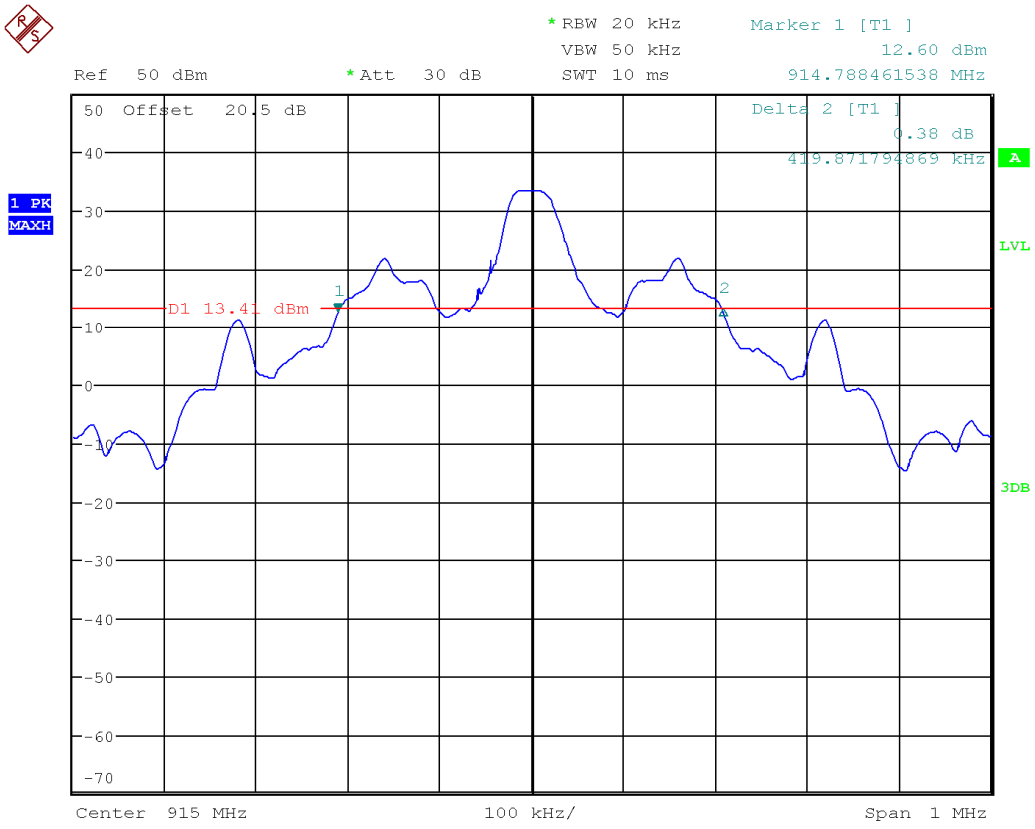
Date: 29.APR.2022 11:37:54

6C – 909.75 – 921.75 MHz Sub-Band
Mid Channel
99% BW



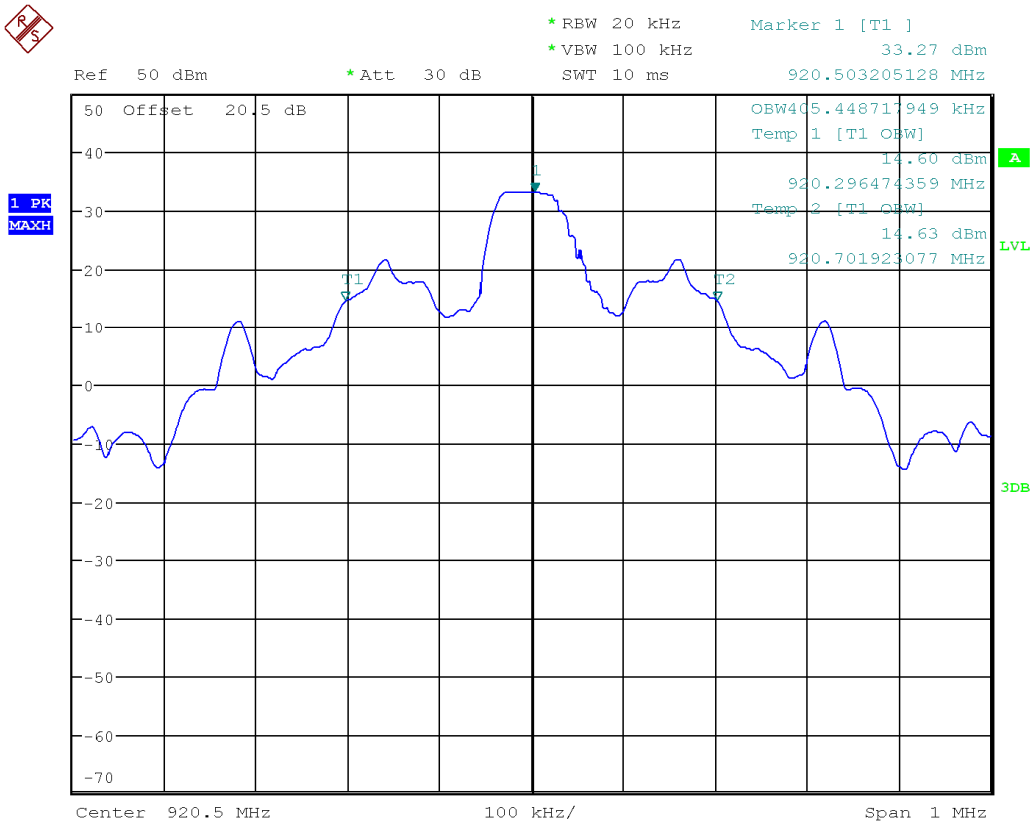
Date: 29.APR.2022 12:04:05

20dB BW



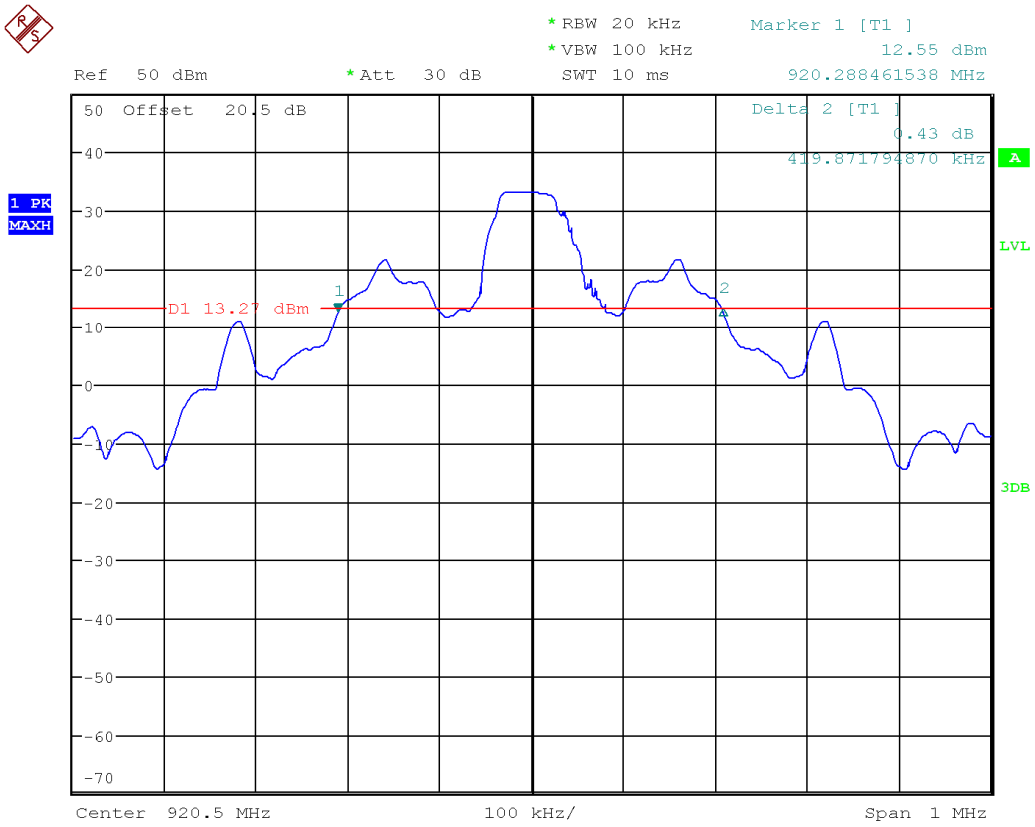
Date: 29.APR.2022 12:00:26

6C – 909.75 – 921.75 MHz Sub-Band
High Channel
99% BW



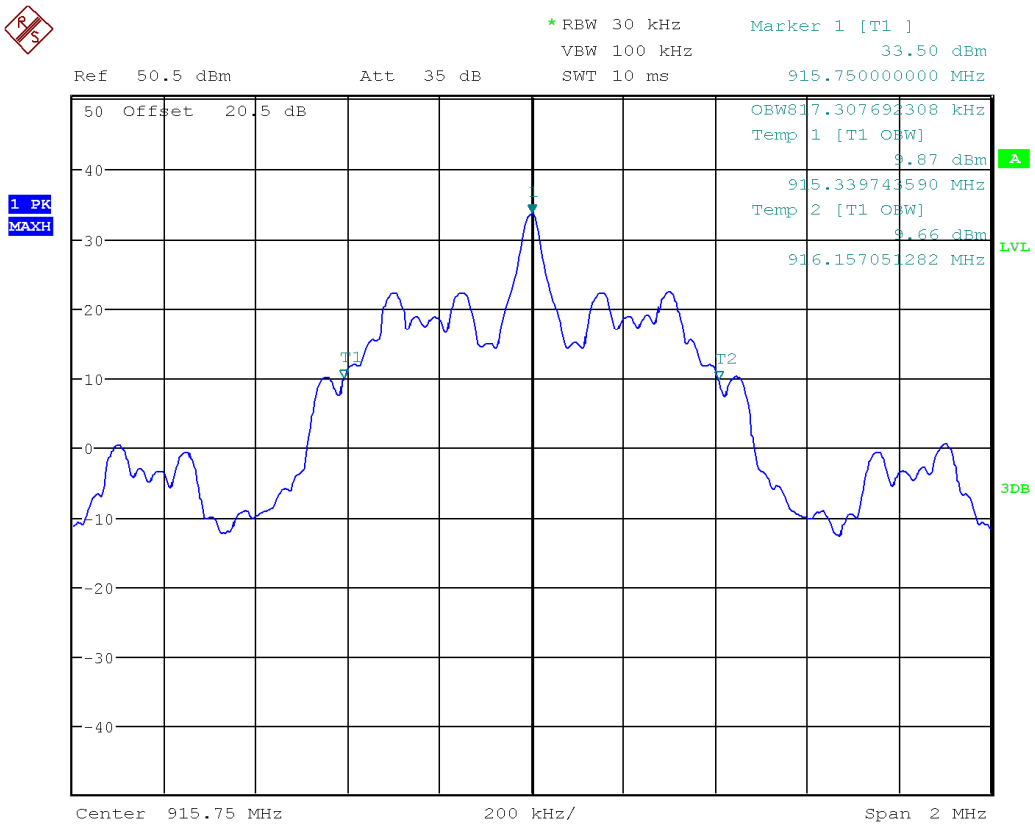
Date: 29.APR.2022 12:10:55

20dB BW



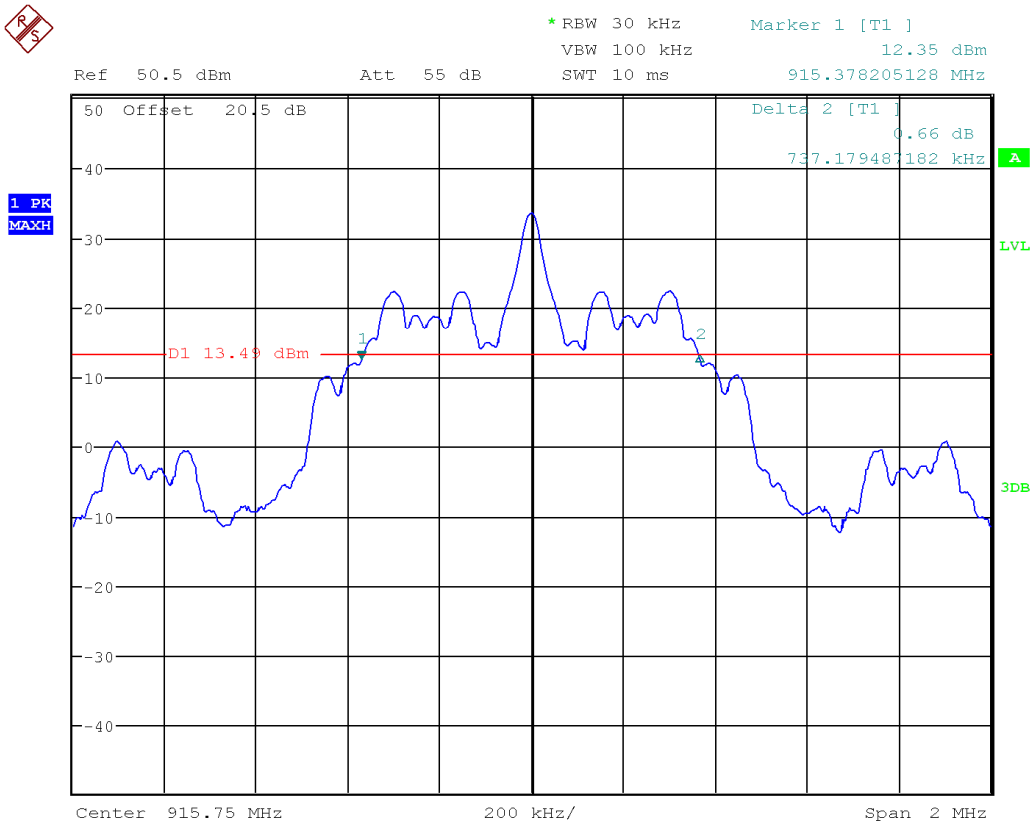
Date: 29.APR.2022 12:12:05

T21
99% BW



Date: 29.APR.2022 14:05:03

20 dB BW



Date: 29.APR.2022 14:06:23

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 #
Signal Analyzer	FSQ 26	Rohde & Schwarz	Nov. 30 2021	Nov. 30, 2023	GEMC 234
10dB Attenuator	6N5W-10	Inmet	NCR	NCR	GEMC 348
10dB Attenuator	18N5W-10	Inmet	NCR	NCR	GEMC 358

Emission Mask

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

The Limit is as specified in FCC Part 90.210 (K) and RSS-137 Clause 6.5.3

Emission Mask K—(1) Wideband multilateration transmitters. For transmitters authorized under subpart M to provide forward or reverse links in a multilateration system in the subbands 904-909.75 MHz, 921.75-927.25 MHz and 919.75-921.75 MHz, and which transmit an emission occupying more than 50 kHz bandwidth: in any 100 kHz band, the center frequency of which is removed from the center of authorized sub-band(s) by more than 50 percent of the authorized bandwidth, the power of emissions shall be attenuated below the transmitter output power, as specified by the following equation, but in no case less than 31 dB:

A=16+0.4 (D−50)+10 log B (attenuation greater than 66 dB is not required)
Where:

A = attenuation (in decibels) below the maximum permitted output power level
D = displacement of the center frequency of the measurement bandwidth from the center frequency of the authorized sub-band, expressed as a percentage of the authorized bandwidth B
B = authorized bandwidth in megahertz.

(2) Narrowband forward link transmitters. For LMS multilateration narrowband forward link transmitters operating in the 927.25-928 MHz frequency band the power of any emission shall be attenuated below the transmitter output power (P) in accordance with following schedule:

On any frequency outside the authorized sub-band and removed from the edge of the authorized sub-band by a displacement frequency (f_d in kHz): at least 116 log ((f_d+10)/6.1) dB or 50 + 10 log (P) dB or 70 dB, whichever is the lesser attenuation.

(3) Other transmitters. For all other transmitters authorized under subpart M that operate in the 902-928 MHz band, the peak power of any emission shall be attenuated below the power of the highest emission contained within the licensee's sub-band in accordance with the following schedule:

(i) On any frequency within the authorized bandwidth: Zero dB.
(ii) On any frequency outside the licensee's sub-band edges: 55 + 10 log(P) dB, where (P) is the highest emission (watts) of the transmitter inside the licensee's sub-band.

(4) In the 902-928 MHz band, the resolution bandwidth of the instrumentation used to measure the emission power shall be 100 kHz, except that, in regard to paragraph (2) of this section, a minimum spectrum analyzer resolution bandwidth of 300 Hz shall be used for measurement center frequencies with 1 MHz of the edge of the authorized subband. The video filter bandwidth shall not be less than the resolution bandwidth.

(5) Emission power shall be measured in peak values.

(6) The LMS sub-band edges for non-multilateration systems for which emissions must be attenuated are 902.00, 904.00, 909.5 and 921.75 MHz.

Note: The EUT is a non- multilateration LMS transmitter. Emission limit (3) applies to the EUT. A 55 + 10 log(P) dB attenuation (or -25 dBm absolute emission level) was applied all frequency from the outside authorized band.

Test procedure is as per ANSI C63.26 Clause 5.7.

Results

The EUT passed; it meets attenuation requirement at the antenna port.

The worst case is presented as a graph for the spectrum. Band edge requirements were shown for the lower band edge at 902 and 909.5 MHz in the low band where applicable. Band edge requirements were also shown for the higher band edge at 904 and 921.75 MHz in the high band where applicable.

Note: All measurements were made with an attenuator as appropriate to the measurement. The insertion loss was adjusted with Reference Level Offset function in the spectrum analyzer for band edge and Transducer Factor for 30 MHz – 10 GHz.

ATA – 902 – 904 MHz Sub-Band					
Channel	Frequency (MHz)	Band Edge (dBm)	Limit (dBm)	Margin (dB)	Verdict
Low Channel	902	-33.81	-25.0	-8.8	Pass
High Channel	904	-33.43	-25.0	-8.4	Pass
ATA – 909.75 – 921.75 MHz Sub-Band					
Channel	Frequency (MHz)	Band Edge (dBm)	Limit (dBm)	Margin (dB)	Verdict
Low Channel	909.75	-31.95	-25.0	-7.0	Pass
High Channel	921.75	-27.49	-25.0	-2.5	Pass

KTDM					
Channel	Frequency (MHz)	Band Edge (dBm)	Limit (dBm)	Margin (dB)	Verdict
Channel	909.75	-30.46	-25.0	-5.5	Pass
Channel	921.75	-29.07	-25.0	-4.1	Pass

SeGO					
Channel	Frequency (MHz)	Band Edge (dBm)	Limit (dBm)	Margin (dB)	Verdict
Low Channel	909.75	-29.68	-25.0	-6.7	Pass
High Channel	921.75	-29.64	-25.0	-4.6	Pass

6B – 902 – 904 MHz Sub-Band					
Channel	Frequency (MHz)	Band Edge (dBm)	Limit (dBm)	Margin (dB)	Verdict
Channel	902	-30.82	-25.0	-5.8	Pass
Channel	904	-29.43	-25.0	-4.4	Pass
6B - 909.75 to 921.75 MHz Sub-Band					
Channel	Frequency (MHz)	Band Edge (dBm)	Limit (dBm)	Margin (dB)	Verdict
Low Channel	909.75	-28.99	-25.0	-4.0	Pass
High Channel	921.75	-31.34	-25.0	-6.3	Pass

6C – 902 – 904 MHz Sub-Band					
Channel	Frequency (MHz)	Band Edge	Limit	Margin	Verdict
Channel	902	-29.40	-25.0	-4.4	Pass
Channel	904	-29.15	-25.0	-4.2	Pass
6C – 909.75 to 921.75 MHz Sub-Band					
Channel	Frequency (MHz)	Band Edge (dBm)	Limit (dBm)	Margin (dB)	Verdict
Low Channel	909.75	-27.26	-25.0	-2.3	Pass
High Channel	921.75	-28.49	-25.0	-3.5	Pass

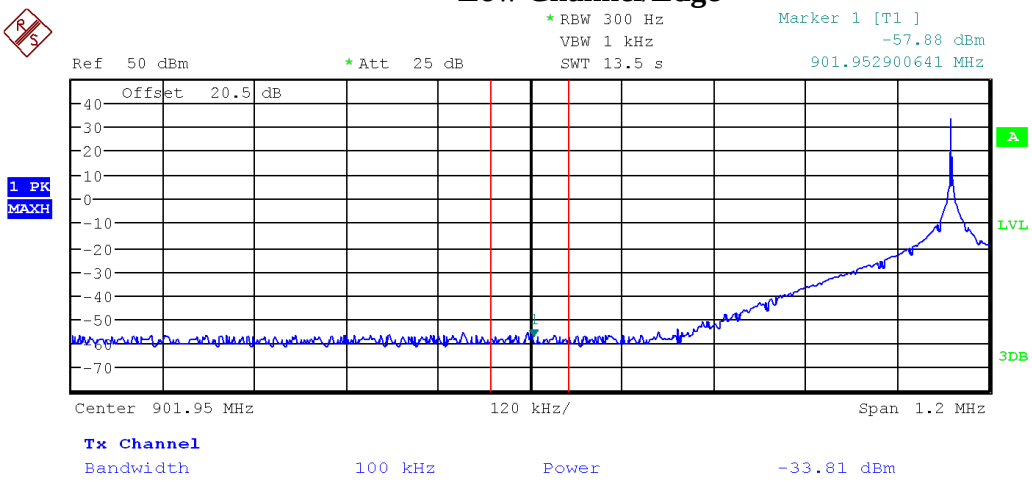
T21					
Channel	Frequency (MHz)	Band Edge (dBm)	Limit (dBm)	Margin (dB)	Verdict
Channel	909.75	-27.49	-25.0	-2.5	Pass
Channel	921.75	-27.26	-25.0	-2.3	Pass

Graph(s)

The graphs shown below shows the integrated band power or peak power of the device during the out-of-band emission measurement. For integrated band power, the center frequency of the spectrum analyzer is center at one-half of the measurement bandwidth away from the band edge and integration is performed over the full required measurement bandwidth.

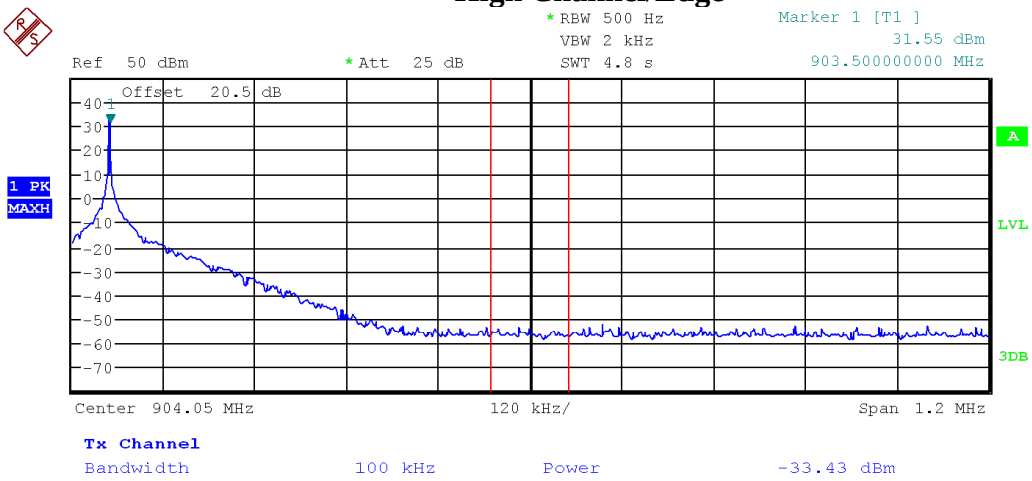
ATA Protocol

Band Edge
902 MHz – 904 MHz Sub-Band
Low Channel/Edge



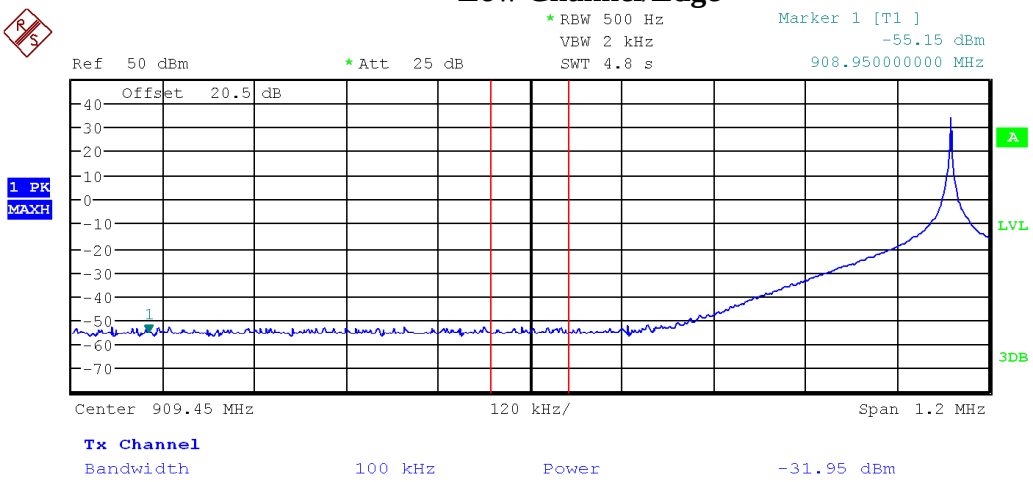
Date: 28.APR.2022 14:04:57

High Channel/Edge



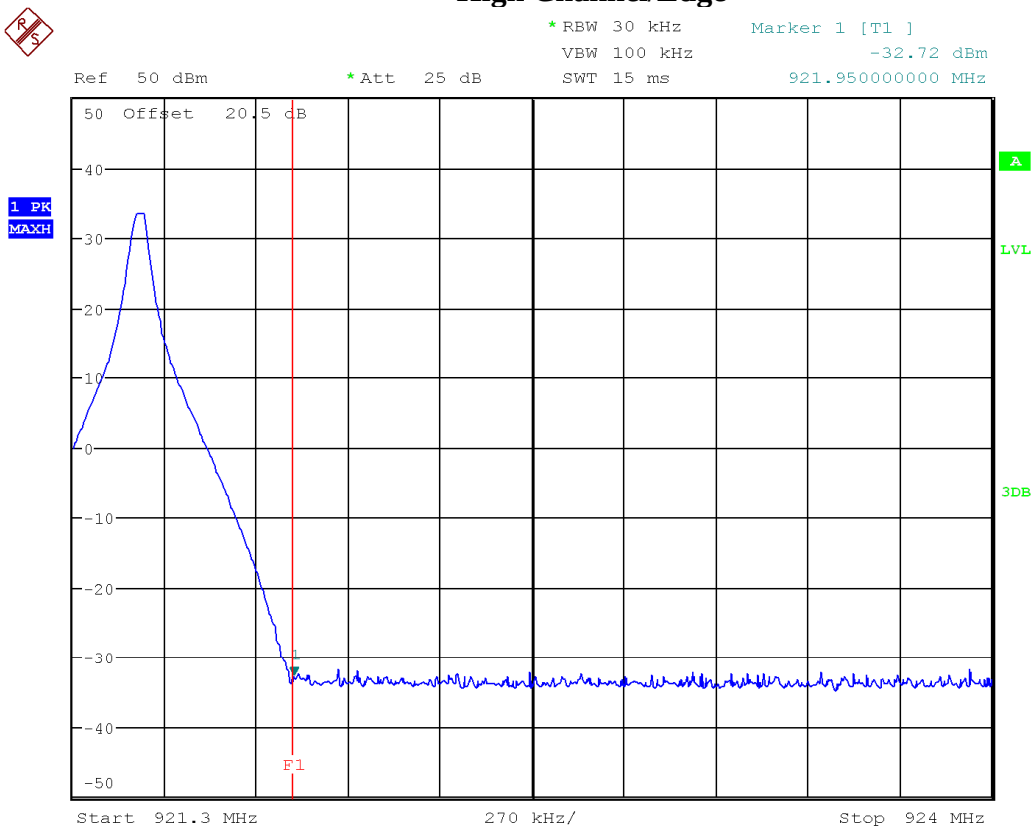
Date: 28.APR.2022 14:29:06

Band Edge
909.75 MHz – 921.75 MHz Sub-Band
Low Channel/Edge



Date: 28.APR.2022 12:17:46

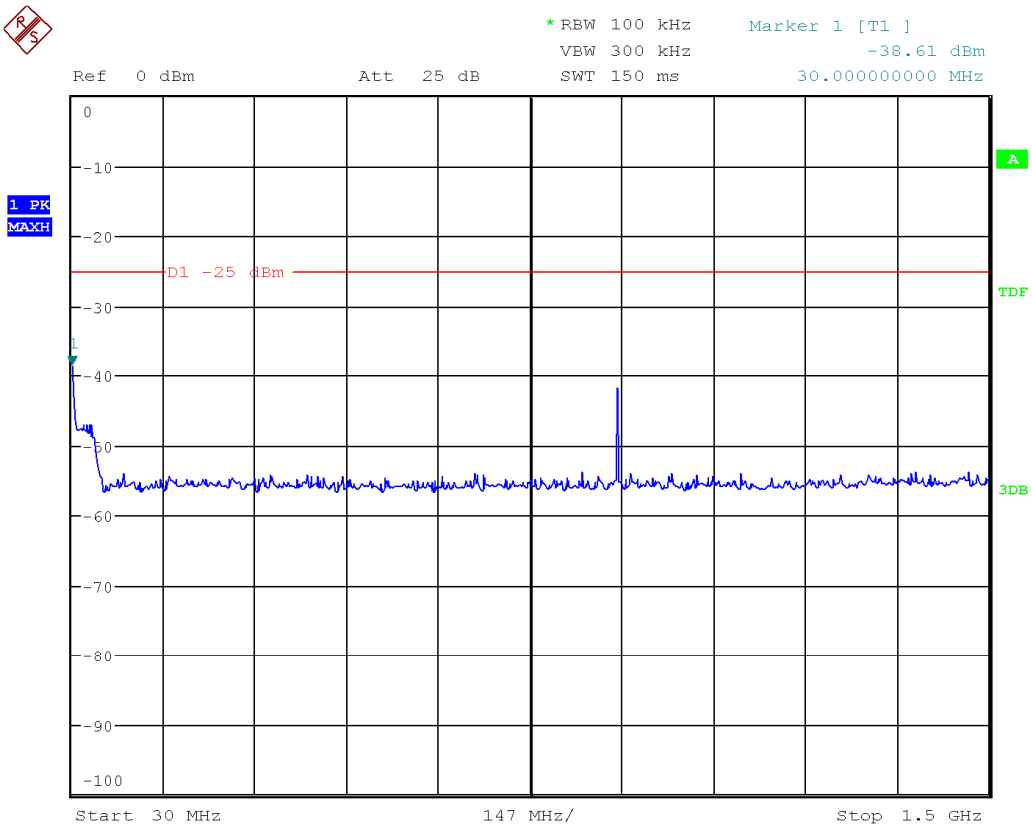
High Channel/Edge



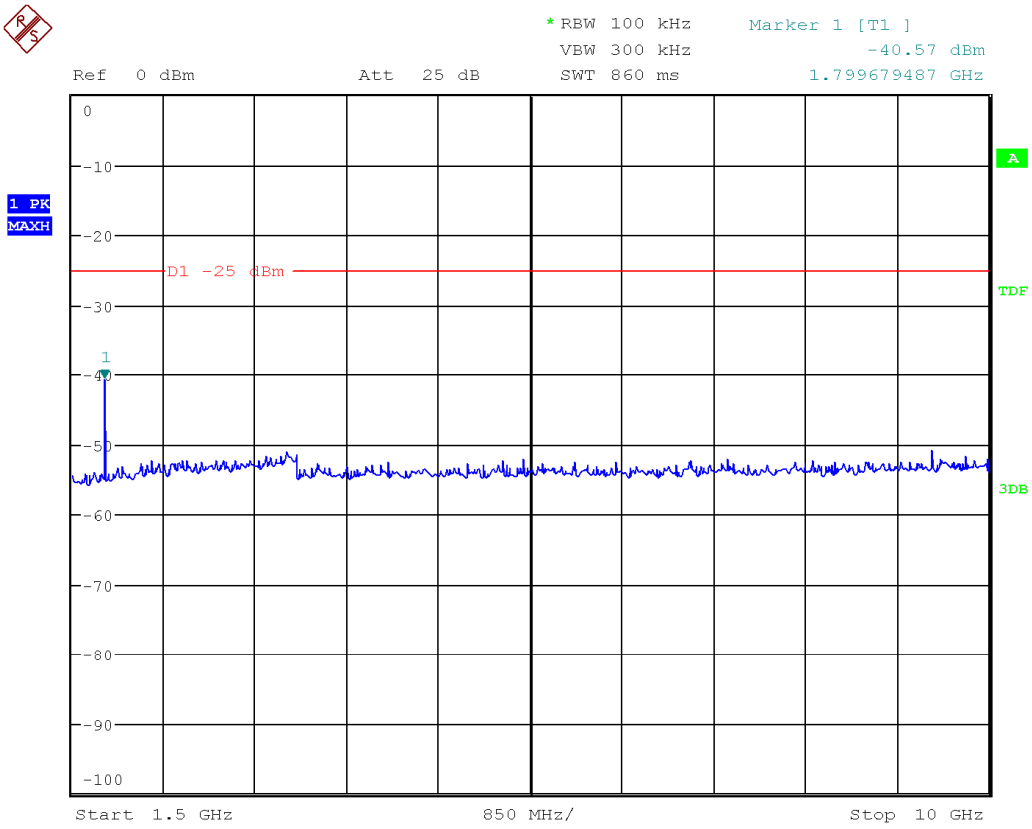
Date: 28.APR.2022 11:17:26

Note: For BE measurement; as per C63.26, 5.7.2, bandwidth correction factor is used. The bandwidth correction factor is 10log(100/30) = 5.23 dB. The measured value is -32.72 dBm thus the corrected value is -27.49 dBm.

Spurious emissions
30 MHz – 1.5 GHz



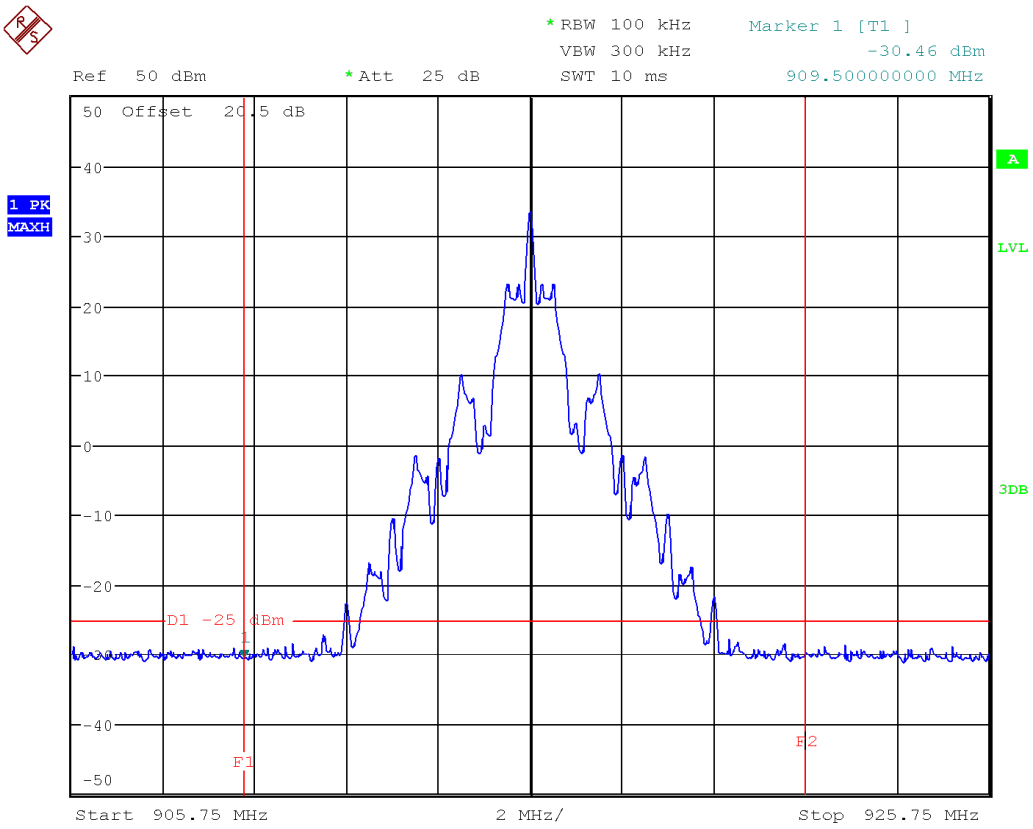
Date: 28.APR.2022 15:23:44



Date: 28.APR.2022 15:26:23

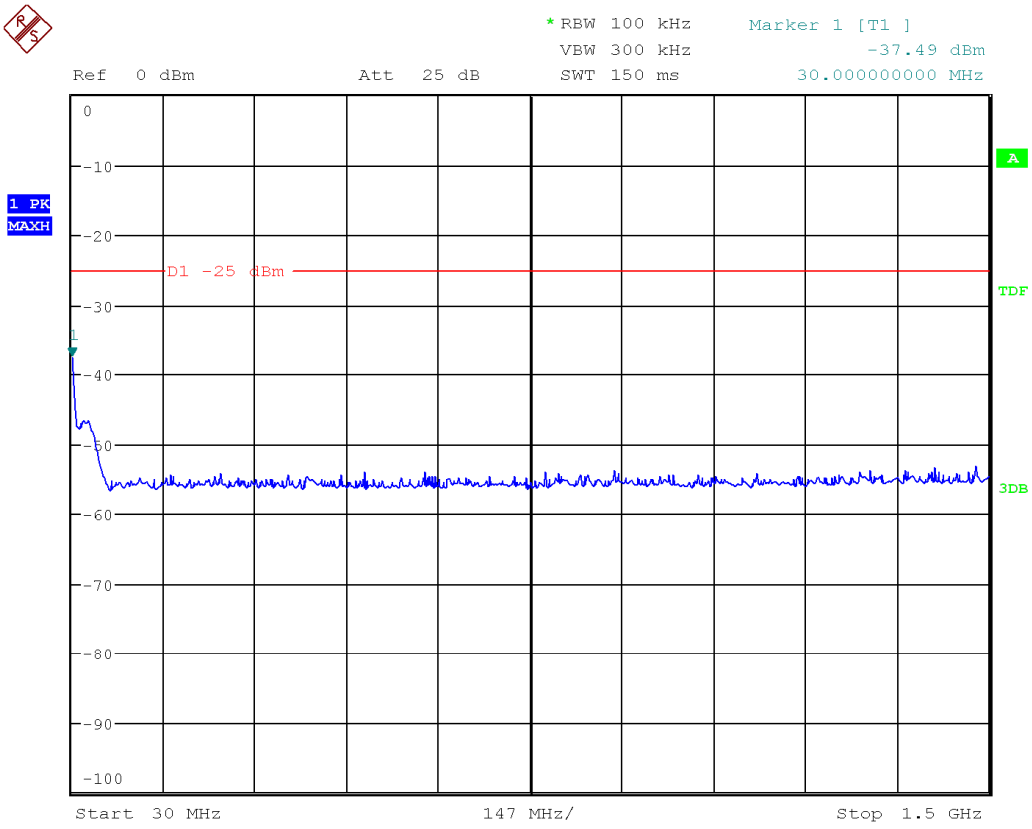
KTDM Protocol

Band Edge
909.75 MHz – 921.75 MHz Sub-Band



Date: 28.APR.2022 14:59:22

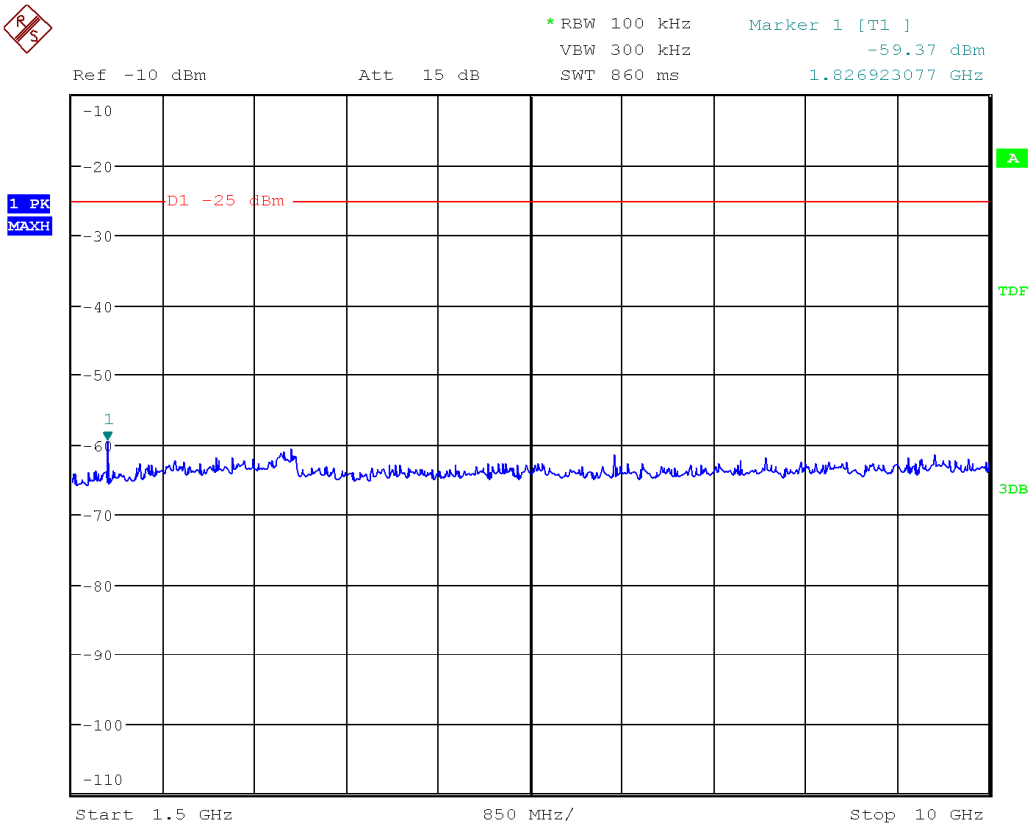
Spurious emissions
30 MHz – 1.5 GHz



Date: 28.APR.2022 15:21:48

No emissions were detected below 30 MHz.

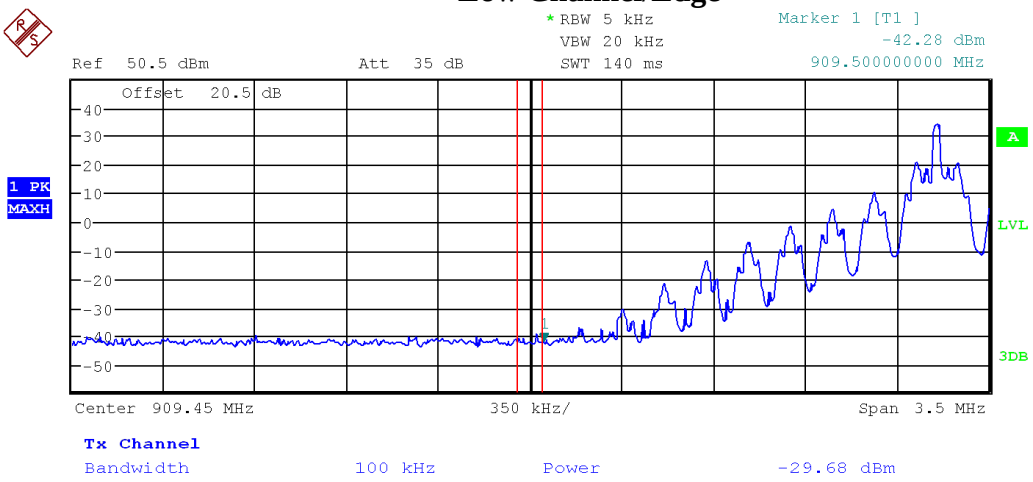
1.5 GHz – 10 GHz



Date: 28.APR.2022 15:33:55

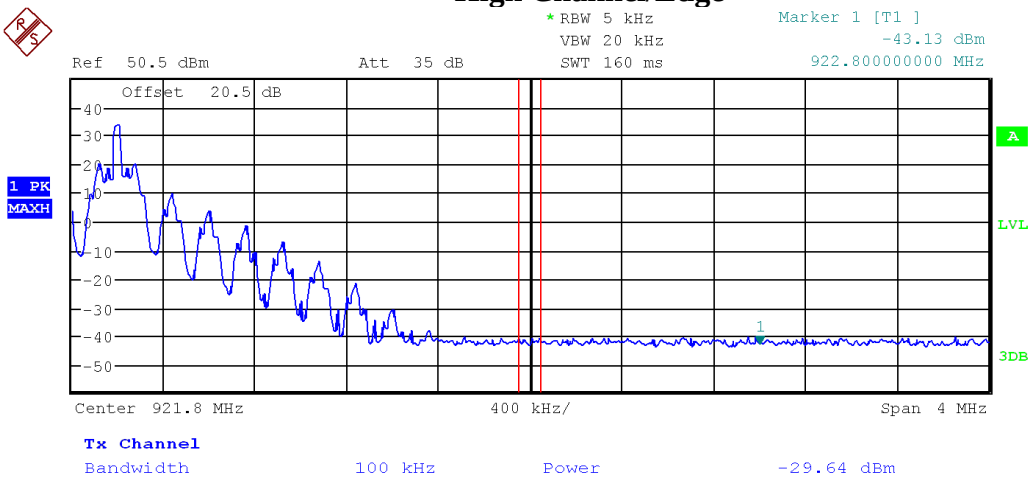
SeGO Protocol

Band Edge
909.75 MHz – 921.75 MHz Sub-Band
Low Channel/Edge



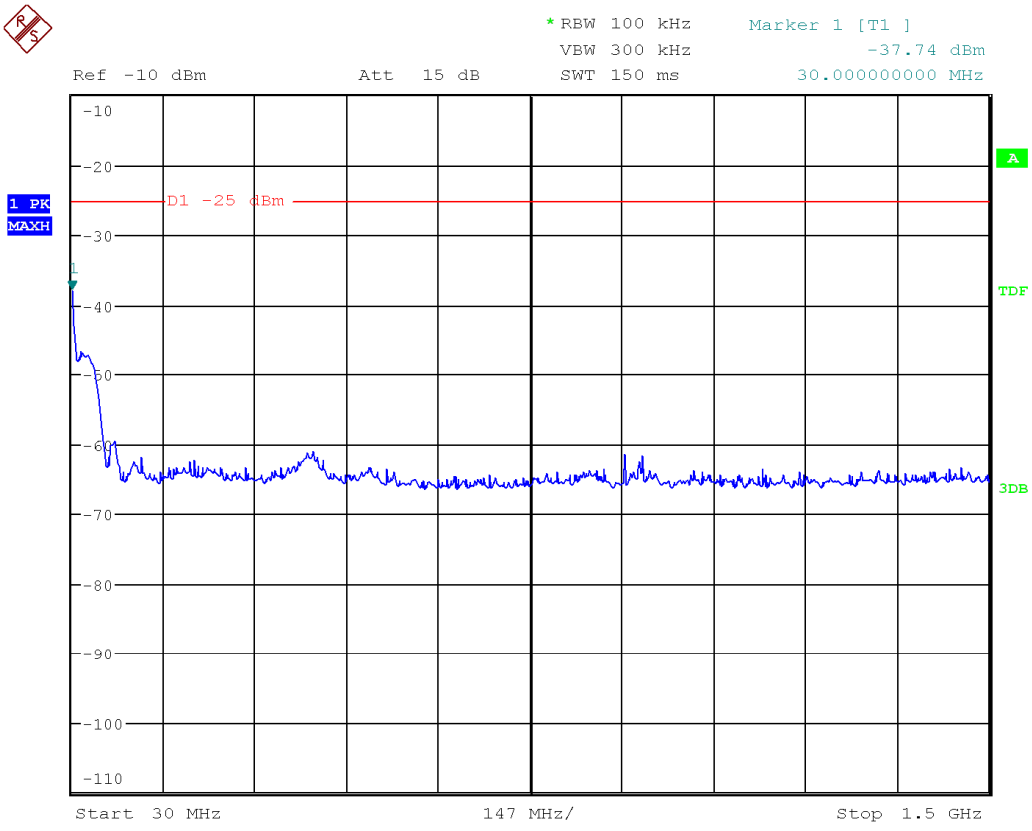
Date: 28.APR.2022 16:05:24

High Channel/Edge



Date: 28.APR.2022 16:18:20

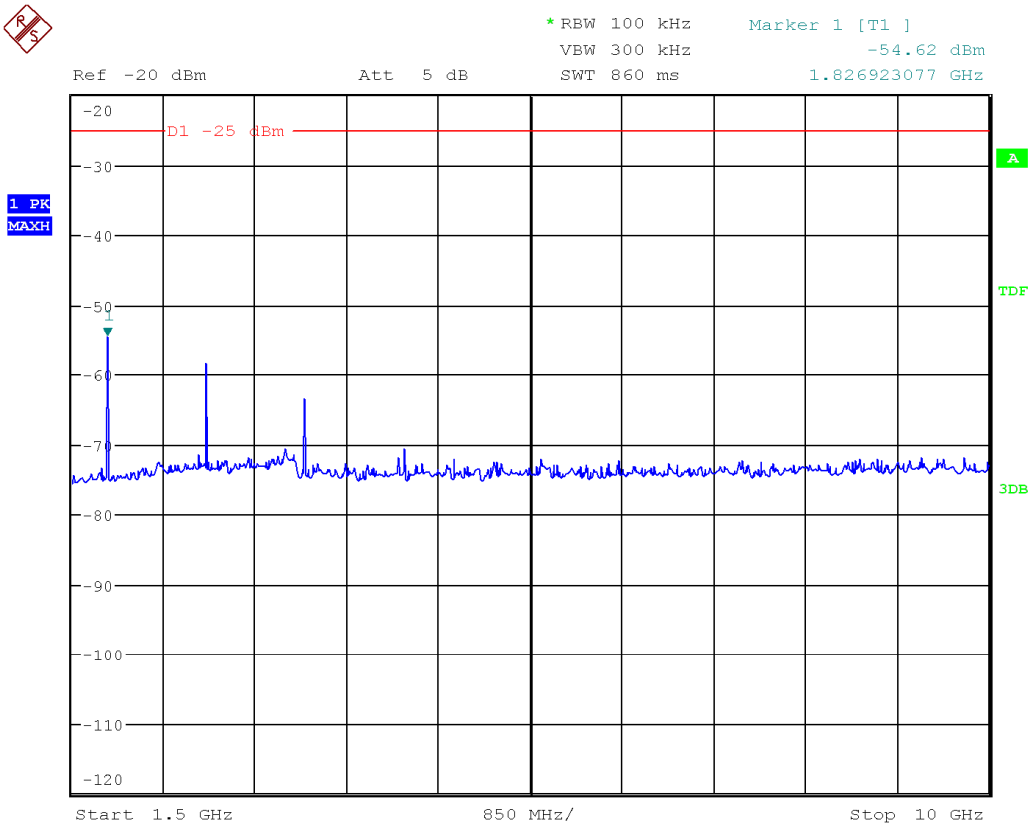
Spurious emissions
30 MHz – 1.5 GHz



Date: 28.APR.2022 15:40:58

No emissions were detected below 30 MHz.

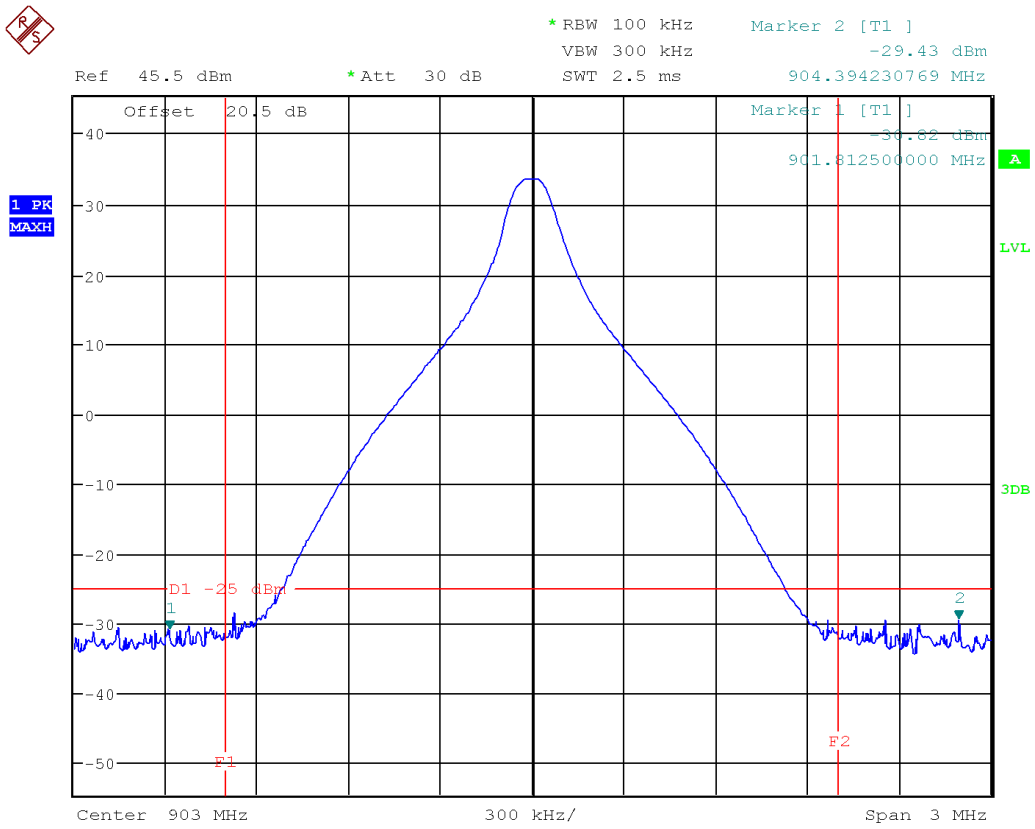
1.5 GHz – 10 GHz



Date: 28.APR.2022 15:36:54

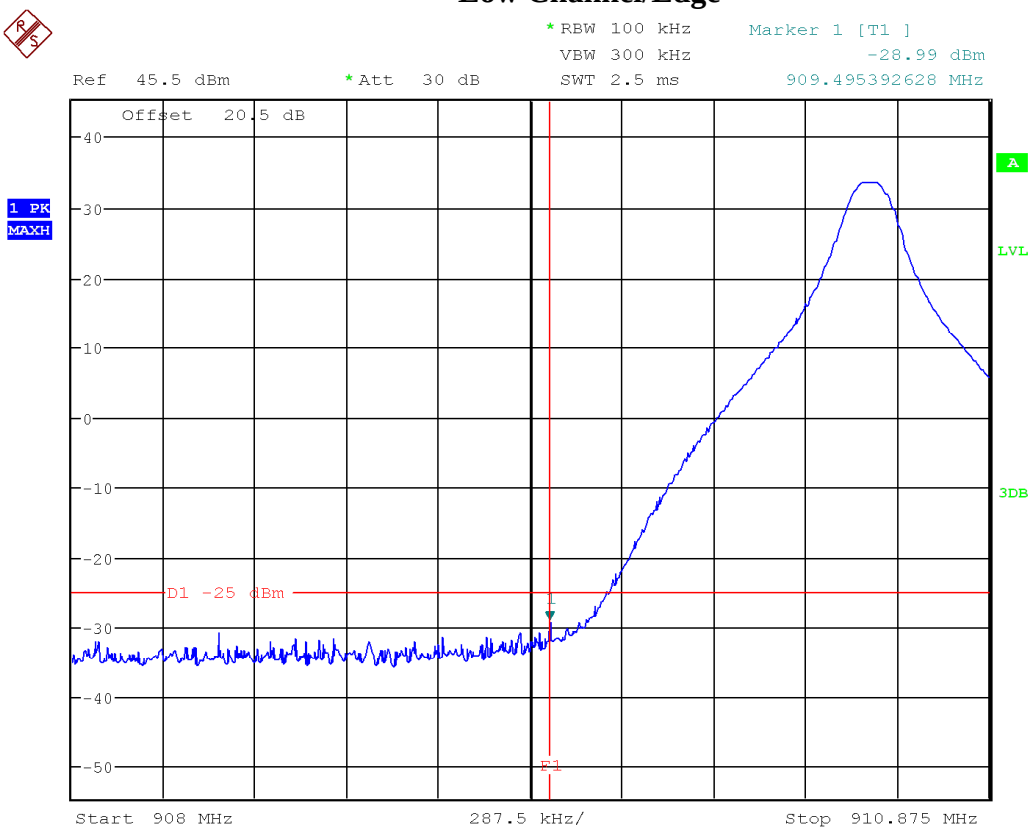
6B Protocol

Band Edge
902 MHz – 904 MHz Sub-Band



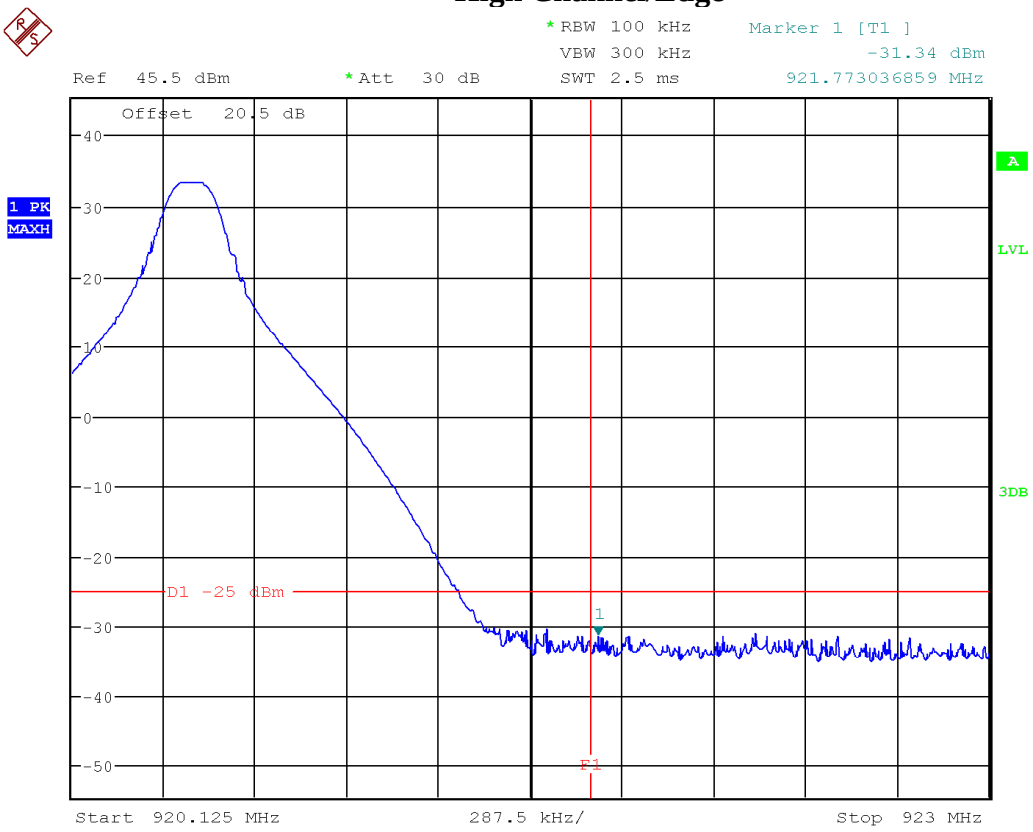
Date: 29.APR.2022 10:09:41

Band Edge
909.75 MHz – 921.75 MHz Sub-Band
Low Channel/Edge



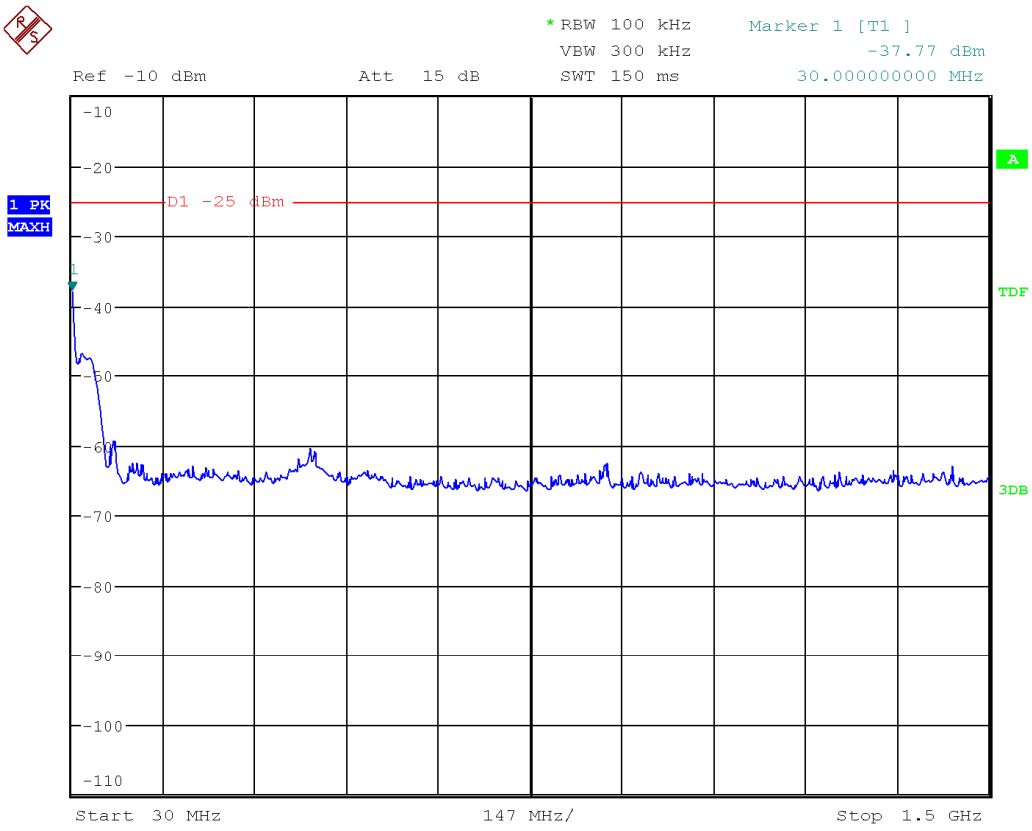
Date: 29.APR.2022 10:24:53

High Channel/Edge



Date: 29.APR.2022 10:43:37

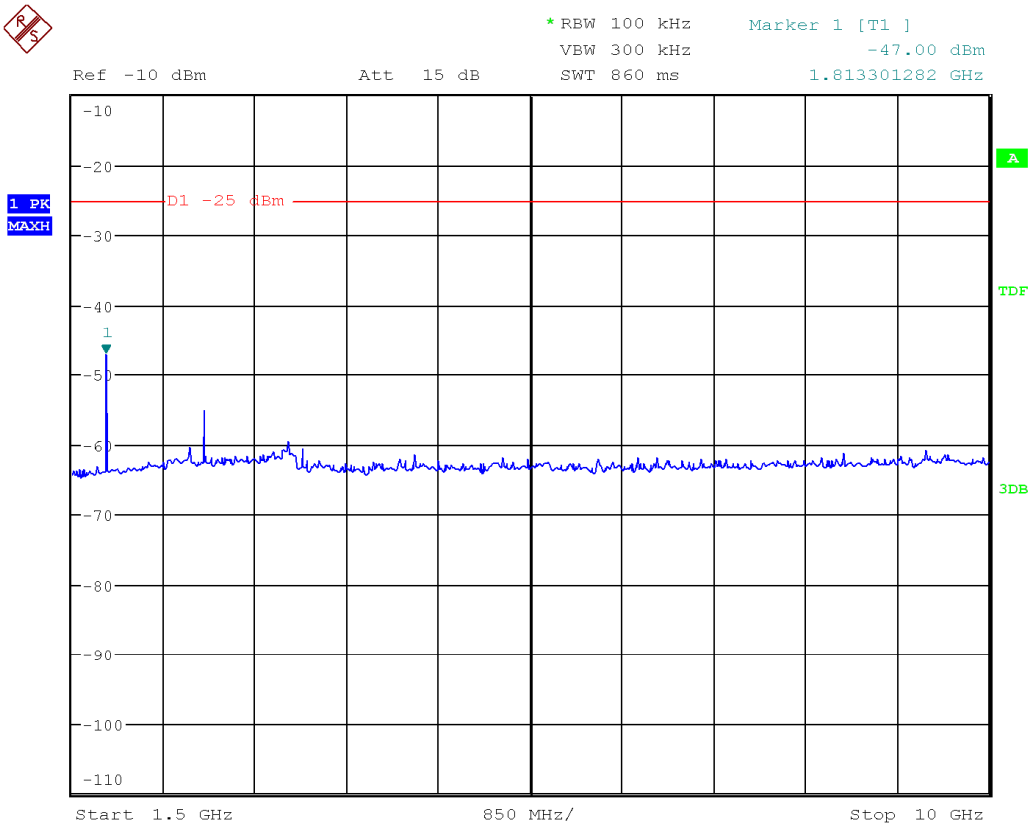
Spurious emissions
30 MHz – 1.5 GHz



Date: 29.APR.2022 10:54:30

No emissions were detected below 30 MHz.

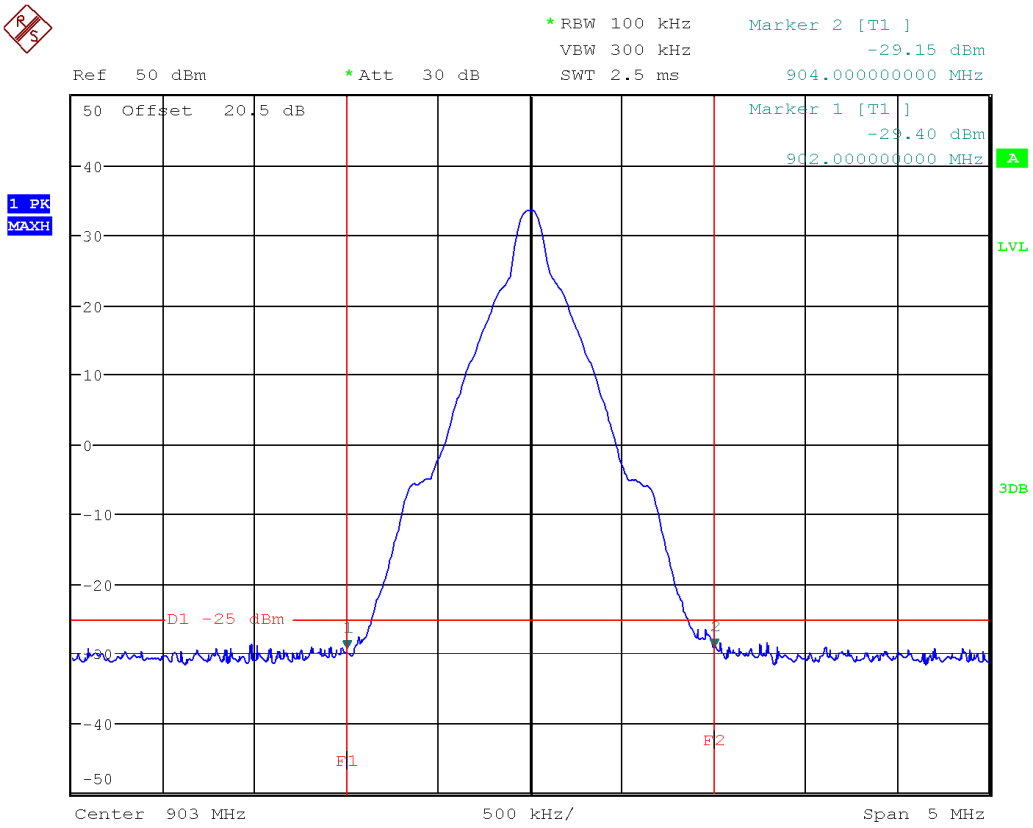
1.5 GHz – 10 GHz



Date: 29.APR.2022 11:02:41

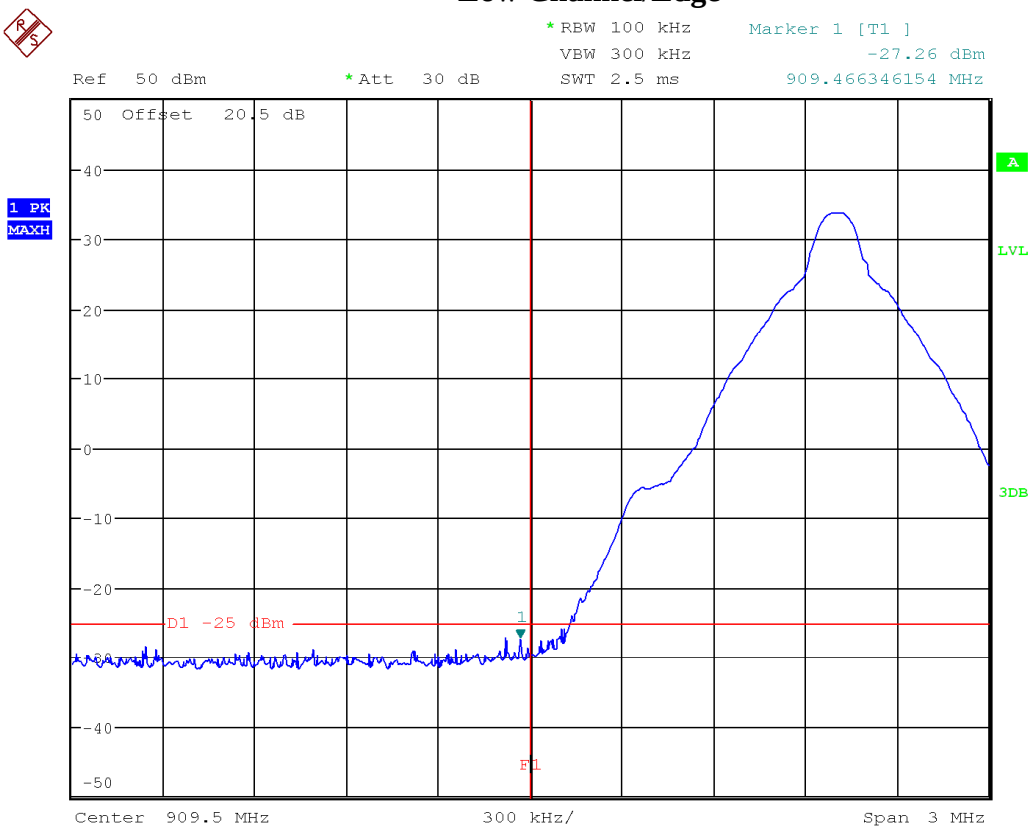
6C Protocol

Band Edge
902 MHz – 904 MHz Sub-Band



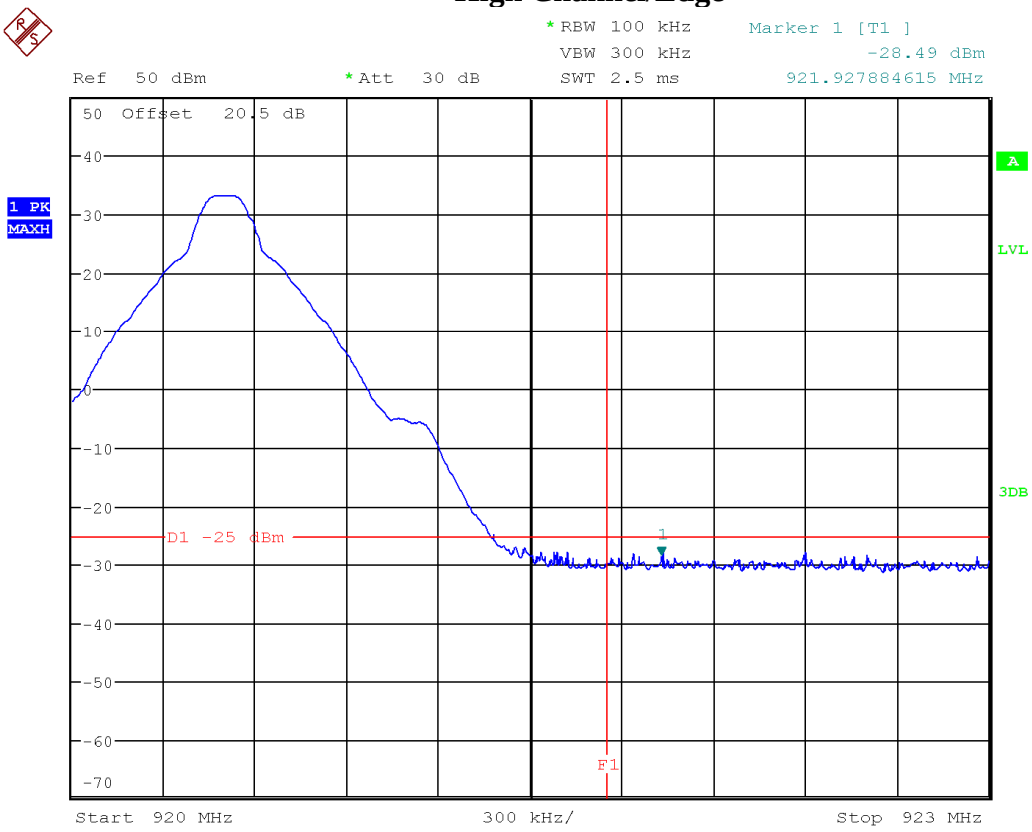
Date: 29.APR.2022 11:21:39

Band Edge
909.75 MHz – 921.75 MHz Sub-Band
Low Channel/Edge



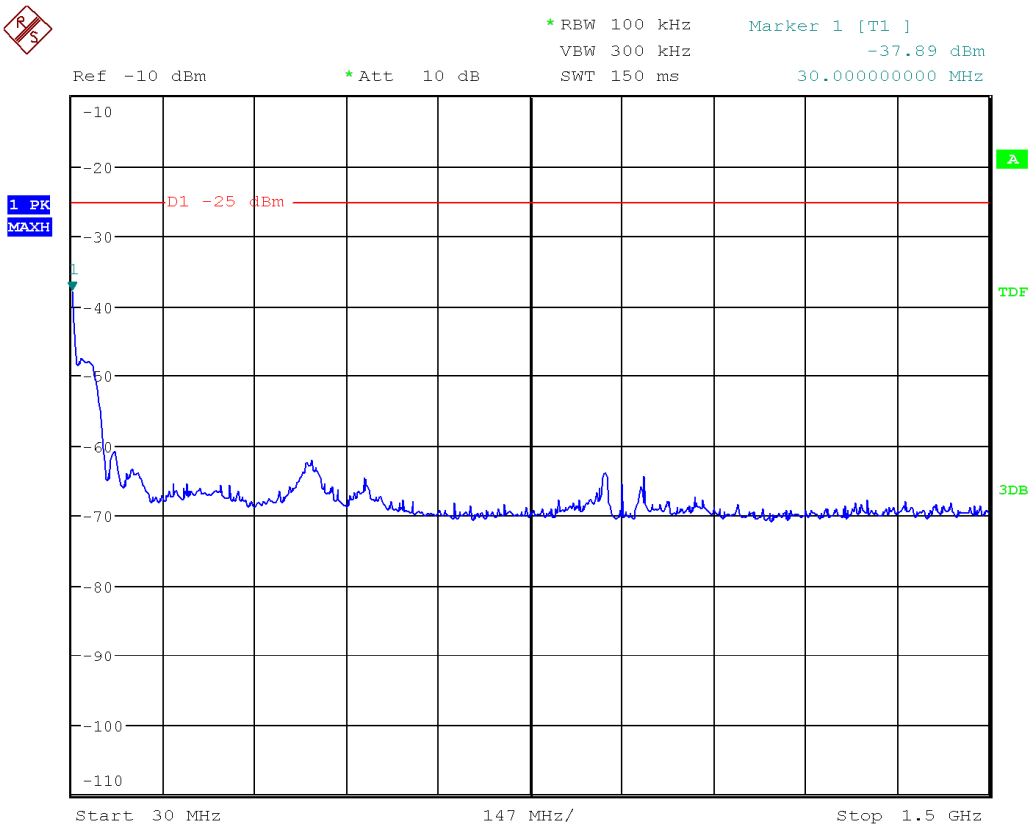
Date: 29.APR.2022 11:55:57

High Channel/Edge



Date: 29.APR.2022 12:14:32

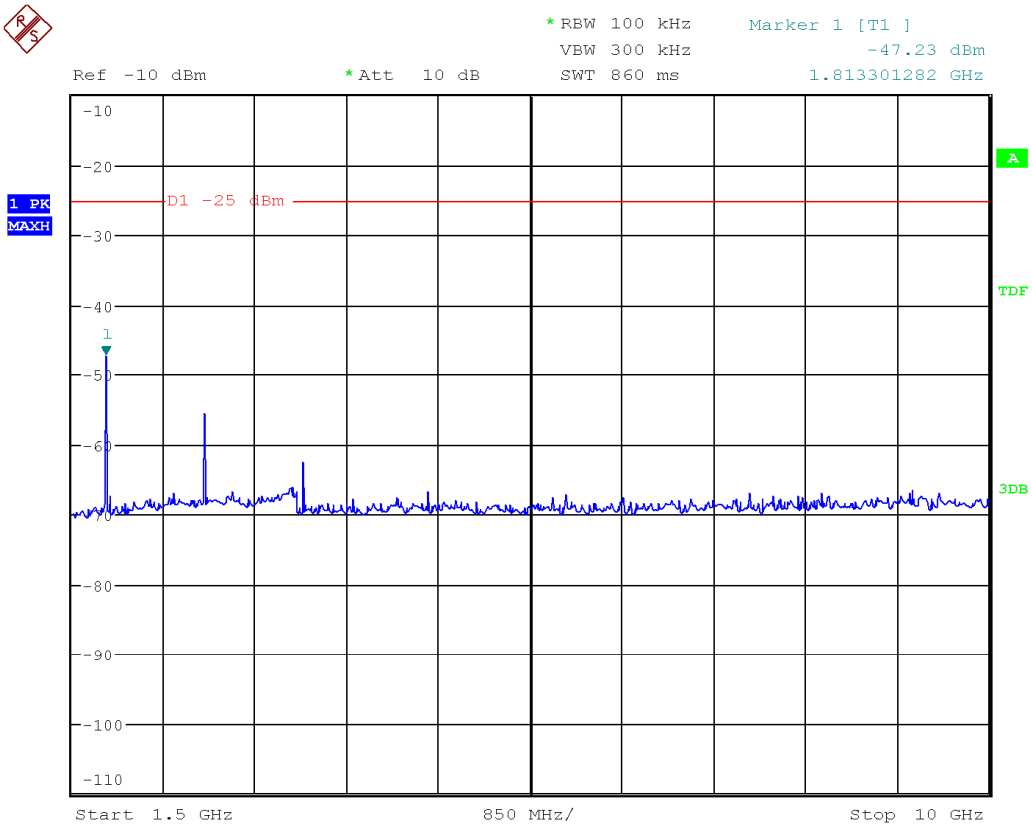
Spurious emissions
30 MHz – 1.5 GHz



Date: 29.APR.2022 12:21:13

No emissions were detected below 30 MHz.

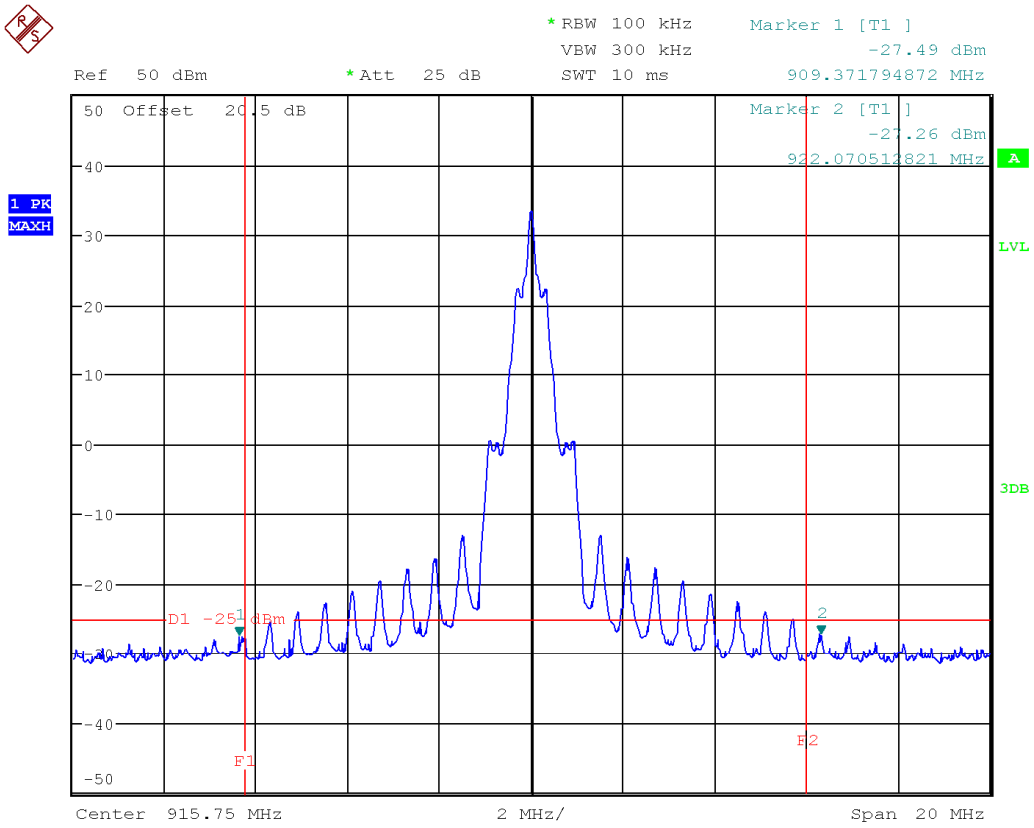
1.5 GHz – 10 GHz



Date: 29.APR.2022 12:23:55

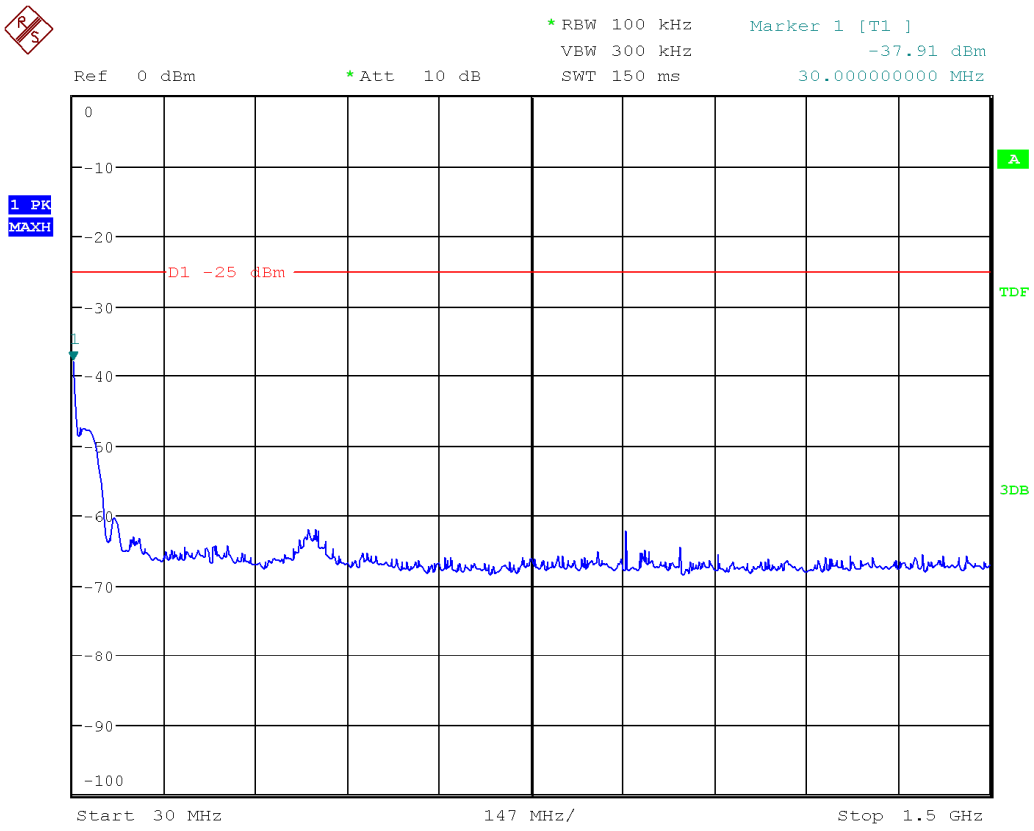
T21 Protocol

Band Edge
909.75 MHz – 921.75 MHz Sub-Band



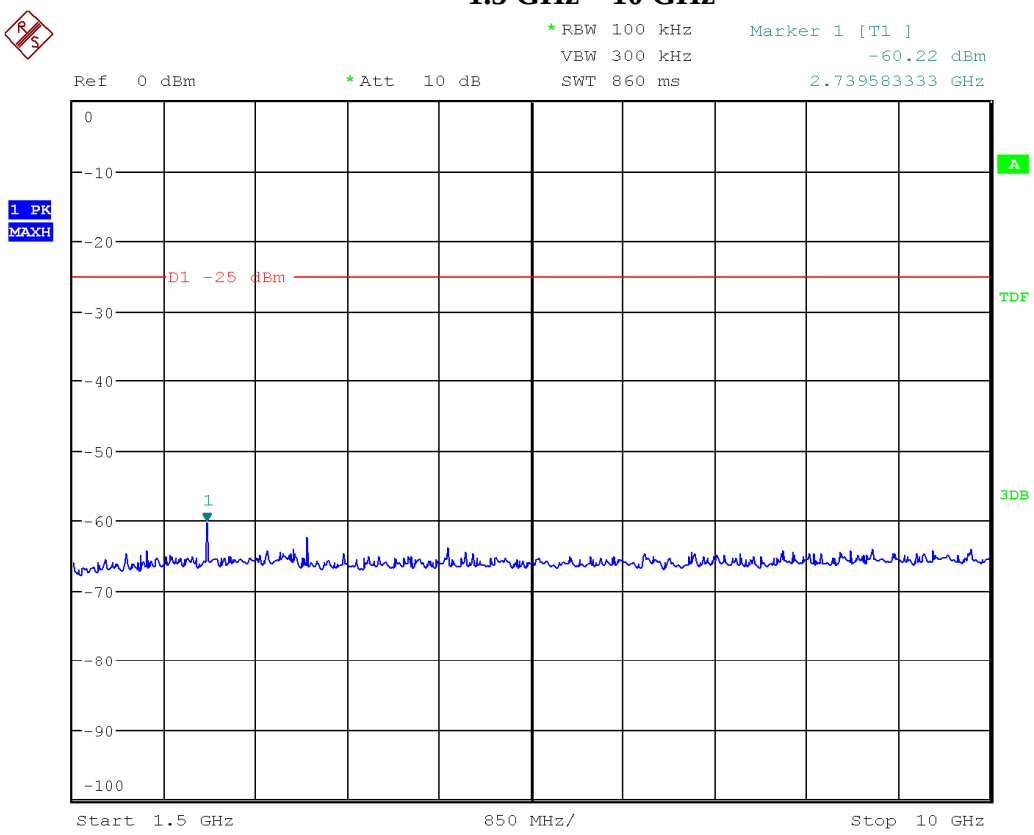
Date: 29.APR.2022 14:18:01

Spurious emissions
30 MHz – 1.5 GHz



Date: 29.APR.2022 15:05:00

1.5 GHz – 10 GHz



Date: 29.APR.2022 15:07:51

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 #
Signal Analyzer	FSQ 26	Rohde & Schwarz	Nov. 30 2021	Nov. 30, 2023	GEMC 234
10dB Attenuator	18N5W-10	Inmet	NCR	NCR	GEMC 358
Band Reject Filter	BRC50722	Micro-Tronics	NCR	NCR	GEMC 186
1.5GHz-18GHz High Pass Filter	5HC1500/18000-3-PP	Trilithic Inc	NCR	NCR	GEMC 327

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.

Limit(s) and Method

The method is as defined in FCC 2.1053 and the limits are as defined in FCC Part 90.210(K).

(3) *Other transmitters*. For all other transmitters authorized under subpart M that operate in the 902-928 MHz band, the peak power of any emission shall be attenuated below the power of the highest emission contained within the licensee's sub-band in accordance with the following schedule:

(i) On any frequency within the authorized bandwidth: Zero dB.

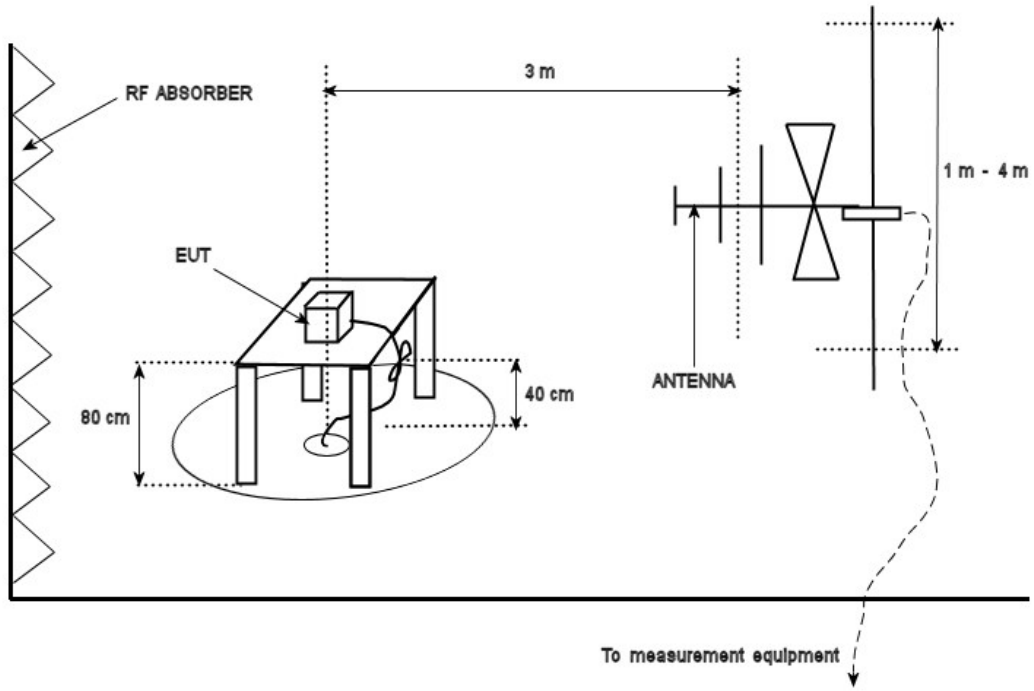
(ii) On any frequency outside the licensee's sub-band edges: 55 + 10 log(P) dB, where (P) is the highest emission (watts) of the transmitter inside the licensee's sub-band.

Spurious radiated emissions of the EUT was performed at 3 meters. The limit specified in FCC 90.210 (K) is 55 + 10 log(P) dBc. For all intensive purpose, the limit is -25 dBm. The field strength limit for the EUT is give in the below:

E(dBµV/m) = EIRP(dBm) + 95.2
Where EIRP = ERP + 2.15
E(dBµV/m) = ERP (dBm) + 97.35
E(dBµV/m) = -25 dBm + 97.35 = 72.35 dBuV

This limit is applicable all emission at 3 meter measurement distance.
The Limit is with 100 kHz measurement bandwidth and using a Peak detector.

Typical Radiated Emissions Setup



Measurement Uncertainty

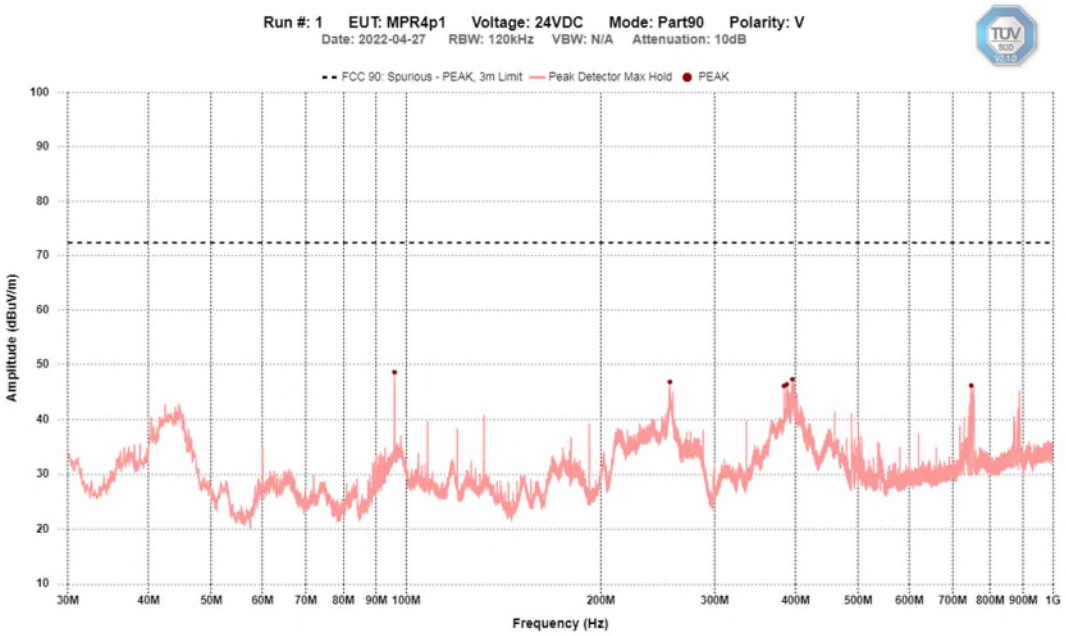
The expanded measurement uncertainty is calculated in accordance with CISPR 16-4-2 and is +/-4.4 dB with a 'k=2' coverage factor and a 95% confidence level.

Preliminary Graphs

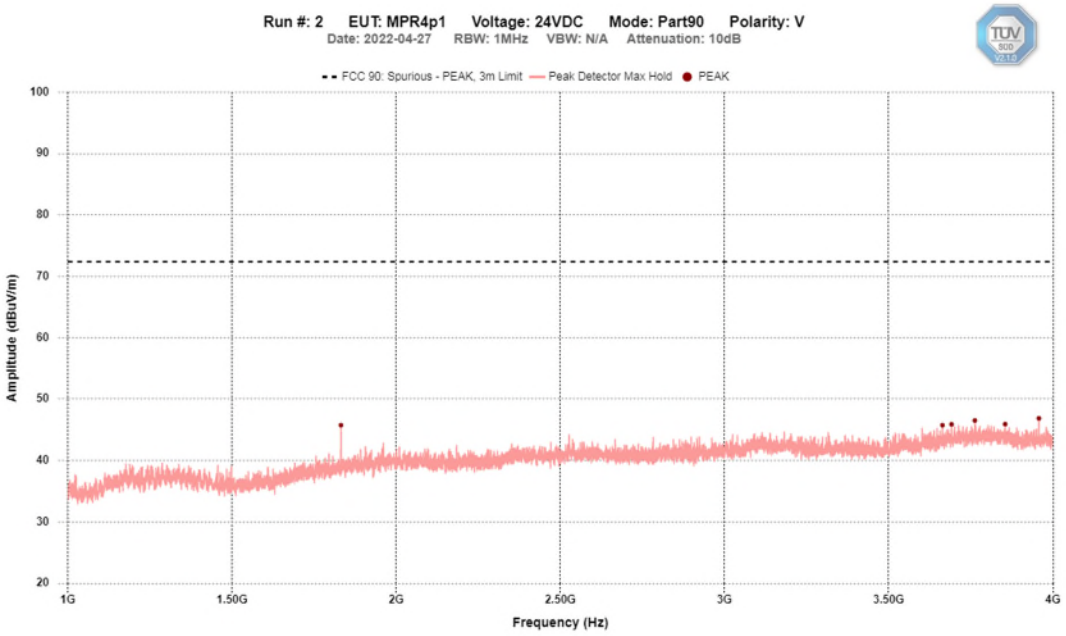
Note the graphs shown below are for graphical illustration only. For final measurements with the appropriate detector, please refer to the final measurement table where applicable. The graph shown below is a maximized peak measurement graph, measured with a resolution bandwidth greater than the final required detector and over a full 0-360 rotation. This peaking process is done as a worst case measurement. This process enables the detection of frequencies of concern for final measurement, and provides considerable time savings.

The device was scanned to the 10^{th} harmonic (a minimum of a 10 GHz).

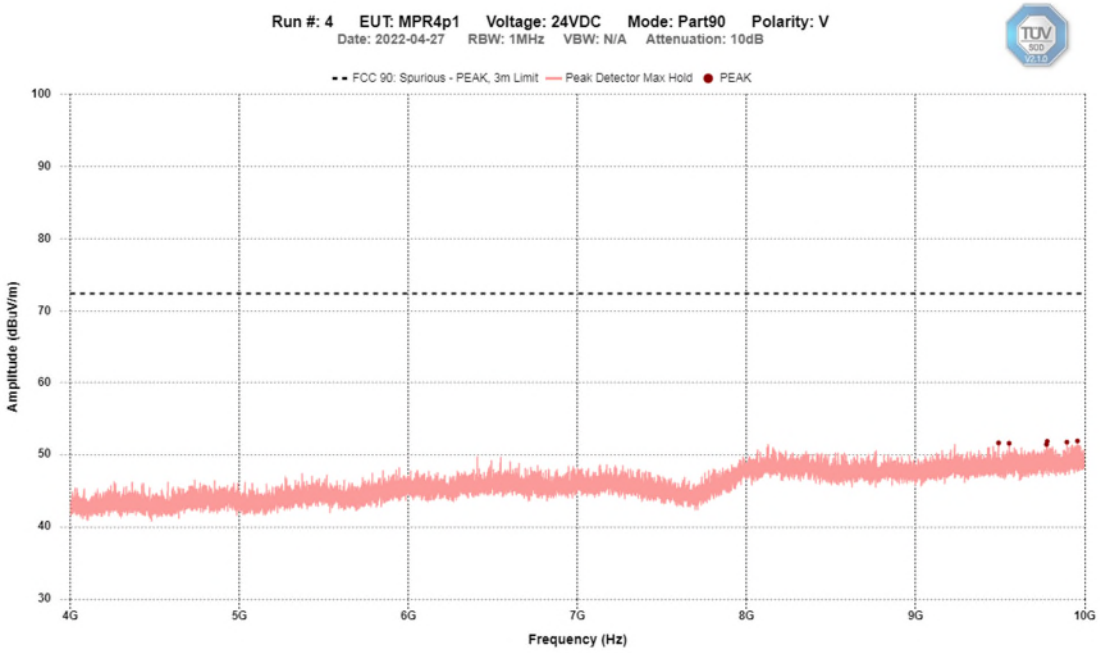
Vertical – Peak Emission Graph
30 MHz – 1000 MHz



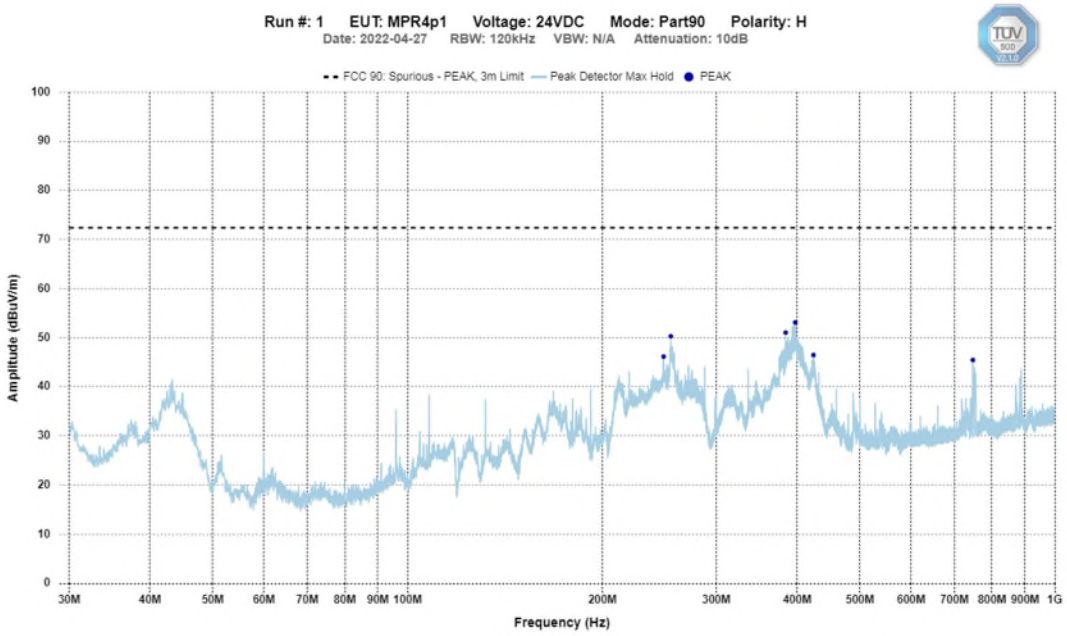
Vertical – Peak Emission Graph
1 GHz – 4 GHz



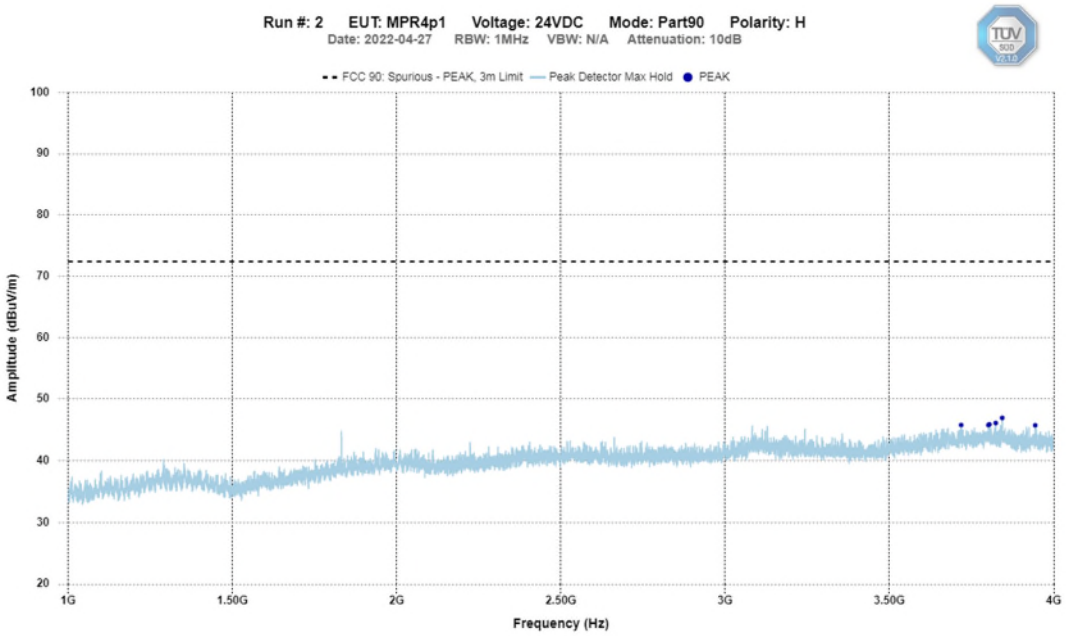
Vertical – Peak Emission Graph
4 GHz – 10 GHz



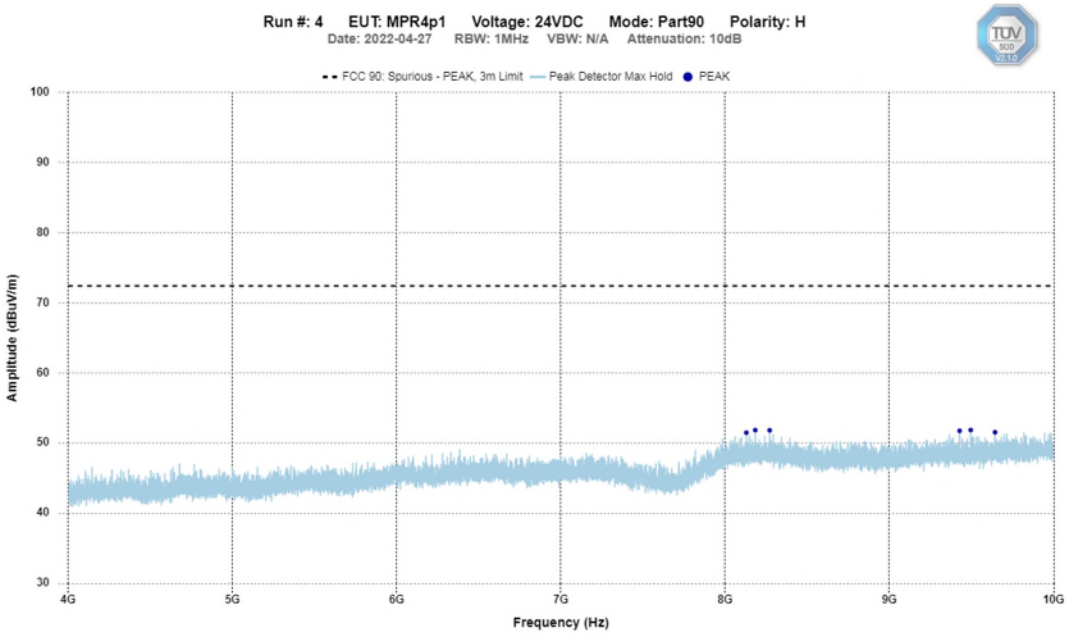
Horizontal – Peak Emission Graph
30 MHz – 1000 MHz



Horizontal – Peak Emission Graph
1 GHz – 4 GHz



Horizontal – Peak Emission Graph
4 GHz – 10 GHz



Results

Pass.

The EUT meets the Transmitter Spurious Radiated Emissions requirements.

EUT Name		MPR4p1				
Limit		FCC 90, Spurious				
Power Supply		**24VDC**				
Frequency (Hz)	**Detector**	**Correction Factor (dB)**	**Level (dBuV/m)**	**PEAK Limit (dBuV/m)**	**PEAK Margin (dB)**	**Test Result**
Horizontal						
397.35M	PEAK	-2.7	53.1	72.4	19.3	Pass
384.0M	PEAK	-2.6	51.0	72.4	21.4	Pass
255.18M	PEAK	-7.6	50.3	72.4	22.1	Pass
423.96M	PEAK	-2.7	46.4	72.4	26.0	Pass
248.79M	PEAK	-7.7	46.1	72.4	26.3	Pass
747.57M	PEAK	4.8	45.4	72.4	27.0	Pass
Vertical						
96.0M	PEAK	-13.1	48.6	72.4	23.8	Pass
395.73M	PEAK	-2.6	47.3	72.4	25.1	Pass
255.84M	PEAK	-7.6	46.9	72.4	25.5	Pass
387.96M	PEAK	-2.5	46.4	72.4	26.0	Pass
747.84M	PEAK	4.8	46.2	72.4	26.2	Pass
384.0M	PEAK	-2.6	46.1	72.4	26.3	Pass

All scans were performed with a measurement bandwidth greater than the required bandwidth. No peak emissions were above the limit.

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	Nov. 25, 2020	Nov. 25, 2022	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
1.5GHz-18GHz High Pass Filter	5HC1500/18000-3-PP	Trilithic Inc	NCR	NCR	GEMC 327
Attenuator 6 dB	6N5W-06	Inmet	NCR	NCR	GEMC 346
Pre-Amp 9 kHz – 1 GHz	LNA 6901	Teseq	Feb. 12, 2021	Feb. 12, 2023	GEMC 168
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 27
RF Cable <1GHz	HP305S	Semflex	NCR	NCR	GEMC 310
RF Cable >1GHz	EMC2	MegaPhase	NCR	NCR	GEMC 370
Emissions Software	V2.1.0	TUV SUD Canada, Inc.	NCR	NCR	GEMC 361

Note: GEMC 287 is part of GEMC 8's calibration.

Temperature Frequency Stability

Purpose

The purpose of this test is to ensure that the RF energy unintentionally emitted from the EUT does not exceed the permitted bandwidth during extreme temperature variations. This helps protect radio broadcasts and receivers with spectrum nearby to the equipment under test from unwanted interference. This also helps ensure proper reception of the intended signal by ensuring the transmit frequency is correct in any temperature.

Limit(s) and Method

The methods are given in FCC Part 2.1055. The limits given in FCC Part 90.213.

However, the device meets the following condition:

Fixed non-multilateration transmitters with an authorized bandwidth that is more than 40 kHz from the band edge, intermittently operated hand-held readers, and mobile transponders are not subject to frequency tolerance restrictions.

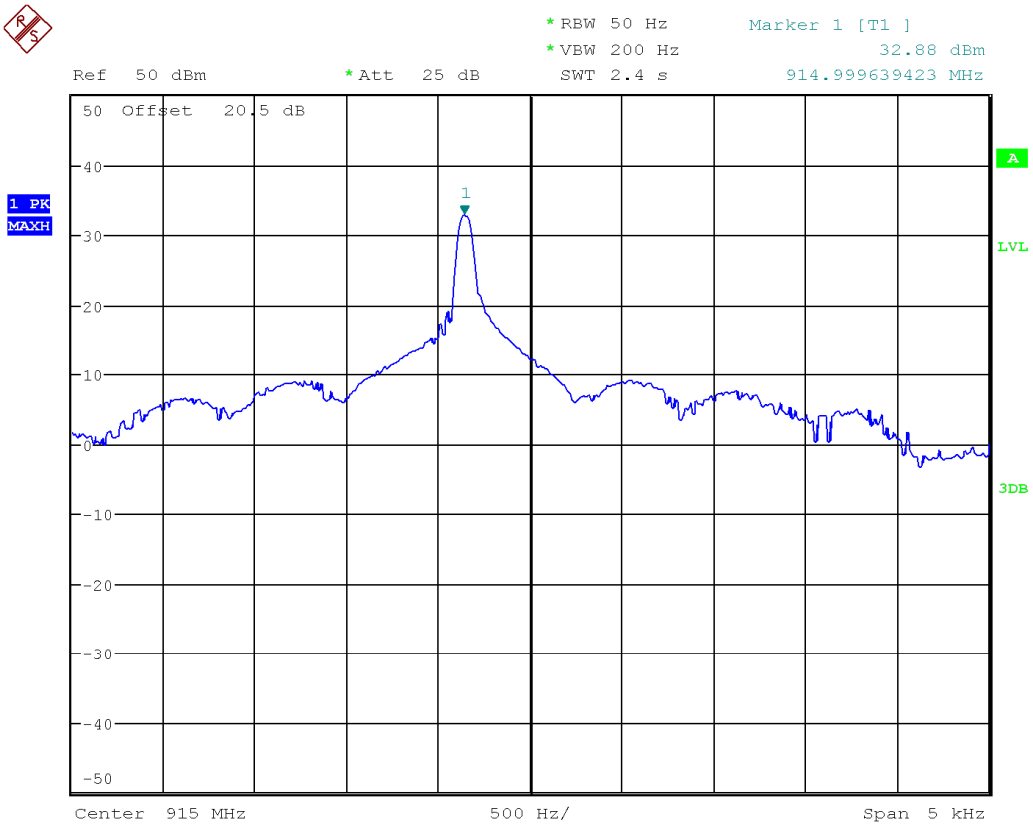
Frequency tolerances measurements are taken for information purpose. Frequency must be maintained from -30 C to +50 C. The EUT is monitored at each 10 degree increment. At each temperature, the device is checked after a stabilization period required for the device to reach the temperature.

Measurements

The worst case results are presented, with the frequency shown. The device was checked at each 10-degree increment of temperature.

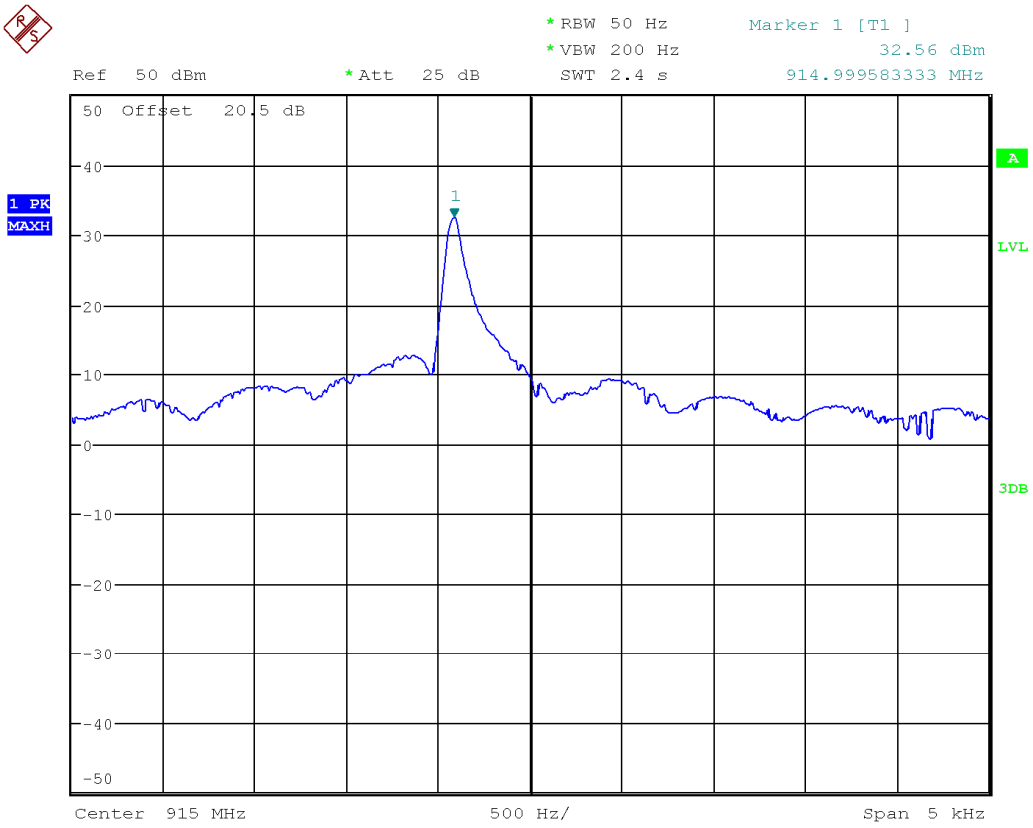
Test Condition	Measured Frequency	Frequency Drift (ppm)
+22°C	914.999639423	
50°C	914.999743590	0.114
40°C	914.999791667	0.166
30°C	914.999735577	0.105
20°C	914.999591346	-0.053
10°C	914.999551282	-0.096
0°C	914.999551282	-0.096
-10°C	914.999591346	-0.053
-20°C	914.999599359	-0.044
-30°C	914.999583333	-0.061

Graphs



Date: 2.MAY.2022 12:07:44

22°C



-30 °C

Test Equipment List

Equipment	Model No.	Manufacturer	Last Calibration Date	Next Calibration Date	Asset #
Signal Analyzer	FSQ 26	Rohde & Schwarz	Nov. 30 2021	Nov. 30, 2023	GEMC 234
Data Acquisition	Tm500	Extech	May 17, 2021	May 17, 2022	CANE00170
10dB Attenuator	6N5W-10	Inmet	NCR	NCR	GEMC 348
10dB Attenuator	18N5W-10	Inmet	NCR	NCR	GEMC 358
Environmental Chamber	SM-32-8200	Thermotron	NCR	NCR	CANE00169

Appendix A – EUT Summary

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

General EUT Description

Client Details	
Organization / Address	Kapsch TrafficCom Canada Inc. 6020 Ambler Drive, Mississauga, ON, Canada L4W 2P1
Contact	Alastair Malarky, Chief Engineer
Phone	416-451-0223
Email	alastair.malarky@kapsch.net
EUT (Equipment Under Test) Details	
EUT Name (for report title)	Multi-Protocol Reader MPR 4.1
EUT Model / SN (if known)	Model #: 802890
EUT revision	New product
Software version	N/A
EUT is powered using	DC
Input voltage range(s) (V)	19 VDC and 30 VDC
Frequency range(s) (Hz)	N/A
Nominal power consumption (W)	50W
Number of power supplies in EUT	None
Transmits RF energy? (describe)	Yes
Basic EUT functionality description	See separate document CONF 802890 - Exhibit 12 - Operating Description
High level block diagram of EUT (attachment)	See separate document CONF 802890 - Exibit 04 - Block Diagram
Modes of operation	See separate document CONF 802890 - Exhibit 12 - Operating Description
Step by step instructions for setup and operation	
Customer to setup EUT on site?	Yes
Frequency of all clocks present in EUT	48 MHz used for FPGA, 40 MHz reference for Synthesizer,12 MHz data, 8 MHz for microcontroller, 3-4 MHz for power

	supplies;1.9GHz for CPU module, 125MHz for Ethernet and PCI
Available connectors on EUT	Four RF Antenna N type connectors SYNC: to sync multiple readers INTER READER: is an ethernet connector to connect to several readers and support inter-reader voting LANE CONTROLLER: ethernet connector to connect with an external lane controller POWER: DC power connector to supply 19 to 30 VDC
Peripherals required to exercise EUT Ex. Signal generator	N/A
Dimensions of product	L 483 mm W 387 mm H 96 mm

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'.

Technical Specifications

Operation Band: 902 – 928 MHz

Modulation: On-Off Keying

Emission Designator ATA Protocol: N0N
6B, 6C, SeGO, KTDM, T21: K1D

Operation Frequency:

Protocol	ATA	SeGO	6B	6C	KTDM	T21
TX modulation symbol rate	CW only	Manchester 80 kbps	Manchester Bi Phase 40 kbps	Pulse Interval Encoded 160 kbps	Manchester 500 kbps	Manchester 300 kbps
TX frequency range permitted	902.5 MHz to 903.5 MHz 910 MHz to 921.5 MHz	911.0 MHz to 920.0 MHz	903 MHz 910.5 MHz to 920.5 MHz	903 MHz 910.5 MHz to 920.5 MHz	915.75 MHz	915.75 MHz

EUT Configurations

Please see Appendix B for a picture of the unit running in normal conditions.

- Unit was tested as a standalone device.
- During Transmitter spurious radiated emissions, RF output was dissipated in a 50 Ω load.
- Cables and earthing are connected as per manufacturer's specification.

Operational Setup

These devices are required to be attached to the EUT for its normal operation.

- The EUT transmits continuously