REGULATORY COMPLIANCE TEST REPORT

FCC CFR 47 Part 90 & ISED RSS-119

Report No.: SATE01-U4 Rev A

Company: SATEL OY

Model Name: SATEL-TR49 SnapOn

REGULATORY COMPLIANCE TEST REPORT

Company Name: SATEL OY

Model Name: SATEL-TR49 SnapOn

To: FCC CFR 47 Part 90 & ISED RSS-119

Test Report Serial No.: SATE01-U4 Rev A

This report supersedes: NONE

Applicant: SATEL OY
Meriniitynkatu 17
Salo, 24100
Finland

Issue Date: 23rd September 2021

This Test Report is Issued Under the Authority of:

MiCOM Labs, Inc.
575 Boulder Court
Pleasanton California 94566
USA
Phone: +1 (925) 462-0304
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www.micomlabs.com

ACCREDITED
TESTING CERT #2381.01

MiCOM Labs is an ISO 17025 Accredited Testing Laboratory

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1. ACCREDITATION, LISTINGS & RECOGNITION

1.1. TESTING ACCREDITATION

MiCOM Labs, Inc. is an accredited Electrical testing laboratory per the international standard ISO/IEC 17025:2017. The company is accredited by the American Association for Laboratory Accreditation (A2LA) www.a2la.org test laboratory number 2381.01. MiCOM Labs test schedule is available at the following URL; http://www.a2la.org/scopepdf/2381-01.pdf

Accredited Laboratory

A2LA has accredited

MICOM LABS

Pleasanton, CA

for technical competence in the field of

Electrical Testing

This laboratory is accredited in accordance with the recognized International Standard ISO/IEC 17025:2017 *General requirements for the competence of testing and calibration laboratories*. This accreditation demonstrates technical competence for a defined scope and the operation of a laboratory quality management system (*refer to joint ISO-ILAC-IAF Communiqué dated April 2017*).

Presented this 24th day of February 2020.

Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 2381.01
Valid to November 30, 2021

For the tests to which this accreditation applies, please refer to the laboratory's Electrical Scope of Accreditation.

1.2. RECOGNITION

MiCOM Labs, Inc is widely recognized for its wireless testing and certification capabilities. In addition to being recognized for Testing and Certification under Phase 2 Mutual Recognition Agreements (MRA) with Canada, Europe, United Kingdom and Japan, our international recognition includes Conformity Assessment Body (CAB) designation status under agreements with Asia Pacific (APEC) MRA Phase 1 countries giving acceptance of MiCOM Labs test reports. MiCOM Labs test reports are accepted globally.

Country	Recognition Body	Status	MRA Phase	Identification No.
USA	Federal Communications Commission (FCC)	TCB	-	US0159 Test Firm Designation#: US1084
Canada	Industry Canada (ISED)	FCB	APEC MRA 2	US0159 ISED#: 4143A
Japan	MIC (Ministry of Internal Affairs and Communication)	CAB	Japan MRA 2	RCB 210
	Japan Approvals Institute for Telecommunication Equipment (JATE)			
	VCCI	--	--	A-0012
Europe	European Commission	NB	EU MRA 2	NB 2280
United Kingdom	Department for Business, Energy & Industrial Strategy (BEIS)	AB	UK MRA 2	AB 2280
Mexico	Instituto Federal de Telecomunicaciones (IFT)	CAB	Mexico MRA 1	US0159
Australia	Australian Communications and Media Authority (ACMA)	CAB	APEC MRA 1	US0159
Hong Kong	Office of the Telecommunication Authority (OFTA)			
Korea	Ministry of Information and Communication Radio Research Laboratory (RRL)			
Singapore	Infocomm Development Authority (IDA)			
Taiwan	National Communications Commission (NCC) Bureau of Standards, Metrology and Inspection (BSMI)			
Vietnam	Ministry of Communication (MIC)			

TCB – Telecommunications Certification Bodies (TCB)
FCB – Foreign Certification Body
CAB – Conformity Assessment Body
NB – Notified Body
AB – Approved Body
MRA – Mutual Recognition Agreement
MRA PhasePhase I - recognition for product testing
Phase II – recognition for both product testing and certification

1.3. PRODUCT CERTIFICATION

MiCOM Labs, Inc. is an accredited Product Certification Body per the international standard ISO/IEC 17065:2012. The company is accredited by the American Association for Laboratory Accreditation (A2LA) www.a2la.org test laboratory number 2381.02. MiCOM Labs test schedule is available at the following URL; http://www.a2la.org/scopepdf/2381-02.pdf

Accredited Product Certification Body

A2LA has accredited

MiCOM LABS

Pleasanton, CA

This product certification body is accredited in accordance with the recognized International Standard ISO/IEC 17065:2012 *Requirements for bodies certifying products, processes and services*. This product certification body also meets the *A2LA R322 – Specific Requirements – Notified Body Accreditation Requirements* and *A2LA R308 - Specific Requirements - ISO-IEC 17065 - Telecommunication Certification Body Accreditation Program*. This accreditation demonstrates technical competence for a defined scope and the operation of a management system.

Presented this 24th day of February 2020

Vice President, Accreditation Services
For the Accreditation Council
Certificate Number 2381.02
Valid to November 30, 2021

For the product certification schemes to which this accreditation applies, please refer to the organization's Product Certification Scope of Accreditation.

United States of America – Telecommunication Certification Body (TCB)
Industry Canada – Certification Body, CAB Identifier – US0159
Europe – Notified Body (NB), NB Identifier - 2280
UK – Approved Body (AB), AB Identifier - 2280
Japan – Recognized Certification Body (RCB), RCB Identifier - 210

2. DOCUMENT HISTORY

Document History		
Revision	Date	Comments
Draft	9th April 2021	Draft report for client review.
Rev A	23rd September 2021	Initial release.
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In the above table the latest report revision will replace all earlier versions.

3. TEST RESULT CERTIFICATE

Manufacturer:	SATEL OY Meriniitynkatu 17 Salo 24100 Finland	**Tested By:**	MiCOM Labs, Inc. 575 Boulder Court Pleasanton California 94566 USA
Model:	SATEL-TR49 SnapOn	**Telephone:**	+1 925 462 0304
Type Of Equipment:	Dual Band Radio Modem	**Fax:**	+1 925 462 0306
S/N's:	1906000771		
Test Date(s):	15th – 22nd March 2021	**Website:**	www.micomlabs.com

STANDARD(S)	TEST RESULTS
FCC CFR 47 Part 15 Part 90 & ISED RSS-119	**EQUIPMENT COMPLIES**

MiCOM Labs, Inc. tested the equipment mentioned in accordance with the requirements set forth in the above standards. Test results indicate that the equipment tested is capable of demonstrating compliance with the requirements as documented within this report.

Notes:

1. This document reports conditions under which testing was conducted and the results of testing performed.

2. Details of test methods used have been recorded and kept on file by the laboratory.

3. Test results apply only to the item(s) tested.

ACCREDITED
TESTING CERT #2381.01

Approved & Released for MiCOM Labs, Inc. by:

Graeme Grieve
Quality Manager MiCOM Labs, Inc.

Gordon Hurst
President & CEO MiCOM Labs, Inc.

4. REFERENCES AND MEASUREMENT UNCERTAINTY

4.1. Normative References

REF.	PUBLICATION	YEAR	TITLE
I	A2LA	5th October 2020	R105 - Requirement's When Making Reference to A2LA Accreditation Status
II	ANSI C63.10	2013	American National Standard for Testing Unlicensed Wireless Devices
III	ANSI C63.4	2014	American National Standards for Methods of Measurement of Radio-Noise Emissions from Low-Voltage Electrical and Electronic Equipment in the Range of 9 kHz to 40 GHz
IV	CISPR 32	2015	Electromagnetic compatibility of multimedia equipment - Emission requirements
V	ETSI TR 100 028	2001-12	Parts 1 and 2 Electromagnetic compatibility and Radio Spectrum Matters (ERM); Uncertainties in the measurement of mobile radio equipment characteristics
VI	FCC 47 CFR Part 15, Subpart B	2020	Title 47: Telecommunication PART 15 B; Unintentional Radiators
VII	ICES-003	Issue 7 ; October 15,2020	Information Technology Equipment (Including Digital Apparatus) – Limits and methods of measurement.
VIII	M 3003	Edition 3 Nov.2012	Expression of Uncertainty and Confidence in Measurements
IX	RSS-Gen Issue 5	2018	General Requirements for Compliance of Radio Apparatus With Amendments 1: March 2019 and 2: Feb 2021.
X	FCC 47 CFR Part 2.1033	2020	FCC requirements and rules regarding photographs and test setup diagrams.
XI	FCC Part 90	March 30th 2021	Private Land Mobile Radio Services
XII	ISED RSS-119 Issue 12	May 28th 2015	Land Mobile and Fixed Equipment Operating in the Frequency Range 27.41-960 MHz

4.2. Test and Uncertainty Procedure

Conducted and radiated emission measurements were conducted in accordance with American National Standards Institute ANSI C63.4, listed in the Normative References section of this report.

Measurement uncertainty figures are calculated in accordance with ETSI TR 100 028 Parts 1 and 2.

Measurement uncertainties stated are based on a standard uncertainty multiplied by a coverage factor k = 2, providing a level of confidence of approximately 95 % in accordance with UKAS document M 3003 listed in the Normative References section of this report.

5. PRODUCT DETAILS AND TEST CONFIGURATIONS

5.1. Technical Details

Details	Description
Purpose:	Test of the SATEL OY TR49 SnapOn to FCC CFR 47 Part 90 & ISED RSS-119.
Applicant:	SATEL OY Meriniitynkatu 17 Salo 24100 Finland
Manufacturer:	SATEL OY
Laboratory performing the tests:	MiCOM Labs, Inc. 575 Boulder Court Pleasanton California 94566 USA
Test report reference number:	SATE01-U4 Rev A
Date EUT received:	18th March 2021
Standard(s) applied:	FCC Part 90 & ISED RSS-119
Dates of test (from - to):	15th – 22nd March 2021
No of Units Tested:	1
Product Family Name:	SnapOn
Model(s):	SATEL-TR49 SnapOn
Location for use:	Indoor & Outdoor
Declared Frequency Range(s):	410-430MHz; 450-470MHz
Type of Modulation:	GFSK, GMSK
EUT Modes of Operation:	GFSK, GMSK
Declared Nominal Output Power (dBm):	410-430MHz; 450-470MHz: 30 dBm
Transmit/Receive Operation:	Transceiver
Rated Input Voltage and Current:	5VDC 2A
Operating Temperature Range:	-47°C to +70 °C.
ITU Emission Designator:	7K61F1D 14K8F1D 8K41G1D 10K6G1D
Equipment Dimensions:	51 mm x 30 mm x 4.75 mm
Weight:	0.01 Kg
Hardware Rev:	1.3
Software Rev:	44_2_5_0_2

5.2. Scope Of Test Program

SATEL OY TR49 SnapOn

The scope of the test program was to test the SATEL OY TR49 SnapOn, in the frequency ranges 410-430MHz; 450-470MHz; for compliance against the following specifications:

FCC CFR 47 Part 90; 410-430MHz, 450-470MHz

ISED RSS-119; 410-430MHz, 450-470MHz

The SATEL OY TR49 SnapOn employs two modulation schemes:

- GFSK
- GMSK

5.3. Equipment Model(s) and Serial Number(s)

Type (EUT/ Support)	Equipment Description (Including Brand Name)	Mfr.	Model No.	Serial No.
EUT	SnapOn	SATEL OY	TR49	1906000771
Support	Laptop	Dell	N/A	N/A

5.4. Antenna Details

Type	Manufacturer	Model	Family	Gain (dBi)	BF Gain	Dir BW	X-Pol	Frequency Band (MHz)
external	Laird	Whip	OMNI	6.0	-	360	-	400 - 470

BF Gain - Beamforming Gain
Dir BW - Directional BeamWidth
X-Pol - Cross Polarization

5.5. Cabling and I/O Ports

Port Type	Max Cable Length	# of Ports	Screened	Conn Type	Data Type
USB	<3m	1	No	Data	Digital

5.6. Test Configurations

Results for the following configurations are provided in this report:

Operational Mode (GFSK & GMSK)	Data Rate with Highest Power MBit/s	Channel Frequency (MHz)		
		Low	Mid	High
410 - 470 MHz				
12.5 kHz GFSK	115.2	410.0	--	429.5
25 kHz GFSK	115.2	450.5	--	469.5
12.5 kHz GMSK	115.2	410.0	--	429.5
25 kHz GMSK	115.2	450.5	--	469.5

The EUT operates in the frequency bands 410 – 430 MHz & 450 - 470 MHz.

5.7. Equipment Modifications

The following modifications were required to bring the equipment into compliance:
1. NONE

5.8. Deviations from the Test Standard

The following deviations from the test standard were required in order to complete the test program:
1. NONE

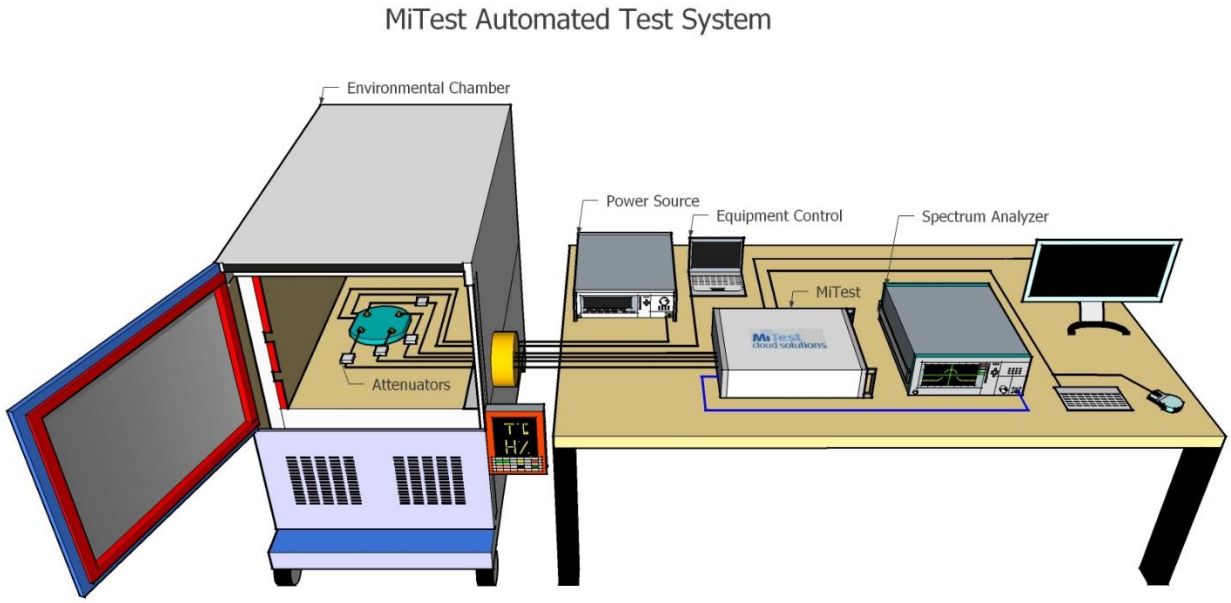
6. TEST SUMMARY

List of Measurements

Test Header	Result	Data Link
99% Occupied Bandwidth	Complies	View Data
Output Power	Complies	View Data
Transient Frequency Behavior	Complies	View Data
Frequency Stability	Complies	View Data
Emissions	Complies	-
(1) Conducted Emissions	Complies	-
(i) Conducted Unwanted Spurious Emissions	Complies	View Data
(ii) Conducted Emission Mask	Complies	View Data
(2) Radiated Emissions	Complies	-
(i) TX Spurious & Restricted Band Emissions	Complies	View Data

7. TEST EQUIPMENT CONFIGURATION(S)

7.1. Conducted Test Setup



A full system calibration was performed on the test station and any resulting system losses (or gains) were considered in the production of all final measurement data.

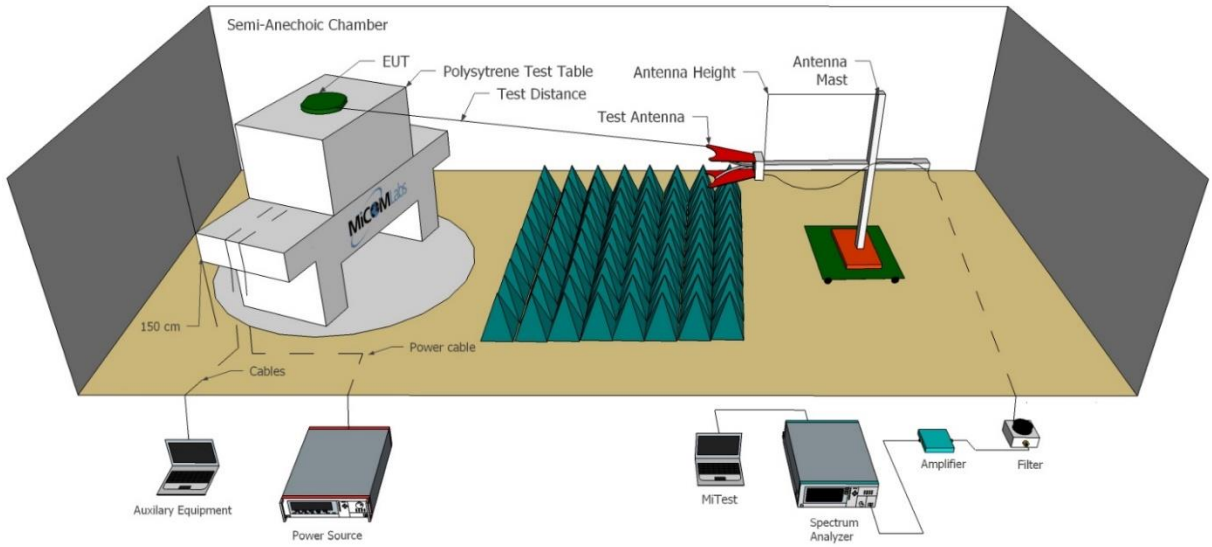
Asset#	Description	Manufacturer	Model#	Serial#	Calibration Due Date
#3 SA	MiTest Box to SA	Fairview Microwave	SCA1814-0101-72	#3 SA	4 Jun 2021
#3P1	EUT to MiTest box port 1	Fairview Microwave	SCA1814-0101-72	#3P1	4 Jun 2021
#3P2	EUT to MiTest box port 2	Fairview Microwave	SCA1814-0101-72	#3P2	4 Jun 2021
#3P3	EUT to MiTest box port 3	Fairview Microwave	SCA1814-0101-72	#3P3	4 Jun 2021
#3P4	EUT to MiTest box port 4	Fairview Microwave	SCA1812-0101-72	#3P4	4 Jun 2021
249	Thermocouple; Resistance Thermometer	Thermotronics	GR2105-02	9340 #2	30 Oct 2021
287	Rohde & Schwarz 40 GHz Receiver	Rhode & Schwarz	ESIB40	100201	8 Oct 2021
378	Rohde & Schwarz 40 GHz Receiver with Generator	Rhode & Schwarz	ESIB40	100107/040	12 Jun 2021
398	MiTest RF Conducted Test Software	MiCOM	MiTest ATS	Version 4.2.3.0	Not Required
405	DC Power Supply 0-60V	Agilent	6654A	MY4001826	Cal when used

408	USB to GPIB interface	National Instruments	GPIB-USB HS	14C0DE9	Not Required
440	USB Wideband Power Sensor	Boonton	55006	9178	22 Jun 2021
441	USB Wideband Power Sensor	Boonton	55006	9179	20 Jun 2021
442	USB Wideband Power Sensor	Boonton	55006	9181	19 Jun 2021
445	PoE Injector	D-Link	DPE-101GL	QTAH1E 2000625	Not Required
461	Spectrum Analyzer	Agilent	E4440A	MY46185 537	20 Jun 2021
510	Barometer/Thermometer	Control Company	68000-49	1708713 75	20 Dec 2021
515	MiTest Cloud Solutions RF Test Box	MiCOM	2nd Gen with DFS	515	4 Jun 2021
534	Power Sensor 50 GHz - 70dBm to +20dBm	R&S	NRP50SN	1419.009 3K02-100888-SB	26 Feb 2022
75	Environmental Chamber	Thermatron	SE-300-2-2	27946	20 Feb 2022

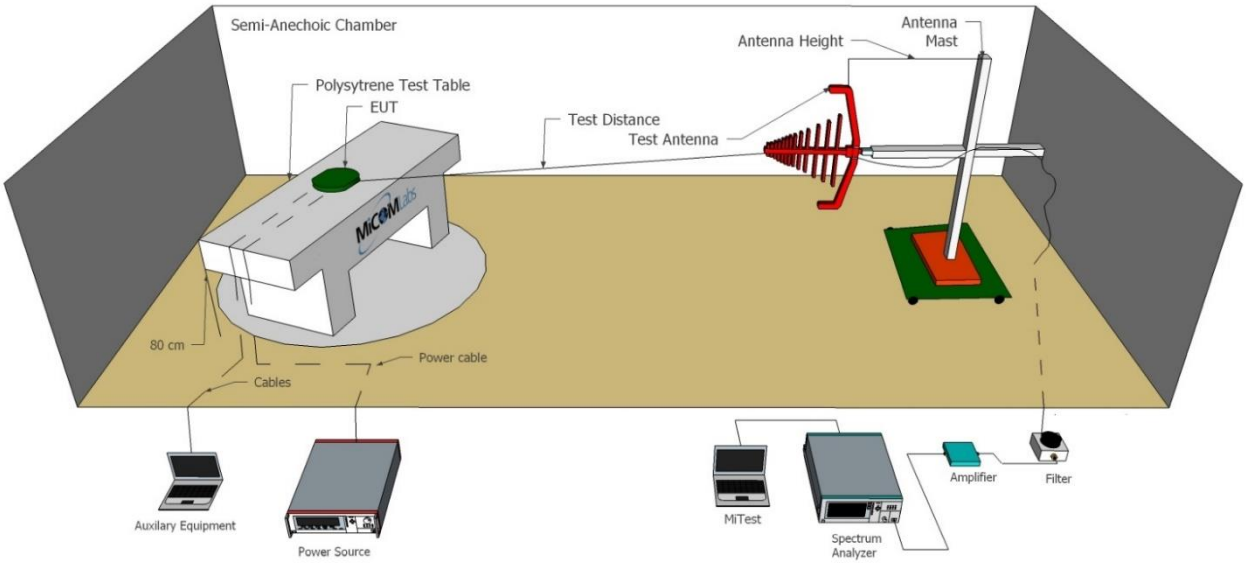
7.2. Radiated Emissions - 3m Chamber

The following tests were performed using the radiated test set-up shown in the diagram below. Radiated emissions above and below 1GHz.

Radiated Emissions Above 1GHz Test Setup



Radiated Emissions Below 1GHz Test Setup



A full system calibration was performed on the test station and any resulting system losses (or gains) were considered in the production of all final measurement data.

Asset#	Description	Manufacturer	Model#	Serial#	Calibration Due Date
170	Video System Controller for Semi Anechoic Chamber	Panasonic	WV-CU101	04R08507	Not Required
287	Rohde & Schwarz 40 GHz Receiver	Rhode & Schwarz	ESIB40	100201	8 Oct 2021
330	Variac 0-280 Vac	Staco Energy Co	3PN1020B	0546	Cal when used
336	Active loop Ant 10kHz to 30 MHz	EMCO	EMCO 6502	00060498	29 Nov 2021
338	Sunol 30 to 3000 MHz Antenna	Sunol	JB3	A052907	4 Oct 2021
341	900MHz Notch Filter	EWT	EWT-14-0199	H1	4 May 2021
342	2.4 GHz Notch Filter	EWT	EWT-14-0203	H1	4 May 2021
346	1.6 TO 10GHz High Pass Filter	EWT	EWT-57-0112	H1	4 May 2021
373	26III RMS Multimeter	Fluke	Fluke 26 series III	76080720	21 Jun 2021
378	Rohde & Schwarz 40 GHz Receiver with Generator	Rhode & Schwarz	ESIB40	100107/040	12 Jun 2021
397	Amp 10 - 2500MHz	MiCOM Labs	Amp 10 - 2500 MHz	NA	9 May 2021
399	ETS 1-18 GHz Horn Antenna	ETS	3117	00154575	12 May 2021
406	Amplifier for Radiated Emissions	MiCOM Labs	40dB 1 to 18GHz Amp	0406	9 May 2021
410	Desktop Computer	Dell	Inspiron 620	WS38	Not Required
411	Mast/Turntable Controller	Sunol Sciences	SC98V	060199-1D	Not Required
412	USB to GPIB Interface	National Instruments	GPIB-USB HS	11B8DC2	Not Required
413	Mast Controller	Sunol Science	TWR95-4	030801-3	Not Required
414	DC Power Supply 0-60V	HP	6274	1029A01285	Cal when used
415	Turntable Controller	Sunol Sciences	Turntable Controller	None	Not Required
416	Gigabit ethernet filter	ETS-Lingren	Gigafoil 260366	None	Not Required
447	MiTest Rad Emissions Test Software	MiCOM	Rad Emissions Test Software Version 1.0	447	Not Required
462	Schwarzbeck cable from Antenna to Amplifier.	Schwarzbeck	AK 9513	462	4 May 2021
463	Schwarzbeck cable from Amplifier to Bulkhead.	Schwarzbeck	AK 9513	463	4 May 2021

464	Schwarzbeck cable from Bulkhead to Receiver	Schwarzbeck	AK 9513	464	4 May 2021
466	Low Pass Filter DC-1500 MHz	Mini-Circuits	NLP-1750+	VUU10401438	4 May 2021
480	Cable - Bulkhead to Amp	SRC Haverhill	157-3050360	480	4 May 2021
481	Cable - Bulkhead to Receiver	SRC Haverhill	151-3050787	481	4 May 2021
510	Barometer/Thermometer	Control Company	68000-49	170871375	20 Dec 2021
518	Cable - Amp to Antenna	SRC Haverhill	157-3051574	518	4 May 2021
87	Uninterruptible Power Supply	Falcon Electric	ED2000-1/2LC	F3471 02/01	Cal when used

8. MEASUREMENT AND PRESENTATION OF TEST DATA

The measurement and graphical data presented in this test report was generated automatically using state-of-the-art technology creating an easy to read report structure. Numerical measurement data is separated from supporting graphical data (plots) through hyperlinks. Numerical measurement data can be reviewed without scrolling through numerous graphical pages to arrive at the next data matrix.

Plots have been relegated into the Appendix 'Graphical Data'.

Test and report automation was performed by MiTest. MiTest is an automated test system developed by MiCOM Labs. MiTest is the first cloud based modular test system enabling end-to-end automation of regulatory compliance testing for conducted RF testing.

The MiCOM Labs "MiTest" Automated Test System" (Patent Pending)

9. TEST RESULTS

9.1. 99% Occupied Bandwidth

Conducted Test Conditions for 20 dB and 99% Bandwidth			
Standard:	FCC CFR 47:Part 90 ISED RSS-119	**Ambient Temp. (ºC):**	24.0 - 27.5
Test Heading:	99% Occupied Bandwidth	**Rel. Humidity (%):**	32 - 45
Standard Section(s):	90.210 RSS-119 Sect 5.5	**Pressure (mBars):**	999 - 1001
Reference Document(s):	See Normative References		

Test Procedure for 99% Occupied Bandwidth Measurement

The bandwidth at 99 % was measured with a spectrum analyzer connected to the antenna terminal, while EUT is operating in transmission mode at the appropriate center frequency.

Testing was performed under ambient conditions at nominal voltage. Where the device operated with multiple antenna ports i.e. MIMO device, each port was measured and reported.

Test configuration and setup used for the measurement was per the Conducted Test Set-up specified in this document.

Limits:

Emission Mask C & D determine the operating bandwidth and which shall be declared

9.1.1.1. 12.5 KHz GFSK

Equipment Configuration for 99% Bandwidth

Variant:	12.5KHz	**Duty Cycle (%):**	99
Data Rate:	Not Applicable	**Antenna Gain (dBi):**	Not Applicable
Modulation:	GFSK	**Beam Forming Gain (Y)(dB):**	Not Applicable
TPC:	Not Applicable	**Tested By:**	SB
Engineering Test Notes:			

Test Measurement Results

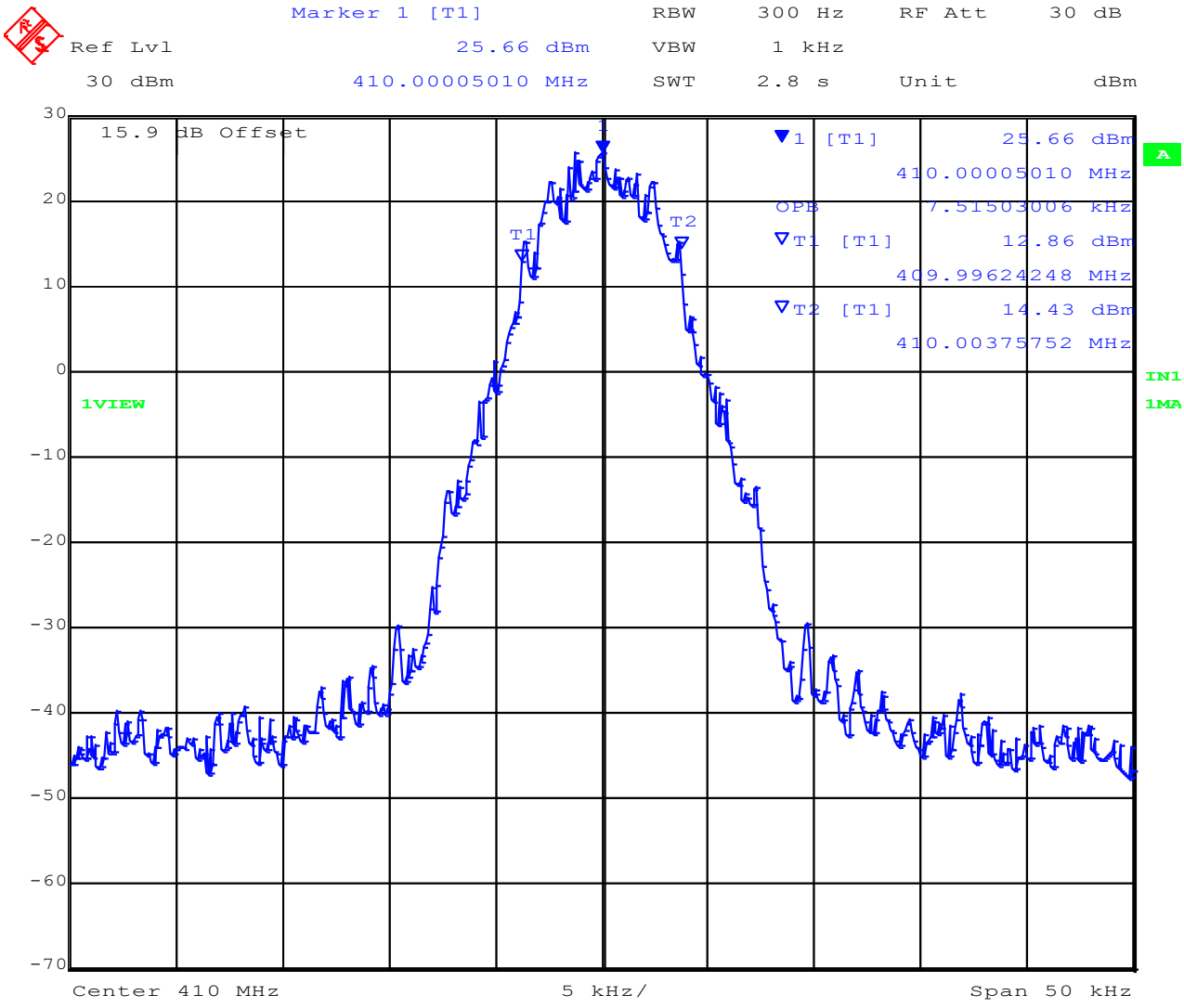
Test Frequency	Measured 99% Bandwidth (KHz)				Maximum 99% Bandwidth (KHz)		
	Port(s)						
MHz	a	b	c	d			
410.0	7.51				7.51		
429.5	7.61				7.61		
450.5	7.51				7.51		
469.5	7.51				7.51		

Traceability to Industry Recognized Test Methodologies	
Work Instruction:	WI-03 MEASURING RF SPECTRUM MASK
Measurement Uncertainty:	±2.81 dB

Note: click the links in the above matrix to view the graphical image (plot).

99% BANDWIDTH

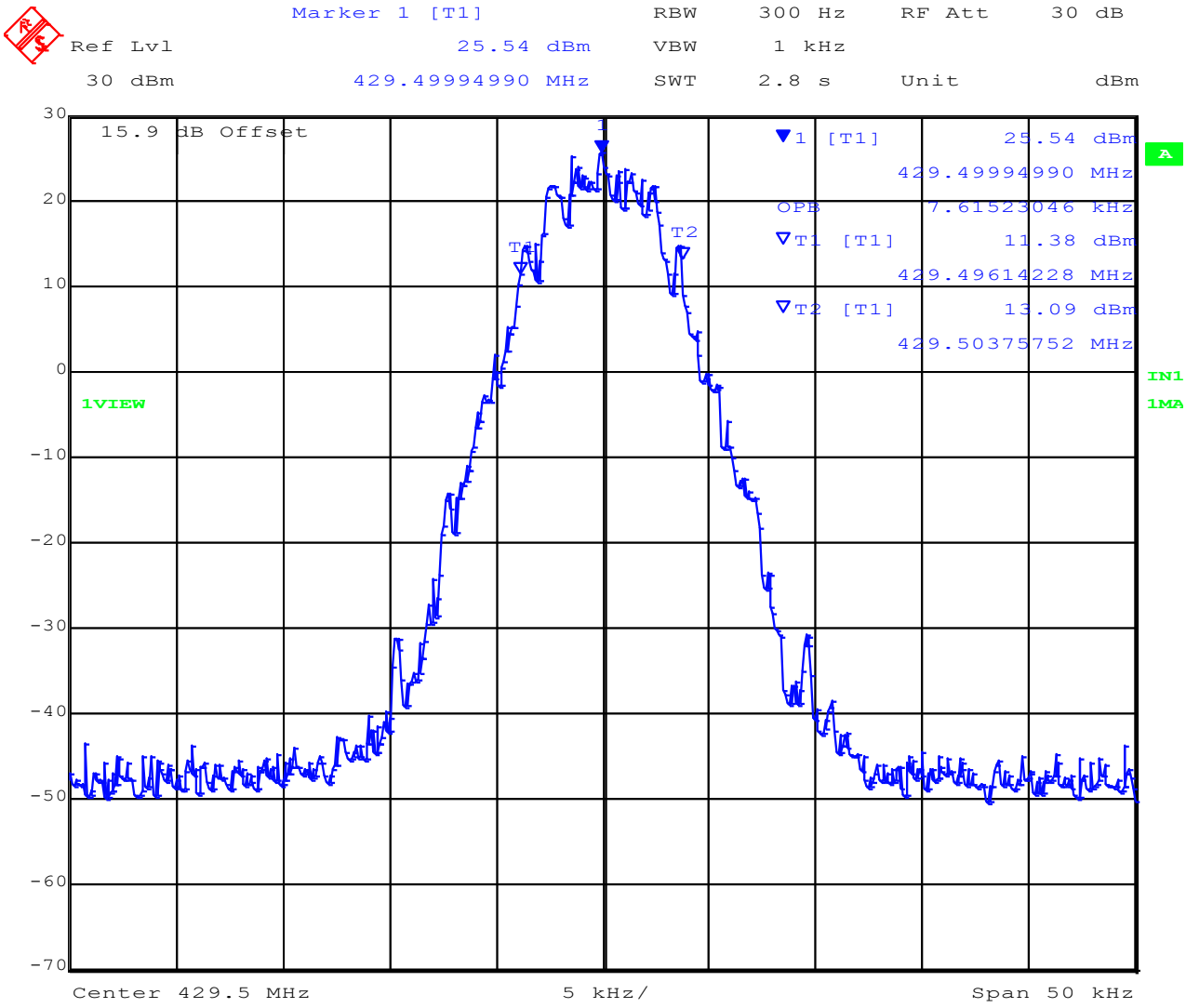
Variant: 12.5KHz, Channel: 410.0 MHz, Chain a



Date: 18.MAR.2021 08:11:21

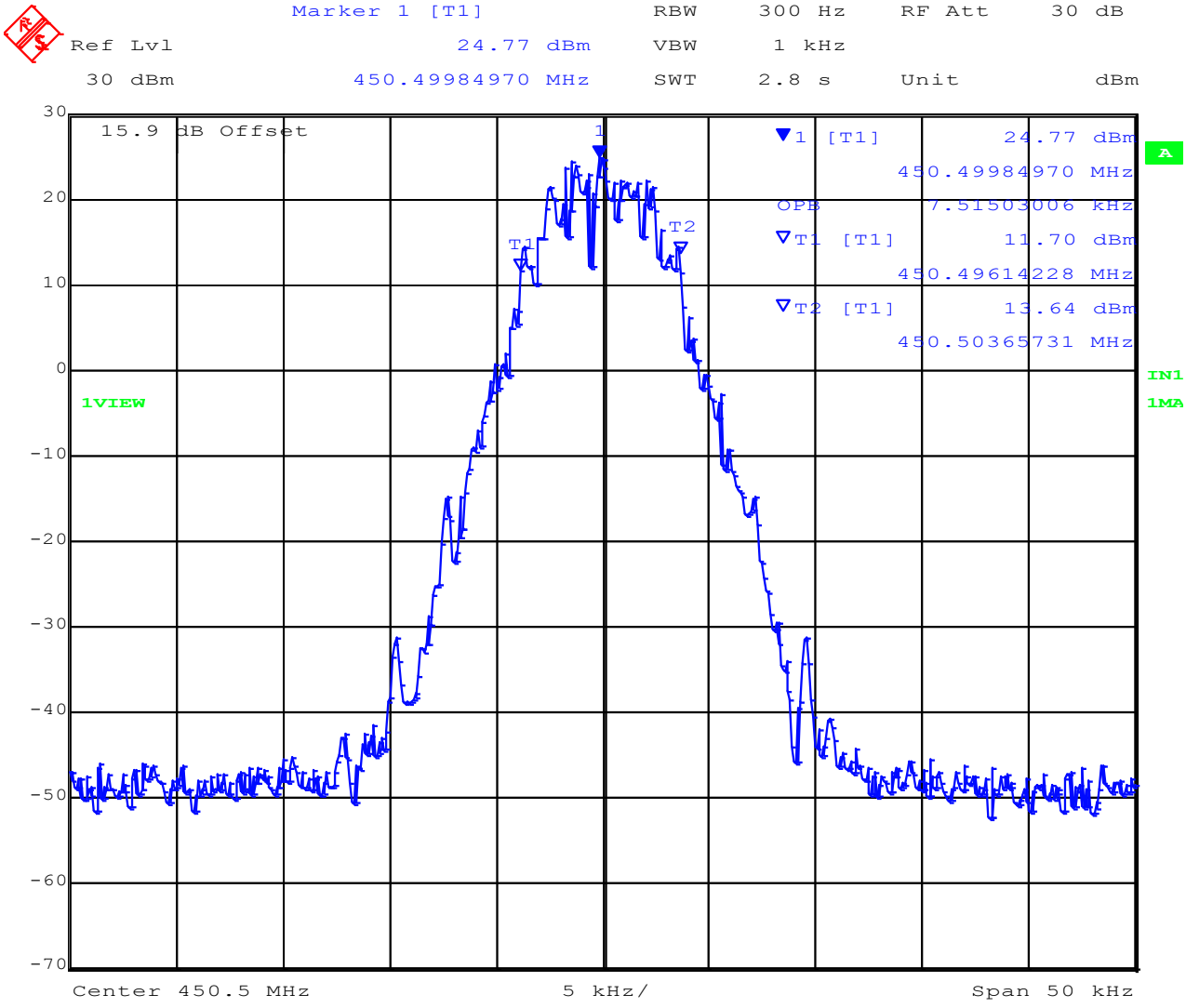
99% BANDWIDTH

Variant: 12.5KHz, Channel: 429.5MHz, Chain a



99% BANDWIDTH

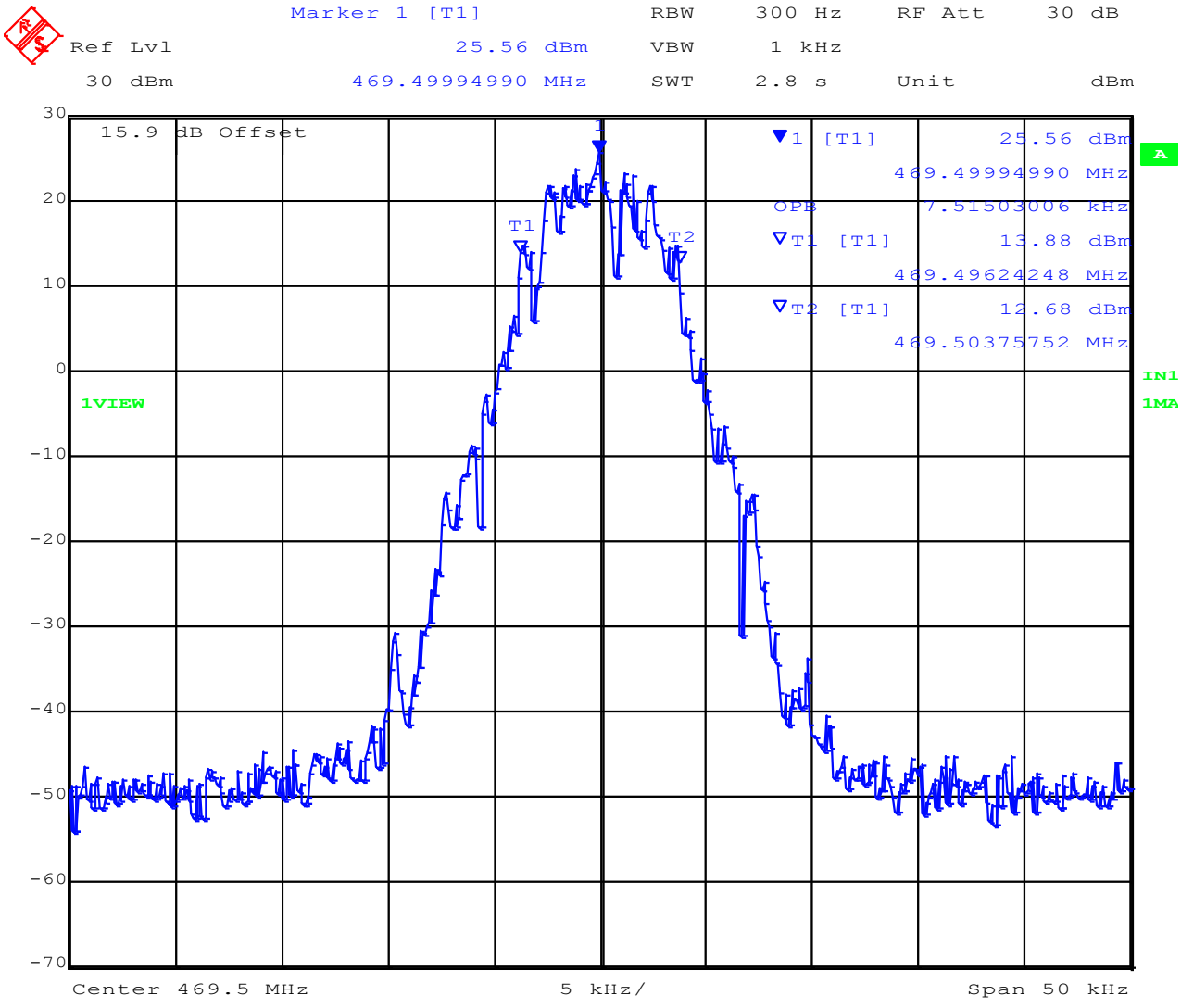
Variant: 12.5KHz, Channel: 450.5 MHz, Chain a



Date: 18.MAR.2021 08:32:34

99% BANDWIDTH

Variant: 12.5KHz, Channel: 469.5 MHz, Chain a



Date: 18.MAR.2021 08:58:06

9.1.1.2. 12.5 KHz GMSK

Equipment Configuration for 99% Bandwidth

Variant:	12.5KHz	**Duty Cycle (%):**	99
Data Rate:	Not Applicable	**Antenna Gain (dBi):**	Not Applicable
Modulation:	GMSK	**Beam Forming Gain (Y)(dB):**	Not Applicable
TPC:	Not Applicable	**Tested By:**	SB
Engineering Test Notes:			

Test Measurement Results

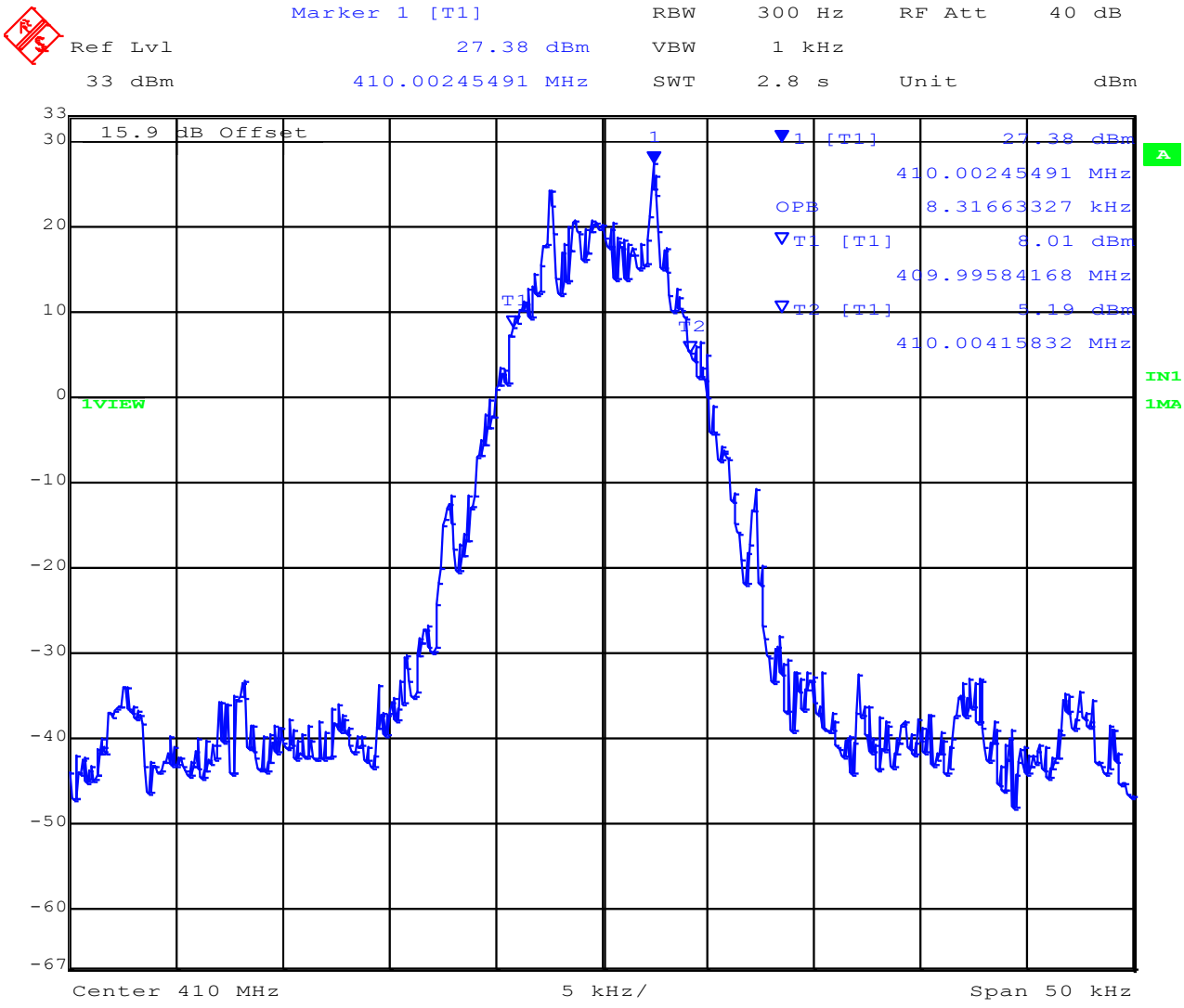
Test Frequency	Measured 99% Bandwidth (KHz) Port(s)				Maximum 99% Bandwidth (KHz)		
MHz	a	b	c	d			
410.0	8.31				8.31		
429.5	8.21				8.21		
450.5	8.31				8.31		
469.5	8.41				8.41		

Traceability to Industry Recognized Test Methodologies	
Work Instruction:	WI-03 MEASURING RF SPECTRUM MASK
Measurement Uncertainty:	±2.81 dB

Note: click the links in the above matrix to view the graphical image (plot).

99% BANDWIDTH

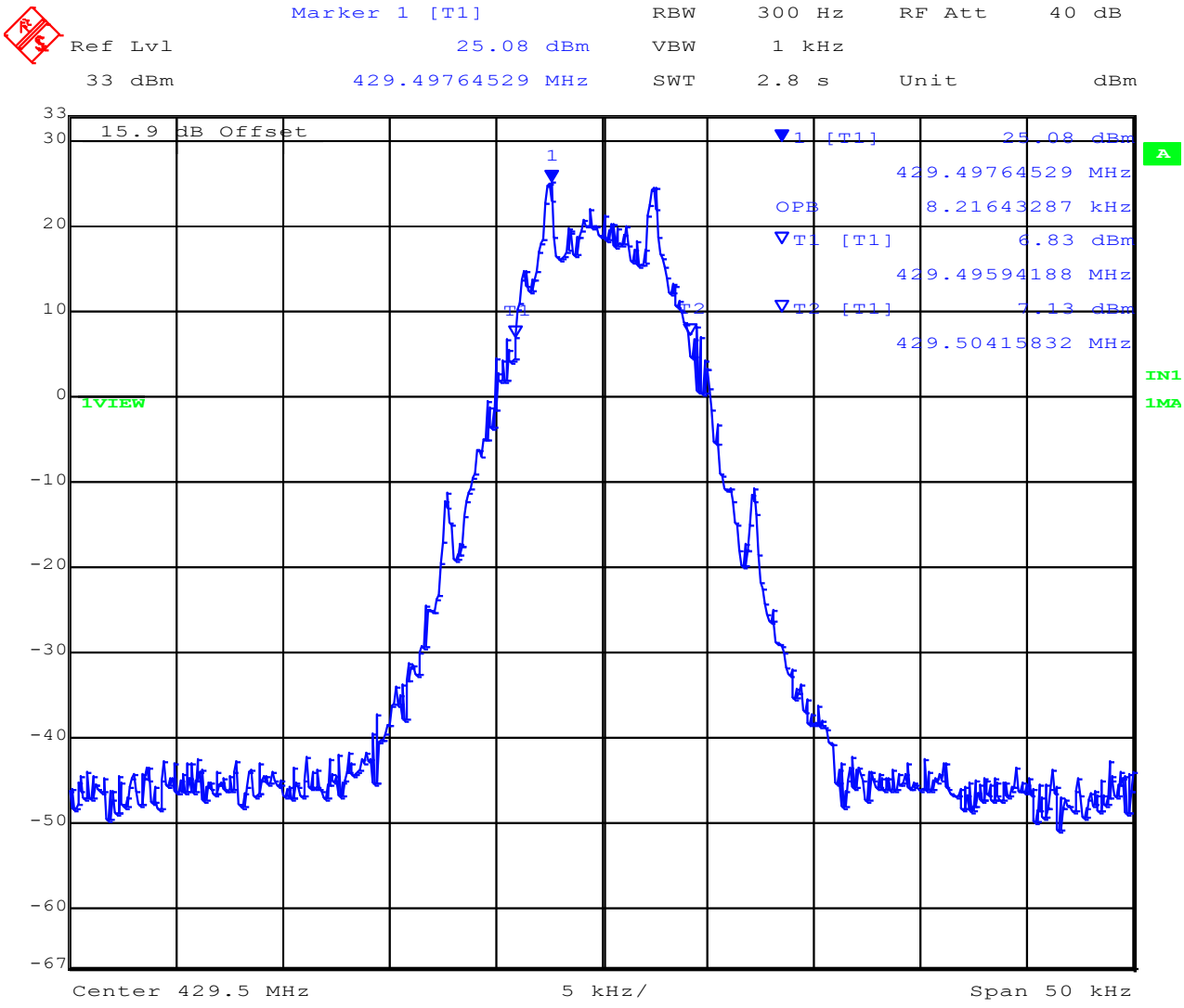
Variant: 12.5KHz, Channel: 410.0 MHz, Chain a



Date: 22.MAR.2021 09:56:24

99% BANDWIDTH

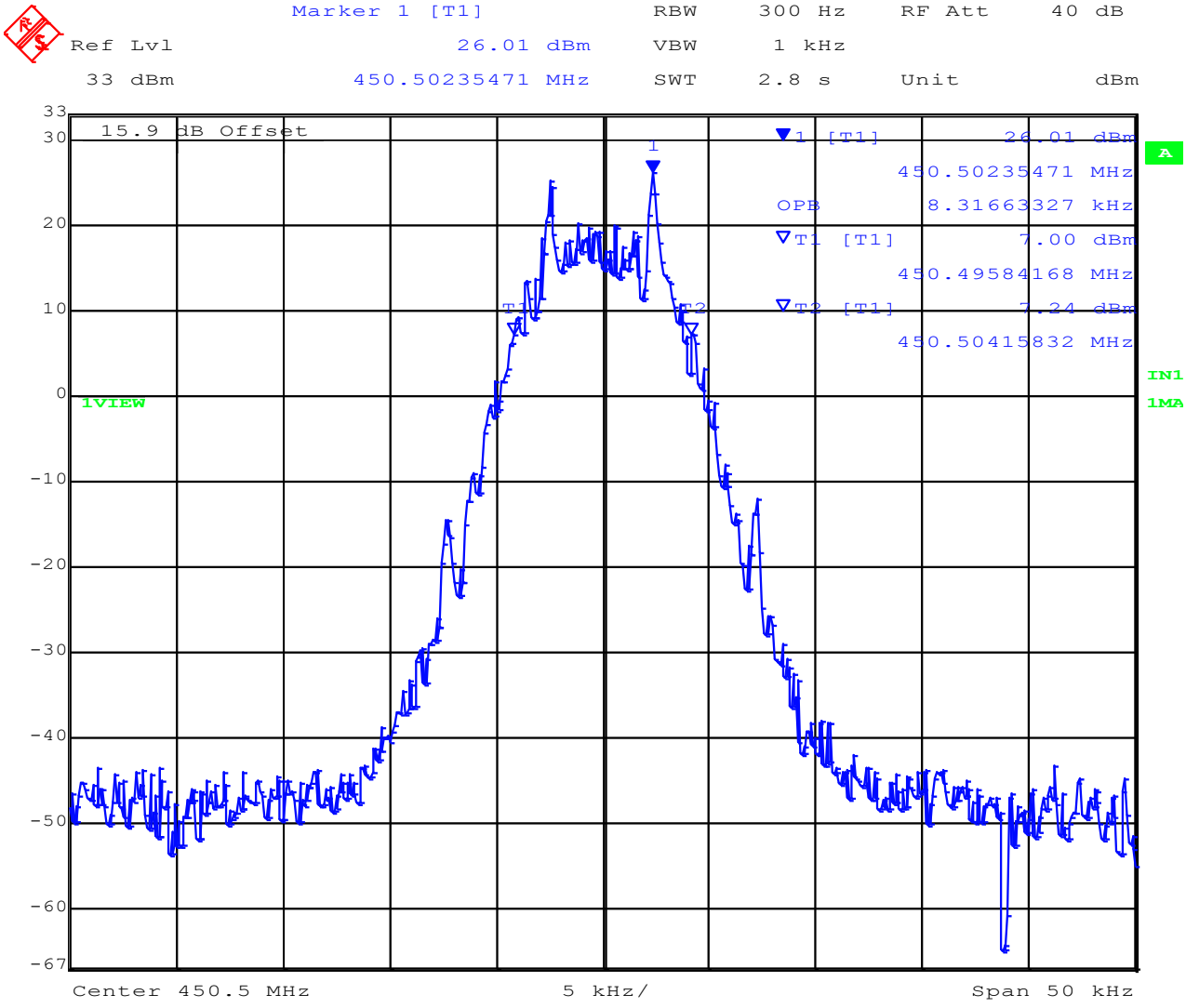
Variant: 12.5KHz, Channel: 429.5.MHz, Chain a



Date: 22.MAR.2021 09:55:27

99% BANDWIDTH

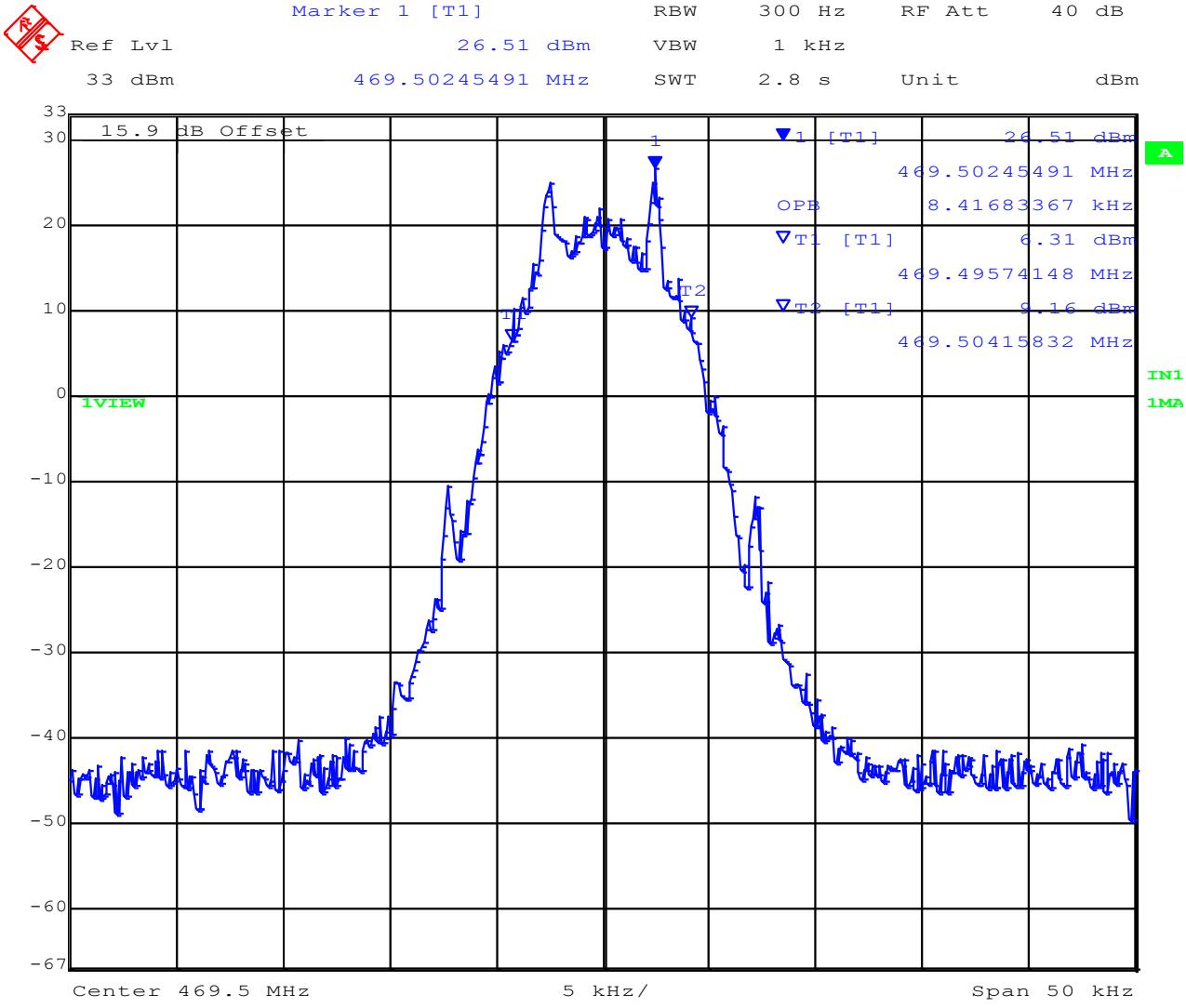
Variant: 12.5KHz, Channel: 450.5 MHz, Chain a



Date: 22.MAR.2021 09:57:54

99% BANDWIDTH

Variant: 12.5KHz, Channel: 469.5 MHz, Chain a



Date: 22.MAR.2021 09:58:59

9.1.1.3. 25 KHz GFSK

Equipment Configuration for 99% Bandwidth			
Variant:	25KHz	**Duty Cycle (%):**	99
Data Rate:	Not Applicable	**Antenna Gain (dBi):**	Not Applicable
Modulation:	FSK	**Beam Forming Gain (Y)(dB):**	Not Applicable
TPC:	Not Applicable	**Tested By:**	SB
Engineering Test Notes:			

Test Measurement Results

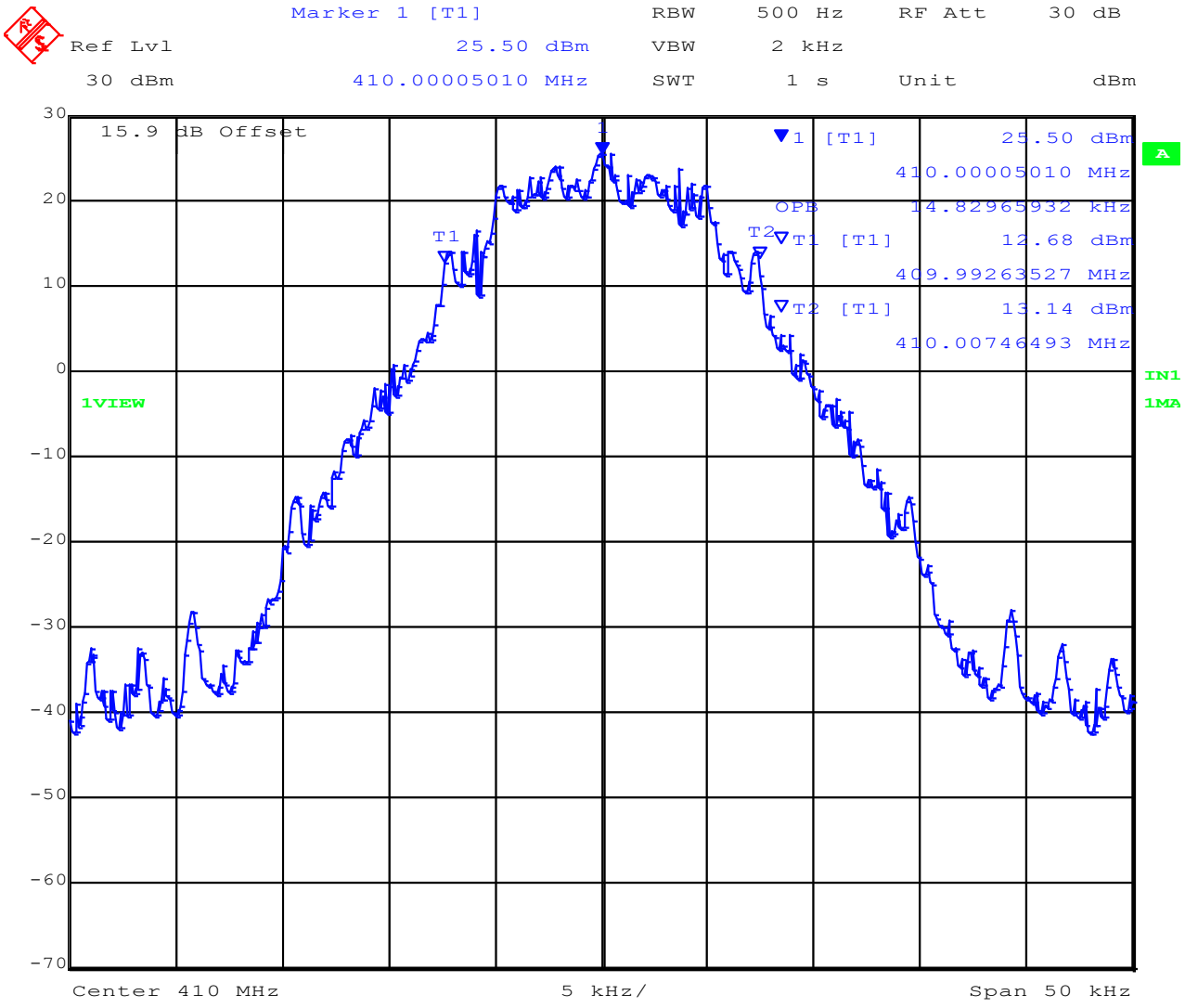
Test Frequency	Measured 99% Bandwidth (KHz) Port(s)				Maximum 99% Bandwidth (KHz)		
MHz	a	b	c	d			
410.0	14.82				14.82		
429.5	14.82				14.82		
450.5	14.82				14.82		
469.5	14.82				14.82		

Traceability to Industry Recognized Test Methodologies	
Work Instruction:	WI-03 MEASURING RF SPECTRUM MASK
Measurement Uncertainty:	±2.81 dB

Note: click the links in the above matrix to view the graphical image (plot).

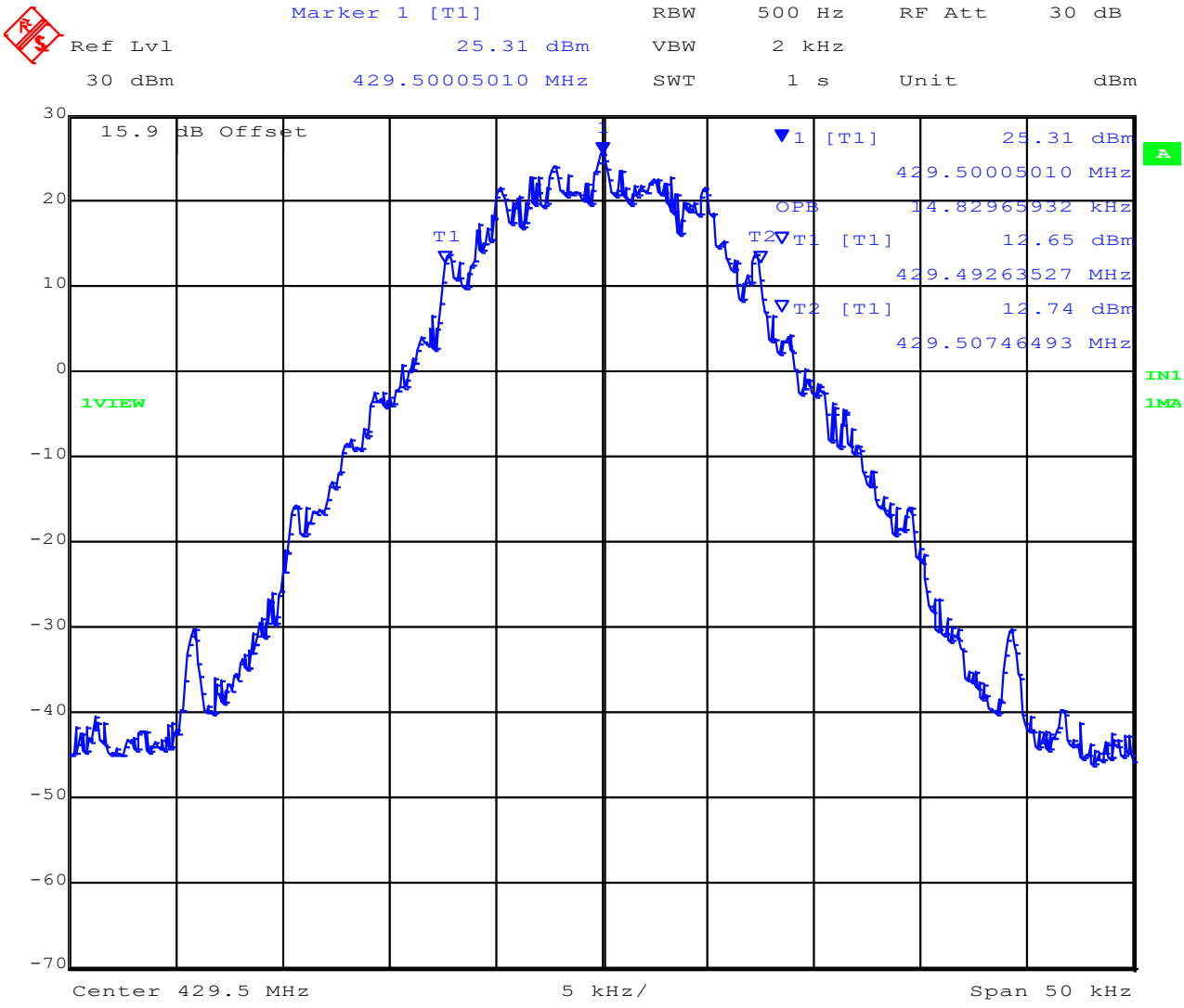
99% BANDWIDTH

Variant: 25KHz, Channel: 410.0 MHz, Chain a



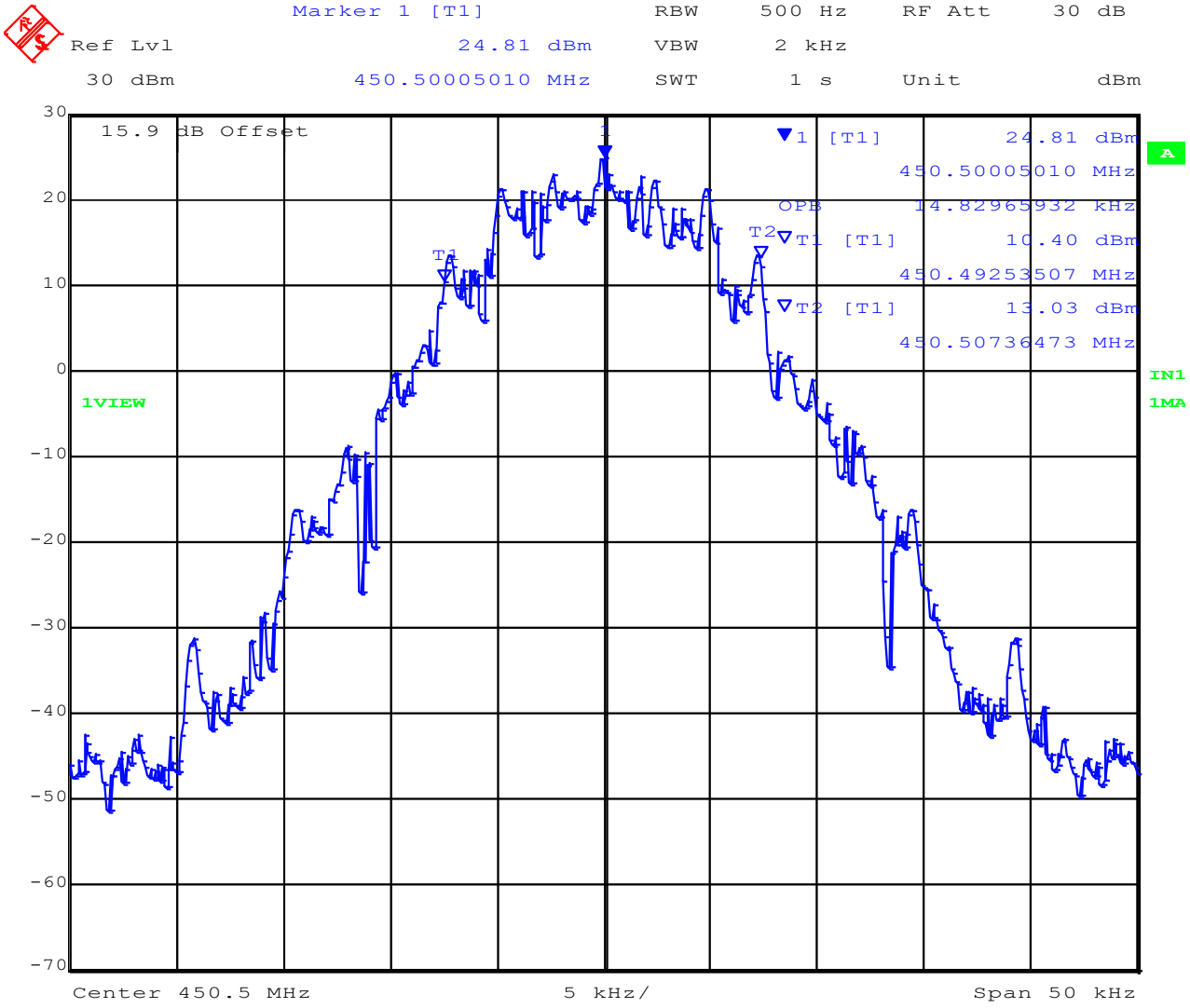
99% BANDWIDTH

Variant: 25KHz, Channel: 429.5MHz, Chain a



99% BANDWIDTH

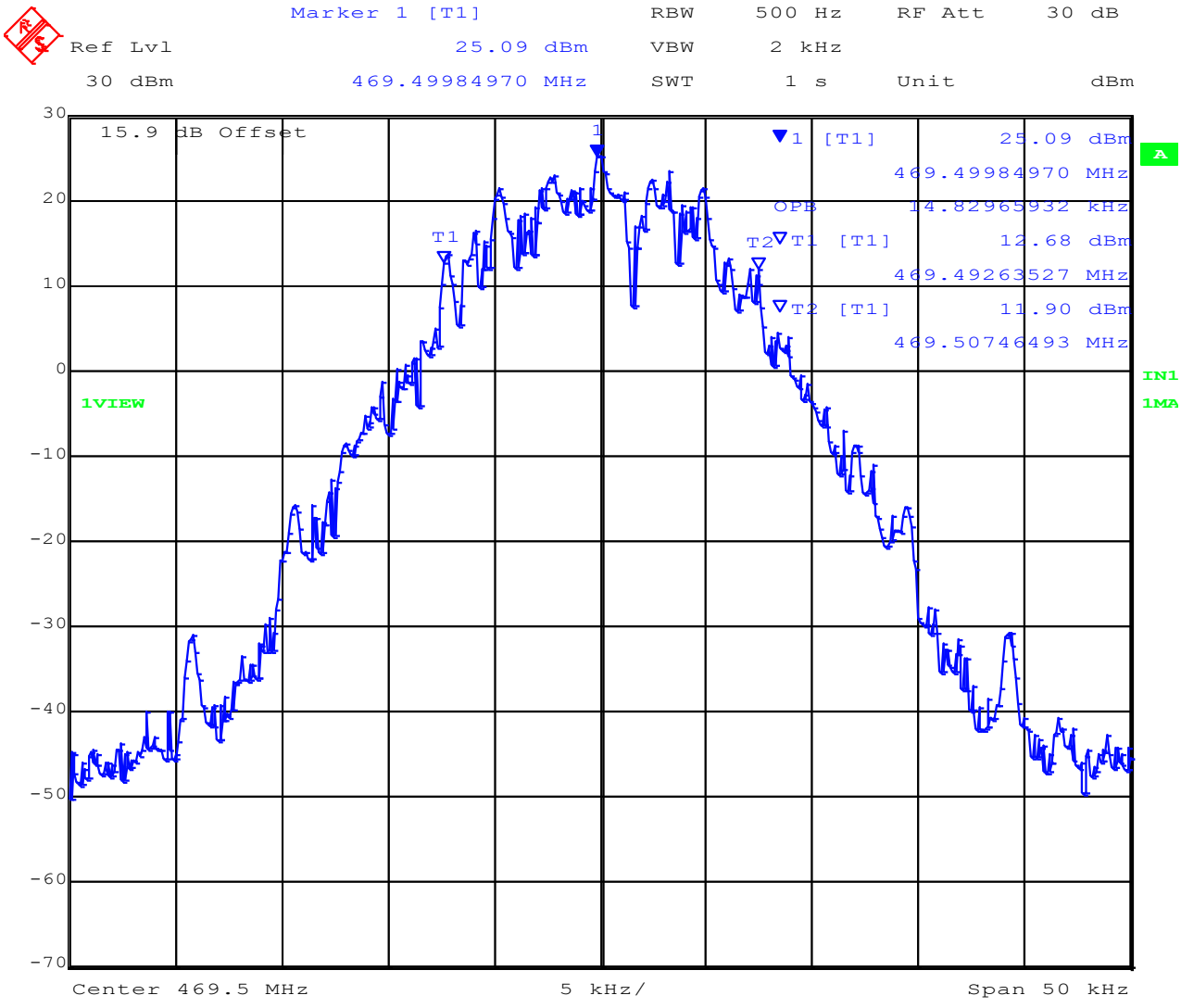
Variant: 25KHz, Channel: 450.5 MHz, Chain a



Date: 18.MAR.2021 09:04:01

99% BANDWIDTH

Variant: 25KHz, Channel: 469.5 MHz, Chain a



Date: 18.MAR.2021 09:06:53

9.1.1.4. 25 KHz GMSK

Equipment Configuration for 99% Bandwidth			
Variant:	25KHz	**Duty Cycle (%):**	99
Data Rate:	Not Applicable	**Antenna Gain (dBi):**	Not Applicable
Modulation:	GMSK	**Beam Forming Gain (Y)(dB):**	Not Applicable
TPC:	Not Applicable	**Tested By:**	SB
Engineering Test Notes:			

Test Measurement Results

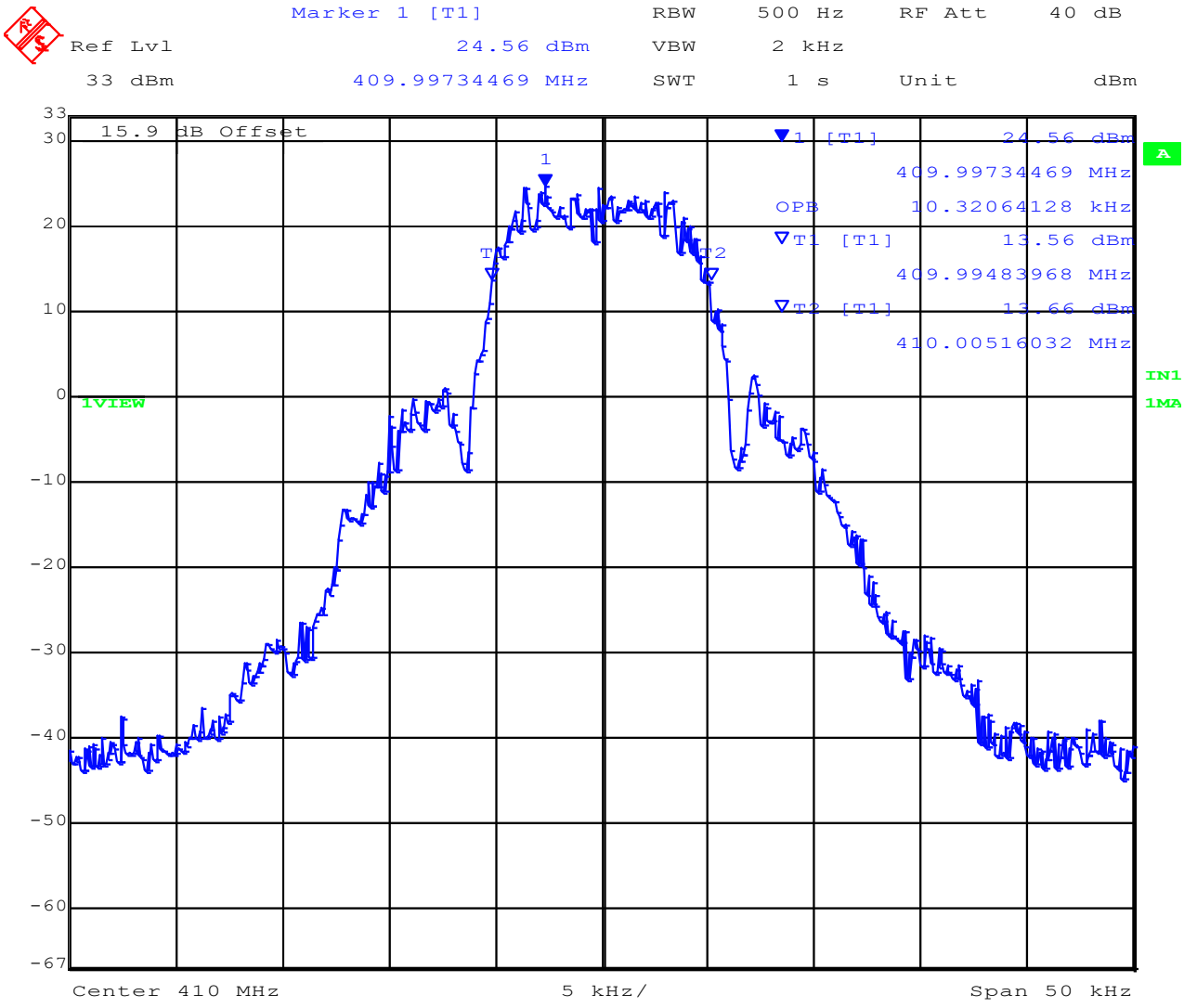
Test Frequency	Measured 99% Bandwidth (KHz) Port(s)				Maximum 99% Bandwidth (KHz)		
MHz	a	b	c	d			
410.0	10.32				10.32		
429.5	10.52				10.52		
450.5	10.62				10.62		
469.5	10.52				10.52		

Traceability to Industry Recognized Test Methodologies	
Work Instruction:	WI-03 MEASURING RF SPECTRUM MASK
Measurement Uncertainty:	±2.81 dB

Note: click the links in the above matrix to view the graphical image (plot).

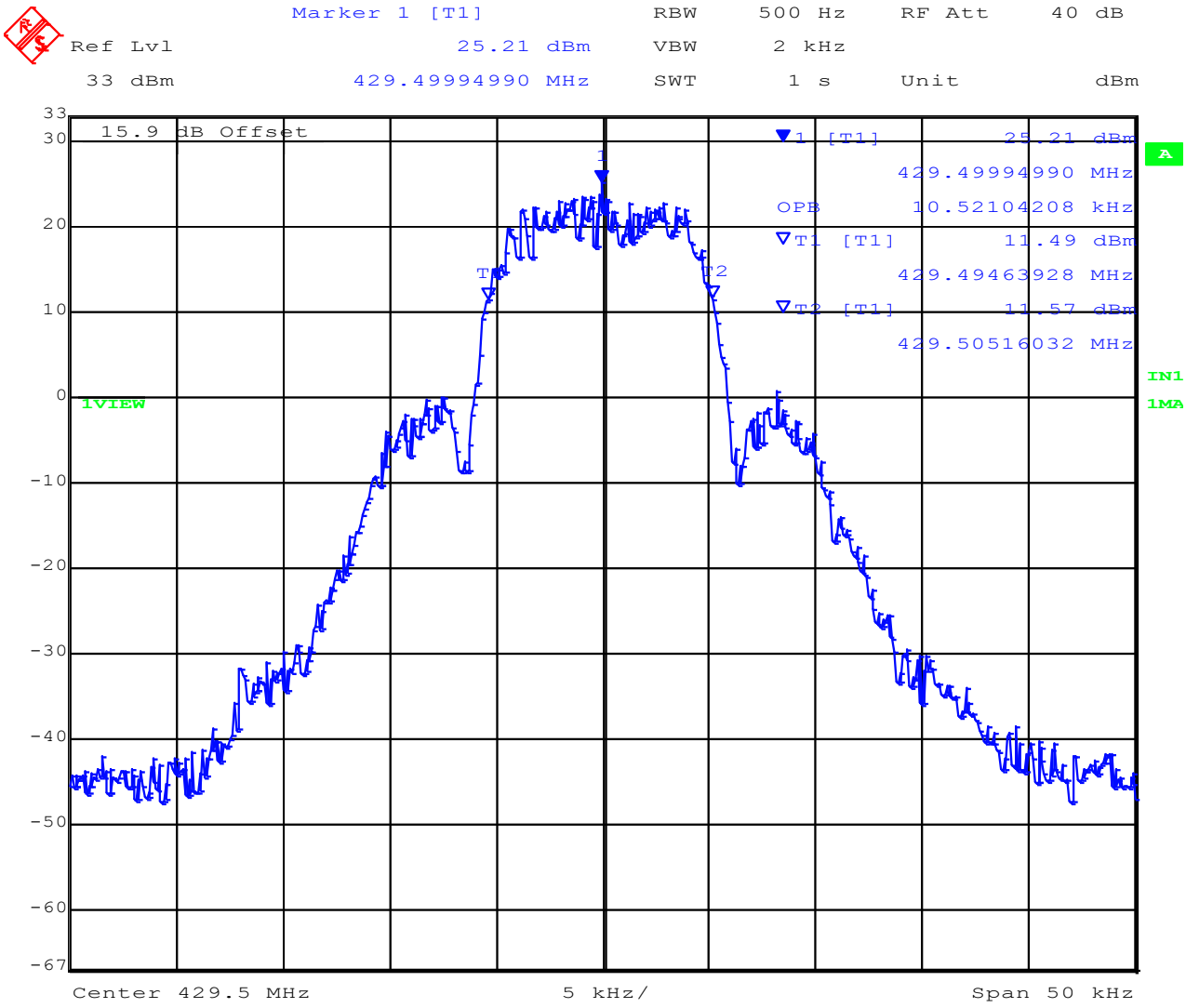
99% BANDWIDTH

Variant: 25KHz, Channel: 410.0 MHz, Chain a



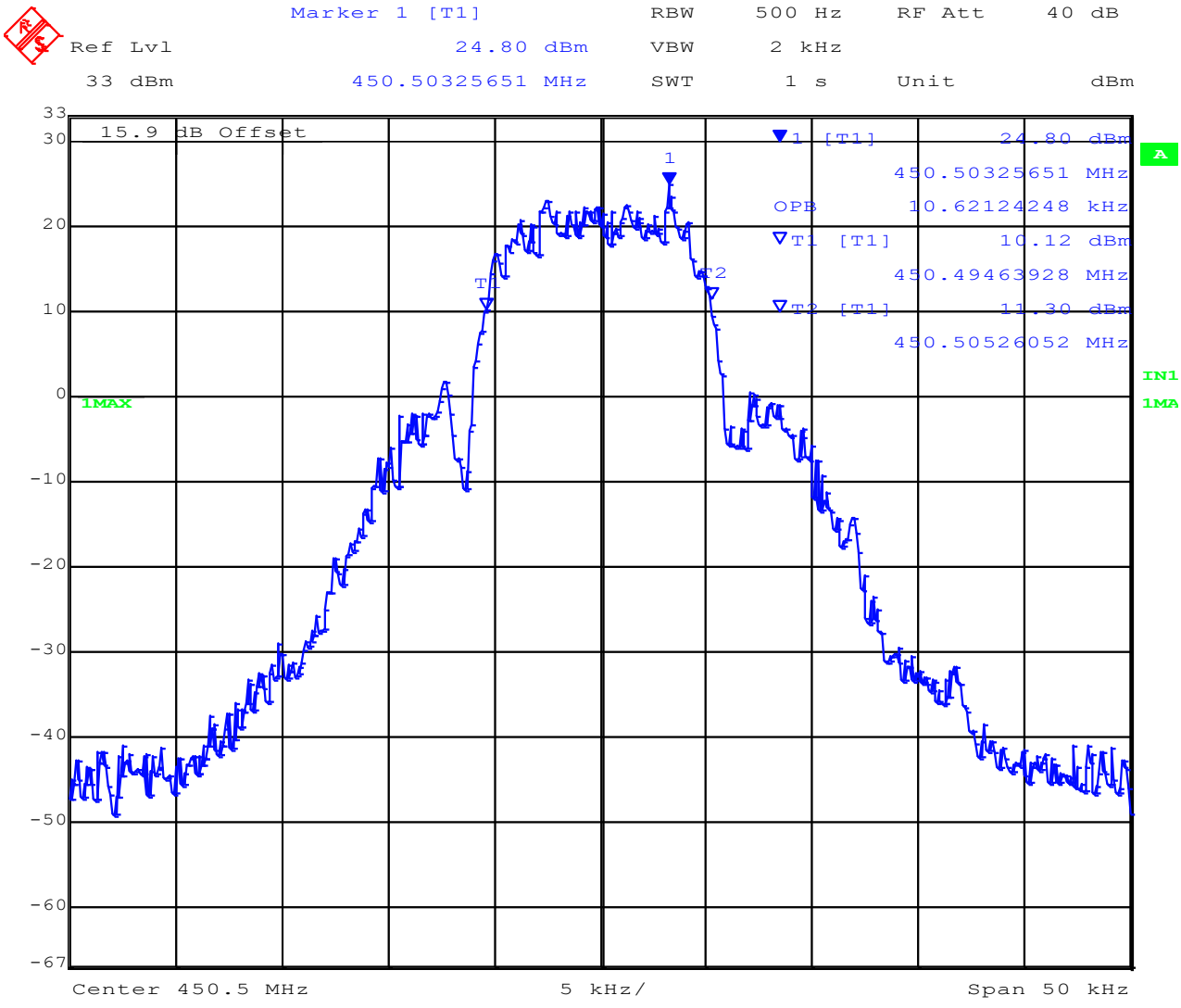
99% BANDWIDTH

Variant: 25KHz, Channel: 429.5 MHz, Chain a



99% BANDWIDTH

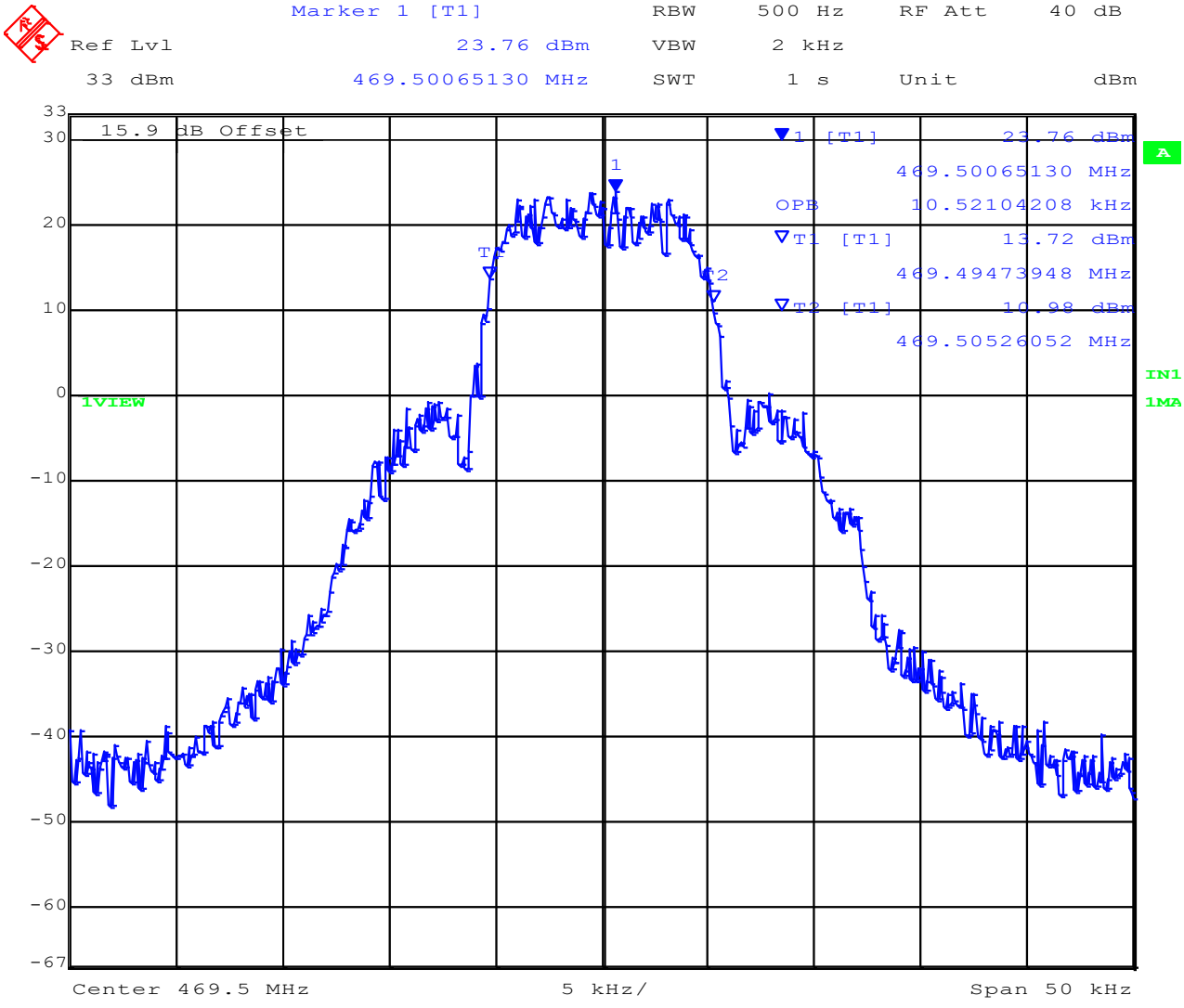
Variant: 25KHz, Channel: 450.5 MHz, Chain a



Date: 22.MAR.2021 10:04:27

99% BANDWIDTH

Variant: 25KHz, Channel: 469.5 MHz, Chain a



Date: 22.MAR.2021 10:07:34

9.2. Output Power

Conducted Test Conditions for Fundamental Emission Output Power			
Standard:	FCC CFR 47:Part 90 ISED RSS-119	**Ambient Temp. (ºC):**	24.0 - 27.5
Test Heading:	Output Power	**Rel. Humidity (%):**	32 - 45
Standard Section(s):	90.205,90.279 RSS-119 5.4	**Pressure (mBars):**	999 - 1001
Reference Document(s):	See Normative References		

Test Procedure for Fundamental Emission Output Power Measurement

In the case of average power measurements an average power sensor was utilized.

For peak power measurements the spectrum analyzer built-in power function was used to integrate peak power over the 20 dB bandwidth.

Testing was performed under ambient conditions, nominal voltage. Where the device operated with multiple antenna ports i.e. MIMO device, each port was measured, summed (Σ) and reported.

Test configuration and setup used for the measurement was per the Conducted Test Set-up specified in this document.
Supporting Information
Calculated Power = A + G + Y+ 10 log (1/x) dBm

Limit
The output power shall be within ±1 dB of the manufacturers declared power per Section 5.1. of this report.

FCC Part §90.205(h)
Power limit according to 90.205(h) 450–470 MHz. The maximum allowable station effective radiated power (ERP) is dependent upon the station's antenna HAAT and required service area and will be authorized in accordance with table 2. (i.e. 2W for service area less than 3 km.)

FCC Part §90.279(g)
Power limit according to 90.279 Table 7: 75W ERP

Industry Canada RSS-119 §5.4
Typical output powers for mobile equipment is 60W.

9.2.1.5. 12.5 KHz GFSK

Equipment Configuration for Output Power Peak

Variant:	12.5KHz	**Duty Cycle (%):**	99
Data Rate:	Not Applicable	**Antenna Gain (dBi):**	Not Applicable
Modulation:	GFSK	**Beam Forming Gain (Y)(dB):**	Not Applicable
TPC:	Not Applicable	**Tested By:**	SB
Engineering Test Notes:			

Test Measurement Results

Test Frequency	Measured Output Power (dBm) Port(s)				Calculated Total Power Σ Port(s)	Limit	Margin	EUT Power Setting
MHz	a	b	c	d	dBm	dBm	dB	
410.0	29.85				29.85	30.00±1	-0.15	Max
429.5	29.88				29.88	30.00±1	-0.12	Max
450.5	29.89				29.89	30.00±1	-0.11	Max
469.5	29.88				29.88	30.00±1	-0.12	Max

Traceability to Industry Recognized Test Methodologies	
Work Instruction:	WI-01 MEASURING RF OUTPUT POWER
Measurement Uncertainty:	±1.33 dB

The above measurements are true pulse readings and therefore a Duty Cycling correction factor is not required.

9.2.1.6. 12.5 KHz GMSK

Equipment Configuration for Output Power Peak

Variant:	12.5KHz	**Duty Cycle (%):**	99
Data Rate:	Not Applicable	**Antenna Gain (dBi):**	Not Applicable
Modulation:	GFSK	**Beam Forming Gain (Y)(dB):**	Not Applicable
TPC:	Not Applicable	**Tested By:**	SB
Engineering Test Notes:			

Test Measurement Results

Test Frequency	Measured Output Power (dBm) Port(s)				Calculated Total Power Σ Port(s)	Limit	Margin	EUT Power Setting
MHz	a	b	c	d	dBm	dBm	dB	
410.0	29.77				29.77	30.00±1	-0.23	Max
429.5	29.81				29.81	30.00±1	-0.19	Max
450.5	29.88				29.88	30.00±1	-0.12	Max
469.5	29.80				29.80	30.00±1	-0.20	Max

Traceability to Industry Recognized Test Methodologies	
Work Instruction:	WI-01 MEASURING RF OUTPUT POWER
Measurement Uncertainty:	±1.33 dB

The above measurements are true pulse readings and therefore a Duty Cycling correction factor is not required.

9.2.1.7. 25 KHz GFSK

Equipment Configuration for Output Power Peak			
Variant:	25KHz	**Duty Cycle (%):**	99
Data Rate:	Not Applicable	**Antenna Gain (dBi):**	Not Applicable
Modulation:	GFSK	**Beam Forming Gain (Y)(dB):**	Not Applicable
TPC:	Not Applicable	**Tested By:**	SB
Engineering Test Notes:			

Test Measurement Results

Test Frequency	Measured Output Power (dBm) Port(s)				Calculated Total Power Σ Port(s)	Limit	Margin	EUT Power Setting
MHz	a	b	c	d	dBm	dBm	dB	
410.0	29.91				29.91	30.00±1	-0.09	Max
429.5	29.95				29.95	30.00±1	-0.05	Max
450.5	29.95				29.95	30.00±1	-0.05	Max
469.5	29.97				29.97	30.00±1	-0.03	Max

Traceability to Industry Recognized Test Methodologies	
Work Instruction:	WI-01 MEASURING RF OUTPUT POWER
Measurement Uncertainty:	±1.33 dB

The above measurements are true pulse readings and therefore a Duty Cycling correction factor is not required.

9.2.1.8. 25 KHz GMSK

Equipment Configuration for Output Power Peak			
Variant:	25KHz	**Duty Cycle (%):**	99
Data Rate:	Not Applicable	**Antenna Gain (dBi):**	Not Applicable
Modulation:	GMSK	**Beam Forming Gain (Y)(dB):**	Not Applicable
TPC:	Not Applicable	**Tested By:**	SB
Engineering Test Notes:			

Test Measurement Results

Test Frequency	Measured Output Power (dBm) Port(s)				Calculated Total Power Σ Port(s)	Limit	Margin	EUT Power Setting
MHz	a	b	c	d	dBm	dBm	dB	
410.0	29.79				29.79	30.00±1	-0.21	Max
429.5	29.78				29.78	30.00±1	-0.22	Max
450.5	29.81				29.81	30.00±1	-0.19	Max
469.5	29.83				29.83	30.00±1	-0.17	Max

Traceability to Industry Recognized Test Methodologies	
Work Instruction:	WI-01 MEASURING RF OUTPUT POWER
Measurement Uncertainty:	±1.33 dB

The above measurements are true pulse readings and therefore a Duty Cycling correction factor is not required.

9.3. Transient Frequency Behavior

Conducted Test Conditions for Fundamental Emission Output Power			
Standard:	FCC CFR 47:Part 90 ISED RSS-119	**Ambient Temp. (ºC):**	24.0 - 27.5
Test Heading:	Output Power	**Rel. Humidity (%):**	32 - 45
Standard Section(s):	90.205,90.214 RSS-119 5.9	**Pressure (mBars):**	999 - 1001
Reference Document(s):	See Normative References		

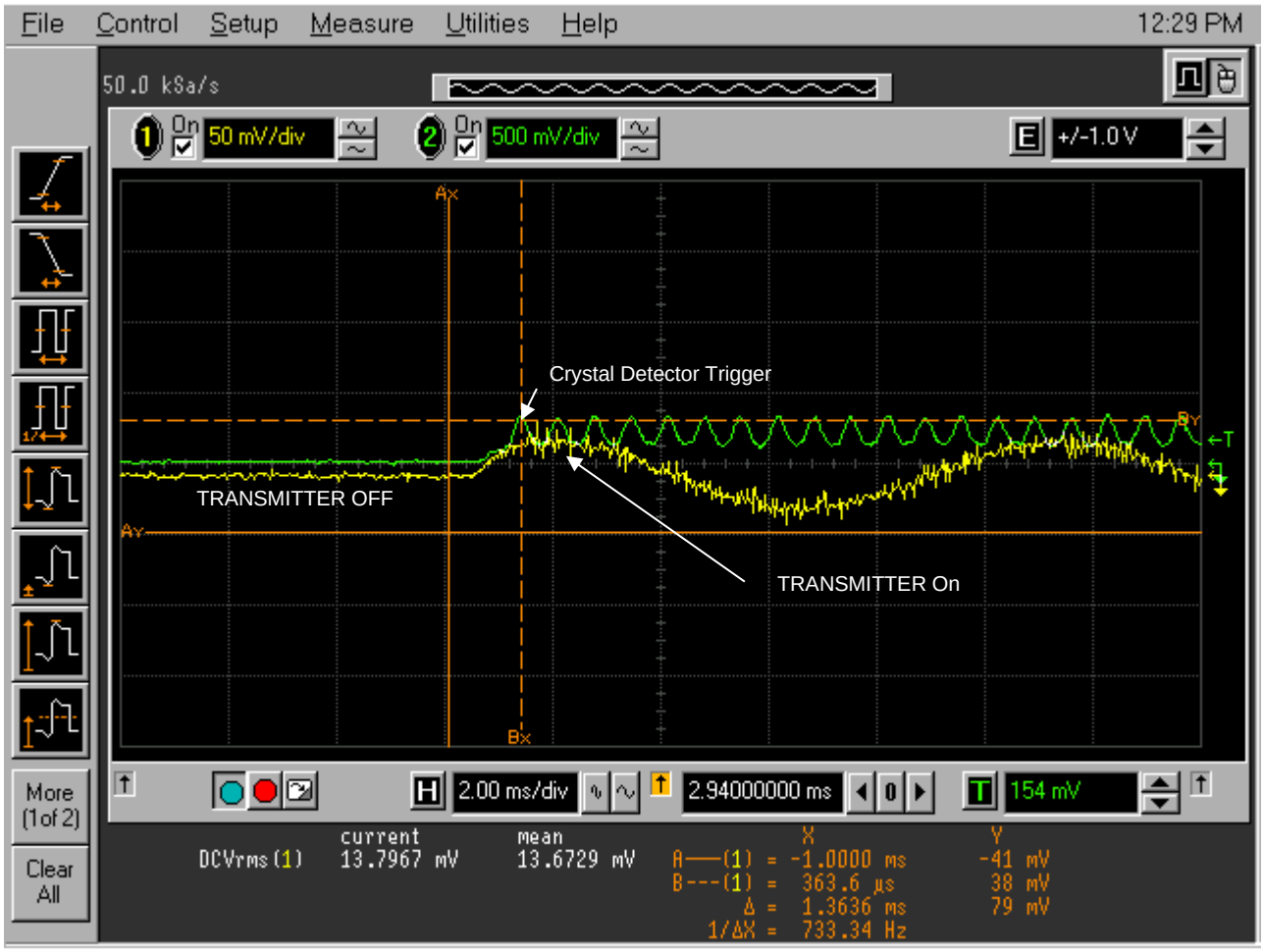
Test Procedure
Transmitters designed to operate in the 421 to 512 MHz frequency bands must maintain transient frequencies within the maximum frequency difference limits during the time intervals indicated. Testing which was performed to the limits specified for 6.25 kHz channel spacing operation, worst case or tightest limits. Compliance to these limits implies the EUT will meet the 12.5 and 25 kHz limits given the same conditions.

Limit:

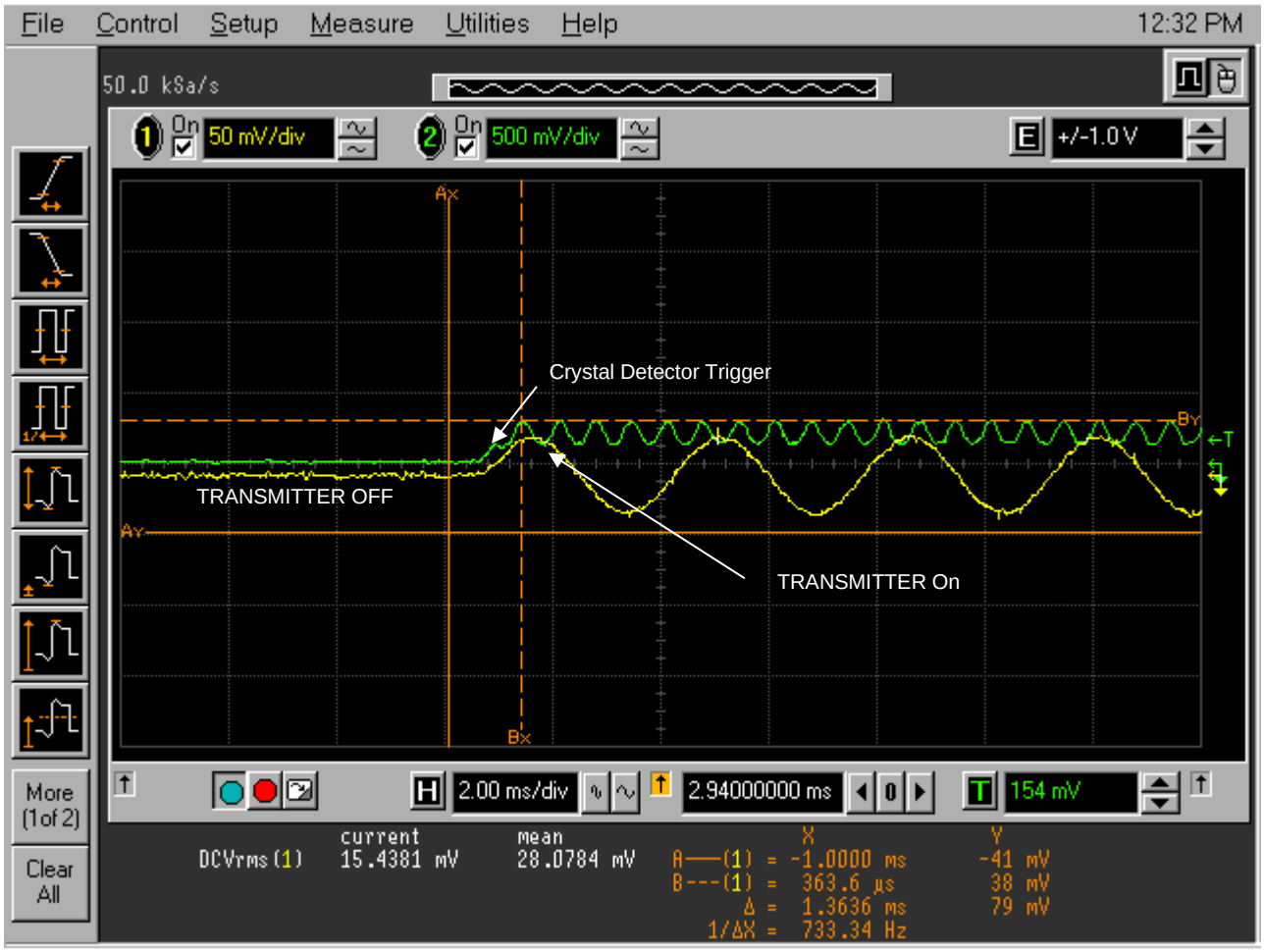
Frequency (MHz)	Channel Bandwidth (kHz)	Transient Period	Transient Behavior
450	6.25	t_1 = 10 ms	< ± 6.25 kHz
		t_2 = 25 ms	< ± 3.15 kHz
		t_3 = 10 ms	< ± 6.25 kHz
	12.5	t_1 = 10 ms	< ±12.5 kHz
		t_2 = 25 ms	< ± 6.25 kHz
		t_3 = 10 ms	< ±12.5 kHz
	25	t_1 = 10 ms	< ± 25.0 kHz
		t_2 = 25 ms	< ±12.5 kHz
		t_3 = 10 ms	< ± 25.0 kHz

Result: Pass no transient pulses were observed

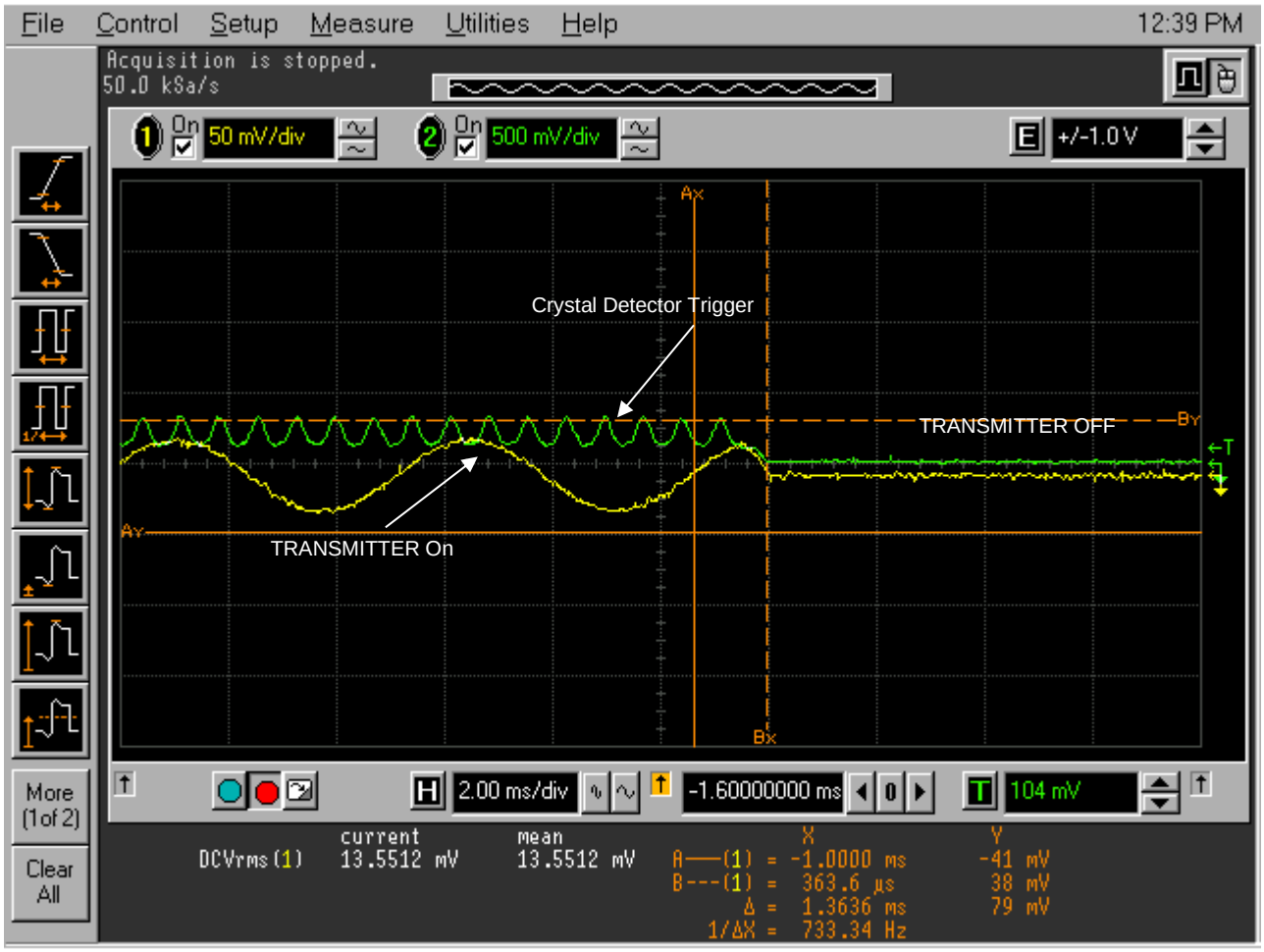
9.3.1.9. Transmitter on 12.5 KHz 410 MHz



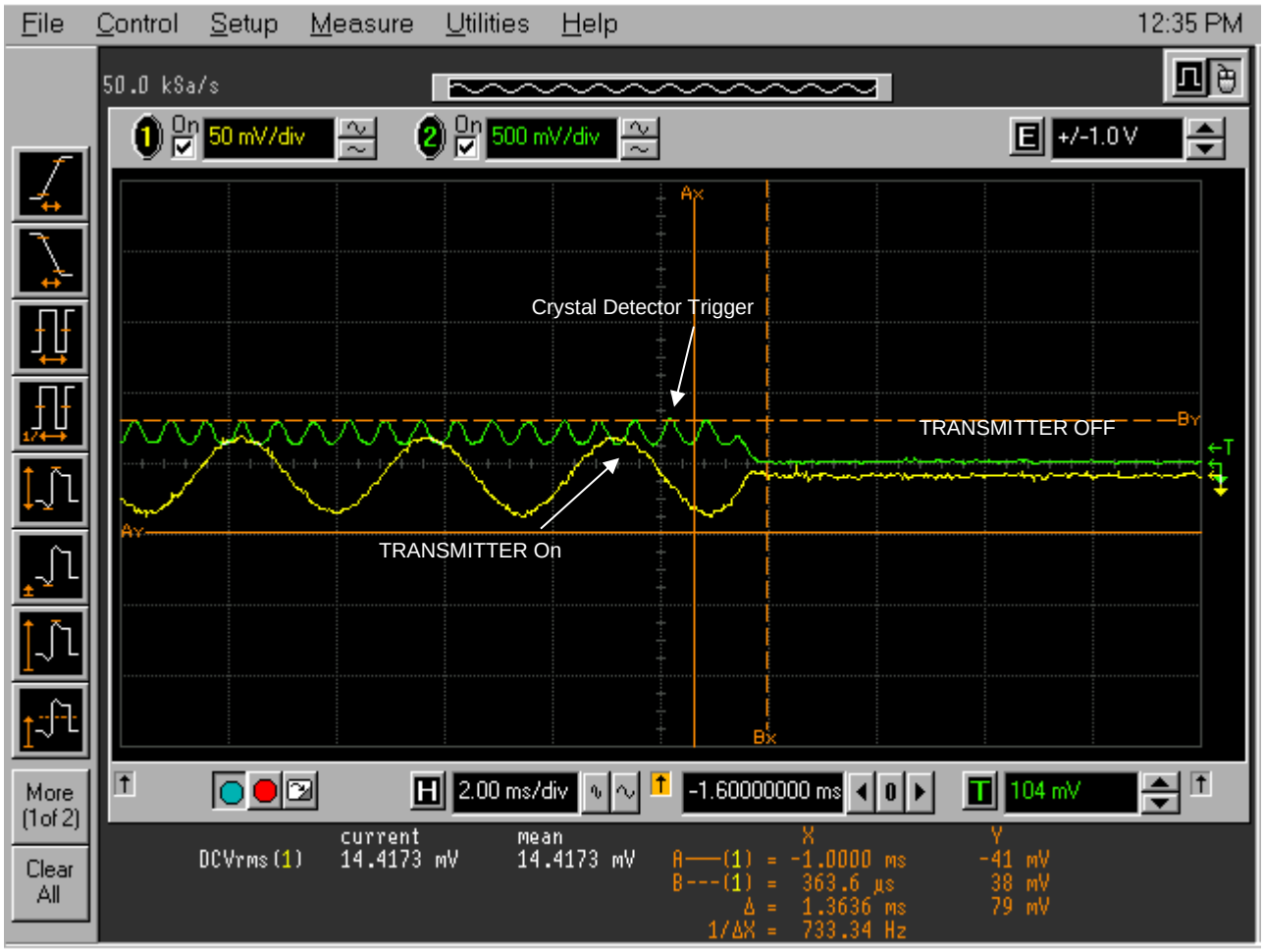
9.3.1.10. Transmitter off 12.5 KHz 469.5 MHz



9.3.1.11. Transmitter off 12.5 KHz 410 MHz



9.3.1.12. Transmitter on 12.5 KHz 469.6 MHz



9.4. Frequency Stability

Conducted Test Conditions for Frequency Stability			
Standard:	FCC CFR 47:90 ISED RSS-119	**Ambient Temp. (ºC):**	24.0 - 27.5
Test Heading:	Frequency Stability	**Rel. Humidity (%):**	32 - 45
Standard Section(s):	90.213 RSS-119 5.3	**Pressure (mBars):**	999 - 1001
Reference Document(s):	See Normative References		

Test Procedure for Frequency Stability Measurement

The Frequency Error was measured with a spectrum analyzer connected to the antenna terminal, while EUT is operating in transmission mode at the appropriate center frequency.

Testing was performed under ambient conditions at extreme voltages and over extreme temperatures at nominal voltages. Where the device operated with multiple antenna ports i.e. MIMO device, each port was measured and reported.

Test configuration and setup used for the measurement was per the Conducted Test Set-up specified in this document.

Limits:
12.5KHz:±2.5ppm & 25KHz:±5.0ppm

Equipment Configuration for Nominal Centre frequencies

Variant:	12.5KHz	**Duty Cycle (%):**	99
Data Rate:	Not Applicable	**Antenna Gain (dBi):**	Not Applicable
Modulation:	GMSK	**Beam Forming Gain (Y)(dB):**	Not Applicable
TPC:	Not Applicable	**Tested By:**	SB
Engineering Test Notes:			

Test Measurement Results

Test frequency	410.00 MHz	Measured Frequency	Frequency Error		Limit	Margin
Temperature	**Voltage**	**MHz**	**kHz**	**ppm**	**ppm**	**ppm**
20 °C	5.0 Vdc	409999929.86	-0.07014	-0.171073171	±2.5	-2.32892683
20 °C	5.5 Vdc	409999953.91	-0.04609	-0.112414634	±2.5	-2.38758537
20 °C	4.5 Vdc	409999981.96	-0.01804	-0.044	±2.5	-2.456
70 °C	5.0 Vdc	410000126.25	0.12625	0.307926829	±2.5	-2.19207317
60 °C	5.0 Vdc	410000006.01	0.00601	0.014658537	±2.5	-2.48534146
50 °C	5.0 Vdc	409999879.76	-0.12024	-0.293268293	±2.5	-2.20673171
40 °C	5.0 Vdc	409999867.74	-0.13226	-0.322585366	±2.5	-2.17741463
30 °C	5.0 Vdc	409999955.91	-0.04409	-0.107536585	±2.5	-2.39246341
10 °C	5.0 Vdc	409999995.99	-0.00401	-0.009780488	±2.5	-2.49021951
0 °C	5.0 Vdc	409999901.80	-0.0982	-0.239512195	±2.5	-2.2604878
-7 °C	5.0 Vdc	409999833.67	-0.16633	-0.405682927	±2.5	-2.09431707
-17 °C	5.0 Vdc	409999821.64	-0.17836	-0.43502439	±2.5	-2.06497561
-27 °C	5.0 Vdc	409999933.87	-0.06613	-0.161292683	±2.5	-2.33870732
-37 °C	5.0 Vdc	409999945.89	-0.05411	-0.13197561	±2.5	-2.36802439
-47 °C	5.0 Vdc	409999929.86	-0.07014	-0.171073171	±2.5	-2.32892683

Traceability to Industry Recognized Test Methodologies	
Work Instruction:	WI-02 MEASURING FREQUENCY
Measurement Uncertainty:	±0.86 ppm

Equipment Configuration for Nominal Centre frequencies			
Variant:	12.5KHz	**Duty Cycle (%):**	99
Data Rate:	Not Applicable	**Antenna Gain (dBi):**	Not Applicable
Modulation:	GMSK	**Beam Forming Gain (Y)(dB):**	Not Applicable
TPC:	Not Applicable	**Tested By:**	SB
Engineering Test Notes:			

Test Measurement Results

Test frequency	469.5 MHz	Measured Frequency	Frequency Error		Limit	Margin
Temperature	Voltage	MHz	kHz	ppm	ppm	ppm
20 °C	5.0 Vdc	469499989.98	-0.01002	-0.021341853	±2.5	-2.47865815
20 °C	5.5 Vdc	469500010.02	0.01002	0.021341853	±2.5	-2.47865815
20 °C	4.5 Vdc	469499953.91	-0.04609	-0.098168264	±2.5	-2.40183174
70 °C	5.0 Vdc	469500148.30	0.1483	0.315867945	±2.5	-2.18413206
60 °C	5.0 Vdc	469499917.84	-0.08216	-0.174994675	±2.5	-2.32500532
50 °C	5.0 Vdc	469499859.72	-0.14028	-0.298785942	±2.5	-2.20121406
40 °C	5.0 Vdc	469499835.67	-0.16433	-0.35001065	±2.5	-2.14998935
30 °C	5.0 Vdc	469499867.74	-0.13226	-0.28170394	±2.5	-2.21829606
10 °C	5.0 Vdc	469499989.98	-0.01002	-0.021341853	±2.5	-2.47865815
0 °C	5.0 Vdc	469499833.67	-0.16633	-0.3542705	±2.5	-2.1457295
-7 °C	5.0 Vdc	469499801.60	-0.1984	-0.42257721	±2.5	-2.07742279
-17 °C	5.0 Vdc	469499765.53	-0.23447	-0.499403621	±2.5	-2.00059638
-27 °C	5.0 Vdc	469499825.65	-0.17435	-0.371352503	±2.5	-2.1286475
-37 °C	5.0 Vdc	469499845.69	-0.15431	-0.328668797	±2.5	-2.1713312
-47 °C	5.0 Vdc	469499989.98	-0.01002	-0.021341853	±2.5	-2.47865815

Traceability to Industry Recognized Test Methodologies	
Work Instruction:	WI-02 MEASURING FREQUENCY
Measurement Uncertainty:	±0.86 ppm

9.5. Emissions

9.5.1. Conducted Emissions

Conducted Test Conditions for Transmitter Conducted Spurious and Band-Edge Emissions			
Standard:	FCC CFR 47:90 ISED RSS-119	**Ambient Temp. (ºC):**	24.0 - 27.5
Test Heading:	Transmitter Conducted Spurious and Band-Edge Emissions	**Rel. Humidity (%):**	32 - 45
Standard Section(s):	90.210 RSS-119 5.8	**Pressure (mBars):**	999 - 1001
Reference Document(s):	See Normative References		

Test Procedure for Transmitter Conducted Spurious and Band-Edge Emissions Measurement

Transmitter Spurious and Band-Edge emissions were measured with a spectrum analyzer. Measurements were made while EUT was operating in transmit mode of operation at the appropriate center frequency closest to the band-edge. Emissions were maximized during the measurement and limits derived from the peak spectral power and drawn on each plot.

Where the device operated with multiple antenna ports i.e. MIMO device, each port was measured separately. Testing was performed under ambient conditions at nominal voltage only.

Test configuration and setup used for the measurement was per the Conducted Test Set-up specified in this document.

Limits Transmitter Conducted Spurious

Emission Mask C

(3) On any frequency removed from the center of the authorized bandwidth by more than 250 percent of the authorized bandwidth: At least 43 + 10 log (P) dB.

Emission Mask D

(3) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 12.5 kHz: At least 50 + 10 log (P) dB or 70 dB, whichever is the lesser attenuation.

9.5.1.13. Conducted Unwanted Spurious Emissions

9.5.1.14. 12.5 KHz GFSK

Equipment Configuration for Unwanted Emissions Peak

Variant:	12.5KHz	**Duty Cycle (%):**	99
Data Rate:	Not Applicable	**Antenna Gain (dBi):**	Not Applicable
Modulation:	GFSK	**Beam Forming Gain (Y)(dB):**	Not Applicable
TPC:	Not Applicable	**Tested By:**	SB
Engineering Test Notes:			

Test Measurement Results

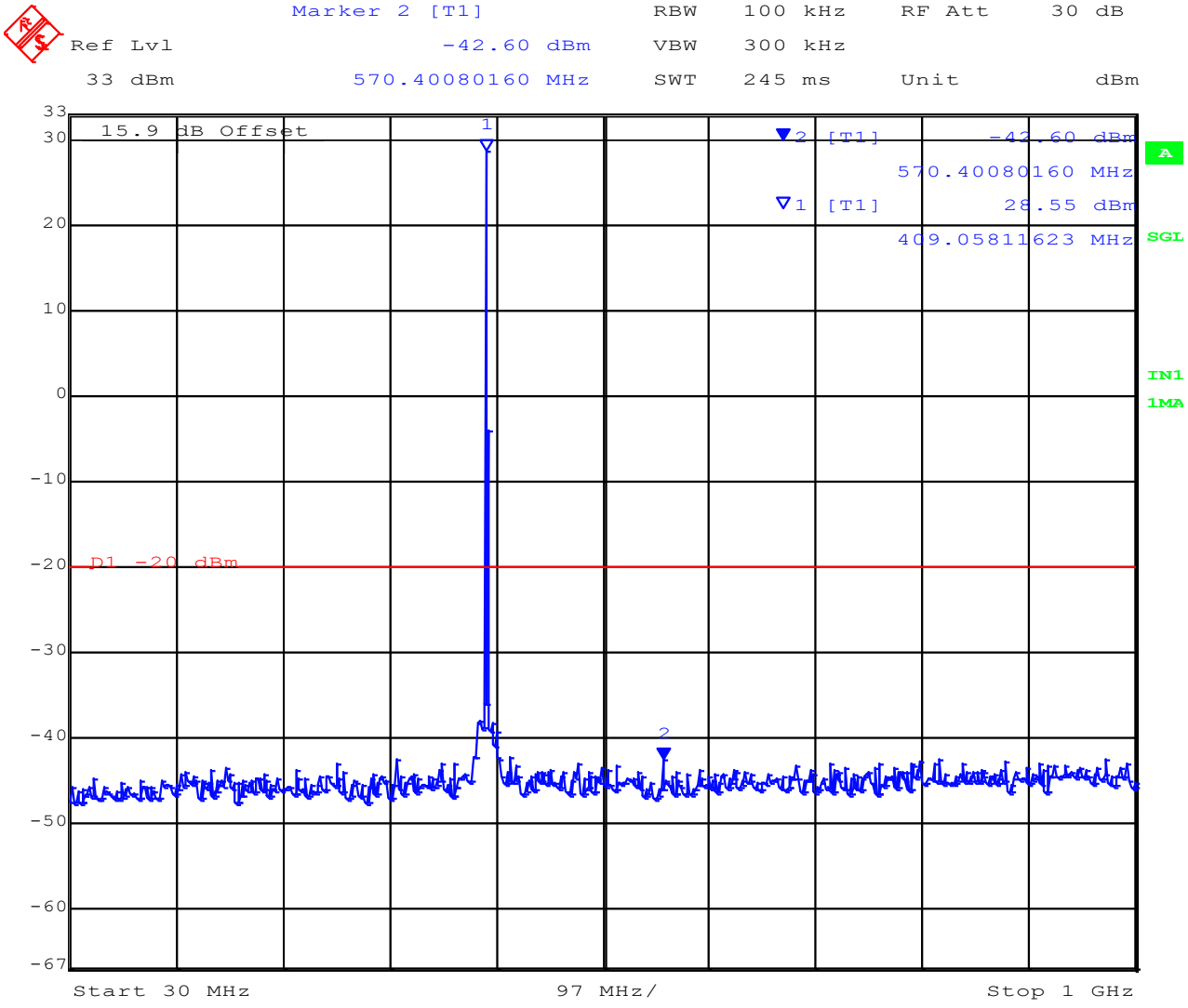
Test Frequency	Frequency Range	Unwanted Emissions Peak (dBm)							
		Port a		Port b		Port c		Port d	
MHz	MHz	SE	Limit	SE	Limit	SE	Limit	SE	Limit
410.0	30 - 1000	-42.60	-20						
	1000 - 5000	-32.50	-20						
429.5	30 - 1000	-42.21	-20						
	1000 - 5000	-31.53	-20						
450.5	30 - 1000	-41.90	-20						
	1000 - 5000	-32.35	-20						
469.5	30 - 1000	-39.93	-20						
	1000 - 5000	-32.74	-20						

Traceability to Industry Recognized Test Methodologies	
Work Instruction:	WI-05 MEASUREMENT OF SPURIOUS EMISSIONS
Measurement Uncertainty:	<=40 GHz ±2.37 dB, > 40 GHz ±4.6 dB

Note: click the links in the above matrix to view the graphical image (plot).

Transmitter Spurious Emissions 30MHz to 1GHz

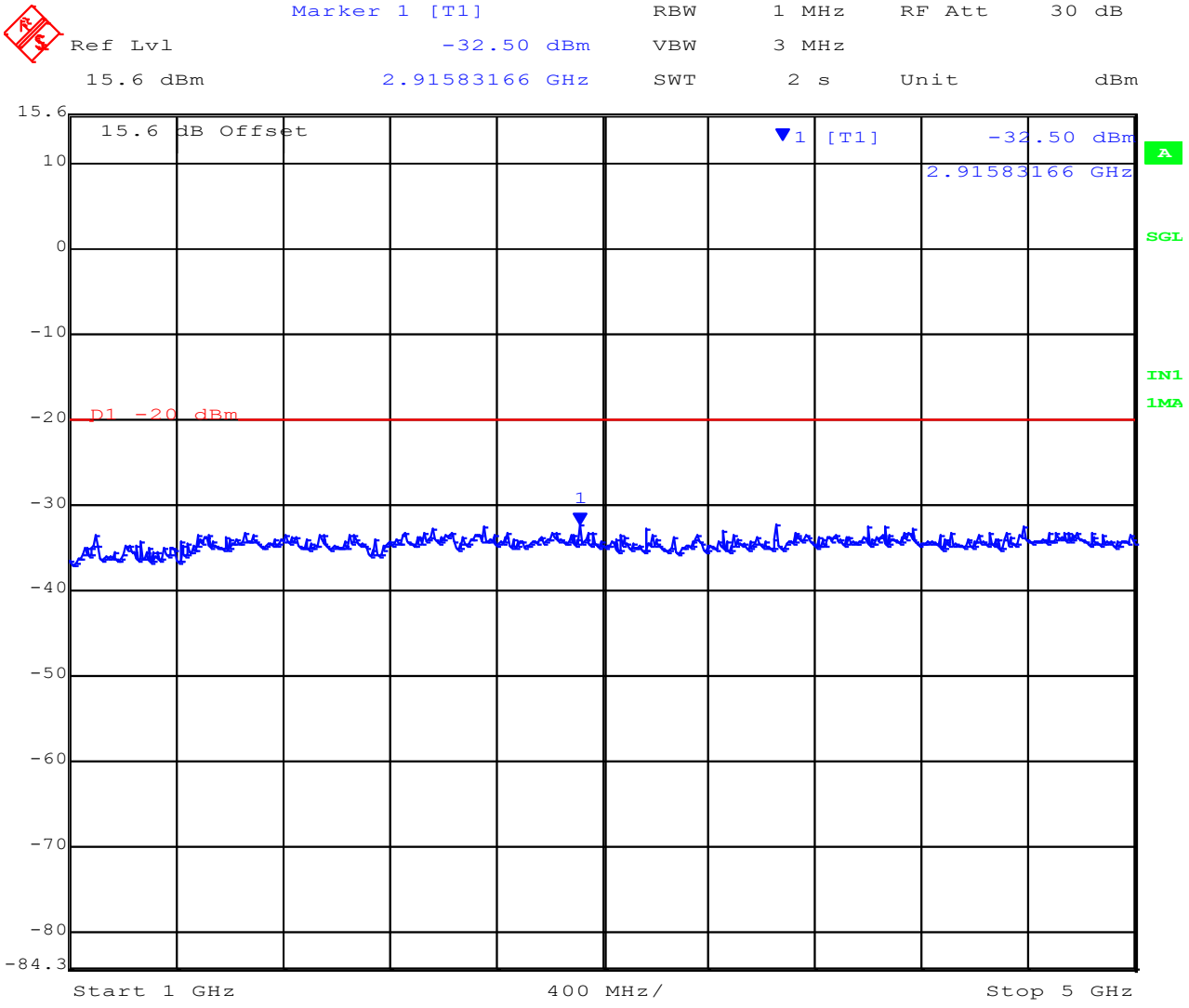
Variant: 12.5KHz, Channel: 410.0 MHz, Chain a



Date: 19.MAR.2021 08:51:58

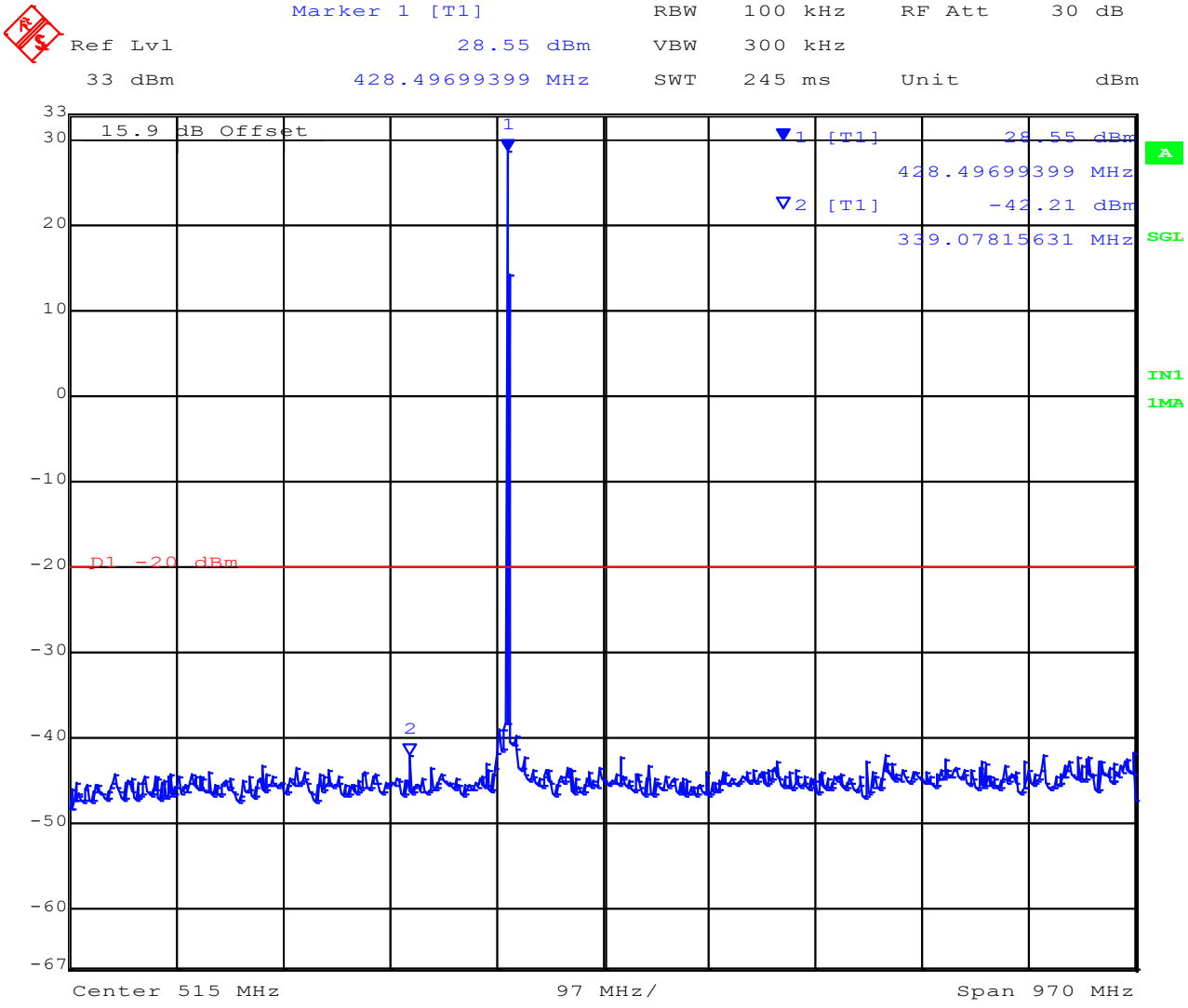
Transmitter Spurious Emissions 1GHz to 5GHz

Variant: 12.5KHz, Channel: 410.0 MHz, Chain a



Transmitter Spurious Emissions 30MHz to 1GHz

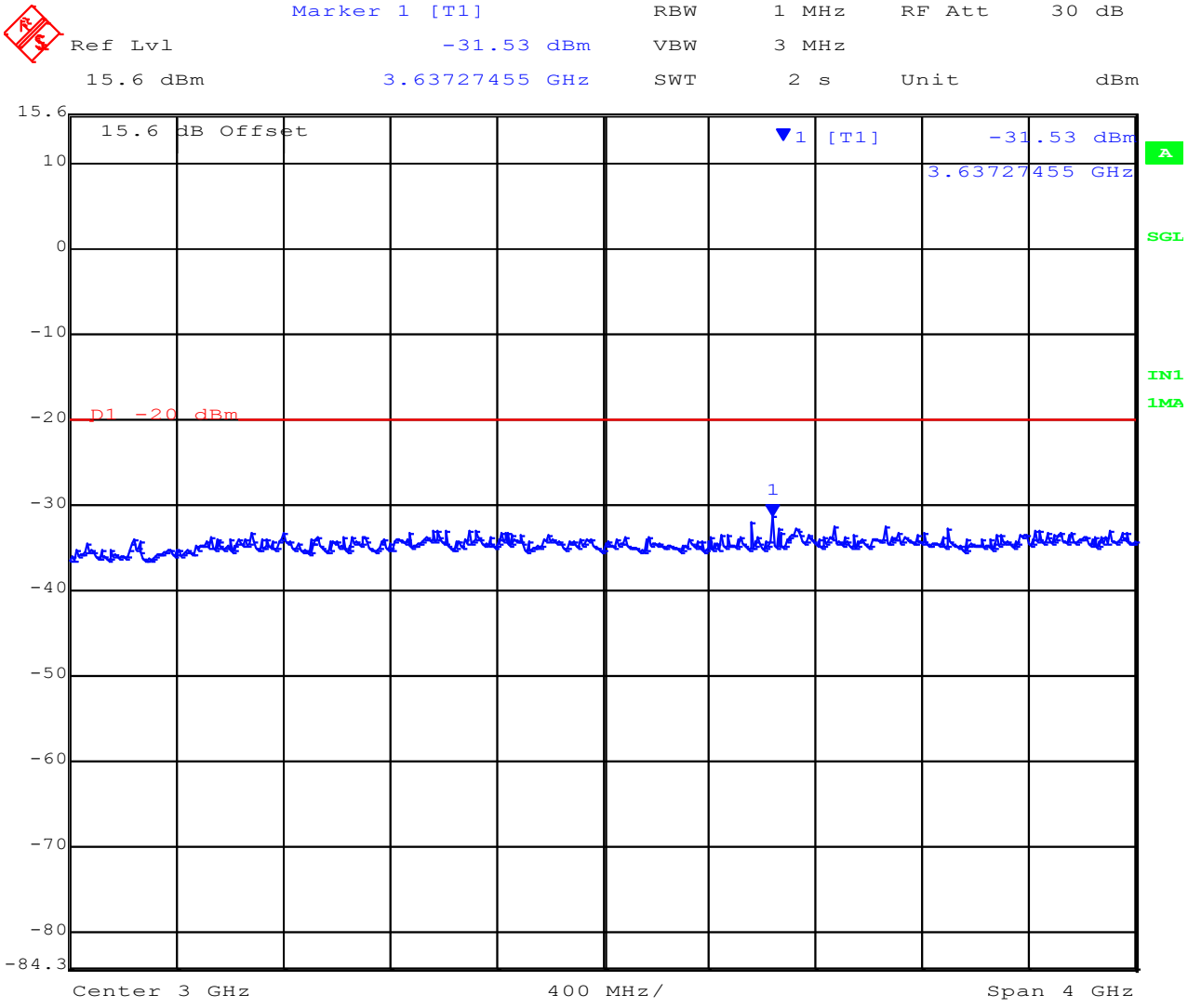
Variant: 12.5KHz, Channel: 429.5 MHz, Chain a



Date: 19.MAR.2021 08:59:59

Transmitter Spurious Emissions 1GHz to 5GHz

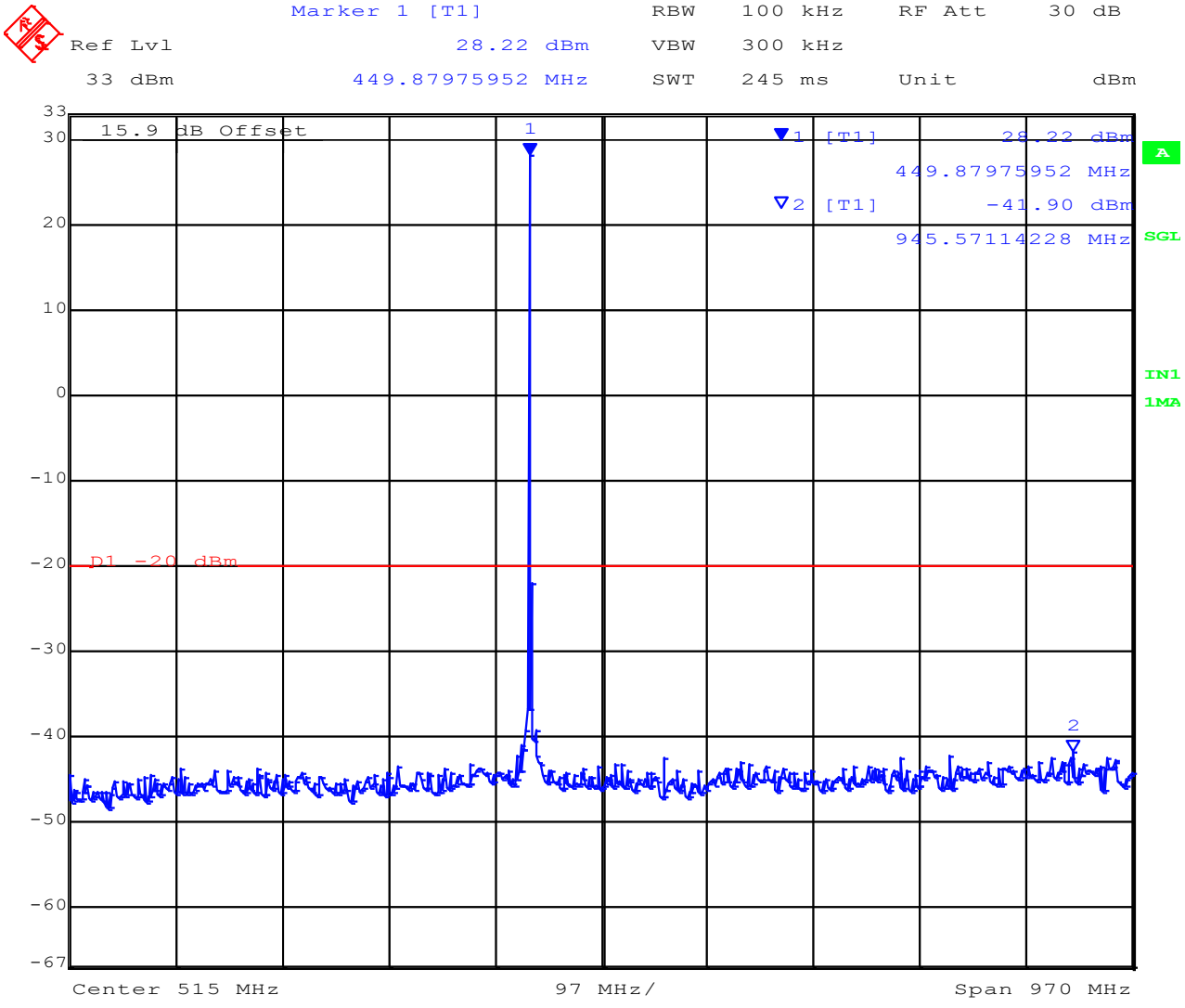
Variant: 12.5KHz, Channel: 429.5 MHz, Chain a



Date: 25.MAR.2021 13:34:02

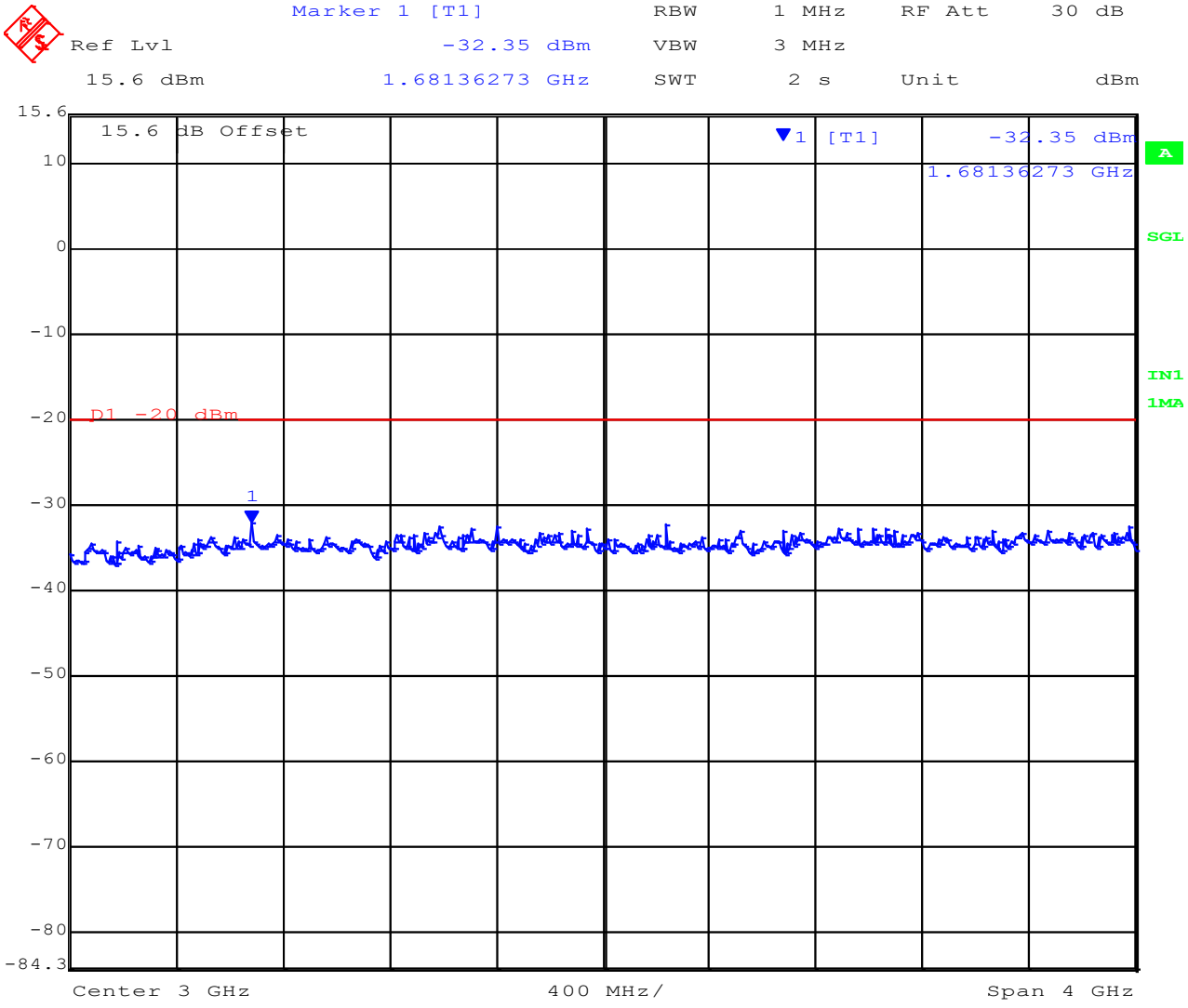
Transmitter Spurious Emissions 30MHz to 1GHz

Variant: 12.5KHz, Channel: 450.5 MHz, Chain a



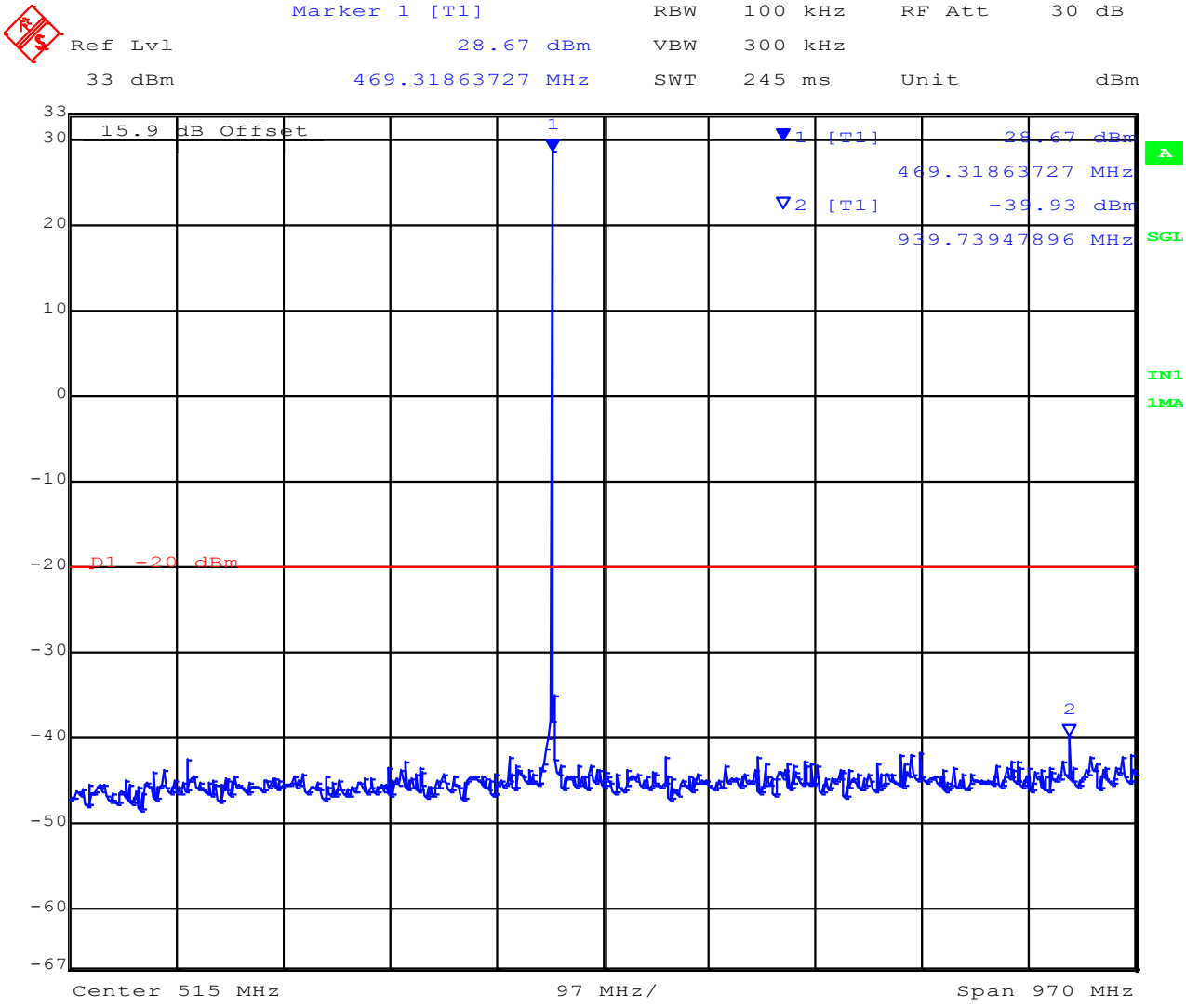
Transmitter Spurious Emissions 1GHz to 5GHz

Variant: 12.5KHz, Channel: 450.5 MHz, Chain a



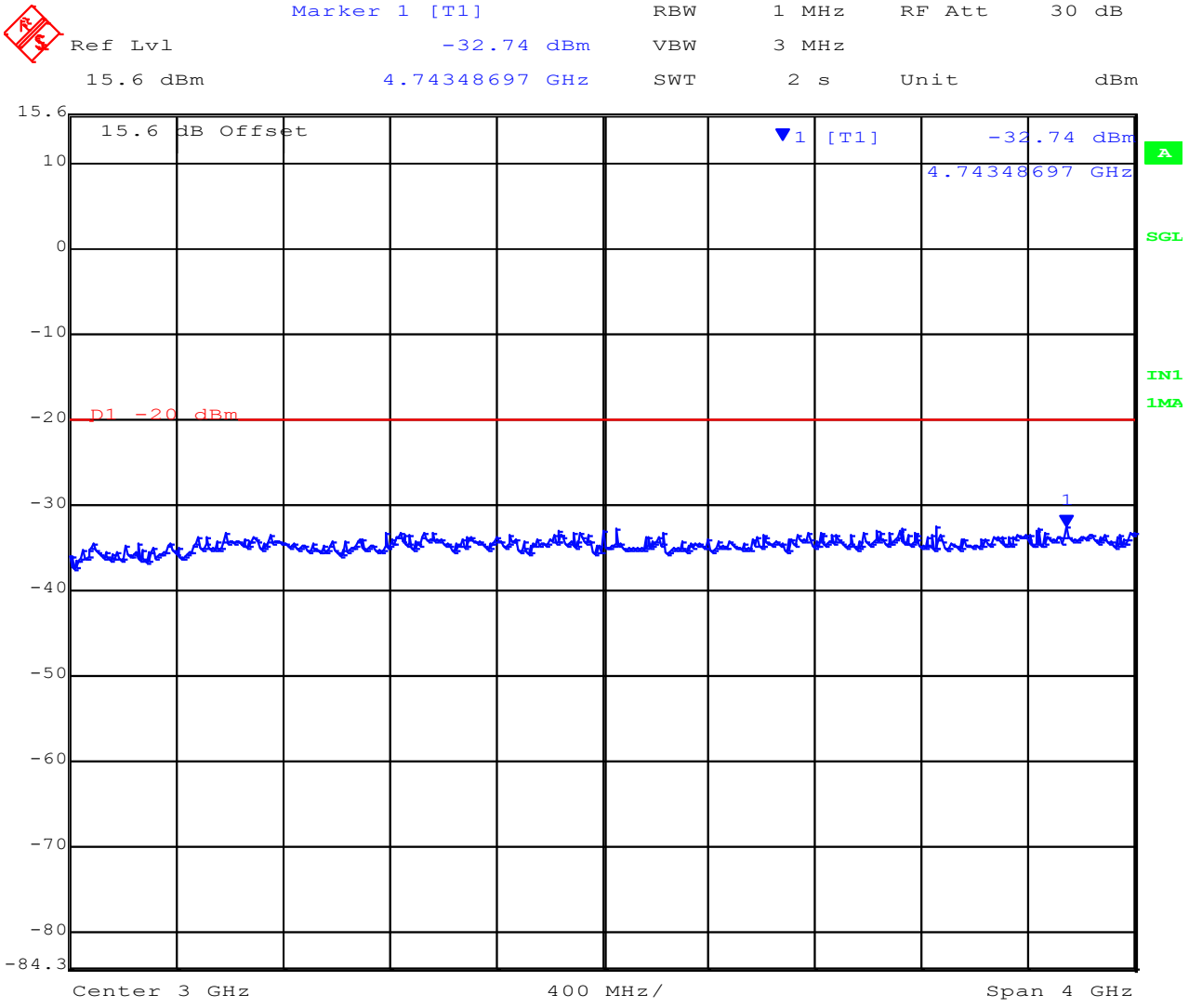
Transmitter Spurious Emissions 30MHz to 1GHz

Variant: 12.5KHz, Channel: 469.5 MHz, Chain a



Transmitter Spurious Emissions 1GHz to 5GHz

Variant: 12.5KHz, Channel: 469.5 MHz, Chain a



Date: 25.MAR.2021 13:34:52

9.5.1.15. 12.5 KHz GMSK

Equipment Configuration for Unwanted Emissions Peak

Variant:	12.5KHz	**Duty Cycle (%):**	99
Data Rate:	Not Applicable	**Antenna Gain (dBi):**	Not Applicable
Modulation:	GMSK	**Beam Forming Gain (Y)(dB):**	Not Applicable
TPC:	Not Applicable	**Tested By:**	SB
Engineering Test Notes:			

Test Measurement Results

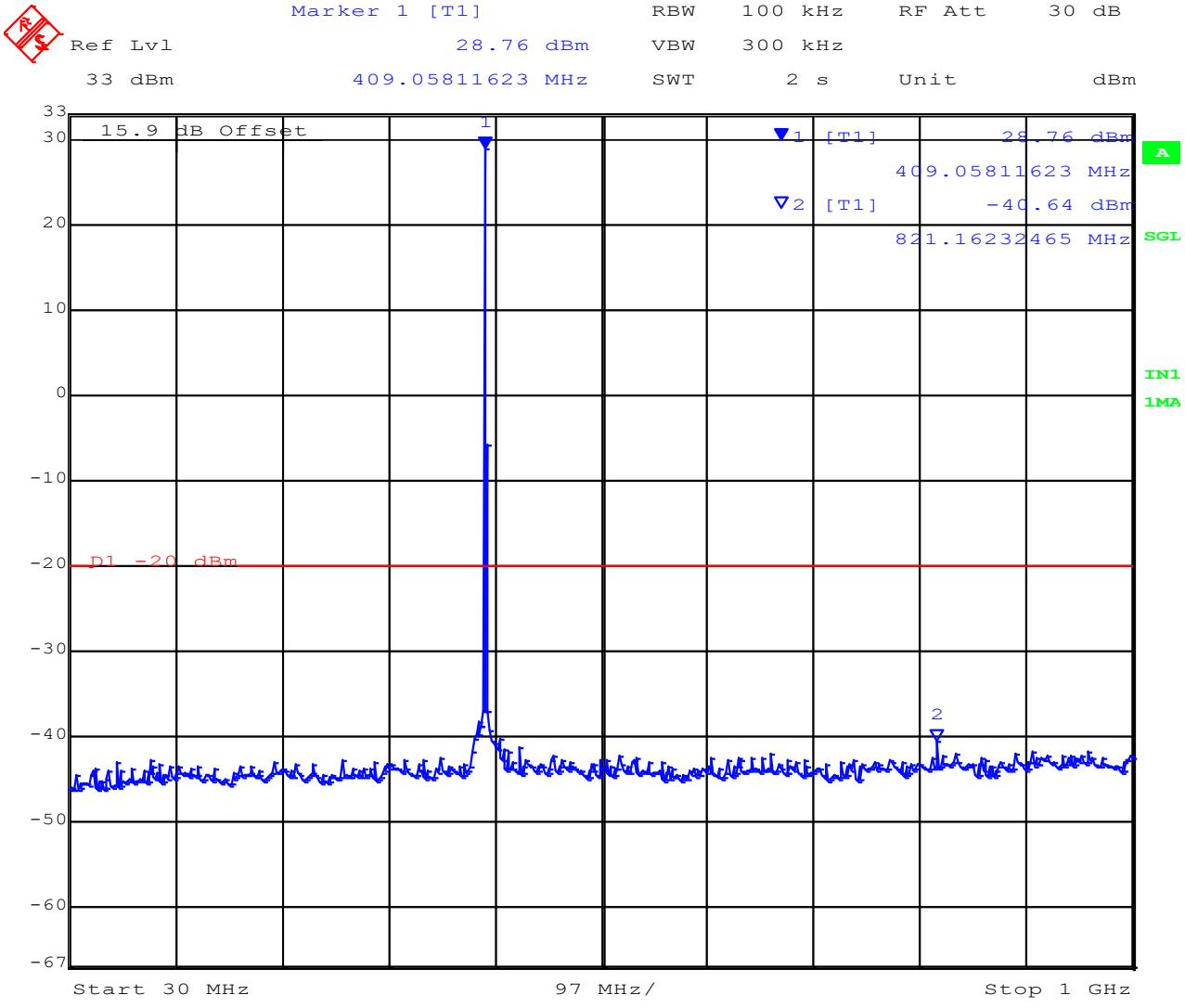
Test Frequency	Frequency Range	Unwanted Emissions Peak (dBm)							
		Port a		Port b		Port c		Port d	
MHz	MHz	SE	Limit	SE	Limit	SE	Limit	SE	Limit
410.0	30 - 1000	-40.64	-20						
	1000 - 5000	-33.07	-20						
429.5	30 - 1000	-39.63	-20						
	1000 - 5000	-33.22	-20						
450.5	30 - 1000	-40.79	-20						
	1000 - 5000	-34.07	-20						
469.5	30 - 1000	-37.39	-20						
	1000 - 5000	-33.73	-20						

Traceability to Industry Recognized Test Methodologies	
Work Instruction:	WI-05 MEASUREMENT OF SPURIOUS EMISSIONS
Measurement Uncertainty:	<=40 GHz ±2.37 dB, > 40 GHz ±4.6 dB

Note: click the links in the above matrix to view the graphical image (plot).

Transmitter Spurious Emissions 30MHz to 1GHz

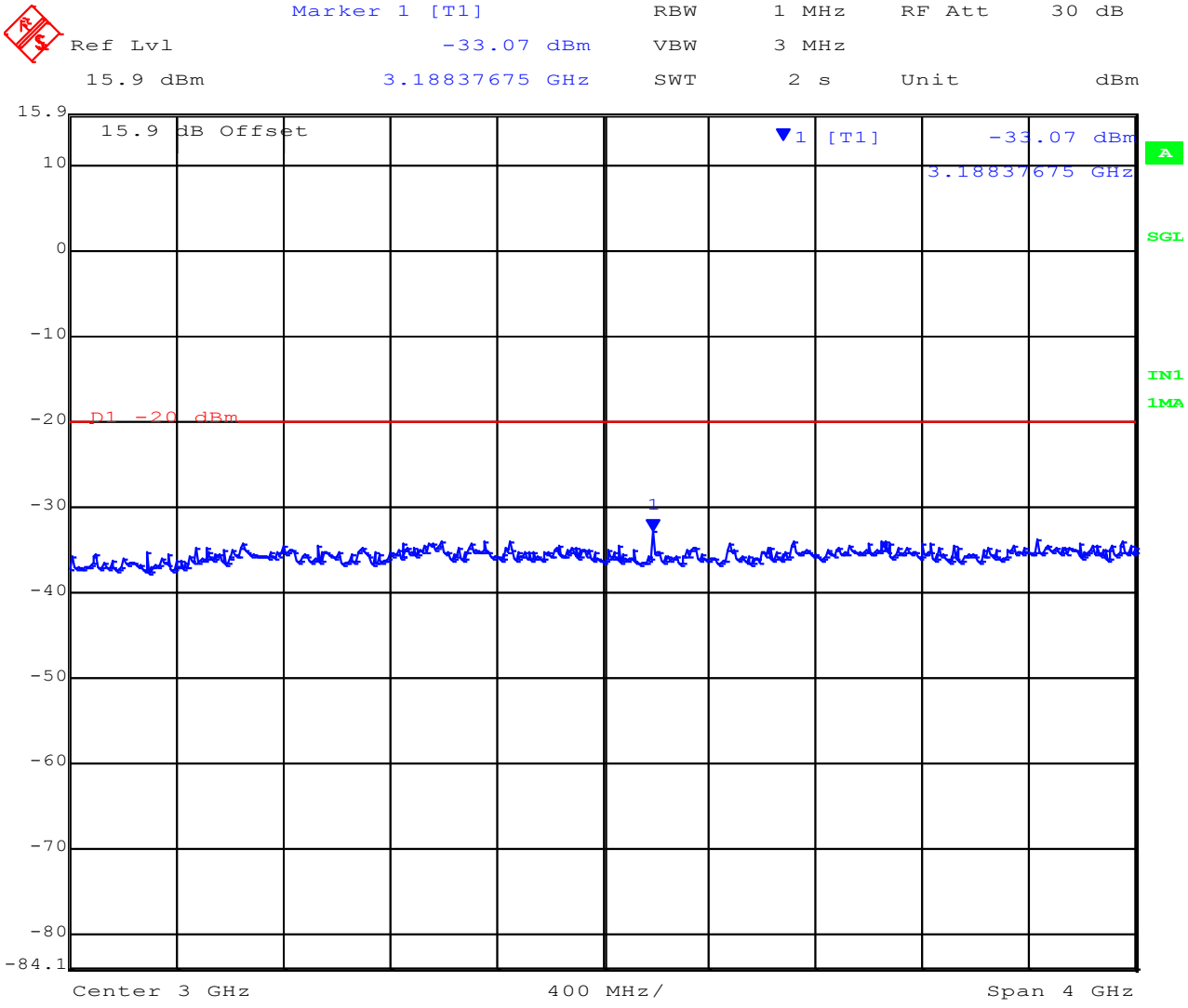
Variant: 12.5KHz, Channel: 410.0 MHz, Chain a



Date: 22.MAR.2021 12:50:09

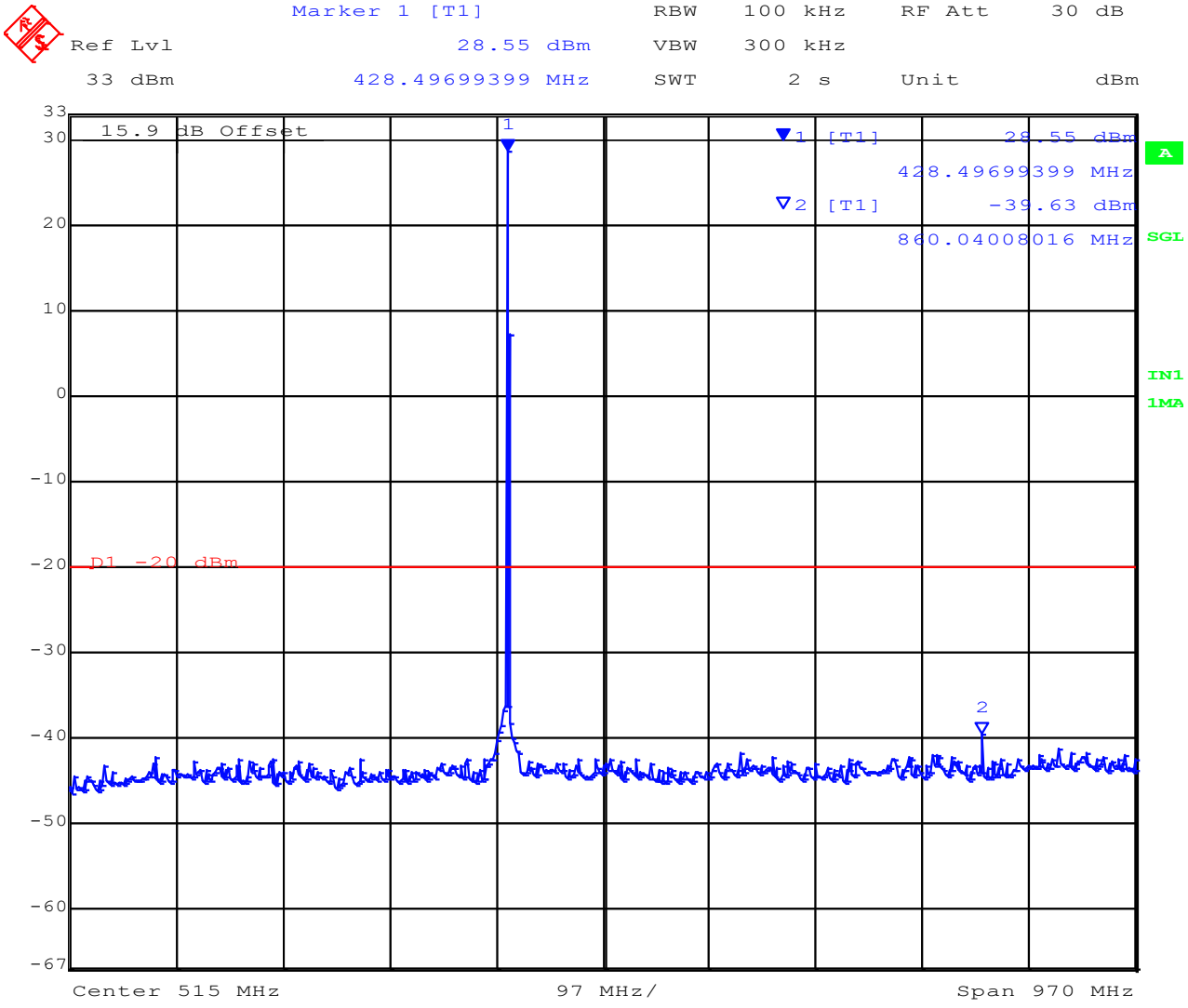
Transmitter Spurious Emissions 1GHz to 5GHz

Variant: 12.5KHz, Channel: 410.0 MHz, Chain a



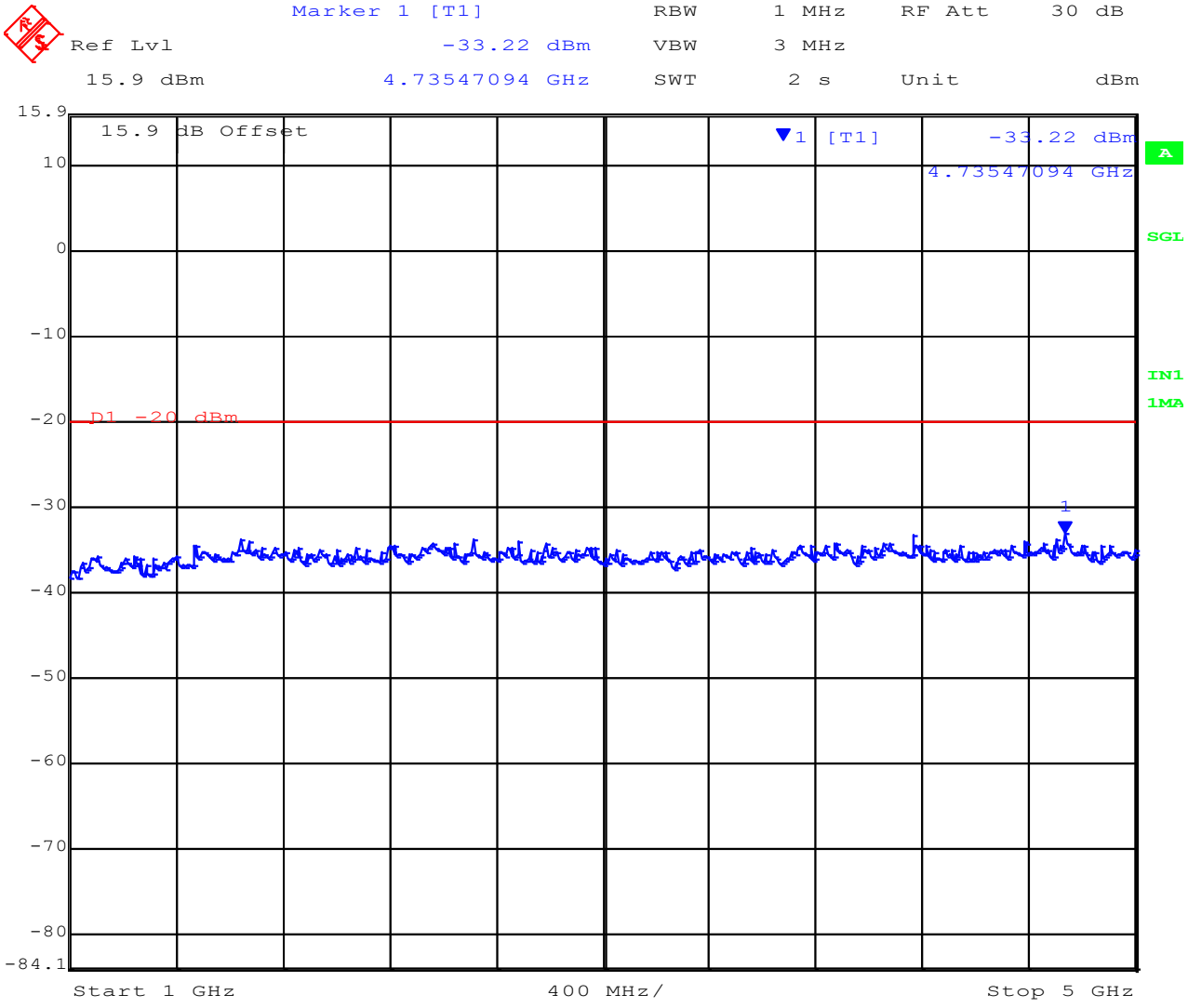
Transmitter Spurious Emissions 30MHz to 1GHz

Variant: 12.5KHz, Channel: 429.5 MHz, Chain a



Transmitter Spurious Emissions 1GHz to 5GHz

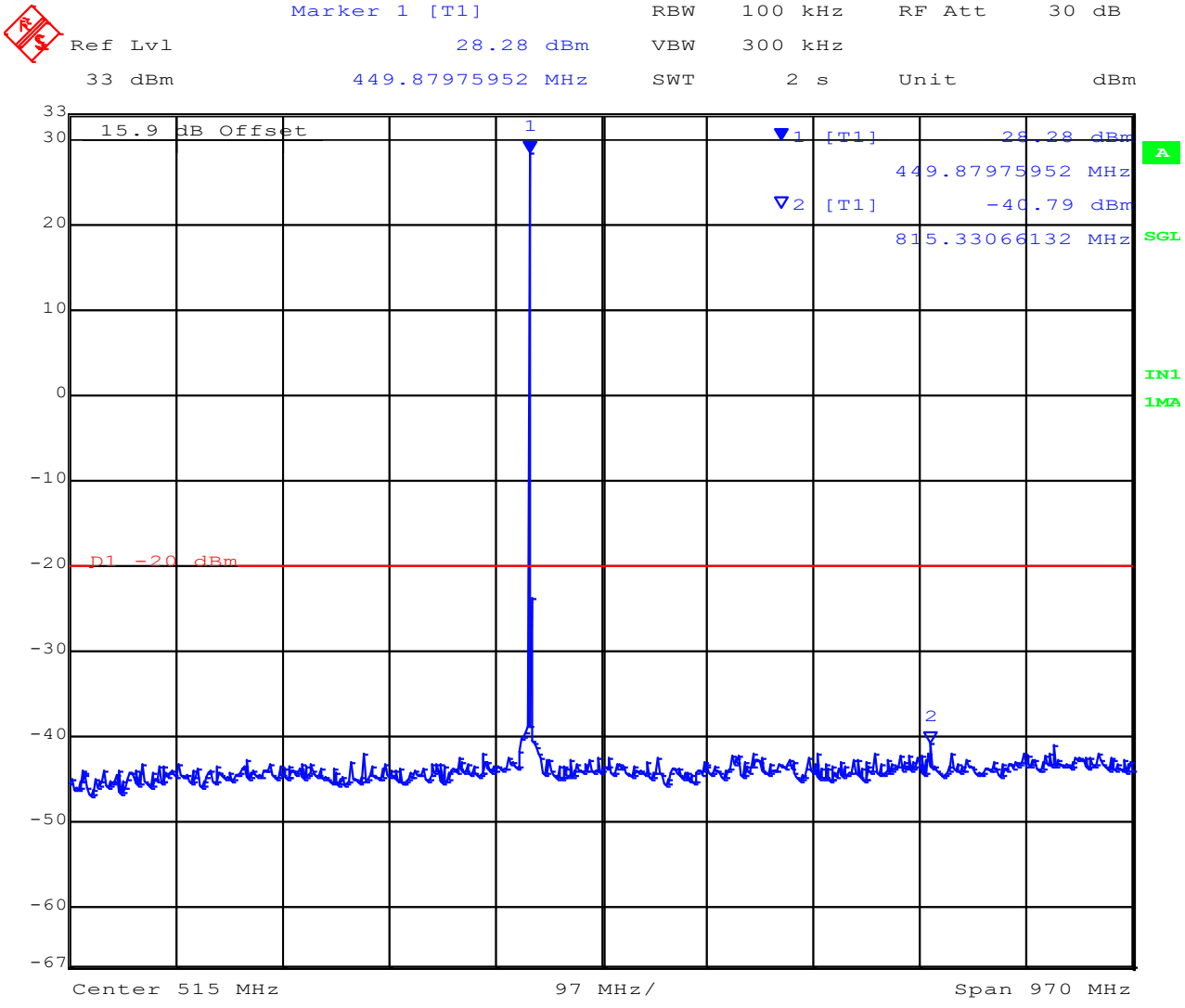
Variant: 12.5KHz, Channel: 429.5 MHz, Chain a



Date: 22.MAR.2021 13:13:48

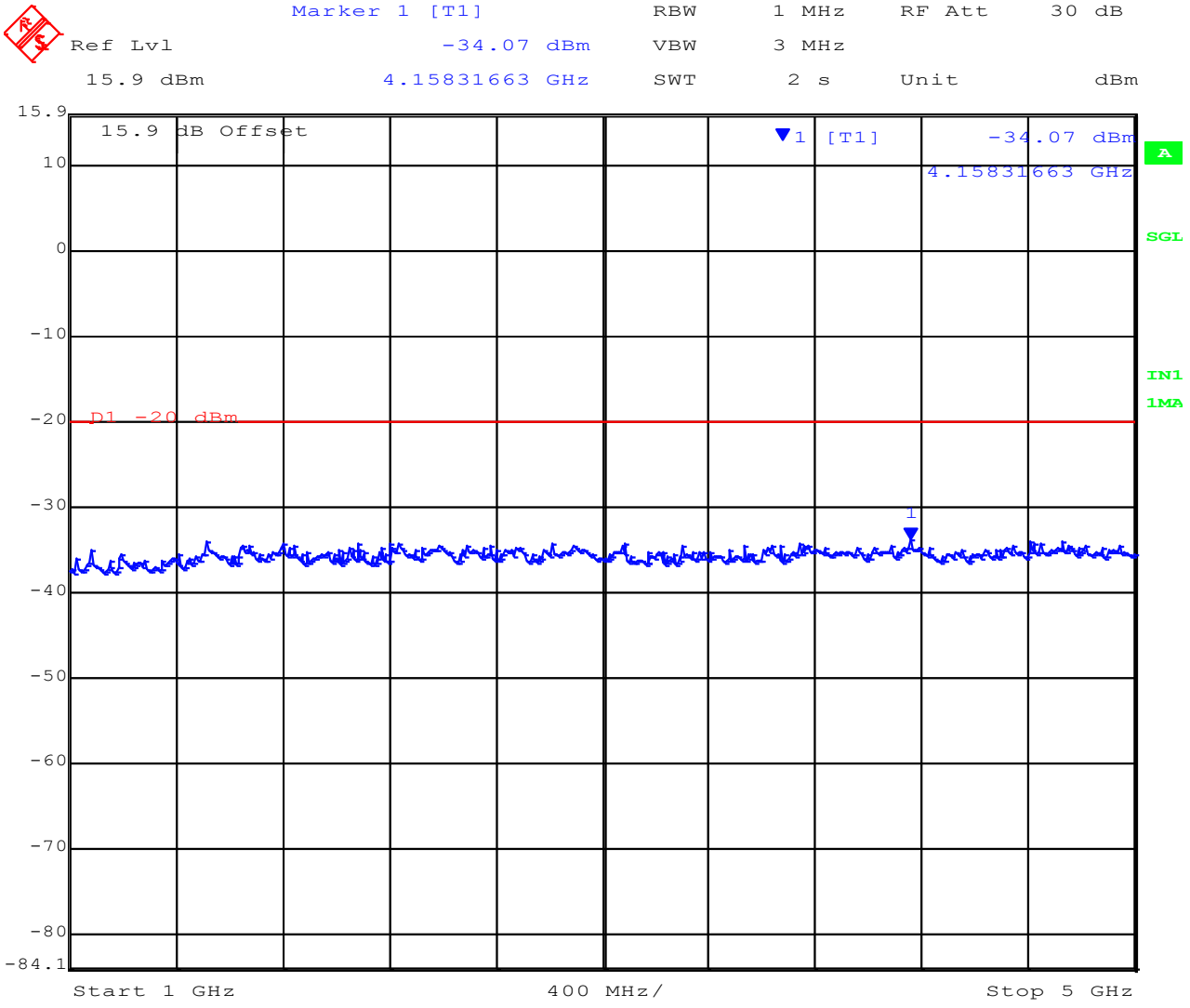
Transmitter Spurious Emissions 30MHz to 1GHz

Variant: 12.5KHz, Channel: 450.5 MHz, Chain a



Transmitter Spurious Emissions 1GHz to 5GHz

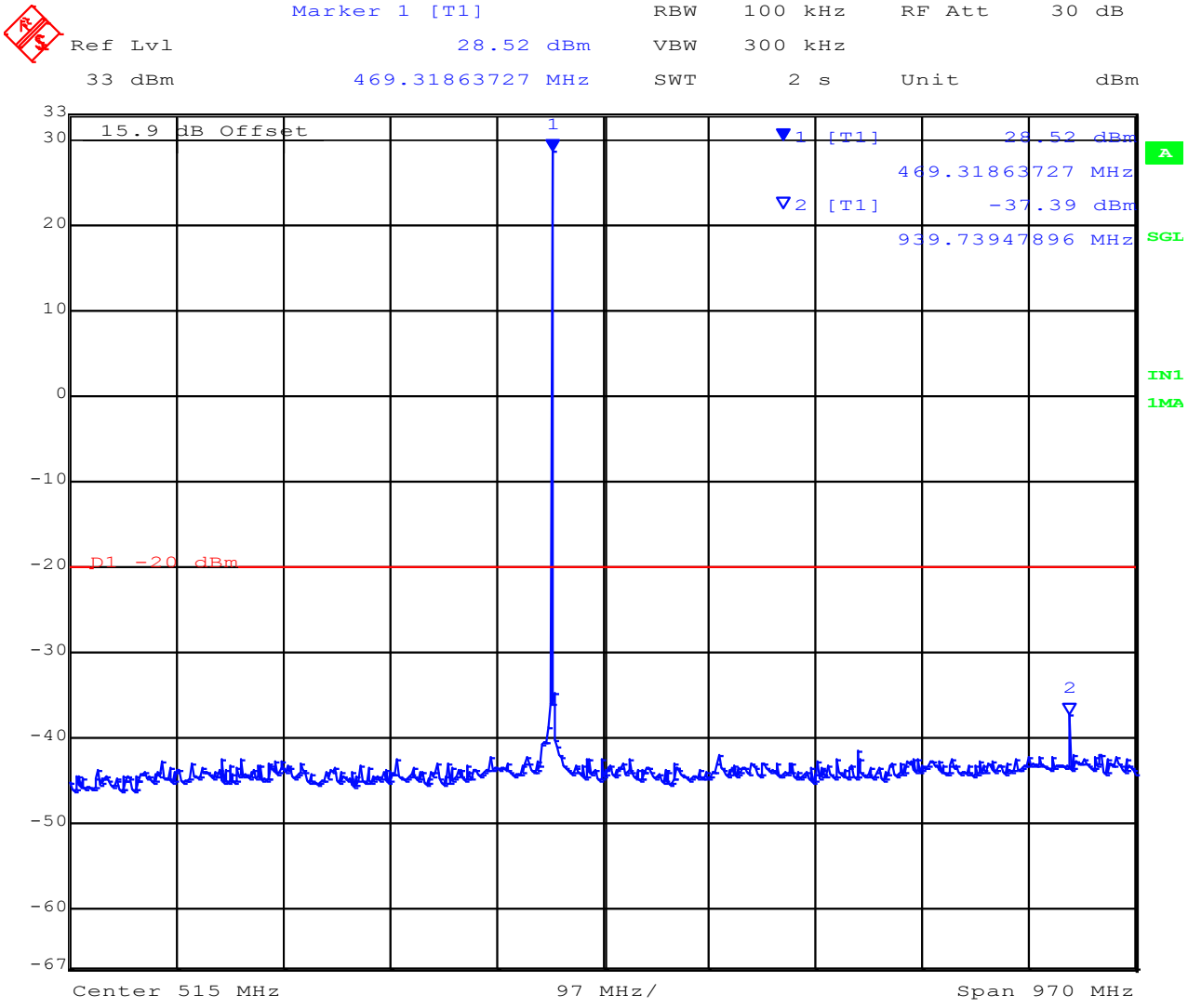
Variant: 12.5KHz, Channel: 450.5 MHz, Chain a



Date: 22.MAR.2021 13:14:18

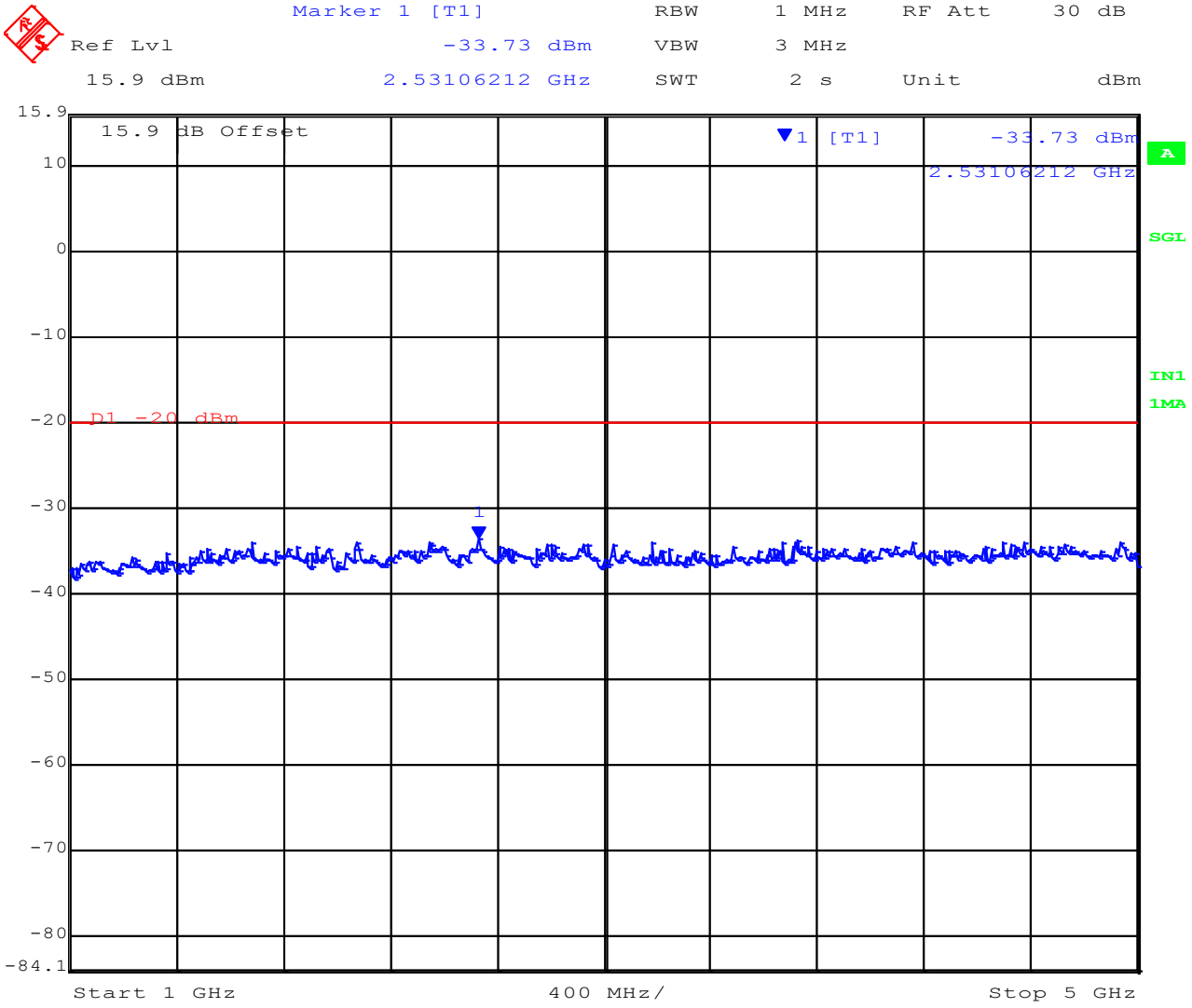
Transmitter Spurious Emissions 30MHz to 1GHz

Variant: 12.5KHz, Channel: 469.5 MHz, Chain a



Transmitter Spurious Emissions 1GHz to 5GHz

Variant: 12.5KHz GFSK, Channel: 469.5 MHz, Chain a



Date: 22.MAR.2021 13:15:40

9.5.1.16. 25 KHz GFSK

Equipment Configuration for Unwanted Emissions Peak			
Variant:	25KHz	**Duty Cycle (%):**	99
Data Rate:	Not Applicable	**Antenna Gain (dBi):**	Not Applicable
Modulation:	GFSK	**Beam Forming Gain (Y)(dB):**	Not Applicable
TPC:	Not Applicable	**Tested By:**	SB
Engineering Test Notes:			

Test Measurement Results

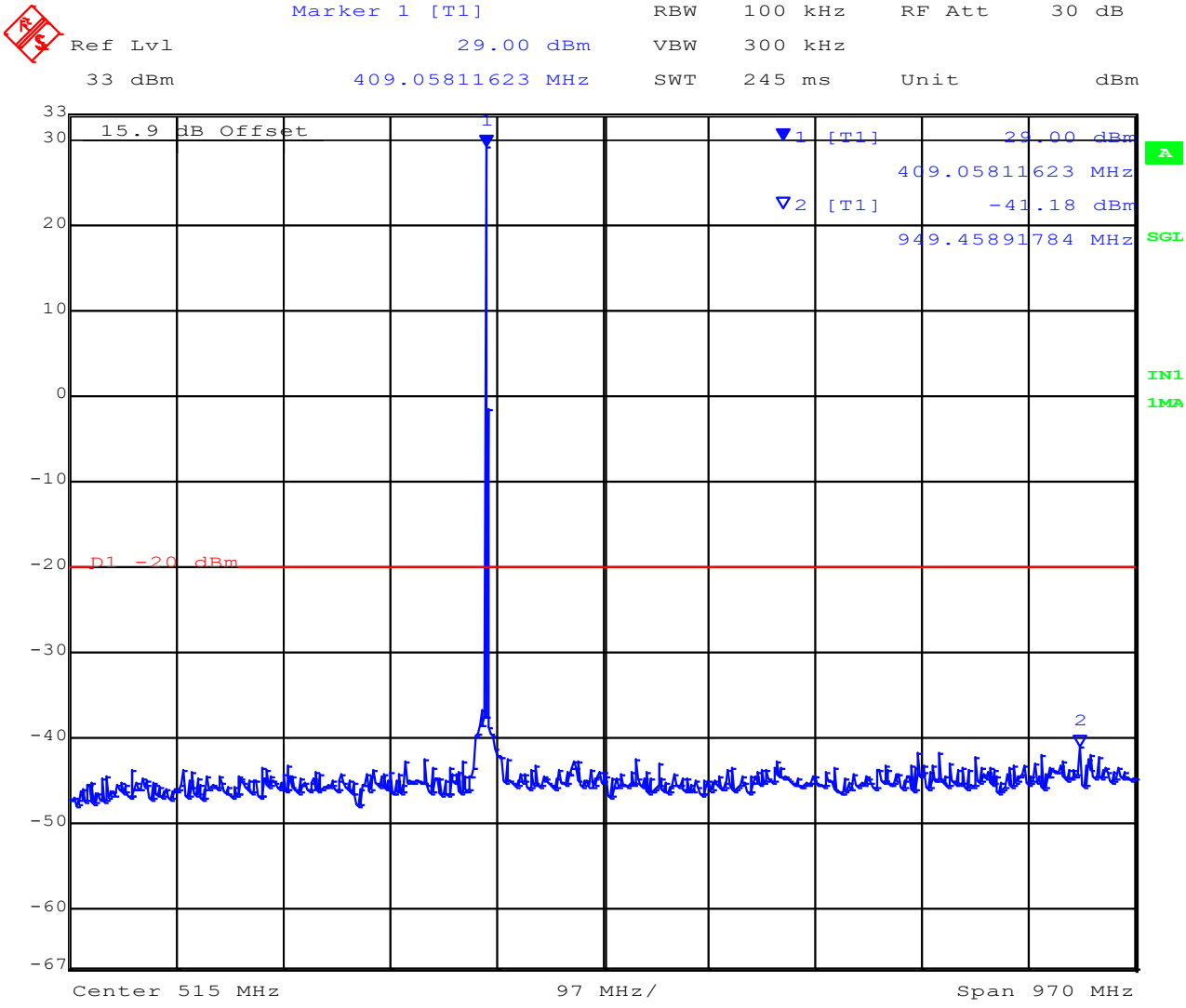
Test Frequency	Frequency Range	Unwanted Emissions Peak (dBm)							
		Port a		Port b		Port c		Port d	
MHz	MHz	SE	Limit	SE	Limit	SE	Limit	SE	Limit
410.0	30 - 1000	-41.18	-20						
	1000 - 5000	-32.53	-20						
429.5	30 - 1000	-38.26	-20						
	1000 - 5000	-32.73	-20						
450.5	30 - 1000	-41.31	-20						
	1000 - 5000	-32.73	-20						
469.5	30 - 1000	-39.80	-20						
	1000 - 5000	-32.29	-20						

Traceability to Industry Recognized Test Methodologies	
Work Instruction:	WI-05 MEASUREMENT OF SPURIOUS EMISSIONS
Measurement Uncertainty:	<=40 GHz ±2.37 dB, > 40 GHz ±4.6 dB

Note: click the links in the above matrix to view the graphical image (plot).

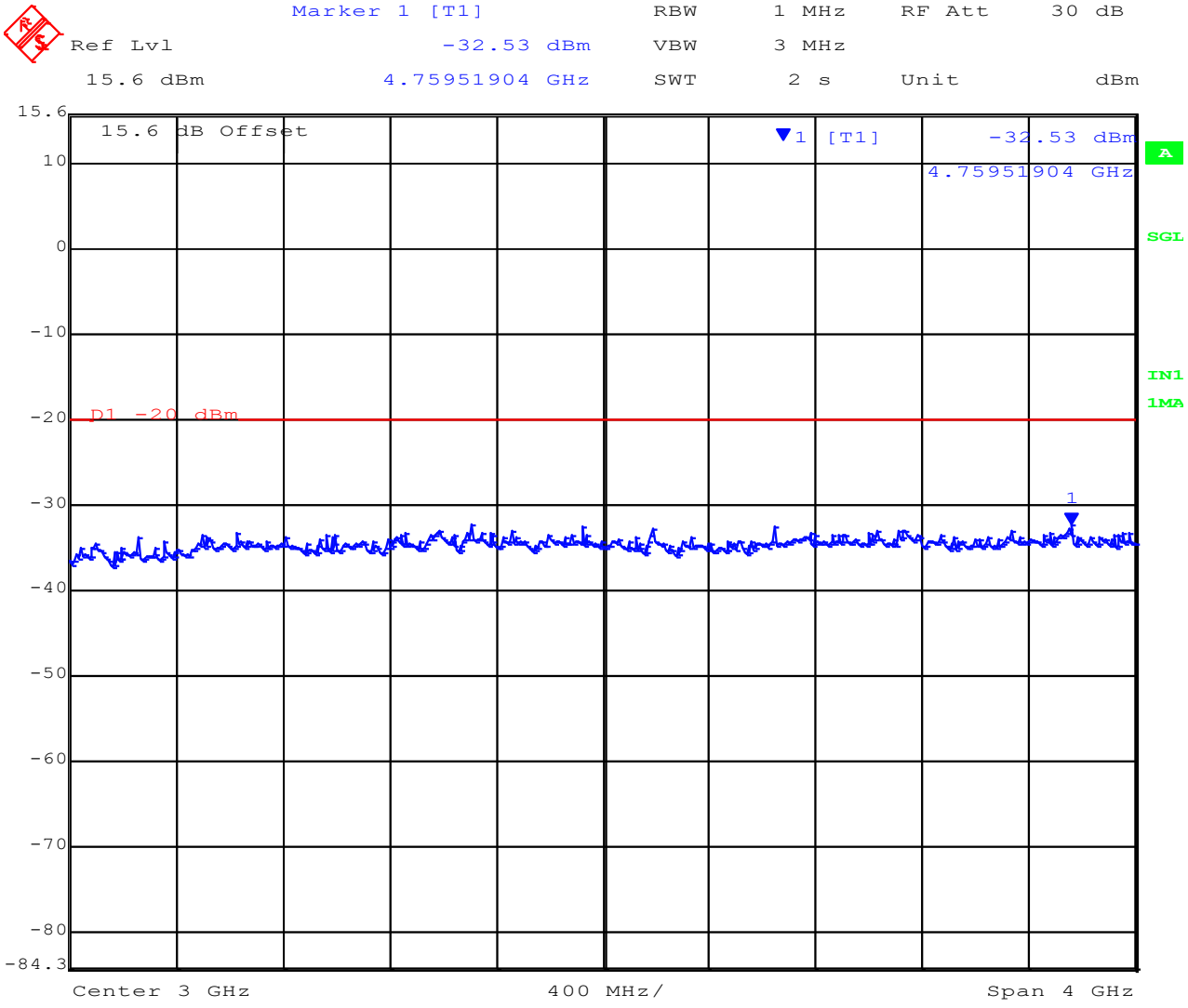
Transmitter Spurious Emissions 30MHz to 1GHz

Variant: 25KHz, Channel: 410.0 MHz, Chain a



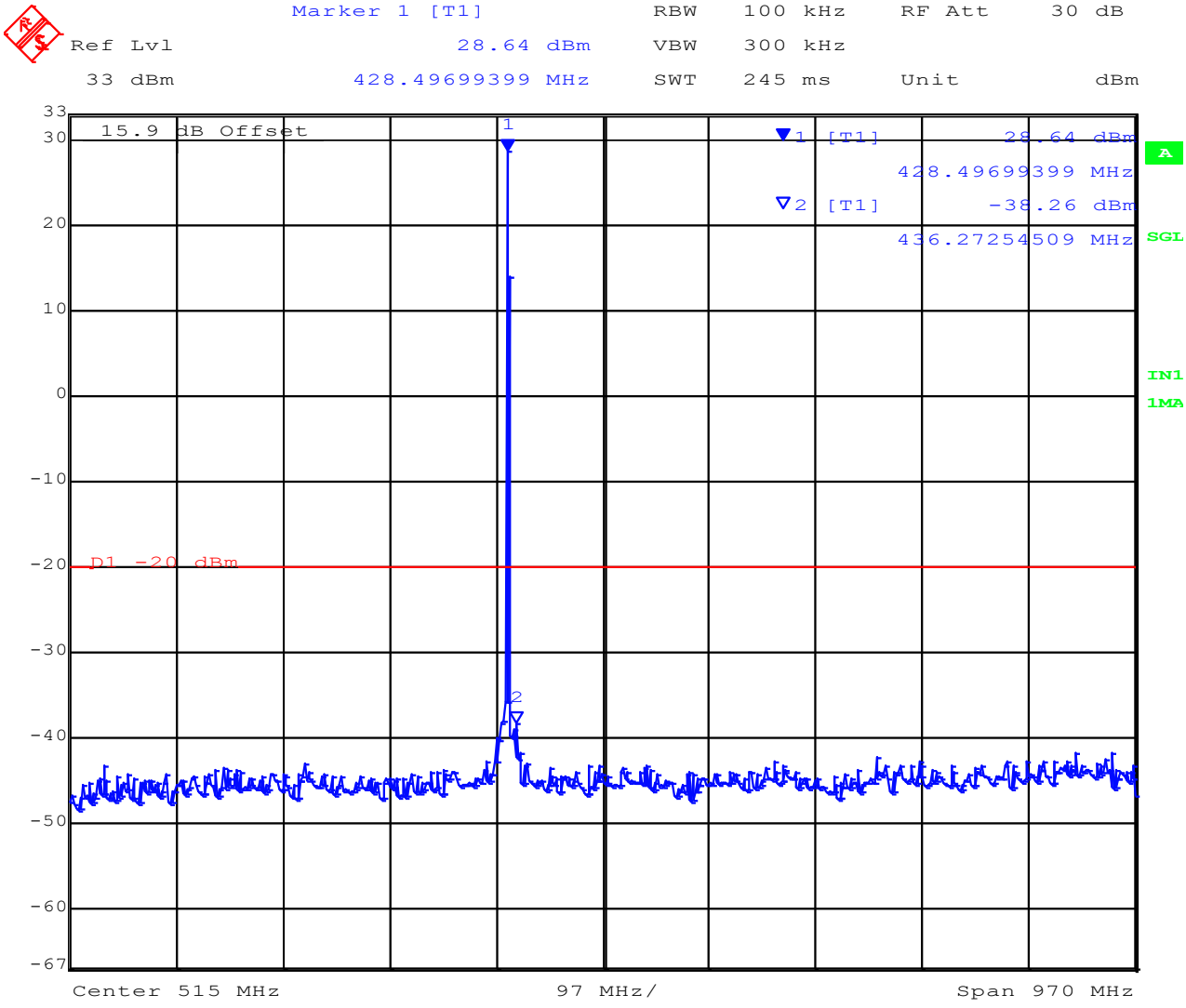
Transmitter Spurious Emissions 1GHz to 5GHz

Variant: 25KHz, Channel: 410.0 MHz, Chain a



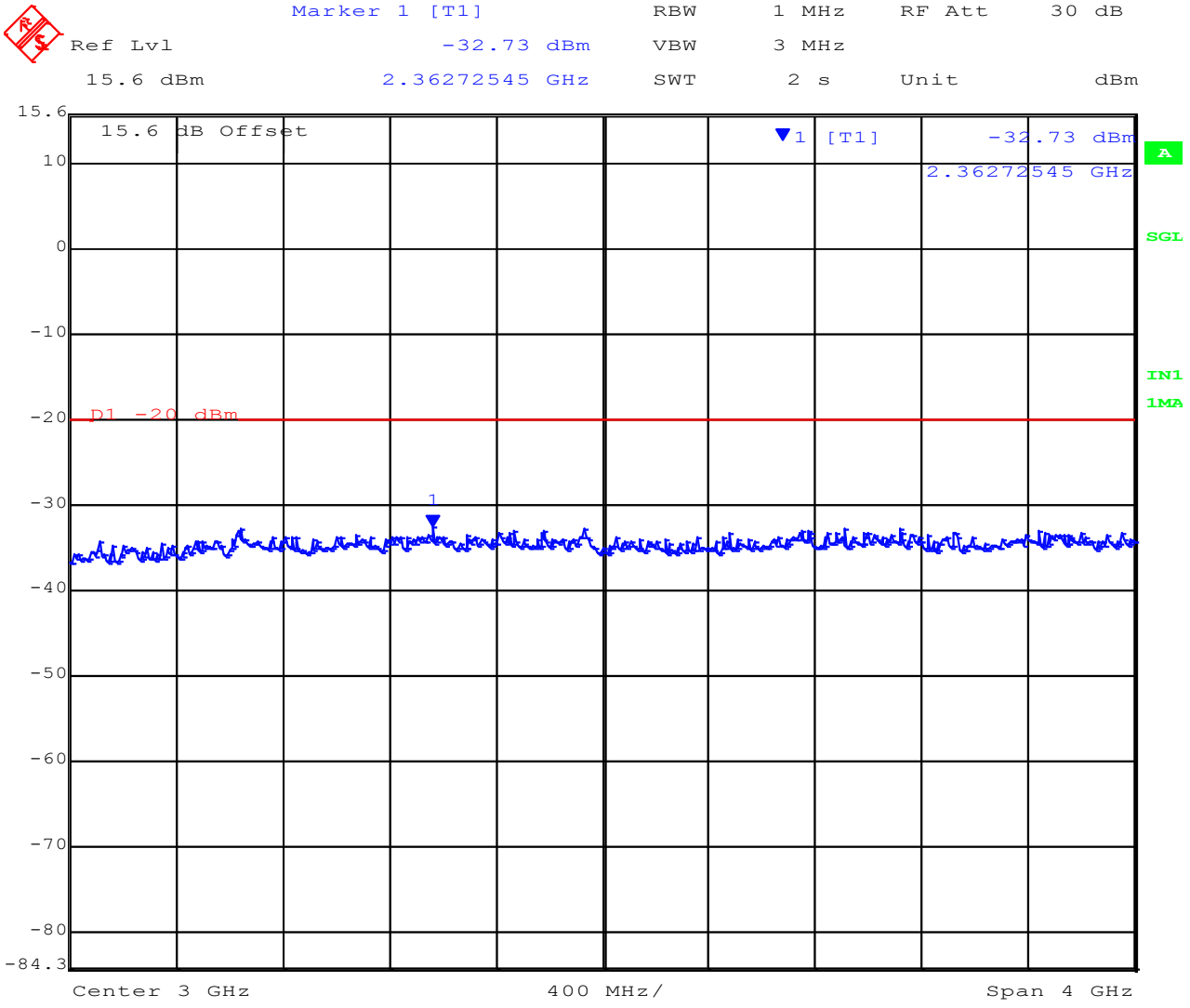
Transmitter Spurious Emissions 30MHz to 1GHz

Variant: 25KHz, Channel: 429.5 MHz, Chain a



Transmitter Spurious Emissions 1GHz to 5GHz

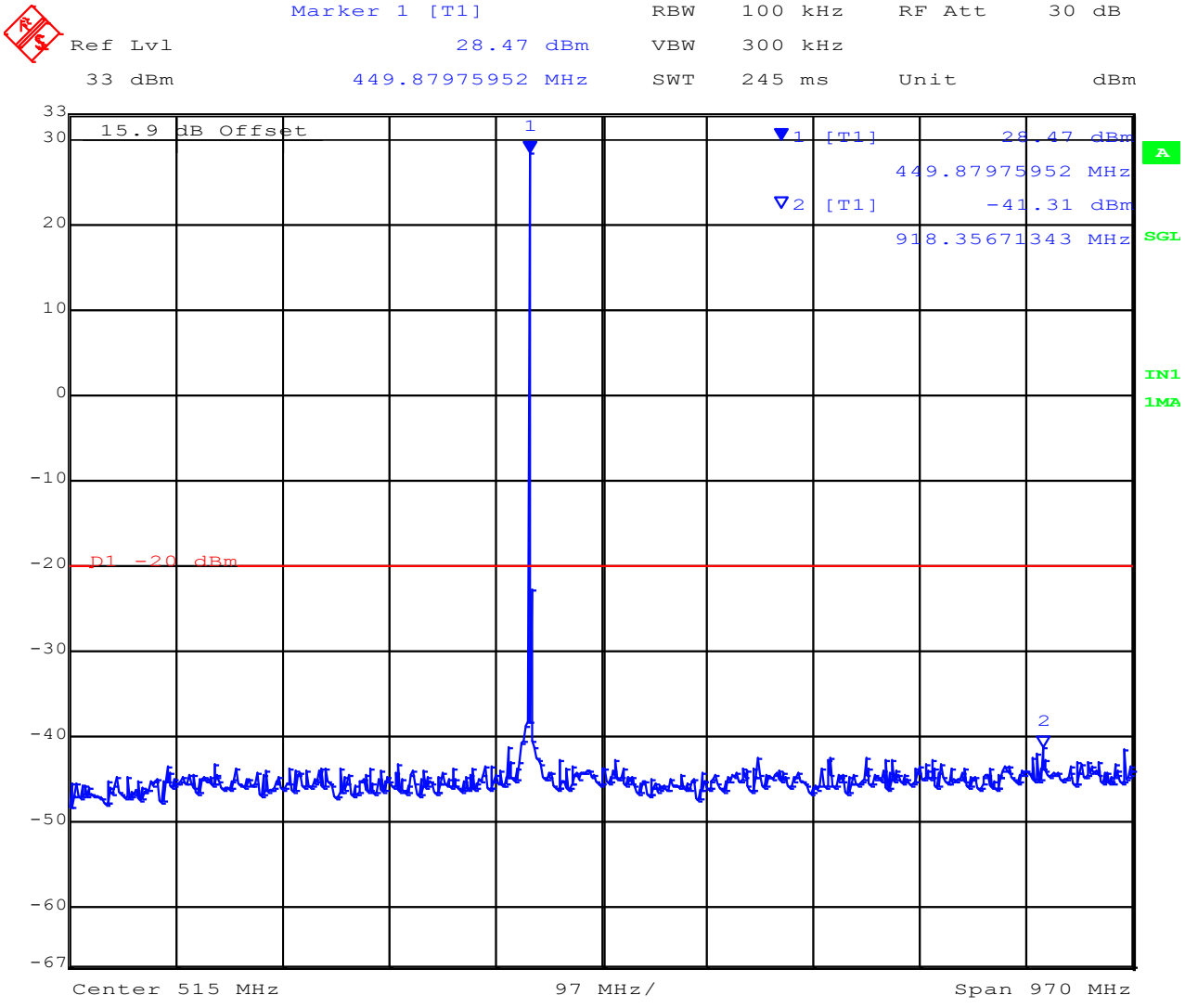
Variant: 25KHz, Channel: 429.5 MHz, Chain a



Date: 25.MAR.2021 13:36:35

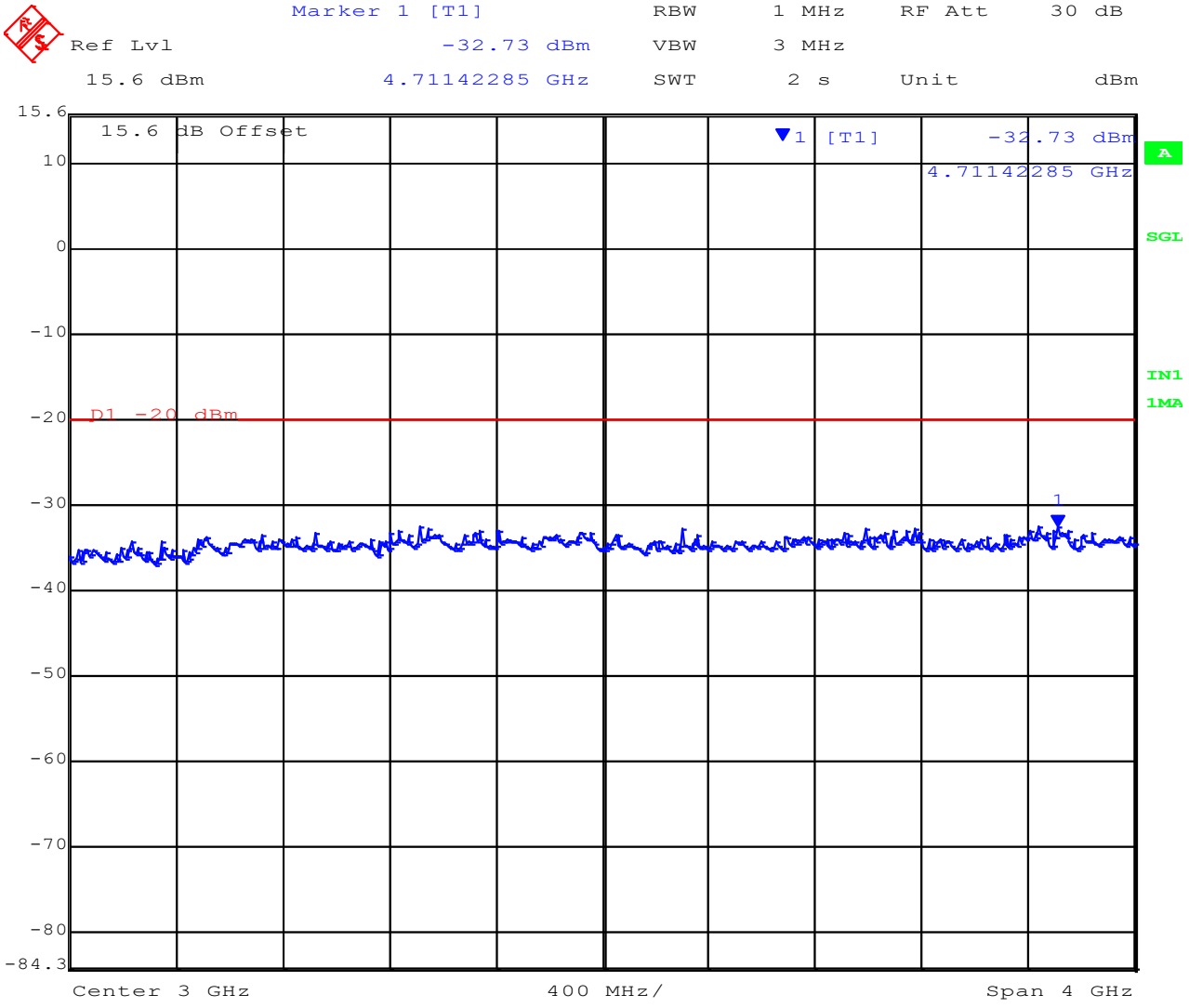
Transmitter Spurious Emissions 30MHz to 1GHz

Variant: 25KHz, Channel: 450.5 MHz, Chain a



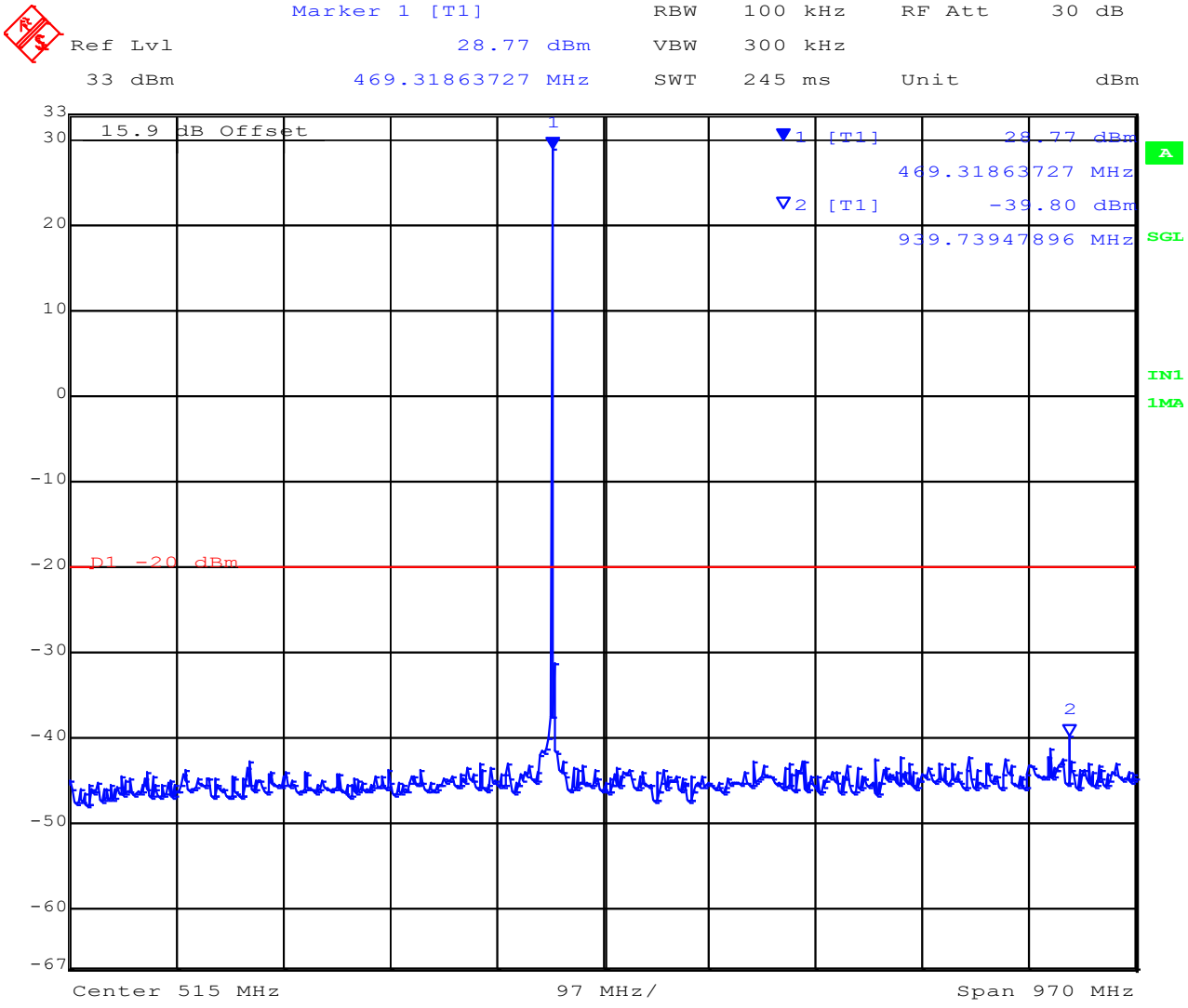
Transmitter Spurious Emissions 1GHz to 5GHz

Variant: 25KHz, Channel: 450.5 MHz, Chain a



Transmitter Spurious Emissions 30MHz to 1GHz

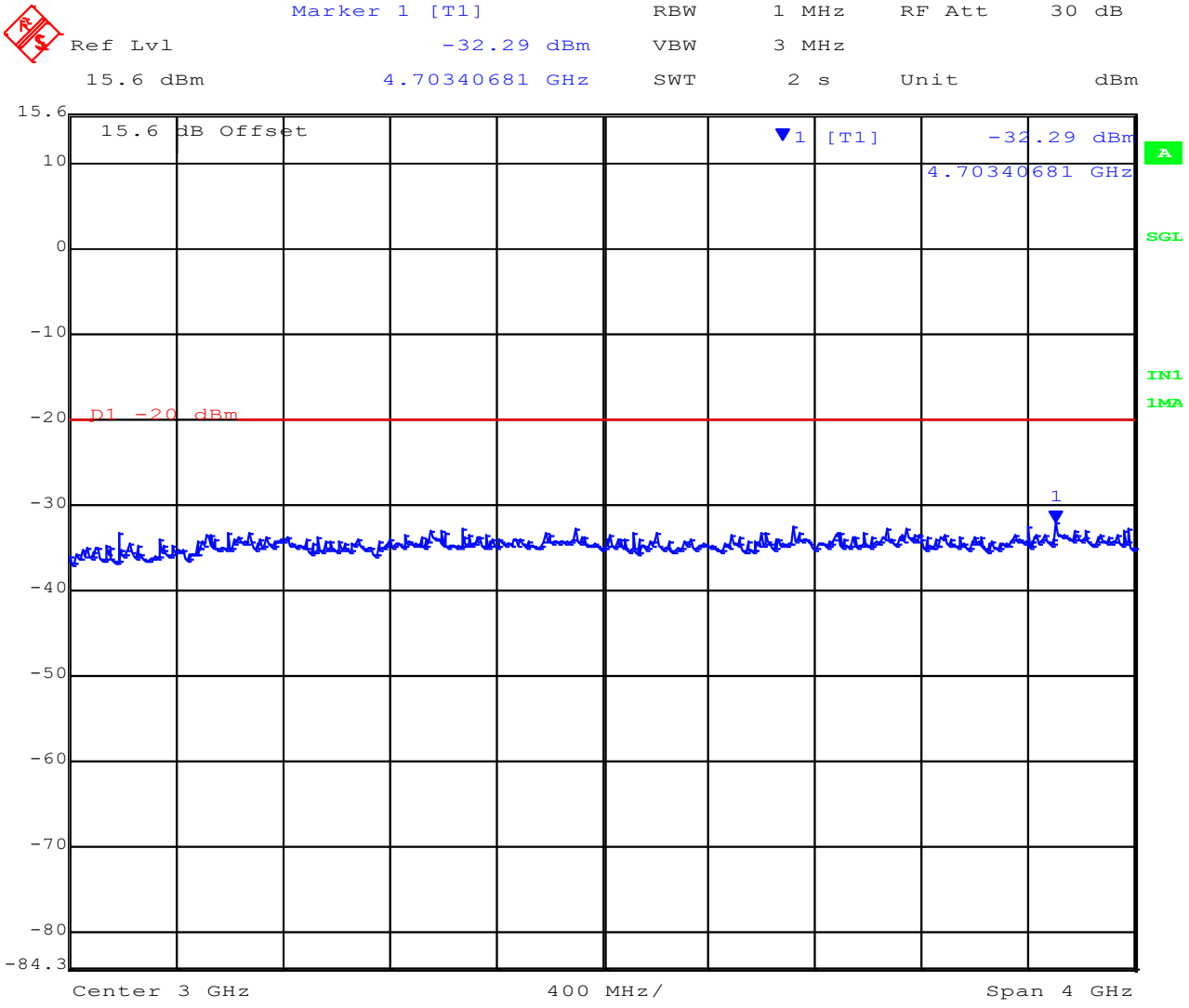
Variant: 25KHz, Channel: 469.5 MHz, Chain a



Date: 19.MAR.2021 10:00:44

Transmitter Spurious Emissions 1GHz to 5GHz

Variant: 25KHz GFSK, Channel: 469.5 MHz, Chain a



9.5.1.17. 25 KHz GMSK

Equipment Configuration for Unwanted Emissions Peak

Variant:	12.5KHz	**Duty Cycle (%):**	99
Data Rate:	Not Applicable	**Antenna Gain (dBi):**	Not Applicable
Modulation:	GMSK	**Beam Forming Gain (Y)(dB):**	Not Applicable
TPC:	Not Applicable	**Tested By:**	SB
Engineering Test Notes:			

Test Measurement Results

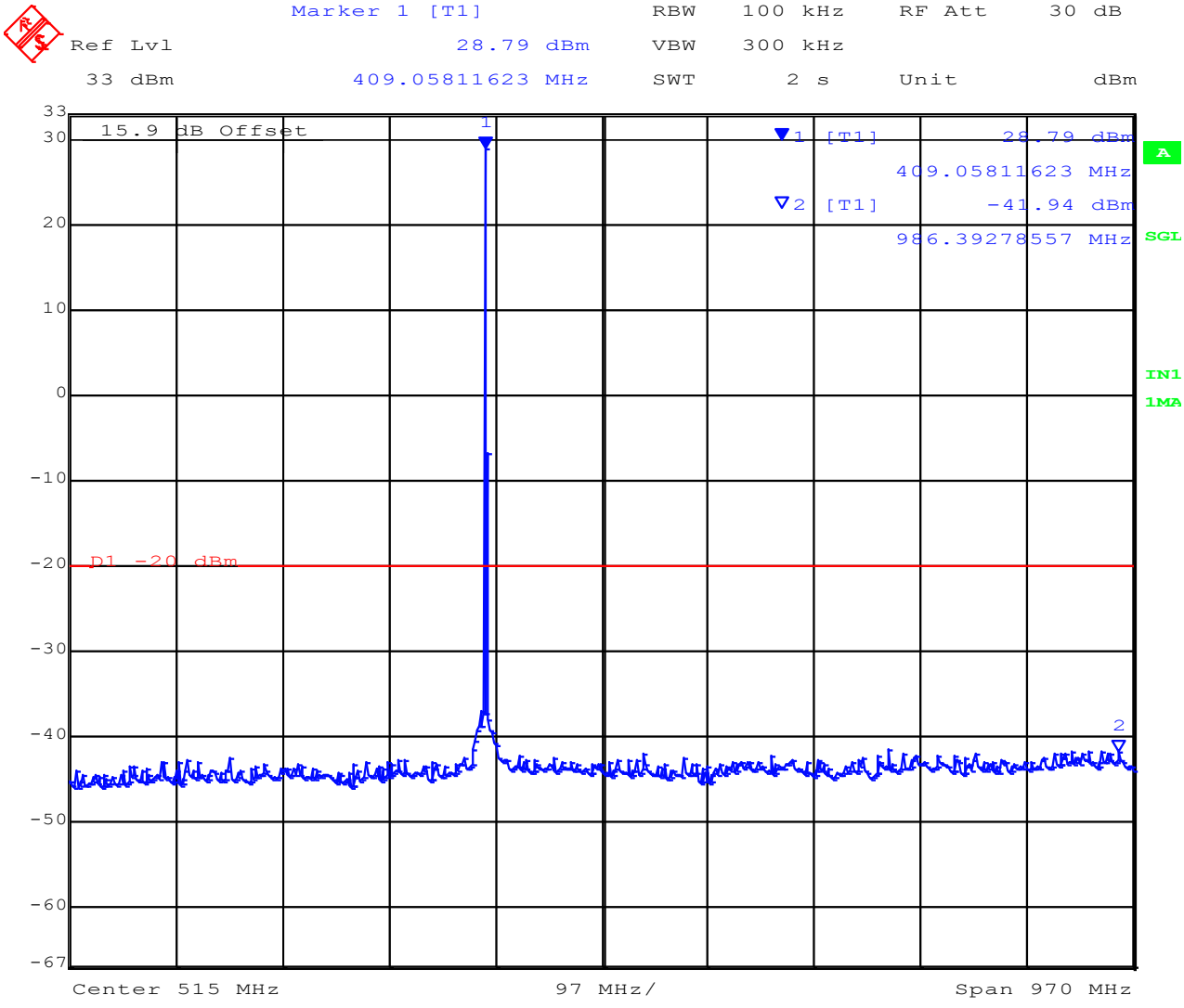
Test Frequency	Frequency Range	Unwanted Emissions Peak (dBm)							
		Port a		Port b		Port c		Port d	
MHz	MHz	SE	Limit	SE	Limit	SE	Limit	SE	Limit
410.0	30 - 1000	-41.94	-20						
	1000 - 5000	-33.28	-20						
429.5	30 - 1000	-41.26	-20						
	1000 - 5000	-33.91	-20						
450.5	30 - 1000	-41.80	-20						
	1000 - 5000	-33.60	-20						
469.5	30 - 1000	-37.04	-20						
	1000 - 5000	-33.30	-20						

Traceability to Industry Recognized Test Methodologies	
Work Instruction:	WI-05 MEASUREMENT OF SPURIOUS EMISSIONS
Measurement Uncertainty:	<=40 GHz ±2.37 dB, > 40 GHz ±4.6 dB

Note: click the links in the above matrix to view the graphical image (plot).

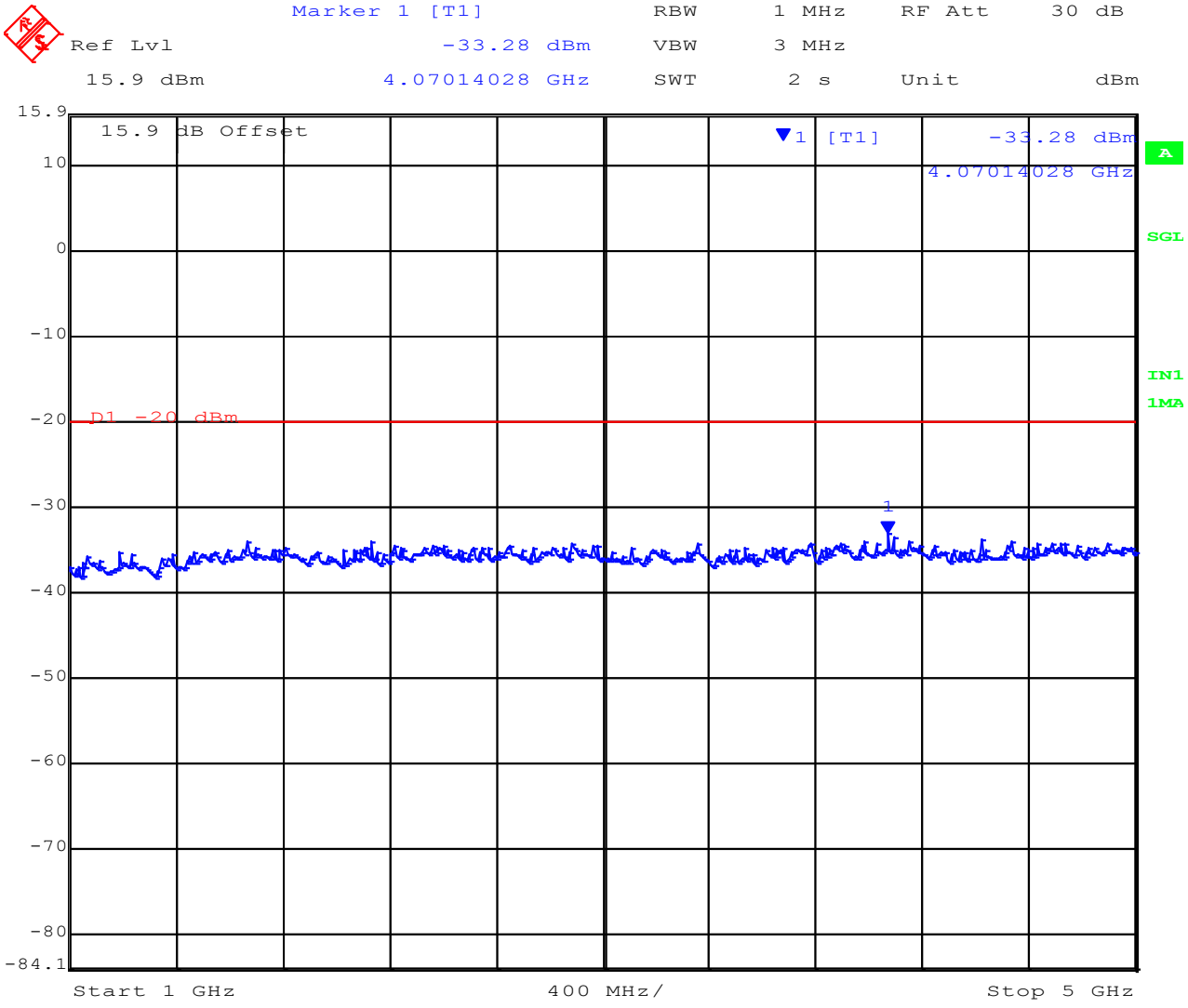
Transmitter Spurious Emissions 30MHz to 1GHz

Variant: 25KHz, Channel: 410.0 MHz, Chain a



Transmitter Spurious Emissions 1GHz to 5GHz

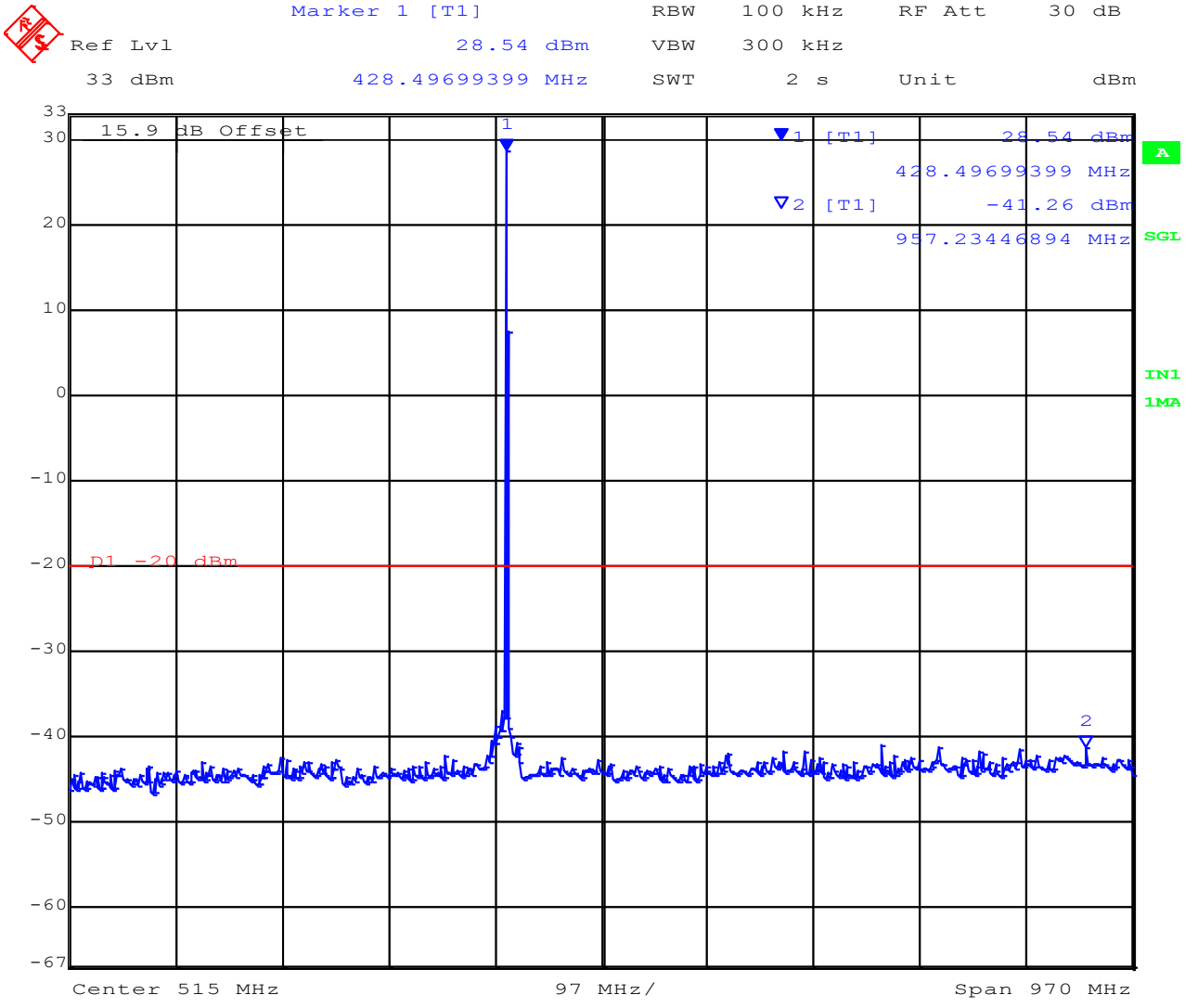
Variant: 25KHz, Channel: 410.0 MHz, Chain a



Date: 22.MAR.2021 13:08:13

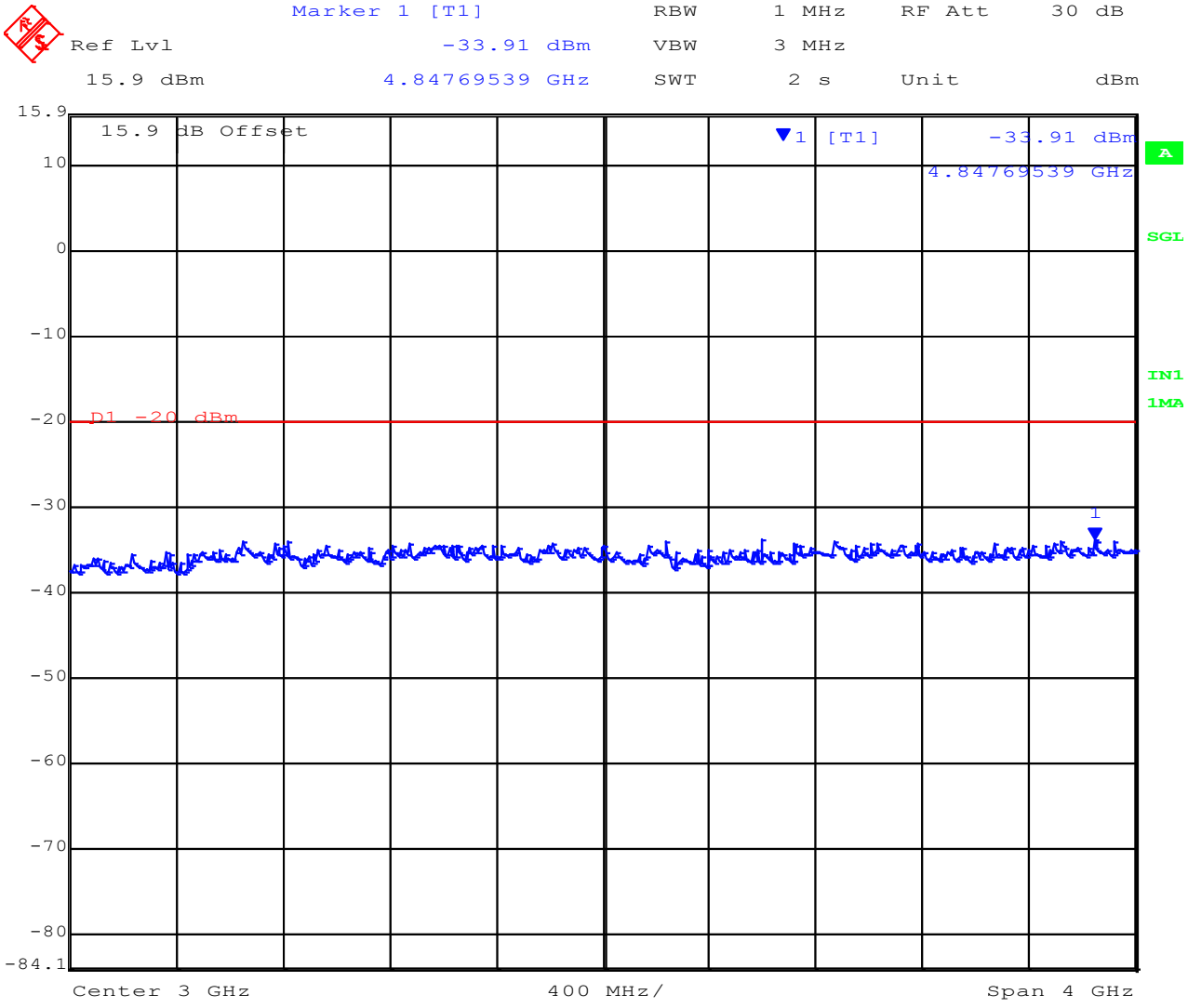
Transmitter Spurious Emissions 30MHz to 1GHz

Variant: 25KHz, Channel: 429.5 MHz, Chain a



Transmitter Spurious Emissions 1GHz to 5GHz

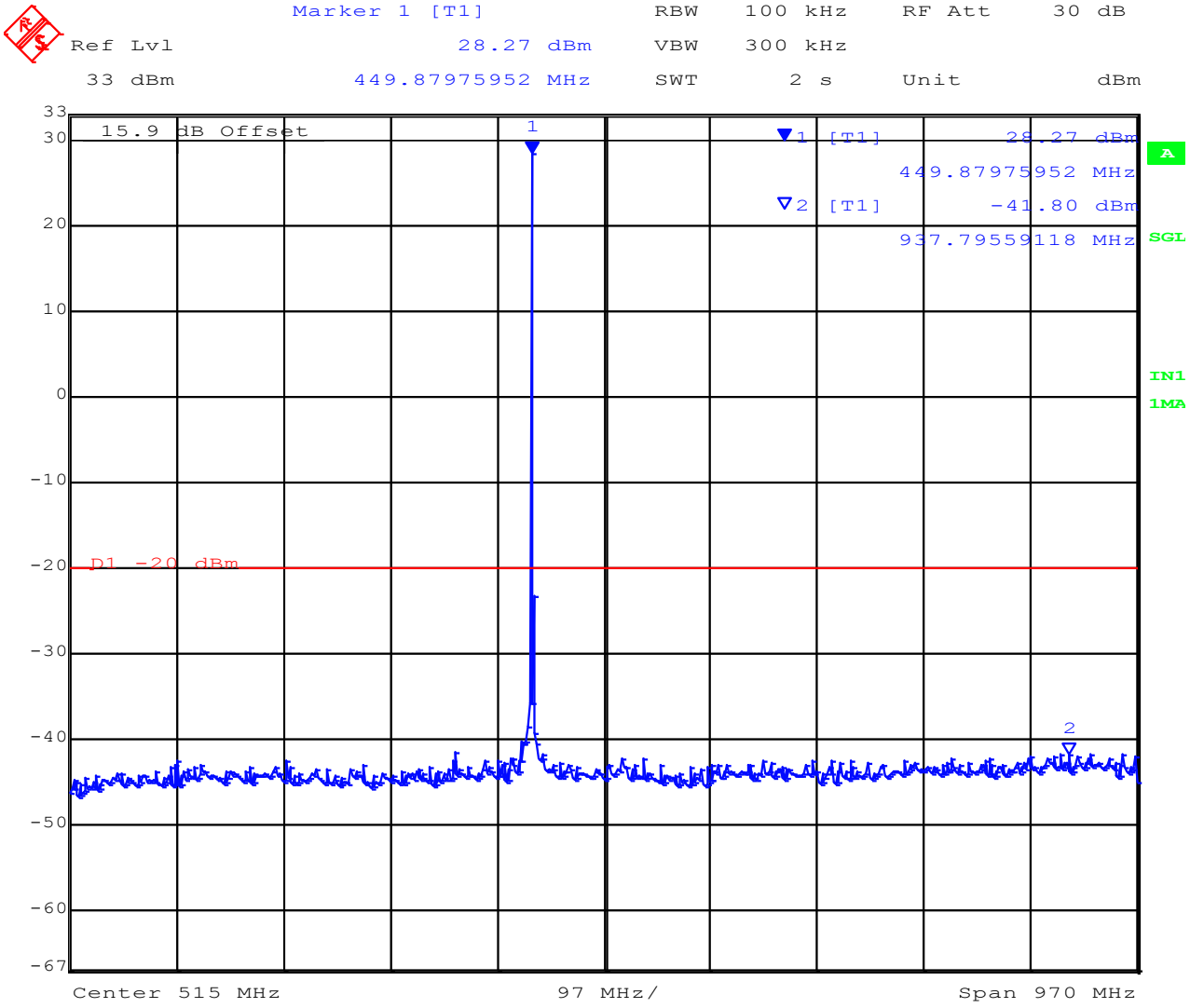
Variant: 25KHz, Channel: 429.5 MHz, Chain a



Date: 22.MAR.2021 13:07:34

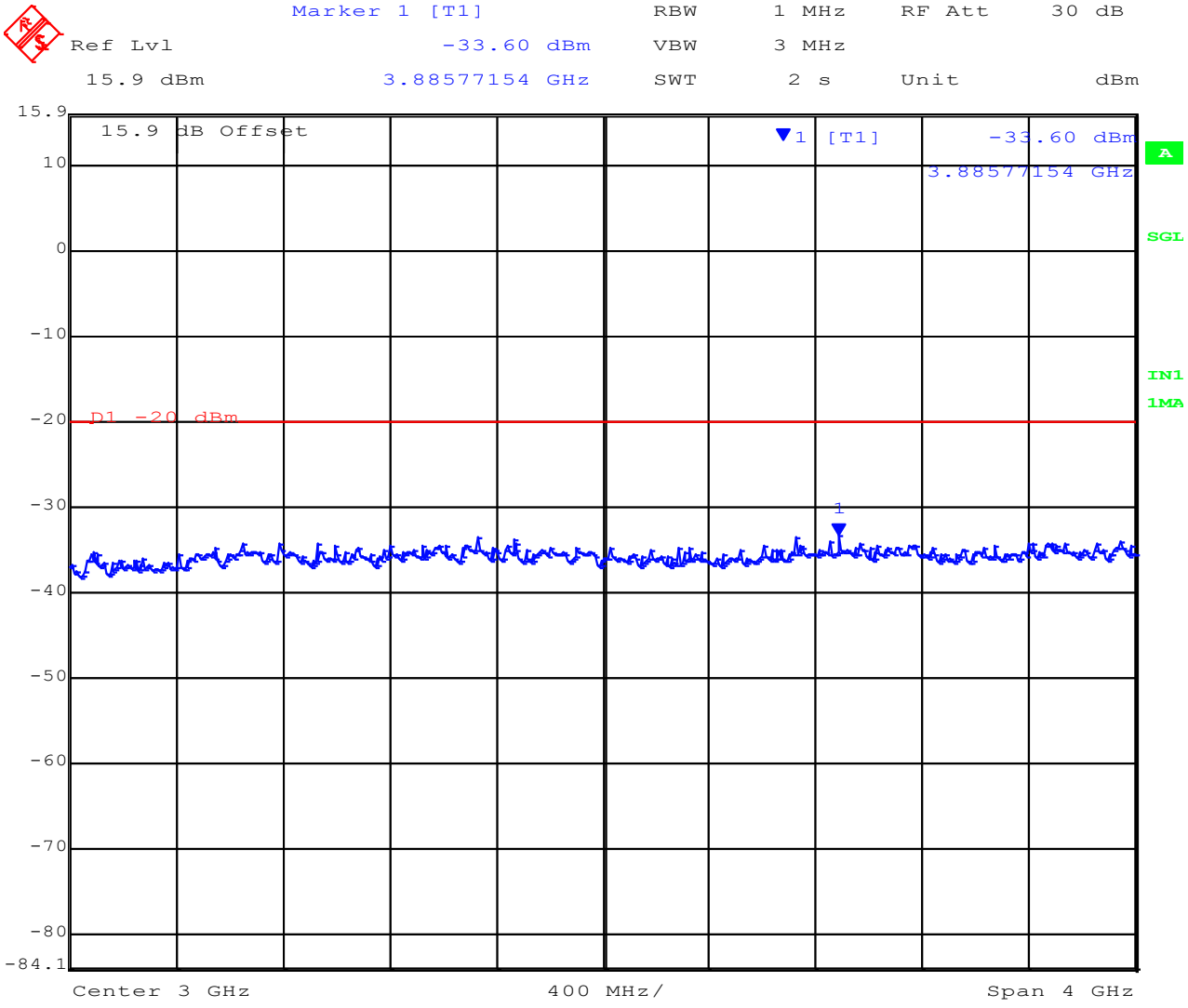
Transmitter Spurious Emissions 30MHz to 1GHz

Variant: 25KHz, Channel: 450.5 MHz, Chain a



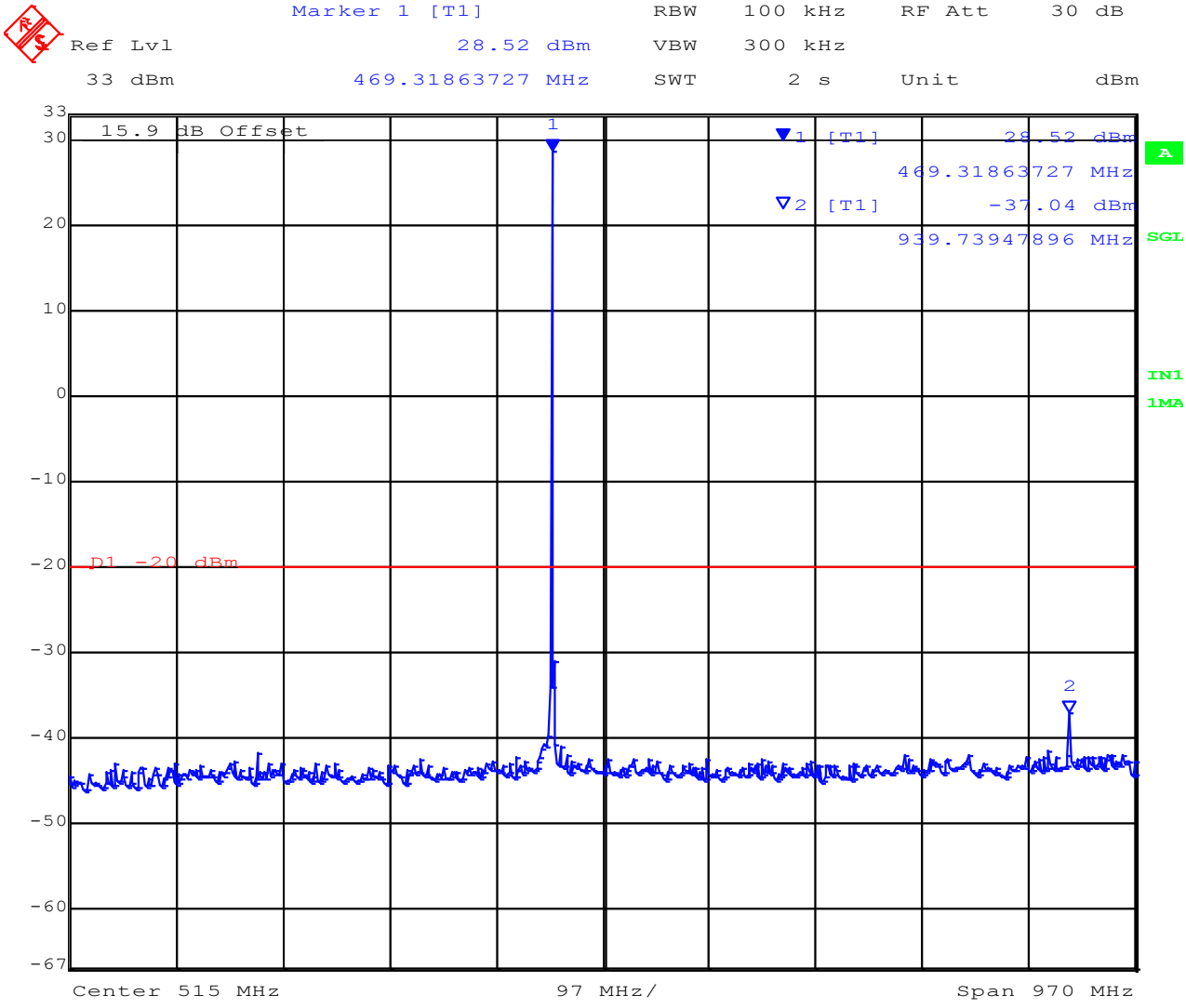
Transmitter Spurious Emissions 1GHz to 5GHz

Variant: 25KHz, Channel: 450.5 MHz, Chain a



Transmitter Spurious Emissions 30MHz to 1GHz

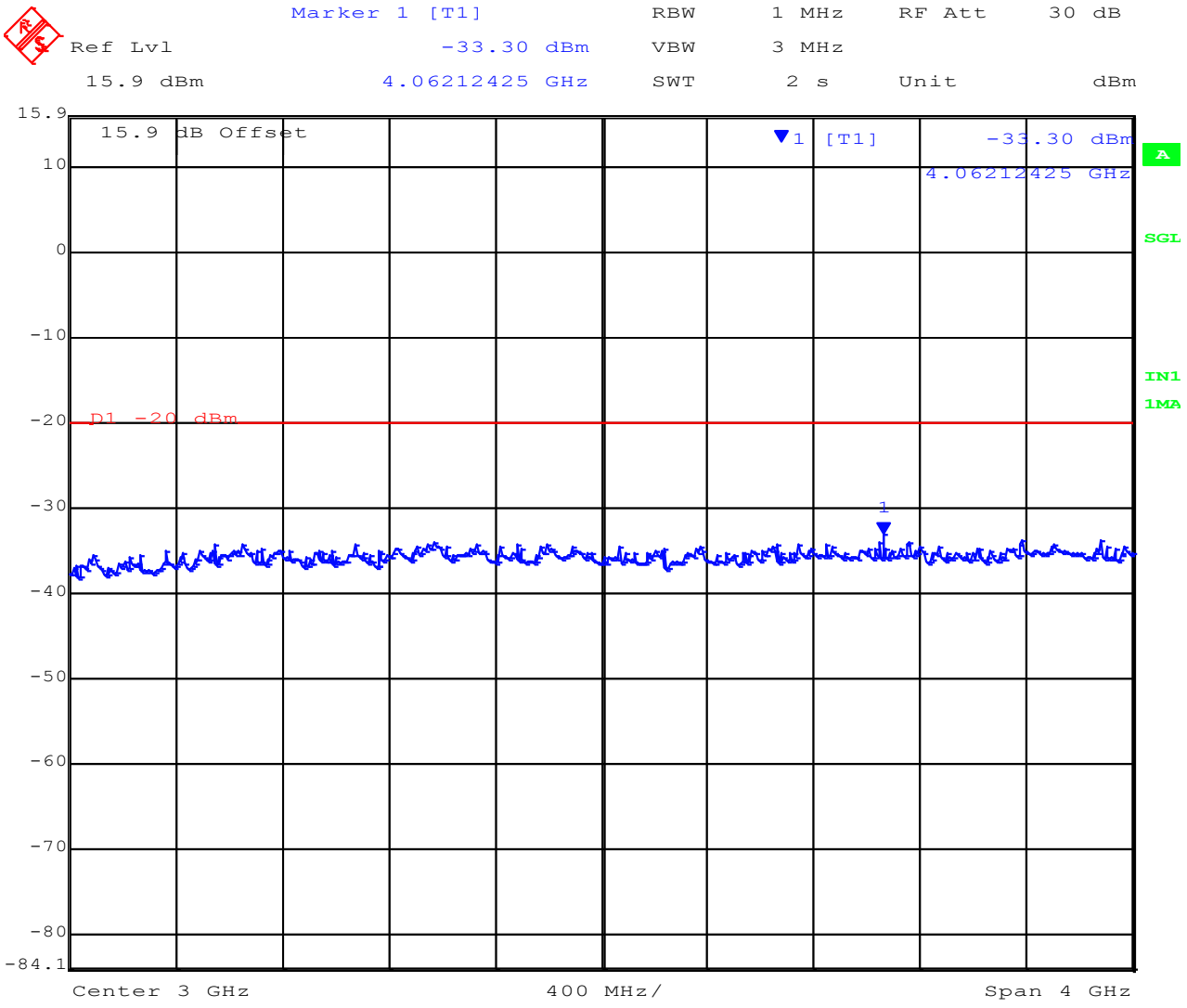
Variant: 25KHz, Channel: 469.5 MHz, Chain a



Date: 22.MAR.2021 12:56:09

Transmitter Spurious Emissions 1GHz to 5GHz

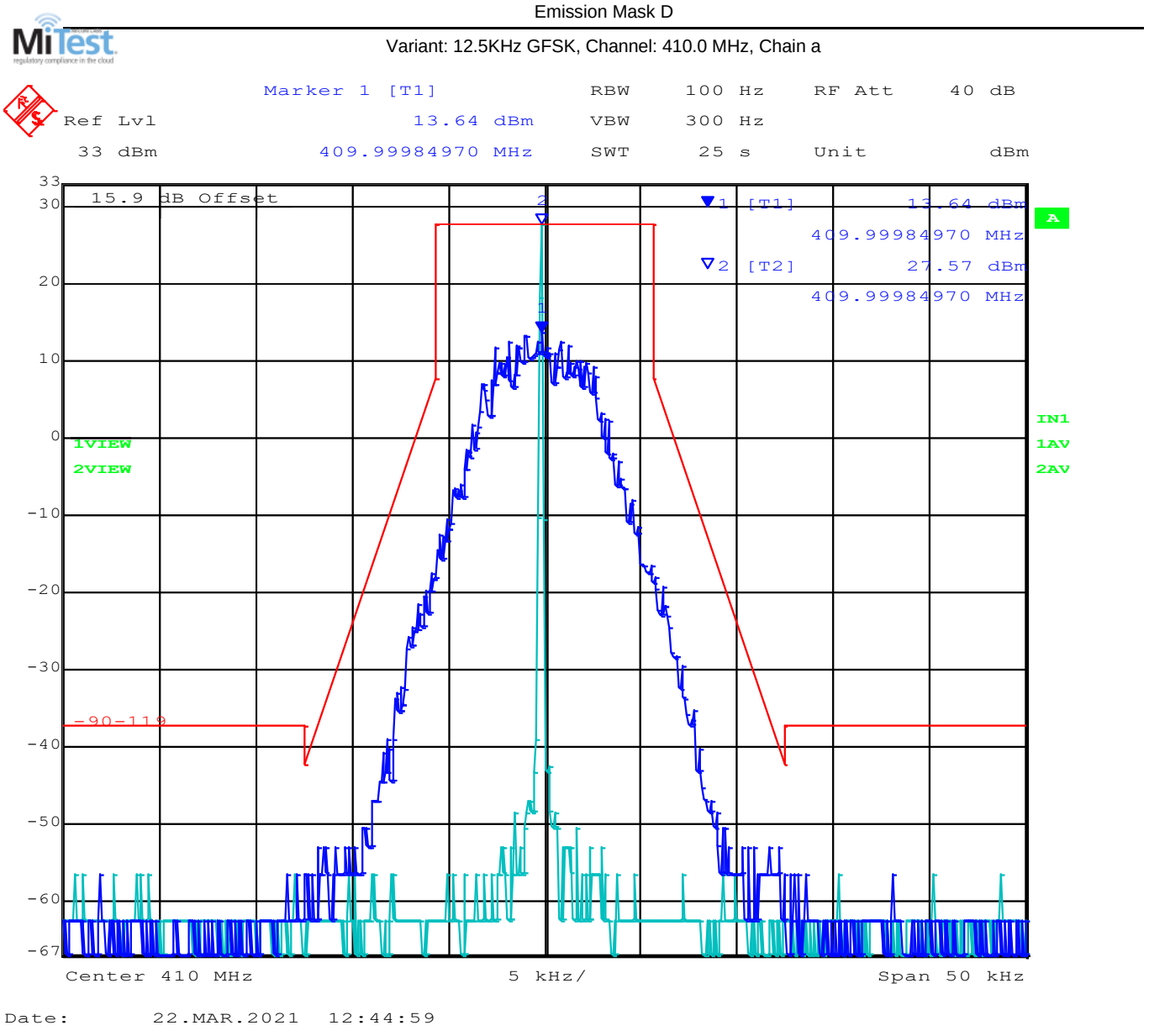
Variant: 25KHz GFSK, Channel: 469.5 MHz, Chain a



Date: 22.MAR.2021 13:06:32

9.5.1.18. Conducted Emission Mask

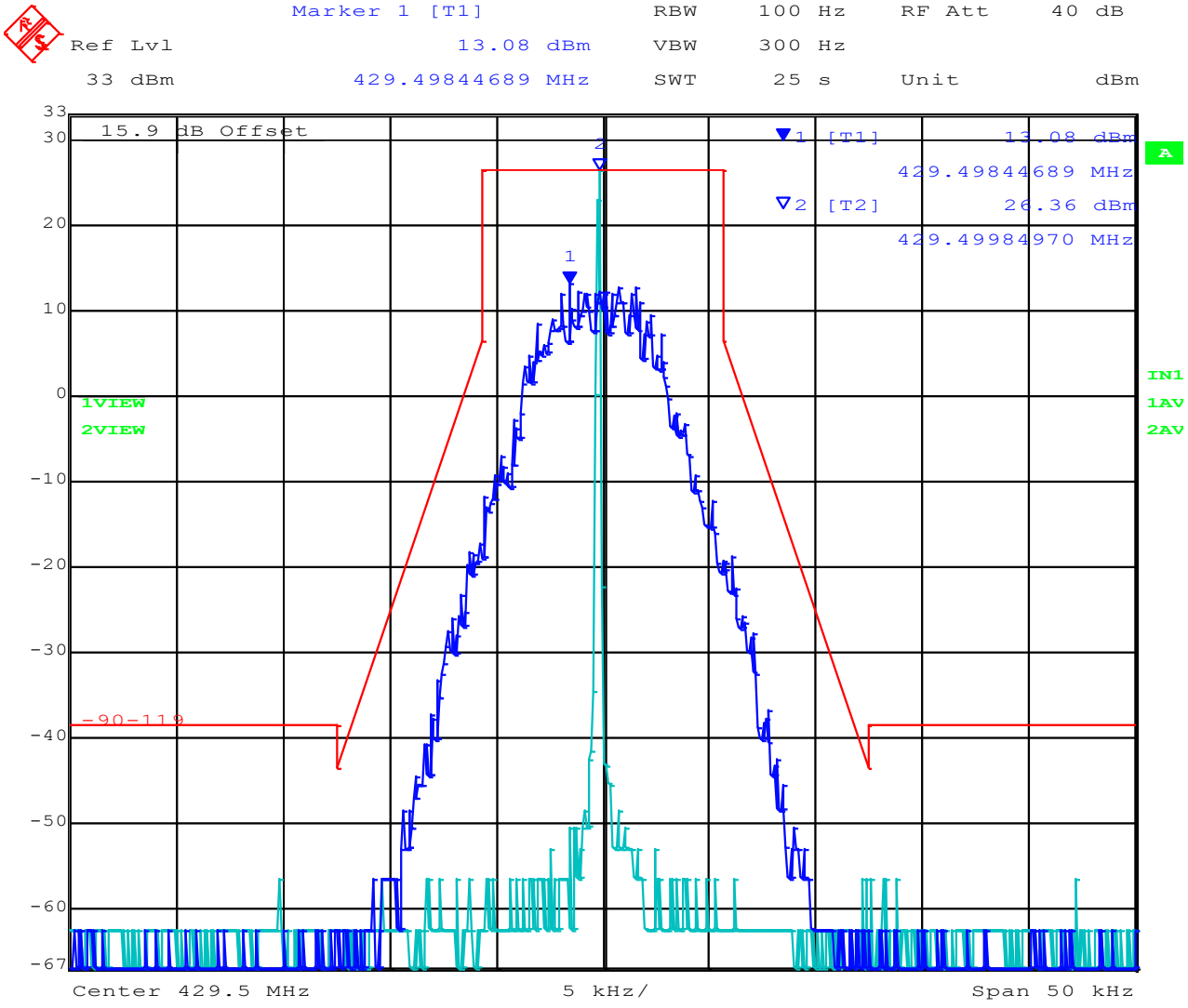
9.5.1.19. 12.5 KHz GFSK



Test Result: Pass

Emission Mask D

Variant: 12.5KHz GFSK, Channel: 429.5 MHz, Chain a

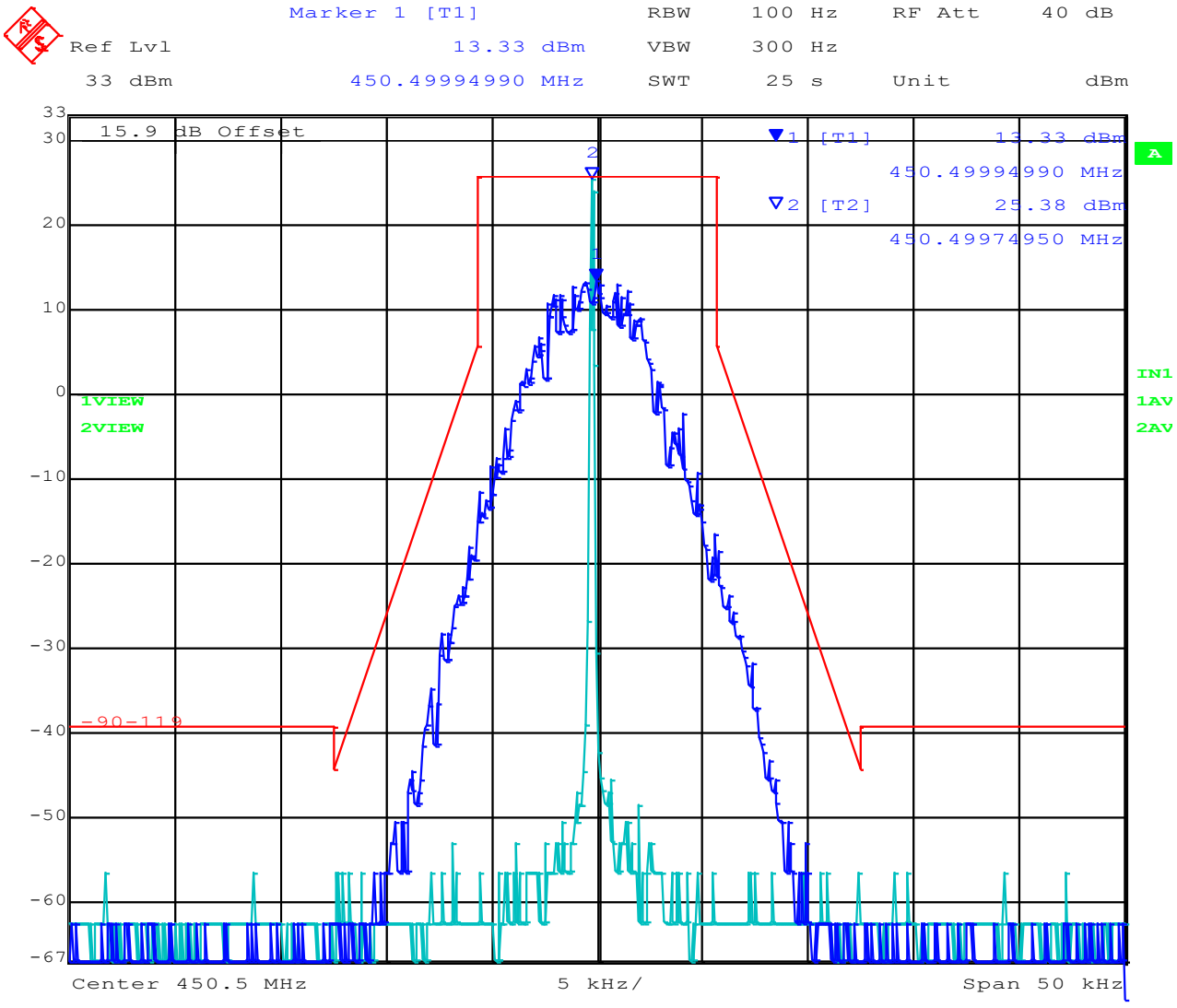


Date: 22.MAR.2021 12:38:31

Test Result: Pass

Emission Mask D

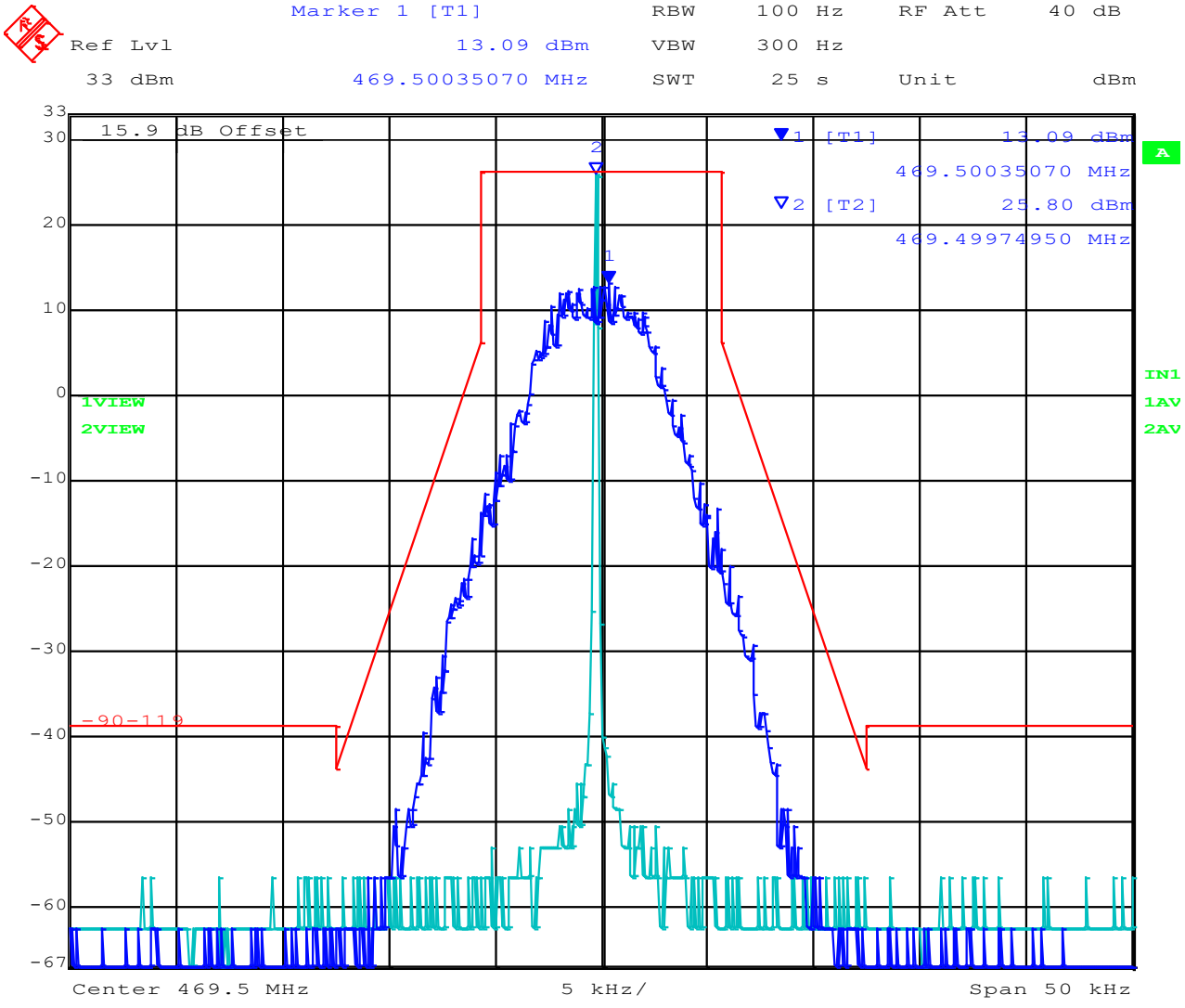
Variant: 12.5KHz GFSK, Channel: 450.5 MHz, Chain a



Test Result: Pass

Emission Mask D

Variant: 12.5KHz GFSK, Channel: 469.5 MHz, Chain a

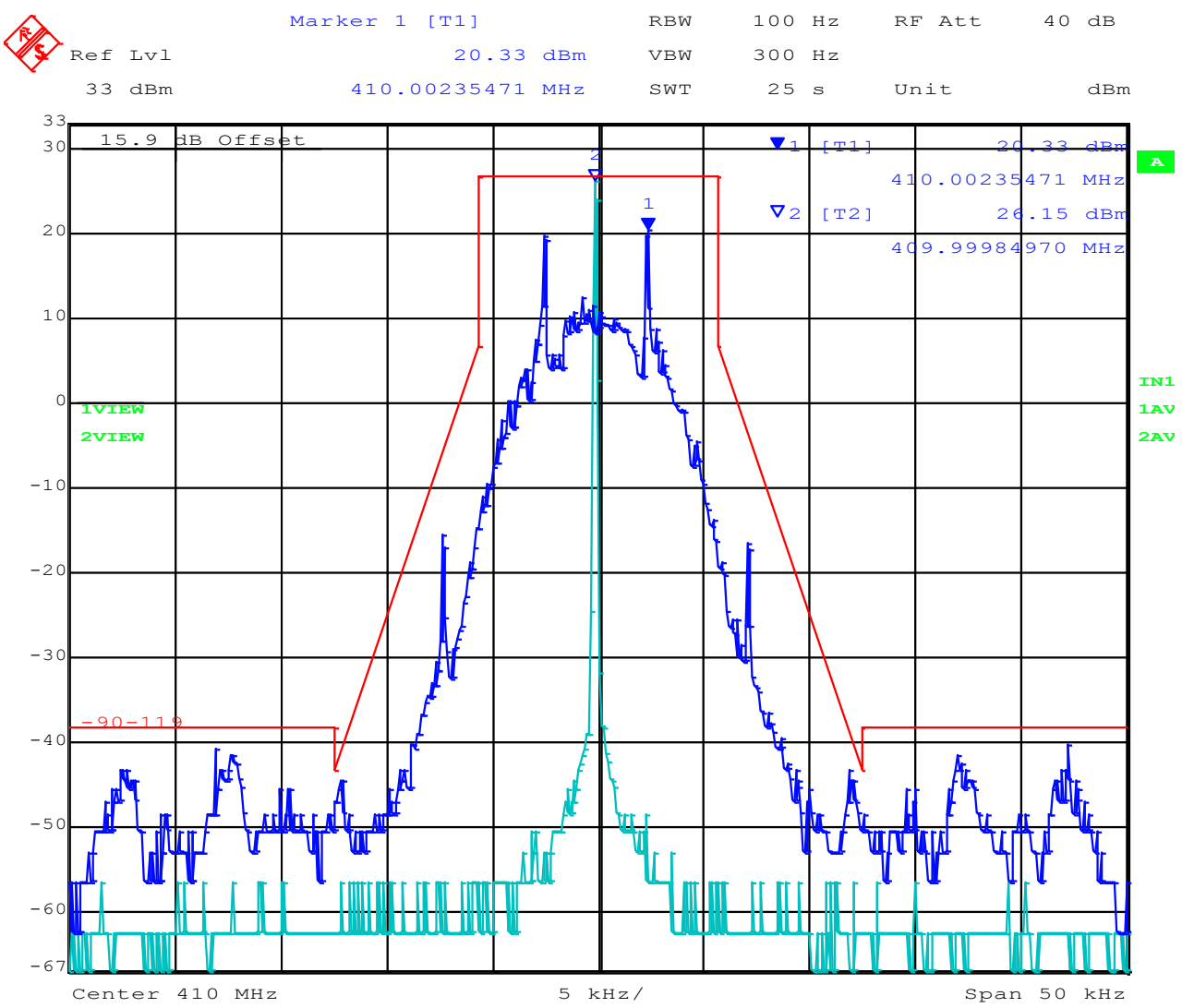


Test Result: Pass

9.5.1.20. 12.5 KHz GMSK

Emission Mask D

Variant: 12.5KHz GFSK, Channel: 410.0 MHz, Chain a

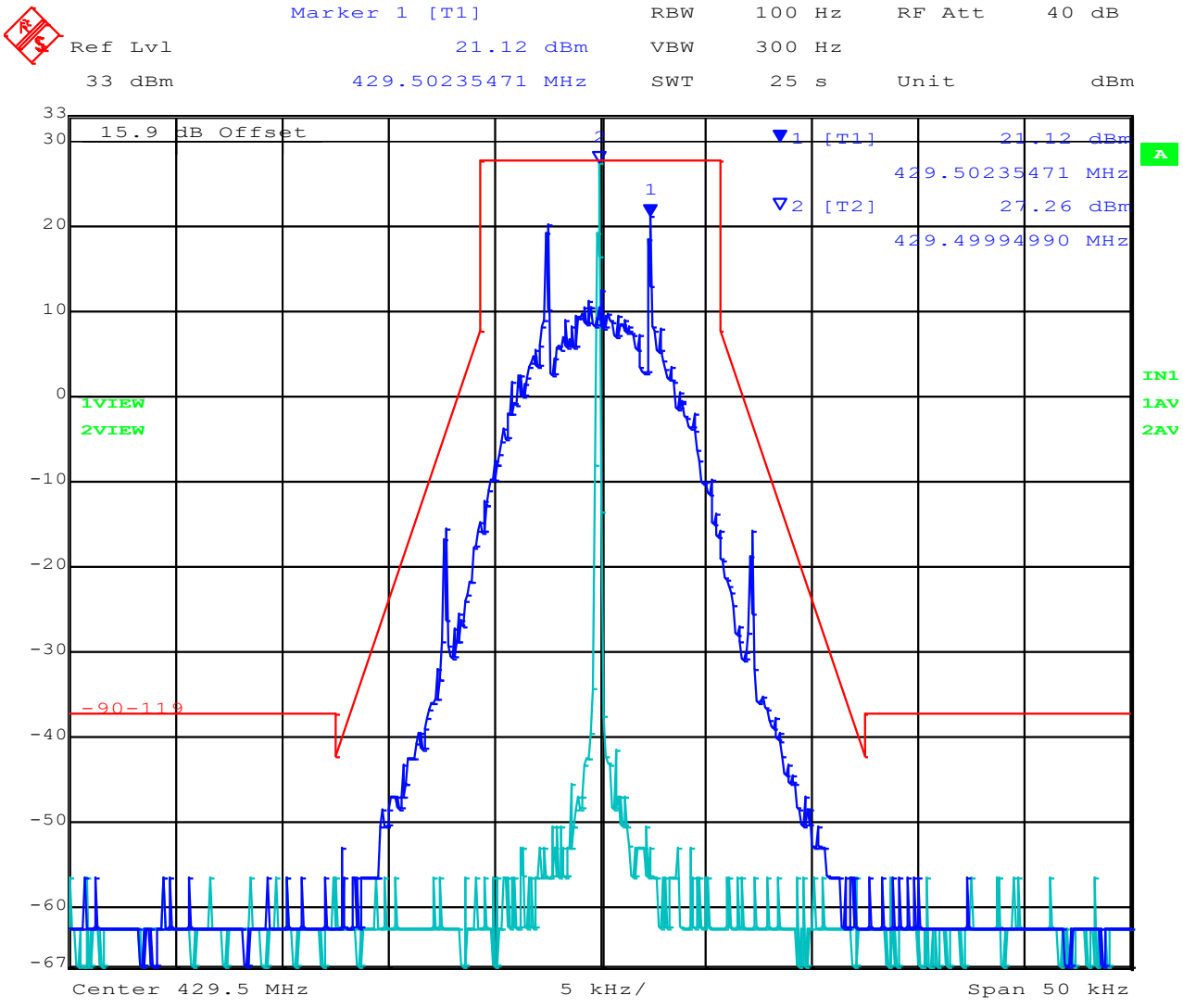


Date: 22.MAR.2021 10:39:45

Test Result: Pass

Emission Mask D

Variant: 12.5KHz GFSK, Channel: 429.5 MHz, Chain a

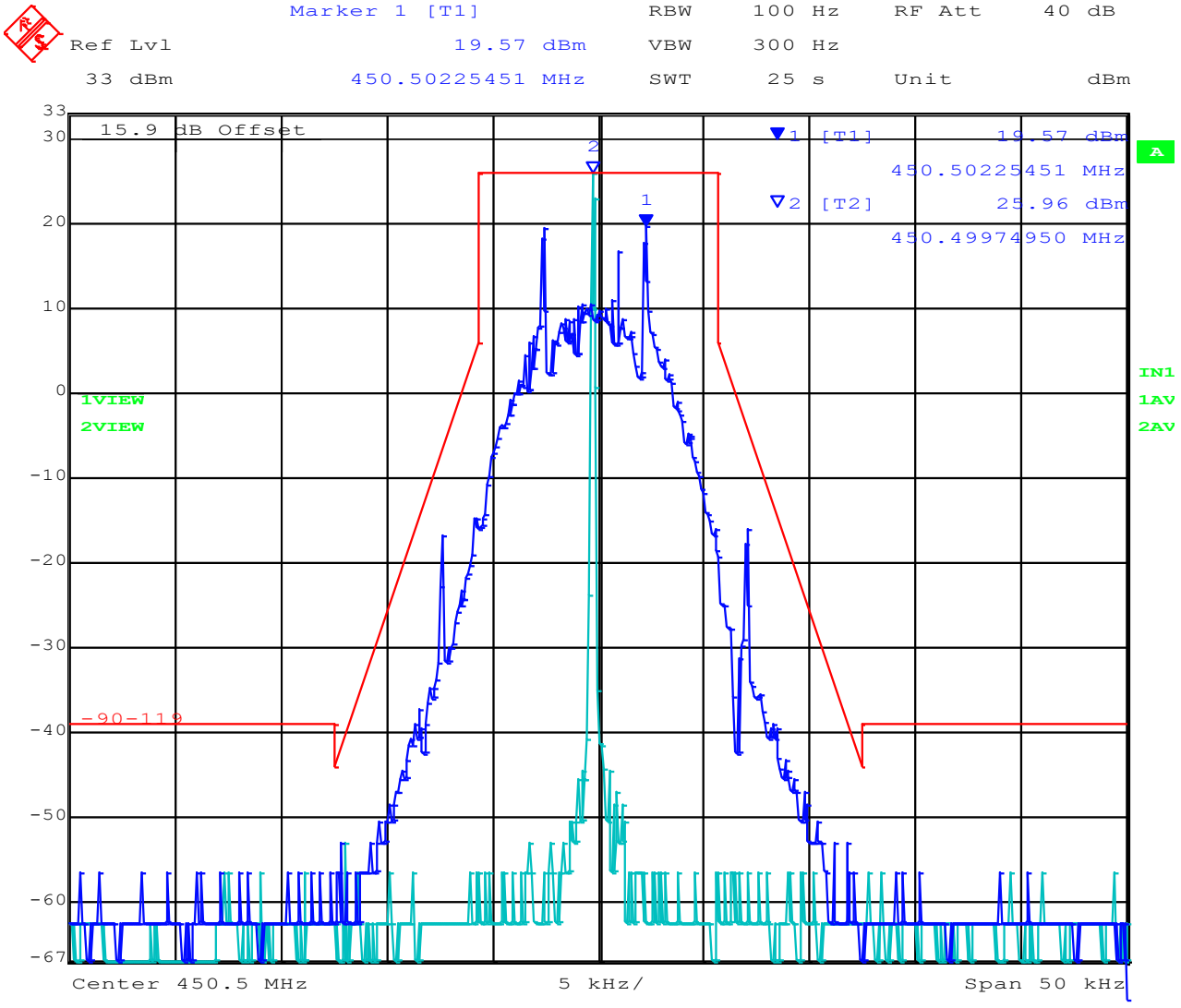


Date: 22.MAR.2021 10:43:15

Test Result: Pass

Emission Mask D

Variant: 12.5KHz GFSK, Channel: 450.5 MHz, Chain a

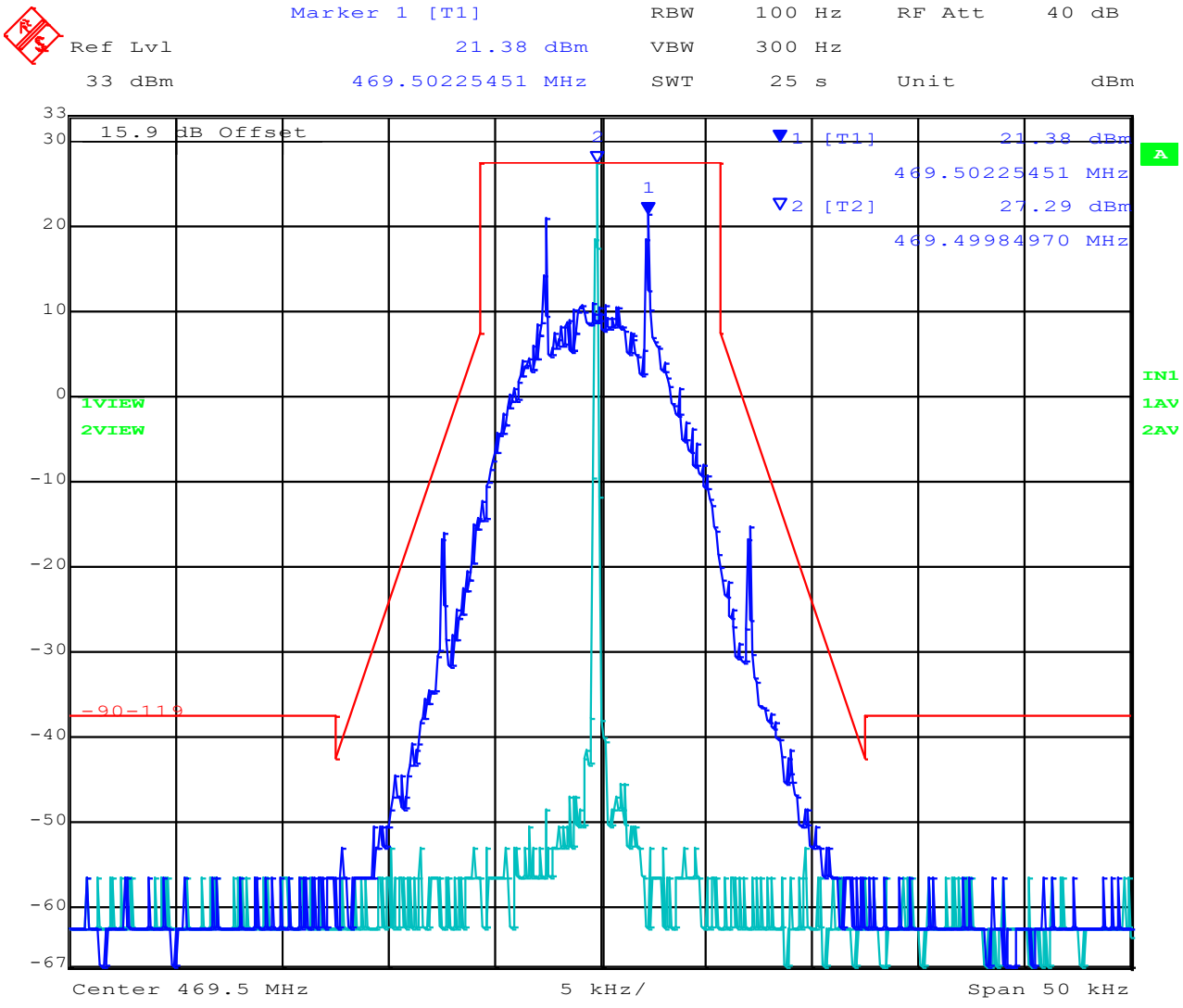


Date: 22.MAR.2021 11:27:29

Test Result: Pass

Emission Mask D

Variant: 12.5KHz GFSK, Channel: 469.5 MHz, Chain a



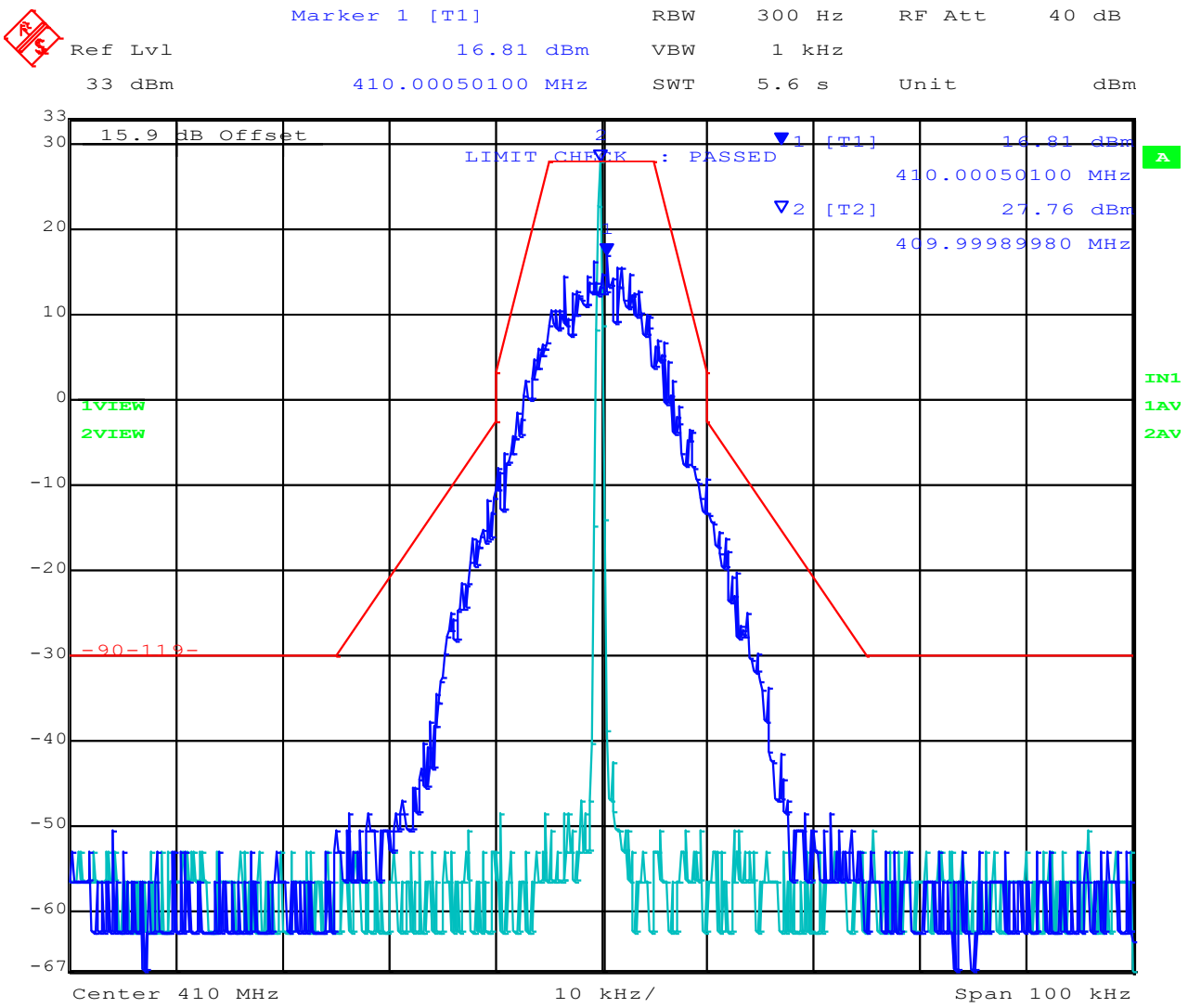
Date: 22.MAR.2021 11:38:57

Test Result: Pass

9.5.1.21. 25 KHz GFSK

Emission Mask C

Variant: 25KHz GFSK, Channel: 410.0 MHz, Chain a

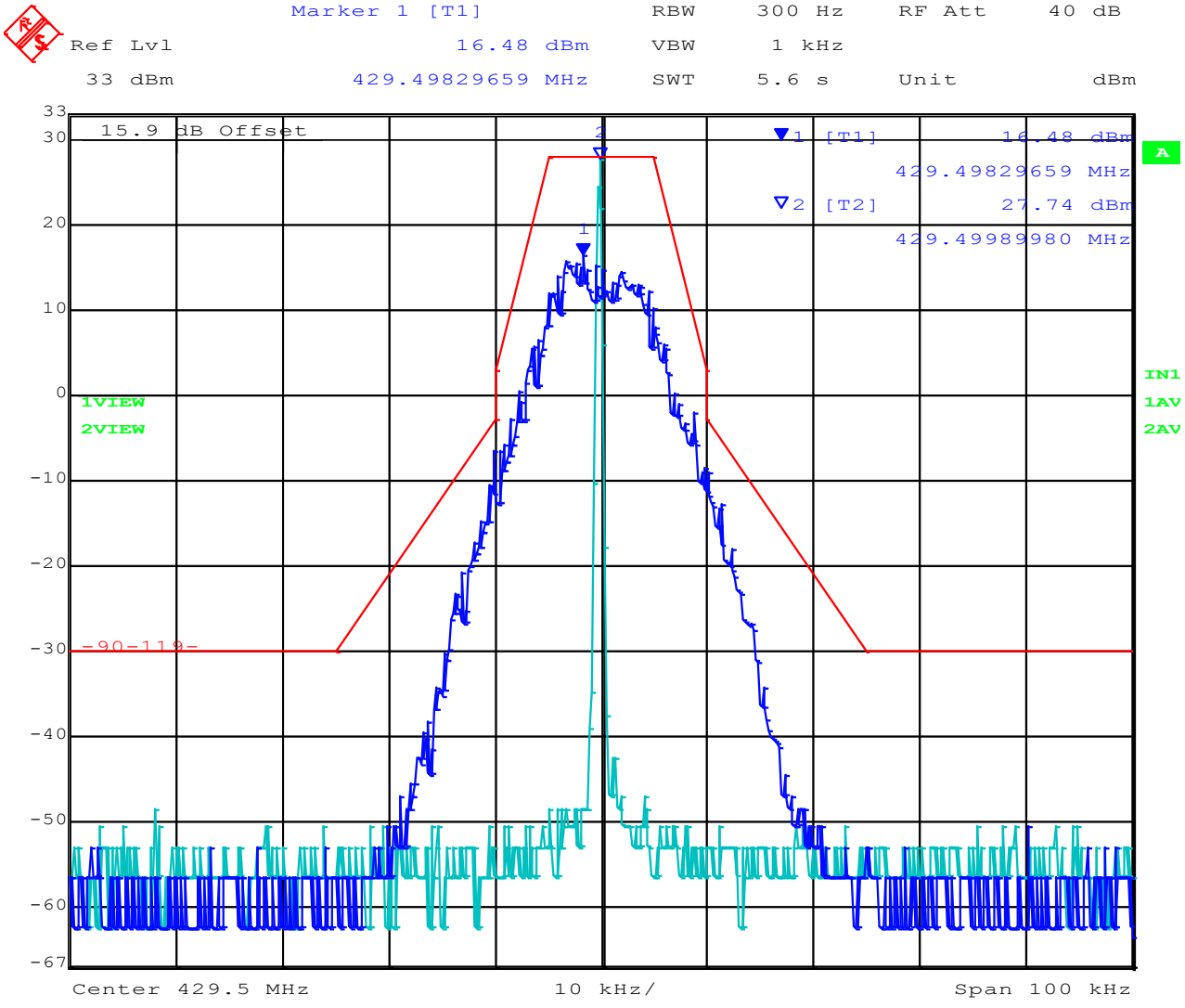


Date: 22.MAR.2021 12:06:27

Test Result: Pass

Emission Mask C

Variant: 25KHz GFSK, Channel: 429.5 MHz, Chain a

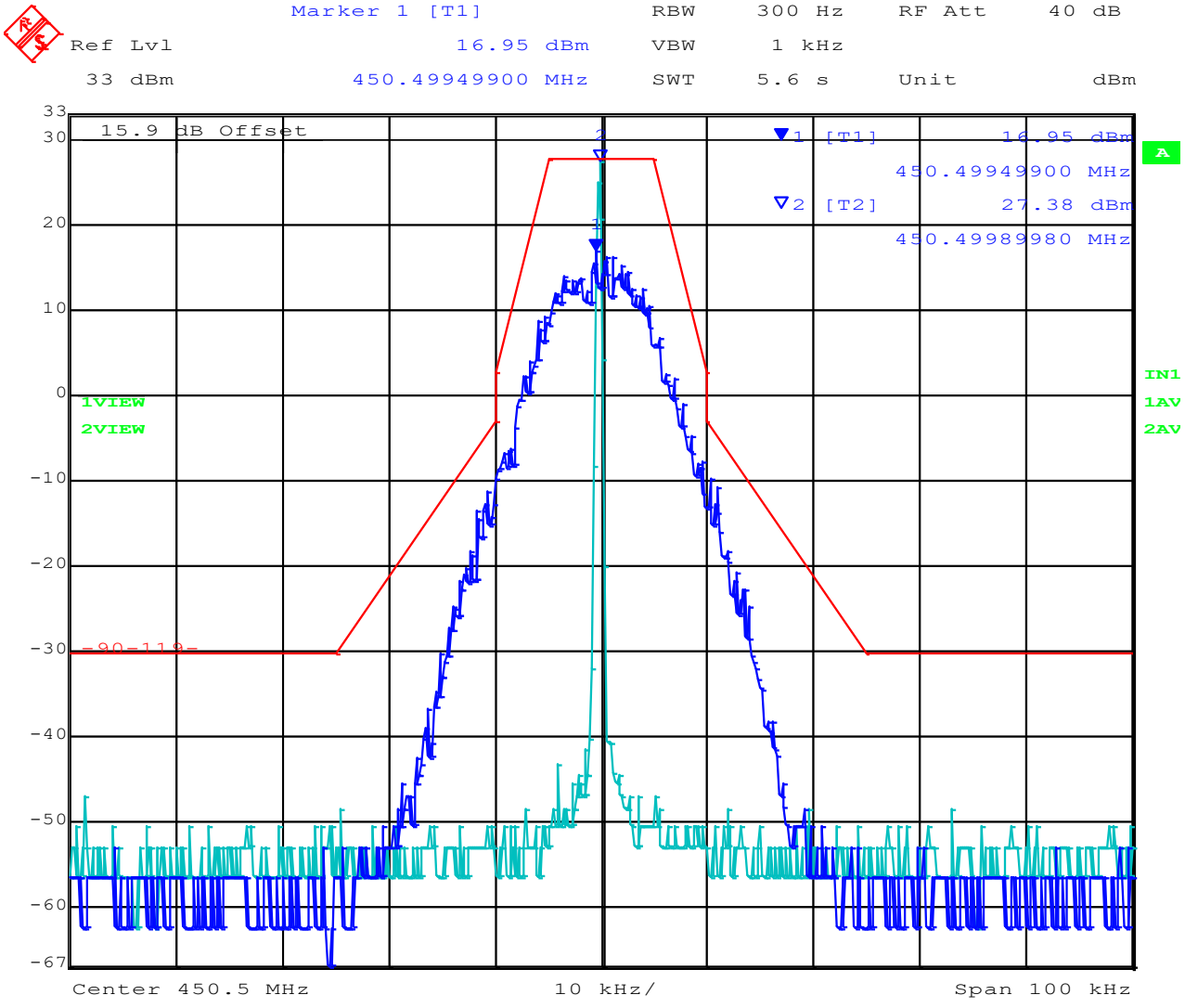


Date: 22.MAR.2021 12:14:49

Test Result: Pass

Emission Mask C

Variant: 25KHz GFSK, Channel: 450.5 MHz, Chain a

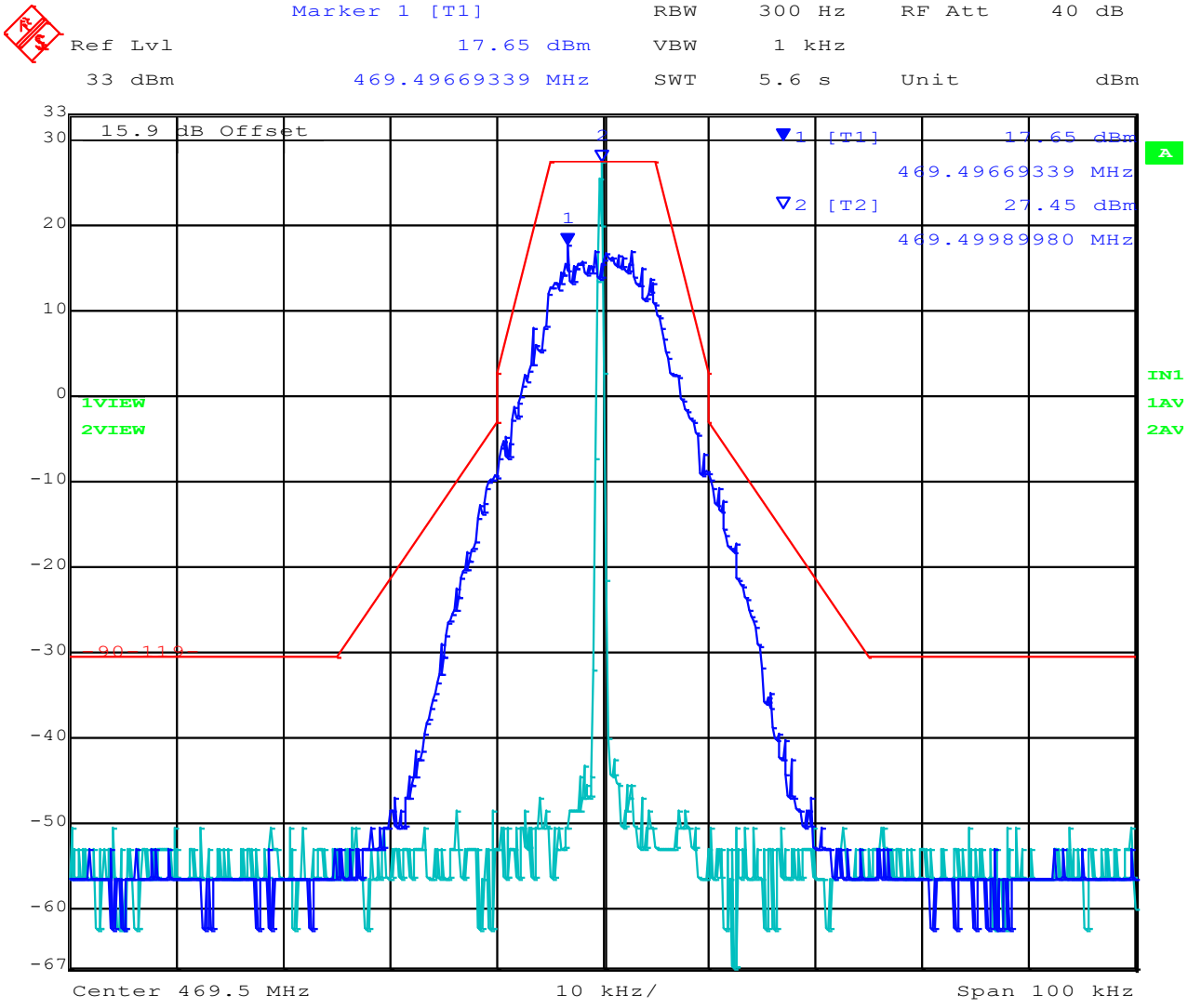


Date: 22.MAR.2021 12:18:58

Test Result: Pass

Emission Mask C

Variant: 25KHz GFSK, Channel: 469.5 MHz, Chain a



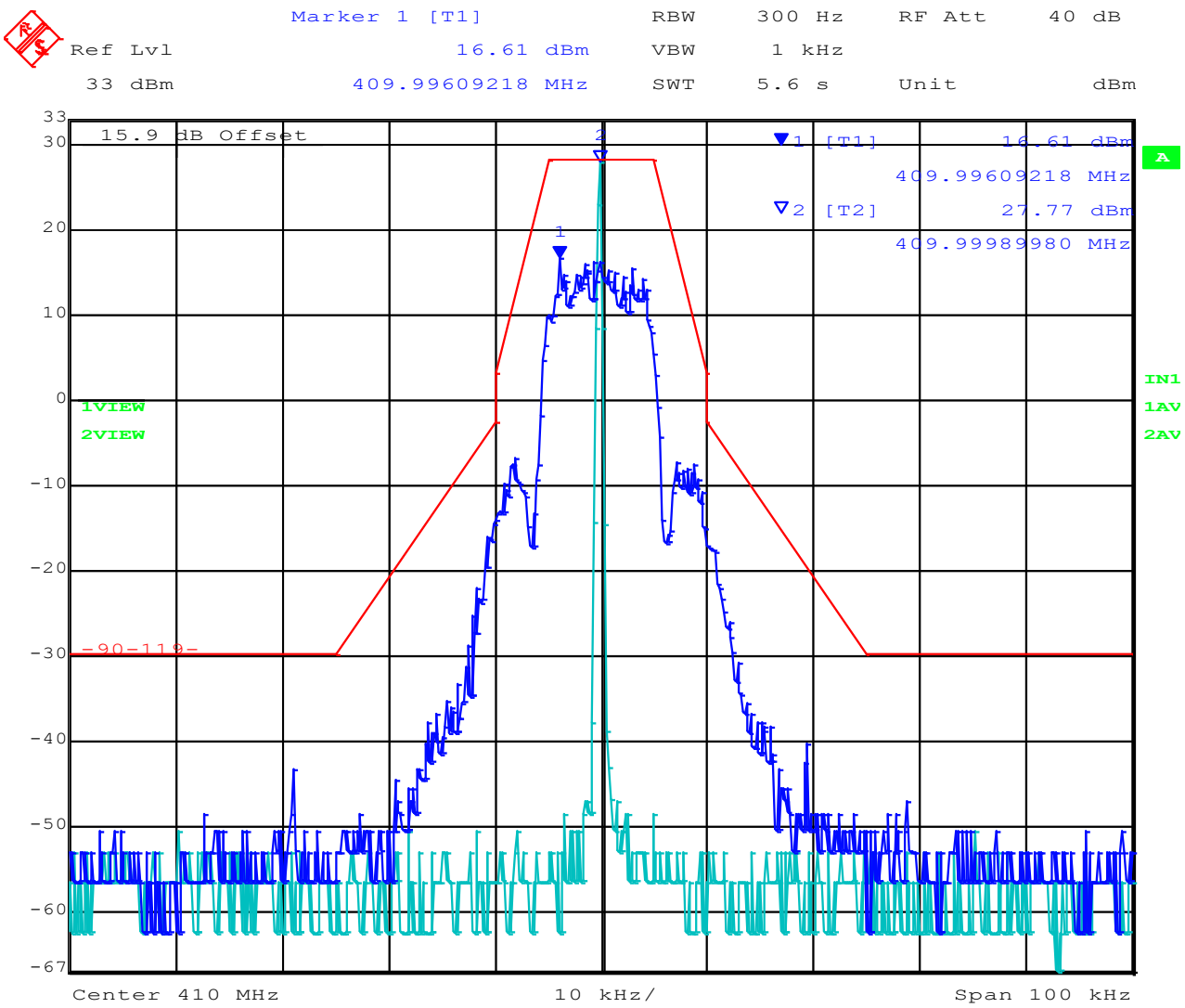
Date: 22.MAR.2021 12:23:45

Test Result: Pass

9.5.1.22. 25 KHz GMSK

Emission Mask C

Variant: 25KHz GFSK, Channel: 410.0 MHz, Chain a

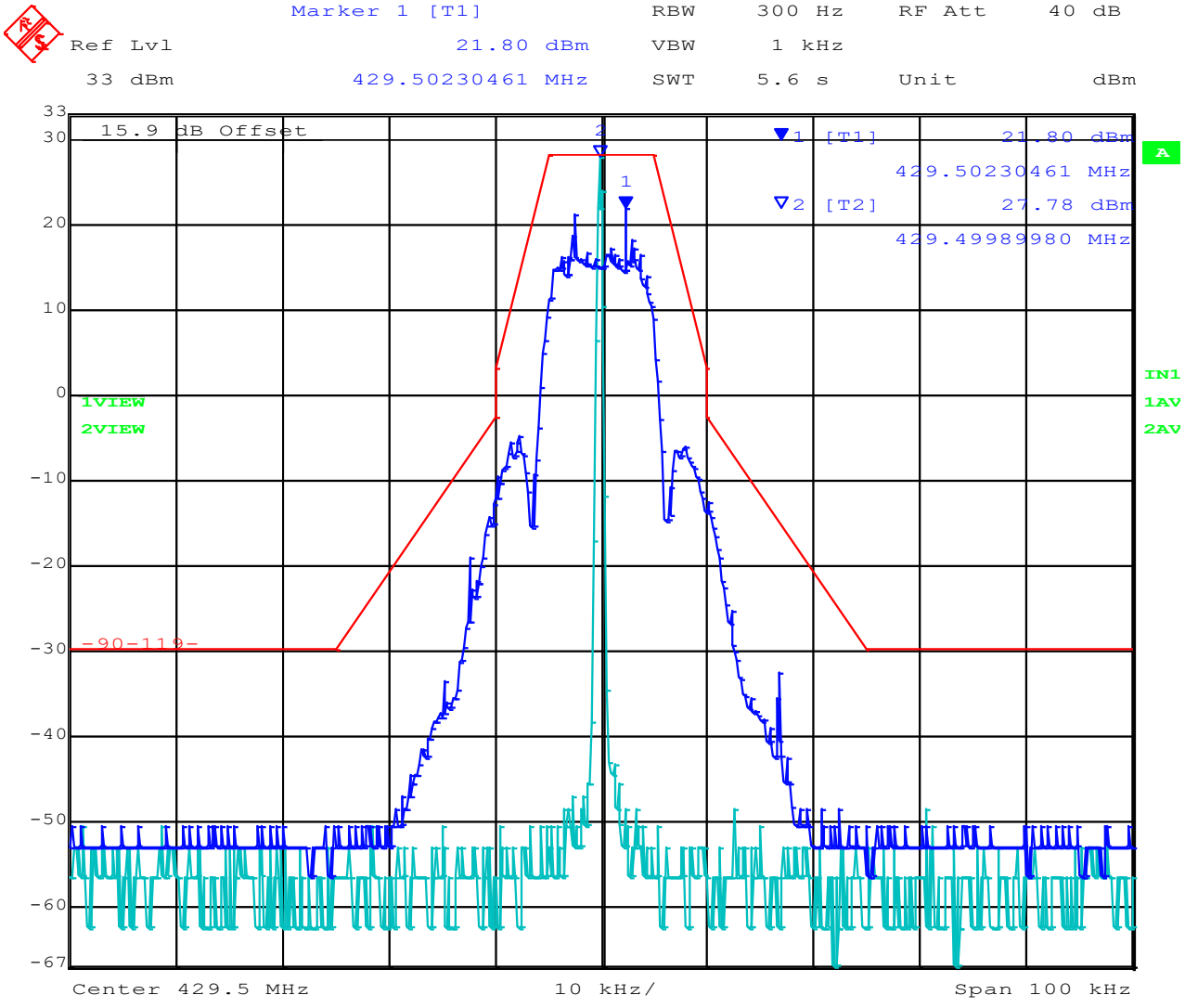


Date: 22.MAR.2021 12:03:40

Test Result: Pass

Emission Mask C

Variant: 25KHz GFSK, Channel: 429.5 MHz, Chain a

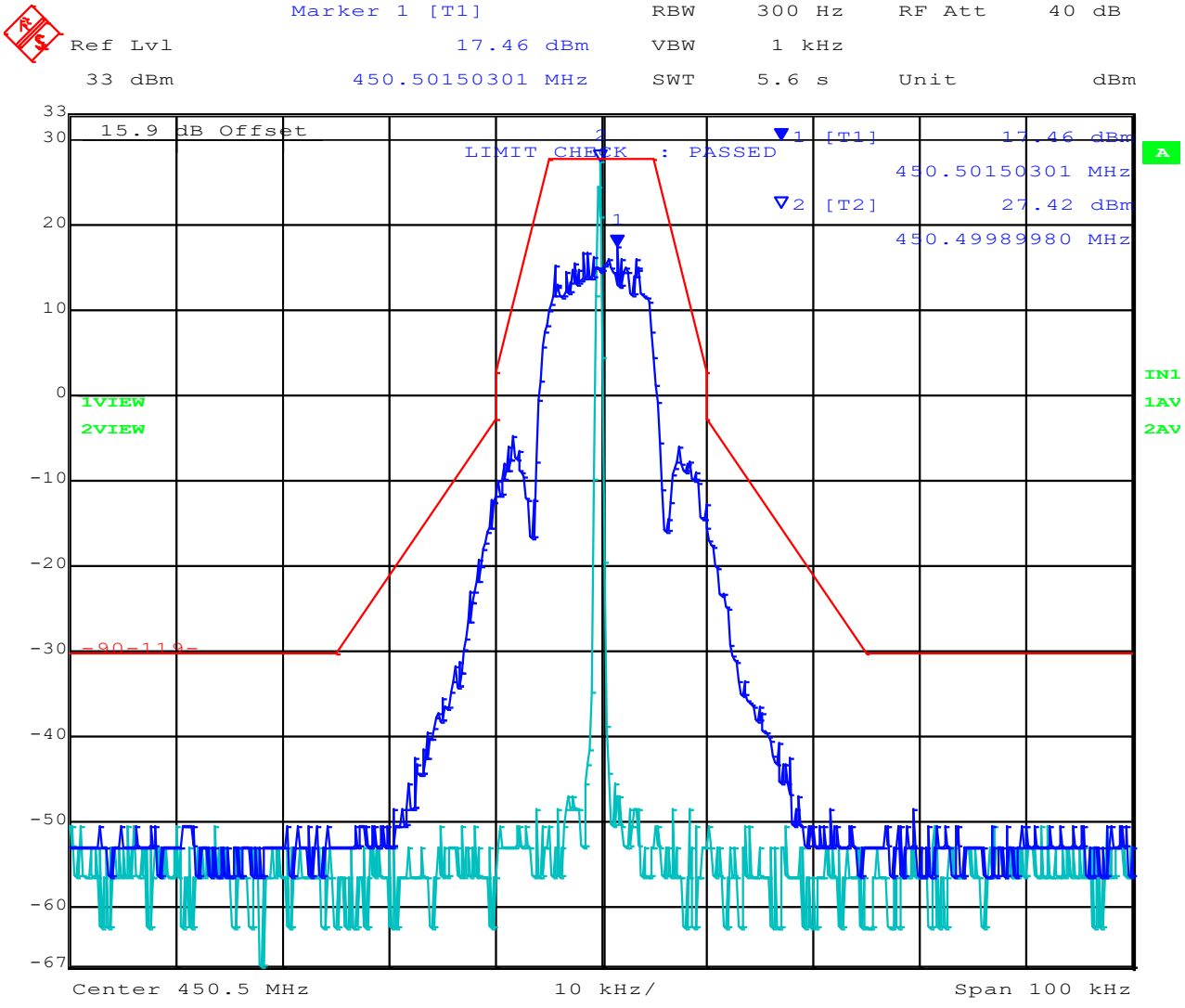


Date: 22.MAR.2021 11:57:15

Test Result: Pass

Emission Mask C

Variant: 25KHz GFSK, Channel: 450.5 MHz, Chain a

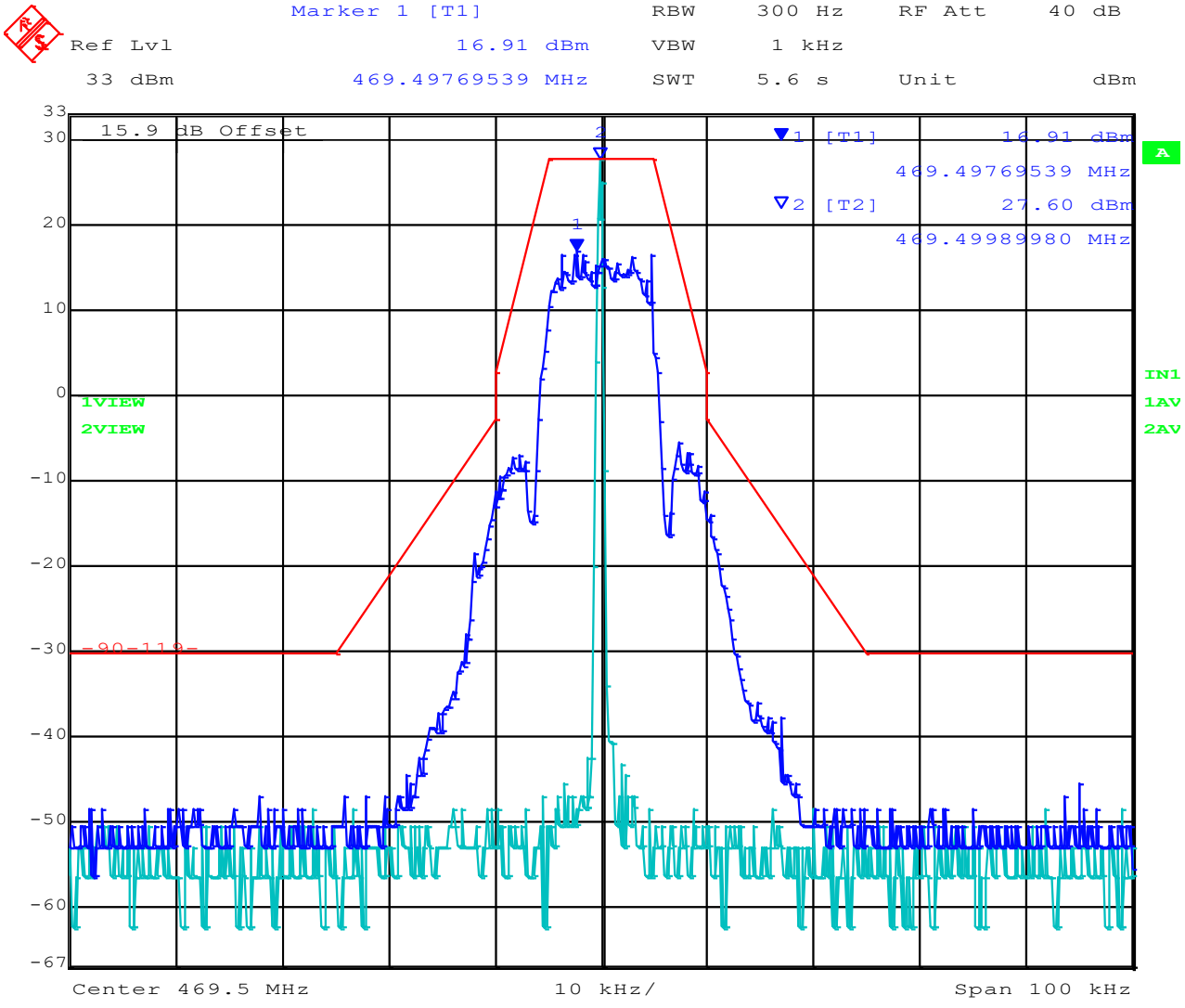


Date: 22.MAR.2021 11:51:29

Test Result: Pass

Emission Mask C

Variant: 25KHz GFSK, Channel: 469.5 MHz, Chain a



Test Result: Pass

9.5.2. Radiated Emissions

Conducted Test Conditions for Transmitter Spurious and Band-Edge Emissions			
Standard:	FCC CFR 47:90 ISED RSS-119	**Ambient Temp. (ºC):**	24.0 - 27.5
Test Heading:	Transmitter Conducted Spurious and Band-Edge Emissions	**Rel. Humidity (%):**	32 - 45
Standard Section(s):	90.210 RSS-119 5.8	**Pressure (mBars):**	999 - 1001
Reference Document(s):	See Normative References		

Test Procedure for Transmitter Spurious

Transmitter Spurious and Band-Edge emissions were measured with a spectrum analyzer. Measurements were made while EUT was operating in transmit mode of operation at the appropriate center frequency closest to the band-edge. Emissions were maximized during the measurement and limits derived from the peak spectral power and drawn on each plot.

Where the device operated with multiple antenna ports i.e. MIMO device, each port was measured separately. Testing was performed under ambient conditions at nominal voltage only.

Test configuration and setup used for the measurement was per the Radiated Test Set-up specified in this document.

Limits Transmitter Conducted Spurious

12.5KHz Channel Spacing Emission Mask C:

On any frequency removed from the carrier frequency by a displacement frequency of than 12.5 kHz: At least 50 + 10 Log10 (P) or 70 dB, whichever is the lesser attenuation. Only 12.5KHz was tested as it would provide a higher power density due to the narrower bandwidth.

Attenuation for 1 W carrier power: 50 + 10 Log (P) dB = 50 + 10 Log (1) = 50

ERP Limit for any emission: 30 dBm – 50 dBm = -20 dBm

Field Strength Limit: E (dBuV/m) = ERP (dBm) -20log(D)+107 where D = measurement distance

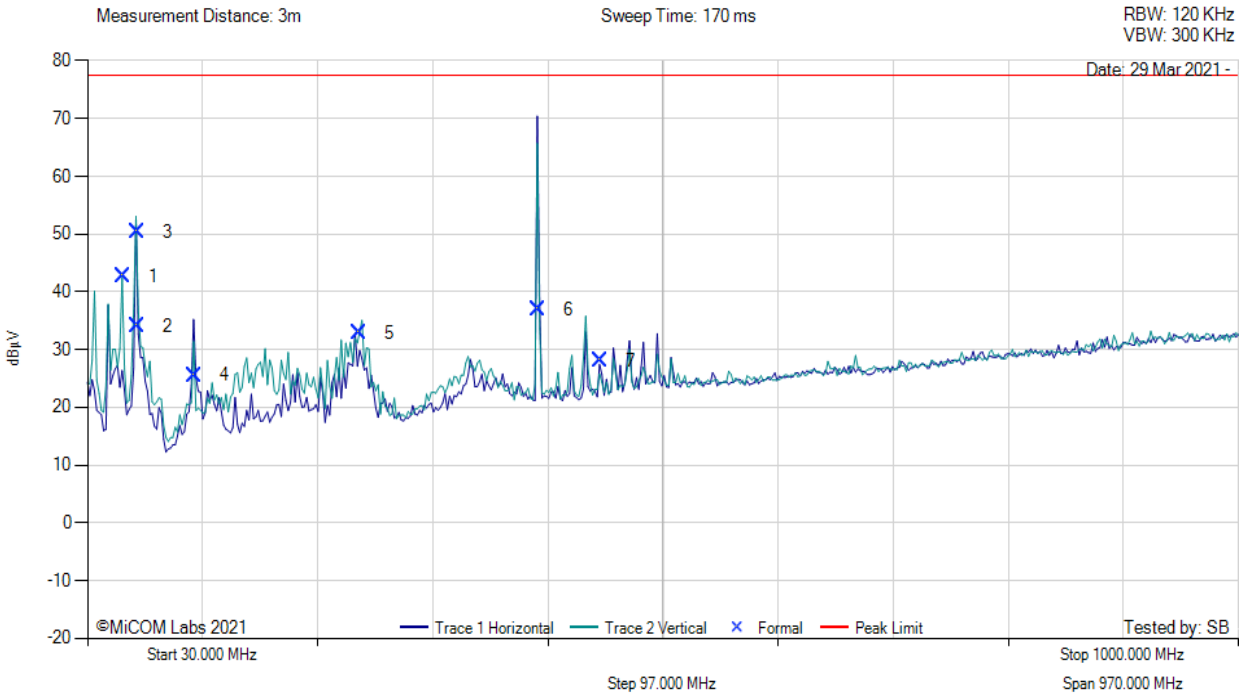
E (dBuV/m) = -20 – 20 Log (3) + 107 = 77.5 dBuv/m

Equipment Configuration for Radiated Digital Emissions

Antenna:	Not Applicable	**Variant:**	12.5KHz
Antenna Gain (dBi):	Not Applicable	**Modulation:**	GFSK
Beam Forming Gain (Y):	Not Applicable	**Duty Cycle (%):**	99
Channel Frequency (MHz):	410.00	**Data Rate:**	Not Applicable
Power Setting:	Max	**Tested By:**	SB

Test Measurement Results

Variant: 12.5KHz, Test Freq: 410.00 MHz, Power Setting: Max, Duty Cycle (%): 99

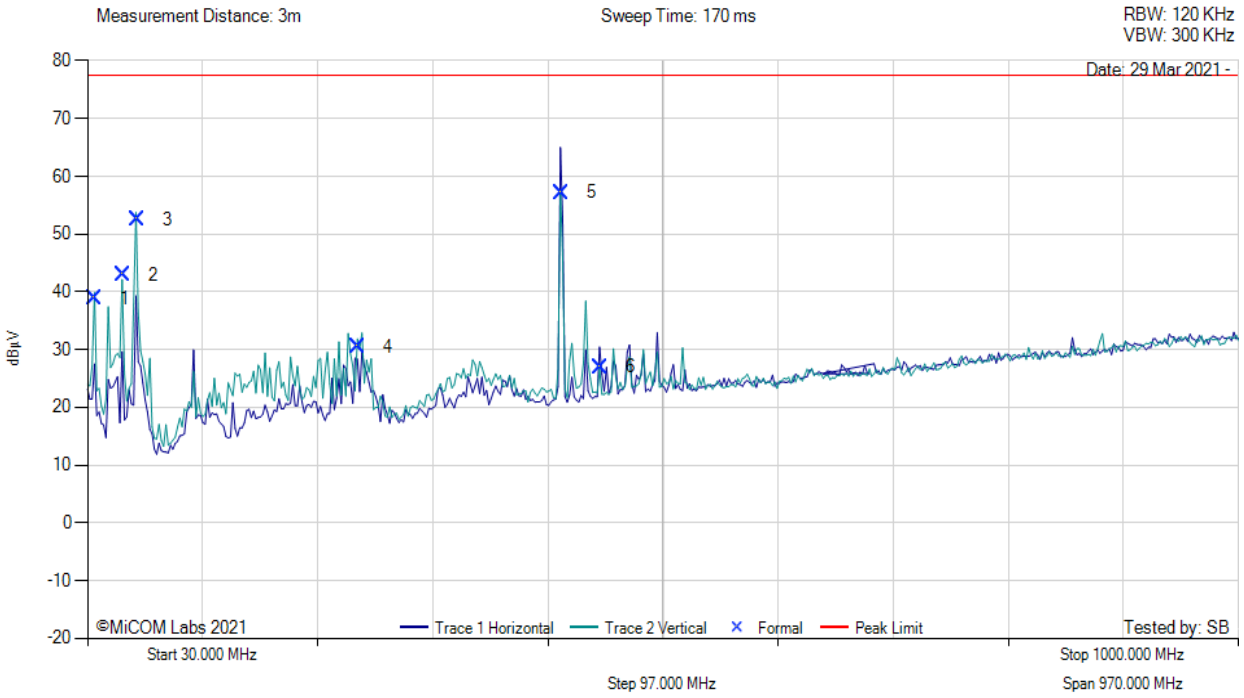


30.00 - 1000.00 MHz												
Num	**Frequency MHz**	**Raw dBµV**	**Cable Loss dB**	**AF dB/m**	**Level dBµV/m**	**Measurement Type**	**Pol**	**Hgt cm**	**Azt Deg**	**Limit dBµV/m**	**Margin dB**	**Pass /Fail**
1	60.06	59.99	3.80	-21.08	42.71	Peak (NRB)	Vertical	100	0	--	--	Pass
2	71.99	50.58	3.89	-20.42	34.05	Peak (NRB)	Horizontal	100	0	--	--	Pass
3	71.99	66.92	3.89	-20.42	50.39	Peak (NRB)	Vertical	100	0	--	--	Pass
4	120.03	36.18	4.17	-14.78	25.57	Peak (Scan)	Horizontal	100	0	77.5	-51.9	Pass
5	258.57	43.86	4.76	-15.83	32.79	Peak (Scan)	Vertical	100	0	77.5	-44.7	Pass
6	410.05	43.32	5.29	-11.65	36.96	Fundamental	Horizontal	100	0	--	--	
7	462.04	33.21	5.46	-10.65	28.02	Peak (NRB)	Vertical	100	0	--	--	Pass

Equipment Configuration for Radiated Digital Emissions			
Antenna:	Not Applicable	**Variant:**	12.5KHz
Antenna Gain (dBi):	Not Applicable	**Modulation:**	GFSK
Beam Forming Gain (Y):	Not Applicable	**Duty Cycle (%):**	99
Channel Frequency (MHz):	429.50	**Data Rate:**	Not Applicable
Power Setting:	Max	**Tested By:**	SB

Test Measurement Results

Variant: 12.5KHz, Test Freq: 429.50 MHz, Power Setting: Max, Duty Cycle (%): 99

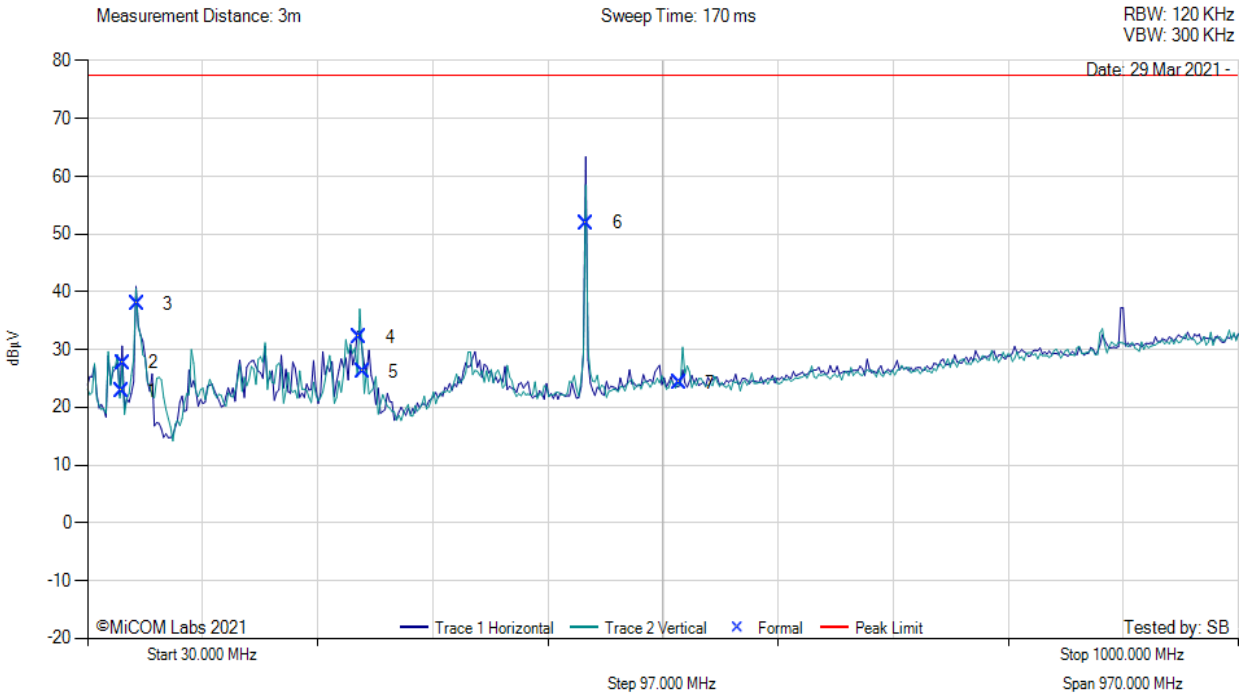


30.00 - 1000.00 MHz												
Num	**Frequency MHz**	**Raw dBµV**	**Cable Loss dB**	**AF dB/m**	**Level dBµV/m**	**Measurement Type**	**Pol**	**Hgt cm**	**Azt Deg**	**Limit dBµV/m**	**Margin dB**	**Pass /Fail**
1	36.08	47.74	3.62	-12.51	38.84	Peak (NRB)	Vertical	100	0	--	--	Pass
2	60.03	60.13	3.80	-21.08	42.85	Peak (NRB)	Vertical	100	0	--	--	Pass
3	72.06	69.03	3.90	-20.49	52.44	Peak (NRB)	Vertical	100	0	--	--	Pass
4	258.08	41.53	4.76	-15.83	30.45	Peak (Scan)	Vertical	100	0	77.5	-47.1	Pass
5	429.54	63.12	5.35	-11.31	57.16	Peak (NRB)	Horizontal	100	0	--	--	Pass
6	461.98	32.21	5.46	-10.64	27.03	Peak (NRB)	Vertical	100	0	--	--	Pass

Equipment Configuration for Radiated Digital Emissions			
Antenna:	Not Applicable	**Variant:**	12.5KHz
Antenna Gain (dBi):	Not Applicable	**Modulation:**	GFSK
Beam Forming Gain (Y):	Not Applicable	**Duty Cycle (%):**	99
Channel Frequency (MHz):	450.50	**Data Rate:**	Not Applicable
Power Setting:	Max	**Tested By:**	SB

Test Measurement Results

Variant: 12.5KHz, Test Freq: 450.50 MHz, Power Setting: Max, Duty Cycle (%): 99

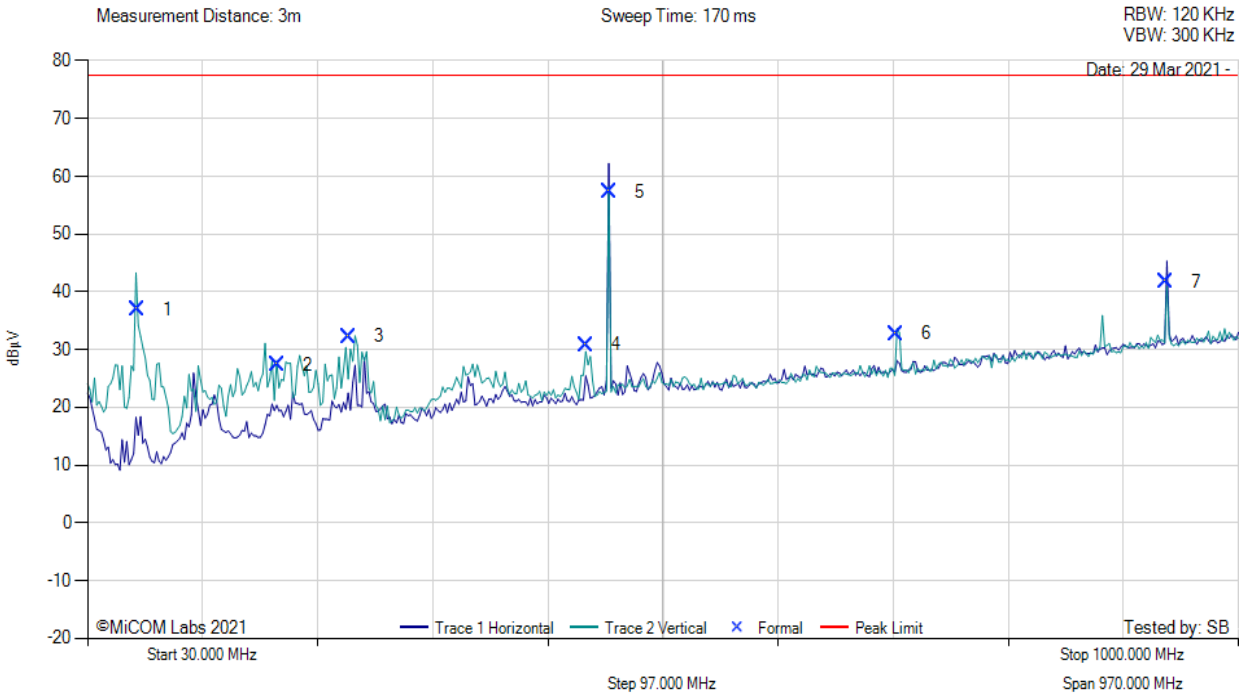


30.00 - 1000.00 MHz												
Num	**Frequency MHz**	**Raw dBµV**	**Cable Loss dB**	**AF dB/m**	**Level dBµV/m**	**Measurement Type**	**Pol**	**Hgt cm**	**Azt Deg**	**Limit dBµV/m**	**Margin dB**	**Pass /Fail**
1	58.87	40.23	3.79	-21.16	22.85	Peak (NRB)	Horizontal	100	0	--	--	Pass
2	59.98	44.87	3.80	-20.97	27.70	Peak (NRB)	Vertical	100	0	--	--	Pass
3	72.01	54.47	3.90	-20.49	37.88	Peak (NRB)	Horizontal	100	0	--	--	Pass
4	259.35	43.13	4.76	-15.73	32.15	Peak (Scan)	Vertical	100	0	77.5	-45.4	Pass
5	262.43	36.69	4.77	-15.35	26.11	Peak (Scan)	Horizontal	100	0	77.5	-51.4	Pass
6	450.59	57.50	5.42	-11.05	51.87	Fundamental	Horizontal	100	0	--	--	
7	528.99	28.08	5.67	-9.55	24.20	Peak (NRB)	Vertical	100	0	--	--	Pass

Equipment Configuration for Radiated Digital Emissions			
Antenna:	Not Applicable	**Variant:**	12.5KHz
Antenna Gain (dBi):	Not Applicable	**Modulation:**	GFSK
Beam Forming Gain (Y):	Not Applicable	**Duty Cycle (%):**	99
Channel Frequency (MHz):	469.50	**Data Rate:**	Not Applicable
Power Setting:	Max	**Tested By:**	SB

Test Measurement Results

Variant: 12.5KHz, Test Freq: 469.50 MHz, Power Setting: Max, Duty Cycle (%): 99



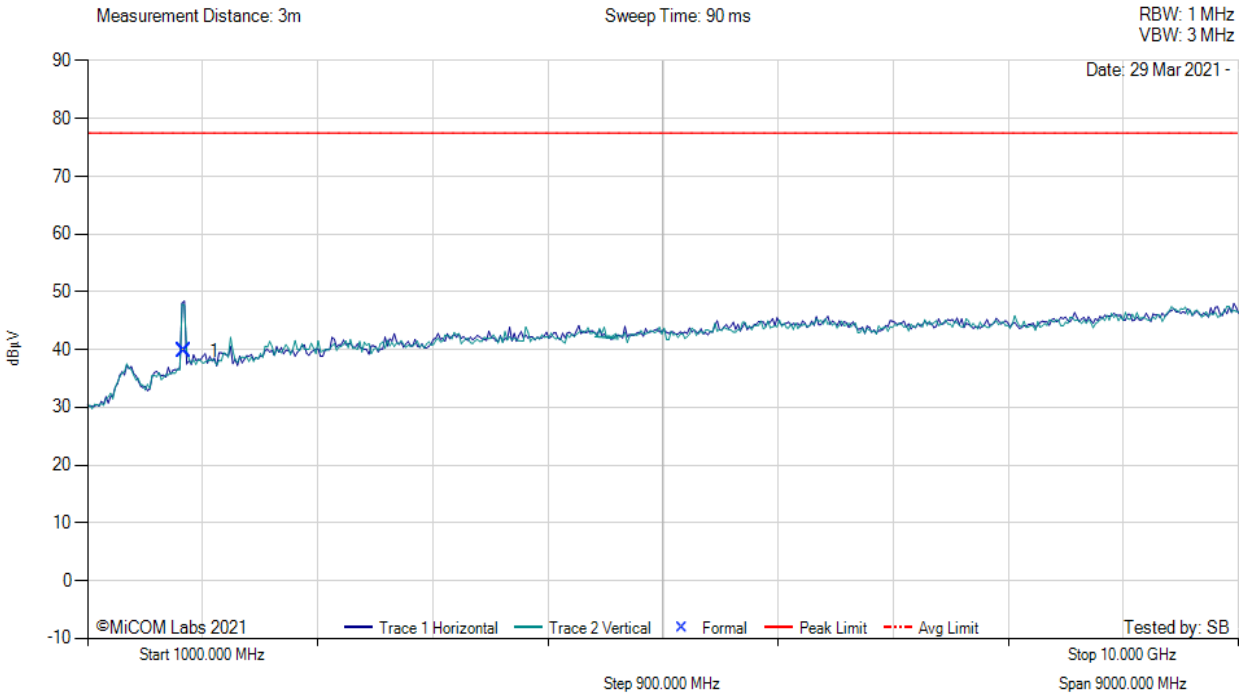
30.00 - 1000.00 MHz												
Num	**Frequency MHz**	**Raw dBµV**	**Cable Loss dB**	**AF dB/m**	**Level dBµV/m**	**Measurement Type**	**Pol**	**Hgt cm**	**Azt Deg**	**Limit dBµV/m**	**Margin dB**	**Pass /Fail**
1	72.10	53.53	3.90	-20.49	36.94	Peak (NRB)	Vertical	100	0	--	--	Pass
2	190.26	39.68	4.48	-16.82	27.34	Peak (NRB)	Vertical	100	0	--	--	Pass
3	249.78	43.73	4.72	-16.24	32.22	Peak (Scan)	Vertical	100	0	77.5	-45.3	Pass
4	449.76	36.46	5.42	-11.05	30.83	Peak (NRB)	Vertical	100	205	--	--	Pass
5	469.51	62.22	5.48	-10.36	57.34	Peak (NRB)	Horizontal	100	205	--	--	Pass
6	710.96	33.64	6.23	-7.14	32.73	Peak (NRB)	Vertical	100	205	--	--	Pass
7	939.03	39.14	6.87	-4.36	41.65	Peak (NRB)	Horizontal	100	205	--	--	Pass

Equipment Configuration for Restricted Band Spurious Emissions

Antenna:	Not Applicable	**Variant:**	12.5KHz
Antenna Gain (dBi):	Not Applicable	**Modulation:**	GFSK
Beam Forming Gain (Y):	Not Applicable	**Duty Cycle (%):**	99
Channel Frequency (MHz):	410.00	**Data Rate:**	Not Applicable
Power Setting:	Max	**Tested By:**	SB

Test Measurement Results

Variant: 12.5KHz, Test Freq: 410.00 MHz, Power Setting: Max, Duty Cycle (%): 99



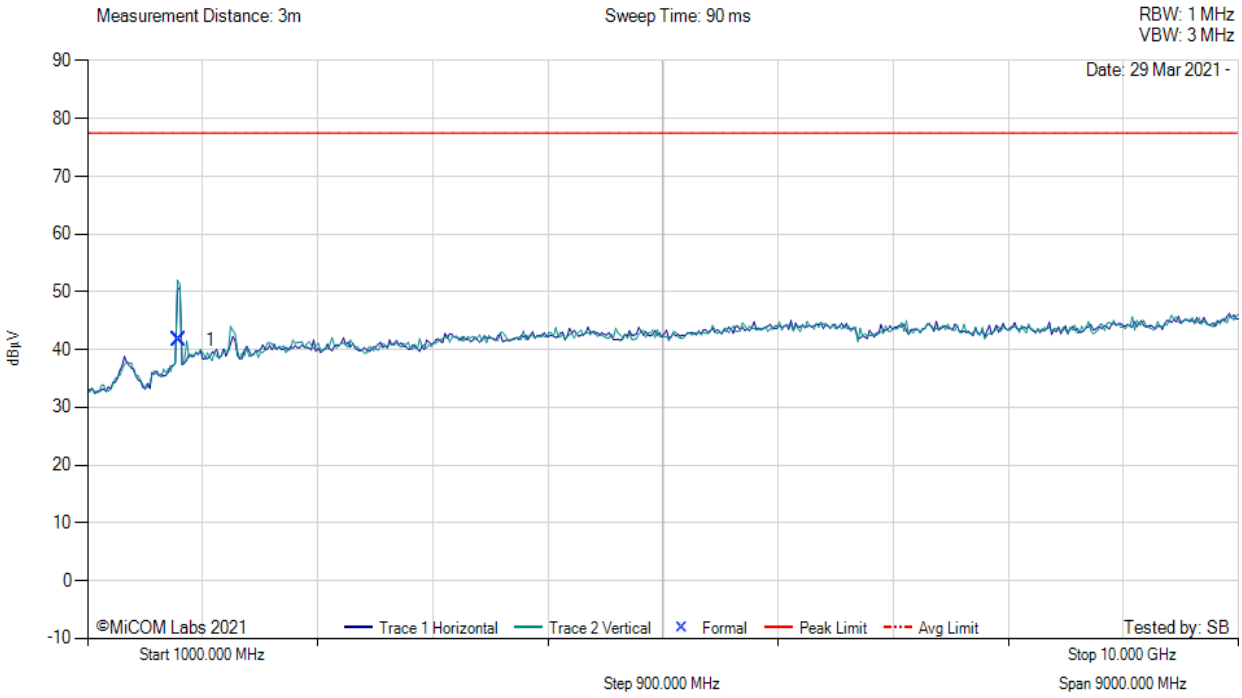
1000.00 - 10000.00 MHz												
Num	**Frequency MHz**	**Raw dBµV**	**Cable Loss dB**	**AF dB/m**	**Level dBµV/m**	**Measurement Type**	**Pol**	**Hgt cm**	**Azt Deg**	**Limit dBµV/m**	**Margin dB**	**Pass /Fail**
1	1752.10	53.24	1.69	-15.20	39.73	Peak (NRB)	Vertical	100	0	--	--	Pass

Equipment Configuration for Restricted Band Spurious Emissions

Antenna:	Not Applicable	**Variant:**	12.5KHz
Antenna Gain (dBi):	Not Applicable	**Modulation:**	GFSK
Beam Forming Gain (Y):	Not Applicable	**Duty Cycle (%):**	99
Channel Frequency (MHz):	429.50	**Data Rate:**	Not Applicable
Power Setting:	Max	**Tested By:**	SB

Test Measurement Results

Variant: 12.5KHz, Test Freq: 429.50 MHz, Power Setting: Max, Duty Cycle (%): 99

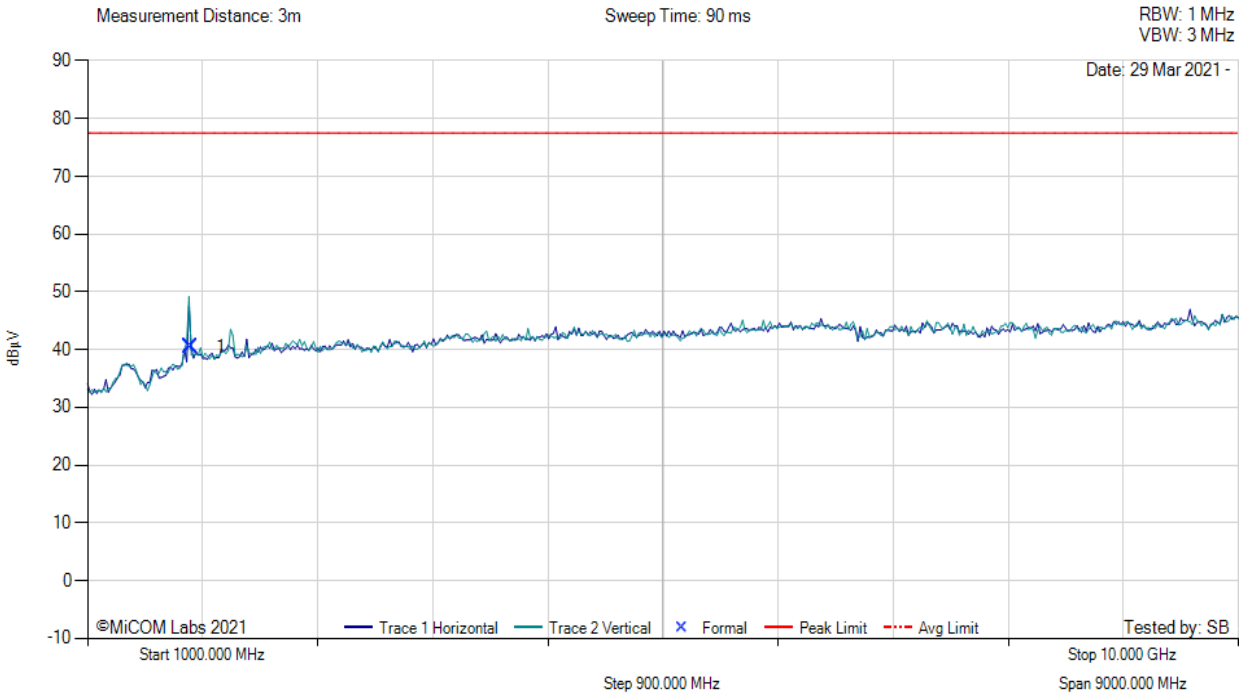


1000.00 - 10000.00 MHz												
Num	**Frequency MHz**	**Raw dBµV**	**Cable Loss dB**	**AF dB/m**	**Level dBµV/m**	**Measurement Type**	**Pol**	**Hgt cm**	**Azt Deg**	**Limit dBµV/m**	**Margin dB**	**Pass /Fail**
1	1718.43	55.60	1.71	-15.71	41.60	Peak (NRB)	Vertical	100	0	--	--	Pass

Equipment Configuration for Restricted Band Spurious Emissions			
Antenna:	Not Applicable	**Variant:**	12.5KHz
Antenna Gain (dBi):	Not Applicable	**Modulation:**	GFSK
Beam Forming Gain (Y):	Not Applicable	**Duty Cycle (%):**	99
Channel Frequency (MHz):	450.50	**Data Rate:**	Not Applicable
Power Setting:	Max	**Tested By:**	SB

Test Measurement Results

Variant: 12.5KHz, Test Freq: 450.50 MHz, Power Setting: Max, Duty Cycle (%): 99



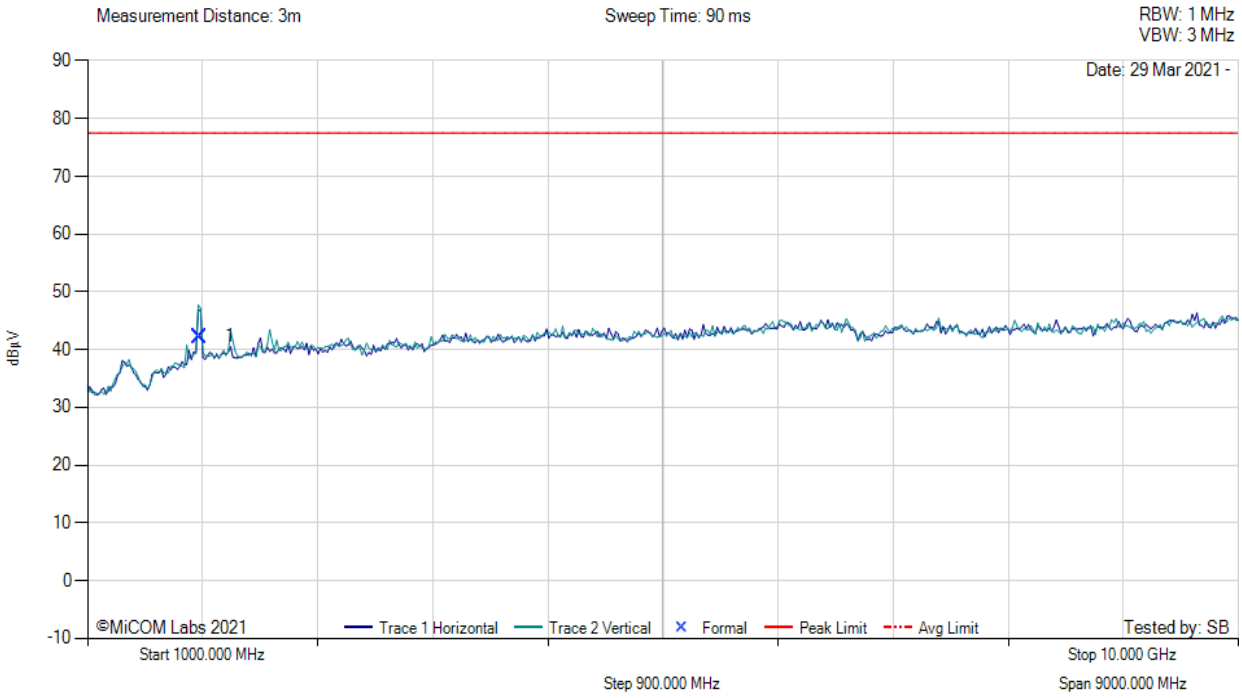
1000.00 - 10000.00 MHz												
Num	**Frequency MHz**	**Raw dBµV**	**Cable Loss dB**	**AF dB/m**	**Level dBµV/m**	**Measurement Type**	**Pol**	**Hgt cm**	**Azt Deg**	**Limit dBµV/m**	**Margin dB**	**Pass /Fail**
1	1802.02	53.25	1.75	-14.55	40.45	Peak (NRB)	Vertical	130	0	--	--	Pass

Equipment Configuration for Restricted Band Spurious Emissions

Antenna:	Not Applicable	**Variant:**	12.5KHz
Antenna Gain (dBi):	Not Applicable	**Modulation:**	GFSK
Beam Forming Gain (Y):	Not Applicable	**Duty Cycle (%):**	99
Channel Frequency (MHz):	469.50	**Data Rate:**	Not Applicable
Power Setting:	Max	**Tested By:**	SB

Test Measurement Results

Variant: 12.5KHz, Test Freq: 469.50 MHz, Power Setting: Max, Duty Cycle (%): 99



1000.00 - 10000.00 MHz												
Num	**Frequency MHz**	**Raw dBµV**	**Cable Loss dB**	**AF dB/m**	**Level dBµV/m**	**Measurement Type**	**Pol**	**Hgt cm**	**Azt Deg**	**Limit dBµV/m**	**Margin dB**	**Pass /Fail**
1	1878.51	54.45	1.80	-13.96	42.29	Peak (NRB)	Vertical	140	0	--	--	Pass

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