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TIMCO ENGINEERING, Inc.

An IIA Company

FCC CFR 47 Part 80 & 90 Radar Test Report

APPLICANT	NAVICO INC.
ADDRESS	4500 S. 129TH EAST AVENUE SUITE 200, TULSA OK 74134-5885 USA
FCC ID	RAYHALO24
MODEL NUMBER	Halo24
PRODUCT DESCRIPTION	BROADBAND RADAR
DATE SAMPLE RECEIVED	07/05/2018
FINAL TEST DATE	08/01/2018
TESTED BY	Franklin Rose
APPROVED BY	Tim Royer
TEST RESULTS	☒ PASS ☐ FAIL

Report Number	Report Version	Description	Issue Date
988AUT18TestReport_	Rev1	Initial Issue	08/01/2018

TABLE OF CONTENTS

GENERAL REMARKS

Summary

The device under test does:

☒ Fulfill the general approval requirements as identified in this test report and was selected by the customer.

☐ Not fulfill the general approval requirements as identified in this test report

Attestations

This equipment has been tested in accordance with the standards identified in this test report. To the best of my knowledge and belief, these tests were performed using the measurement procedures described in this report.

All instrumentation and accessories used to test products for compliance to the indicated standards are calibrated regularly in accordance with ISO 17025 requirements.

I attest that the necessary measurements were made at:

Timco Engineering Inc.
849 NW State Road 45
Newberry, FL 32669
Designation #: US1070

Tested by:

Name and Title	Franklin Rose, Project Manager / EMC Testing Technician
Date	08/01/2018

Reviewed and Approved by:

Name and Title	Tim Royer, Project Manager / EMC Testing Engineer
Date	08/01/2018

GENERAL INFORMATION

Definitions: FCC Part 80.5, 87.3, 90.7

The EUT is a Ship-borne Radar Station operating in the Maritime Radiodetermination Service performing radiodetermination and/or radionavigation.

Radar. A radiodetermination system based upon the comparison of reference signals with radio signals reflected, or re-transmitted, from the position to be determined.

Maritime radiodetermination service. A maritime radiocommunication service for determining the position, velocity, and/or other characteristics of an object, or the obtaining of information relating to these parameters, by the propagation properties of radio waves.

Radiolocation. Radiodetermination used for purposes other than those of radionavigation.

Radionavigation. Radiodetermination used for the purposes of navigation, including obstruction warning.

Radiodetermination service. A radiocommuncation service which uses radiodetermination. Radiodetermination is the determination of the position, velocity and/or other characteristics of an object, or the obtaining of information relating to these parameters, by means of the propagation of radio waves. A station in this service is called a radiodetermination station.

Radionavigation service. A radiodetermination service for the purpose of radionavigation. Radionavigation is the use of radiodetermination for the purpose of navigation, including obstruction warning.

GENERAL INFORMATION

Testing Information

EUT Description	BROADBAND RADAR		
FCC ID	RAYHALO24		
Model Number	Halo24		
Operating Range(s)	Band 1: 9.3 – 9.5 GHz		
Test Frequencies	Band 1: 9390, 9400.93, 9418.11, 9427.65, 9430.7, 9427.32 MHz		
Type of Emission	100MP0N		
Modulation	Pulse/FM Chirp		
EUT Power Source	☐110–120 VAC	☒ DC Power (12 V)	☐ Battery Operated
Test Item	☐ Prototype	☒ Pre-Production	☐ Production
Type of Equipment	☒ Fixed	☐ Mobile	☐ Portable
Antenna Connector	Precision N-Connector		
Modification to the EUT	The EUT was tested without the rotational antenna, using an N-type connector for conducted power output measurement.		
Test Exercise	The EUT was operated using control software provided by the manufacturer in accordance with the user manual.		
Applicable Standards	FCC CFR 47 Part 2, Part 80, Part 90 using ANSI C63.26-2015, TIA-603-E 2015. Referencing: ITU-R M.1177-4, NTIA “Manual Of Regulations”		
Test Conditions	Laboratory temperature: 26ºC, Relative humidity: 50%		
Test Facility	Timco Engineering Inc. at 849 NW State Road 45 Newberry, FL 32669 USA. Designation #: US1070		

GENERAL INFORMATION

Operating Frequencies

EUT Intended Band(s) of Operation

Band 1: 9.3 – 9.5 GHz

Rule Part No.: FCC Part 80.45, 80.375, 90.103

(d) *Radiodetermination frequency bands above 2400 MHz.* (1) The radiodetermination frequency bands assignable to ship and shore stations including ship and shore radar and transponder stations are as follows: 2450-2500 MHz; 2900-3100 MHz; 5460-5650 MHz; and 9300-9500 MHz.

(2) Assignment of these bands to ship and coast stations are subject to the following conditions:

(ii) The use of the 2900-3100 MHz, 5470-5650 MHz and 9300-9500 MHz bands for radiolocation must not cause harmful interference to the radionavigation and Government radiolocation services. Additionally, the use of the 2900-3000 MHz band for radiolocation must not cause harmful interference to the Government meteorological aids service.

(iii) In the 2920-3100 MHz and 9320-9500 MHz bands the use of fixed-frequency transponders for radionavigation is not permitted;

§90.103 Radiolocation Service.

(b) *Frequencies available.* The following table indicates frequencies available for assignment to stations in the Radiolocation Service, together with the class of station(s) to which they are normally assigned, and the specific assignment limitations, which are explained in paragraph (c) of this section:

RADIOLOCATION SERVICE FREQUENCY TABLE

Frequency or band	Class of station(s)	Limitation
Megahertz		
9300 to 9500	.....do	10, 15, 18

(10) Speed measuring devices will not be authorized in this band.

(15) The non-Government Radiolocation Service in this band is secondary to the Maritime Radionavigation Stations (part 80), the Aeronautical Radionavigation Service (part 87) and the Government Radiolocation Service.

(18) Radiolocation installations will be coordinated with the Government Meteorological Aids Service, and insofar as practicable, will be adjusted to meet the needs of that service.

GENERAL INFORMATION

Operating Modes

The EUT operates in the following modes. For the sake of brevity, the modes are also referred to using a alternate name, below:

Mode Name	Alternate Name
< 400 ft.	< 0.0625 nm
1/8 Nautical Mile	0.125 nm
1/4 Nautical Mile	0.25 nm
1/2 Nautical Mile	0.5 nm
3/4 Nautical Mile	0.75 nm
1 Nautical Mile	1 nm
1.5 Nautical Mile	1.5 nm
2 Nautical Mile	2 nm
3 Nautical Mile	3 nm
4 Nautical Mile	4 nm
6 Nautical Mile	6 nm
8 Nautical Mile	8 nm
12 Nautical Mile	12 nm
16 Nautical Mile	16 nm
24 Nautical Mile	24 nm
≥ 36 Nautical Mile	≥ 36 nm

SUMMARY OF TESTING

Rule Part No.	Test Performed	Result
2.1033(c)(4), 80.207(d), 80.205(a)	Modulation Characteristics	**PASS**
N/A	Pulse Characteristics	N/A
2.1046(a), 80.215(a)(3), 80.215(i)(1), (2), 90.205(r)	RF Power Output	**PASS**
2.1049(i), 80.213(g), 80.209(b), 90.207(k), (n), 90.209(b)(5)	Occupied Bandwidth	**PASS**
80.211(f)(1), (2), 90.210(n), (b)(1), (2)	Emission Masks	**PASS**
2.1051(a), 2.1057(a)(1), 80.211(f)(3), 90.210(n), (b)(3)	Spurious Emissions at Antenna Terminals	**PASS**
2.1053(a), 2.1057(a)(1), 80.211(f)(3), 90.210(n), (b)(3)	Field Strength of Spurious Emissions	**PASS**
2.1055(a)(2), 80.209(b), 90.213(a)	Frequency Stability	**PASS**

MODULATION CHARACTERISTICS

FCC Rule Parts: Part 2.1033(c)(4), 80.207(d), 80.205(a)

§80.207 Classes of emission.

(d) The authorized classes of emission are as follows:

Types of stations	Classes of emission
Ship Stations[1]	
Radiodetermination:	
2.4-9.5 GHz	PON.
Land Stations[1]	
Radiodetermination:	
2.4-9.6 GHz	PON.

[1]Excludes distress, EPIRBs, survival craft, and automatic link establishment.

§80.205 Bandwidths.

(a) An emission designator shows the necessary bandwidth for each class of emission of a station except that in ship earth stations it shows the occupied or necessary bandwidth, whichever is greater. The following table gives the class of emission and corresponding emission designator and authorized bandwidth:

Class of emission	Emission designator	Authorized bandwidth (kHz)
PON	([12])	([12])

[12]Applicable to radiolocation and associated telecommand ship stations operating on 154.585 MHz, 159.480 MHz, 160.725 MHz. 160.785 MHz, 454.000 MHz, and 459.000 MHz; emergency position indicating radiobeacons operating in the 406.000-406.1000 MHz frequency bank; and data transmissions in the 156-162 MHz band.

Note: Per footnote 12, 80.205(a) does not state requirements for an emission designator or an Authorized bandwidth for radar operating above 2.4 GHz. However, the class of emission shall be P0N.

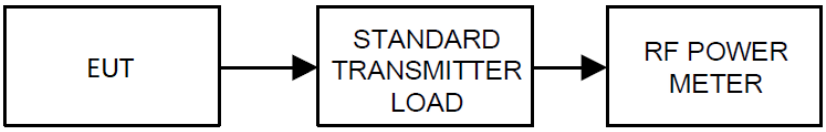
100MP0N Bandwidth

Worst-case 99% Occupied Bandwidth: **100.2 MHz**

Note: Please see "99% Occupied Bandwidth" section for details.

PULSE CHARACTERISTICS

Test Setup Block Diagram:

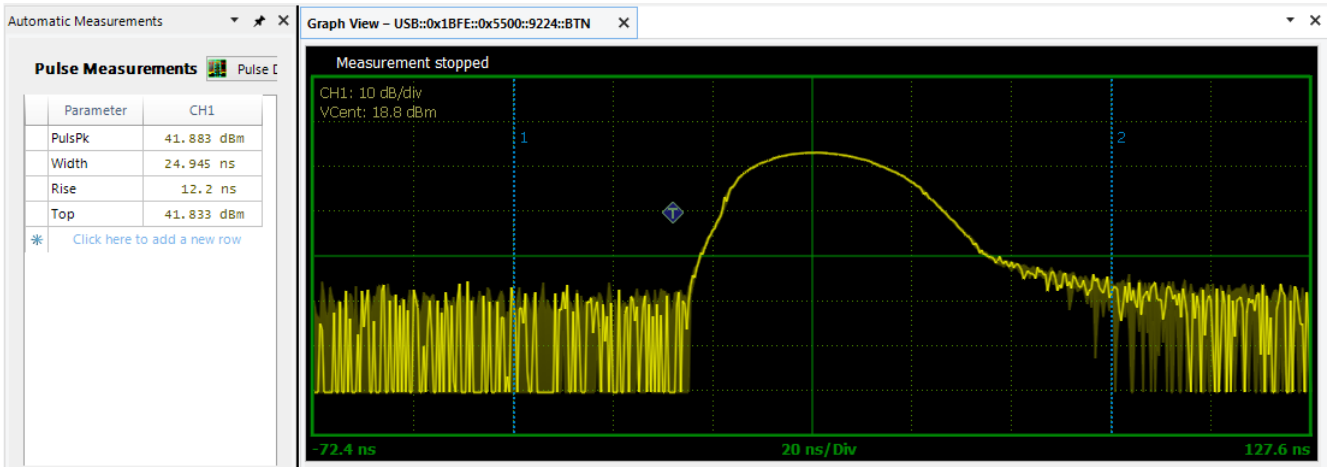


Test Data: Pulse Measurement Table

The EUT employs 16 operational modes, each consisting of a fixed array of pulses from among 7 pulse types, P1 – P7.

Pulse Name	Width (µs)	Rise Time (µs)	Peak Power (dBm)
P1	0.025	0.0122	41.883
P2	1.6	0.182	43.500
P3	7.1	0.778	43.316
P4	14.1	1.49	43.247
P5	27.8	3.15	42.800
P6	55.2	6.58	42.559
P7	55.1	6.61	43.316

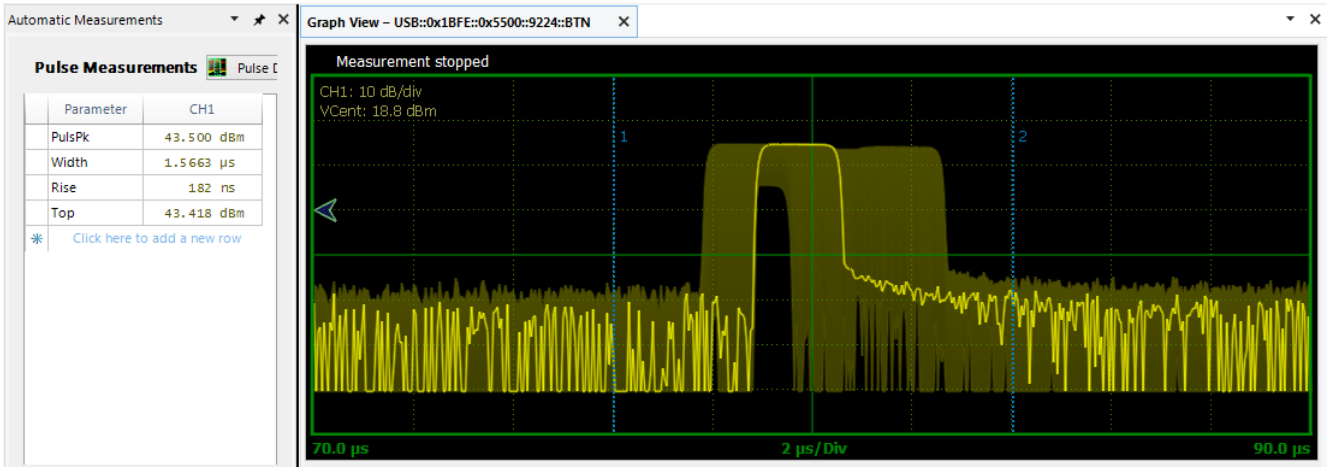
Test Data: P1 Pulse Plot



P1 Pulse Width = **0.024945 µs**
P1 Rise Time = **0.0122 µs**
P1 Pulse Peak = **41.883 dBm**

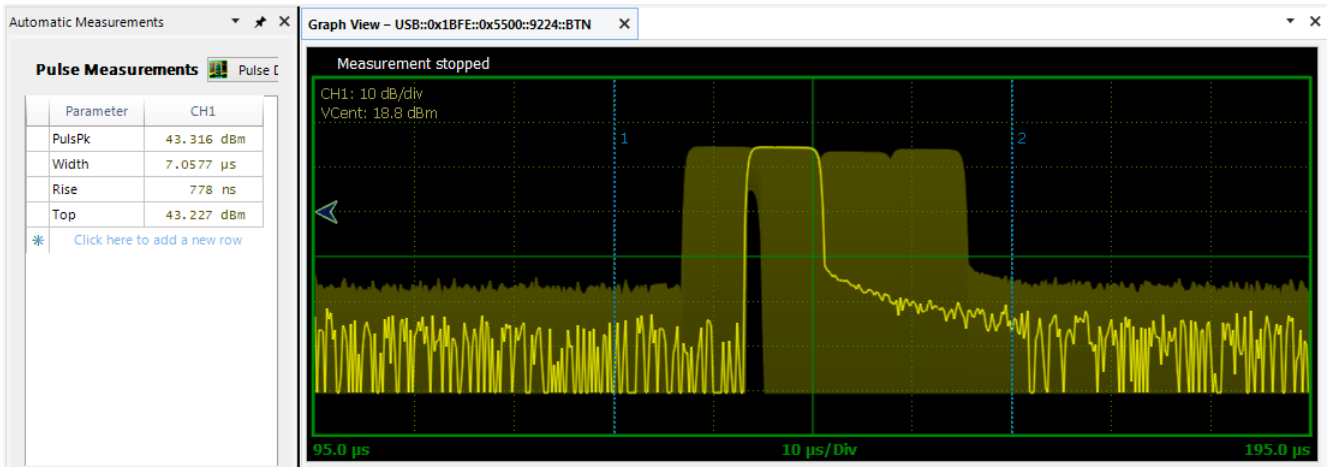
PULSE CHARACTERISTICS

Test Data: P2 Pulse Plot



P2 Pulse Width = **1.5663 µs**
P2 Rise Time = **0.0122 µs**
P2 Peak Power = **43.500 dBm**

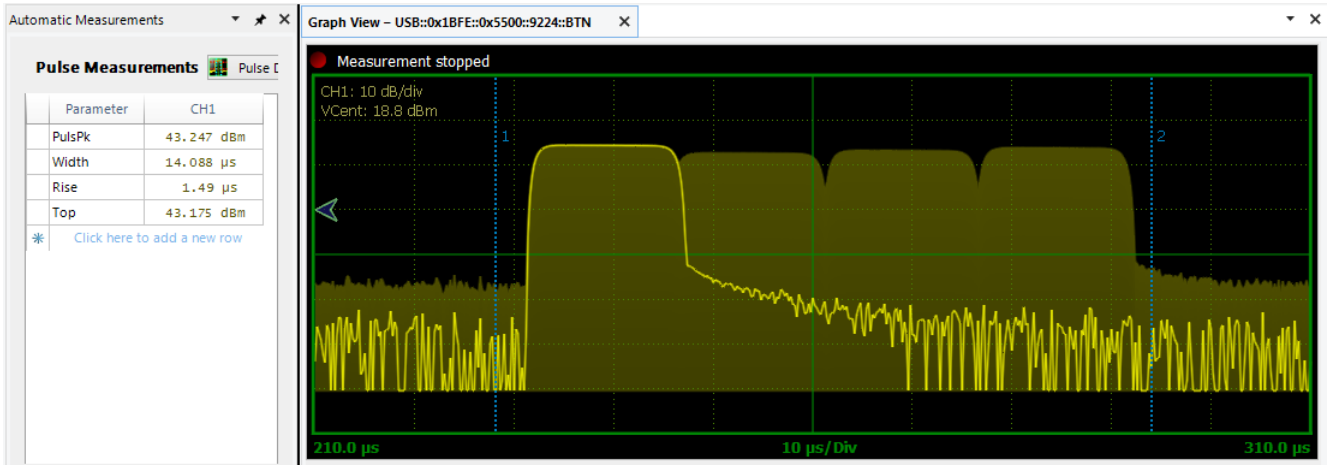
Test Data: P3 Pulse Plot



P3 Pulse Width = **7.0577 µs**
P3 Rise Time = **0.778 µs**
P3 Peak Power = **43.316 dBm**

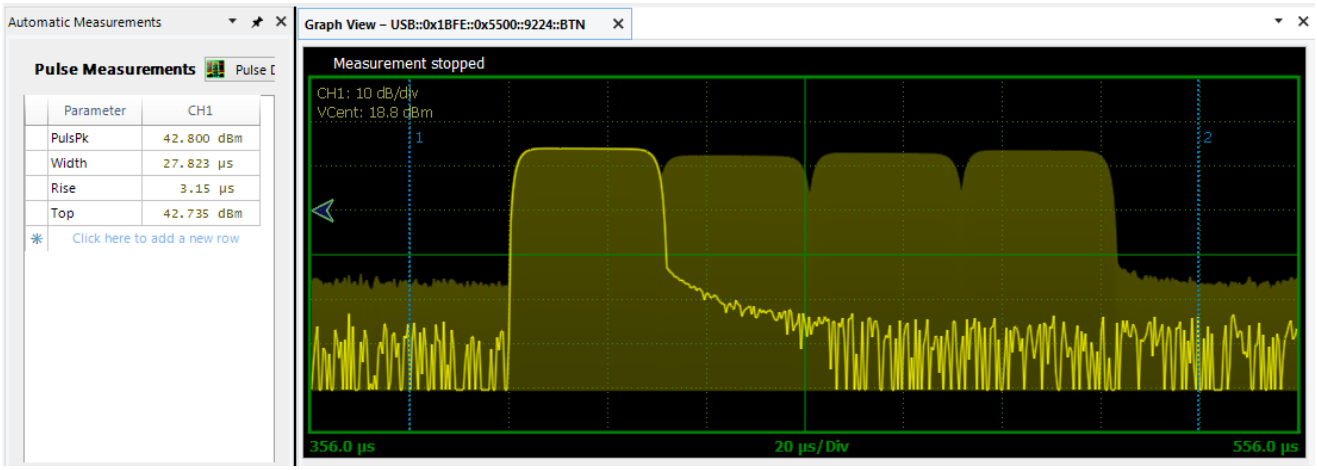
PULSE CHARACTERISTICS

Test Data: P4 Pulse Plot



P4 Pulse Width = **14.088 µs**
P4 Rise Time = **1.49 µs**
P4 Peak Power = **43.247 dBm**

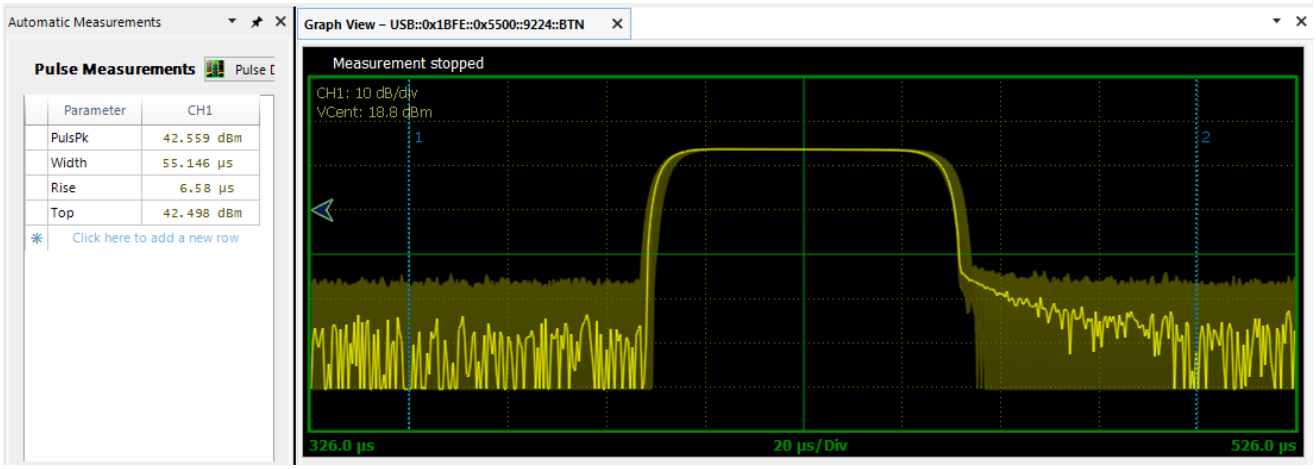
Test Data: P5 Pulse Plot



P5 Pulse Width = **27.823 µs**
P5 Rise Time = **3.15 µs**
P5 Peak Power = **42.800 dBm**

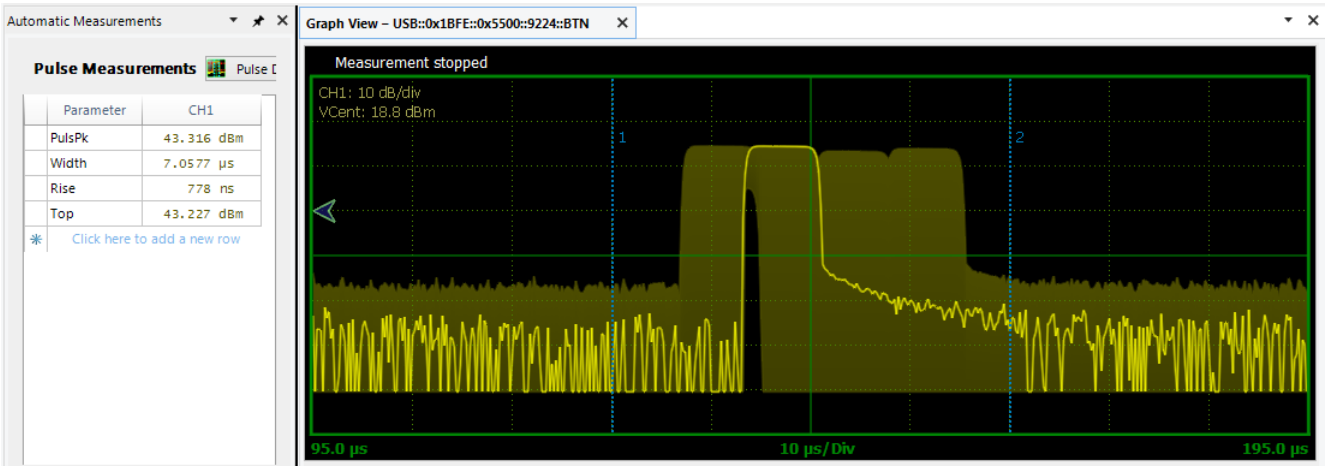
PULSE CHARACTERISTICS

Test Data: P6 Pulse Plot



P6 Pulse Width = **55.146 µs**
P6 Rise Time = **6.58 µs**
P6 Peak Power = **42.559 dBm**

Test Data: P7 Pulse Plot



P7 Pulse Width = **7.0577 µs**
P7 Rise Time = **0.778 µs**
P7 Peak Power = **43.316 dBm**

PULSE TRAIN CHARACTERISTICS

Test Data: Pulse Train Measurement Table

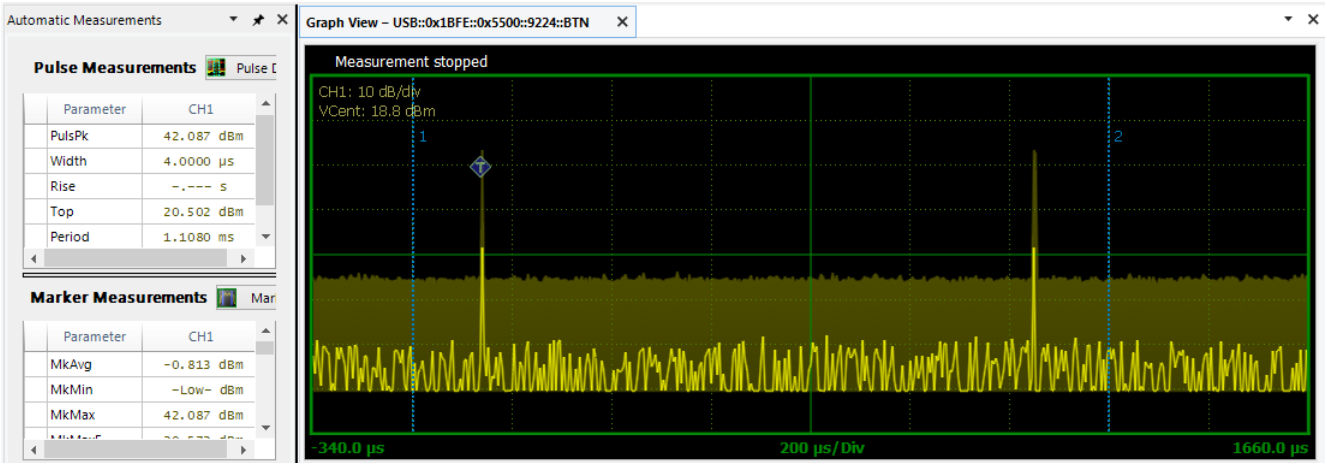
Operating Mode	Pulse Train	Total Pulse Width (µs)	Rep Rate (µs)	Duty Cycle (%)
≤ 400 ft	P1	0.025	1108.0	0.002%
1/8 nm	P1	0.025	1112.0	0.002%
1/4 nm	P1-P2	1.625	1023.8	0.159%
1/2 nm	P1-P2	1.625	1080.0	0.150%
3/4 nm	P1-P3	8.725	1031.2	0.846%
1 nm	P1-P3	8.725	1051.4	0.830%
1.5 nm	P1-P3	8.725	1105.1	0.790%
2 nm	P1-P4	22.825	1060.0	2.153%
3 nm	P1-P4	22.825	1100.0	2.075%
4 nm	P1-P5	50.625	1082.0	4.679%
6 nm	P1-P5	50.625	1045.0	4.844%
8 nm	P1-P4, P6	78.025	1110.0	7.029%
12 nm	P1-P4, P6	78.025	1110.0	7.029%
16 nm	P1-P4, P6	78.025	1130.0	6.905%
24 nm	P1-P4, P6	78.025	1220.0	6.395%
≥ 36 nm	P1-P4, P7	77.925	1230.0	6.335%

Worst-case Pulse Width = **78.025 µs**

Worst-case Duty Cycle = **7.029 %**

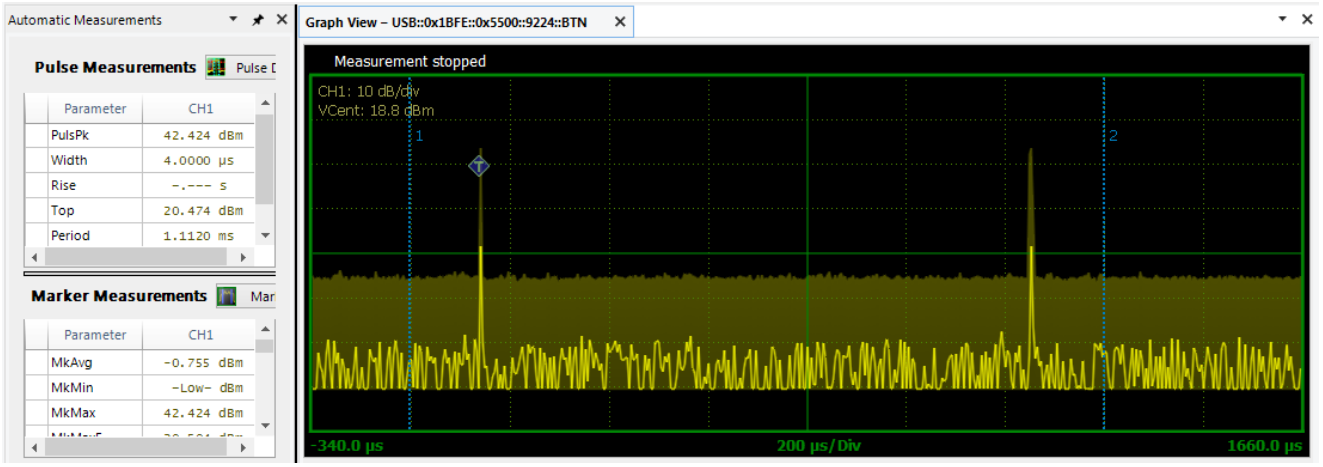
PULSE TRAIN CHARACTERISTICS

Test Data: ≤ 400 ft Mode



≤ 400 ft Mode Repetition Rate = **1.1080 ms**

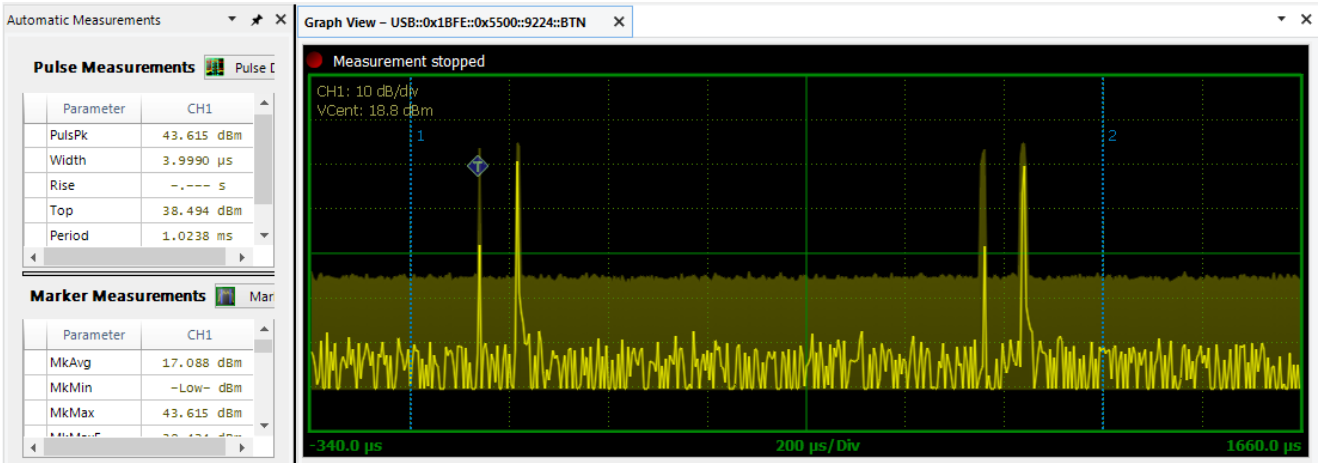
Test Data: 1/8 Nautical Mile Mode



1/8 Nautical Mile Mode Repetition Rate = **1.1120 ms**

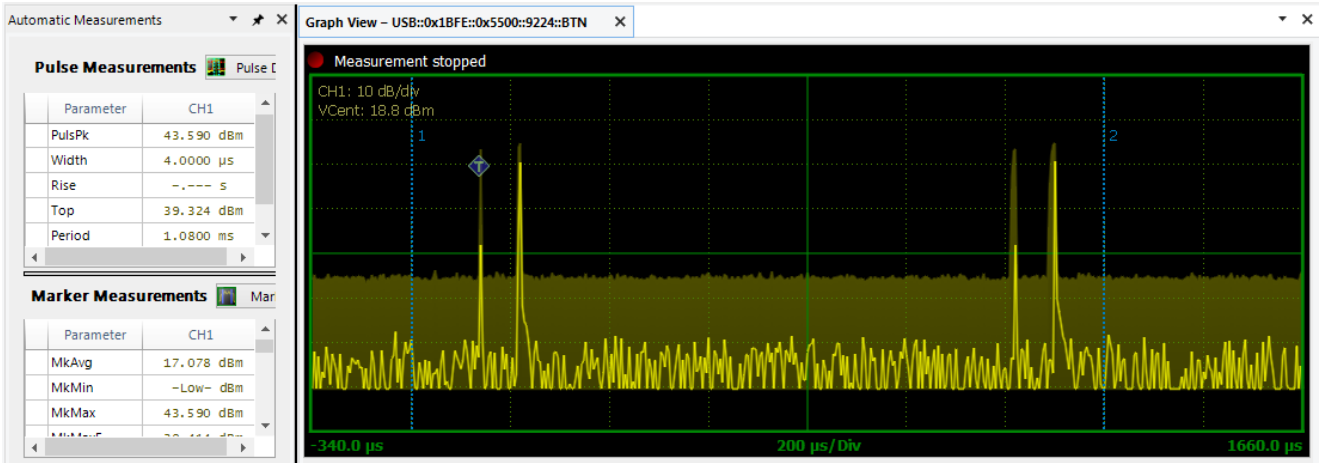
PULSE TRAIN CHARACTERISTICS

Test Data: 1/4 Nautical Mile Mode



1/4 Nautical Mile Mode Repetition Rate = **1.0238 ms**

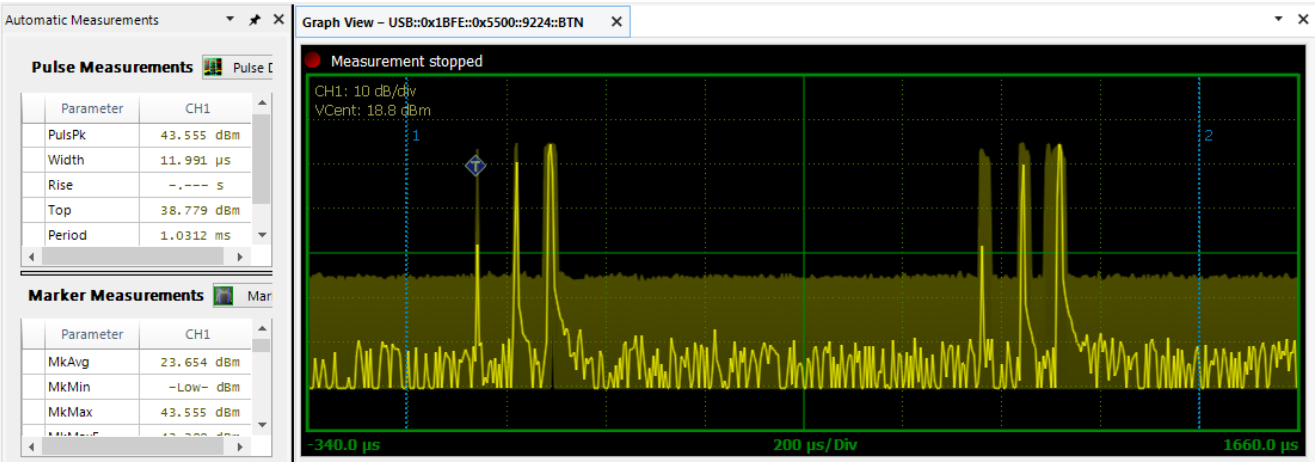
Test Data: 1/2 Nautical Mile Mode



1/2 Nautical Mile Mode Repetition Rate = **1.0800 ms**

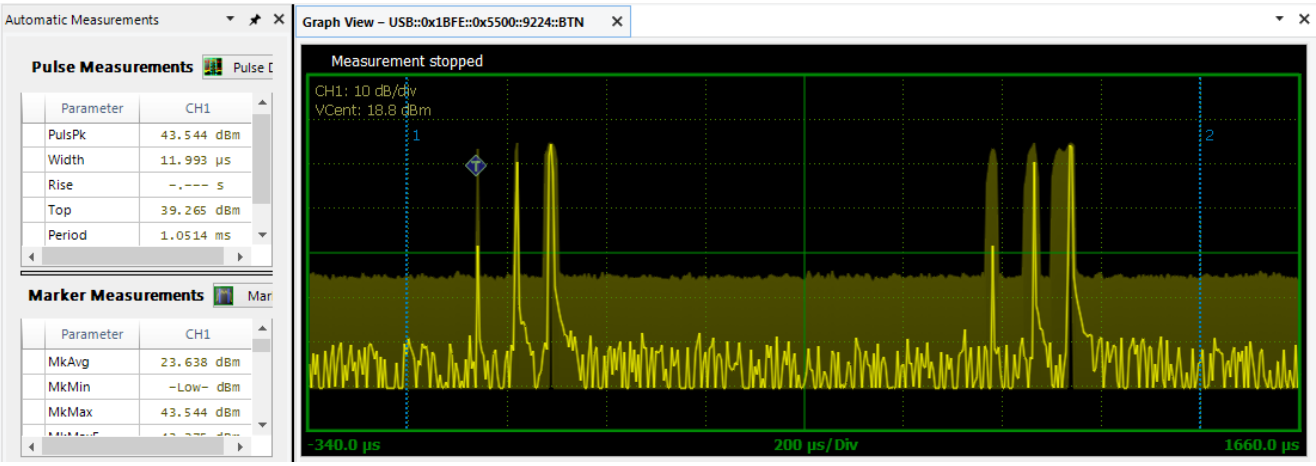
PULSE TRAIN CHARACTERISTICS

Test Data: 3/4 Nautical Mile Mode



3/4 Nautical Mile Mode Repetition Rate = **1.0312 ms**

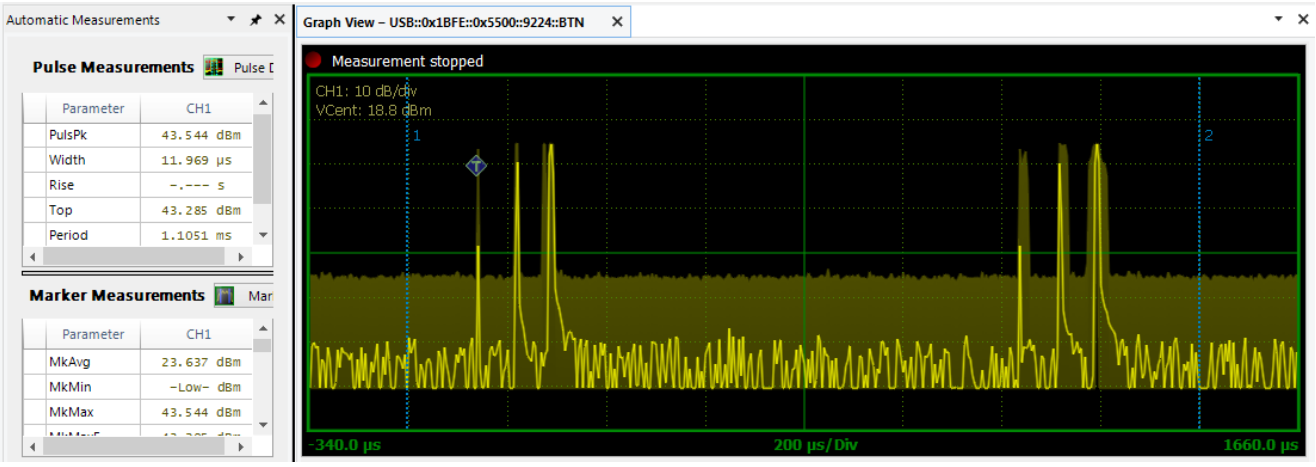
Test Data: 1 Nautical Mile Mode



1 Nautical Mile Mode Repetition Rate = **1.0514 ms**

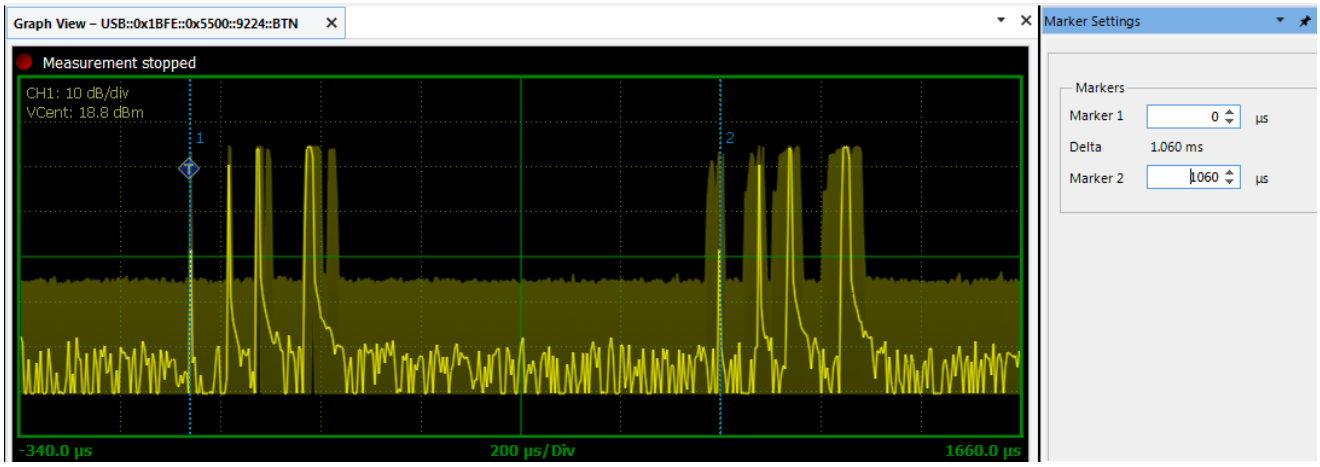
PULSE TRAIN CHARACTERISTICS

Test Data: 1.5 Nautical Mile Mode



1.5 Nautical Mile Mode Repetition Rate = **1.1051 ms**

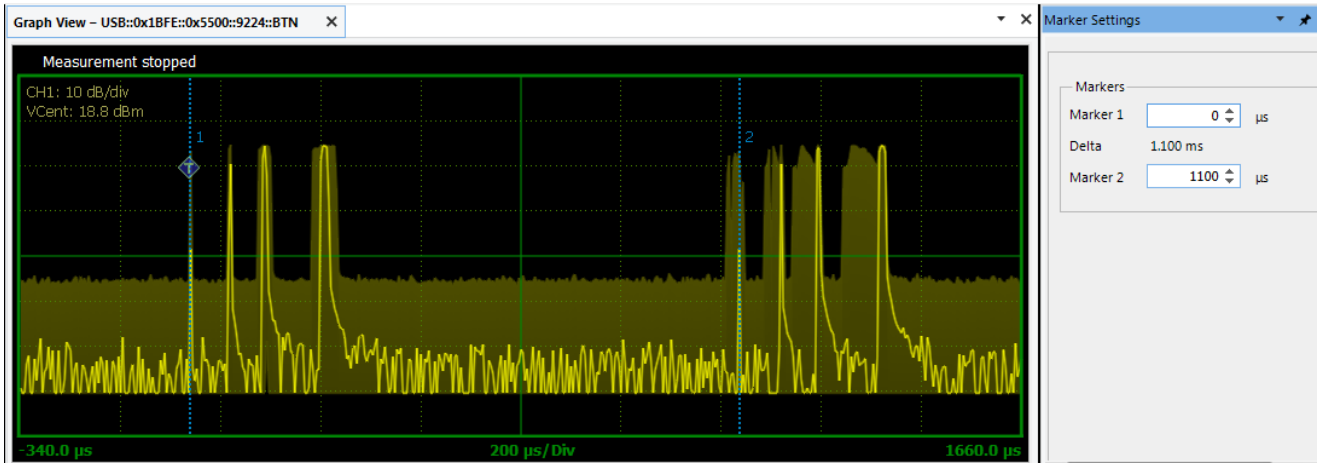
Test Data: 2 Nautical Mile Mode



2 Nautical Mile Mode Repetition Rate = **1.060 ms**

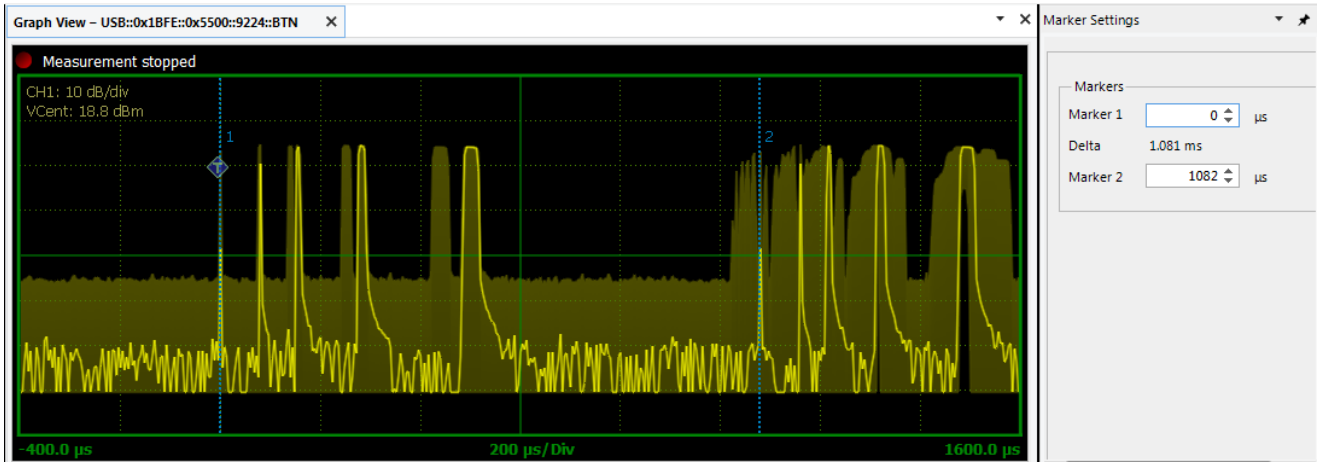
PULSE TRAIN CHARACTERISTICS

Test Data: 3 Nautical Mile Mode



3 Nautical Mile Mode Repetition Rate = **1.100 ms**

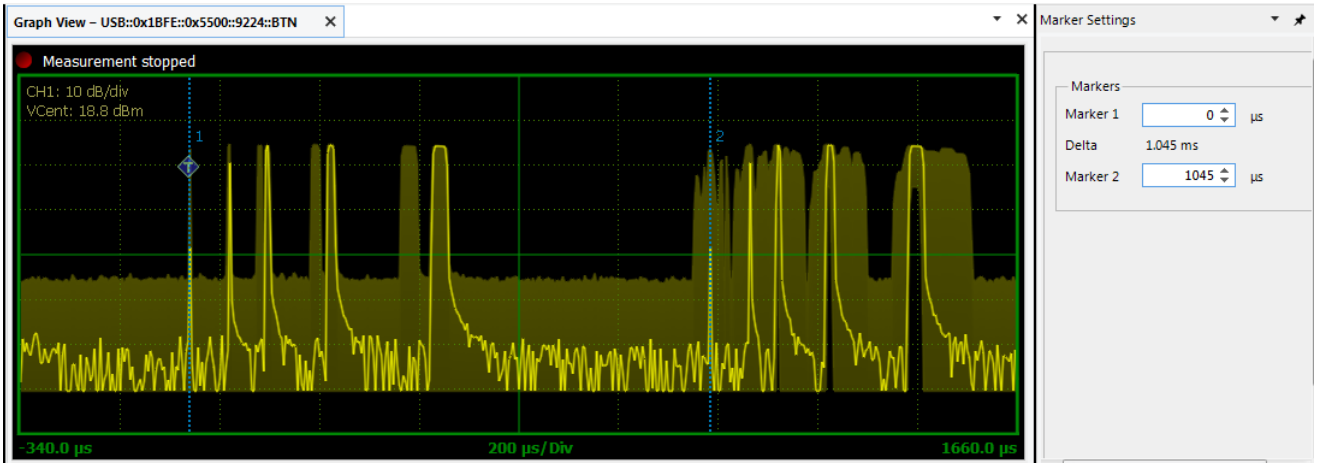
Test Data: 4 Nautical Mile Mode



4 Nautical Mile Mode Repetition Rate = **1.082 ms**

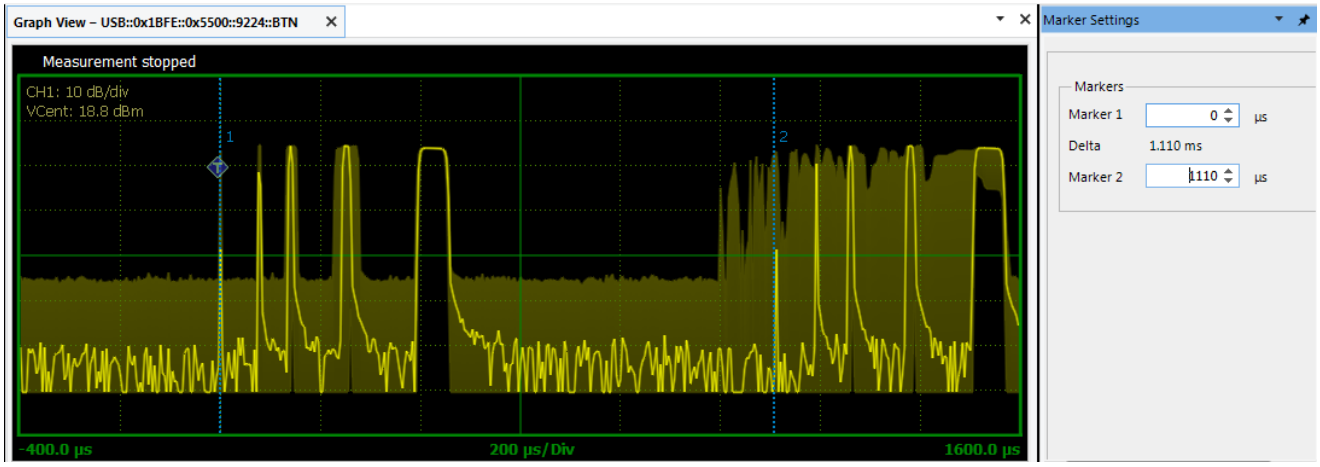
PULSE TRAIN CHARACTERISTICS

Test Data: 6 Nautical Mile Mode



6 Nautical Mile Mode Repetition Rate = **1.045 ms**

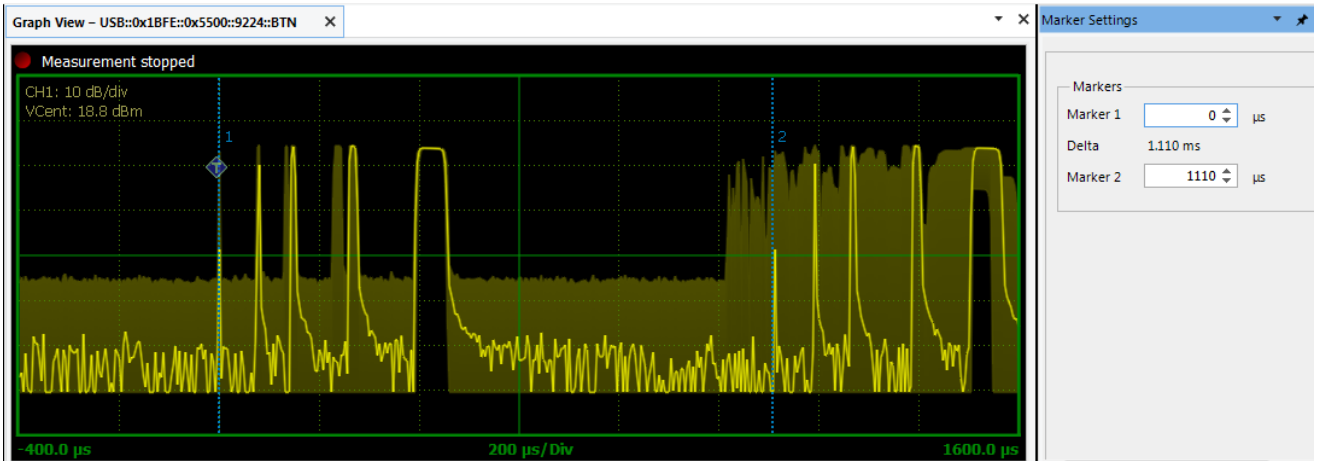
Test Data: 8 Nautical Mile Mode



8 Nautical Mile Mode Repetition Rate = **1.110 ms**

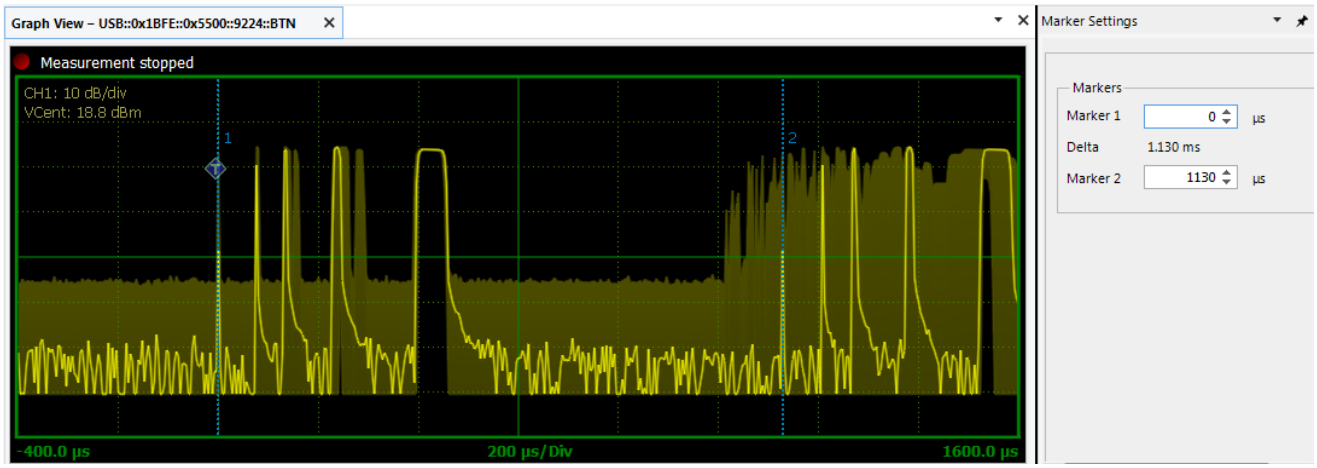
PULSE TRAIN CHARACTERISTICS

Test Data: 12 Nautical Mile Mode



12 Nautical Mile Mode Repetition Rate = **1.110 ms**

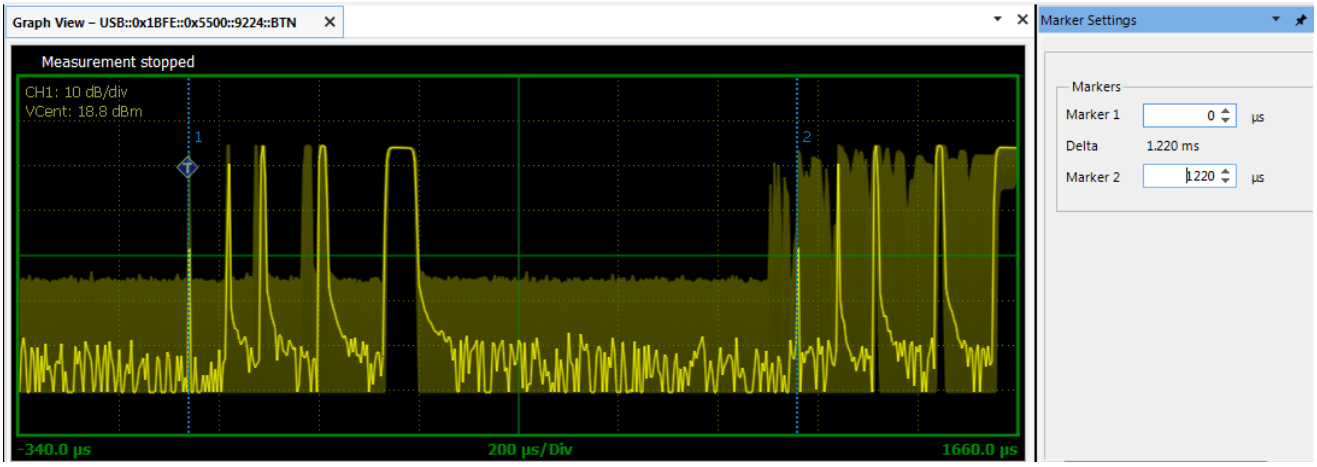
Test Data: 16 Nautical Mile Mode



16 Nautical Mile Mode Repetition Rate = **1.130 ms**

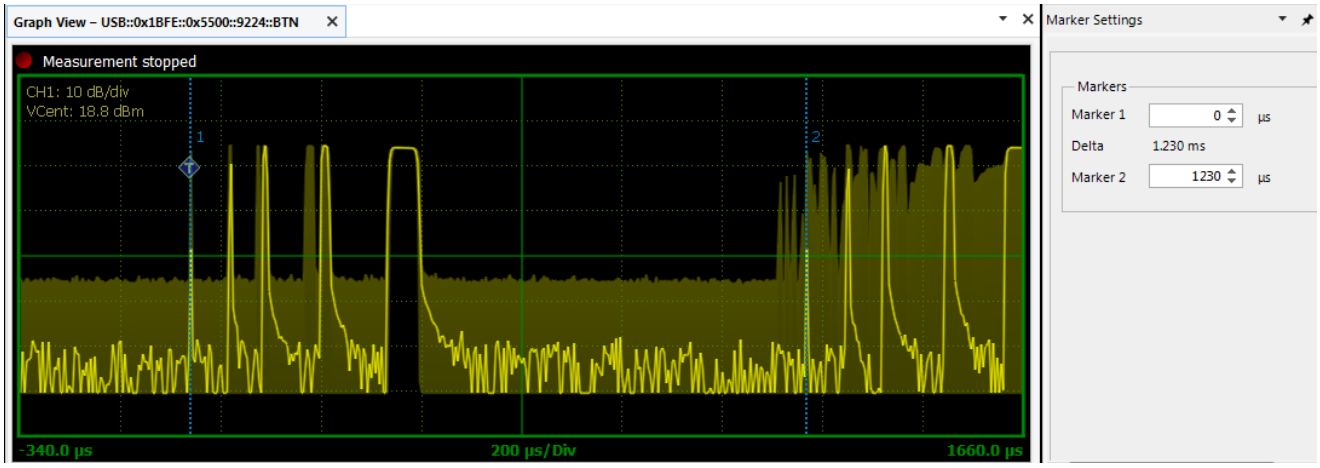
PULSE TRAIN CHARACTERISTICS

Test Data: 24 Nautical Mile Mode



24 Nautical Mile Mode Repetition Rate = **1.220 ms**

Test Data: ≥ 36 Nautical Mile Mode



≥ 36 Nautical Mile Mode Repetition Rate = **1.230 ms**

RF POWER OUTPUT

Rule Part No.: FCC Part 2.1046(a), 80.215(a)(3), 80.215(i)(1), (2), 90.205(r)

Requirements:

§80.215 Transmitter power.

(a) Transmitter power shown on the radio station authorization is the maximum power the licensee is authorized to use. Power is expressed in the following terms:

(3) For PON and F3N emission: Mean power;

(i) A ship station must have a transmitter output not exceeding 25 watts and an ERP not exceeding 18 watts. The maximum transmitter output power is permitted to be increased to 50 watts under the following conditions:

(1) Increases exceeding 25 watts are made only by radio command from the controlling coast stations; and

(2) The application for an equipment authorization demonstrates that the transmitter output power is 25 watts or less when external radio commands are not present.

§90.205 Power and antenna height limits.

(r) *All other frequency bands.* Requested transmitter power will be considered and authorized on a case by case basis.

Note: the frequency bands referred to in 90.205 do not include 9.3 – 9.5 GHz. These frequencies are covered by clause (r).

Test Procedure: ANSI C63.26

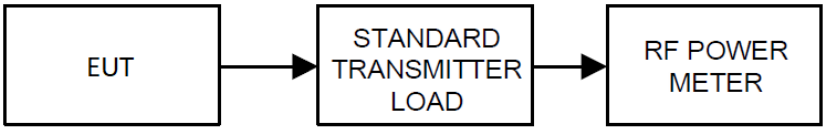
The mean power was calculated based on formula:

Pa = Pm * DC

Where:

Pa	Mean linear power in Watts (W)
Pm	Peak linear power in Watts (W)
DC	Duty Cycle in Percentage (%)

Test Setup Block Diagram:



RF POWER OUTPUT

Test Data: Power Measurement Table

Mode	Center Freq (MHz)	Total Pulse Width (µs)	Period (µs)	Duty Cycle (%)	Mesured Output (dBm)	Cable Loss (dBm)	Peak Power (dBm)	Peak Power (W)	Mean Power (W)
< 0.0625 nm	9390.00	0.03	1108.00	0.00%	41.883	0.400	42.283	16.92	0.00
0.125 nm	9390.00	0.03	1112.00	0.00%	43.500	0.400	43.900	24.55	0.00
0.25 nm	9400.93	1.63	1023.80	0.16%	43.500	0.400	43.900	24.55	0.04
0.5 nm	9400.93	1.63	1080.00	0.15%	43.500	0.400	43.900	24.55	0.04
0.75 nm	9418.11	8.73	1031.20	0.85%	43.500	0.400	43.900	24.55	0.21
1 nm	9418.11	8.73	1051.40	0.83%	43.500	0.400	43.900	24.55	0.20
1.5 nm	9418.11	8.73	1105.10	0.79%	43.500	0.400	43.900	24.55	0.19
2 nm	9427.65	22.83	1060.00	2.15%	43.500	0.400	43.900	24.55	0.53
3 nm	9427.65	22.83	1100.00	2.08%	43.500	0.400	43.900	24.55	0.51
4 nm	9430.70	50.63	1082.00	4.68%	43.500	0.400	43.900	24.55	1.15
6 nm	9430.70	50.63	1045.00	4.84%	43.500	0.400	43.900	24.55	1.19
8 nm	9427.32	78.03	1110.00	7.03%	43.500	0.400	43.900	24.55	1.73
12 nm	9427.32	78.03	1110.00	7.03%	43.500	0.400	43.900	24.55	1.73
16 nm	9427.32	78.03	1130.00	6.90%	43.500	0.400	43.900	24.55	1.69
24 nm	9427.32	78.03	1220.00	6.40%	43.500	0.400	43.900	24.55	1.57
≥ 36 nm	9427.32	77.93	1230.00	6.34%	43.500	0.400	43.900	24.55	1.56

Maximum Peak Power: **24.55 W**

Maximum Mean Power: **1.73 W**

POWER AT THE FINAL AMPLIFIER

Rule Part No.: FCC Part 2.1033(c)(8)

Requirement:

(c) Applications for equipment other than that operating under parts 15, 11 and 18 of this chapter shall be accompanied by a technical report containing the following information:

(8) The dc voltages applied to and dc currents into the several elements of the final radio frequency amplifying device for normal operation over the power range.

Test Data: Power at the Final Amplifier

INPUT POWER: (110 VAC) (11.5A) = **1265 Watts**

99% OCCUPIED BANDWIDTH & EMISSION MASK

Bandwidth:

FCC Rule Parts: Part 2.1049(i), 80.213(g), 80.209(b), 90.207(k), (n), 90.209(b)(5)

§2.1049 Measurements required: Occupied bandwidth.

The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission shall be measured under the following conditions as applicable:

(i) Transmitters designed for other types of modulation—when modulated by an appropriate signal of sufficient amplitude to be representative of the type of service in which used. A description of the input signal should be supplied.

§80.213 Modulation requirements.

(g) Radar stations operating in the bands above 2.4 GHz may use any type of modulation consistent with the bandwidth requirements in §80.209(b).

§80.209 Transmitter frequency tolerances.

(b) When pulse modulation is used in land and ship radar stations operating in the bands above 2.4 GHz the frequency at which maximum emission occurs must be within the authorized bandwidth and must not be closer than 1.5/T MHz to the upper and lower limits of the authorized bandwidth where "T" is the pulse duration in microseconds. In the band 14.00-14.05 GHz the center frequency must not vary more than 10 MHz from 14.025 GHz.

§90.207 Types of emissions.

(k) For radiolocation operations as may be authorized in accordance with subpart F, unless otherwise provided for any type of emission may be authorized upon a satisfactory showing of need.

(n) *Other emissions.* Requests for emissions other than those listed in paragraphs (c) through (e) of this section will be considered on a case-by-case basis to ensure that the requested emission will not cause more interference than other currently permitted emissions.

§90.209 Bandwidth limitations.

(b) The maximum authorized single channel bandwidth of emission corresponding to the type of emission specified in §90.207 is as follows:

STANDARD CHANNEL SPACING/BANDWIDTH

Frequency band (MHz)	Channel spacing (kHz)	Authorized bandwidth (kHz)
Above 2500[2]		

[2]Bandwidths for radiolocation stations in the 420-450 MHz band and for stations operating in bands subject to this footnote will be reviewed and authorized on a case-by-case basis.

Test Procedure: ANSI C63.26, 5.4.4

Note: The receiver's automatic 99% Occupied Bandwidth function was used. The function is identical in operation to ANSI C63.26, 5.4.4, Step e).

99% OBW & EMISSION MASK

Emission Mask:

FCC Rule Parts: 80.211(f)(1), (2), 90.210(n), (b)(1), (2)

Requirements:

§80.211 Emission limitations.

(f) The mean power when using emissions other than those in paragraphs (a), (b), (c) and (d) of this section:

(1) On any frequency removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth: At least 25 dB;

(2) On any frequency removed from the assigned frequency by more than 100 percent up to and including 250 percent of the authorized bandwidth: At least 35 dB; and

§90.210 Emission masks.

(n) *Other frequency bands.* Transmitters designed for operation under this part on frequencies other than listed in this section must meet the emission mask requirements of Emission Mask B. Equipment operating under this part on frequencies allocated to but shared with the Federal Government, must meet the applicable Federal Government technical standards.

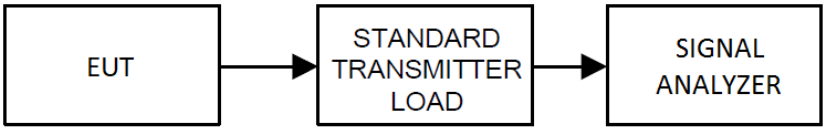
(b) *Emission Mask B.* For transmitters that are equipped with an audio low-pass filter, the power of any emission must be attenuated below the unmodulated carrier power (P) as follows:

(1) On any frequency removed from the assigned frequency by more than 50 percent, but not more than 100 percent of the authorized bandwidth: At least 25 dB.

(2) On any frequency removed from the assigned frequency by more than 100 percent, but not more than 250 percent of the authorized bandwidth: At least 35 dB.

Test Procedure: ANSI C63.26, 5.4.4; ITU-R M.1177-4

Test Setup Block Diagram:



Note: 99% OBW and Emission Mask plots are compatible, and the data has been combined in the plots below.

99% OBW & EMISSION MASK

Test Data: 99% OBW Measurement Table

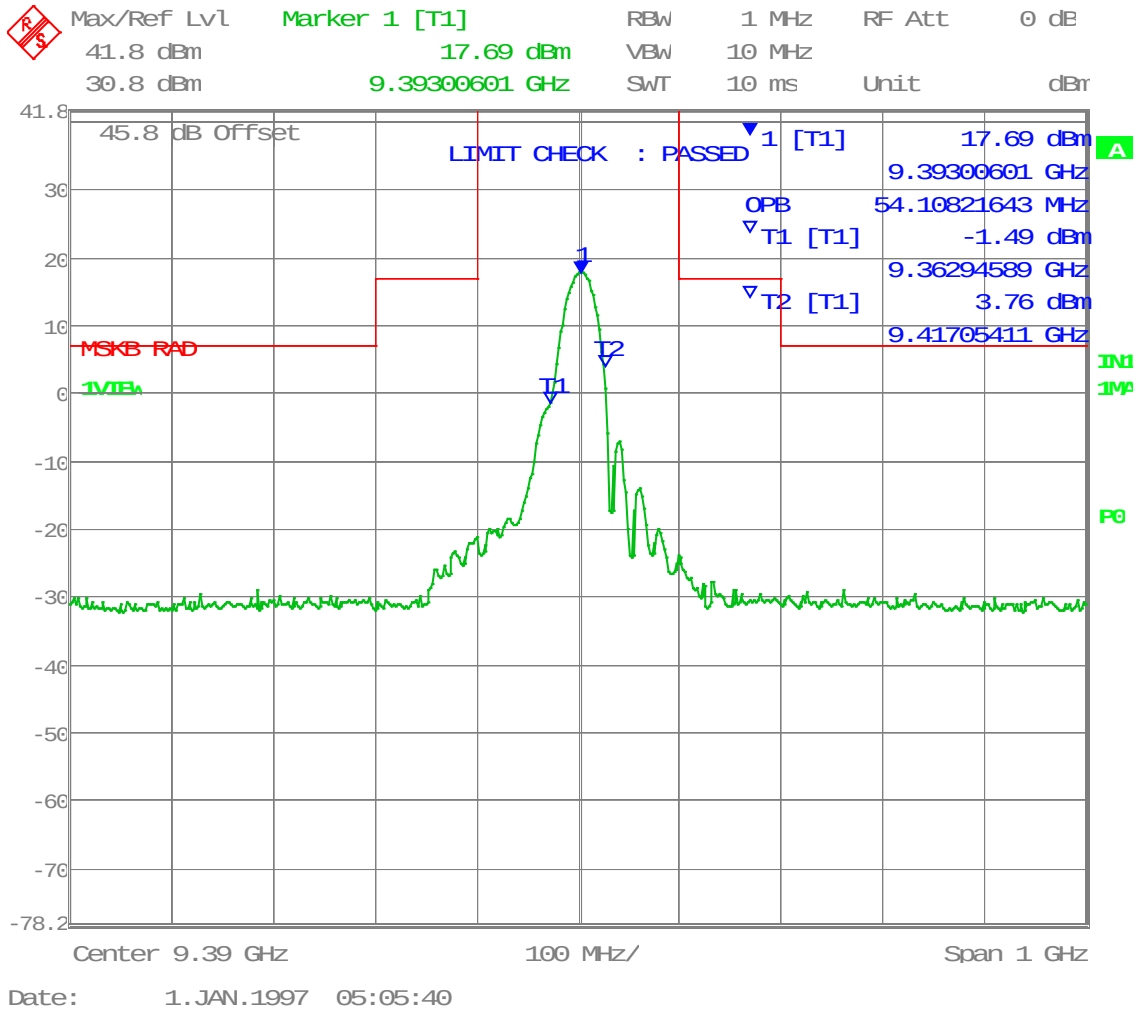
Mode	Center Freq (MHz)	99% OBW (MHz)
< 0.0625 nm	9390.00	54.10
0.125 nm	9390.00	54.10
0.25 nm	9400.93	34.10
0.5 nm	9400.93	34.10
0.75 nm	9418.11	68.10
1 nm	9418.11	66.10
1.5 nm	9418.11	66.10
2 nm	9427.65	66.10
3 nm	9427.65	66.10
4 nm	9430.70	94.20
6 nm	9430.70	94.20
8 nm	9427.32	98.20
12 nm	9427.32	98.20
16 nm	9427.32	98.20
24 nm	9427.32	100.20
≥ 36 nm	9427.32	100.20

Max Occupied Bandwidth of EUT = **100.20 MHz**

EUT Emission Designator = **100MP0N**

99% OBW & EMISSION MASK

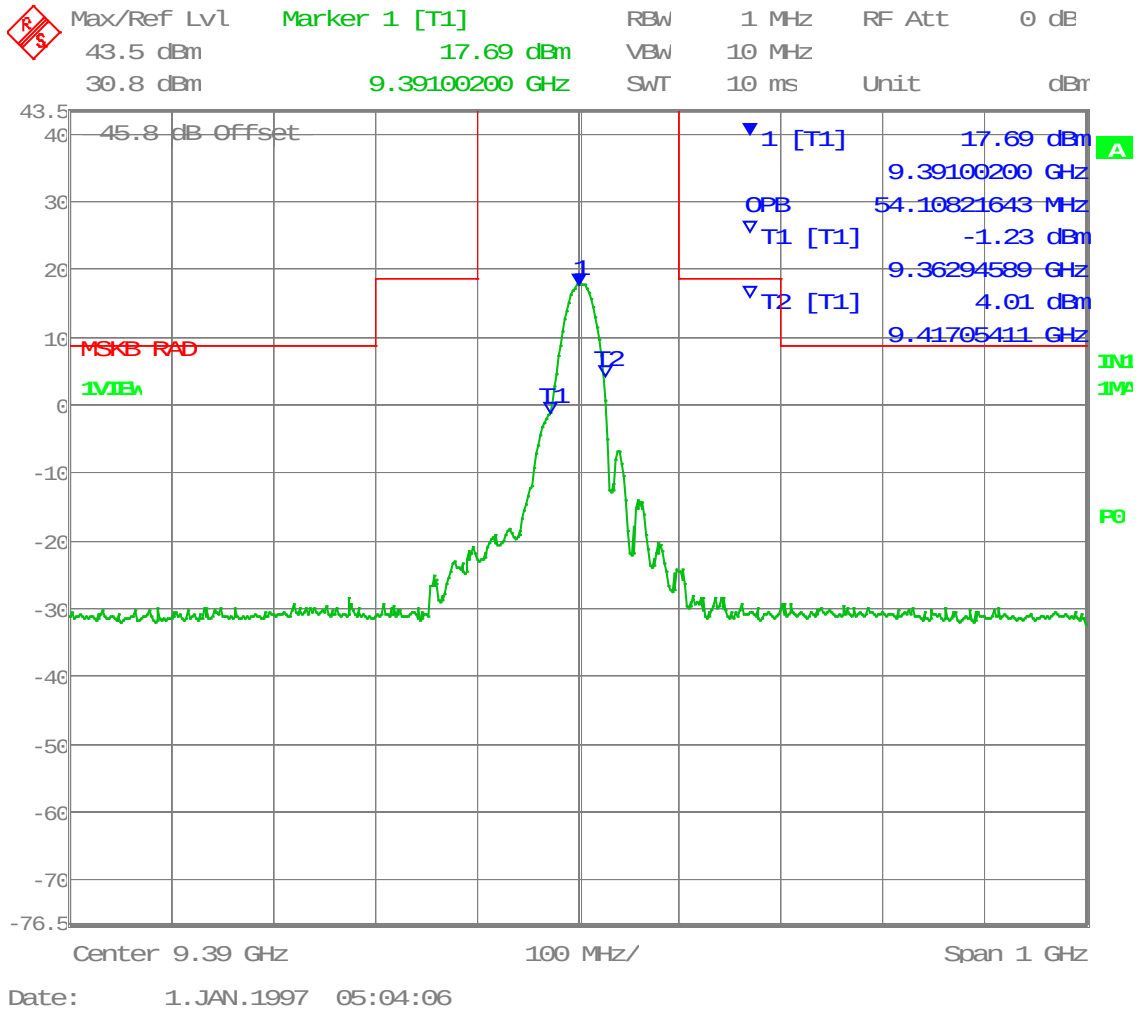
Test Data: ≤ 400 ft Mode 99% OBW Plot



≤ 400 ft Mode 99% OBW = **54.108 MHz**

99% OBW & EMISSION MASK

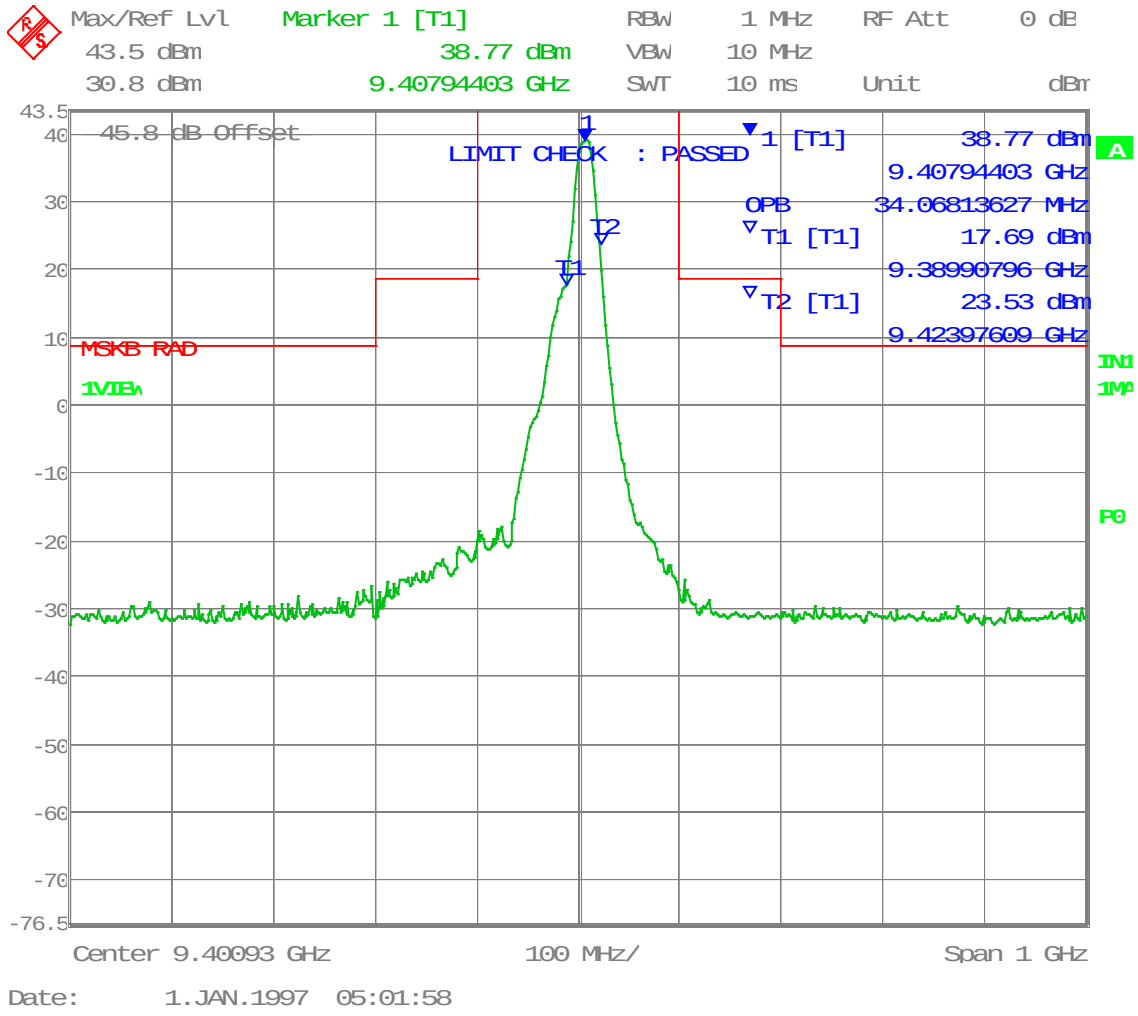
Test Data: 1/8 Nautical Mile Mode 99% OBW Plot



1/8 Nautical Mile Mode 99% OBW = **54.108 MHz**

99% OBW & EMISSION MASK

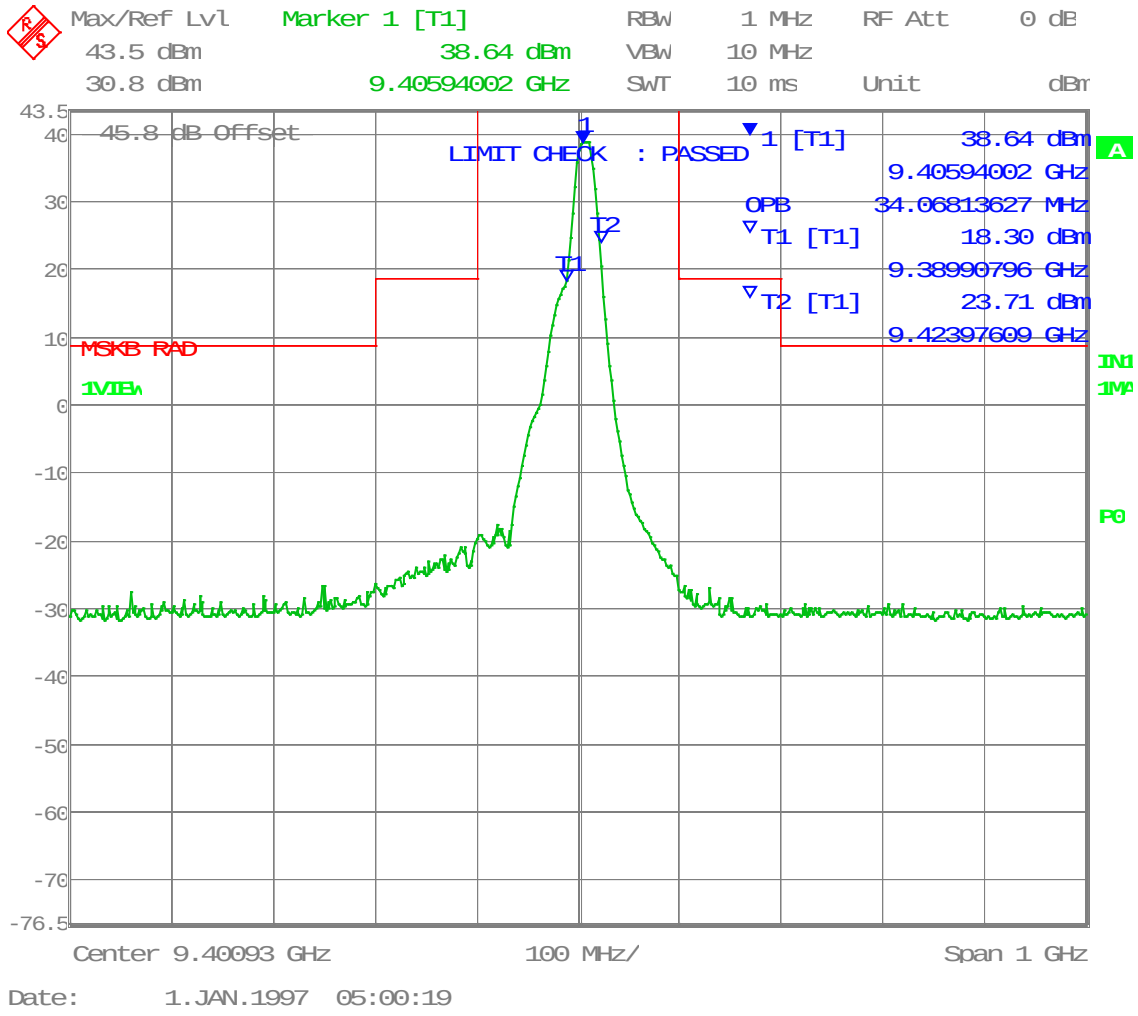
Test Data: 1/4 Nautical Mile Mode 99% OBW Plot



1/4 Nautical Mile Mode 99% OBW = **34.068 MHz**

99% OBW & EMISSION MASK

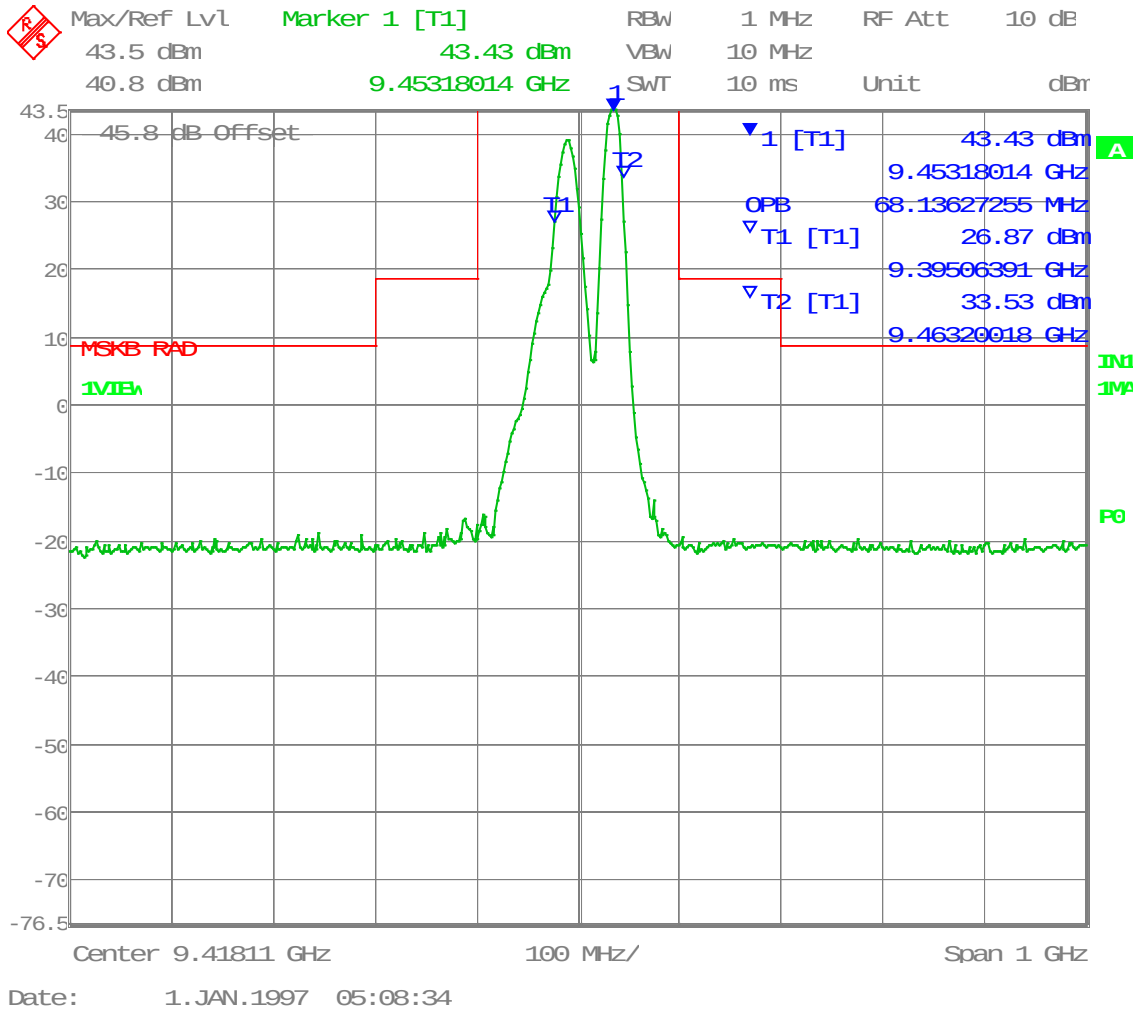
Test Data: 1/2 Nautical Mile Mode 99% OBW Plot



1/2 Nautical Mile Mode 99% OBW = **34.068 MHz**

99% OBW & EMISSION MASK

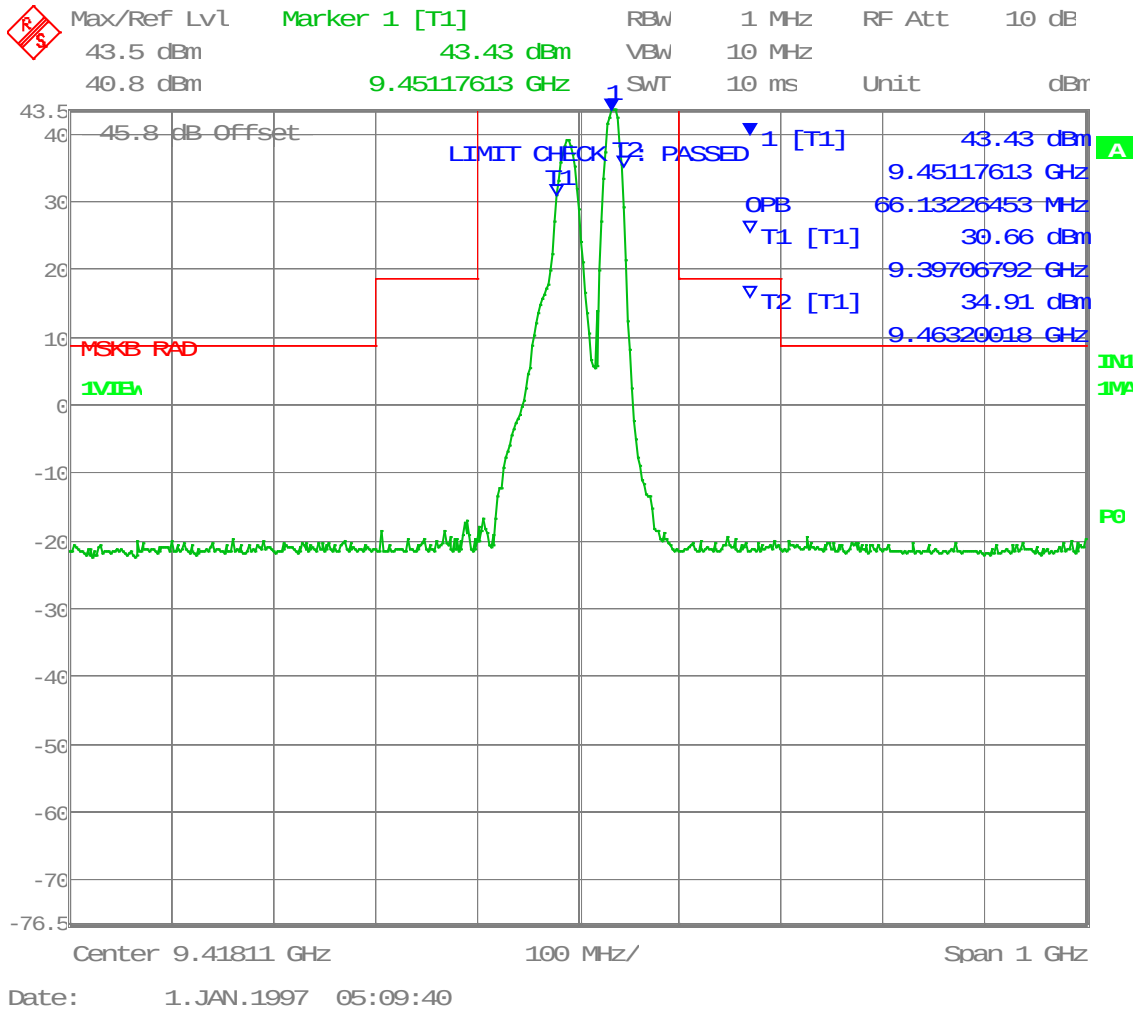
Test Data: 3/4 Nautical Mile Mode 99% OBW Plot



3/4 Nautical Mile Mode 99% OBW = **68.136 MHz**

99% OBW & EMISSION MASK

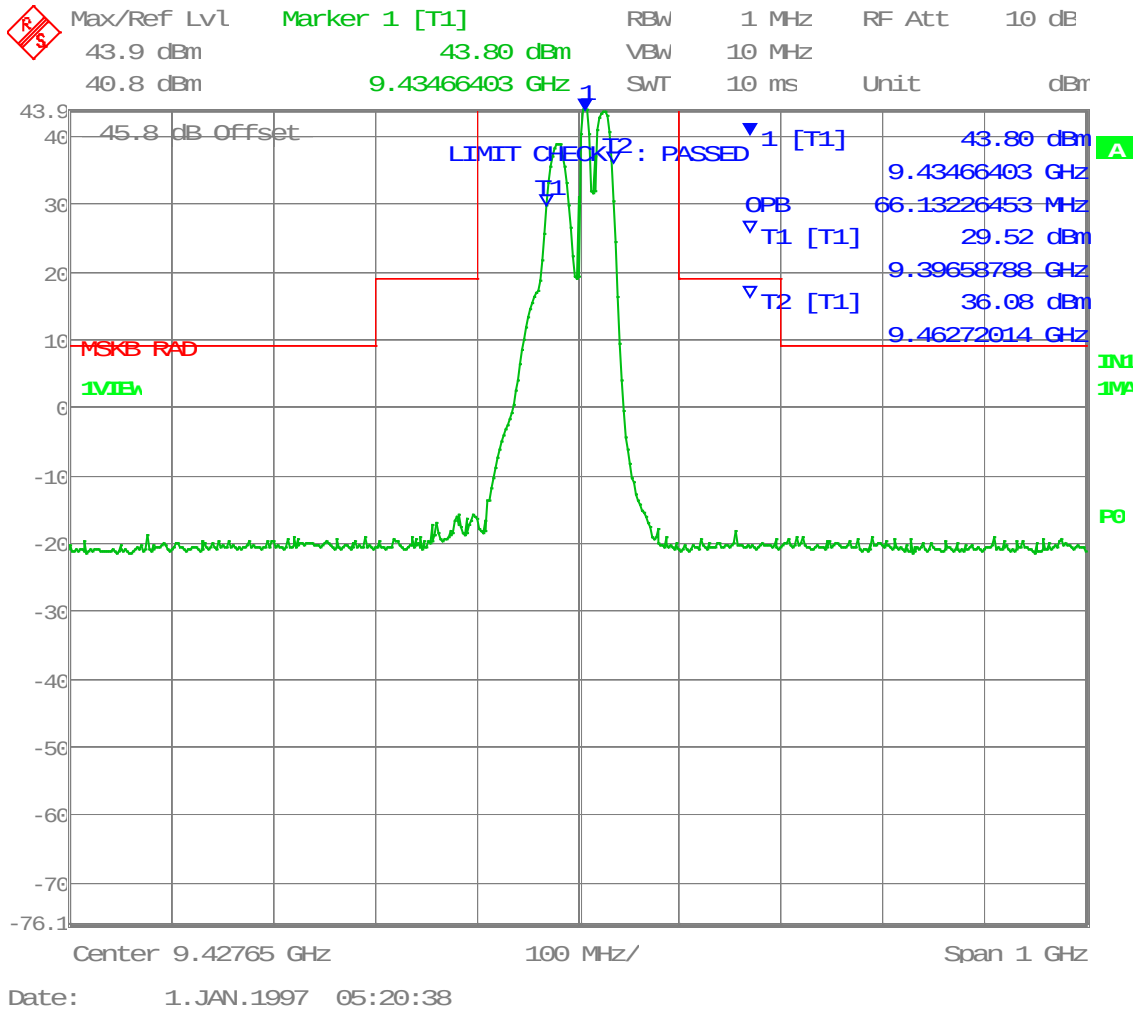
Test Data: 1 Nautical Mile Mode 99% OBW Plot



1 Nautical Mile Mode 99% OBW = **66.132 MHz**

99% OBW & EMISSION MASK

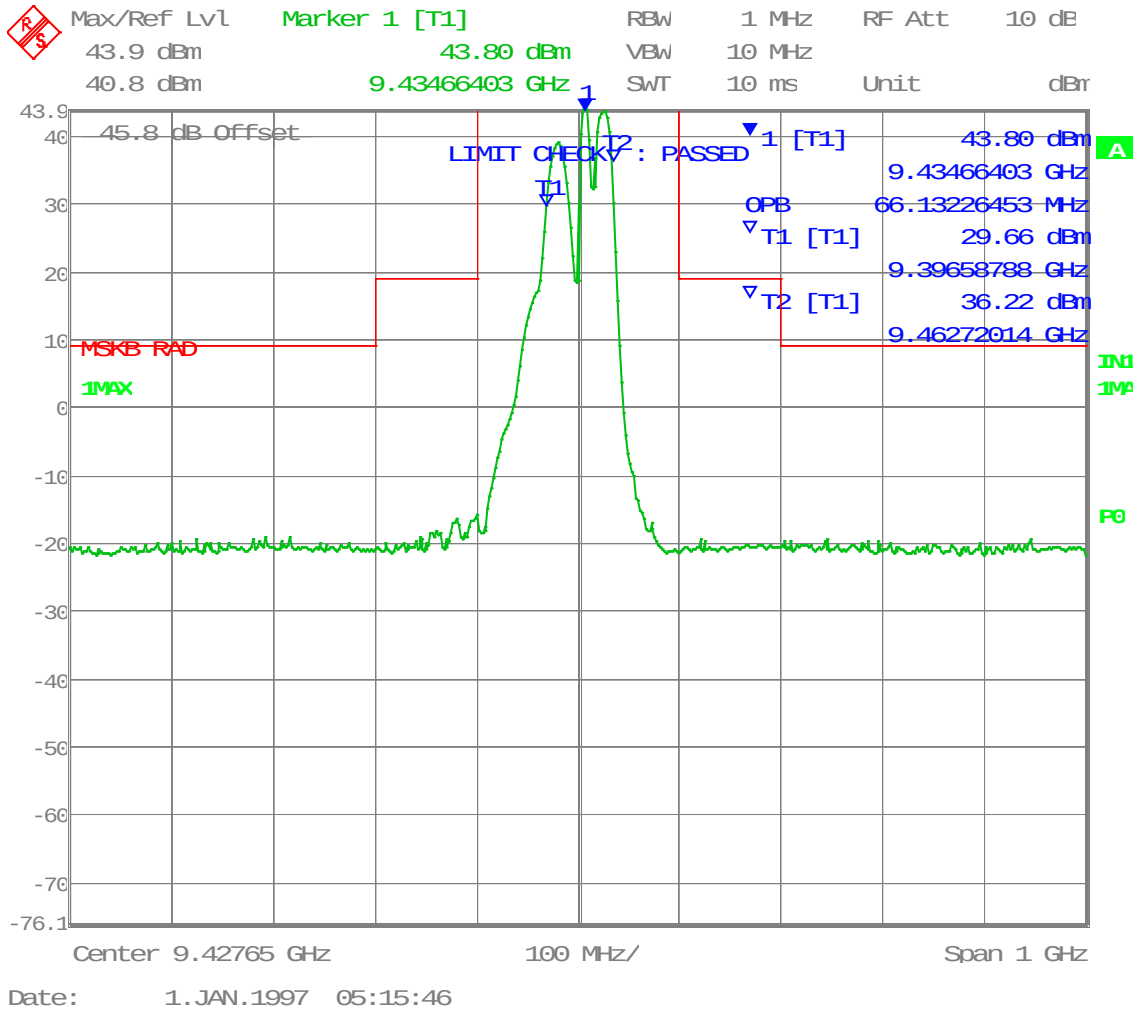
Test Data: 2 Nautical Mile Mode 99% OBW Plot



2 Nautical Mile Mode 99% OBW = **66.132 MHz**

99% OBW & EMISSION MASK

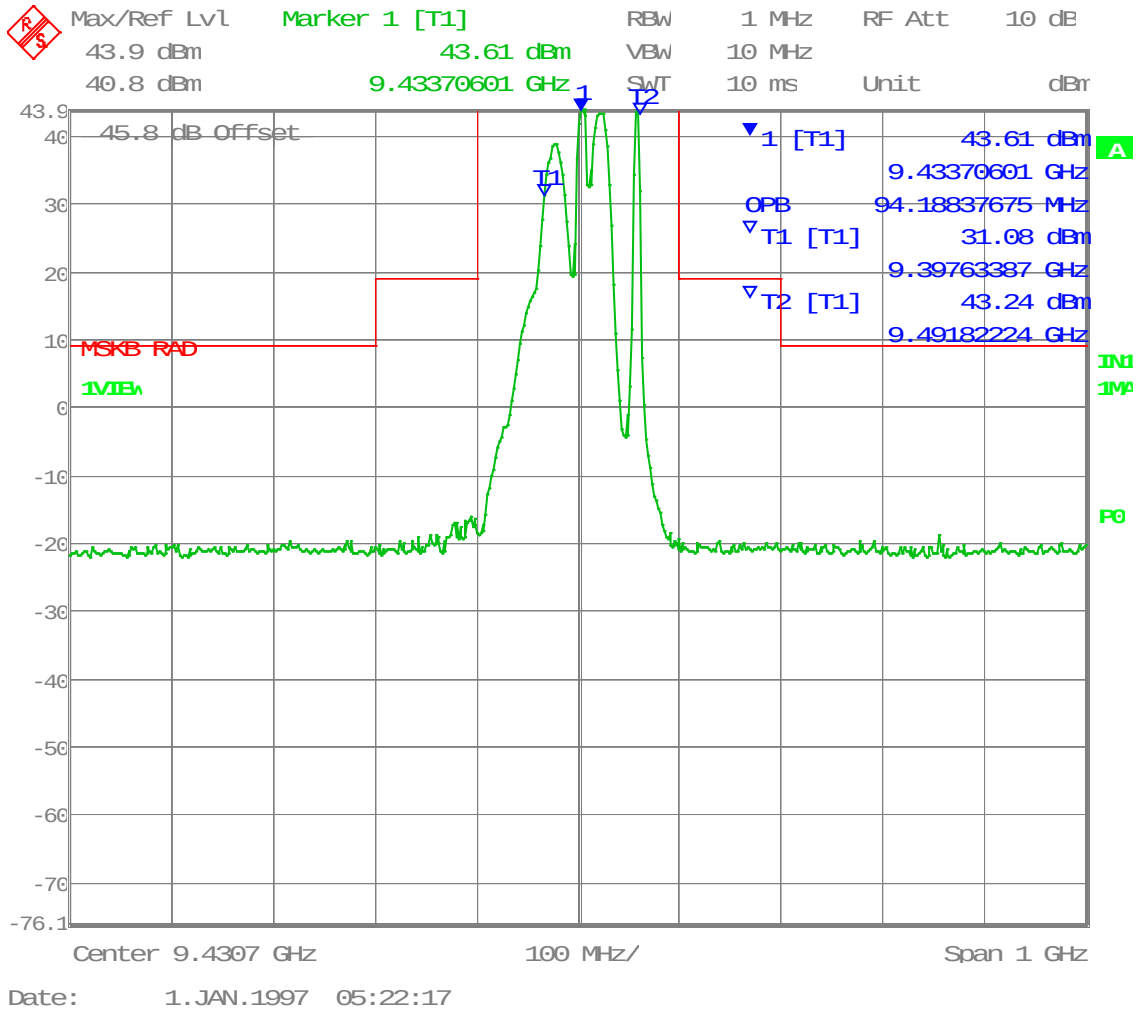
Test Data: 3 Nautical Mile Mode 99% OBW Plot



3 Nautical Mile Mode 99% OBW = **66.132 MHz**

99% OBW & EMISSION MASK

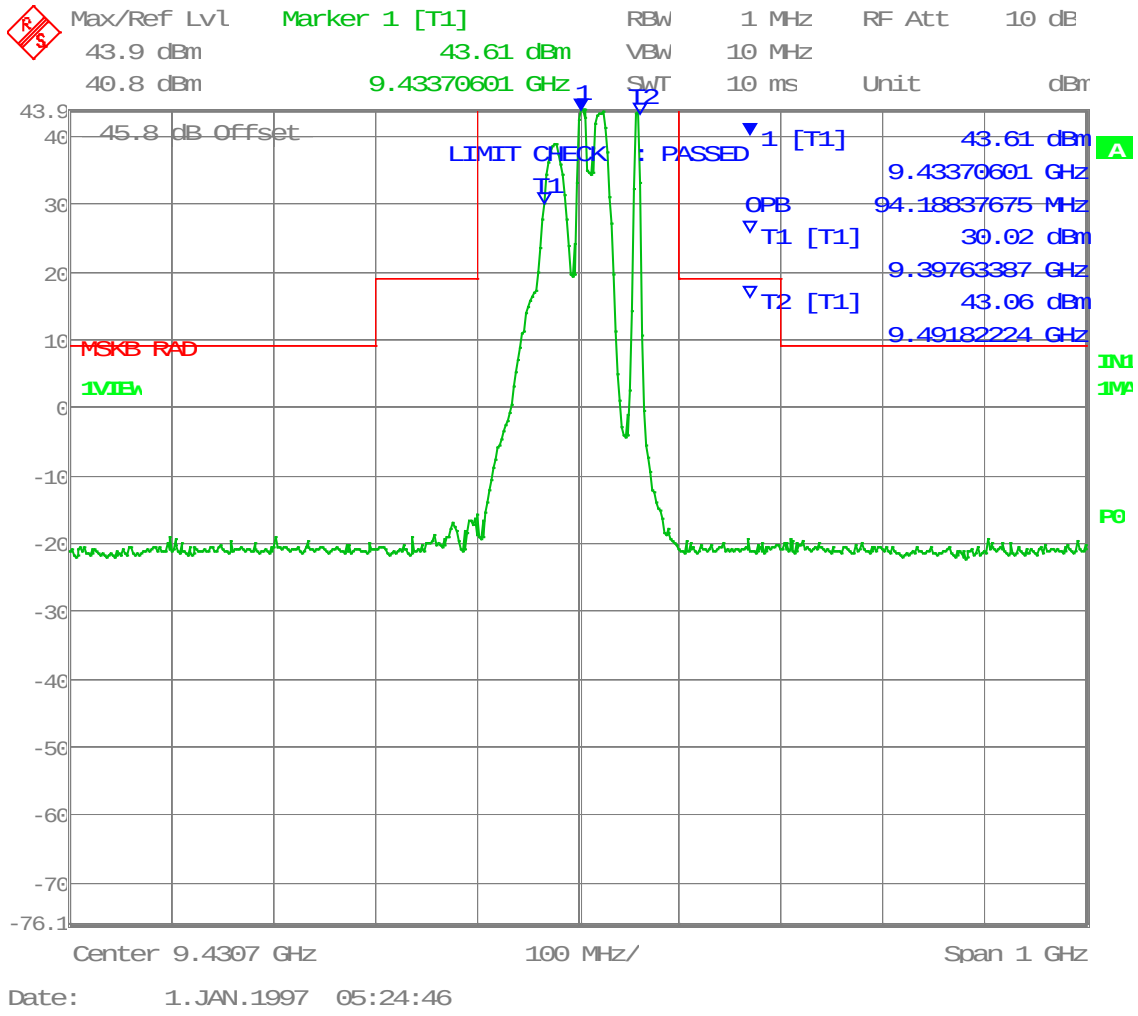
Test Data: 4 Nautical Mile Mode 99% OBW Plot



4 Nautical Mile Mode 99% OBW = **94.188 MHz**

99% OBW & EMISSION MASK

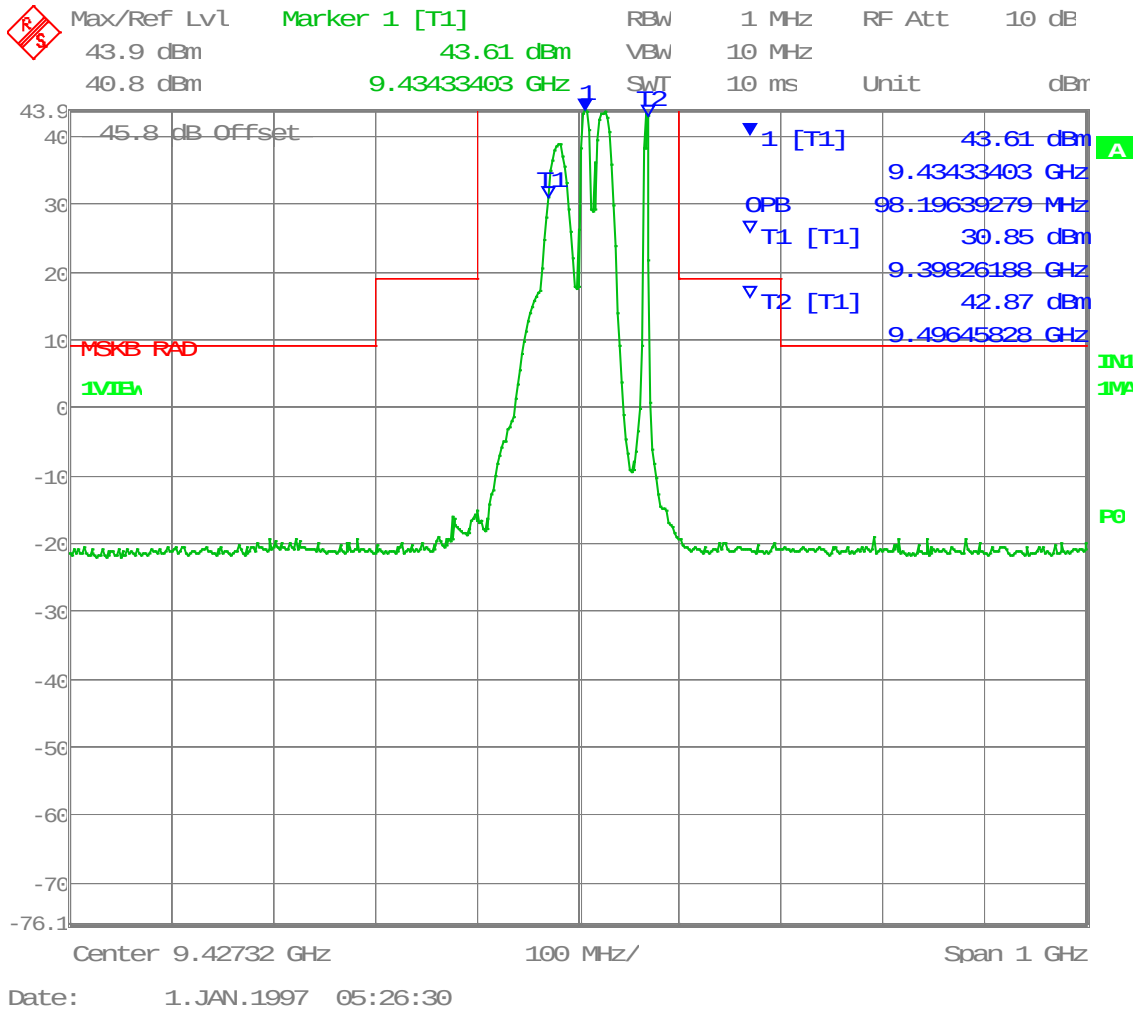
Test Data: 6 Nautical Mile Mode 99% OBW Plot



6 Nautical Mile Mode 99% OBW = **94.188 MHz**

99% OBW & EMISSION MASK

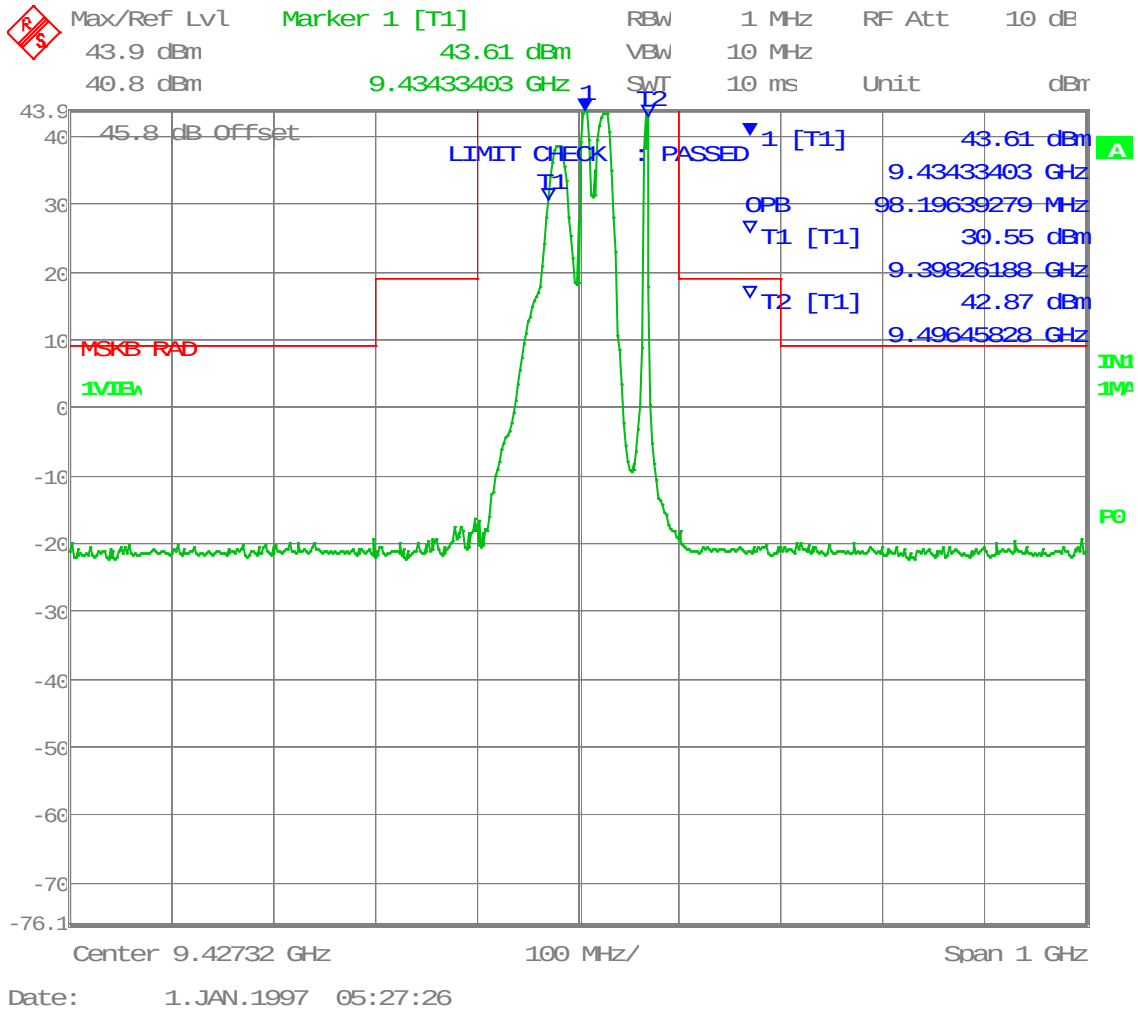
Test Data: 8 Nautical Mile Mode 99% OBW Plot



8 Nautical Mile Mode 99% OBW = **98.196 MHz**

99% OBW & EMISSION MASK

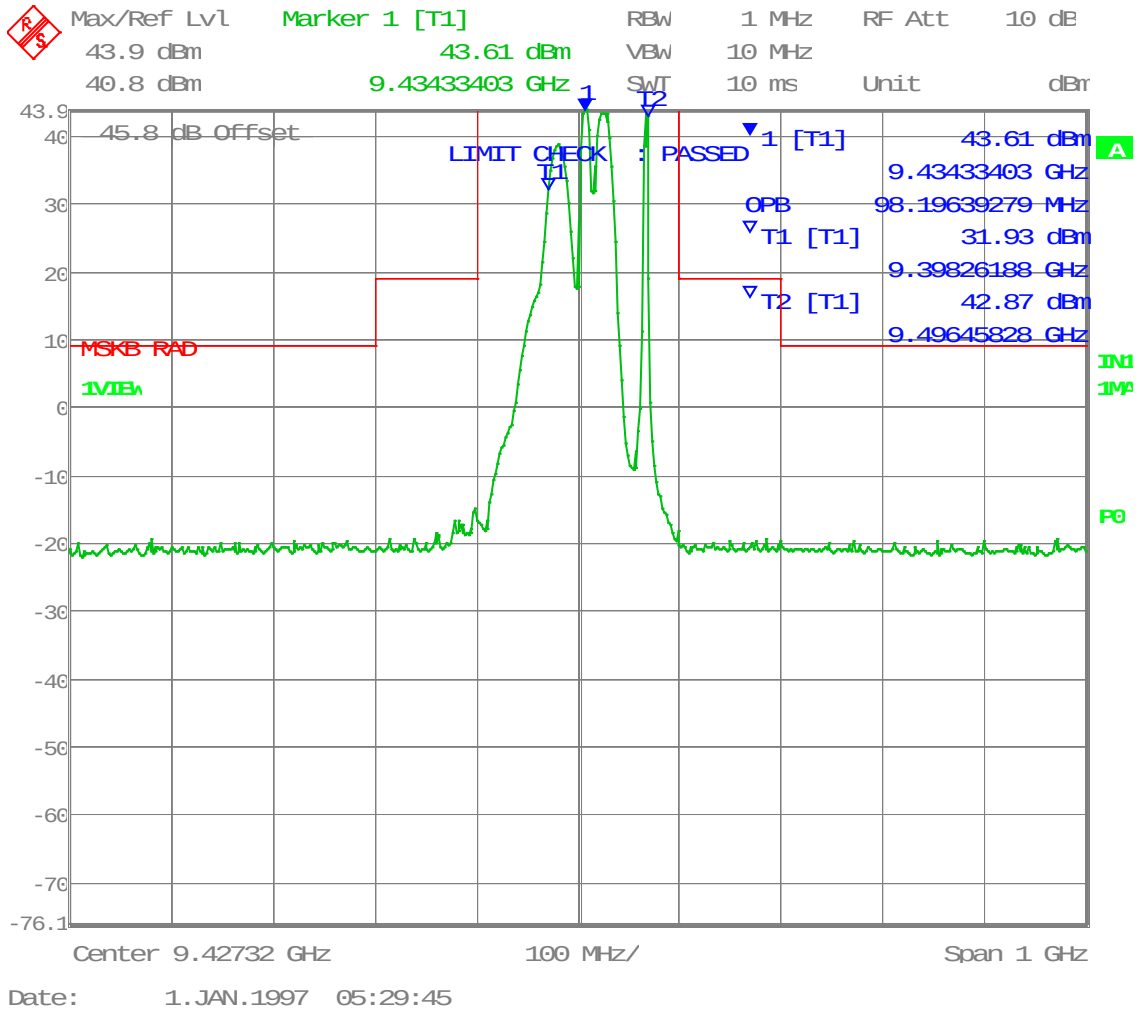
Test Data: 12 Nautical Mile Mode 99% OBW Plot



12 Nautical Mile Mode 99% OBW = **98.196 MHz**

99% OBW & EMISSION MASK

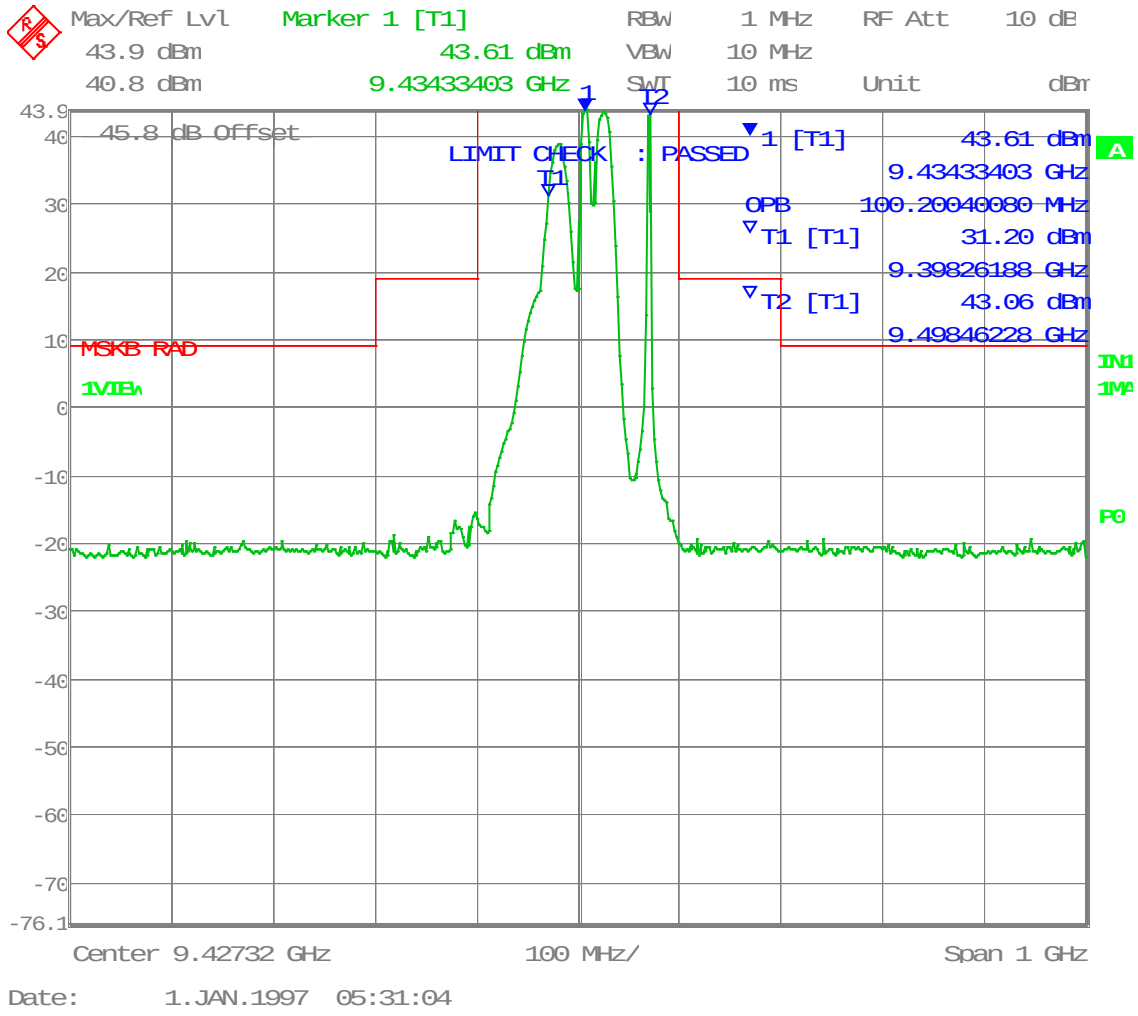
Test Data: 16 Nautical Mile Mode 99% OBW Plot



16 Nautical Mile Mode 99% OBW = **98.196 MHz**

99% OBW & EMISSION MASK

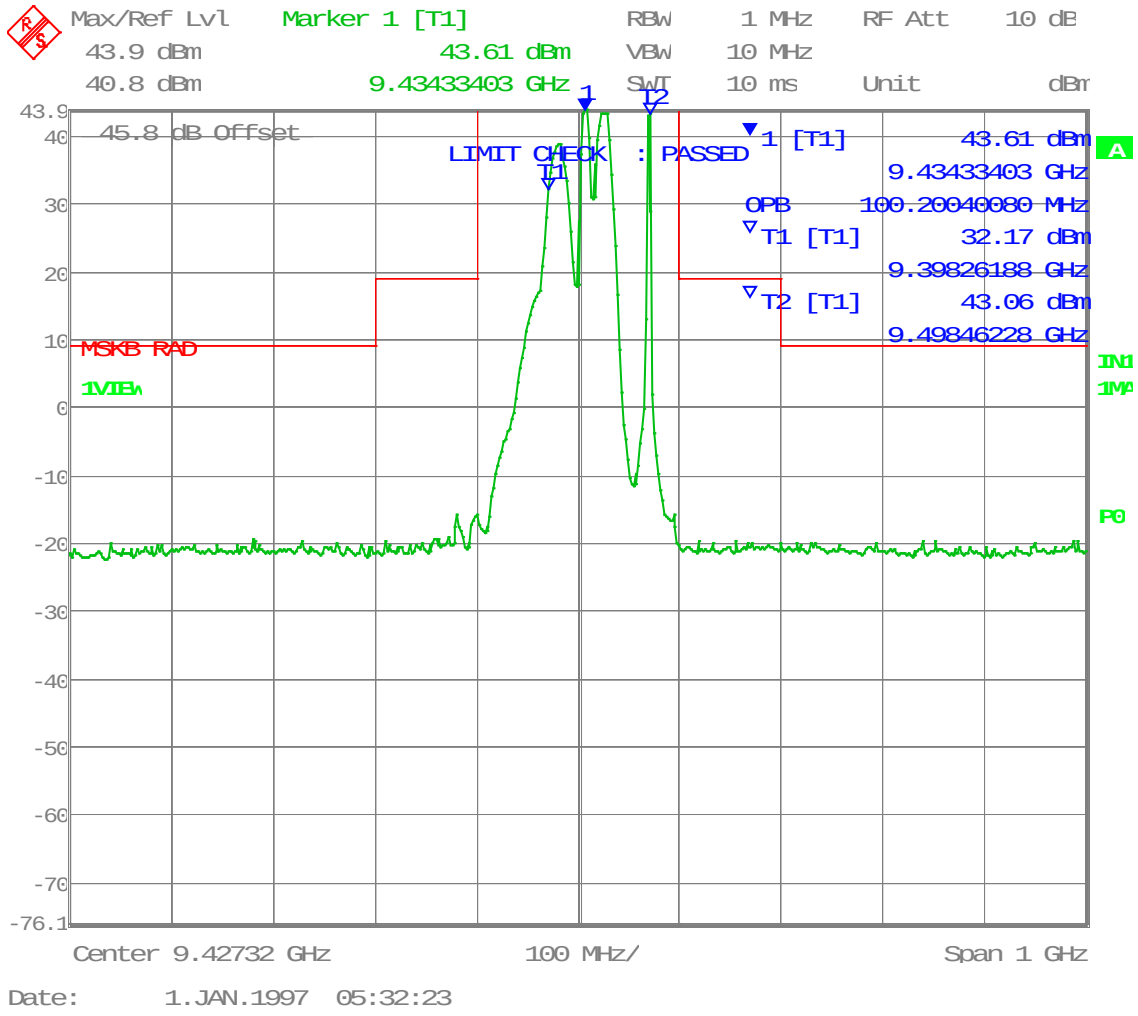
Test Data: 24 Nautical Mile Mode 99% OBW Plot



24 Nautical Mile Mode 99% OBW = **100.200 MHz**

99% OBW & EMISSION MASK

Test Data: ≥ 36 Nautical Mile Mode 99% OBW Plot



≥ 36 Nautical Mile Mode 99% OBW = **100.200 MHz**

SPURIOUS EMISSIONS AT ANTENNA TERMINAL (CONDUCTED)

FCC Rule Parts: Part 2.1051(a), 2.1057(a)(1), 80.211(f)(3), 90.210(n), (b)(3)

§2.1057 Frequency spectrum to be investigated.

(a) In all of the measurements set forth in §§2.1051 and 2.1053, the spectrum shall be investigated from the lowest radio frequency signal generated in the equipment, without going below 9 kHz, up to at least the frequency shown below:

(1) If the equipment operates below 10 GHz: to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

§80.211 Emission limitations.

(f) The mean power when using emissions other than those in paragraphs (a), (b), (c) and (d) of this section:

(3) On any frequency removed from the assigned frequency by more than 250 percent of the authorized bandwidth: At least 43 plus $10\log_{10}$ (mean power in watts) dB.

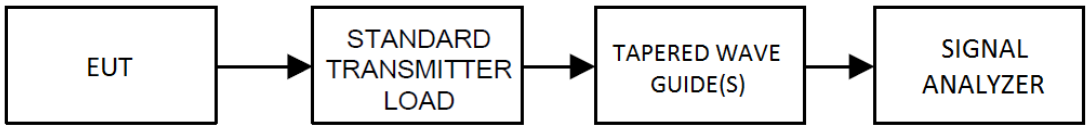
§90.210 Emission masks.

(n) *Other frequency bands.* Transmitters designed for operation under this part on frequencies other than listed in this section must meet the emission mask requirements of Emission Mask B. Equipment operating under this part on frequencies allocated to but shared with the Federal Government, must meet the applicable Federal Government technical standards.

(b) *Emission Mask B.* For transmitters that are equipped with an audio low-pass filter, the power of any emission must be attenuated below the unmodulated carrier power (P) as follows:

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

Test Setup Block Diagram:



Note: Frequencies below the fundamental were pre-scanned, and the pre-scan data was included below, and tabular data has been included to compare the calculated value of the noise floor based on the bandwidth compensation formulae, found in ITU-R M.1177, Annex 1 (cited below) with the limit.

Note: Frequencies above the fundamental were pre-scanned for all emissions prior to capturing data. All emissions above the noise floor are shown below, and tabular data has been included to compare the calculated value of emissions based on the bandwidth compensation formulae, found in ITU-R M.1177, Annex 1 (cited below) with the limit.

Unwanted spurious emission max worst-case emission:

0.5 nm Mode, 2nd Harmonic

UNWANTED SPURIOUS EMISSIONS

Test Procedure: TIA 603-E, 2.2.13; ITU-R M.1177-4, Annex 1

2 Reference bandwidth

For radar systems, the reference bandwidth, B_{ref}, used to define unwanted emission limits (Recommendations ITU-R SM.329 and ITU-R SM.1541, and RR Appendix 3) should be calculated for each particular radar system. For the four general types of radar pulse modulation utilized for radionavigation, radiolocation, acquisition, tracking and other radiodetermination functions, the reference bandwidth values are determined using the following formulas:

– for FM or chirped radar, the square root of the quantity obtained by dividing the chirp bandwidth (MHz) by the pulse length (μs) (e.g. if the FM is from 1 250 MHz to 1 280 MHz or 30 MHz during the pulse of 10 μs, then the reference bandwidth is $(30\ \text{MHz}/10\ \mu\text{s})^{1/2} = 1.73$ MHz);

In all cases, where the bandwidths above are greater than 1 MHz, then a reference bandwidth, B_{ref}, of 1 MHz should be used.

3 Measurement bandwidth and detector parameters

The measurement bandwidth, B_m, is defined as the impulse bandwidth of the receiver and is greater than the IF bandwidth, B_{if}, (sometimes referred to as resolution bandwidth for spectrum analyzers). The measurement bandwidth, B_m, may be derived from the following equation:

$$B_m = B_{if} \times MBR$$

The MBR needs to be determined for the measurement receiver being used. MBR is approximately 3/2 for a –3 dB IF bandwidth Gaussian filter as typically used in many commercial spectrum analyzer receivers (in some instruments the IF bandwidth is defined at the –6 dB point).

An appropriate receiver IF bandwidth should be selected to give one of the following recommended measurement bandwidths.

Measurement bandwidth B_m[1]	≤	$(B_c/T)^{1/2}$ for swept-frequency (FM, or chirp) radars, where B_c is the range of frequency sweep during each pulse and T is the pulse length (e.g. if radar sweeps (chirps) across the frequency range of 1 250-1 280 MHz (= 30 MHz of spectrum) during each pulse, and if the pulse length is 10 μs, then the measurement bandwidth should be $\leq ((30\ \text{MHz})/(10\ \mu\text{s}))^{1/2} = \sqrt{3}$ MHz ≈ 1.73 MHz. In accordance with footnote [1] a measurement bandwidth close to but less than or equal to 1 MHz should be used in this example.
Video bandwidth	≥	measurement system bandwidth.
Detector		positive peak.

[1] In all cases, if the above derived measurement bandwidth is greater than 1 MHz, then the corrections described in § 3.2 should be used.

UNWANTED SPURIOUS EMISSIONS

Test Procedures, Con't.

3.2 Measurements within the spurious domain

3.2.1 Correction of the measurement within the spurious domain

Where the measurement bandwidth, B_m, differs from the reference bandwidth, B_{ref}, a correction factor needs to be applied to the measurements conducted within the spurious domain to express the results in the reference bandwidth. Then the following correction factor should be applied:

$$\text{Spurious level, } B_{ref} = \text{Spurious level (measured in } B_m) + 10 \times \log(B_{ref}/B_m)$$

NOTE 1 – This correction factor should be used except where it is known that the spurious is not noise-like, where a factor between 10 and 20 $\log(B_{ref}/B_m)$ may apply and may be derived by measurements in more than one bandwidth. In all cases the most precise result will be obtained using a measurement bandwidth (B_m) equal to the reference bandwidth. For radars operating above 1 GHz the reference bandwidth (B_{ref}) is 1 MHz.

Bandwidth Compensation Calculation Table:

Mode	T (µs)	Bc (MHz)	Bref (MHz)		MBR (MHz)	Bm (MHz)	Correction (dBm)	Correction (dBm)
	Total Pulse Length (µs)	99% OBW (MHz)	(Bc/T)^0.5 = Bref	If Bref > 1, Bref = 1 (for measuring)	If 3/2 > Bref, MBR = Bref, Else MBR = 3/2	Bif x MBR = Bm	Noise: If Bm > 1, 10 x Log(Bref/Bm)	Emission: If Bm > 1, 20 x Log(Bref/Bm)
< 0.0625 nm	0.025	54.1	46.519	1.0	1.500	29.831	10.144	29.831
0.125 nm	0.025	54.1	46.519	1.0	1.500	29.831	10.144	29.831
0.25 nm	1.625	34.1	4.581	1.0	1.500	9.697	0.077	9.697
0.5 nm	1.625	34.1	4.581	1.0	1.500	9.697	0.077	9.697
0.75 nm	8.725	68.1	2.794	1.0	1.500	5.402	-2.070	5.402
1 nm	8.725	66.1	2.752	1.0	1.500	5.273	-2.135	5.273
1.5 nm	8.725	66.1	2.752	1.0	1.500	5.273	-2.135	5.273
2 nm	22.825	66.1	1.702	1.0	1.500	1.096	-4.223	1.096
3 nm	22.825	66.1	1.702	1.0	1.500	1.096	-4.223	1.096
4 nm	50.625	94.2	1.364	1.0	1.364	0.000	-4.771	0.000
6 nm	50.625	94.2	1.364	1.0	1.364	0.000	-4.771	0.000
8 nm	78.025	98.2	1.122	1.0	1.122	0.000	-4.771	0.000
12 nm	78.025	98.2	1.122	1.0	1.122	0.000	-4.771	0.000
16 nm	78.025	98.2	1.122	1.0	1.122	0.000	-4.771	0.000
24 nm	78.025	100.2	1.133	1.0	1.133	0.000	-4.771	0.000
≥ 36 nm	77.925	100.2	1.134	1.0	1.134	0.000	-4.771	0.000

UNWANTED SPURIOUS EMISSIONS

Limit Calculation Part 80.211(f)(3)

43 + 10 x Log(Power, in Watts)

Mode	Measured Output (dBm)	43+10 x Log(P) Limit (dBm)
< 0.0625 nm	41.883	-13.00
0.125 nm	43.500	-13.00
0.25 nm	43.500	-13.00
0.5 nm	43.500	-13.00
0.75 nm	43.500	-13.00
1 nm	43.500	-13.00
1.5 nm	43.500	-13.00
2 nm	43.500	-13.00
3 nm	43.500	-13.00
4 nm	43.500	-13.00
6 nm	43.500	-13.00
8 nm	43.500	-13.00
12 nm	43.500	-13.00
16 nm	43.500	-13.00
24 nm	43.500	-13.00
≥ 36 nm	43.500	-13.00

UNWANTED SPURIOUS EMISSIONS

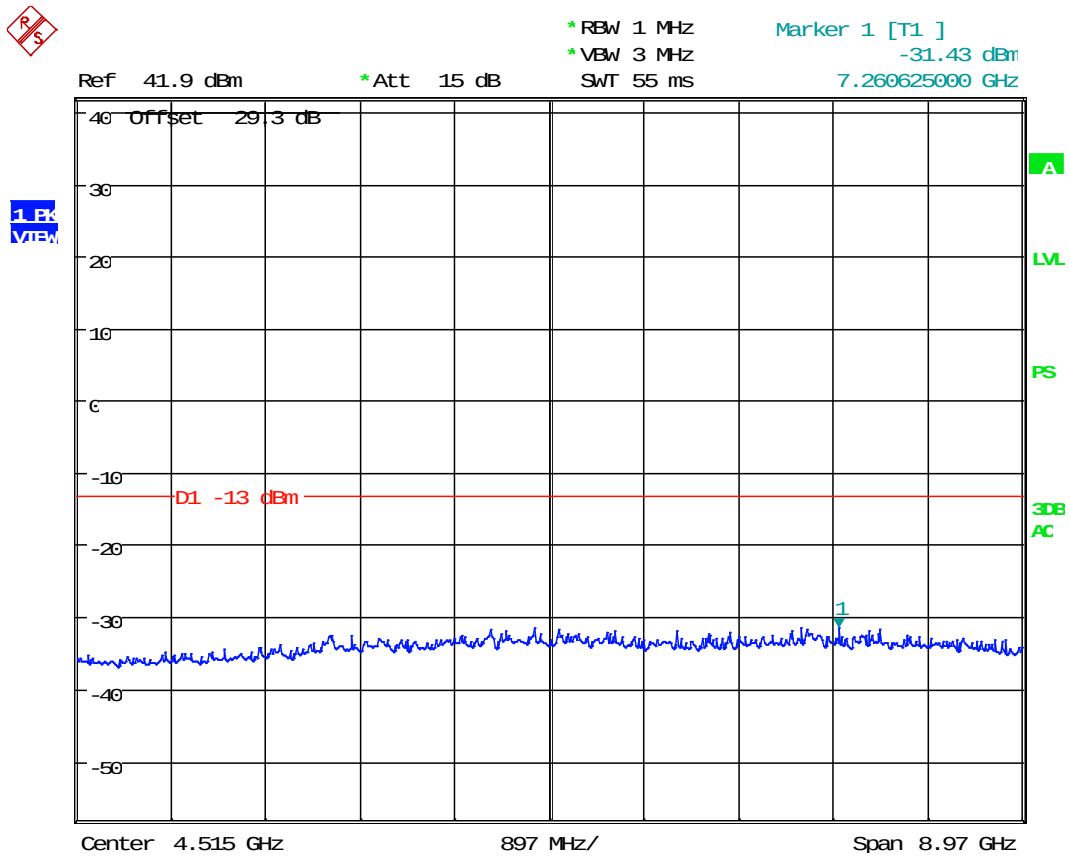
Test Data: 30 MHz to 9 GHz Scan, Peak Table

Mode	Peak Marker in Bref (dBm)	Spurious Emission Correction (dBm)	Noise floor, Low End, Out of Band		
		If Bm > 1, 10 x Log(Bref/Bm)	Corrected to Bm (dBm)	43+10 x Log(P) Limit (dBm)	Margin (dB)
< 0.0625 nm	-31.43	10.144	-21.286	-13.00	-8.286
0.125 nm	**-30.12**	**10.144**	**-19.976**	**-13.00**	**-6.976**
0.25 nm	-31.27	0.077	-31.193	-13.00	-18.193
0.5 nm	-30.47	0.077	-30.393	-13.00	-17.393
0.75 nm	-30.75	-2.070	-32.820	-13.00	-19.820
1 nm	-30.72	-2.135	-32.855	-13.00	-19.855
1.5 nm	-30.72	-2.135	-32.855	-13.00	-19.855
2 nm	-30.59	-4.223	-34.813	-13.00	-21.813
3 nm	-31.21	-4.223	-35.433	-13.00	-22.433
4 nm	-31.21	-4.771	-35.981	-13.00	-22.981
6 nm	-31.21	-4.223	-35.981	-13.00	-22.981
8 nm	-30.88	-4.771	-35.651	-13.00	-22.651
12 nm	-30.88	-4.771	-35.651	-13.00	-22.651
16 nm	-31.08	-4.771	-35.851	-13.00	-22.851
24 nm	-30.80	-4.771	-35.571	-13.00	-22.571
36 nm	-30.94	-4.771	-35.711	-13.00	-22.711

Worst-case Emission: **0.125 nm Mode**

UNWANTED SPURIOUS EMISSIONS

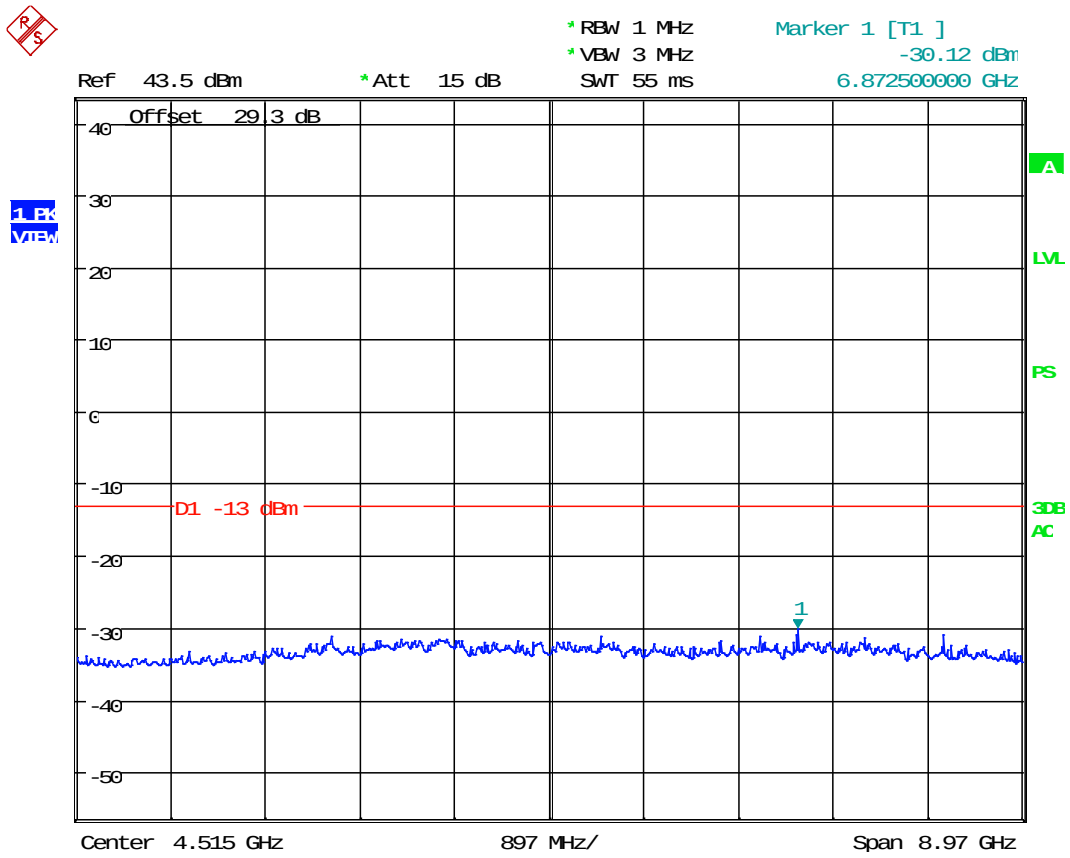
Test Data: ≤ 400 ft Mode, 30 MHz to 9 GHz Plot



Date: 25.JUL.2018 16:59:59

UNWANTED SPURIOUS EMISSIONS

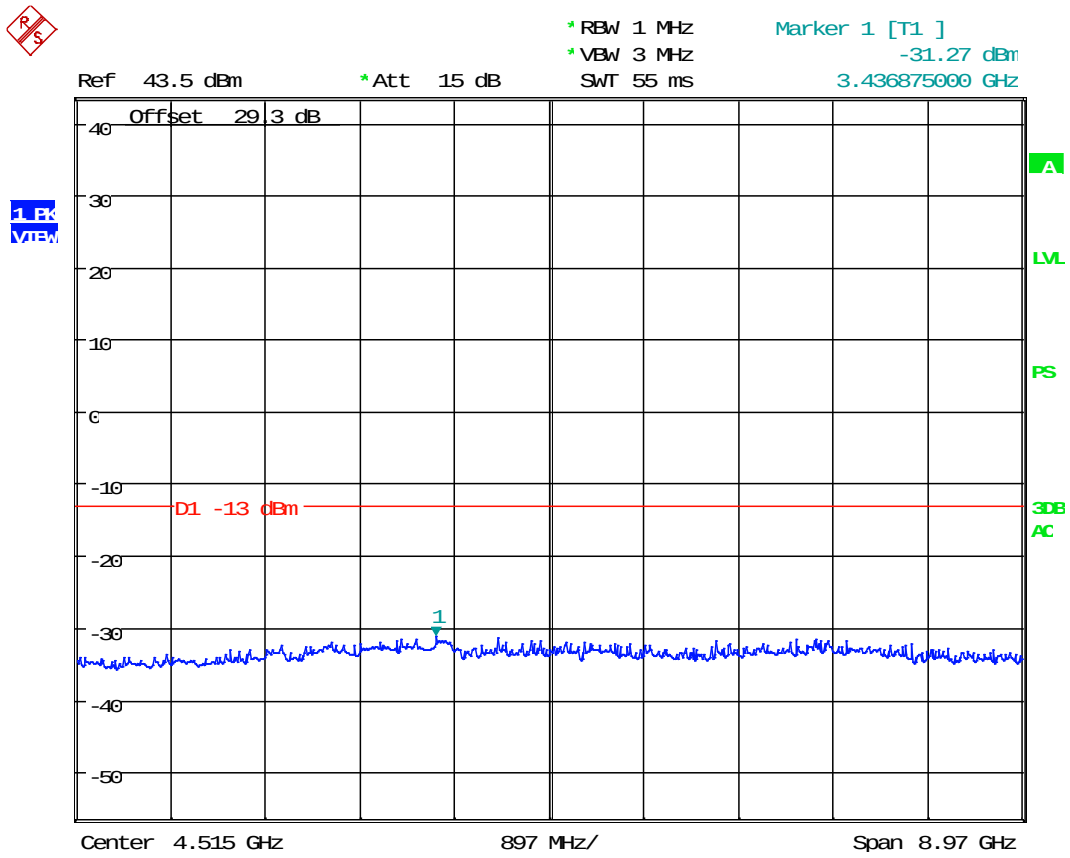
Test Data: 1/8 Nautical Mile Mode, 30 MHz to 9 GHz Plot



Date: 25.JUL.2018 16:59:11

UNWANTED SPURIOUS EMISSIONS

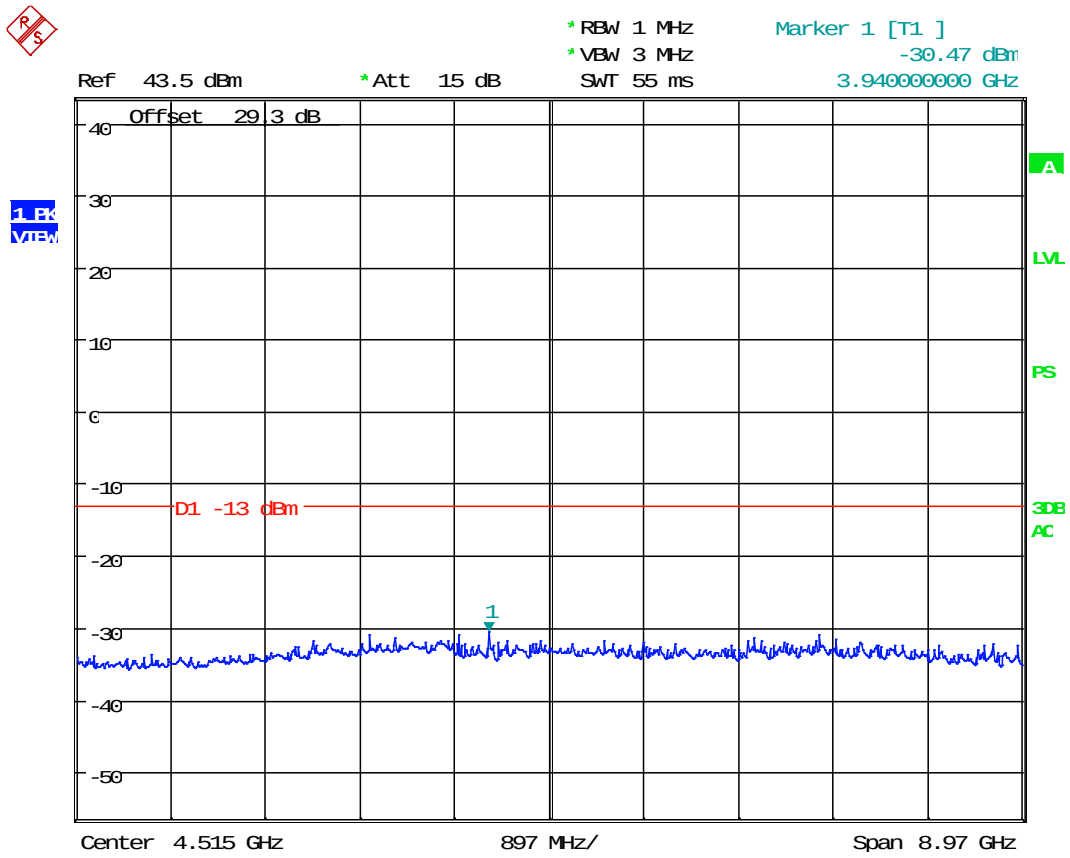
Test Data: 1/4 Nautical Mile Mode, 30 MHz to 9 GHz Plot



Date: 25.JUL.2018 16:58:34

UNWANTED SPURIOUS EMISSIONS

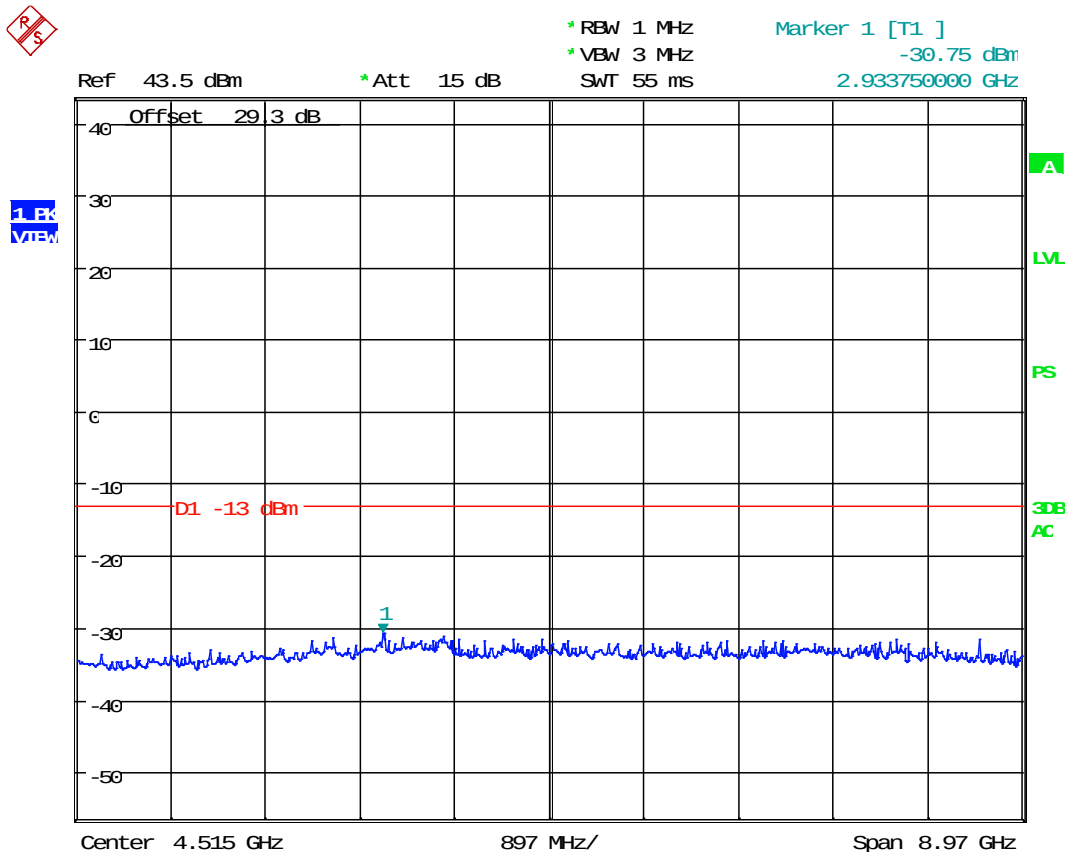
Test Data: 1/2 Nautical Mile Mode, 30 MHz to 9 GHz Plot



Date: 25.JUL.2018 16:58:02

UNWANTED SPURIOUS EMISSIONS

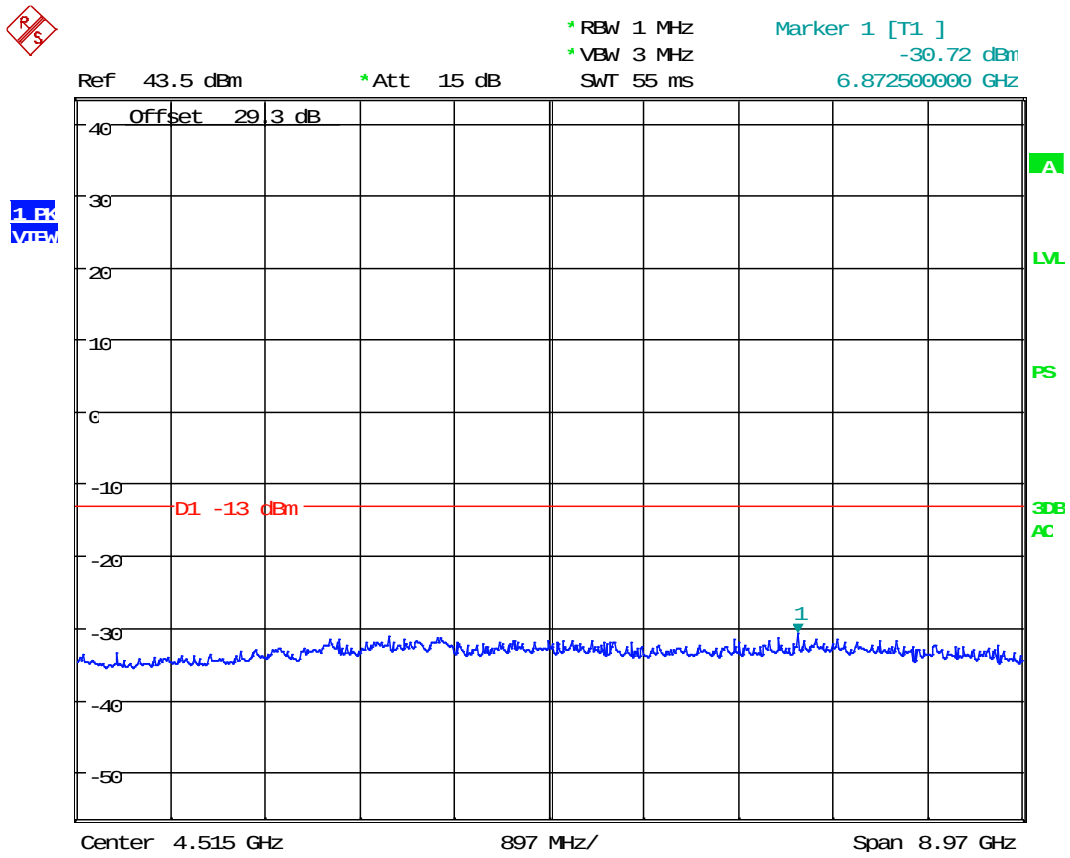
Test Data: 3/4 Nautical Mile Mode, 30 MHz to 9 GHz Plot



Date: 25.JUL.2018 16:57:19

UNWANTED SPURIOUS EMISSIONS

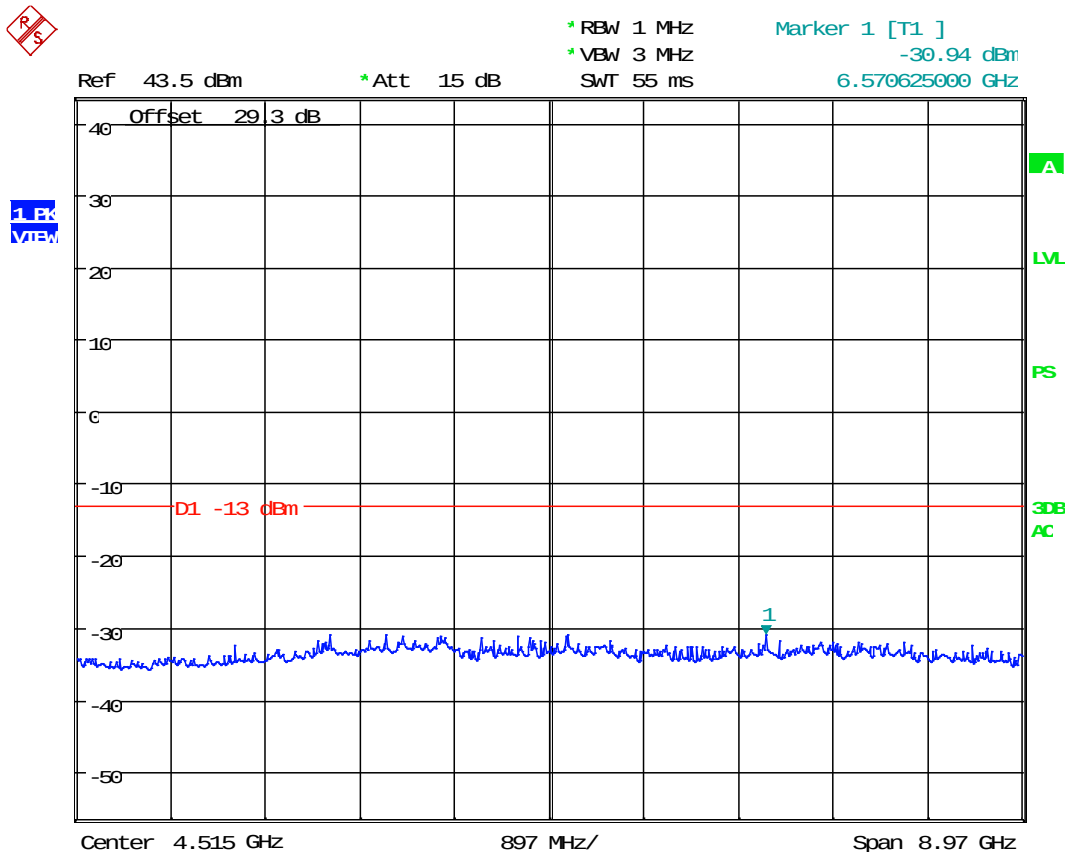
Test Data: 1 Nautical Mile Mode, 30 MHz to 9 GHz Plot



Date: 25.JUL.2018 16:56:48

UNWANTED SPURIOUS EMISSIONS

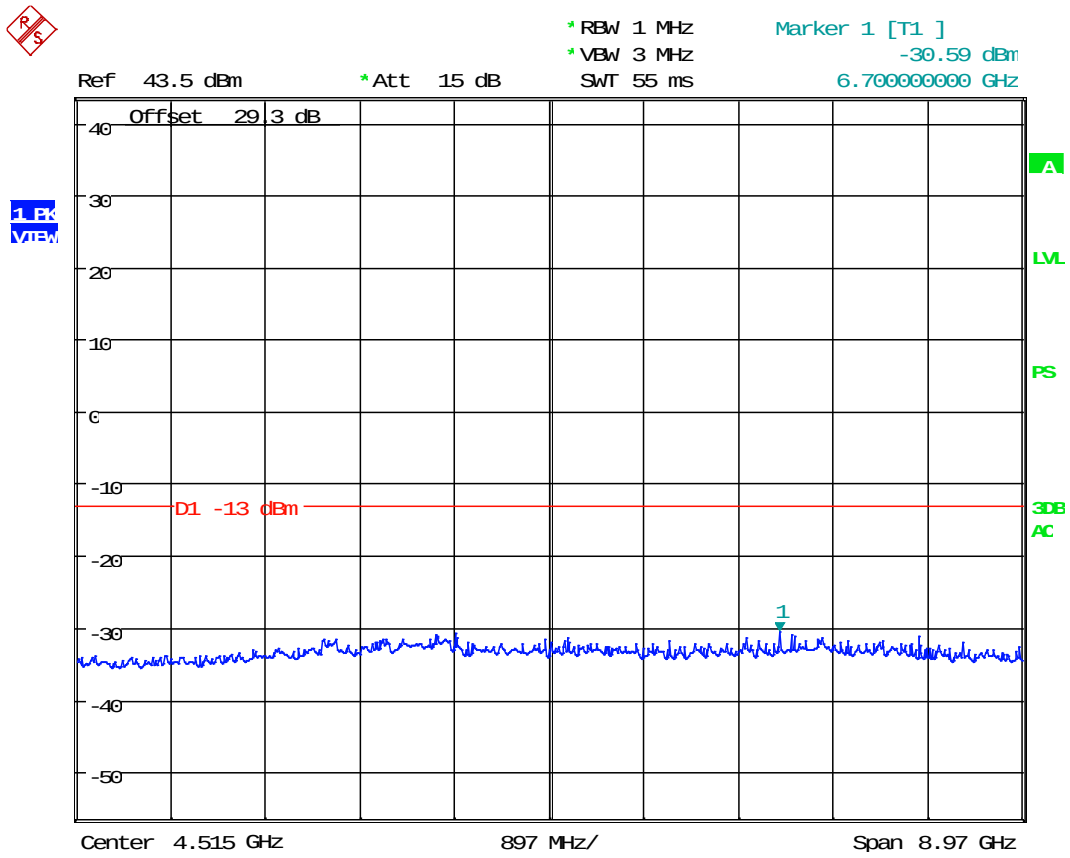
Test Data: 1.5 Nautical Mile Mode, 30 MHz to 9 GHz Plot



Date: 25.JUL.2018 16:56:04

UNWANTED SPURIOUS EMISSIONS

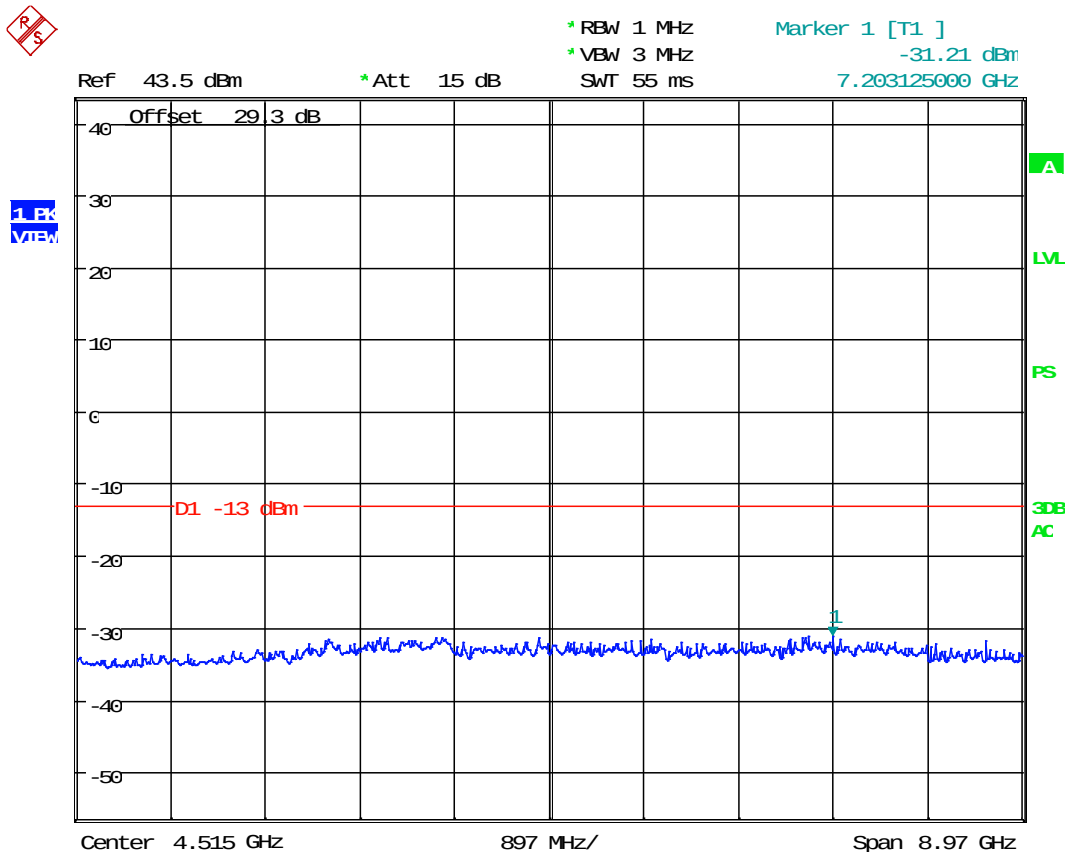
Test Data: 2 Nautical Mile Mode, 30 MHz to 9 GHz Plot



Date: 25.JUL.2018 16:55:32

UNWANTED SPURIOUS EMISSIONS

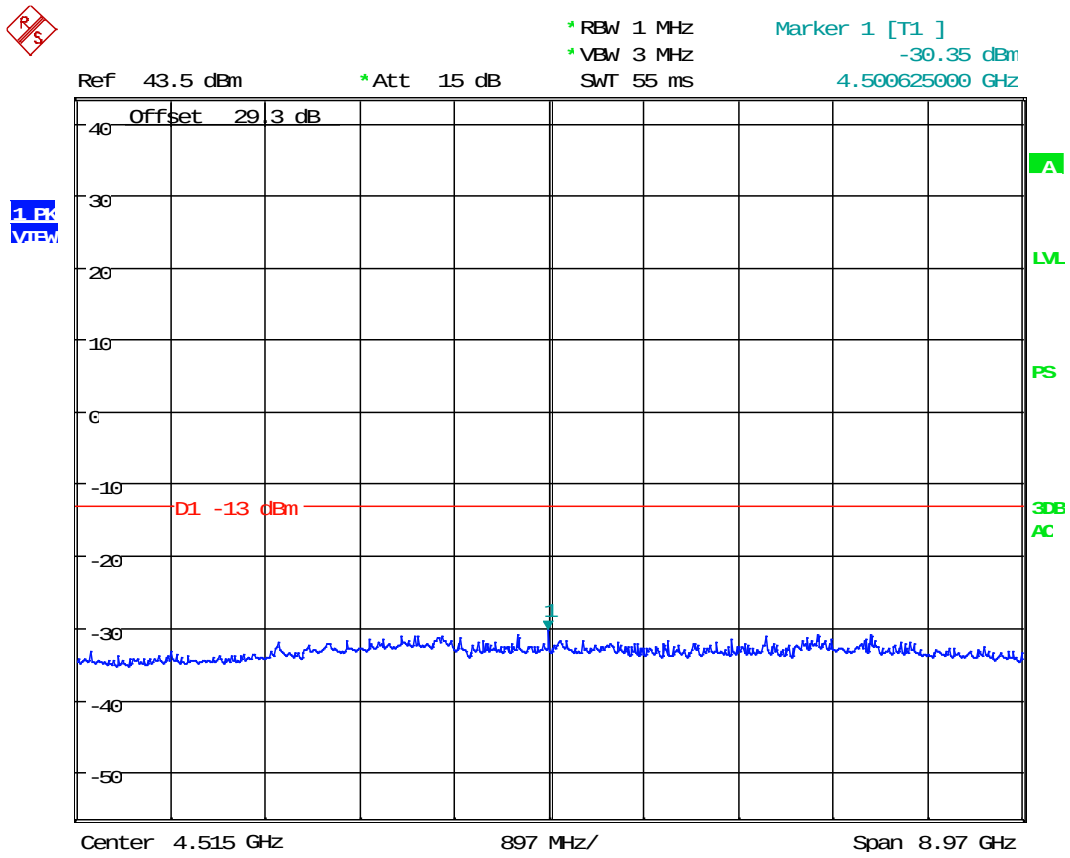
Test Data: 3 Nautical Mile Mode, 30 MHz to 9 GHz Plot



Date: 25.JUL.2018 16:54:53

UNWANTED SPURIOUS EMISSIONS

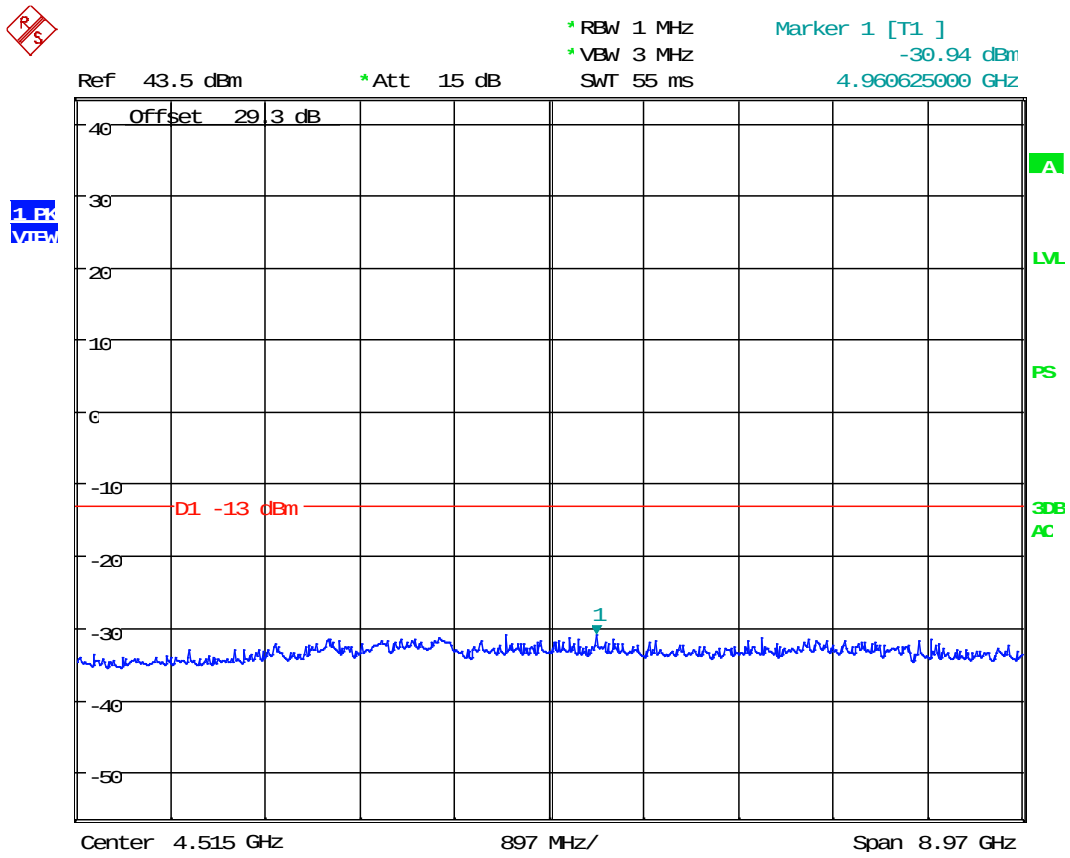
Test Data: 4 Nautical Mile Mode, 30 MHz to 9 GHz Plot



Date: 25.JUL.2018 16:54:18

UNWANTED SPURIOUS EMISSIONS

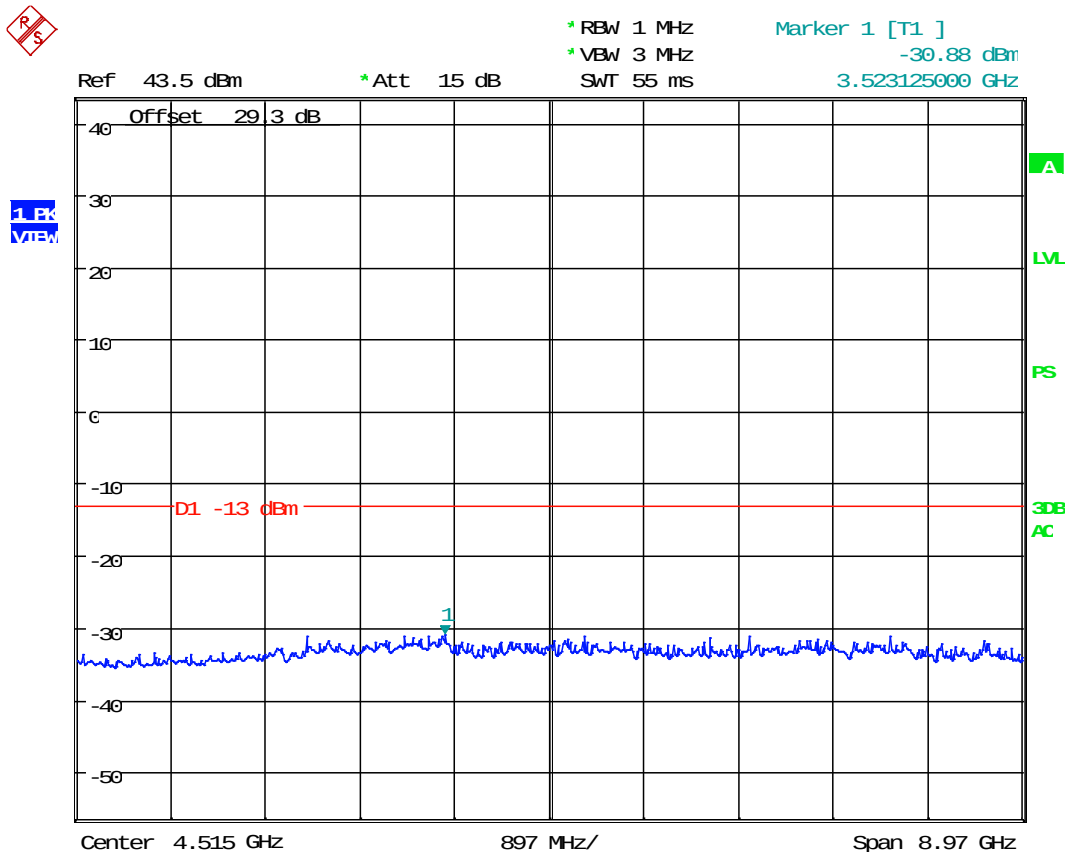
Test Data: 6 Nautical Mile Mode, 30 MHz to 9 GHz Plot



Date: 25.JUL.2018 16:53:23

UNWANTED SPURIOUS EMISSIONS

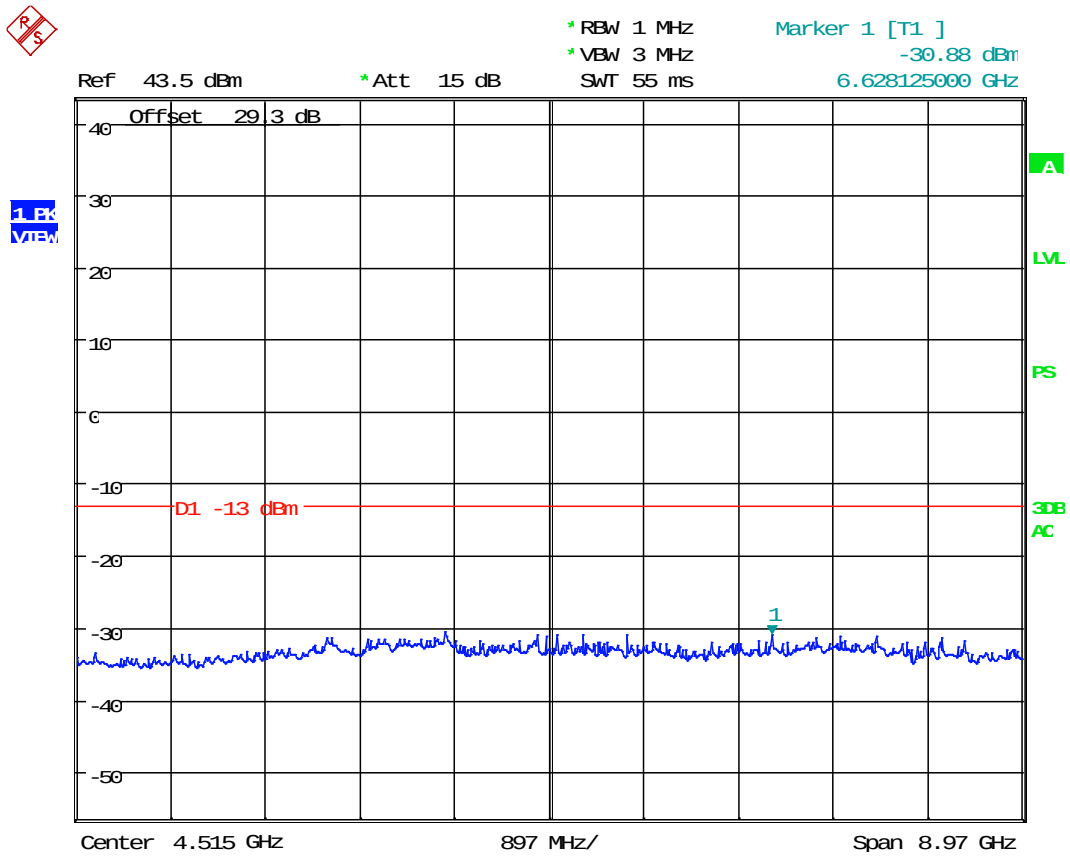
Test Data: 8 Nautical Mile Mode, 30 MHz to 9 GHz Plot



Date: 25.JUL.2018 16:52:41

UNWANTED SPURIOUS EMISSIONS

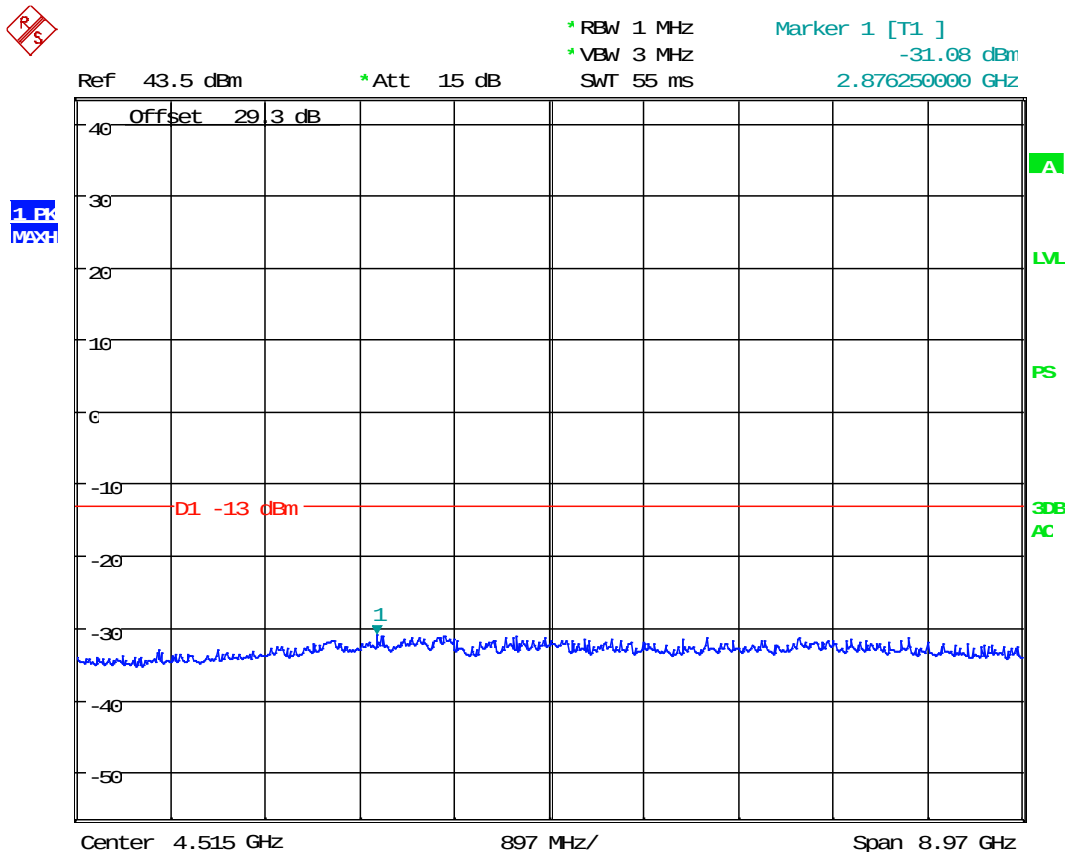
Test Data: 12 Nautical Mile Mode, 30 MHz to 9 GHz Plot



Date: 25.JUL.2018 16:52:03

UNWANTED SPURIOUS EMISSIONS

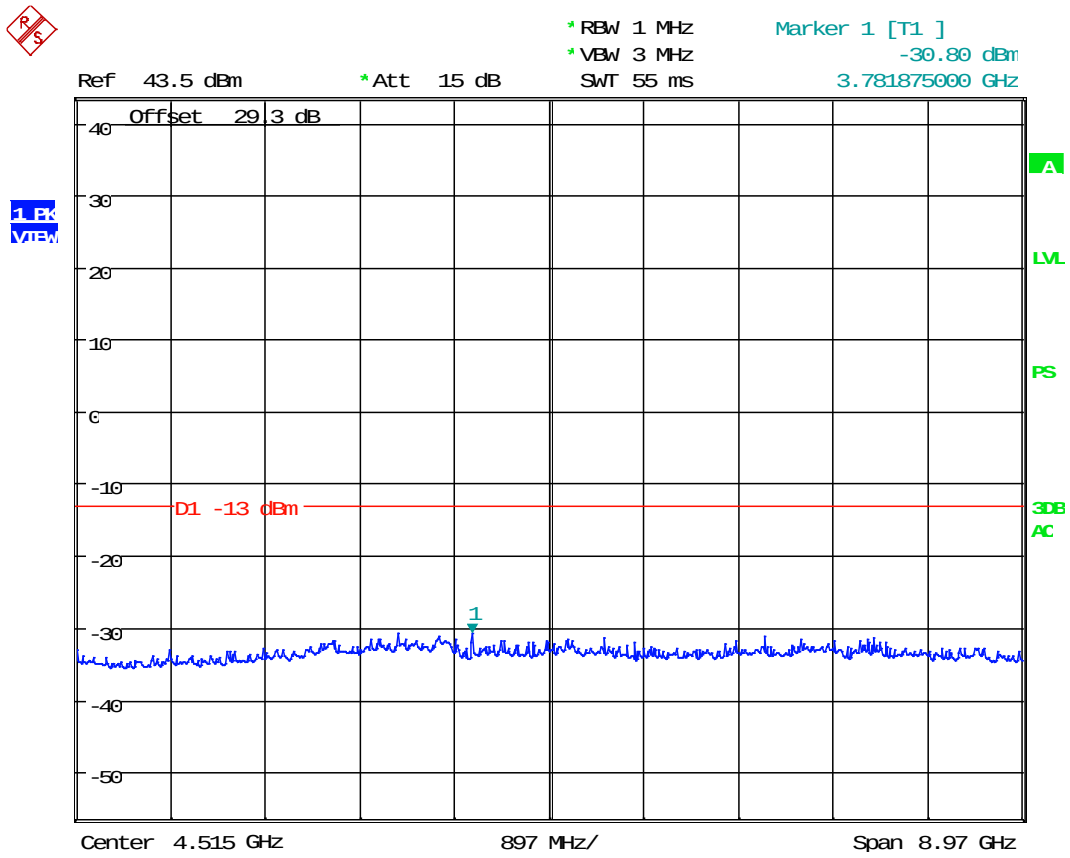
Test Data: 16 Nautical Mile Mode, 30 MHz to 9 GHz Plot



Date: 25.JUL.2018 16:51:26

UNWANTED SPURIOUS EMISSIONS

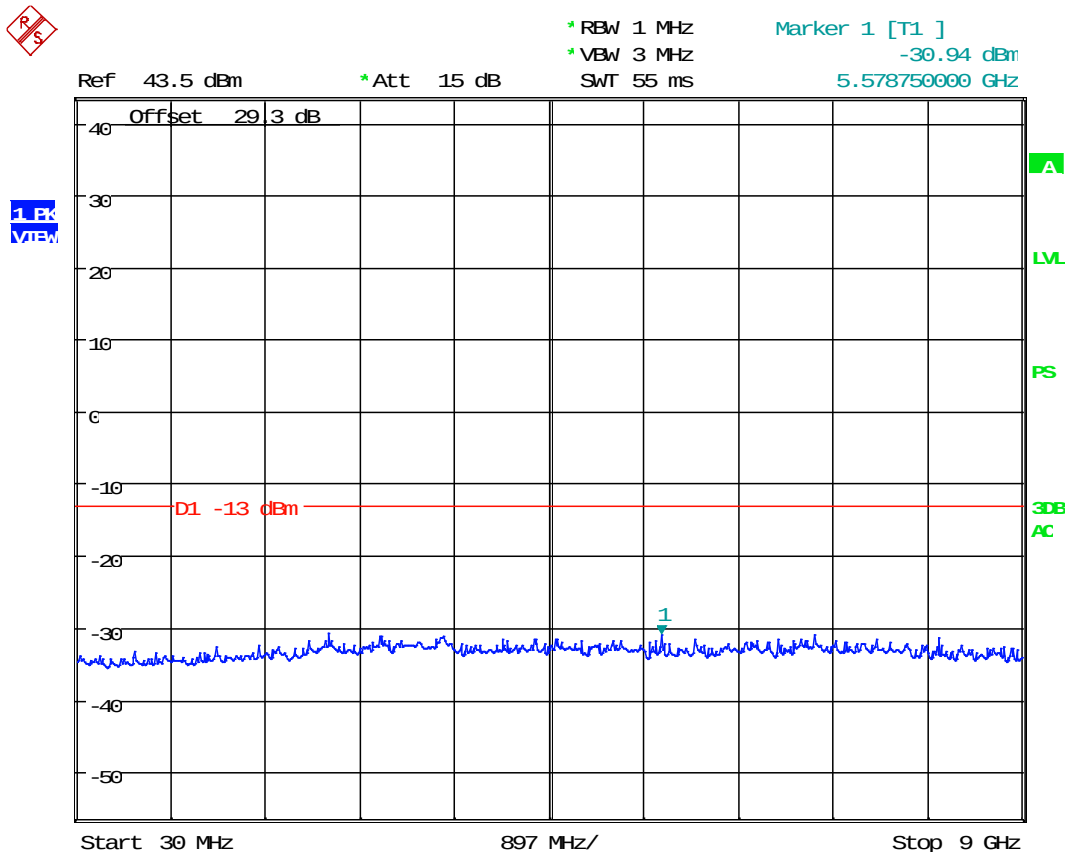
Test Data: 24 Nautical Mile Mode, 30 MHz to 9 GHz Plot



Date: 25.JUL.2018 16:50:30

UNWANTED SPURIOUS EMISSIONS

Test Data: 36 Nautical Mile Mode, 30 MHz to 9 GHz Plot



Date: 25.JUL.2018 16:49:49

UNWANTED SPURIOUS EMISSIONS

Test Data: 2nd Harmonic Peak Table

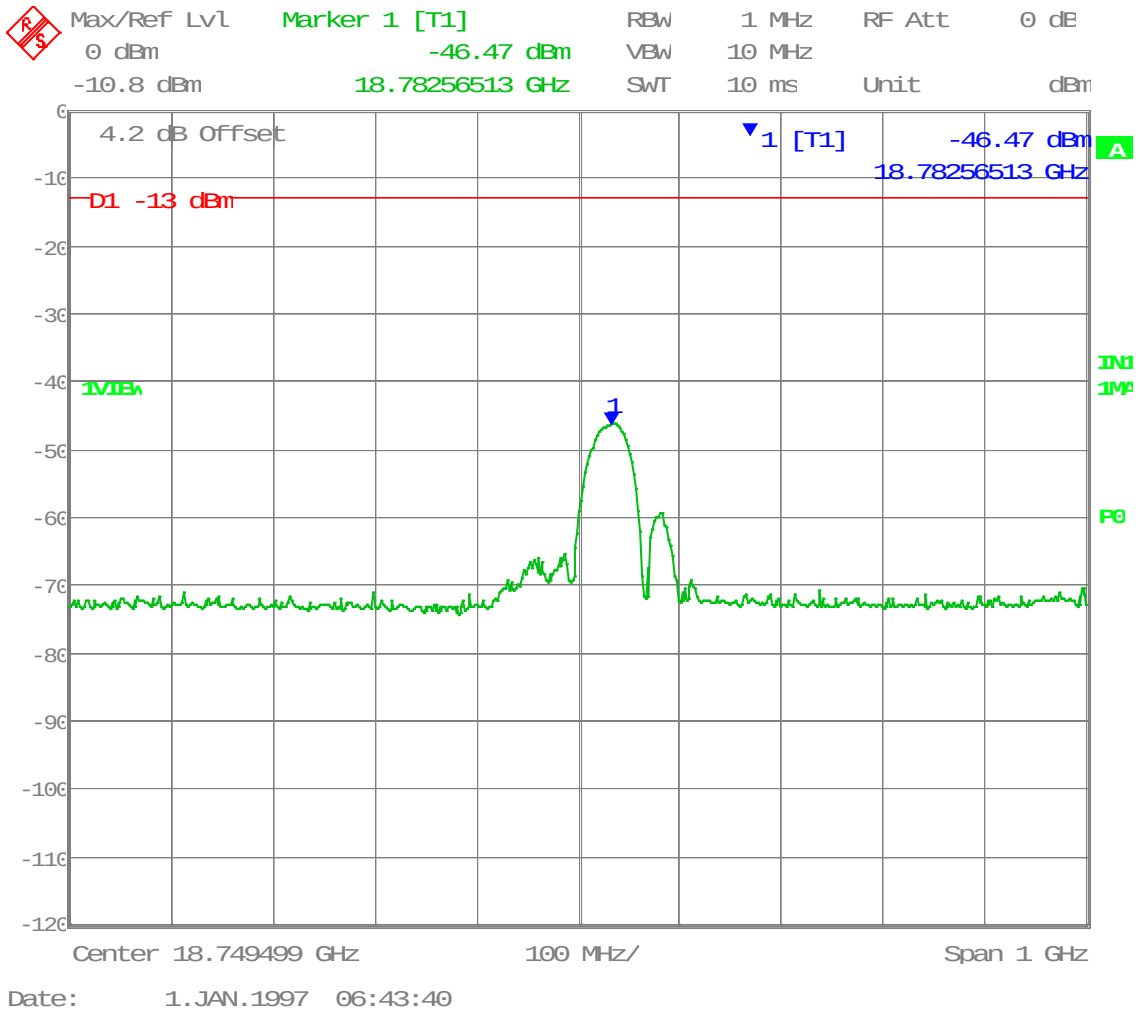
Mode	Center Freq (MHz)	Peak Output Power (dBm)	Spurious Emission Correction (dBm)	2nd Harmonic				
			If Bm > 1, 20 x Log(Bref/Bm)	Harmonic Frequency (MHz)	Measured Peak in Bref (dBm)	Corrected to Bm (dBm)	43+10 x Log(P) Limit (dBm)	Margin (dB)
< 0.0625 nm	9390.00	41.883	29.831	18780.000	-46.470	-16.639	-13.00	3.64
0.125 nm	9390.00	43.500	29.831	18780.000	-46.340	-16.509	-13.00	3.51
0.25 nm	9400.93	43.500	9.697	18801.860	-24.940	-15.243	-13.00	2.24
0.5 nm	**9400.93**	**43.500**	**9.697**	**18801.860**	**-24.850**	**-15.153**	**-13.00**	**2.15**
0.75 nm	9418.11	43.500	5.402	18836.220	-24.730	-19.328	-13.00	6.33
1 nm	9418.11	43.500	5.273	18836.220	-24.730	-19.457	-13.00	6.46
1.5 nm	9418.11	43.500	5.273	18836.220	-24.730	-19.457	-13.00	6.46
2 nm	9427.65	43.500	1.096	18855.300	-23.780	-22.684	-13.00	9.68
3 nm	9427.65	43.500	1.096	18855.300	-24.140	-23.044	-13.00	10.04
4 nm	9430.70	43.500	0.000	18861.400	-23.780	-23.780	-13.00	10.78
6 nm	9430.70	43.500	0.000	18861.400	-24.140	-24.140	-13.00	11.14
8 nm	9427.32	43.500	0.000	18854.640	-24.390	-24.390	-13.00	11.39
12 nm	9427.32	43.500	0.000	18854.640	-24.020	-24.020	-13.00	11.02
16 nm	9427.32	43.500	0.000	18854.640	-24.510	-24.510	-13.00	11.51
24 nm	9427.32	43.500	0.000	18854.640	-24.390	-24.390	-13.00	11.39
≥ 36 nm	9427.32	43.500	0.000	18854.640	-24.610	-24.610	-13.00	11.61

* Indicates No emission was present and/or emission was below noise floor of instrumentation

Worst-case Emission: **0.5 nm Mode**

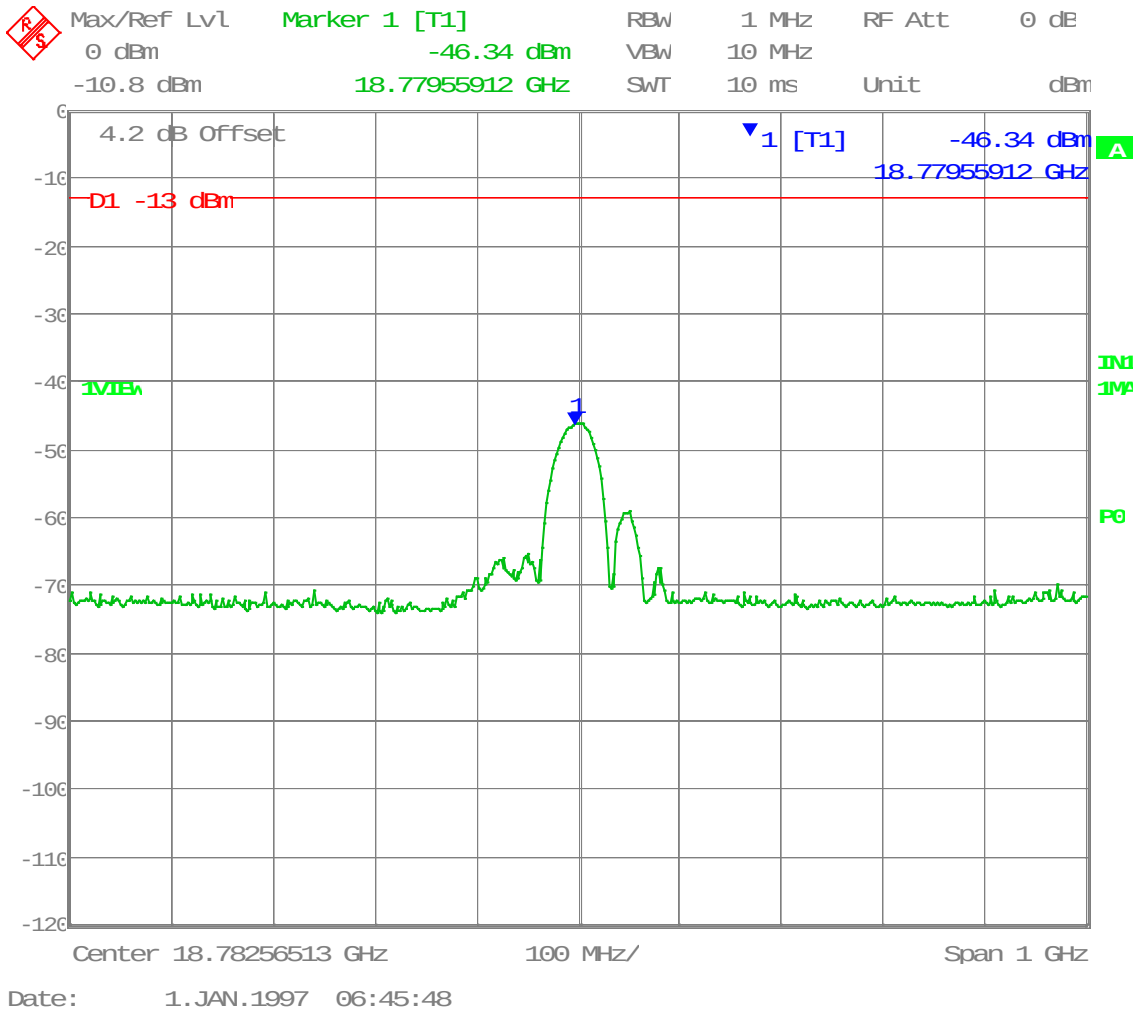
UNWANTED SPURIOUS EMISSIONS

Test Data: ≤ 400 ft Mode, 2nd Harmonic Plot



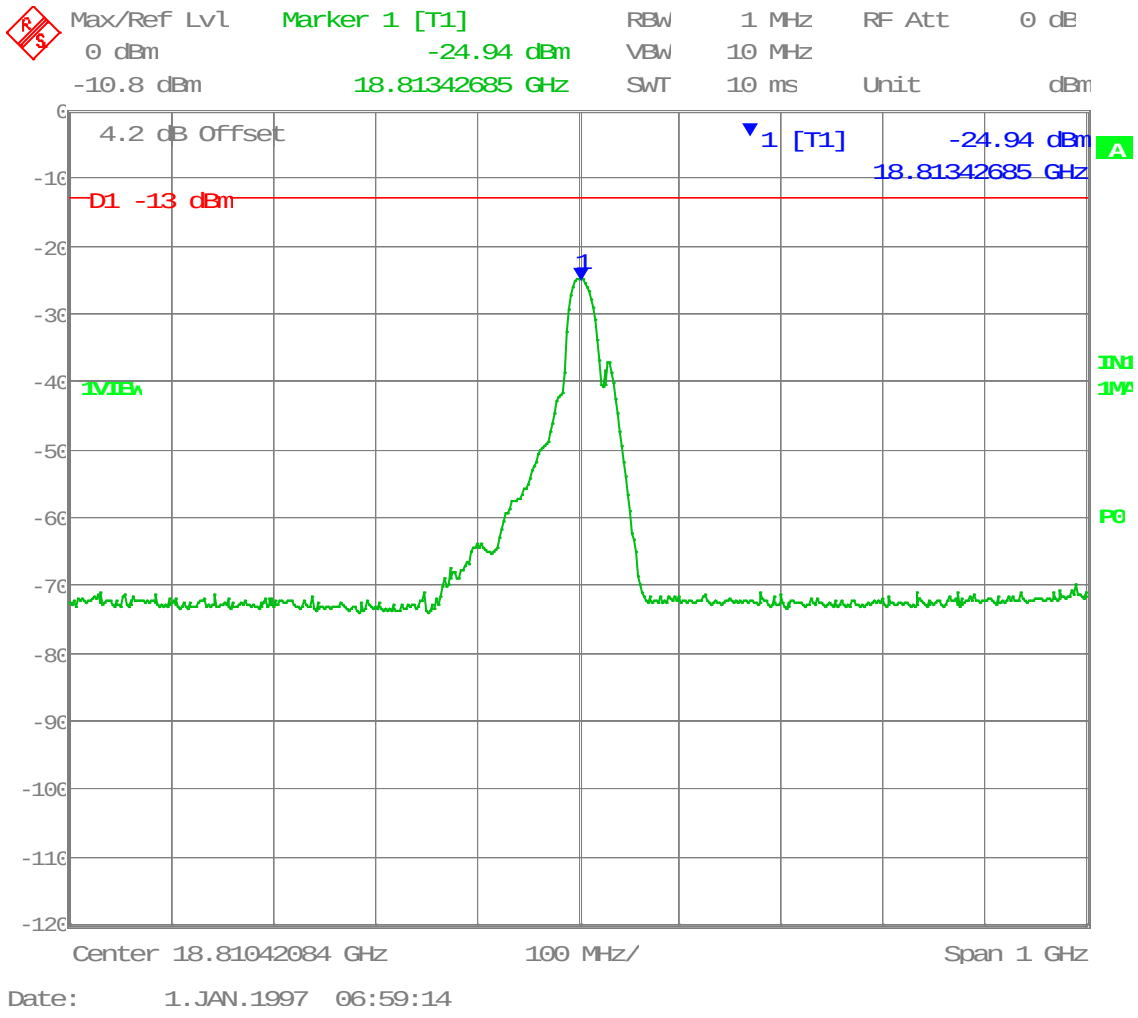
UNWANTED SPURIOUS EMISSIONS

Test Data: 1/8 Nautical Mile Mode, 2nd Harmonic Plot



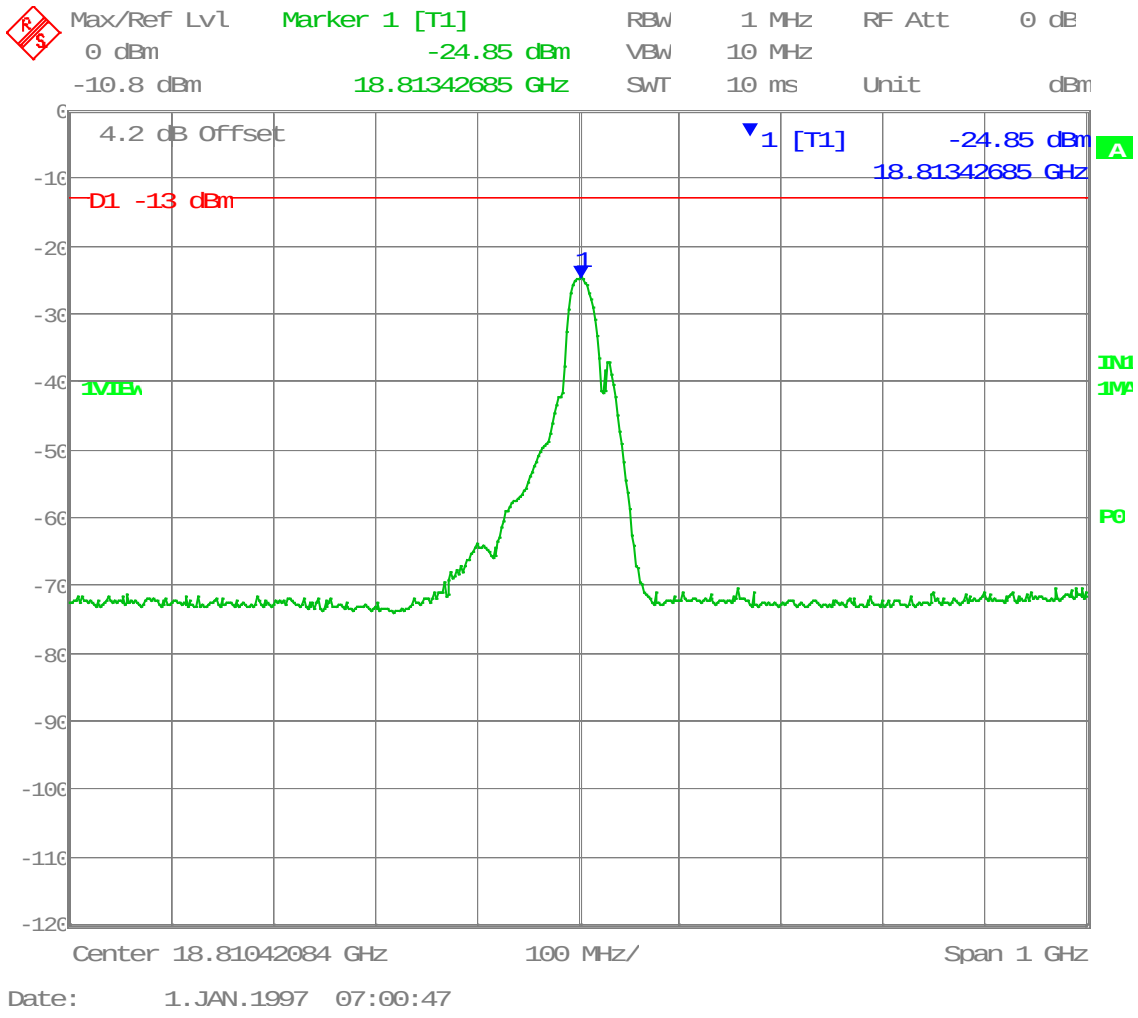
UNWANTED SPURIOUS EMISSIONS

Test Data: 1/4 Nautical Mile Mode, 2nd Harmonic Plot



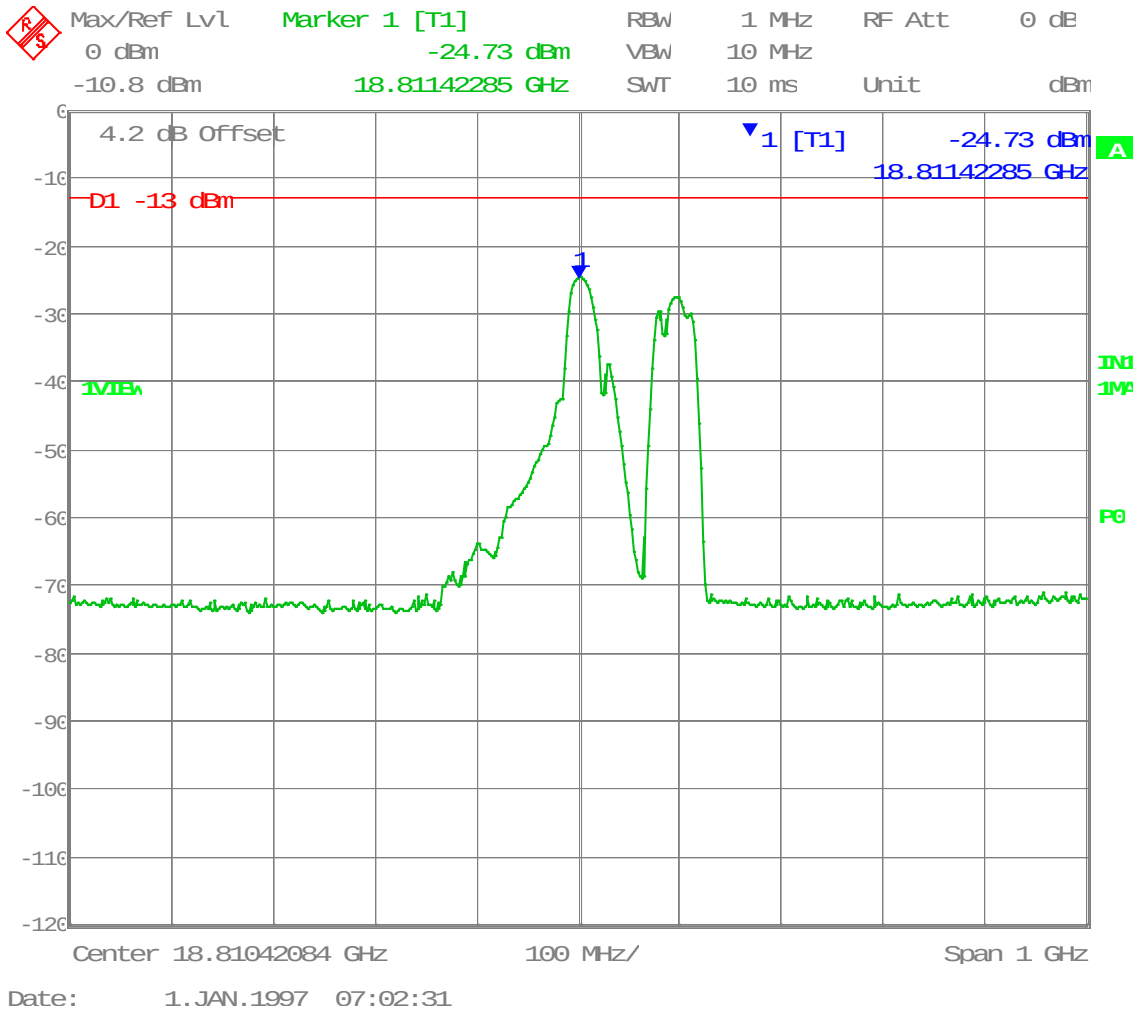
UNWANTED SPURIOUS EMISSIONS

Test Data: 1/2 Nautical Mile Mode, 2nd Harmonic Plot



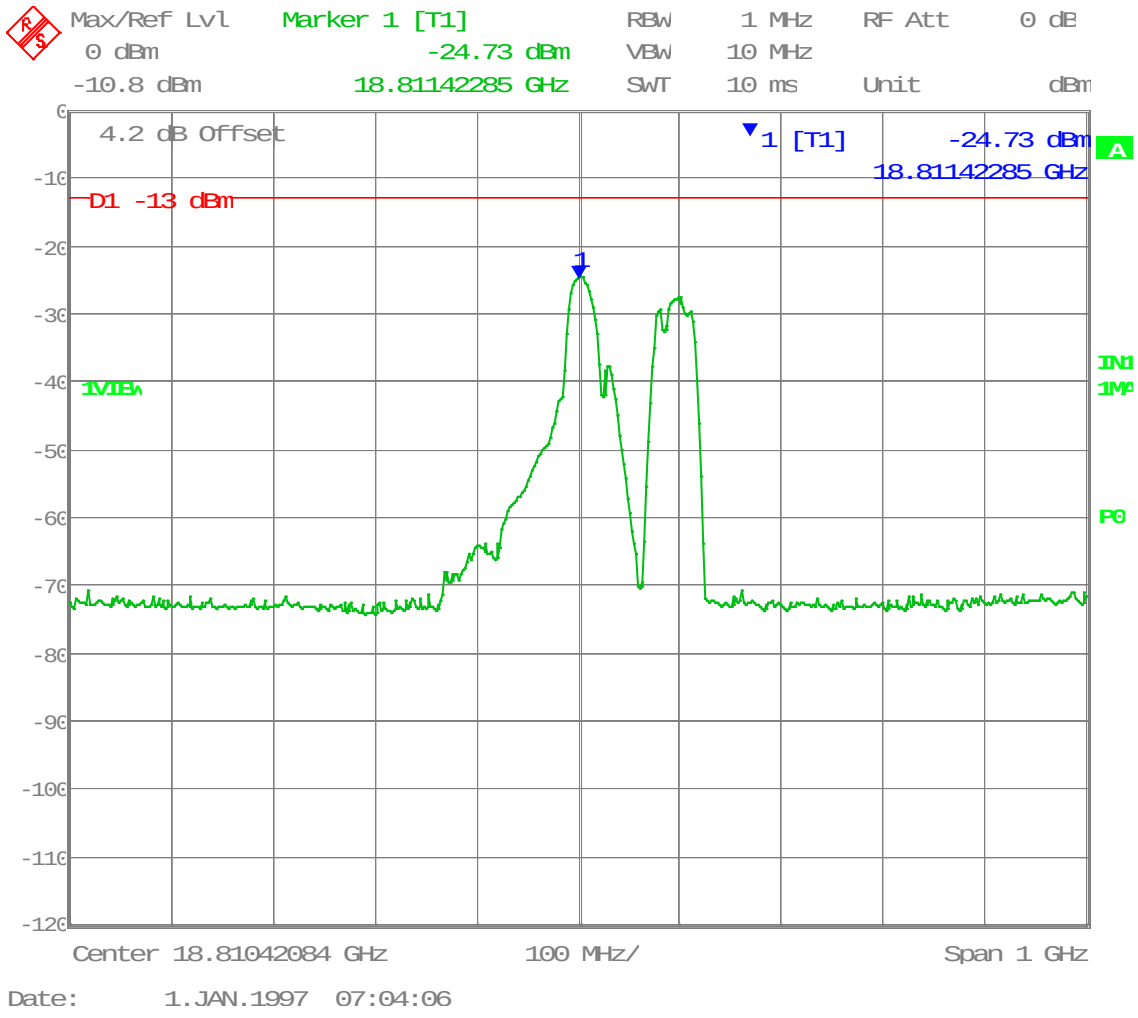
UNWANTED SPURIOUS EMISSIONS

Test Data: 3/4 Nautical Mile Mode, 2nd Harmonic Plot



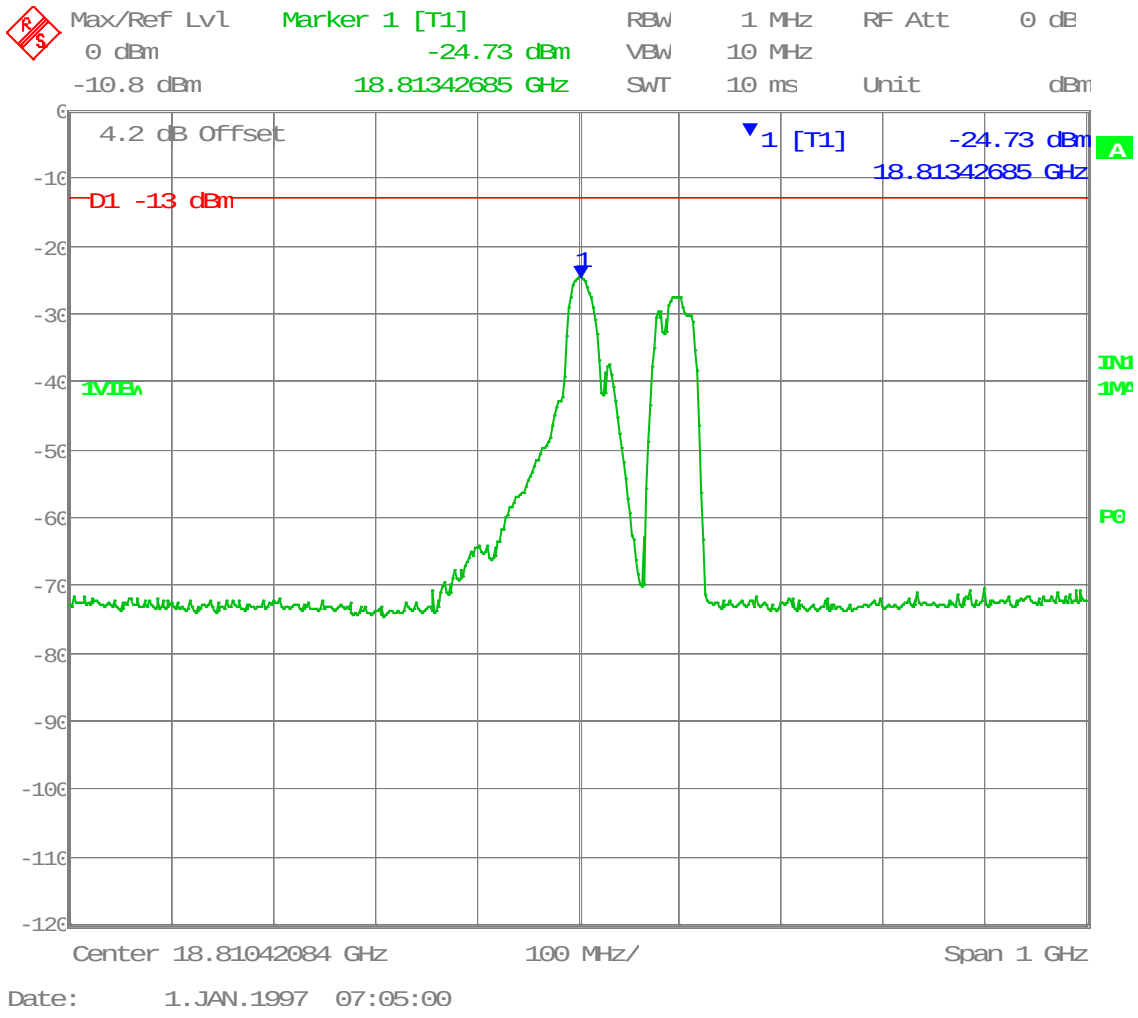
UNWANTED SPURIOUS EMISSIONS

Test Data: 1 Nautical Mile Mode, 2nd Harmonic Plot



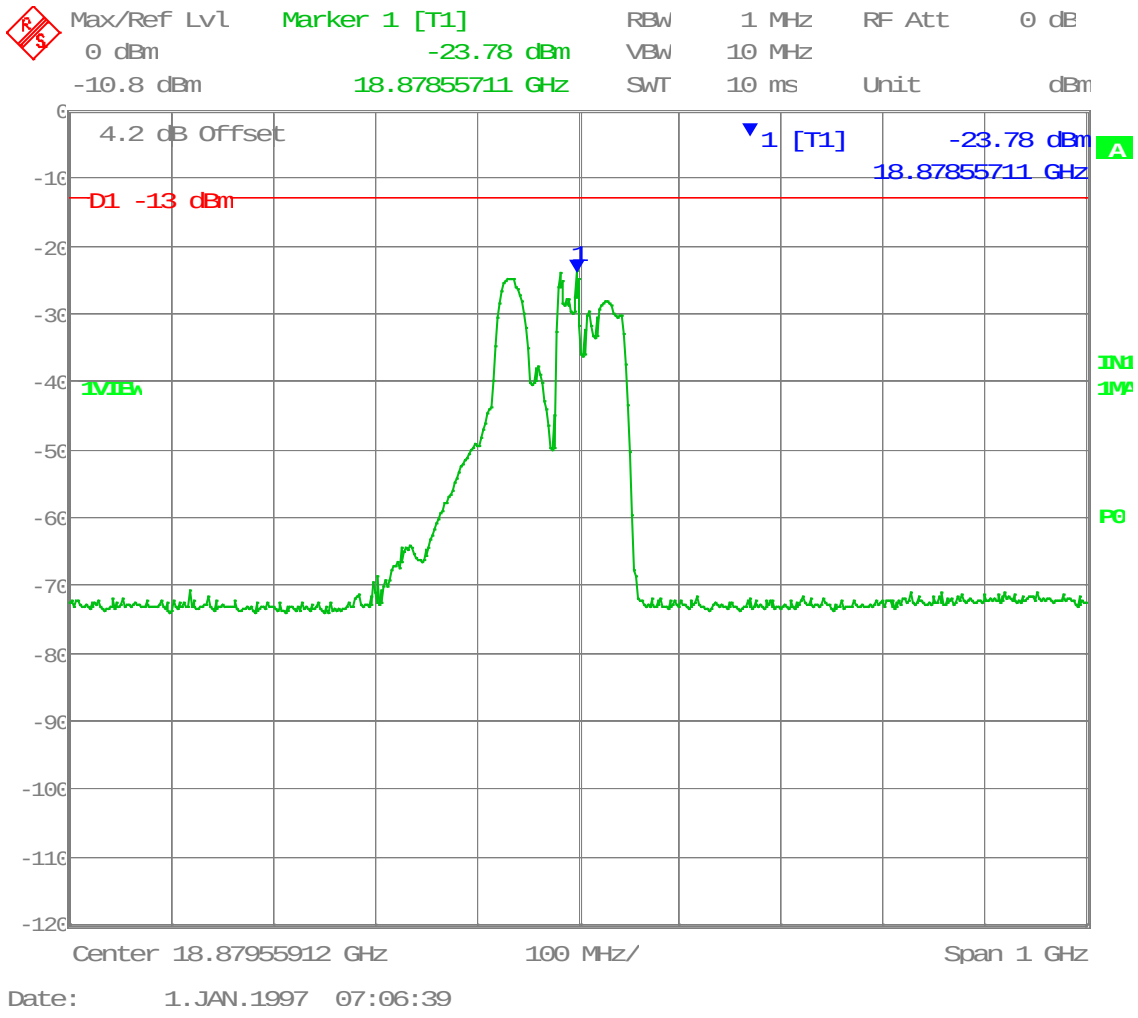
UNWANTED SPURIOUS EMISSIONS

Test Data: 1.5 Nautical Mile Mode, 2nd Harmonic Plot



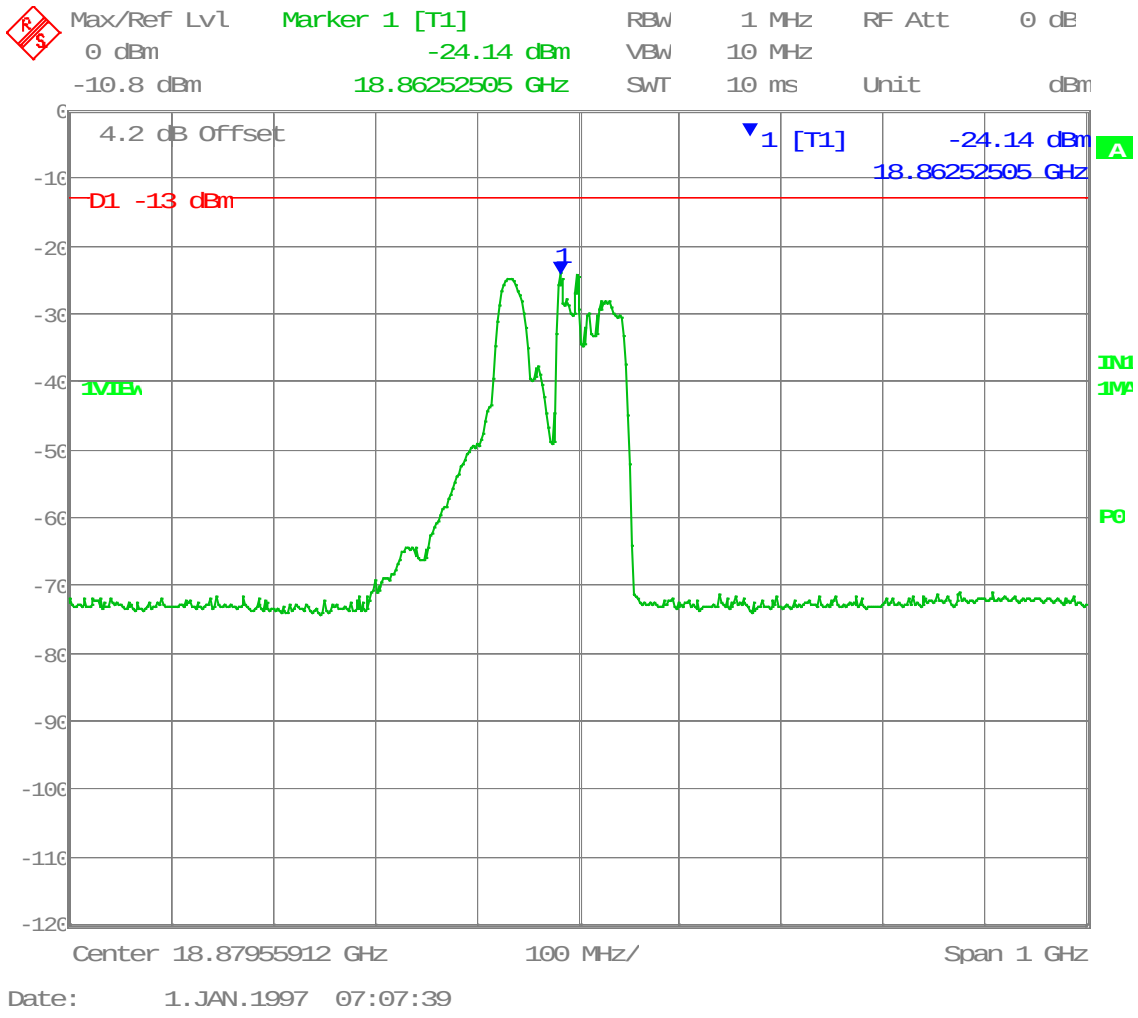
UNWANTED SPURIOUS EMISSIONS

Test Data: 2 Nautical Mile Mode, 2nd Harmonic Plot



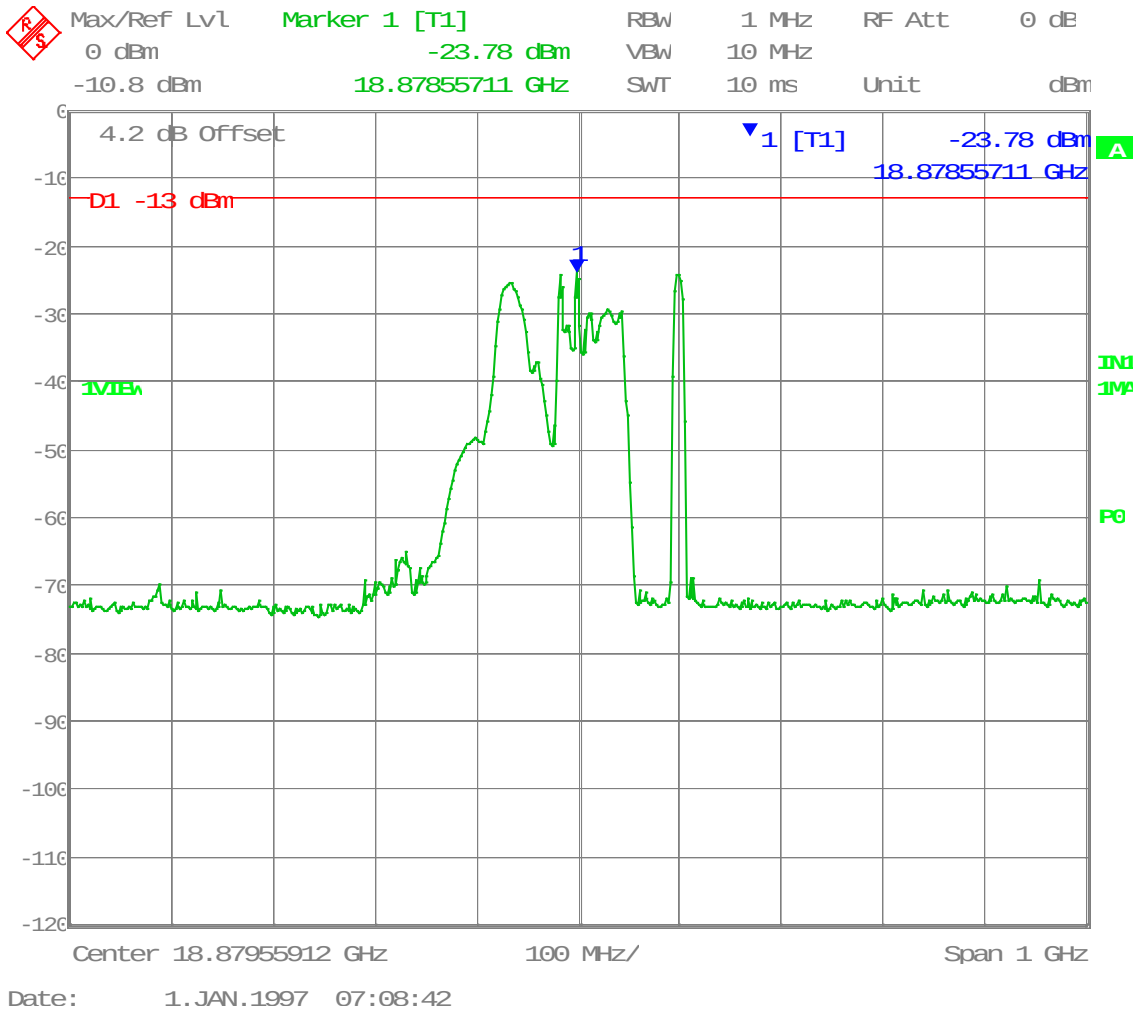
UNWANTED SPURIOUS EMISSIONS

Test Data: 3 Nautical Mile Mode, 2nd Harmonic Plot



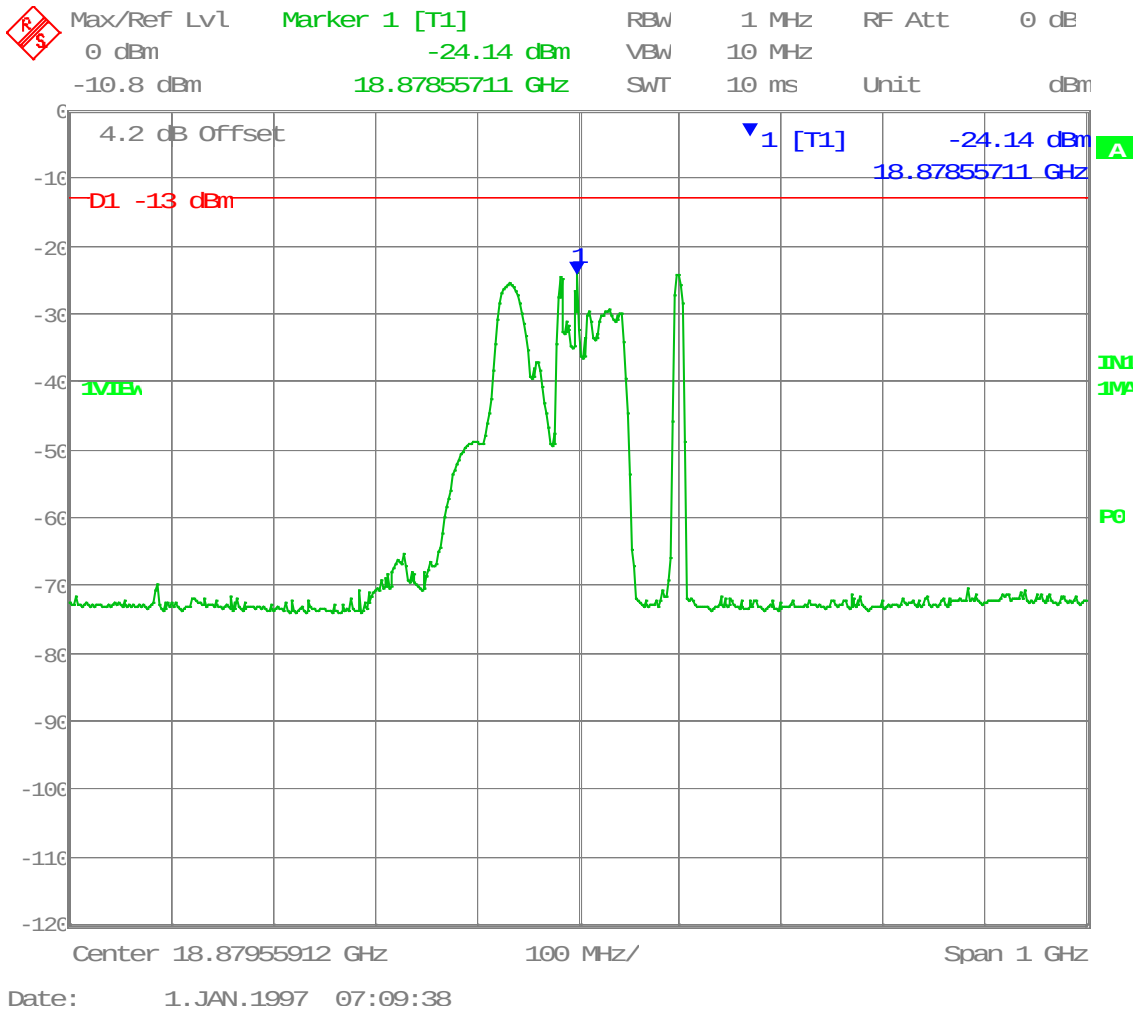
UNWANTED SPURIOUS EMISSIONS

Test Data: 4 Nautical Mile Mode, 2nd Harmonic Plot



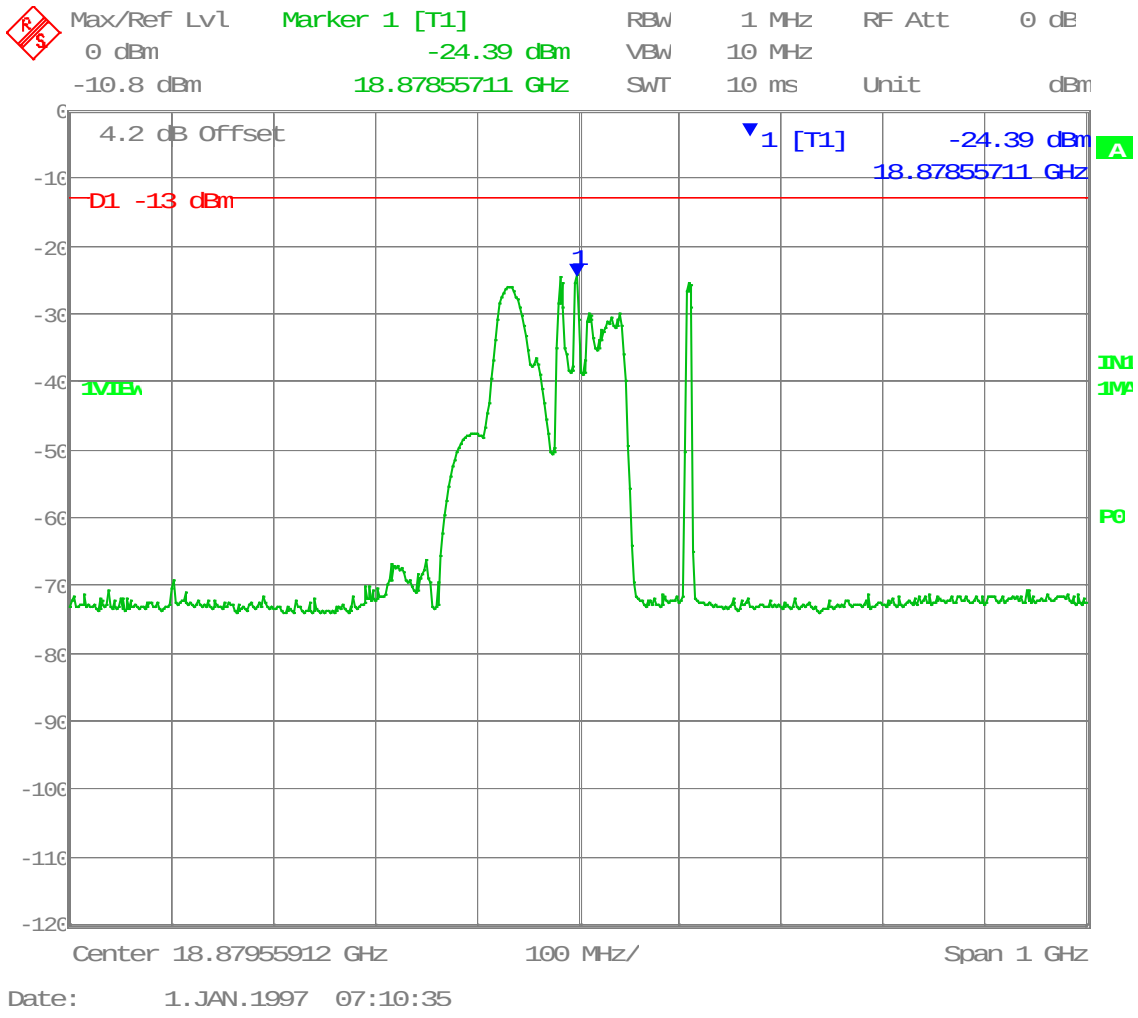
UNWANTED SPURIOUS EMISSIONS

Test Data: 6 Nautical Mile Mode, 2nd Harmonic Plot



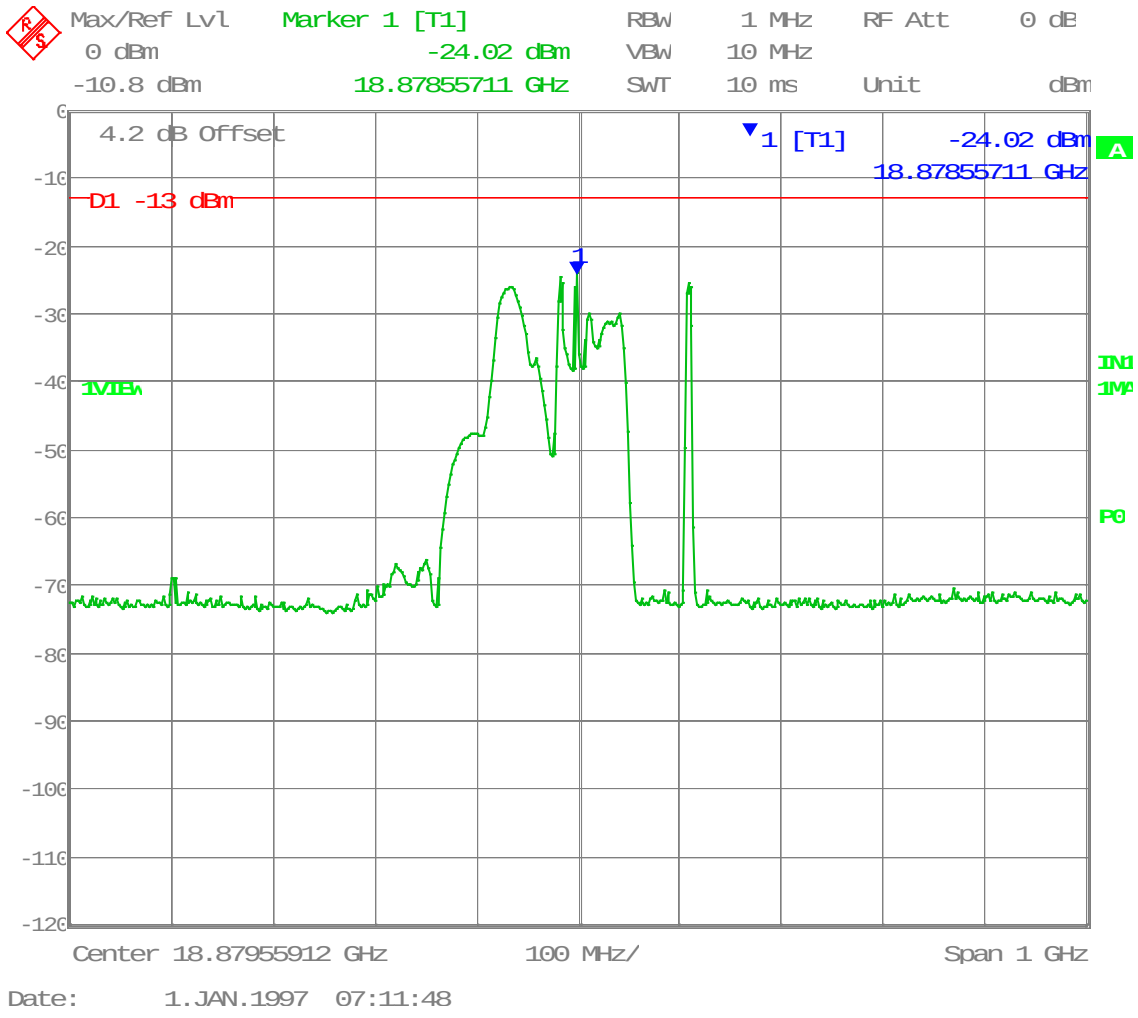
UNWANTED SPURIOUS EMISSIONS

Test Data: 8 Nautical Mile Mode, 2nd Harmonic Plot



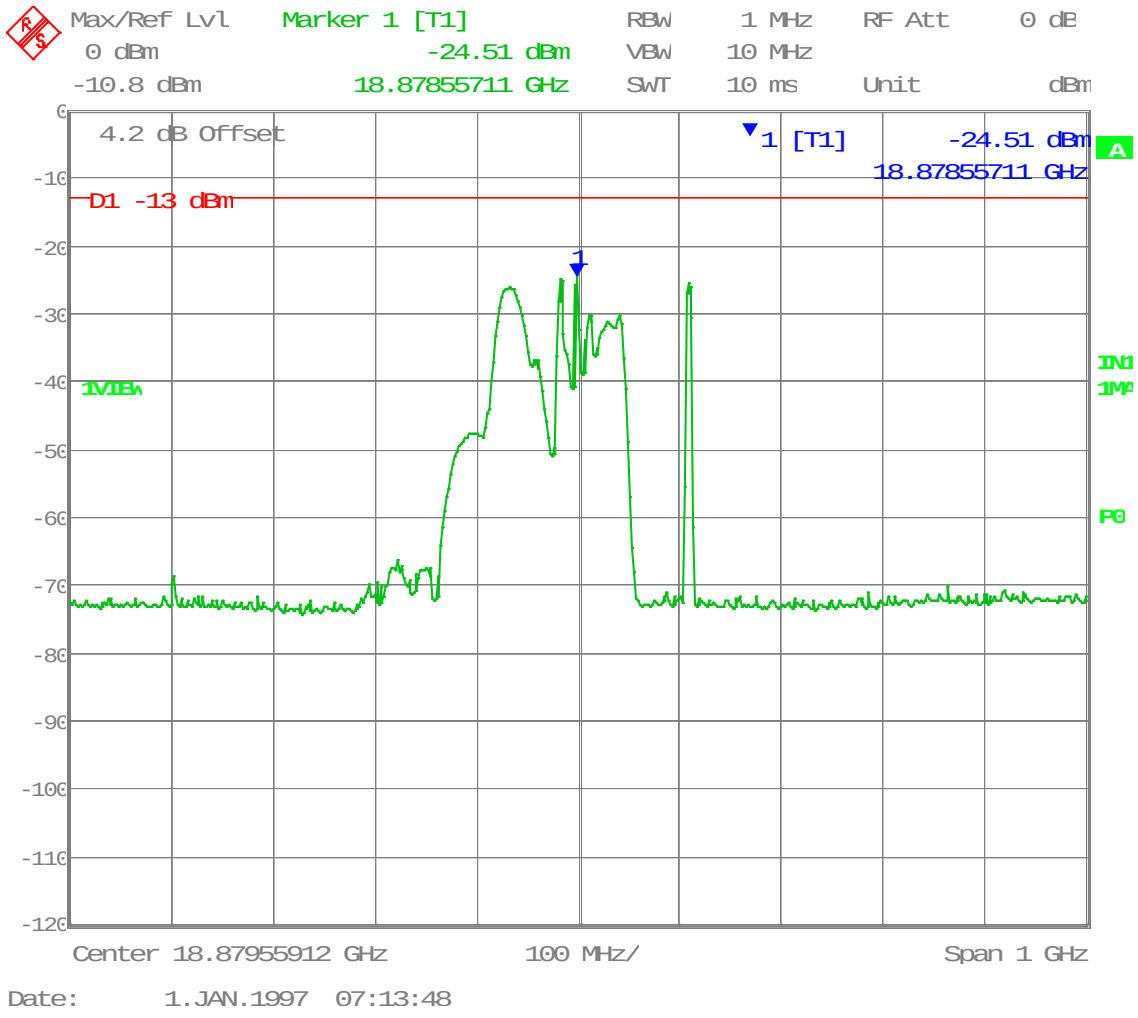
UNWANTED SPURIOUS EMISSIONS

Test Data: 12 Nautical Mile Mode, 2nd Harmonic Plot



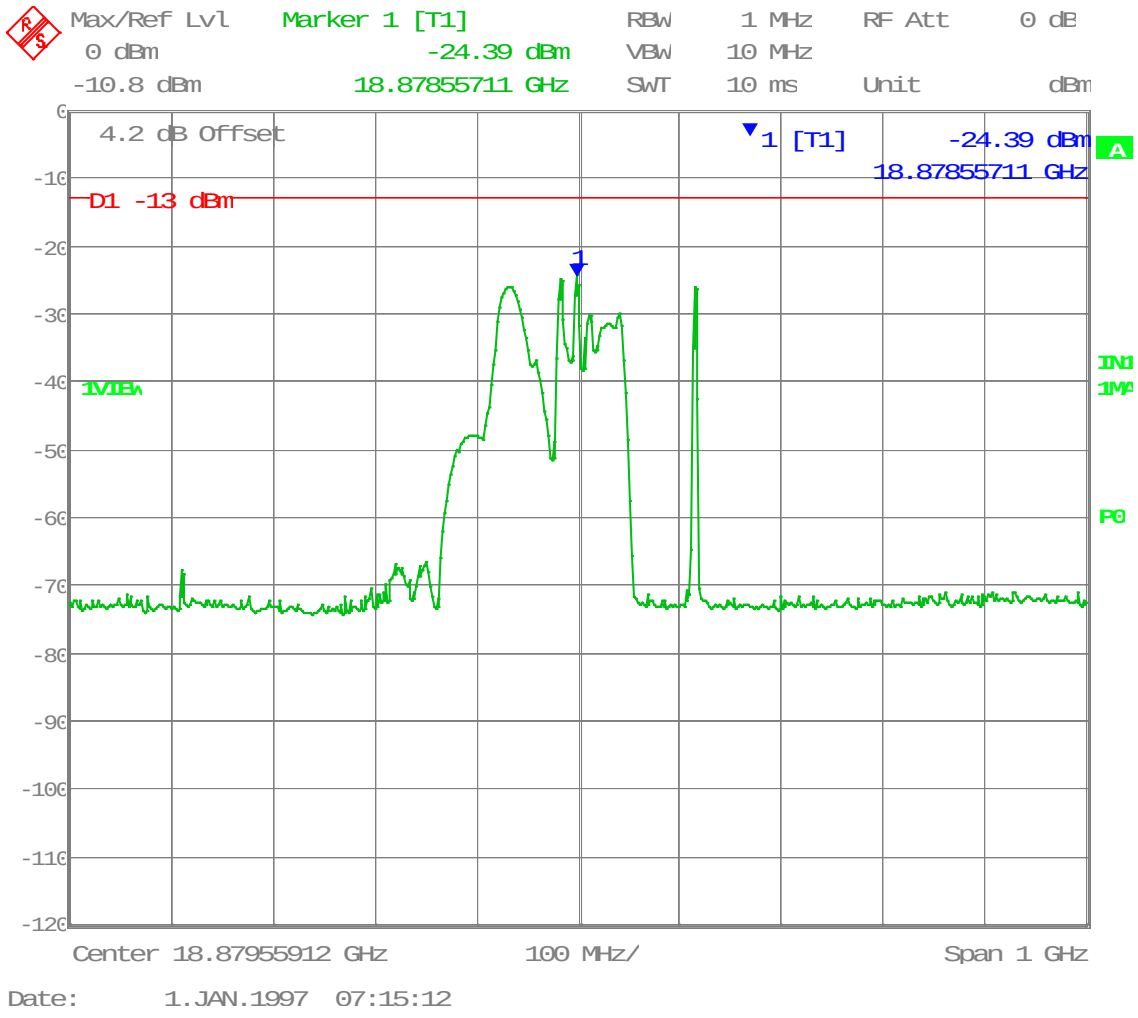
UNWANTED SPURIOUS EMISSIONS

Test Data: 16 Nautical Mile Mode, 2nd Harmonic Plot



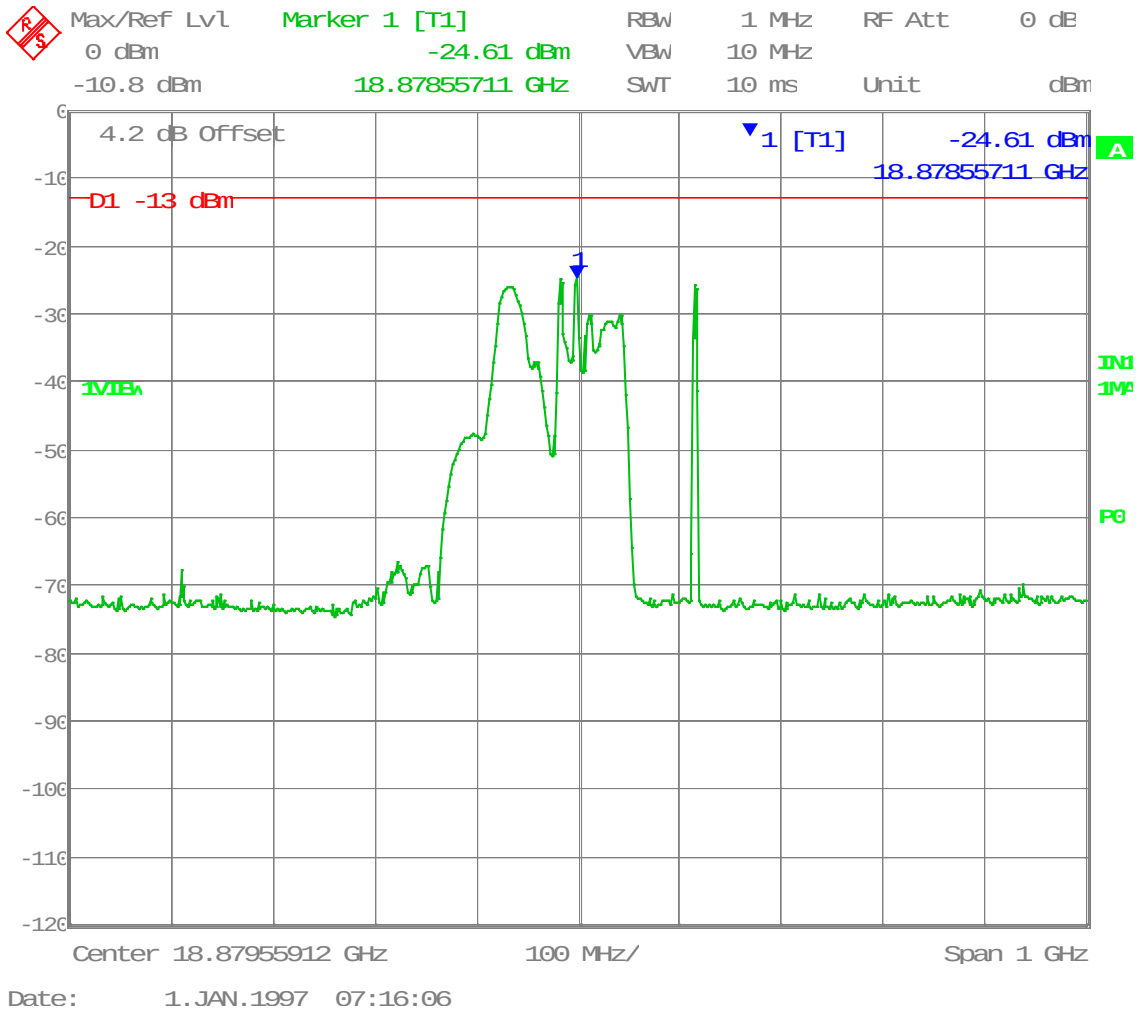
UNWANTED SPURIOUS EMISSIONS

Test Data: 24 Nautical Mile Mode, 2nd Harmonic Plot



UNWANTED SPURIOUS EMISSIONS

Test Data: 36 Nautical Mile Mode, 2nd Harmonic Plot



Test Data: 3rd Harmonic Peak Table

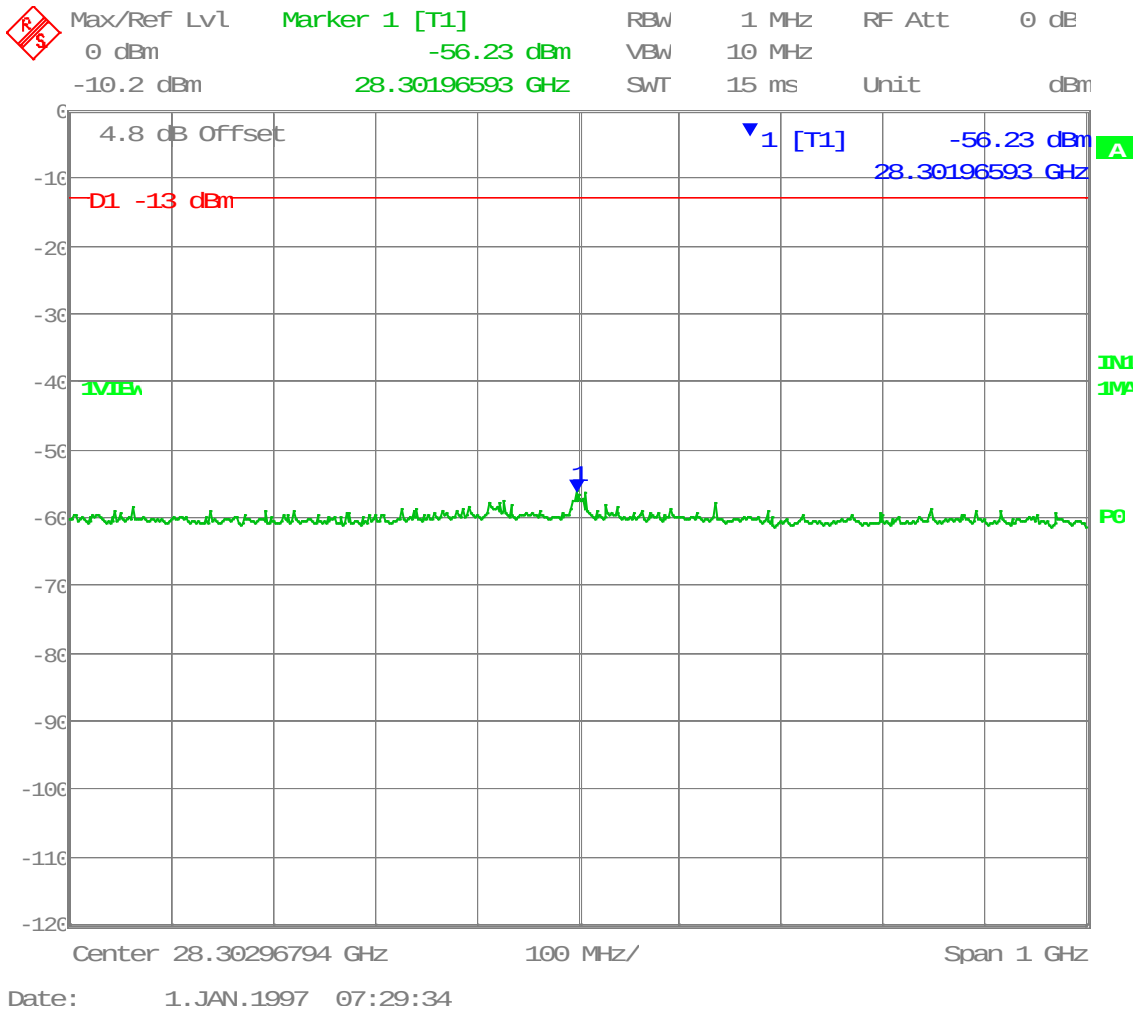
Mode	Center Freq (MHz)	Peak Output Power (dBm)	Spurious Emission Correction (dBm)	3rd Harmonic				
			If Bm > 1, 20 x Log(Bref/Bm)	Harmonic Frequency (MHz)	Measured Peak in Bref (dBm)	Corrected to Bm (dBm)	43+10 x Log(P) Limit (dBm)	Margin (dB)
< 0.0625 nm	9390.00	41.883	29.831	28170.000	*			
0.125 nm	9390.00	43.500	29.831	28170.000	*			
0.25 nm	9400.93	43.500	9.697	28202.790	*			
0.5 nm	9400.93	43.500	9.697	28202.790	*			
0.75 nm	9418.11	43.500	5.402	28254.330	*			
1 nm	9418.11	43.500	5.273	28254.330	*			
1.5 nm	9418.11	43.500	5.273	28254.330	*			
2 nm	9427.65	43.500	1.096	28282.950	-56.230	-55.134	-13.00	42.13
3 nm	**9427.65**	**43.500**	**1.096**	**28282.950**	**-56.100**	**-55.004**	**-13.00**	**42.00**
4 nm	9430.70	43.500	0.000	28292.100	-56.100	-56.100	-13.00	43.10
6 nm	9430.70	43.500	0.000	28292.100	-57.260	-57.260	-13.00	44.26
8 nm	9427.32	43.500	0.000	28281.960	-56.750	-56.750	-13.00	43.75
12 nm	9427.32	43.500	0.000	28281.960	-56.750	-56.750	-13.00	43.75
16 nm	9427.32	43.500	0.000	28281.960	-56.750	-56.750	-13.00	43.75
24 nm	9427.32	43.500	0.000	28281.960	-56.100	-56.100	-13.00	43.10
≥ 36 nm	9427.32	43.500	0.000	28281.960	-55.830	-55.830	-13.00	42.83

* Indicates No emission was present and/or emission was below noise floor of instrumentation

Worst-case Emission: **3 nm Mode**

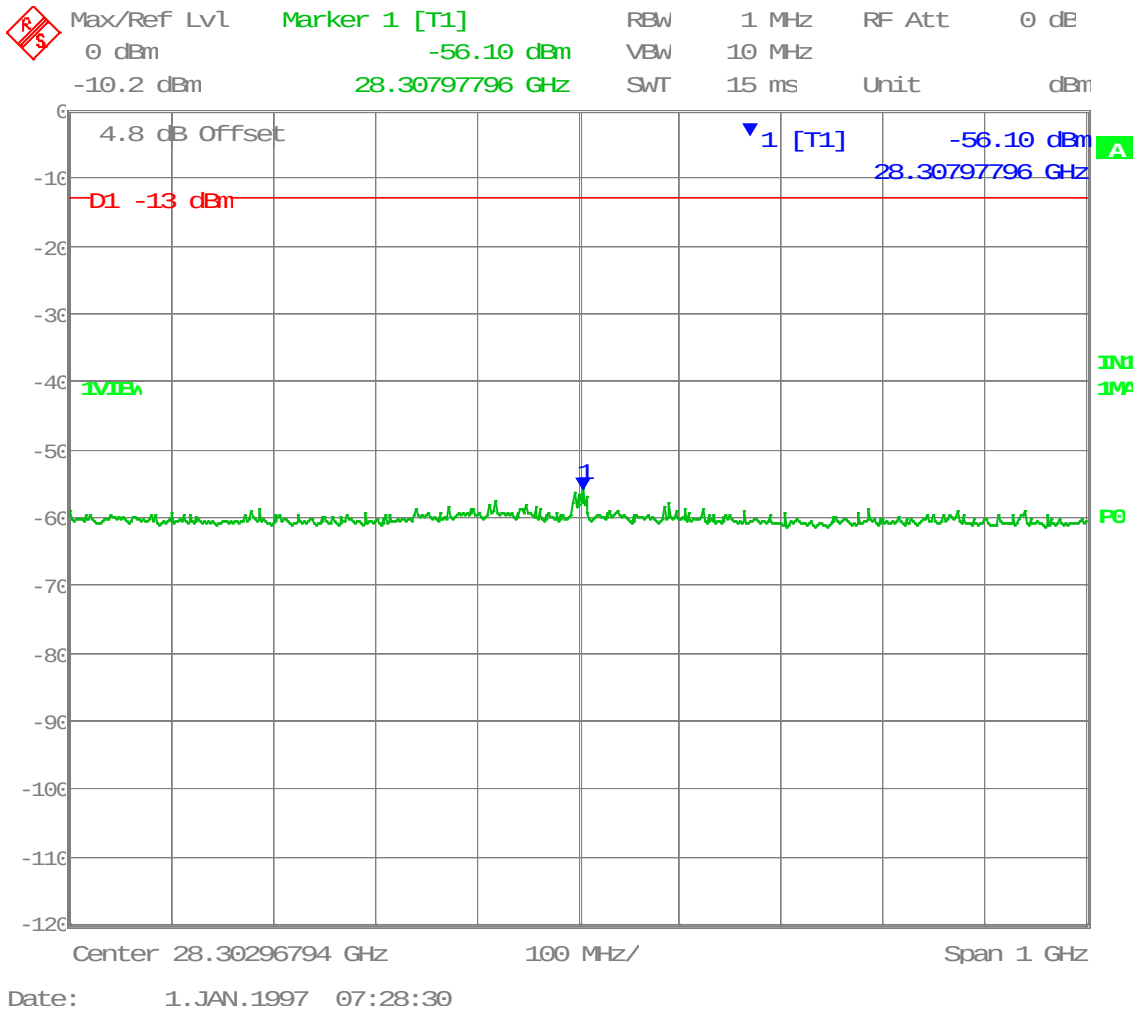
UNWANTED SPURIOUS EMISSIONS

Test Data: 2 Nautical Mile Mode, 3rd Harmonic Plot



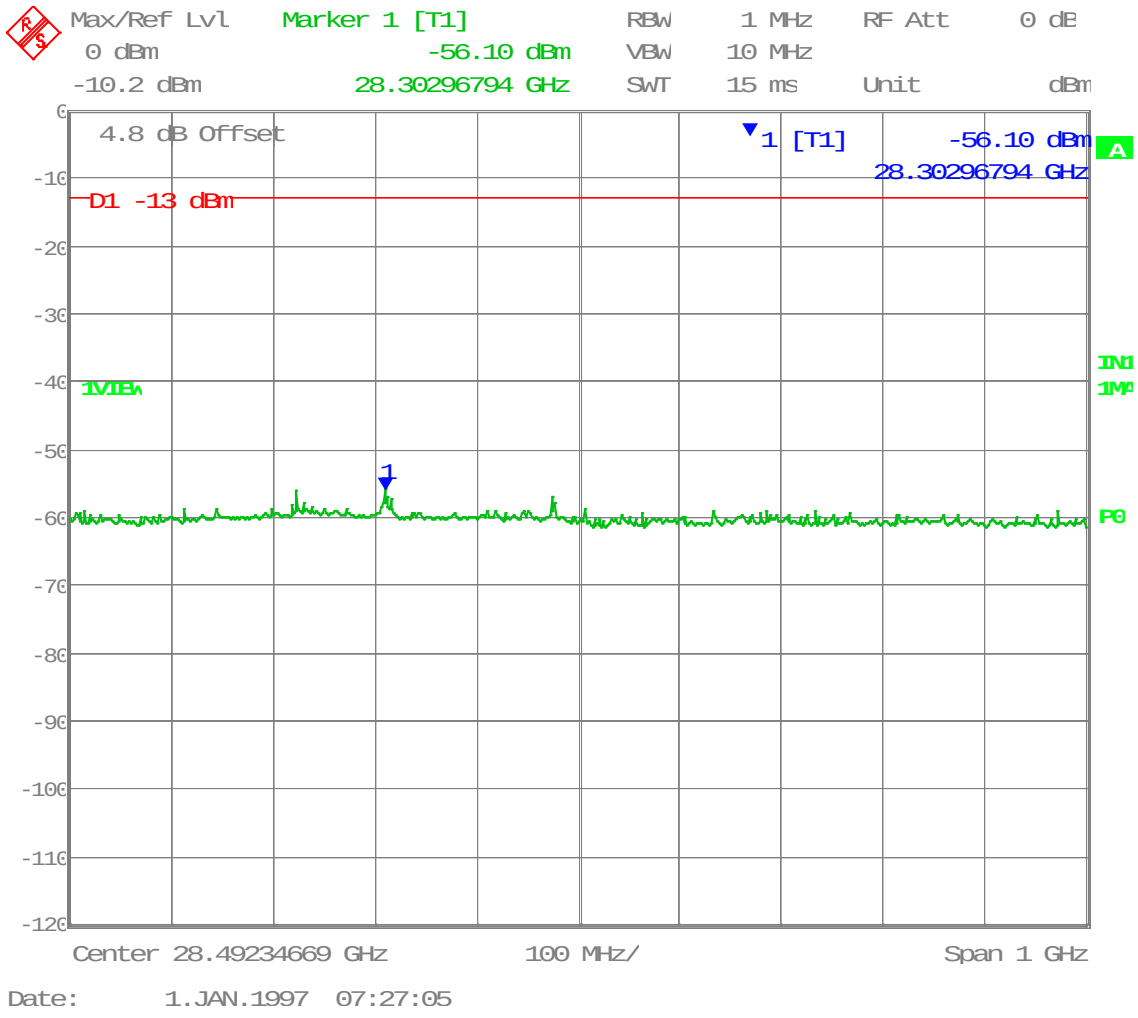
UNWANTED SPURIOUS EMISSIONS

Test Data: 3 Nautical Mile Mode, 3rd Harmonic Plot



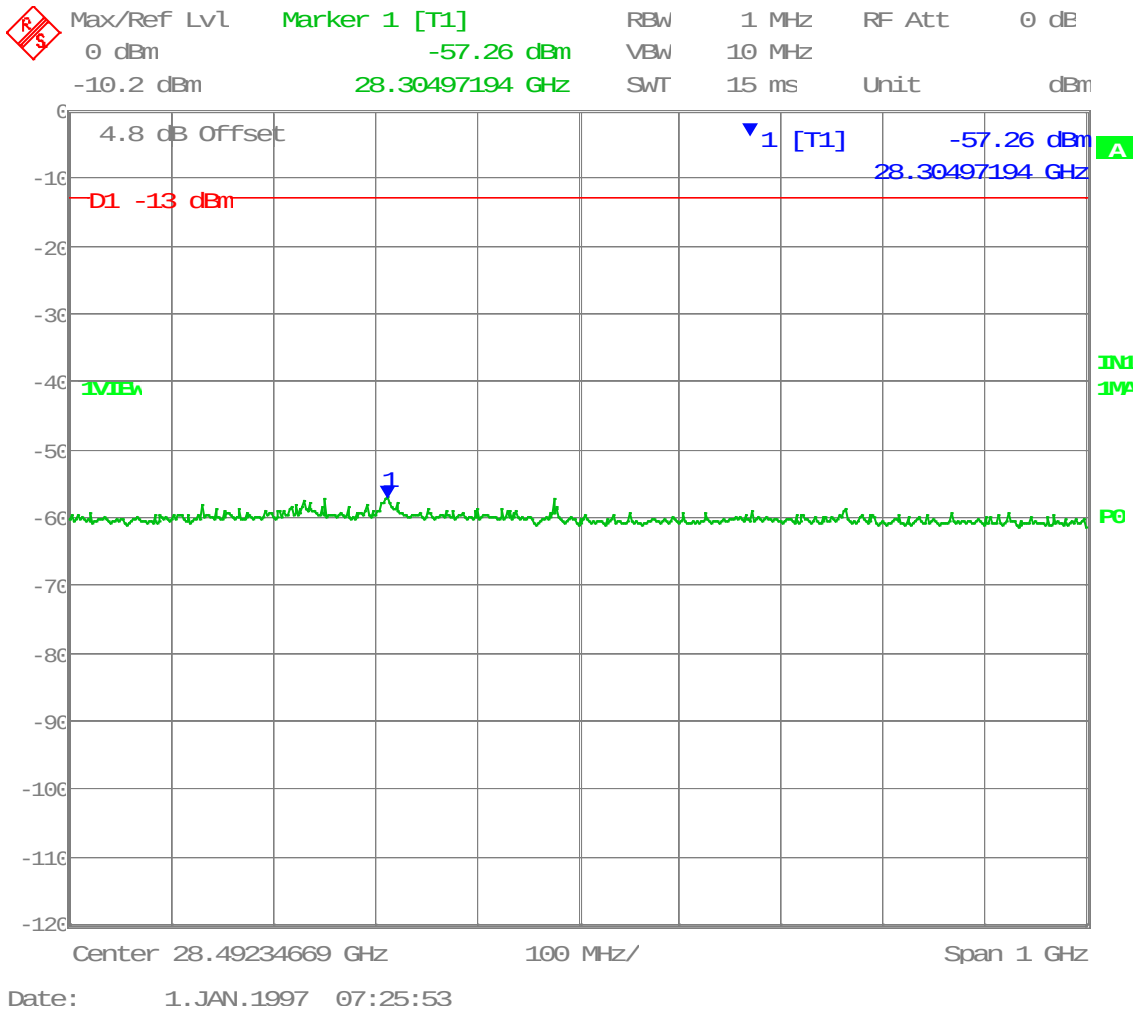
UNWANTED SPURIOUS EMISSIONS

Test Data: 4 Nautical Mile Mode, 3rd Harmonic Plot



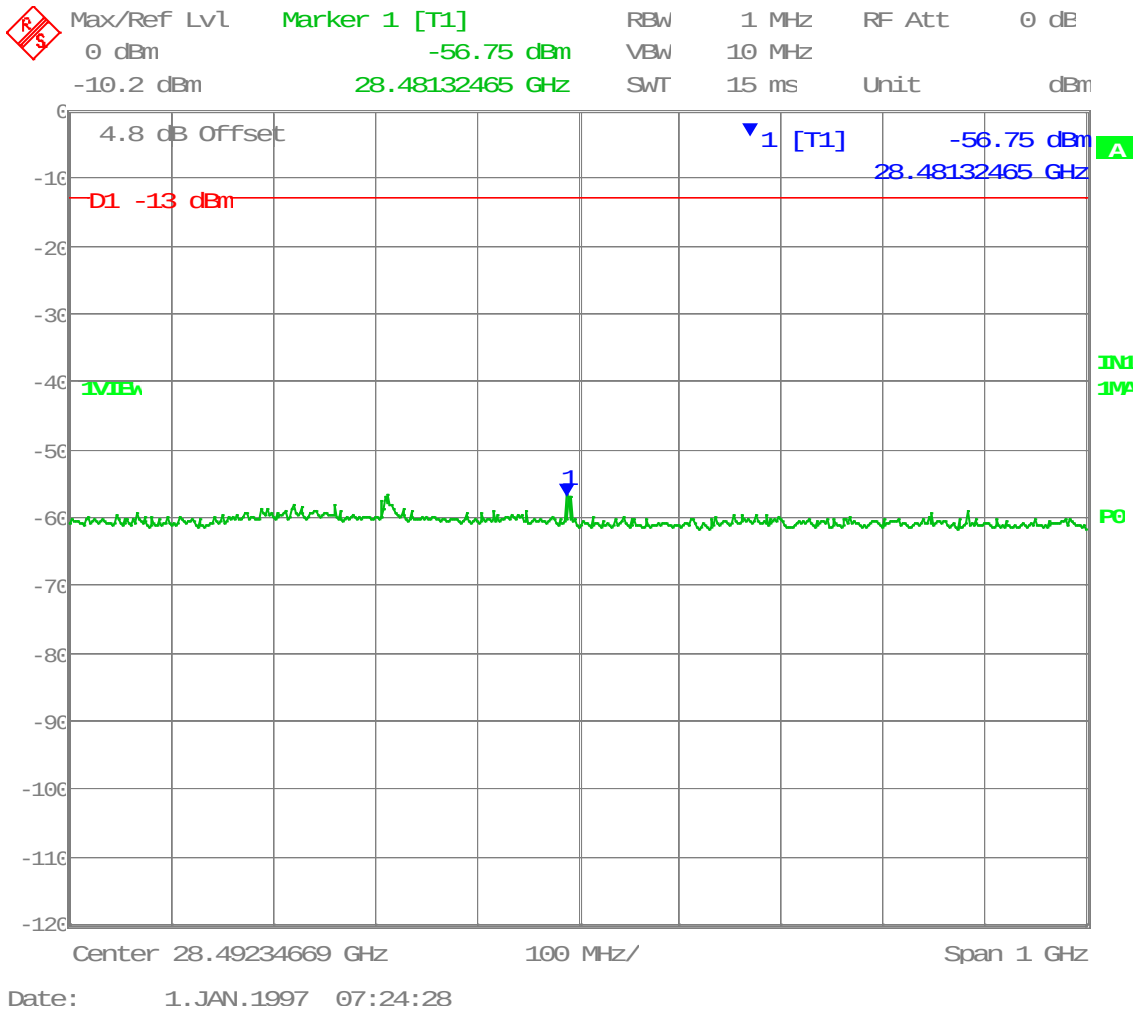
UNWANTED SPURIOUS EMISSIONS

Test Data: 6 Nautical Mile Mode, 3rd Harmonic Plot



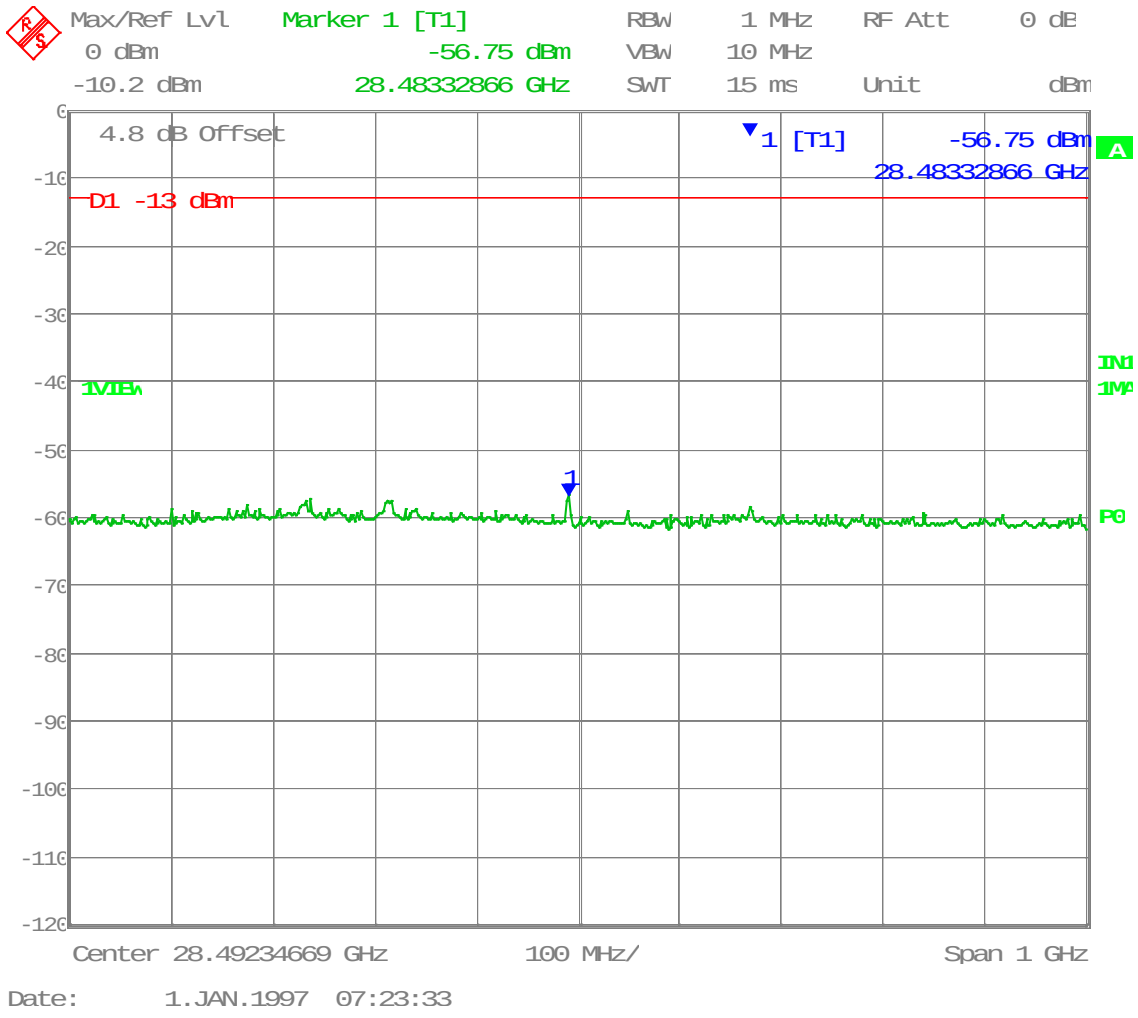
UNWANTED SPURIOUS EMISSIONS

Test Data: 8 Nautical Mile Mode, 3rd Harmonic Plot



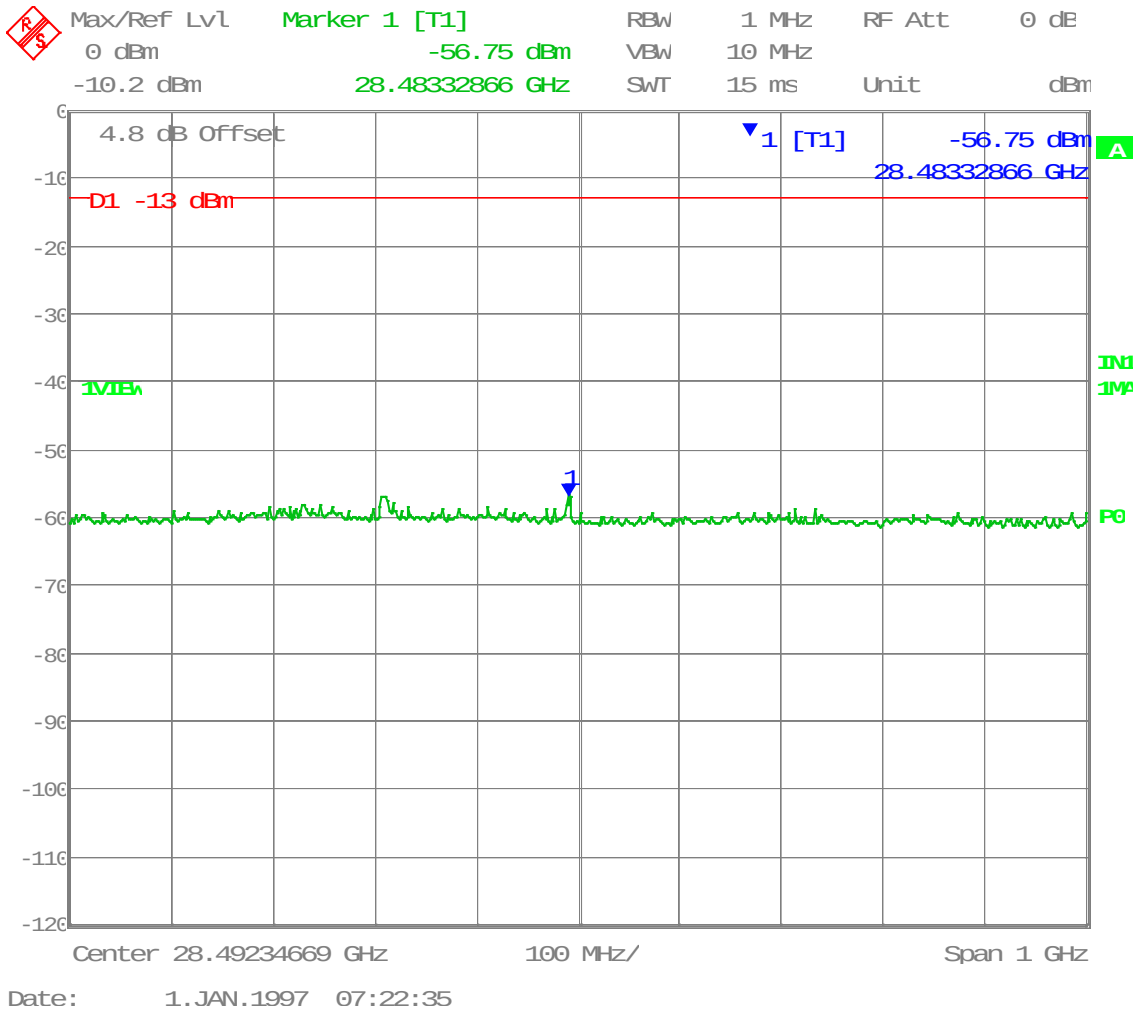
UNWANTED SPURIOUS EMISSIONS

Test Data: 12 Nautical Mile Mode, 3rd Harmonic Plot



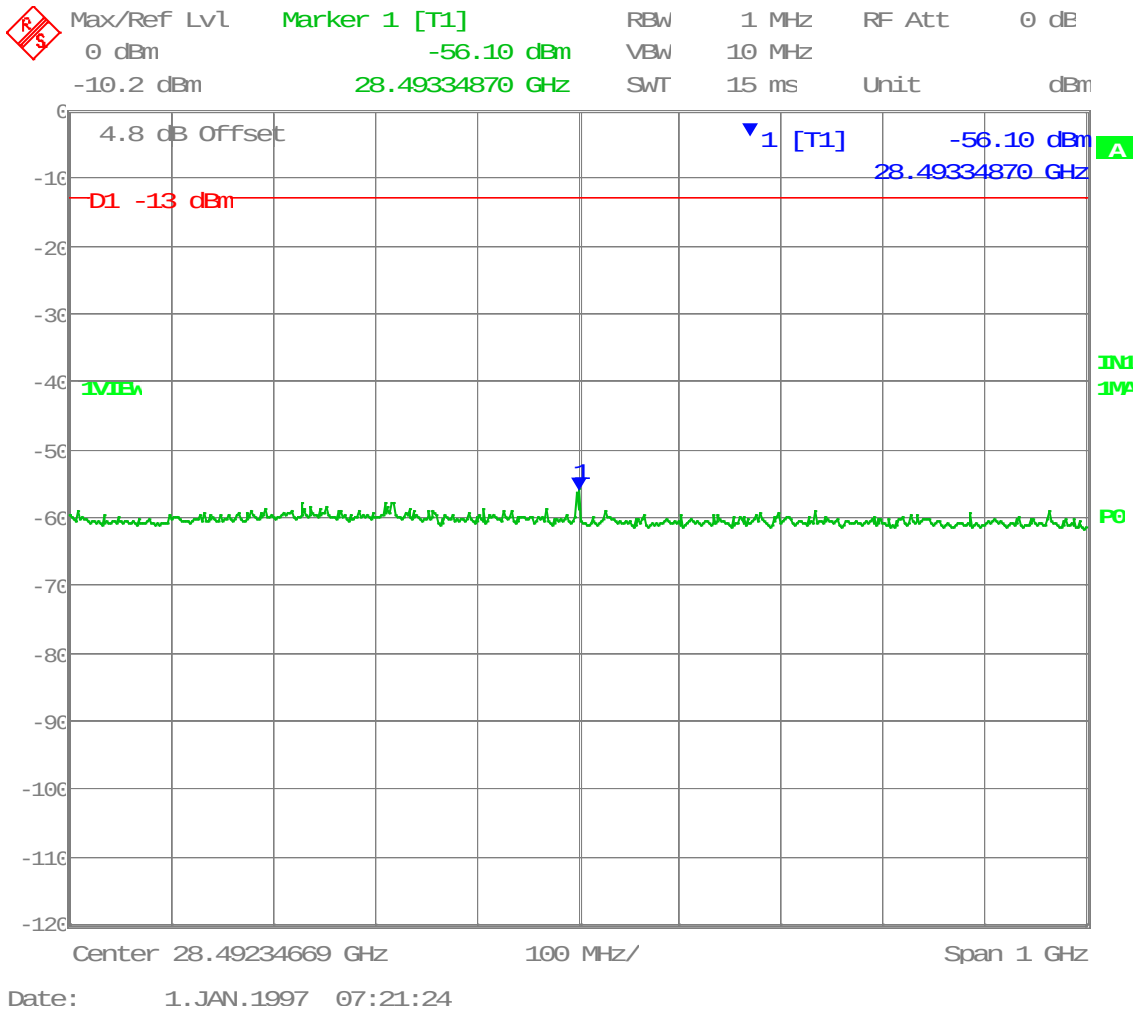
UNWANTED SPURIOUS EMISSIONS

Test Data: 16 Nautical Mile Mode, 3rd Harmonic Plot



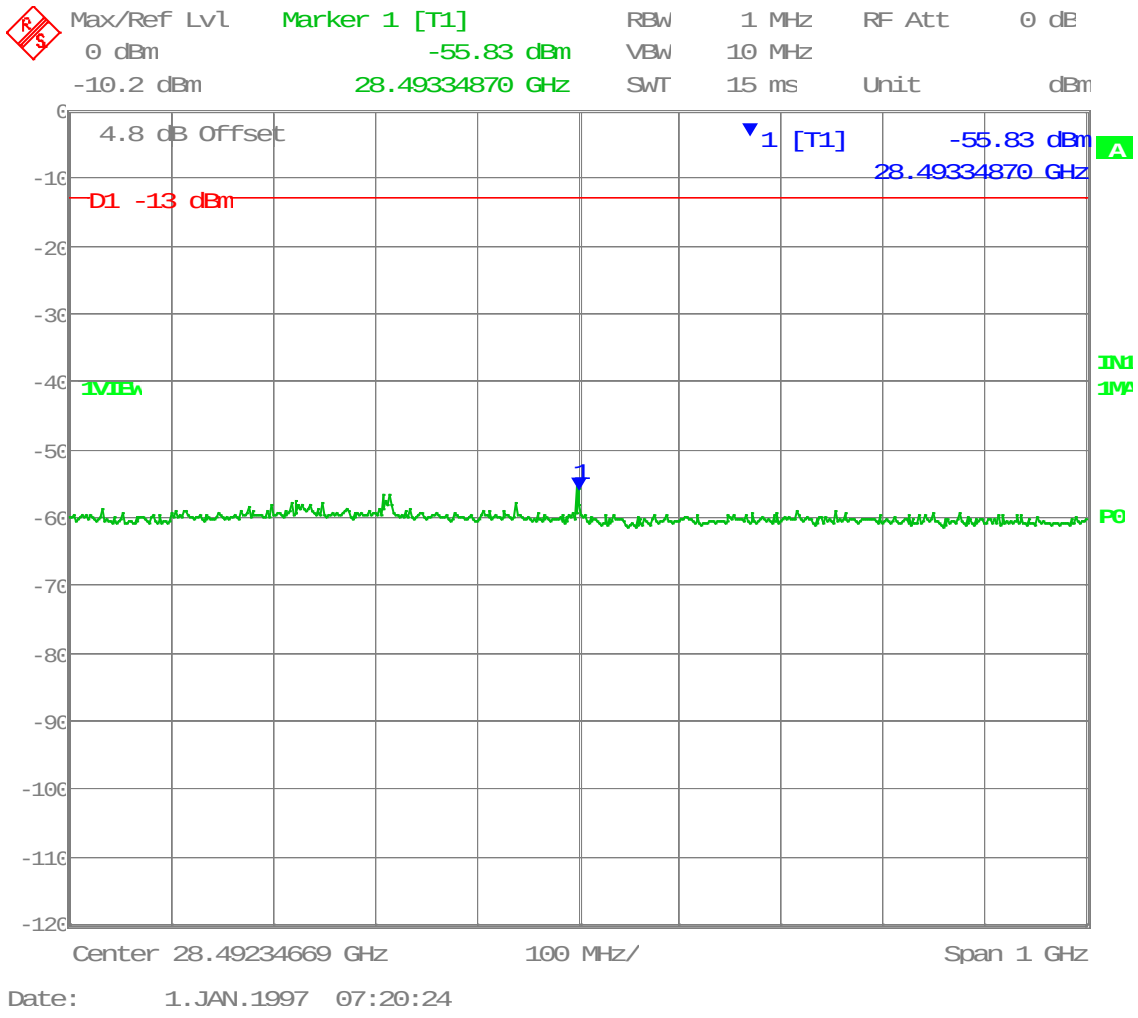
UNWANTED SPURIOUS EMISSIONS

Test Data: 24 Nautical Mile Mode, 3rd Harmonic Plot



UNWANTED SPURIOUS EMISSIONS

Test Data: 36 Nautical Mile Mode, 3rd Harmonic Plot



Test Data: 4th Harmonic Peak Table

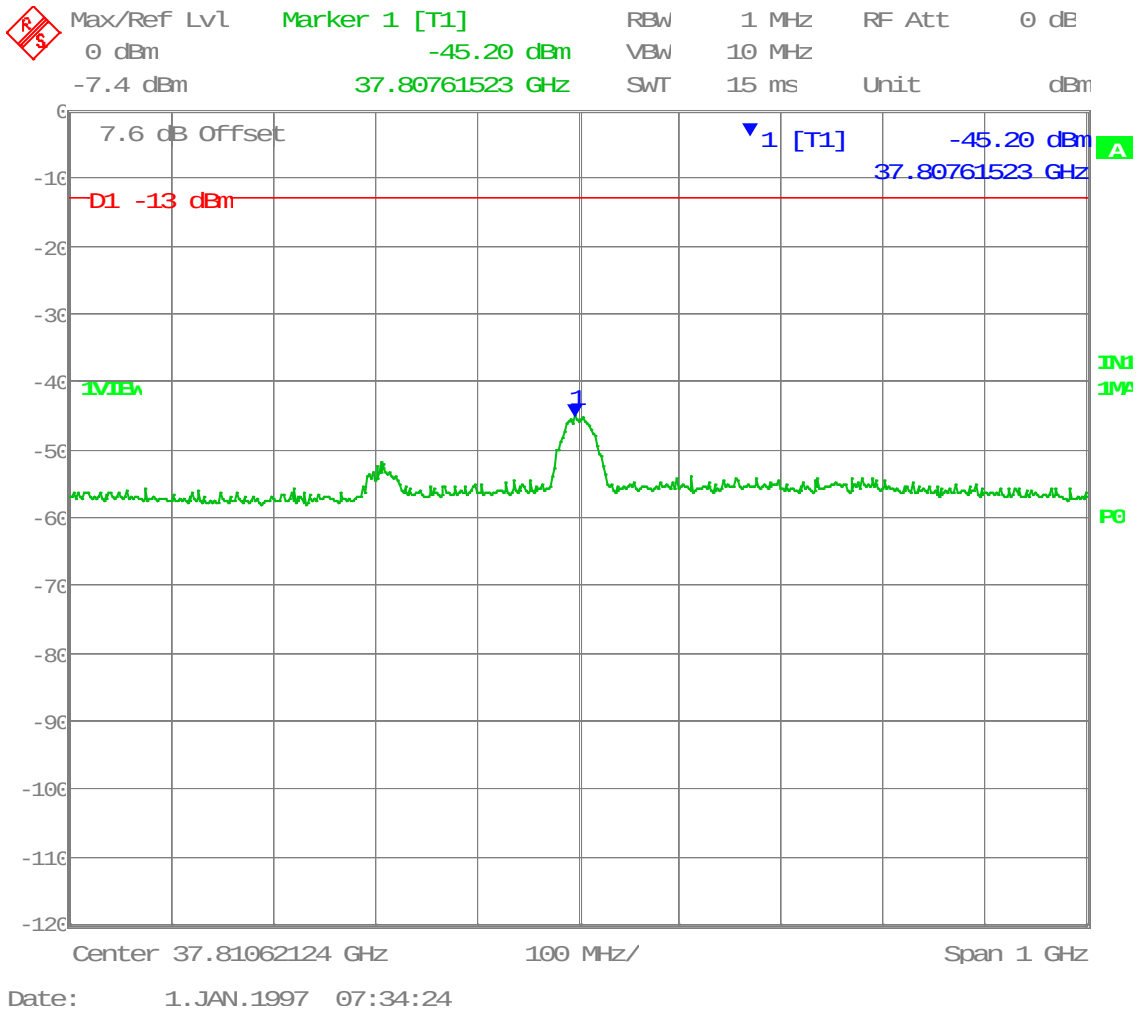
Mode	Center Freq (MHz)	Peak Output Power (dBm)	Spurious Emission Correction (dBm)	4th Harmonic				
			If Bm > 1, 20 x Log(Bref/Bm)	Harmonic Frequency (MHz)	Measured Peak in Bref (dBm)	Corrected to Bm (dBm)	43+10 x Log(P) Limit (dBm)	Margin (dB)
< 0.0625 nm	9390.00	41.883	29.831	37560.000	*			
0.125 nm	9390.00	43.500	29.831	37560.000	*			
0.25 nm	9400.93	43.500	9.697	37603.720	*			
0.5 nm	9400.93	43.500	9.697	37603.720	*			
0.75 nm	9418.11	43.500	5.402	37672.440	-45.200	-39.798	-13.00	26.80
1 nm	**9418.11**	**43.500**	**5.273**	**37672.440**	**-44.820**	**-39.547**	**-13.00**	**26.55**
1.5 nm	9418.11	43.500	5.273	37672.440	-45.320	-40.047	-13.00	27.05
2 nm	9427.65	43.500	1.096	37710.600	-42.560	-41.464	-13.00	28.46
3 nm	9427.65	43.500	1.096	37710.600	-42.560	-41.464	-13.00	28.46
4 nm	9430.70	43.500	0.000	37722.800	-42.810	-42.810	-13.00	29.81
6 nm	9430.70	43.500	0.000	37722.800	-42.560	-42.560	-13.00	29.56
8 nm	9427.32	43.500	0.000	37709.280	-42.810	-42.810	-13.00	29.81
12 nm	9427.32	43.500	0.000	37709.280	-42.560	-42.560	-13.00	29.56
16 nm	9427.32	43.500	0.000	37709.280	-42.810	-42.810	-13.00	29.81
24 nm	9427.32	43.500	0.000	37709.280	-43.320	-43.320	-13.00	30.32
≥ 36 nm	9427.32	43.500	0.000	37709.280	-43.070	-43.070	-13.00	30.07

* Indicates No emission was present and/or emission was below noise floor of instrumentation

Worst-case Emission: **1 nm Mode**

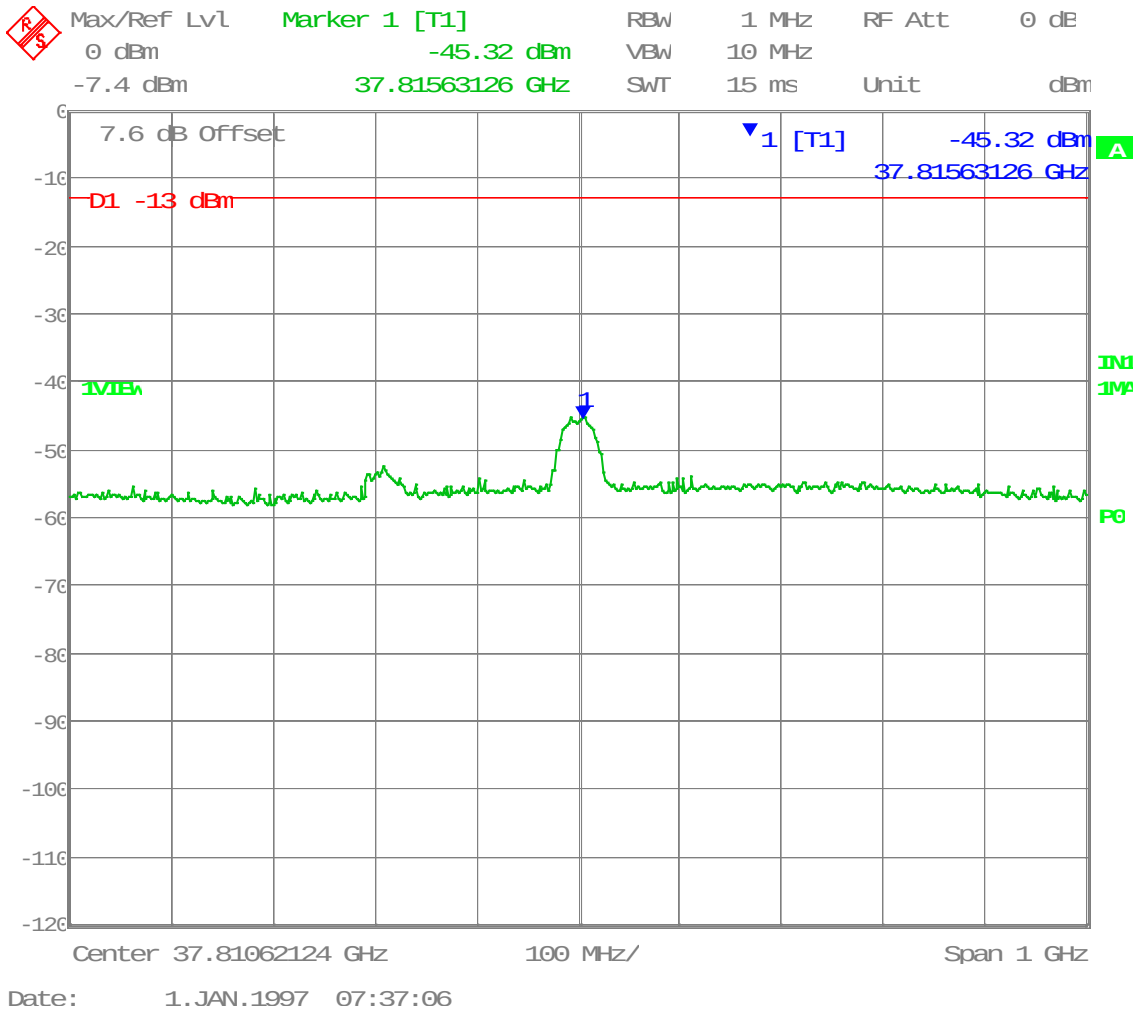
UNWANTED SPURIOUS EMISSIONS

Test Data: 3/4 Nautical Mile Mode, 4th Harmonic Plot



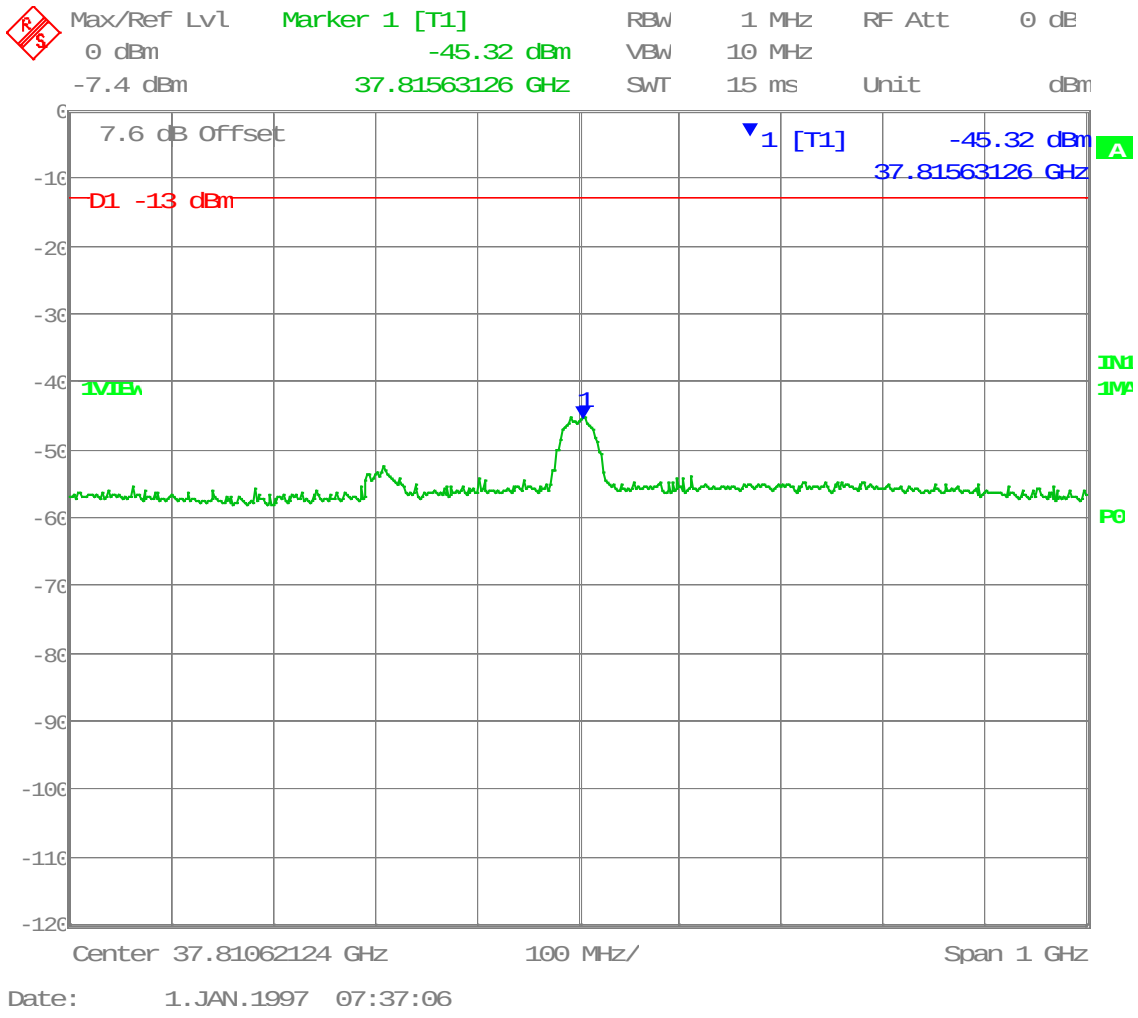
UNWANTED SPURIOUS EMISSIONS

Test Data: 1 Nautical Mile Mode, 4th Harmonic Plot



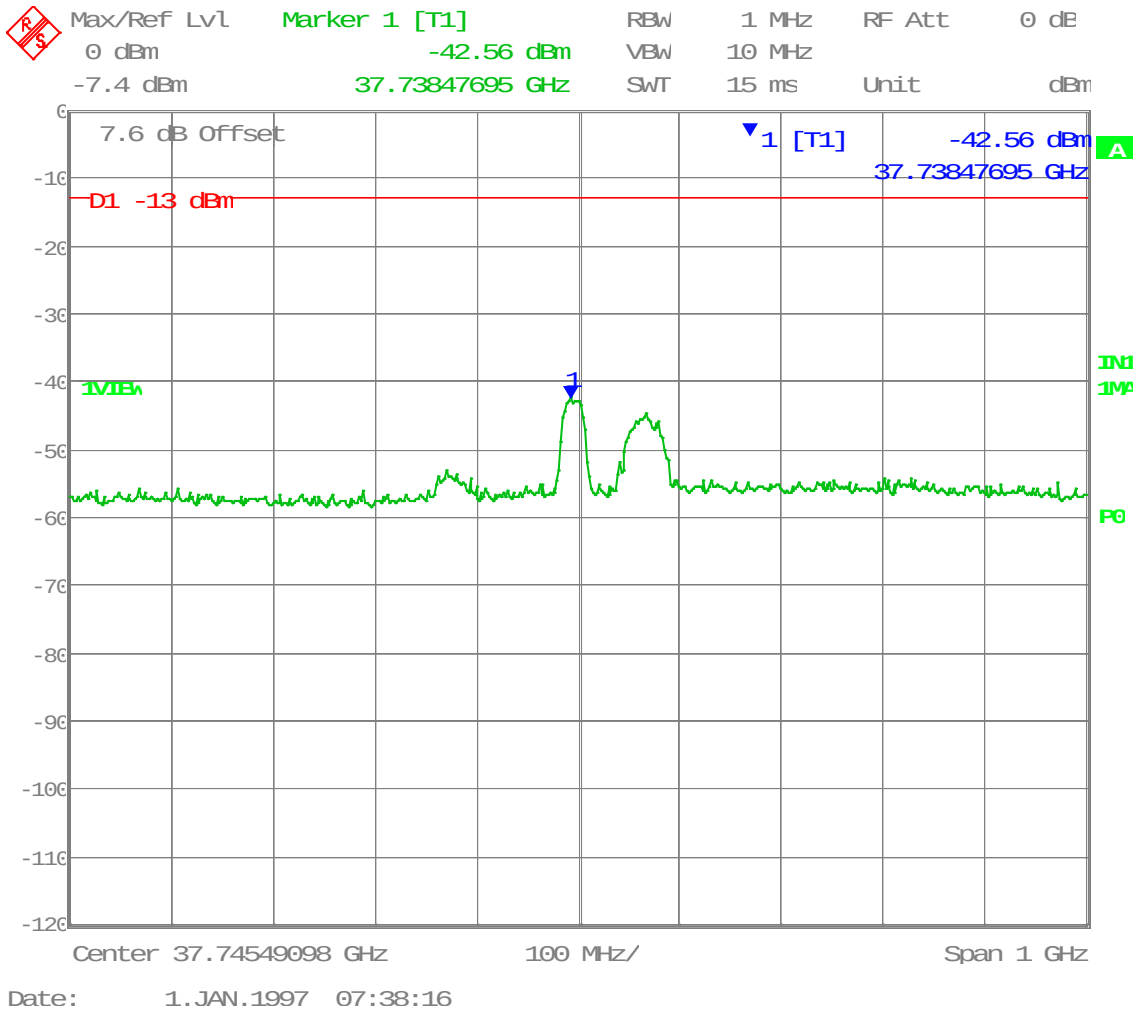
UNWANTED SPURIOUS EMISSIONS

Test Data: 1.5 Nautical Mile Mode, 4th Harmonic Plot



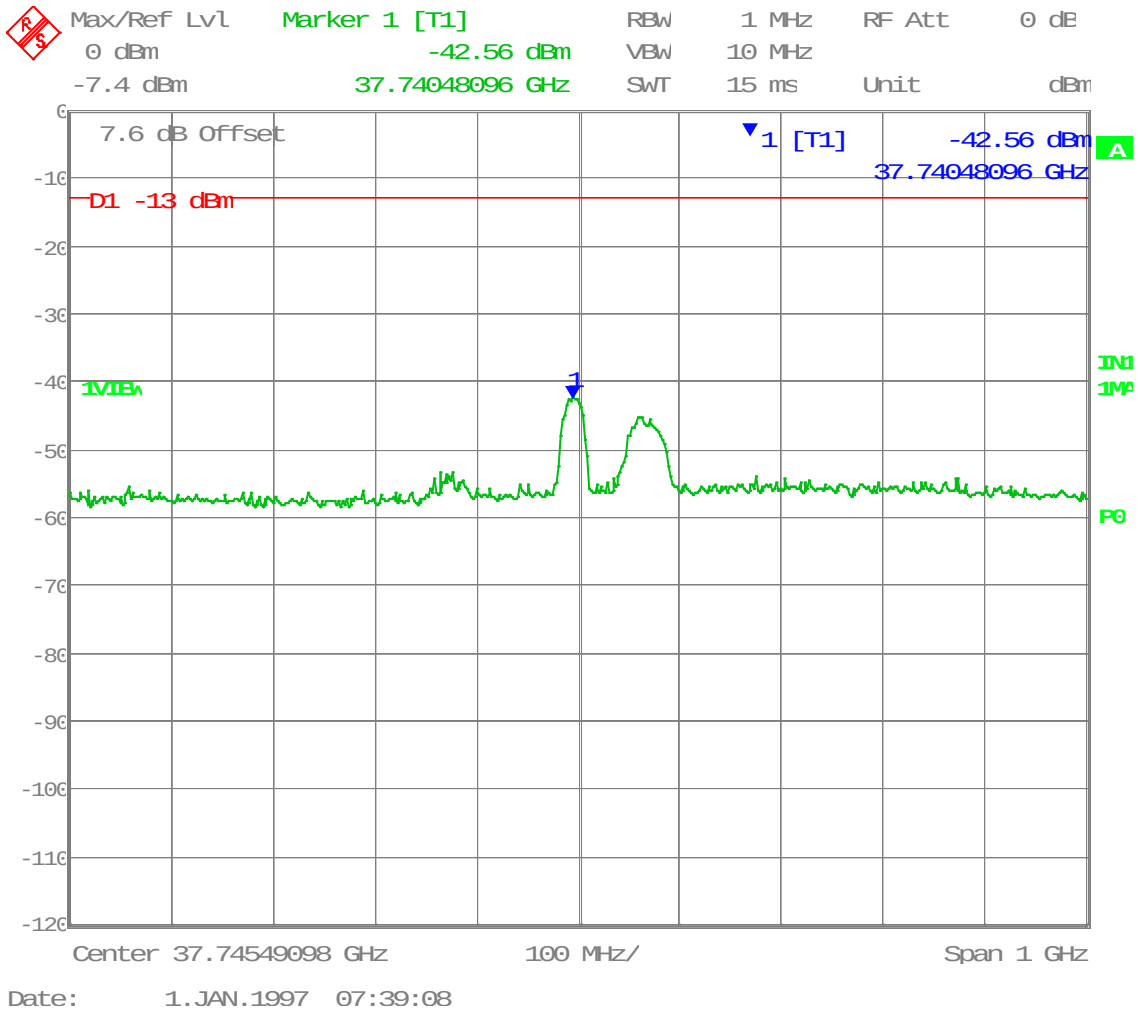
UNWANTED SPURIOUS EMISSIONS

Test Data: 2 Nautical Mile Mode, 4th Harmonic Plot



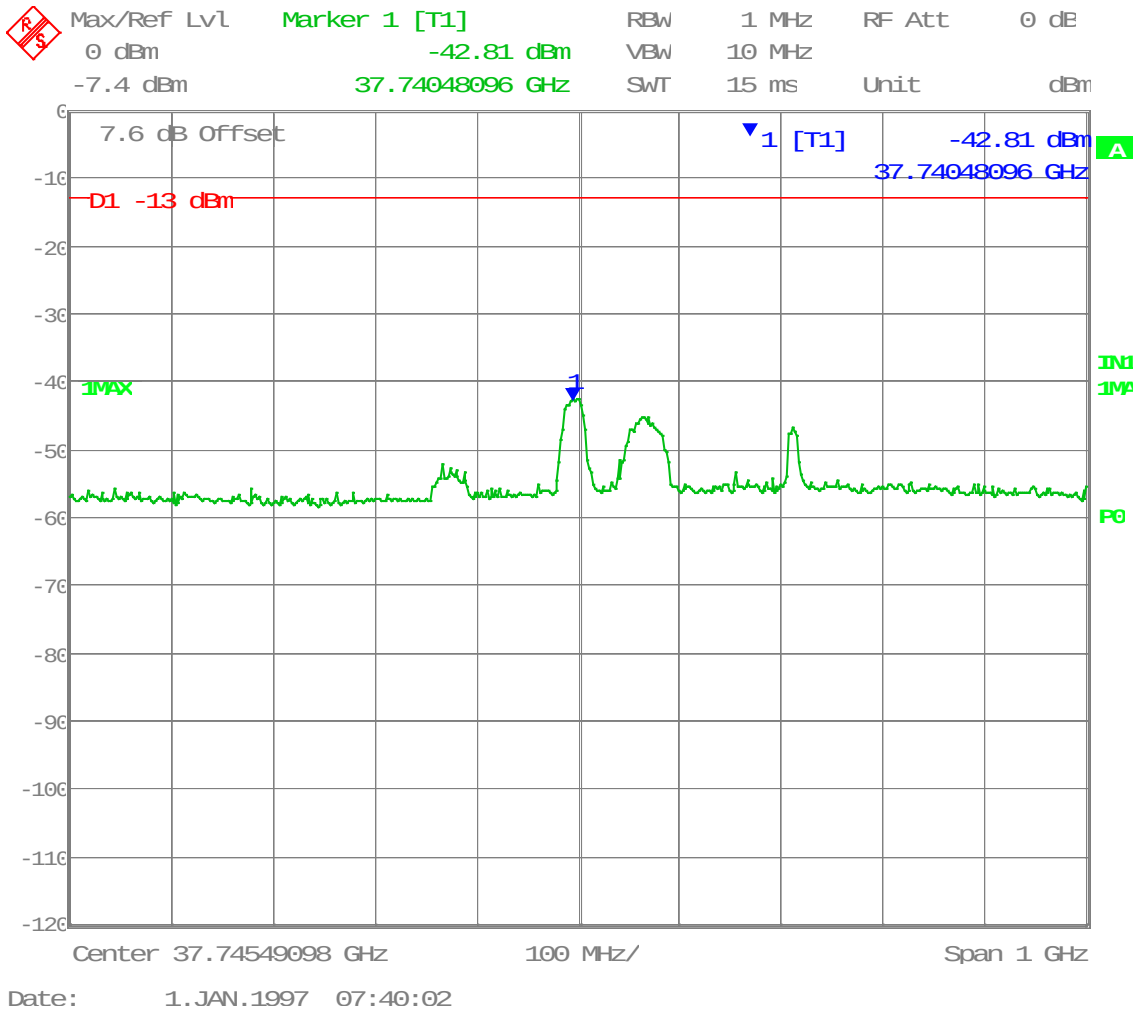
UNWANTED SPURIOUS EMISSIONS

Test Data: 3 Nautical Mile Mode, 4th Harmonic Plot



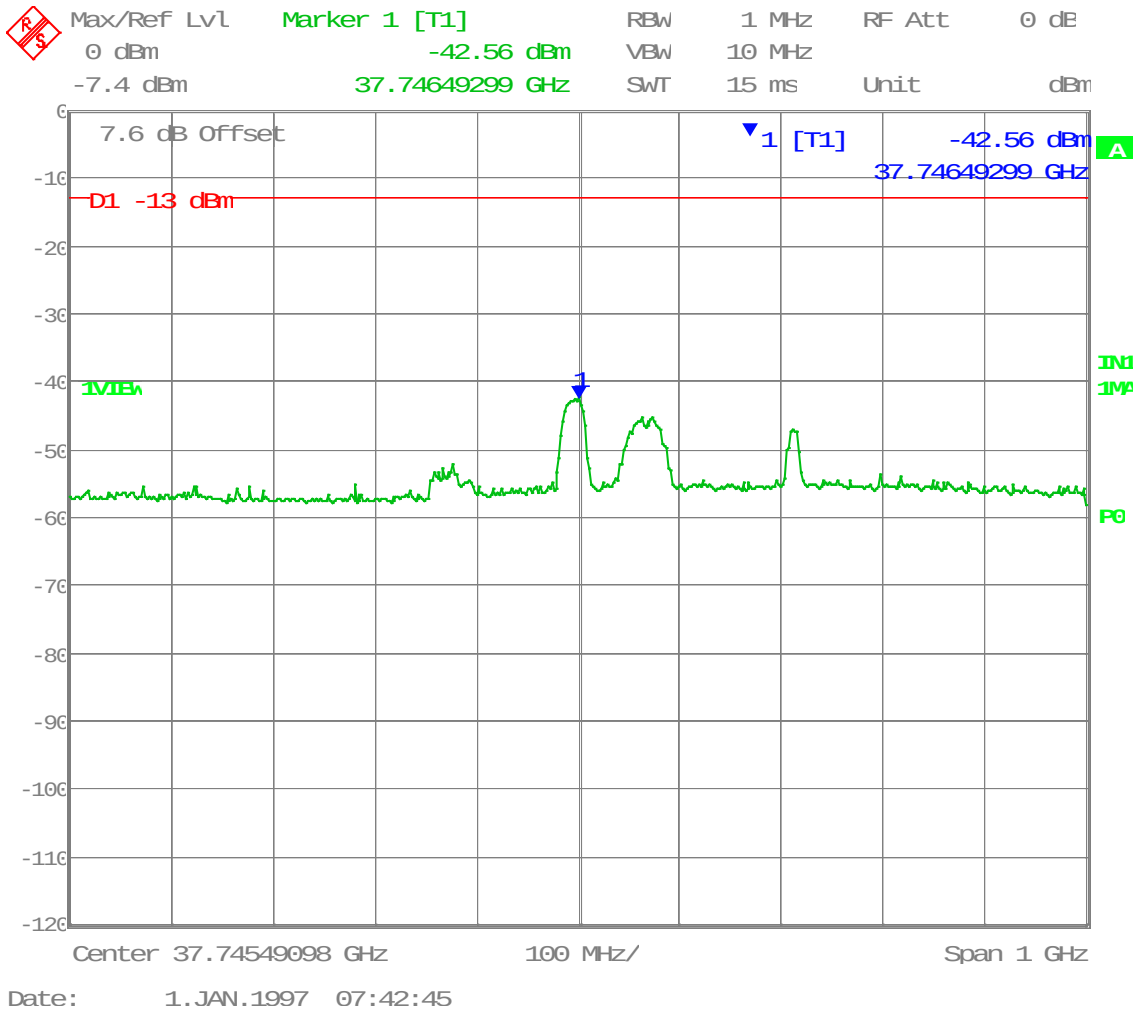
UNWANTED SPURIOUS EMISSIONS

Test Data: 4 Nautical Mile Mode, 4th Harmonic Plot



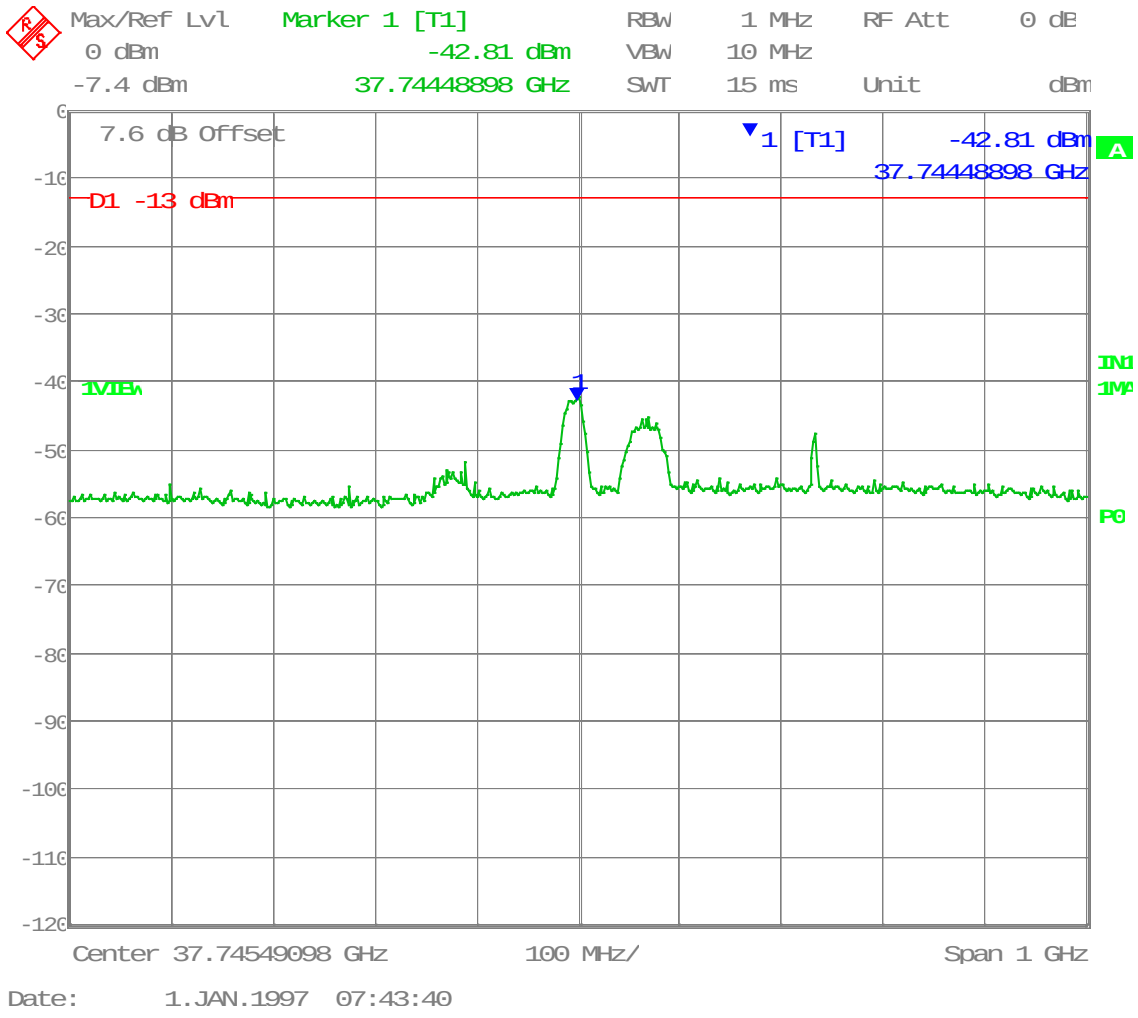
UNWANTED SPURIOUS EMISSIONS

Test Data: 6 Nautical Mile Mode, 4th Harmonic Plot



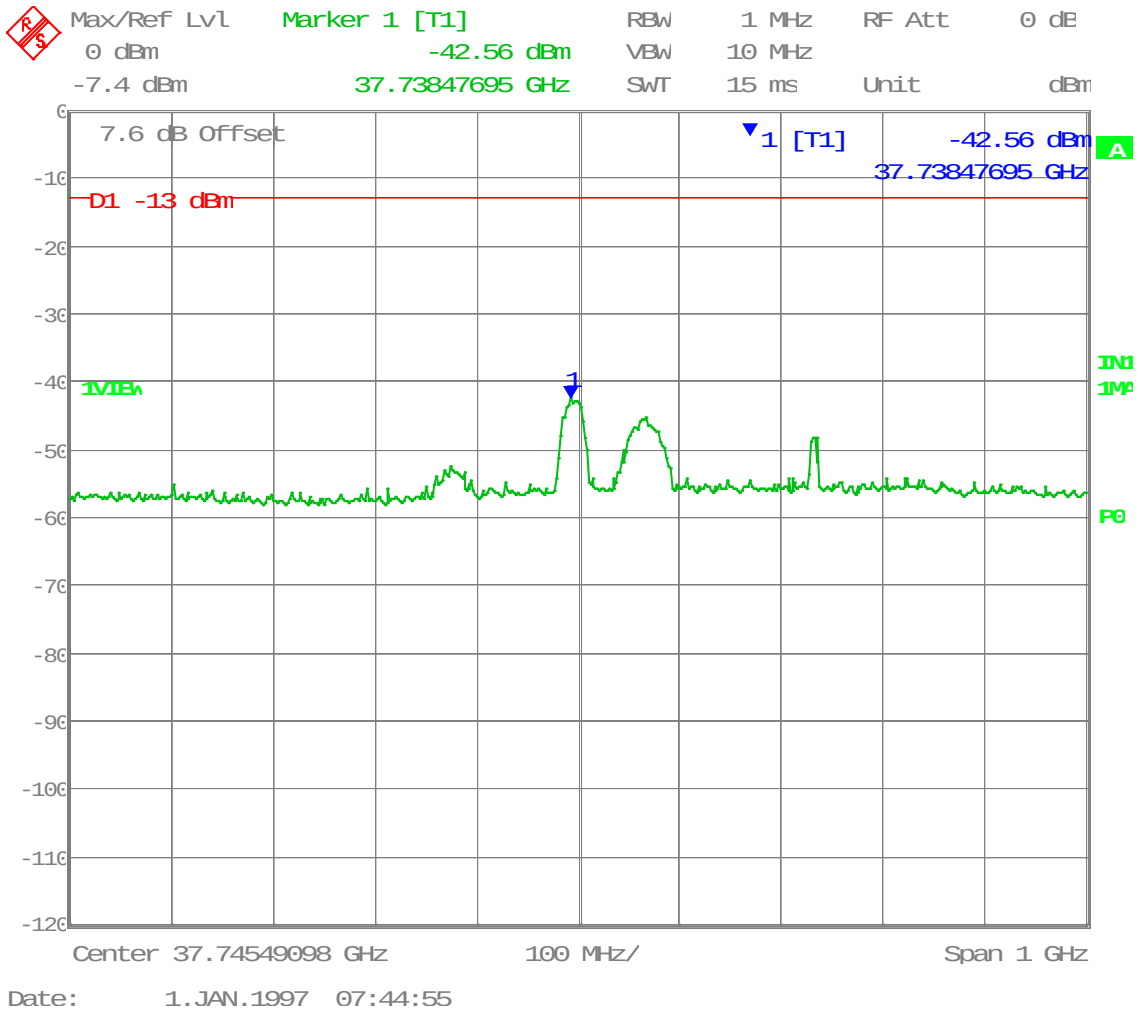
UNWANTED SPURIOUS EMISSIONS

Test Data: 8 Nautical Mile Mode, 4th Harmonic Plot



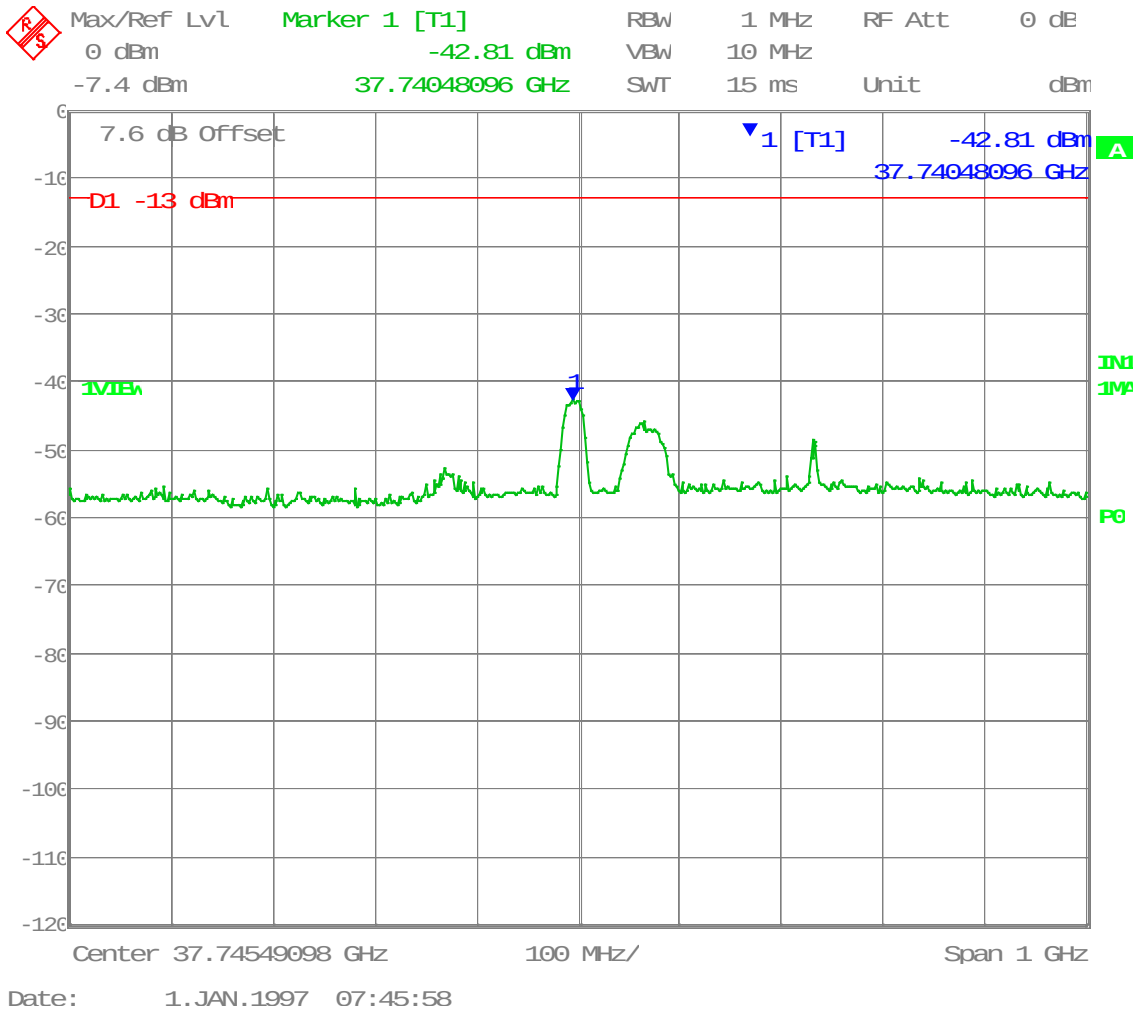
UNWANTED SPURIOUS EMISSIONS

Test Data: 12 Nautical Mile Mode, 4th Harmonic Plot



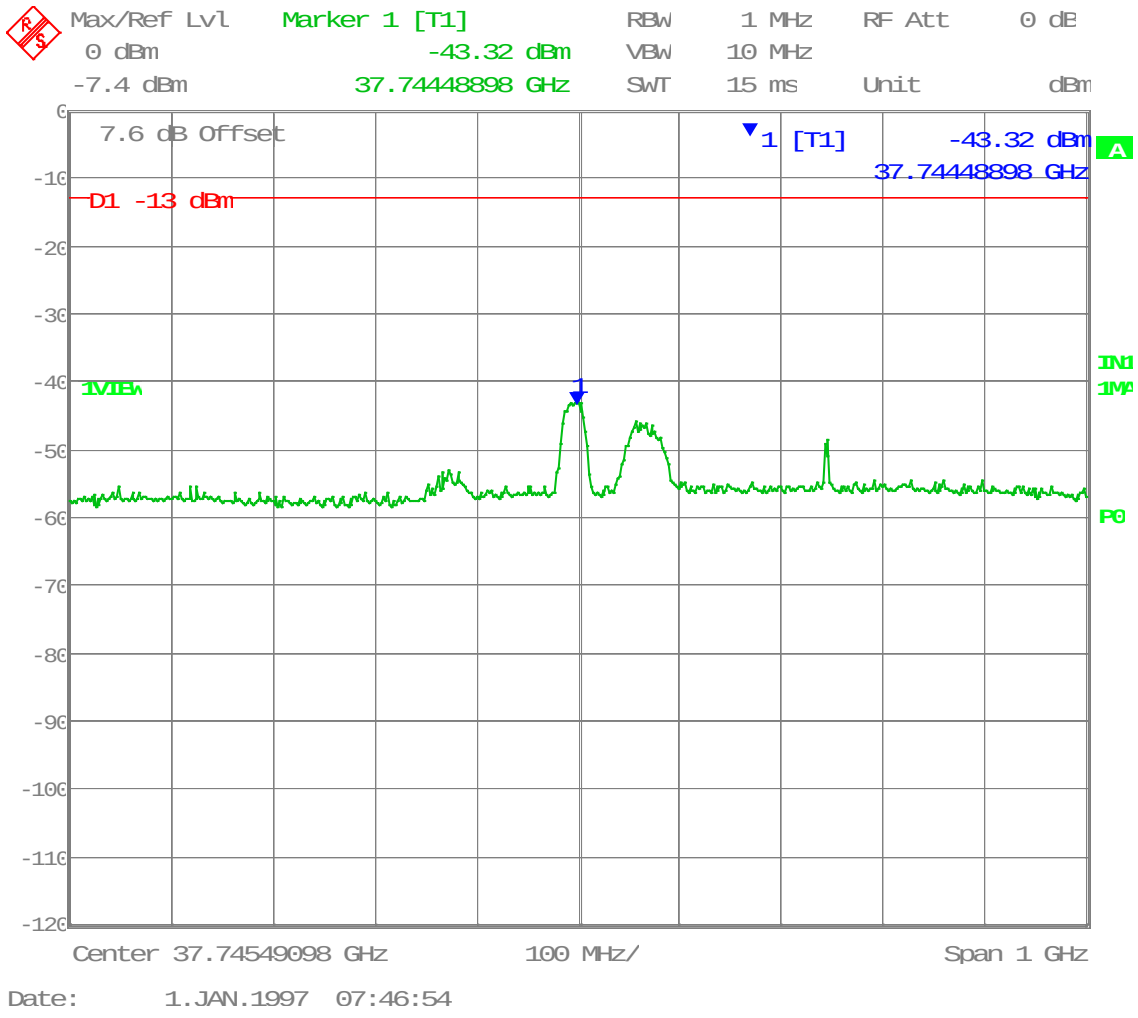
UNWANTED SPURIOUS EMISSIONS

Test Data: 16 Nautical Mile Mode, 4th Harmonic Plot



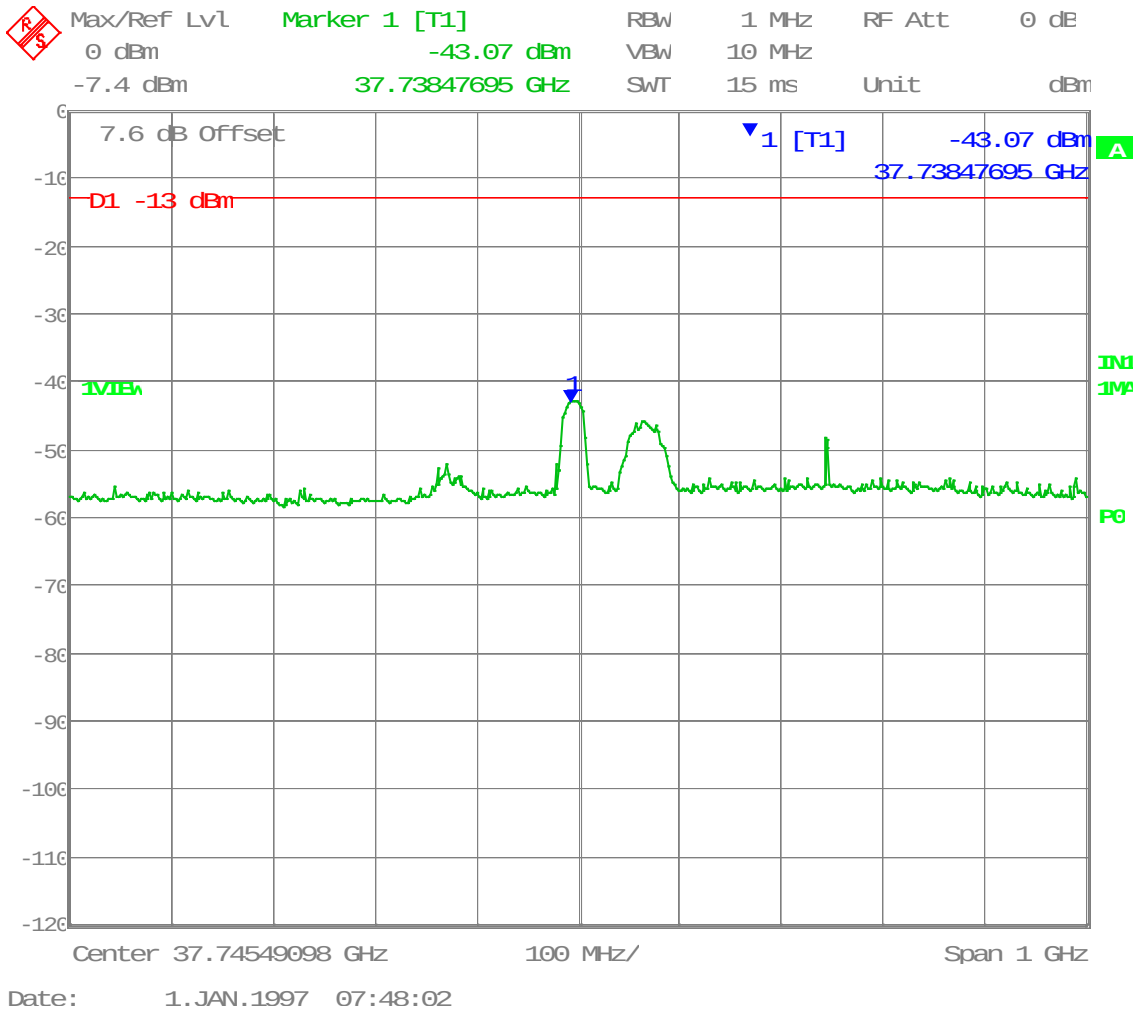
UNWANTED SPURIOUS EMISSIONS

Test Data: 24 Nautical Mile Mode, 4th Harmonic Plot



UNWANTED SPURIOUS EMISSIONS

Test Data: 36 Nautical Mile Mode, 4th Harmonic Plot



FIELD STRENGTH OF SPURIOUS EMISSIONS

FCC Rule Parts: Part 2.1053(a), 2.1057(a)(1), 80.211(f)(3), 90.210(n), (b)(3)

Requirements:

§2.1057 Frequency spectrum to be investigated.

(a) In all of the measurements set forth in §§2.1051 and 2.1053, the spectrum shall be investigated from the lowest radio frequency signal generated in the equipment, without going below 9 kHz, up to at least the frequency shown below:

(1) If the equipment operates below 10 GHz: to the tenth harmonic of the highest fundamental frequency or to 40 GHz, whichever is lower.

§80.211 Emission limitations.

(f) The mean power when using emissions other than those in paragraphs (a), (b), (c) and (d) of this section:

(3) On any frequency removed from the assigned frequency by more than 250 percent of the authorized bandwidth: At least 43 plus $10\log_{10}$ (mean power in watts) dB.

§90.210 Emission masks.

(n) *Other frequency bands.* Transmitters designed for operation under this part on frequencies other than listed in this section must meet the emission mask requirements of Emission Mask B. Equipment operating under this part on frequencies allocated to but shared with the Federal Government, must meet the applicable Federal Government technical standards.

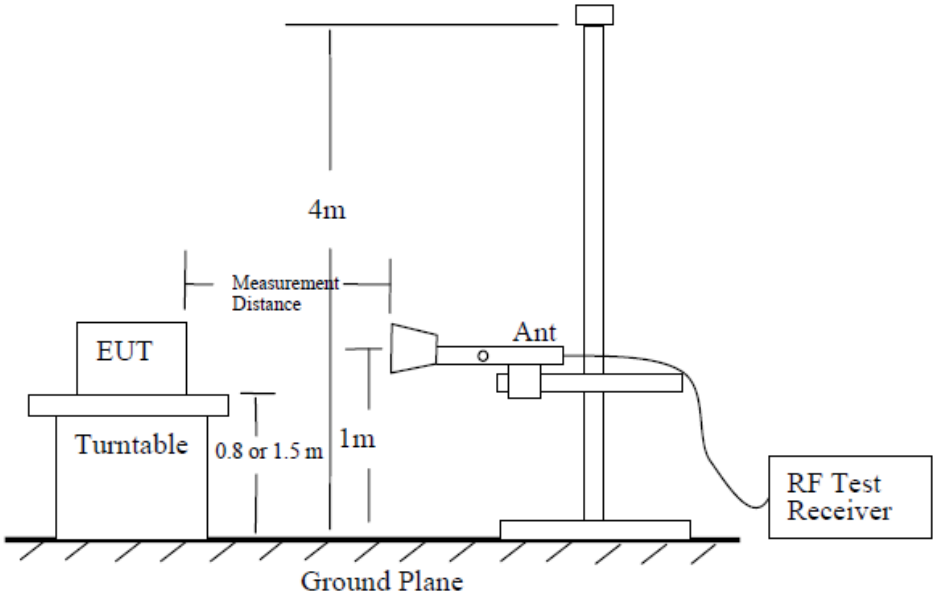
(b) *Emission Mask B.* For transmitters that are equipped with an audio low-pass filter, the power of any emission must be attenuated below the unmodulated carrier power (P) as follows:

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

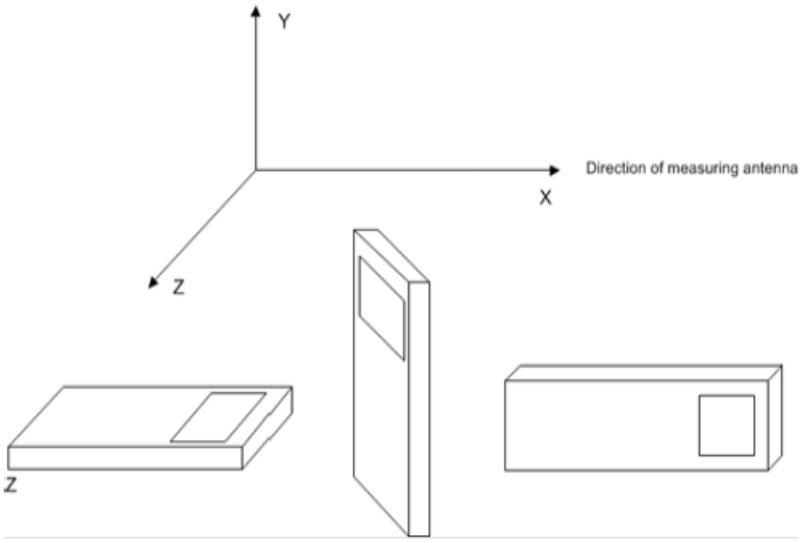
Test Procedure: ANSI C63.26, 5.5.4; ITU-R M.1177-4, ANNEX 1

FIELD STRENGTH OF SPURIOUS EMISSIONS

Test Site Setup:



EUT Orientation(s):



FIELD STRENGTH OF SPURIOUS EMISSIONS

Test Procedure: TIA 603-E, 2.2.13; ITU-R M.1177-4, Annex 1

2 Reference bandwidth

For radar systems, the reference bandwidth, B_{ref}, used to define unwanted emission limits (Recommendations ITU-R SM.329 and ITU-R SM.1541, and RR Appendix 3) should be calculated for each particular radar system. For the four general types of radar pulse modulation utilized for radionavigation, radiolocation, acquisition, tracking and other radiodetermination functions, the reference bandwidth values are determined using the following formulas:

– for FM or chirped radar, the square root of the quantity obtained by dividing the chirp bandwidth (MHz) by the pulse length (μs) (e.g. if the FM is from 1 250 MHz to 1 280 MHz or 30 MHz during the pulse of 10 μs, then the reference bandwidth is $(30\ \text{MHz}/10\ \mu\text{s})^{1/2} = 1.73\ \text{MHz}$);

In all cases, where the bandwidths above are greater than 1 MHz, then a reference bandwidth, B_{ref}, of 1 MHz should be used.

3 Measurement bandwidth and detector parameters

The measurement bandwidth, B_m, is defined as the impulse bandwidth of the receiver and is greater than the IF bandwidth, B_{if}, (sometimes referred to as resolution bandwidth for spectrum analyzers). The measurement bandwidth, B_m, may be derived from the following equation:

$$B_m = B_{if} \times MBR$$

The MBR needs to be determined for the measurement receiver being used. MBR is approximately 3/2 for a –3 dB IF bandwidth Gaussian filter as typically used in many commercial spectrum analyzer receivers (in some instruments the IF bandwidth is defined at the –6 dB point).

An appropriate receiver IF bandwidth should be selected to give one of the following recommended measurement bandwidths.

Measurement bandwidth B_m[1]	≤	$(B_c/T)^{1/2}$ for swept-frequency (FM, or chirp) radars, where B_c is the range of frequency sweep during each pulse and T is the pulse length (e.g. if radar sweeps (chirps) across the frequency range of 1 250-1 280 MHz (= 30 MHz of spectrum) during each pulse, and if the pulse length is 10 μs, then the measurement bandwidth should be $\leq ((30\ \text{MHz})/(10\ \mu\text{s}))^{1/2} = \sqrt{3}\ \text{MHz} \approx 1.73\ \text{MHz}$. In accordance with footnote [1] a measurement bandwidth close to but less than or equal to 1 MHz should be used in this example.
Video bandwidth	≥	measurement system bandwidth.
Detector		positive peak.

[1] In all cases, if the above derived measurement bandwidth is greater than 1 MHz, then the corrections described in § 3.2 should be used.

FIELD STRENGTH OF SPURIOUS EMISSIONS

3.2 Measurements within the spurious domain

3.2.1 Correction of the measurement within the spurious domain

Where the measurement bandwidth, B_m, differs from the reference bandwidth, B_{ref}, a correction factor needs to be applied to the measurements conducted within the spurious domain to express the results in the reference bandwidth. Then the following correction factor should be applied:

$$\text{Spurious level, } B_{ref} = \text{Spurious level (measured in } B_m) + 10 \times \log(B_{ref}/B_m)$$

NOTE 1 – This correction factor should be used except where it is known that the spurious is not noise-like, where a factor between 10 and 20 $\log(B_{ref}/B_m)$ may apply and may be derived by measurements in more than one bandwidth. In all cases the most precise result will be obtained using a measurement bandwidth (B_m) equal to the reference bandwidth. For radars operating above 1 GHz the reference bandwidth (B_{ref}) is 1 MHz.

Bandwidth Compensation Calculation Table:

Mode	T (µs)	Bc (MHz)	Bref (MHz)		MBR (MHz)	Bm (MHz)	Correction (dBm)	Correction (dBm)
	Total Pulse Length (µs)	99% OBW (MHz)	(Bc/T)^0.5 = Bref	If Bref > 1, Bref = 1 (for measuring)	If 3/2 > Bref, MBR = Bref, Else MBR = 3/2	Bif x MBR = Bm	Noise: If Bm > 1, 10 x Log(Bref/Bm)	Emission: If Bm > 1, 20 x Log(Bref/Bm)
0.5 nm	1.625	34.1	4.581	1.0	1.500	9.697	0.077	9.697

Limit Calculation Part 80.211(f)(3)

43 + 10 x Log(Power, in Watts)

Mode	Measured Output (dBm)	43+10 x Log(P) Limit (dBm)
0.5 nm	43.500	-13.00

Note: The tabulated data shows the results of the radiated field strength emissions test. The spectrum was scanned from the lowest frequency generated internally to the tenth harmonic of the fundamental frequency or 40 GHz, whichever is less. This test was conducted in accordance with the standard listed above using the substitution method. Measurements were made at the test site of TIMCO ENGINEERING, INC. located at 849 NW State Road 45, Newberry, FL 32669. The measurements below represent the worst case of all the frequencies tested.

Note: The six (6) highest emissions or more of each worst-case operational modes of the EUT are represented below. Emissions 20 dB below the limit are not required to be reported.

Worst-case Mode of Operation to be Investigated = **0.5 nm Mode**

FIELD STRENGTH OF SPURIOUS EMISSIONS

Test Data: Chirp 9020 MHz Radiated Spurious Emissions Table

Tuned Frequency (MHz)	Emission Frequency (MHz)	Meter Reading (dBµV)	Antenna Polarity	Coax Loss (dB)	Correction Factor (dB/m)	Distance (m)	Field Strength (dBµV/m)	ERP (dBm)	Correction Factor (dBm)	Corrected ERP (dBm)	Margin (dB)
9400.93	62.02	22.69	H	0.93	6.89	3.00	30.506	-66.871	9.697	-57.174	44.17
9400.93	62.02	32.27	V	0.93	6.89	3.00	40.086	-57.291	9.697	-47.594	34.59
9400.93	70.88	32.63	V	1.00	6.09	3.00	39.718	-57.659	9.697	-47.962	34.96
9400.93	108.69	23.07	H	1.19	10.23	3.00	34.495	-62.882	9.697	-53.185	40.19
9400.93	108.70	25.41	V	1.19	10.23	3.00	36.835	-60.542	9.697	-50.845	37.85
9400.93	175.47	17.80	V	1.54	14.51	3.00	33.852	-63.525	9.697	-53.828	40.83
9400.93	189.10	17.84	H	1.59	13.72	3.00	33.147	-64.230	9.697	-54.533	41.53
9400.93	249.70	20.72	H	1.89	11.18	3.00	33.786	-63.591	9.697	-53.894	40.89
9400.93	249.70	20.07	V	1.89	11.18	3.00	33.136	-64.241	9.697	-54.544	41.54
9400.93	419.64	19.44	H	2.34	15.37	3.00	37.149	-60.228	9.697	-50.531	37.53
9400.93	419.64	20.47	V	2.34	15.37	3.00	38.179	-59.198	9.697	-49.501	36.50
9400.93	932.67	19.72	V	3.58	22.46	3.00	45.763	-51.615	9.697	-41.918	28.92
9400.93	948.70	19.55	H	3.61	22.75	3.00	45.907	-51.470	9.697	-41.773	28.77
9400.93	1238.50	-3.54	H	4.11	28.33	3.00	28.898	-68.479	9.697	-58.782	45.78
9400.93	1579.20	-1.54	V	4.71	27.94	3.00	31.110	-66.267	9.697	-56.570	43.57
9400.93	6961.90	-7.68	H	9.99	36.13	3.00	38.441	-58.936	9.697	-49.239	36.24
9400.93	6961.90	-7.56	V	9.99	36.13	3.00	38.561	-58.816	9.697	-49.119	36.12
9400.93	13366.70	-9.72	H	14.08	39.66	3.00	44.020	-53.357	9.697	-43.660	30.66
9400.93	13400.80	-10.48	V	14.09	39.62	3.00	43.231	-54.147	9.697	-44.450	31.45
9400.93	16228.50	-10.93	V	15.59	41.69	3.00	46.347	-51.030	9.697	-41.333	28.33
9400.93	16773.60	-10.73	H	15.86	42.32	3.00	47.452	-49.925	9.697	-40.228	27.23
9400.93	18854.60	-10.76	H	16.54	44.74	3.00	50.517	-46.860	9.697	-37.163	24.16
9400.93	18854.60	-9.75	V	16.54	44.74	3.00	51.527	-45.850	9.697	-36.153	23.15
9400.93	28282.00	6.32	H	20.65	46.79	3.00	73.758	-23.619	9.697	-13.922	0.92
9400.93	28282.00	6.31	V	20.65	46.79	3.00	73.748	-23.629	9.697	-13.932	0.93
9400.93	37709.30	1.60	H	25.30	45.69	3.00	72.594	-24.784	9.697	-15.087	2.09
9400.93	37709.30	1.44	V	25.30	45.69	3.00	72.434	-24.944	9.697	-15.247	2.25

FREQUENCY STABILITY

FCC Rule Parts: Part 2.1055(a)(2), 80.209(b), 90.213(a)

§80.209 Transmitter frequency tolerances.

(b) When pulse modulation is used in land and ship radar stations operating in the bands above 2.4 GHz the frequency at which maximum emission occurs must be within the authorized bandwidth and must not be closer than 1.5/T MHz to the upper and lower limits of the authorized bandwidth where "T" is the pulse duration in microseconds. In the band 14.00-14.05 GHz the center frequency must not vary more than 10 MHz from 14.025 GHz.

§90.213 Frequency stability.

(a) Unless noted elsewhere, transmitters used in the services governed by this part must have a minimum frequency stability as specified in the following table.

MINIMUM FREQUENCY STABILITY

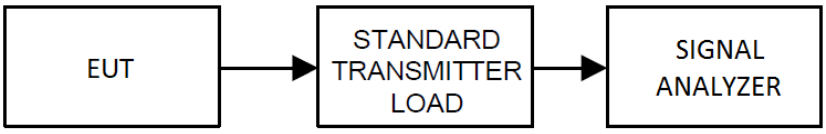
[Parts per million (ppm)]

		Mobile stations	
Frequency range (MHz)	**Fixed and base stations**	**Over 2 watts output power**	**2 watts or less output power**
Above 2450[10]			

[10]Except for DSRCS equipment in the 5850-5925 MHz band, frequency stability is to be specified in the station authorization. Frequency stability for DSRCS equipment in the 5850-5925 MHz band is specified in subpart M of this part.

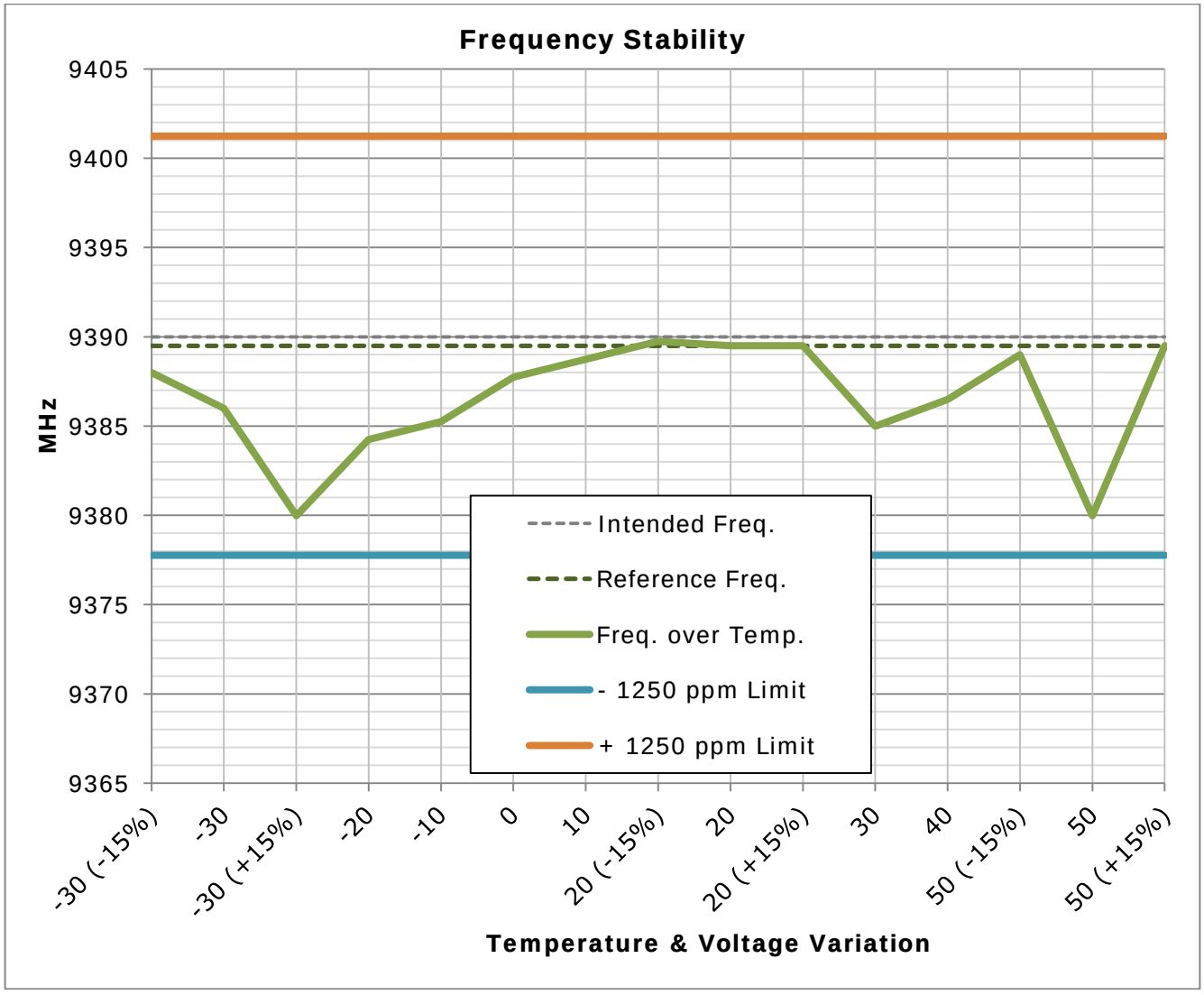
Test Procedure: TIA 603-E, 2.2.2

Test Setup Block Diagram:



FREQUENCY STABILITY

Test Data: Frequency Error Measurement Plot



Note: The EUT is intended for use also within Canada. The more strict frequency stability limit of 1250 ppm from RSS-238 has been applied to the data, below.

FREQUENCY STABILITY

Test Data: Frequency Error Measurement Table

Operating on 9390 MHz, 0.0625 nm Mode				
RSS-238 4.1 Limit:		1250	ppm	
Shortest Pulse Duration:		0.025	µs	
Limit:		60	MHz from Auth. BW	
Authorized Bandwidth		200	MHz	
80.209(b) Limit:		9440	MHz (upper)	
		9360	MHz (lower)	
80.209(b) Limit in PPM:		400,000	ppm	
Most Strict Limit:		1250	ppm	
Temperature (°C)	**Supplied Voltage (VDC)**	**Intended Frequency (Hz)**	**Measured Reference Frequency (Hz)**	**Deviation (Hz)**
20°C (reference)	12	9390000000	9389497645	502355

@ 20°C (reference)				
Supplied Voltage (%)	**Supplied Voltage (VDC)**	**Frequency (Hz)**	**Deviation (Hz)**	**PPM**
-15%	10.20	9389749495	-251850	-26.823
15%	13.80	9389497645	0	0.000

Temperature (°C)	Supplied Voltage (VDC)	Frequency (Hz)	Deviation (Hz)	PPM
50	12	9387494990	2002655.00000	213.287
40	12	9386492985	3004660.00000	320.002
30	12	9384989980	4507665.00000	480.075
20	12	9389497645	0.00000	0.000
10	12	9388747495	750150.00000	79.892
0	12	9387745490	1752155.00000	186.608
-10	12	9385240480	4257165.00000	453.396
-20	12	9384238480	5259165.00000	560.111
-30	12	9385991985	3505660.00000	373.360

RESULT: Meets Requirements

STATEMENT OF MEASUREMENT UNCERTAINTY

The data and results referenced in this document are true and accurate. The measurement uncertainty was calculated for all measurements listed in this test report according To CISPR 16–4 or ENTR 100-028 Specification for radio disturbance and immunity measuring apparatus and methods – Part 4: "Uncertainty in EMC Measurements" and is documented in the Timco Engineering, Inc. quality system according to DIN EN ISO/IEC 17025. Furthermore, component and process variability of devices similar to that tested may result in additional deviation. The manufacturer has the sole responsibility of continued compliance of the device.

Hereafter the best measurement capability for Timco Engineering, Inc. is reported:

Test Items	Measurement Uncertainty	Notes
RF Frequency Accuracy	±49.5 Hz	(1)
RF Conducted Power	±0.93dB	(1)
Conducted spurious emission of transmitter to 40GHz	±1.86dB	
Occupied Bandwidth	±2.65%	
Radiated RF Power	±1.4dB	
Rad Emissions of transmitter up to 26.5GHz	±2.14dB	
Rad Emissions of transmitter to 40GHz	±2.36dB	
Temperature	±1.0°C	(1)
Humidity	±5.0%	

Note: (1) This uncertainty represents an expanded uncertainty expressed at approximately the 95% confidence level using a coverage factor of k=1.96.

EMC EQUIPMENT LIST

Device	Manufacturer	Model	Serial Number	Cal/Char Date	Due Date
Antenna: Biconical 1096	Eaton	94455-1	1096	08/01/17	08/01/19
Antenna: Log-Periodic 1122	Electro-Metrics	LPA-25	1122	07/26/17	07/26/19
Temperature Chamber LARGE	Tenney Engineering	TTRC	11717-7	09/01/16	09/01/18
Coaxial Cable - Chamber 3 cable set (backup)	Micro-Coax	Chamber 3 cable set (backup)	KMKM-0244-02 KMKM-0670-01 KFKF-0197-00	N/A	N/A
CHAMBER	Panashield	3M	N/A	12/31/17	12/31/19
Antenna: Double-Ridged Horn/ETS Horn 2	ETS-Lindgren	3117	00041534	03/01/17	03/01/19
Software: Field Strength Program	Timco	N/A	Version 4.10.7.0	N/A	N/A
Type K J Thermometer	Martel	303	080504494	11/02/17	11/02/19
EMI Test Receiver R & S ESIB 40	Rohde & Schwarz	ESIB 40	100274	08/18/16	08/18/18
EMI Test Receiver R & S ESU 40	Rohde & Schwarz	ESU 40	100320	04/01/16	04/01/19
Attenuator N 10dB 25W DC-8G	Weinschel Eng	33-10-33	AS8999	07/10/17	07/10/19
Attenuator SMA 3dB 5W DC-18G	Pasternack	PE7013-3	#20	11/19/17	11/19/19
Bore-sight Antenna Positioning Tower	Sunol Sciences	TLT2	N/A	N/A	N/A
Terminator N 20W DC-18G	Narda	8205	#14	04/06/17	04/06/19
High Pass Filter 18GHz	Micro-Tronics	HPS18771	-002	05/13/18	05/13/20
Antenna: Double-Ridged Horn 18-40 GHz	EMCO	3116	9011-2145	12/08/17	12/08/19
Coaxial Cable - KMKM-0180-00 Aqua	Micro-Coax	N/A	KMKM-0180-00	07/21/18	07/21/20
Coaxial Cable - SMSM-0019-00 Black	N/A	N/A	SMSM-0019-00	05/16/17	05/16/19

***EMI RECEIVER SOFTWARE VERSION**

The receiver firmware used was version 4.43 Service Pack 3

END OF TEST REPORT