TIMCO ENGINEERING, Inc.

An IIA Company

FCC 47 CFR Part 90 VHF Test Report

APPLICANT	**Cattron North America Inc.**
FCC ID	**CN289693-91072**
MODEL NUMBER	**89693+91072 TRX**
PRODUCT DESCRIPTION	**LRM2 450 MHz Module with Power Ampifier**
DATE SAMPLE RECEIVED	**8/6/2020**
FINAL TEST DATE	**8/12/2020**
REPORT NUMBER	**2801-20_PT90 VHF TestReport_**

AMERICAN ASSOCIATION FOR LABORATORY ACCREDITATION

UNDER ISO/IEC 17025, AND ISO/IEC 17065

A2LA ACCREDITED

Certificate #0955.01

TABLE OF CONTENTS

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SIGNATURE PAGE

Timco Engineering, Inc. attests that:

☒	The EUT tested herein **fulfills** all approval requirements and/or the customer requirements as identified in this test report.
☐	The EUT tested herein **does not fulfill** all approval requirements and/or the customer requirements as identified in this test report.

This report relates only to the Equipment Under Test (EUT) sample(s) tested.

This report shall not be reproduced except in full without the written approval of Timco Engineering, Inc.

To the best of my knowledge and belief, this device has been tested in accordance with the standards identified in this test report, and 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 measurements were made at:

Timco Engineering Inc.
849 NW State Road 45
Newberry, FL 32669

Name and Title Franklin Rose, Project Manager / EMC Specialist

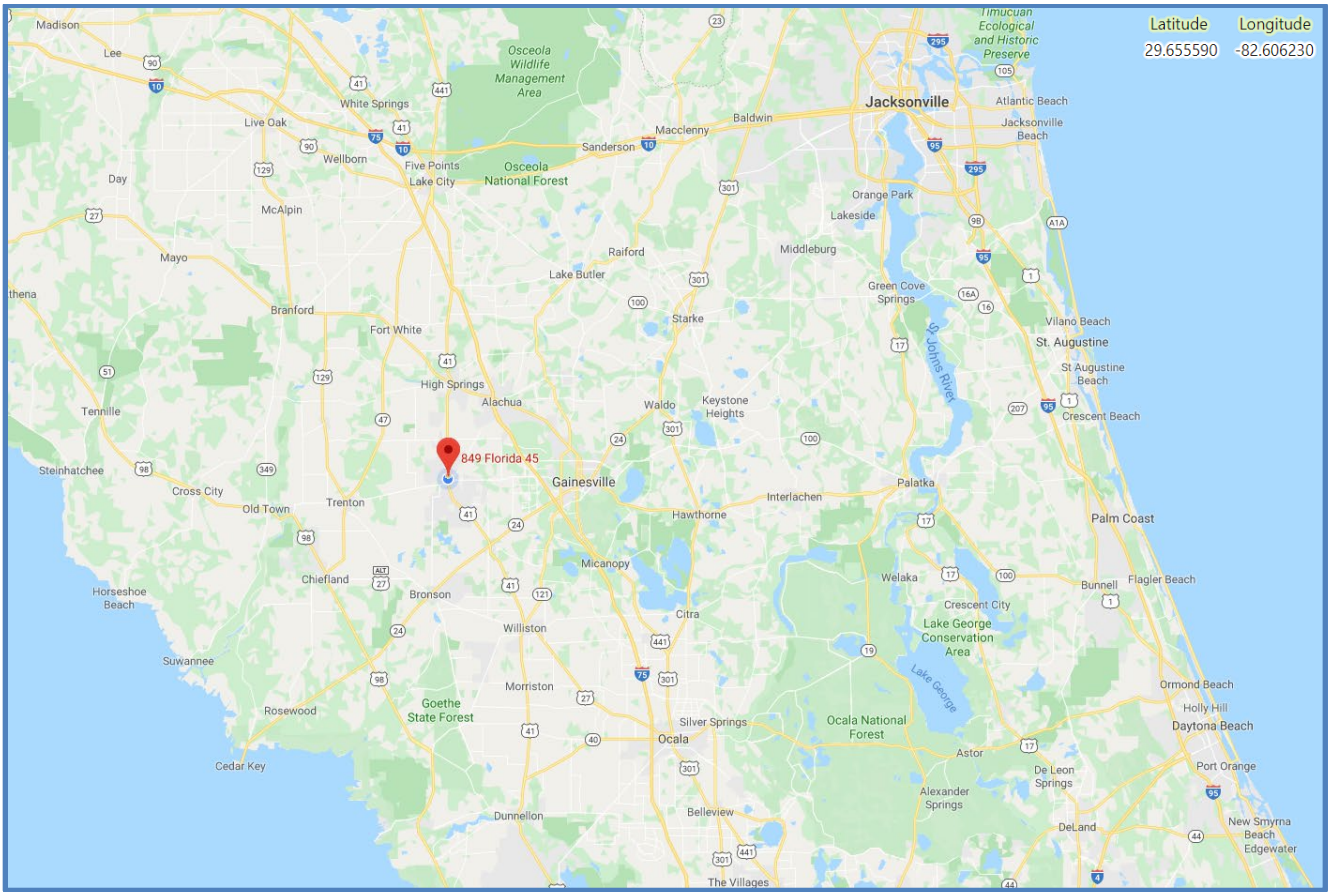
Name and Title Tim Royer, Project Manager / EMC Engineer

Name and Title Sharon Hoffman, Senior Marketing Director / Operations

Date 8/24/2020

TEST LABORATORY INFORMATION

Timco Engineering Inc.
849 NW State Road 45
Newberry, FL 32669, USA



United States	FCC Accredited and Recognized Test Lab & TCB # US1070
	DHS Recognized P25 CAP Test Facility # P25CAPTIMCO081016
Australia / New Zealand	U.S. CABs Recognized by Australia ACMA Under MRA
Canada	U.S. Lab & CB Recognized by Canada ISED, Designation # US0111, Test Site # 2056A
Chinese Taipei	U.S. CABs Recognized by Chinese Taipei BSMI/NCC Under MRA
European Union	U.S. EMC & RE Directive NB's, Designation # US0111, Notified Body # 1177
Hong Kong	U.S. Labs & CBs Recognized by Hong Kong OFCA Under MRA
Israel	U.S. CABs Recognized by Israel MOE/MOC Under MRA
Japan	U.S. RCBs Recognized by Japan MIC
Korea	U.S. CABs Recognized by Korea RRA Under MRA
Mexico	U.S. CABs Recognized by Mexico IFT Under MRA
Singapore	U.S. Labs & CBs Recognized by Singapore IMDA Under MRA
Vietnam	U.S. CABs Recognized by Vietnam MIC Under MRA

TEST INFORMATION

Report Version	Description	Issue Date
Rev1	Initial Issue	8/24/2020
Rev2	Revised report	10/8/2020
Rev3		
Rev4		
Rev5		
Rev6		

Test Conditions	Temperature during testing: 26ºC, Humidity during testing: 50%
Test Exercise	The EUT was operated in accordance with the service manual using software supplied by the manufacturer.
Applicable Standards	ANSI/TIA 603-E, March 2016 ANSI C63.26, December 11, 2015 FCC CFR 47 Part 2, December 5, 2019 FCC CFR 47 Part 90, November 25, 2019
Test Facility	Timco Engineering Inc. at 849 NW State Road 45 Newberry, FL 32669 USA

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EUT INFORMATION

EUT Description	LRM2 450 MHz Module with Power Ampifier		
Model Number	89693+91072 TRX		
Modified for Testing	☐		
Modification	n/a		
Antenna Connector	☐ UHF	☐ BNC	☐ N
	☐ TNC	☐ SMA	☒ Other
EUT Power Source	☐ AC Power (110-120 V)	☒ DC Power	☐ DC Battery (7.4 V)
Test Item	☐ Engineering Prototype	☒ Pre-Production	☐ Post-Production
Type of Equipment	☒ Fixed	☐ Mobile	☐ Portable

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2.1033 APPLICATION REQUIREMENTS

§2.1033 Application for certification.

(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:

Application Requirement	Requirement	Information
2.1033(c)(1)	The full name and mailing address of the applicant for certification	Cattron North America Inc. 655 N. River Road NW Suite A Warren, OH, 44483-2254, US
2.1033(c)(2)	FCC Identifier	CN289693-91072
2.1033(c)(4) 2.1033(c)(13)	Type(s) of Emission & description of Digital Modulation Techniques	☒
2.1033(c)(5)	Frequency Range	450 – 470 MHz
2.1033(c)(6),(7)	Range of operating power or specific operating power levels, and Maximum Power Rating.	0dBm – 30dBm
2.1033(c)(6)	Description of means to vary power	Software
2.1033(c)(8)	The DC voltage & current at the final amplifier for normal operation	**5 VDC * 3.6A = 18 W**
2.1033(c)(14)	Test Results satisfying 2.1046 – 2.1057	☐
2.1033(c)(20)	Part 90 devices operating in the 700 MHz Interoperability Channels must meet P25 CAP CAI or 90.548.	☐
2.1033(c)(21)	Contain > 1 Drawing or Photograph of each test setup applicable to the device	☒

90.203, 90.217 EXEMPTION FROM REQUIREMENTS

§90.217 Exemption from technical standards.

Except as noted herein, transmitters used at stations licensed below 800 MHz on any frequency listed in subparts B and C of this part or licensed on a business category channel above 800 MHz which have an output power not exceeding 120 milliwatts are exempt from the technical requirements set out in this subpart, but must instead comply with the following:

(a) For equipment designed to operate with a 25 kHz channel bandwidth, the sum of the bandwidth occupied by the emitted signal plus the bandwidth required for frequency stability shall be adjusted so that any emission appearing on a frequency 40 kHz or more removed from the assigned frequency is attenuated at least 30 dB below the unmodulated carrier.

(b) For equipment designed to operate with a 12.5 kHz channel bandwidth, the sum of the bandwidth occupied by the emitted signal plus the bandwidth required for frequency stability shall be adjusted so that any emission appearing on a frequency 25 kHz or more removed from the assigned frequency is attenuated at least 30 dB below the unmodulated carrier.

(c) For equipment designed to operate with a 6.25 kHz channel bandwidth, the sum of the bandwidth occupied by the emitted signal plus the bandwidth required for frequency stability shall be adjusted so that any emission appearing on a frequency 12.5 kHz or more removed from the assigned frequency is attenuated at least 30 dB below the unmodulated carrier.

(d) Transmitters may be operated in the continuous carrier transmit mode.

(e) Transmitters used for wireless microphone operations and operating on frequencies allocated for Federal use must comply with the requirements of §90.265(b).

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2.1041 MEASUREMENT PROCEDURE

§2.1041 Measurement procedure.

(a) For equipment operating under parts 15 and 18, the measurement procedures are specified in the rules governing the particular device for which certification is requested.

(b) For equipment operating in the authorized radio services, measurements are required as specified in §§2.1046, 2.1047, 2.1049, 2.1051, 2.1053, 2.1055 and 2.1057. The measurement procedures in ANSI C63.26-2015 (incorporated by reference, see §2.910) are acceptable for performing compliance measurements for equipment types covered by the measurement standard. See also §2.947 for acceptable measurement procedures.

2.1046 – 2.1055 TECHNICAL REQUIREMENTS

General Requirement (FCC PT 2)	Specific Requirement (FCC PT 90)	Requirement	Complies	N/A
2.1033(c)(4)		Modulation Characteristics	☐	☒
2.1046	90.205	RF Power Output	☒	☐
2.1047		Audio Frequency Response	☐	☒
2.1047		Audio Low Pass Filter Response	☐	☒
2.1047		Modulation Limiting	☐	☒
2.1049	90.209	Occupied Bandwidth (99%)	☒	☐
	90.210	Emission Masks	☒	☐
2.1051	90.210	Conducted Spurious Emissions at Antenna Terminals	☒	☐
2.1053	90.210	Radiated Field Strength of Spurious Emissions	☒	☐
2.1055	90.213	Frequency Stability	☒	☐
	90.214	Transient Frequency Response	☒	☐

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2.1057 FREQUENCY SPECTRUM TO BE INVESTIGATED

Requirements: 2.1057, ANSI C63.26 S 5.1.2

§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.

(2) If the equipment operates at or above 10 GHz and below 30 GHz: to the fifth harmonic of the highest fundamental frequency or to 100 GHz, whichever is lower.

(3) If the equipment operates at or above 30 GHz: to the fifth harmonic of the highest fundamental frequency or to 200 GHz, whichever is lower.

(b) Particular attention should be paid to harmonics and subharmonics of the carrier frequency as well as to those frequencies removed from the carrier by multiples of the oscillator frequency. Radiation at the frequencies of multiplier stages should also be checked.

(c) The amplitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be reported.

(d) Unless otherwise specified, measurements above 40 GHz shall be performed using a minimum resolution bandwidth of 1 MHz.

5.1.2 Number of fundamental frequencies to be tested in EUT transmit band

5.1.2.1 General requirement

Measurements of transmitters shall be performed and, if required, reported for each frequency band in which the EUT can be operated with the device transmitting at the number of frequencies in each band specified in Table 2.

Table 2—Number of frequencies to be tested

Frequency range over which EUT operates	Number of frequencies	Location in frequency range of operation
1 MHz or less	1	Middle
1 MHz to 10 MHz	2	1 near top and 1 near bottom
More than 10 MHz	3	1 near top, 1 near middle, and 1 near bottom

5.1.2.2 Test channels and test modes (streamlined test requirements)[25]

Measurement of all modes and all channels is not always necessary to demonstrate compliance. Regardless of the test reduction methods selected, a device must comply with all the applicable rule parts under all modes of operation. A detailed technical rationale must be provided as justification for the selection of a subset of operational modes as being representative of "worst case" conditions.

[25] Use of the procedures in 5.1.2.2 is subject to the discretion of the regulatory authority.

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2.1033 MODULATION CHARACTERISTICS

Requirements: 2.1033(c)(4), 2.1033(c)(13)

Referencing: 2.202(g)

Digital Signals

Emission Designator	Description	Modulation Type	M (modulation Freq., kHz)	R (rate, baud)	D (deviation, kHz)	K (numeric constant)	S (symbols)	Bandwidth Calculation	Bn (necessary bandwidth, kHz)
8K25F1X	Wide NXDN Voice	2FSK,3FSK	-	4800	3	0.984	4		8.30
8K25F1D	Wide NXDN Data	2FSK,3FSK	-	4800	3	0.984	4		8.30
8K25F1W	Wide NXDN Voice & Data	2FSK,3FSK	-	4800	3	0.984	4		8.30

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2.1046 RF POWER OUTPUT

§2.1046 Measurements required: RF power output.

☒ (a) For transmitters other than single sideband, independent sideband and controlled carrier radiotelephone, power output shall be measured at the RF output terminals when the transmitter is adjusted in accordance with the tune-up procedure to give the values of current and voltage on the circuit elements specified in §2.1033(c)(8). The electrical characteristics of the radio frequency load attached to the output terminals when this test is made shall be stated.

☐ (b) For single sideband, independent sideband, and single channel, controlled carrier radiotelephone transmitters the procedure specified in paragraph (a) of this section shall be employed and, in addition, the transmitter shall be modulated during the test as follows. In all tests, the input level of the modulating signal shall be such as to develop rated peak envelope power or carrier power, as appropriate, for the transmitter.

☐ (1) Single sideband transmitters in the A3A or A3J emission modes—by two tones at frequencies of 400 Hz and 1800 Hz (for 3.0 kHz authorized bandwidth), or 500 Hz and 2100 Hz (3.5 kHz authorized bandwidth), or 500 Hz and 2400 Hz (for 4.0 kHz authorized bandwidth), applied simultaneously, the input levels of the tones so adjusted that the two principal frequency components of the radio frequency signal produced are equal in magnitude.

☐ (2) Single sideband transmitters in the A3H emission mode—by one tone at a frequency of 1500 Hz (for 3.0 kHz authorized bandwidth), or 1700 Hz (for 3.5 kHz authorized bandwidth), or 1900 Hz (for 4.0 kHz authorized bandwidth), the level of which is adjusted to produce a radio frequency signal component equal in magnitude to the magnitude of the carrier in this mode.

☐ (3) As an alternative to paragraphs (b) (1) and (2) of this section other tones besides those specified may be used as modulating frequencies, upon a sufficient showing of need. However, any tones so chosen must not be harmonically related, the third and fifth order intermodulation products which occur must fall within the −25 dB step of the emission bandwidth limitation curve, the seventh and ninth order intermodulation product must fall within the 35 dB step of the referenced curve and the eleventh and all higher order products must fall beyond the −35 dB step of the referenced curve.

☐ (4) Independent sideband transmitters having two channels by 1700 Hz tones applied simultaneously in both channels, the input levels of the tones so adjusted that the two principal frequency components of the radio frequency signal produced are equal in magnitude.

☐ (5) Independent sideband transmitters having more than two channels by an appropriate signal or signals applied to all channels simultaneously. The input signal or signals shall simulate the input signals specified by the manufacturer for normal operation.

☐ (6) Single-channel controlled-carrier transmitters in the A3 emission mode—by a 2500 Hz tone.

☐ (c) For measurements conducted pursuant to paragraphs (a) and (b) of this section, all calculations and methods used by the applicant for determining carrier power or peak envelope power, as appropriate, on the basis of measured power in the radio frequency load attached to the transmitter output terminals shall be shown. Under the test conditions specified, no components of the emission spectrum shall exceed the limits specified in the applicable rule parts as necessary for meeting occupied bandwidth or emission limitations.

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90.205 RF POWER OUTPUT

☒ (h) *450-470 MHz.* (1) 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. Applicants requesting an ERP in excess of that listed in table 2 must submit an engineering analysis based upon generally accepted engineering practices and standards that includes coverage contours to demonstrate that the requested station parameters will not produce coverage in excess of that which the applicant requires.

☐ **§90.235 Secondary fixed signaling operations.**

Fixed operations may, subject to the following conditions, be authorized on a secondary basis for voice, tone or impulse signaling on a licensee's mobile service frequency(ies) above 25 MHz within the area normally covered by the licensee's mobile system. Voice signaling will be permitted only in the Public Safety Pool.

(b) The output power shall not exceed 30 watts at the remote site.

☐ **§90.238 Telemetry operations.**

The use of telemetry is authorized under this part on the following frequencies.

(e) In the 450-470 MHz band, telemetry operations will be authorized on a secondary basis with a transmitter output power not to exceed 2 watts on frequencies subject to §90.20(d)(27) or §90.35(c)(30), except that telemetry operations used by Railroad licensees may be authorized on frequency pair 452/457.9375 MHz with a transmitter output power not to exceed 8 watts.

☐ **§90.247 Mobile repeater stations.**

A mobile station authorized to operate on a mobile service frequency above 25 MHz may be used as a mobile repeater to extend the communications range of hand-carried units subject to the following:

(d) In the Industrial/Business Pool, on frequencies designated with an "LR" in the coordinator column of the frequency table in §90.35(b)(3), use of mobile repeaters is on a secondary basis to the stations of any other licensee. Hand carried units used in connection with mobile repeaters on frequencies designated with an "LR" in the coordinator column of the frequency table in §90.35(b)(3) may operate only above 150 MHz and are limited to a maximum output power of six watts. The frequency and maximum power shall be specified in the station authorization.

(e) In the Industrial/Business Pool, on frequencies designated with an "LR" in the coordinator column of the frequency table in §90.35(b)(3), the output power of a mobile repeater station, when transmitting as a repeater station on the frequency used for communication with its associated pack-carried or hand-carried units, shall not exceed 6 watts except when the same frequency is also used by the same station for direct communication with vehicular mobile units or with one or more base stations.

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RF POWER OUTPUT

☐ **§90.265 Assignment and use of frequencies in the bands allocated for Federal use.**

(b) The following frequencies are available for wireless microphone operations to eligibles in this part, subject to the provisions of this paragraph:

Frequencies (MHz)

169.445	169.505	169.545	169.575	169.605	169.995	170.025	170.055
170.245	170.305	171.045	171.075	171.105	171.845	171.875	171.905

(2) The output power shall not exceed 50 milliwatts.

(3) For emissions with a bandwidth not exceeding 54 kHz, the frequency stability of wireless microphones shall limit the total emission to within ±32.5 kHz of the assigned frequency. Emissions with a bandwidth exceeding 54 kHz shall comply with the emission mask in Section 8.3 of ETSI EN 300 422-1 v1.4.2 (2011-08).

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RF POWER OUTPUT

5.2 RF output power measurement procedures

This subclause provides guidance for performing the power measurements necessary to demonstrate compliance to the RF output power limits imposed by regulatory authorities on transmitters. In addition, these procedures can also be utilized to collect the data necessary to demonstrate compliance to regulatory limits placed on unwanted (out-of-band and spurious) emissions.

Test Procedure: ANSI C63.26 S 5.2.3.3

5.2.3.3 Measurement of peak power in a narrowband signal with a spectrum/signal analyzer or EMI receiver

This procedure can be used to measure the peak power in either a CW-like or noise-like narrowband RF signal. The measurement instrument must have a RBW that is greater than or equal to the OBW of the signal to be measured and a VBW $\geq 3 \times$ RBW.

a) Set the RBW $\geq$ OBW.

b) Set VBW $\geq 3 \times$ RBW.

c) Set span $\geq 2 \times$ OBW.

d) Sweep time $\geq 10 \times$ (number of points in sweep) $\times$ (transmission symbol period).

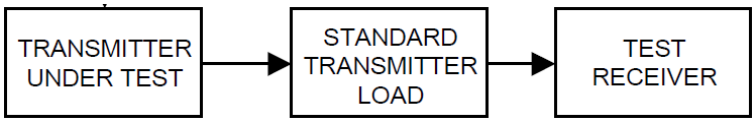
e) Detector = peak.

f) Trace mode = max hold.

g) Allow trace to fully stabilize.

h) Use the peak marker function to determine the peak amplitude level.

Test Setup Block Diagram:



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2.1047 AUDIO FREQUENCY RESPONSE

(a) *Voice modulated communication equipment.* A curve or equivalent data showing the frequency response of the audio modulating circuit over a range of 100 to 5000 Hz shall be submitted. For equipment required to have an audio low-pass filter, a curve showing the frequency response of the filter, or of all circuitry installed between the modulation limiter and the modulated stage shall be submitted.

Test Procedure: ANSI C63.26 S 5.3.3.2

5.3.3.2 Audio frequency response test methodology—Constant Input

a) Connect the equipment as illustrated in Figure 3.

b) Set the test receiver to measure peak positive deviation. Set the audio bandwidth for ≤50 Hz to ≥15 000 Hz. Turn the de-emphasis function off.

c) Adjust the transmitter per the manufacturer's procedure for full rated system deviation.

d) Apply a 1000 Hz tone and adjust the audio frequency generator to produce 20% of the rated system deviation.

e) Set the test receiver to measure rms deviation and record the deviation reading as DEV_{REF}.

f) Set the audio frequency generator to the desired test frequency between 300 Hz and 3000 Hz.

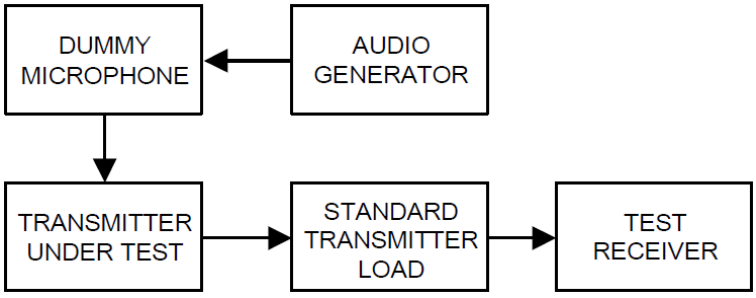
g) Record the test receiver deviation reading as DEV_{FREQ}.

h) Calculate the audio frequency response at the present frequency as follows in Equation (4):

$$\text{audio frequency response} = 20\log_{10}\left(\frac{DEV_{FREQ}}{DEV_{REF}}\right)$$

i) Repeat step f) through step h) for all the desired test frequencies.

Test Setup Block Diagram: ANSI C63.26 S 5.3.3.2



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2.1047 LOW PASS FILTER RESPONSE

(a) *Voice modulated communication equipment.* A curve or equivalent data showing the frequency response of the audio modulating circuit over a range of 100 to 5000 Hz shall be submitted. For equipment required to have an audio low-pass filter, a curve showing the frequency response of the filter, or of all circuitry installed between the modulation limiter and the modulated stage shall be submitted.

Test Procedure: ANSI/TIA-603-E S 2.2.15

a) Connect the equipment as illustrated.

b) Connect the audio frequency generator as close as possible the input of the post limiter low pass filter within the transmitter under test.

c) Connect the audio spectrum analyzer to the output of the post limiter low pass filter within the transmitter under test.

d) Apply a 1000 Hz tone from the audio frequency generator and adjust the level per manufacturer's specifications.

e) Record the dB level of the 1000 Hz spectral line on the audio spectrum analyzer as LEV_{REF} .

f) Set the audio frequency generator to the desired test frequency between 3000 Hz and the upper low pass filter limit.

g) Record audio spectrum analyzer levels, at the test frequency in step f).

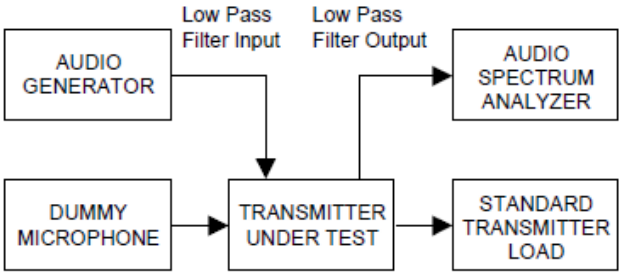
h) Record the dB level on the audio spectrum analyzer as LEV_{FREQ} .

i) Calculate the audio frequency response at the test frequency as:

$$low\ pass\ frequency\ response = LEV_{FREQ} - LEV_{REF}$$

j) Repeat steps f) through i) for all the desired test frequencies.

Test Setup Block Diagram: ANSI/TIA-603-E S 2.2.15.2



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2.1047 MODULATION LIMITING

(b) *Equipment which employs modulation limiting.* A curve or family of curves showing the percentage of modulation versus the modulation input voltage shall be supplied. The information submitted shall be sufficient to show modulation limiting capability throughout the range of modulating frequencies and input modulating signal levels employed.

Test Procedure: ANSI C63.26 S 5.3.3.2

5.3.2 Modulation limiting test methodology

Modulation limiting is the ability of a transmitter circuit to limit the transmitter from producing deviations in excess of a rated system deviation.

a) Connect the equipment as illustrated in Figure 1.

b) Adjust the transmitter per the manufacturer's procedure for full rated system deviation.

c) Set the test receiver to measure peak positive deviation. Set the audio bandwidth for ≤0.25 Hz to ≥15 000 Hz. Turn the de-emphasis function off.

d) Apply a 1000 Hz modulating signal to the transmitter from the audio frequency generator, and adjust the level to obtain 60% of full rated system deviation. This is the 0 dB reference level.

e) Increase the level from the audio generator by 20 dB in 5 dB increments recording the deviation as measured from the test receiver in each step. Verify that the audio level used to make the OBW measurement is included in the sweep.

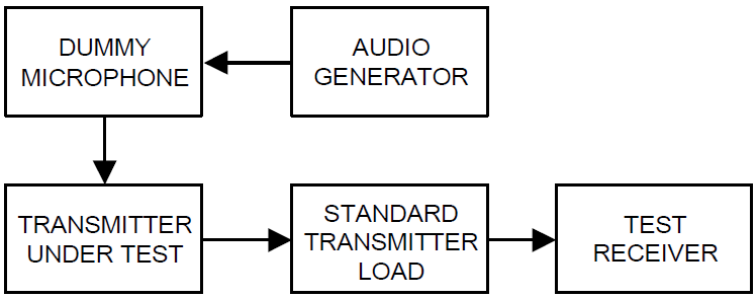
f) Repeat for step e) at 300 Hz, 2500 Hz and 3000 Hz at a minimum using the 0 dB reference level obtained in step d).

g) Set the test receiver to measure peak negative deviation and repeat step d) through step f).

h) The values recorded in step f) and step g) are the modulation limiting.

i) Plot the data set as a percentage of deviation relative to the 0 dB reference point versus input voltage.

Test Setup Block Diagram: ANSI C63.26 S 5.3.3.2



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2.1049 OCCUPIED BANDWIDTH

§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:

☐ (a) Radiotelegraph transmitters for manual operation when keyed at 16 dots per second.

☐ (b) Other keyed transmitters—when keyed at the maximum machine speed.

☐ (c) Radiotelephone transmitters equipped with a device to limit modulation or peak envelope power shall be modulated as follows. For single sideband and independent sideband transmitters, the input level of the modulating signal shall be 10 dB greater than that necessary to produce rated peak envelope power.

☐ (1) Other than single sideband or independent sideband transmitters—when modulated by a 2500 Hz tone at an input level 16 dB greater than that necessary to produce 50 percent modulation. The input level shall be established at the frequency of maximum response of the audio modulating circuit.

☐ (2) Single sideband transmitters in A3A or A3J emission modes—when modulated by two tones at frequencies of 400 Hz and 1800 Hz (for 3.0 kHz authorized bandwidth), or 500 Hz and 2100 Hz (for 3.5 kHz authorized bandwidth), or 500 Hz and 2400 Hz (for 4.0 kHz authorized bandwidth), applied simultaneously. The input levels of the tones shall be so adjusted that the two principal frequency components of the radio frequency signal produced are equal in magnitude.

☐ (3) Single sideband transmitters in the A3H emission mode—when modulated by one tone at a frequency of 1500 Hz (for 3.0 kHz authorized bandwidth), or 1700 Hz (for 3.5 kHz authorized bandwidth), or 1900 Hz (for 4.0 kHz authorized bandwidth), the level of which is adjusted to produce a radio frequency signal component equal in magnitude to the magnitude of the carrier in this mode.

☐ (4) As an alternative to paragraphs (c) (2) and (3) of this section, other tones besides those specified may be used as modulating frequencies, upon a sufficient showing of need. However, any tones so chosen must not be harmonically related, the third and fifth order intermodulation products which occur must fall within the −25 dB step of the emission bandwidth limitation curve, the seventh and ninth order products must fall within the −35 dB step of the referenced curve and the eleventh and all higher order products must fall beyond the −35 dB step of the referenced curve.

☐ (5) Independent sideband transmitters having two channels—when modulated by 1700 Hz tones applied simultaneously to both channels. The input levels of the tones shall be so adjusted that the two principal frequency components of the radio frequency signal produced are equal in magnitude.

☐ (d) Radiotelephone transmitters without a device to limit modulation or peak envelope power shall be modulated as follows. For single sideband and independent sideband transmitters, the input level of the modulating signal should be that necessary to produce rated peak envelope power.

☐ (1) Other than single sideband or independent sideband transmitters—when modulated by a 2500 Hz tone of sufficient level to produce at least 85 percent modulation. If 85 percent modulation is unattainable, the highest percentage modulation shall be used.

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OCCUPIED BANDWIDTH

☐ (f) Transmitters for which peak frequency deviation (D) is determined in accordance with §2.202(f), and in which the modulating baseband comprises more than 3 independent speech channels—when modulated by a test signal determined in accordance with the following:

(1) A modulation reference level is established for the characteristic baseband frequency. (Modulation reference level is defined as the average power level of a sinusoidal test signal delivered to the modulator input which provides the specified value of per-channel deviation.)

(2) Modulation reference level being established, the total rms deviation of the transmitter is measured when a test signal consisting of a band of random noise extending from below 20 kHz to the highest frequency in the baseband, is applied to the modulator input through any preemphasis networks used in normal service. The average power level of the test signal shall exceed the modulation reference level by the number of decibels determined using the appropriate formula in the following table:

Number of message circuits that modulate the transmitter	**Number of dB by which the average power (P_{avg}) level test signal shall exceed the modulation reference level**	**Limits of P_{avg} (dBm0)**
More than 3, but less than 12	To be specified by the equipment manufacturer subject to FCC approval	
At least 12, but less than 60	$X + 2 \log_{10} N_c$	X: −2 to + 2.6
At least 60, but less than 240	$X + 4 \log_{10} N_c$	X: −5.6 to −1.0
240 or more	$X + 10 \log_{10} N_c$	X: −19.6 to −15.0

Where X represents the average power in a message circuit in dBm0; N_c is the number of circuits in the multiplexed message load. P_{avg} shall be selected by the transmitter manufacturer and included with the technical data submitted with the application for type acceptance. (See §2.202(e) in this chapter.)

☐ (g) Transmitters in which the modulating baseband comprises not more than three independent channels—when modulated by the full complement of signals for which the transmitter is rated. The level of modulation for each channel should be set to that prescribed in rule parts applicable to the services for which the transmitter is intended. If specific modulation levels are not set forth in the rules, the tests should provide the manufacturer's maximum rated condition.

☒ (h) Transmitters employing digital modulation techniques—when modulated by an input signal such that its amplitude and symbol rate represent the maximum rated conditions under which the equipment will be operated. The signal shall be applied through any filter networks, pseudo-random generators or other devices required in normal service. Additionally, the occupied bandwidth shall be shown for operation with any devices used for modifying the spectrum when such devices are optional at the discretion of the user.

☐ (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.

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90.209 OCCUPIED BANDWIDTH

§90.209 Bandwidth limitations.

(a) Each authorization issued to a station licensed under this part will show an emission designator representing the class of emission authorized. The designator will be prefixed by a specified necessary bandwidth. This number does not necessarily indicate the bandwidth occupied by the emission at any instant. In those cases where §2.202 of this chapter does not provide a formula for the computation of necessary bandwidth, the occupied bandwidth, as defined in part 2 of this chapter, may be used in lieu of the necessary bandwidth.

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

(1) For A1A or A1B emissions, the maximum authorized bandwidth is 0.25 kHz. The maximum authorized bandwidth for type A3E emission is 8 kHz.

(3) For all other types of emissions, the maximum authorized bandwidth shall not be more than that normally authorized for voice operations.

(4) Where a frequency is assigned exclusively to a single licensee, more than a single emission may be used within the authorized bandwidth. In such cases, the frequency stability requirements of §90.213 must be met for each emission.

(5) Unless specified elsewhere, channel spacings and bandwidths that will be authorized in the following frequency bands are given in the following table.

Standard Channel Spacing/Bandwidth

Applies to EUT	Frequency band (MHz)	Channel spacing (kHz)	Authorized bandwidth (kHz)
☒	406-512[2]	[1]6.25	[1 3 6]20/11.25/6
☐	90.265(a),(c) – (e)	fixed	11.25
☐	90.265(b)	fixed	200 / 54

[1]For stations authorized on or after August 18, 1995.

[3]Operations using equipment designed to operate with a 25 kHz channel bandwidth will be authorized a 20 kHz bandwidth. Operations using equipment designed to operate with a 12.5 kHz channel bandwidth will be authorized a 11.25 kHz bandwidth. Operations using equipment designed to operate with a 6.25 kHz channel bandwidth will be authorized a 6 kHz bandwidth. All stations must operate on channels with a bandwidth of 12.5 kHz or less beginning January 1, 2013, unless the operations meet the efficiency standard of §90.203(j)(3).

[6]Operations using equipment designed to operate with a 25 kilohertz channel bandwidth may be authorized up to a 20 kilohertz bandwidth unless the equipment meets the Adjacent Channel Power limits of §90.221 in which case operations may be authorized up to a 22 kilohertz bandwidth. Operations using equipment designed to operate with a 12.5 kilohertz channel bandwidth may be authorized up to an 11.25 kilohertz bandwidth.

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OCCUPIED BANDWIDTH

☐ **§90.265 Assignment and use of frequencies in the bands allocated for Federal use.**

(a) The following center frequencies are available for assignment to fixed stations in the Public Safety Pool or the Industrial/Business Pool, subject to the provisions of this section:

HYDRO CHANNELS (MHZ)

169.4250	170.2625	171.1000	406.1250
169.4375	170.2750	171.1125	406.1750
169.4500	170.2875	171.1250	412.6625
169.4625	170.3000	171.8250	412.6750
169.4750	170.3125	171.8375	412.6875
169.4875	170.3250	171.8500	412.7125
169.5000	171.0250	171.8625	412.7250
169.5125	171.0375	171.8750	412.7375
169.5250	171.0500	171.8875	412.7625
170.2250	171.0625	171.9000	412.7750
170.2375	171.0750	171.9125	415.1250
170.2500	171.0875	171.9250	415.1750

☐ (5) After May 27, 2005, for the 169-172 MHz band and January 1, 2008 for the 406-416 MHz band, channels for new operations are limited to an authorized bandwidth not to exceed 11.25 kHz. After those dates, existing systems with an authorized bandwidth of greater than 11.25 kHz (including those systems that expand existing operations) may continue to operate with a bandwidth greater than 11.25 kHz until January 1, 2013. Such operations are limited by paragraphs (a)(6) and (a)(7) of this section.

(6) After May 27, 2005, if a licensee of a channel in the band 169-172 MHz which uses equipment with an authorized bandwidth greater than 11.25 kHz cannot resolve an interference complaint to the satisfaction of an impacted Federal agency or is advised to do so by the Hydro Committee as approved by the FCC, then the licensee must cease operation on the frequency upon notification by the Commission.

☐ (b) The following frequencies are available for wireless microphone operations to eligibles in this part, subject to the provisions of this paragraph:

Frequencies (MHz)

169.445	169.505	169.545	169.575	169.605	169.995	170.025	170.055
170.245	170.305	171.045	171.075	171.105	171.845	171.875	171.905

(1) On center frequencies 169.575 MHz, 170.025 MHz, 171.075 MHz, and 171.875 MHz, the emission bandwidth shall not exceed 200 kHz. On the other center frequencies listed in this paragraph (b), the emission bandwidth shall not exceed 54 kHz.

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OCCUPIED BANDWIDTH

☐ **§90.265 Assignment and use of frequencies in the bands allocated for Federal use.**

(c) The following center frequencies are available for assignment to licensees engaged in forest firefighting and conservation activities, subject to the provisions of this section:

FOREST FIREFIGHTING AND CONSERVATION CHANNELS (MHZ)

170.425	171.425	172.225
170.475	171.475	172.275
170.575	171.575	172.375

☐ (7) After May 27, 2005, channels for new operations are limited to an authorized bandwidth not to exceed 11.25 kHz. Between May 27, 2005, and January 1, 2013, existing systems with an authorized bandwidth of greater than 11.25 kHz (including those systems that expand existing operations) may continue to operate with a bandwidth greater than 11.25 kHz, subject to the limitations set forth in paragraph (c)(8), of this section.

☐ (d) The frequencies 166.250 MHz and 170.150 MHz are available for assignment to licensees engaged in public safety activities, subject to the provisions of this section:

(4) After May 27, 2005, channels for new operations are limited to an authorized bandwidth not to exceed 11.25 kHz. Between May 27, 2005, and January 1, 2013, existing systems with an authorized bandwidth of greater than 11.25 kHz (including those systems that expand existing operations) may continue to operate with a bandwidth greater than 11.25 kHz, subject to the limitations set forth in paragraph (d)(3), of this section.

☐ (e) The following frequencies are available for use by Medical Radiocommunication Systems:

(1) The frequencies 150.775 MHz, 150.790 MHz, and 163.250 MHz, subject to following provisions:

(ii) After May 27, 2005, new operations on the frequency 163.250 MHz are limited to an authorized bandwidth not to exceed 11.25 kHz.

(iii) After January 1, 2008, new operations on the frequencies 150.775 MHz and 150.790 MHz are limited to an authorized bandwidth not to exceed 11.25 kHz.

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OCCUPIED BANDWIDTH

Test Procedure: ANSI C63.26 S 5.4

5.4 Occupied bandwidth

The following procedures shall be used for measuring the OBW of the fundamental frequencies of certain transmitters, when required.

5.4.1 General OBW requirements

A spectrum analyzer or other instrument providing a spectral display is recommended for these measurements. The VBW shall be set to a value at least three times greater than the resolution/measurement bandwidth, to avoid the introduction of amplitude smoothing. Video filtering or averaging shall not be used when performing OBW tests.

The applicable regulatory requirements should be consulted to determine which measurement method should be employed. There can be a need to utilize more than one measurement method.

5.4.2 Typical modulation configurations

The OBW shall be measured using the modulation conditions specified in the applicable regulatory requirements.

Voice modulated devices will require the use of a signal/audio generator to produce the required modulation levels.

A modulation analyzer can also be required to measure the modulation characteristics at the output of the EUT to determine if the correct modulation stimulus has been applied.

Digitally modulated devices should be stimulated with a pseudo-random bit sequence.

The OBW shall be measured for all operating modes that will result in transmission in a different OBW (e.g., different channel bandwidth settings).

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OCCUPIED BANDWIDTH

5.4.4 Occupied bandwidth—Power bandwidth (99%) measurement procedure[30]

The OBW is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers are each equal to 0.5% of the total mean power of the given emission.

The following procedure shall be used for measuring (99%) power bandwidth:[31]

a) The spectrum analyzer center frequency is set to the nominal EUT channel center frequency. The frequency span for the spectrum analyzer shall be set wide enough to capture all modulation products including the emission skirts (typically a span of 1.5 × OBW is sufficient).

b) The nominal IF filter 3 dB bandwidth (RBW) shall be in the range of 1% to 5% of the anticipated OBW, and the VBW shall be set ≥ 3 × RBW.

c) Set the reference level of the instrument as required to prevent the signal amplitude from exceeding the maximum spectrum analyzer input mixer level for linear operation. See guidance provided in 4.2.3.

NOTE—Step a), step b), and step c) may require iteration to adjust within the specified tolerances.

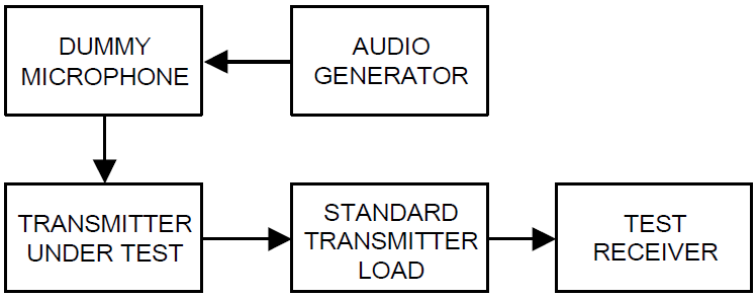
d) Set the detection mode to peak, and the trace mode to max-hold.

e) If the instrument does not have a 99% OBW function, recover the trace data points and sum directly in linear power terms. Place the recovered amplitude data points, beginning at the lowest frequency, in a running sum until 0.5% of the total is reached. Record that frequency as the lower OBW frequency. Repeat the process until 99.5% of the total is reached and record that frequency as the upper OBW frequency. The 99% power OBW can be determined by computing the difference these two frequencies.

f) The OBW shall be reported and plot(s) of the measuring instrument display shall be provided with the test report. The frequency and amplitude axis and scale shall be clearly labeled. Tabular data can be reported in addition to the plot(s).

[30] Measurement method to satisfy 47 CFR 2.1049 and IC RSS-Gen [B60].
[31] See FCC/KDB-971168 D01 [B31].

Test Setup Block Diagram:



90.210 EMISSION MASKS

§90.210 Emission masks.

Except as indicated elsewhere in this part, transmitters used in the radio services governed by this part must comply with the emission masks outlined in this section. Unless otherwise stated, per paragraphs (d)(4), (e)(4), and (o) of this section, measurements of emission power can be expressed in either peak or average values provided that emission powers are expressed with the same parameters used to specify the unmodulated transmitter carrier power. For transmitters that do not produce a full power unmodulated carrier, reference to the unmodulated transmitter carrier power refers to the total power contained in the channel bandwidth. Unless indicated elsewhere in this part, the table in this section specifies the emission masks for equipment operating under this part.

Applies to EUT	Frequency band (MHz)	Mask for equipment with audio low pass filter	Mask for equipment without audio low pass filter
☒	406-512[2]	B, D, or E	C, D, or E
☐	All other bands	B	C
☐	90.265(b)(3) Wireless Mics.	**When OBW > 54 kHz:** ETSI EN 300 422-1 v1.4.2 (2011-08)	

[2]Equipment designed to operate with a 25 kHz channel bandwidth must meet the requirements of Emission Mask B or C, as applicable. Equipment designed to operate with a 12.5 kHz channel bandwidth must meet the requirements of Emission Mask D, and equipment designed to operate with a 6.25 kHz channel bandwidth must meet the requirements of Emission Mask E.

☐ **§90.265 Assignment and use of frequencies in the bands allocated for Federal use.**

(b) The following frequencies are available for wireless microphone operations to eligibles in this part, subject to the provisions of this paragraph:

Frequencies (MHz)

169.445	169.505	169.545	169.575	169.605	169.995	170.025	170.05
170.245	170.305	171.045	171.075	171.105	171.845	171.875	171.90

(3) For emissions with a bandwidth not exceeding 54 kHz, the frequency stability of wireless microphones shall limit the total emission to within ±32.5 kHz of the assigned frequency. Emissions with a bandwidth exceeding 54 kHz shall comply with the emission mask in Section 8.3 of ETSI EN 300 422-1 v1.4.2 (2011-08).

(i) ETSI EN 300 422-1 V1.4.2 (2011-08): "*Electromagnetic compatibility and Radio spectrum Matters (ERM); Wireless microphones in the 25 MHz to 3 GHz frequency range; Part 1: Technical characteristics and methods of measurement,*" Copyright 2011, IBR approved for section 15.236(g).

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EMISSION MASKS

MASK C

(c) *Emission Mask C.* For transmitters that are not equipped with an audio low-pass filter, the power of any emission must be attenuated below the unmodulated carrier output power (P) as follows:

(1) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 5 kHz, but not more than 10 kHz: At least 83 log (f_d/5) dB;

(2) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 10 kHz, but not more than 250 percent of the authorized bandwidth: At least 29 log (f_d^2/11) dB or 50 dB, whichever is the lesser attenuation;

(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.

(4) In the 1427-1432 MHz band, licensees are encouraged to take all reasonable steps to ensure that unwanted emissions power does not exceed the following levels in the 1400-1427 MHz band:

(i) For stations of point-to-point systems in the fixed service: –45 dBW/27 MHz.

(ii) For stations in the mobile service: –60 dBW/27 MHz.

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EMISSION MASKS

MASK D

(d) *Emission Mask D—12.5 kHz channel bandwidth equipment.* For transmitters designed to operate with a 12.5 kHz channel bandwidth, any emission must be attenuated below the power (P) of the highest emission contained within the authorized bandwidth as follows:

(1) On any frequency from the center of the authorized bandwidth f_0 to 5.625 kHz removed from f_0: Zero dB.

(2) On any frequency removed from the center of the authorized bandwidth by a displacement frequency (f_d in kHz) of more than 5.625 kHz but no more than 12.5 kHz: At least 7.27(f_d–2.88 kHz) dB.

(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.

(4) The reference level for showing compliance with the emission mask shall be established using a resolution bandwidth sufficiently wide (usually two or three times the channel bandwidth) to capture the true peak emission of the equipment under test. In order to show compliance with the emission mask up to and including 50 kHz removed from the edge of the authorized bandwidth, adjust the resolution bandwidth to 100 Hz with the measuring instrument in a peak hold mode. A sufficient number of sweeps must be measured to insure that the emission profile is developed. If video filtering is used, its bandwidth must not be less than the instrument resolution bandwidth. For emissions beyond 50 kHz from the edge of the authorized bandwidth, see paragraph (o) of this section. If it can be shown that use of the above instrumentation settings do not accurately represent the true interference potential of the equipment under test, an alternate procedure may be used provided prior Commission approval is obtained.

2.1051 CONDUCTED SPURIOUS EMISSIONS AT ANTENNA TERMINALS

§2.1051 Measurements required: Spurious emissions at antenna terminals.

The radio frequency voltage or powers generated within the equipment and appearing on a spurious frequency shall be checked at the equipment output terminals when properly loaded with a suitable artificial antenna. Curves or equivalent data shall show the magnitude of each harmonic and other spurious emission that can be detected when the equipment is operated under the conditions specified in §2.1049 as appropriate. The magnitude of spurious emissions which are attenuated more than 20 dB below the permissible value need not be specified.

5.2 RF output power measurement procedures

This subclause provides guidance for performing the power measurements necessary to demonstrate compliance to the RF output power limits imposed by regulatory authorities on transmitters. In addition, these procedures can also be utilized to collect the data necessary to demonstrate compliance to regulatory limits placed on unwanted (out-of-band and spurious) emissions.

Test Procedure: ANSI C63.26 S 5.2.3.3

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5.2.3.3 Measurement of peak power in a narrowband signal with a spectrum/signal analyzer or EMI receiver

This procedure can be used to measure the peak power in either a CW-like or noise-like narrowband RF signal. The measurement instrument must have a RBW that is greater than or equal to the OBW of the signal to be measured and a VBW $\geq 3 \times$ RBW.

a) Set the RBW $\geq$ OBW.

b) Set VBW $\geq 3 \times$ RBW.

c) Set span $\geq 2 \times$ OBW.

d) Sweep time $\geq 10 \times$ (number of points in sweep) $\times$ (transmission symbol period).

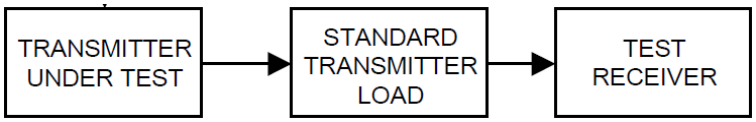
e) Detector = peak.

f) Trace mode = max hold.

g) Allow trace to fully stabilize.

h) Use the peak marker function to determine the peak amplitude level.

Test Setup Block Diagram:



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CONDUCTED SPURIOUS EMISSIONS

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.

(4) In the 1427-1432 MHz band, licensees are encouraged to take all reasonable steps to ensure that unwanted emissions power does not exceed the following levels in the 1400-1427 MHz band:

(i) For stations of point-to-point systems in the fixed service: –45 dBW/27 MHz.

(ii) For stations in the mobile service: –60 dBW/27 MHz.

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.

(4) The reference level for showing compliance with the emission mask shall be established using a resolution bandwidth sufficiently wide (usually two or three times the channel bandwidth) to capture the true peak emission of the equipment under test. In order to show compliance with the emission mask up to and including 50 kHz removed from the edge of the authorized bandwidth, adjust the resolution bandwidth to 100 Hz with the measuring instrument in a peak hold mode. A sufficient number of sweeps must be measured to insure that the emission profile is developed. If video filtering is used, its bandwidth must not be less than the instrument resolution bandwidth. For emissions beyond 50 kHz from the edge of the authorized bandwidth, see paragraph (o) of this section. If it can be shown that use of the above instrumentation settings do not accurately represent the true interference potential of the equipment under test, an alternate procedure may be used provided prior Commission approval is obtained.

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CONDUCTED SPURIOUS EMISSIONS

2.1053 FIELD STRENGTH OF SPURIOUS EMISSIONS

§2.1053 Measurements required: Field strength of spurious radiation.

(a) Measurements shall be made to detect spurious emissions that may be radiated directly from the cabinet, control circuits, power leads, or intermediate circuit elements under normal conditions of installation and operation. Curves or equivalent data shall be supplied showing the magnitude of each harmonic and other spurious emission. For this test, single sideband, independent sideband, and controlled carrier transmitters shall be modulated under the conditions specified in paragraph (c) of §2.1049, as appropriate. For equipment operating on frequencies below 890 MHz, an open field test is normally required, with the measuring instrument antenna located in the far-field at all test frequencies. In the event it is either impractical or impossible to make open field measurements (e.g. a broadcast transmitter installed in a building) measurements will be accepted of the equipment as installed. Such measurements must be accompanied by a description of the site where the measurements were made showing the location of any possible source of reflections which might distort the field strength measurements. Information submitted shall include the relative radiated power of each spurious emission with reference to the rated power output of the transmitter, assuming all emissions are radiated from halfwave dipole antennas.

(b) The measurements specified in paragraph (a) of this section shall be made for the following equipment:

(1) Those in which the spurious emissions are required to be 60 dB or more below the mean power of the transmitter.

(2) All equipment operating on frequencies higher than 25 MHz.

(3) All equipment where the antenna is an integral part of, and attached directly to the transmitter.

(4) Other types of equipment as required, when deemed necessary by the Commission.

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5.5.2 Common requirements

5.5.2.1 General

This subclause details the common requirements applicable to all radiated measurements, except for performing radiated output power measurements per 5.2.7. When conducted measurements cannot be performed (e.g., the EUT utilizes an integrated antenna), then a radiated test configuration must be used to measure the compliance-related technical parameters. Such radiated measurements shall use substitution methods unless a test site validated to ANSI C63.4 requirements is utilized, in which case, radiated fundamental and/or unwanted emissions can be measured using the direct radiated field strength method.

When performing radiated measurements, regardless of whether substitution or direct field strength methods are utilized, the EUT shall be rotated through three axes and the receive (measurement) antenna shall be oriented in both horizontal and vertical polarization. When the direct field strength method is used, then the equations provided in 5.2.7 can be used to determine the radiated output power from either a field strength or received power measurement. Detailed guidance with respect to performing band-edge compliance testing is provided in 5.7.3.

Pre-scan measurements are often performed to identify unwanted emission frequencies and to isolate the associated test variables (e.g., measurement antenna height and polarization, axis orientation, etc.) as discussed in 5.5.2.5. Final compliance tests are performed subsequently using the specified detector(s) at the frequencies and EUT and measurement antenna orientations identified in the pre-scan.

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FIELD STRENGTH OF SPURIOUS EMISSIONS

5.5.2.2 Instrumentation

5.5.2.2.1 General considerations

In addition to the following considerations, the instrumentation and associated guidance provided in Clause 4 shall be applied when performing radiated emissions measurements.

The RF sensitivity of the complete measurement system, relative to the applicable regulatory limit, shall be adequate to permit the anticipated signals (and their related power levels) to be detected and measured. For such purposes, a system noise floor established at 10 dB or more below the relevant power or emission limit is typically adequate. Low-noise preamplifiers, high gain antennas, or reduced test distances (while still maintaining measurement antenna beamwidth coverage of the EUT and a far-field measurement distance relationship) may be required to improve the noise floor-to-limit ratio. These specifics regarding the measurement conditions shall be thoroughly explained in the test report. The use of external band-pass, band-stop, low-pass, and/or high pass filters may be required to provide adequate protection of the measurement instrumentation from overload (see 4.2.3). The insertion losses associated with these external peripherals, to include connecting cables, shall be accounted for in the final measurement data.

5.5.2.2.2 Measurement antenna

Radiated measurements shall be made using antenna(s) as specified in 4.4. The measurement antenna shall be positioned at a suitable test distance from the periphery of the EUT such that the measurement is performed in the far field of the transmitting (EUT) antenna. A practical limitation on test distance can also be set by the available antenna calibration data. The main "beam" or main lobe of the pattern for any antenna used shall be large enough to encompass the physical size of the EUT, or system arrangement, when located at the measurement distance. If the 3 dB beamwidth of the antenna at the specified measurement distance is not large enough to encompass the physical size of the EUT or system arrangement, then multiple radiated scans with the 3 dB beamwidth of the antenna focused on different portions of the EUT or system arrangement will be necessary to ensure that the entirety of the EUT or system arrangement has been measured.

5.5.2.2.3 Test site

The test site shall satisfy the applicable requirements specified in 4.6.

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FIELD STRENGTH OF SPURIOUS EMISSIONS

5.5.2.3 Test arrangement for EUT and antenna positioning

5.5.2.3.1 Test arrangements for tabletop EUTs

For radiated emissions measurements performed at frequencies less than or equal to 1 GHz, the EUT shall be placed on a RF-transparent table or support at a nominal height of 80 cm above the reference ground plane. Radiated measurements shall be made with the measurement antenna positioned in both horizontal and vertical polarization. The measurement antenna shall be varied from 1 m to 4 m in height above the reference ground in a search for the relative positioning that produces the maximum radiated signal level (i.e., field strength or received power). When orienting the measurement antenna in vertical polarization, the minimum height of the lowest element of the antenna shall clear the site reference ground plane by at least 25 cm.

Figure 4 shows a typical EUT configuration with a wireless device placed on a tabletop on an appropriate radiated test site. The measurement antenna shall be placed at the specified distance from the closest point of the EUT. Tabletop devices shall be placed on a RF transparent platform with nominal top surface dimensions of 1 m by 1.5 m. Any necessary support equipment shall be placed far enough away from the EUT, such that changes in relative position of the EUT and support equipment do not influence the measured values. If the EUT requires a connection to a server or computer, via control/data cable(s), to exercise the product, then the controlling server or computer may be placed outside of the test area.

For radiated measurements performed at frequencies above 1 GHz, the EUT shall be placed on an RF transparent table or support at a nominal height of 1.5 m above the ground plane. Radiated measurements shall be made with the measurement antenna positioned in both horizontal and vertical polarization. The height scan of the measurement antenna shall be varied from 1 m to 4 m in a search for the relative positioning that produces the maximum radiated signal level (i.e., field strength or received power). When using the direct field strength method and the EUT is manipulated through three different orientations, then the scan height range of the measurement antenna is limited to 2.5 m, or 0.5 m above the top of the EUT, whichever is higher.

NOTE—The use of waveguide and/or flexible waveguide may be necessary when performing measurements at frequencies above 10 GHz to achieve usable signal-to-noise ratios at acceptable measurement distances. If so, it may be necessary to restrict the height search of the antenna, or conversely to raise or lower the EUT relative to the elevation of the measurement antenna, including its relative angle with respect to the ground plane. In any case, special care should be exercised to ensure that the maximum emissions are identified and measured.

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FIELD STRENGTH OF SPURIOUS EMISSIONS

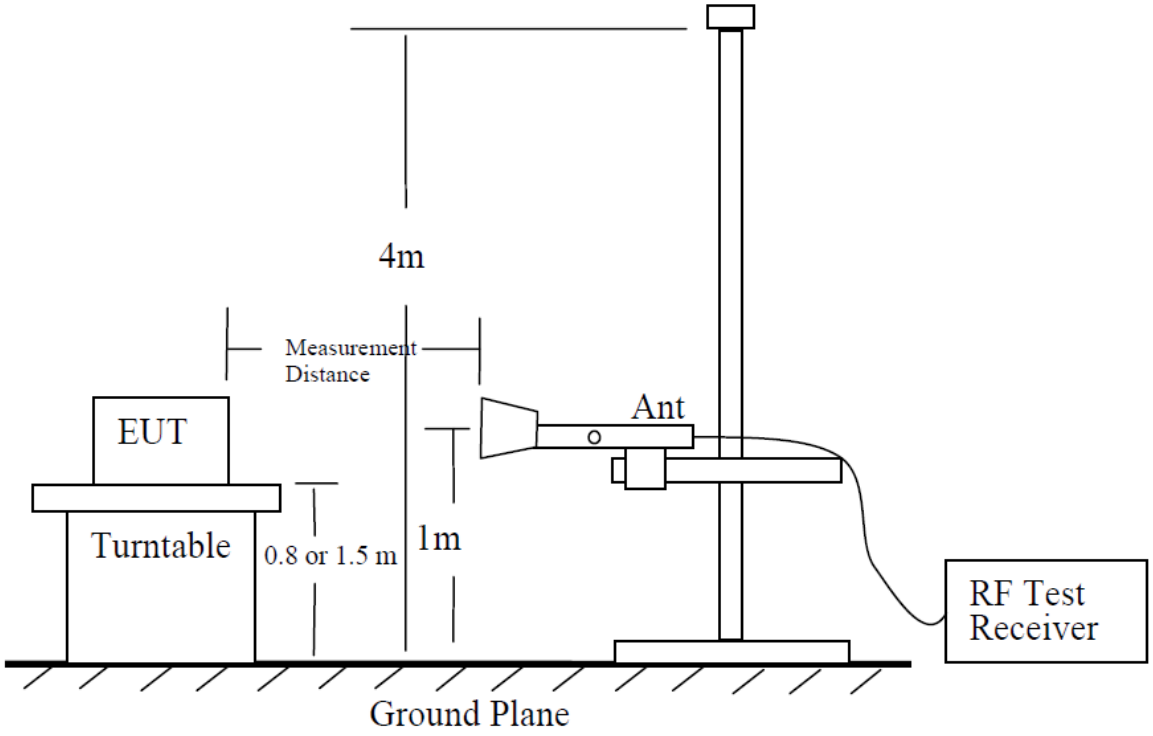

Figure 4—Test set-up for radiated spurious measurements

Radiated unwanted emissions measurements shall be made over the frequency range specified in 5.1, dependent upon the relevant operational frequency band. These radiated measurements shall be made around the EUT (or alternatively, with the EUT rotated on a turntable), while varying the measurement antenna height and examining both horizontal and vertical polarization of the measurement antenna, as described above. Ordinarily, this will require the use of a turntable and an antenna positioner.

The EUT shall be set up in its typical configuration and arrangement and operated in its various modes of operation. Unless the EUT uses an integral antenna, the EUT shall be terminated with a non-radiating transmitter load. In cases where the EUT uses an adjustable antenna, the antenna shall be adjusted through typical positions and lengths to maximize emissions levels. EUTs with integral antennas shall be evaluated in their normal orientation. Where EUTs are designed to be installed in one of two distinct orientations, they shall be tested in both of their possible orientations. EUTs that can be operated in one of multiple orientations (e.g., handheld, portable, or modular devices) shall be tested in a minimum of three orientations. See Figure 5. When large antennas (e.g., high gain) or antennas not structurally supported by the EUT are utilized, a RF transparent supporting structure shall be used to facilitate the compliance testing. In all cases, the EUT, including the transmit antenna, shall be orientated such that the measurement of the emission is maximized.

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FIELD STRENGTH OF SPURIOUS EMISSIONS

Cables or wires inclusive to the EUT shall be configured so as to maximize the measured emission levels. The EUT controls shall also be adjusted to maximize the emission according to the manufacturer's specifications. The modulation applied shall be based on the guidance provided in the manufacturer's specifications. When necessary, field strength measurements shall be converted to ERP or EIRP for comparison to the applicable regulatory limits. See 5.2.7 for additional guidance.

5.5.2.3.2 Test arrangements for floor-standing EUTs

The floor standing EUT should be installed and tested as described in the manufactures instruction manual. If the installation methods are described for indoor and outdoor installations, one of the more typically used installation methods shall be tested. If the installation method provided in the manufacturer's instruction is not practical for testing, then EUT installation method provided in the latest edition of ANSI C63.4 may be used. The grounding of EUT must be achieved in accordance with manufacturer's instructions. However, if grounding studs are provided only at the top of EUT, grounding(s) of EUT may be achieved within 20 cm from the bottom of the EUT cabinet. Grounding of the EUT arbitrarily at middle of the cabinet is not allowed. The grounding material and size should be in accordance with manufacturer's instructions. Electromagnetically shielded ground wires shall not be used. If installation requires use of metal conduits for data, RF, and power cables, then typical or equivalent conduits may be used during the tests. The conduits should be elevated at least 1 cm above the ground plane and can be grounded only at the end of the conduit. All exposed cables shall be routed in accordance with latest edition of ANSI C63.4. The body of the loads connected to the RF ports should be electrically isolated from the cabinet or ground-plane. RF loads can be located outside the measurement area. Leakage radiation from the loads shall not overload the measurement receiver/analyzer.

5.5.2.4 Operational configurations

The EUT shall be tested while operating on the frequency per manufacturer specification. For EUTs that can operate on more than one frequency, unless otherwise specified, measurements shall be performed with the EUT transmitting on a frequency or frequencies as specified in 5.1 for each frequency band of operation.

a) Set the transmitter to operate in continuous transmit mode. For transmitters unable to be configured for ≥98% duty cycle even in a test mode, configure the system to transmit at the maximum duty cycle supported.

b) Compliance testing shall be performed with the minimum number of channels specified in 5.1 for each supported frequency band. A compliance test shall be performed on all channel sets supported by the EUT and permitted under the applicable regulatory requirements.

c) Compliance testing shall be performed for each supported frequency/channel using every available modulation supported by the transmitter, and at minimum and maximum data rate, in an effort to examine all possible combinations with the potential for producing the maximum emission amplitude. The test report shall clearly indicate how the various combinations were examined and a technical justification for any applied streamlining of test requirements. See 5.1.2.2 for guidance with regards to potential streamlined test requirement guidance.

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FIELD STRENGTH OF SPURIOUS EMISSIONS

5.5.2.5 Pre-scan testing

Exploratory radiated measurements (pre-scans) may be performed to determine the general EUT radiated emissions characteristics and, when necessary, the EUT-to-measurement antenna orientation that produces the maximum emission amplitude. Pre-scans shall only be used to determine the emission frequencies (i.e., not amplitude levels). The information garnered from a pre-scan can then be used to perform final compliance measurements using either the substitution or direct field strength method.

Pre-scan tests shall be performed following the test procedures provided in 5.5.2.3 and 5.5.2.4. When maximizing the emissions from the EUT for measurement, the EUT and its transmitting antenna(s) shall be rotated through 360°. For each mode of operation to be tested, the frequency spectrum (based on findings from exploratory measurements) shall be monitored.

5.5.4 Radiated measurement using the field strength method

5.5.4.1 General

Using the test configuration shown in Figure 6, measure the radiated emissions directly from the EUT and convert the measured field strength or received power to ERP or EIRP, as required, for comparison to the applicable limits. As stated in 5.5.1, the field strength measurement method using a test site validated to the requirements of ANSI C63.4 is an alternative to the substitution measurement method described in 5.5.3.

The test site shall satisfy the requirements in 4.6.3. The measurements shall be performed using the instrumentation specified in Clause 4, and using the common procedures in 5.5.2.

5.5.4.2 Radiated measurements for acquiring final compliance data

Final compliance data (i.e., data to be reported to the regulatory agency in support of an application for an equipment authorization) shall be collected in accordance with the procedures provided in 5.5.2, with the EUT transmitting for each frequency specified in 5.1.2. The emission characteristics of the EUT can be identified from the pre-scan measurement information obtained as specified in 5.5.2.5. Final measurements shall be performed for the worst case combination(s) of variable technical parameters that result in the maximum measured emission amplitude as per the guidelines provided in 5.1.2. For each mode selected, record the frequency and amplitude of the highest fundamental emission (if applicable), and the frequency and amplitude data for the six highest-amplitude spurious emissions.

When reduced measurement distances or higher gain antennas are used in the measurement, a far-field measurement distance relationship and measurement antenna beamwidth coverage of the EUT must be maintained. When preamplifiers are used to improve the measurement system noise floor, overload protection shall be ensured (see guidance in 4.2). Any deviations from the specific measurement conditions or requirements shall be fully described in the test report.

See 5.5.2.5 and/or Annex C for guidance on converting measured field strength or received power data to ERP or EIRP, as applicable, for comparison with the applicable regulatory limits.

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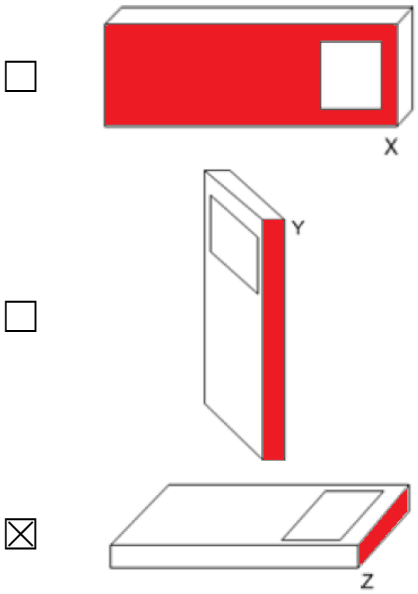
FIELD STRENGTH OF SPURIOUS EMISSIONS

5.5.5 Recording test results

A minimum of six data points representing the highest identified unwanted emission amplitude levels revelant to the limit and associated frequencies must be included in the test report. This information shall be reported in a combination of both plots and tabular data as necessary to demonstrate compliance to the applicable technical requirement(s). When multiple operating modes are evaluated, only the "worst case" plots for each mode in each operating band need to be provided in the test report, along with an explanation and technical rationale supporting the identification of the "worst case." Test set-up photos shall be included and shall be of a sufficient quantity and detail as to allow for replication of the tests (i.e., a single photograph made from several meters away from the EUT is typically not sufficient). Data content and format shall conform to the requirements specified in Clause 8. While it is recognized that a graphical format is not applicable to final tests that utilize the traditional two-stage substitution measurement for every emission, graph(s) of preliminary swept measurement(s) that identify the emissions to be measured during final testing shall be presented in the report.

Worst-Case EUT Orientation



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2.1055 FREQUENCY STABILITY

§2.1055 Measurements required: Frequency stability.

(a) The frequency stability shall be measured with variation of ambient temperature as follows:

☒ (1) From −30° to + 50° centigrade for all equipment except that specified in paragraphs (a) (2) and (3) of this section.

☐ (2) From −20° to + 50° centigrade for equipment to be licensed for use in the Maritime Services under part 80 of this chapter, except for Class A, B, and S Emergency Position Indicating Radiobeacons (EPIRBS), and equipment to be licensed for use above 952 MHz at operational fixed stations in all services, stations in the Local Television Transmission Service and Point-to-Point Microwave Radio Service under part 21 of this chapter, equipment licensed for use aboard aircraft in the Aviation Services under part 87 of this chapter, and equipment authorized for use in the Family Radio Service under part 95 of this chapter.

☐ (3) From 0° to + 50° centigrade for equipment to be licensed for use in the Radio Broadcast Services under part 73 of this chapter.

(b) Frequency measurements shall be made at the extremes of the specified temperature range and at intervals of not more than 10° centigrade through the range. A period of time sufficient to stabilize all of the components of the oscillator circuit at each temperature level shall be allowed prior to frequency measurement. The short term transient effects on the frequency of the transmitter due to keying (except for broadcast transmitters) and any heating element cycling normally occurring at each ambient temperature level also shall be shown. Only the portion or portions of the transmitter containing the frequency determining and stabilizing circuitry need be subjected to the temperature variation test.

☐ (c) In addition to all other requirements of this section, the following information is required for equipment incorporating heater type crystal oscillators to be used in mobile stations, for which type acceptance is first requested after March 25, 1974, except for battery powered, hand carried, portable equipment having less than 3 watts mean output power.

(1) Measurement data showing variation in transmitter output frequency from a cold start and the elapsed time necessary for the frequency to stabilize within the applicable tolerance. Tests shall be made after temperature stabilization at each of the ambient temperature levels; the lower temperature limit, 0° centigrade and + 30° centigrade with no primary power applied.

(2) Beginning at each temperature level specified in paragraph (c)(1) of this section, the frequency shall be measured within one minute after application of primary power to the transmitter and at intervals of no more than one minute thereafter until ten minutes have elapsed or until sufficient measurements are obtained to indicate clearly that the frequency has stabilized within the applicable tolerance, whichever time period is greater. During each test, the ambient temperature shall not be allowed to rise more than 10° centigrade above the respective beginning ambient temperature level.

(3) The elapsed time necessary for the frequency to stabilize within the applicable tolerance from each beginning ambient temperature level as determined from the tests specified in this paragraph shall be specified in the instruction book for the transmitter furnished to the user.

(4) When it is impracticable to subject the complete transmitter to this test because of its physical dimensions or power rating, only its frequency determining and stabilizing portions need be tested.

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FREQUENCY STABILITY

(d) The frequency stability shall be measured with variation of primary supply voltage as follows:

(1) Vary primary supply voltage from 85 to 115 percent of the nominal value for other than hand carried battery equipment.

(2) For hand carried, battery powered equipment, reduce primary supply voltage to the battery operating end point which shall be specified by the manufacturer.

(3) The supply voltage shall be measured at the input to the cable normally provided with the equipment, or at the power supply terminals if cables are not normally provided. Effects on frequency of transmitter keying (except for broadcast transmitters) and any heating element cycling at the nominal supply voltage and at each extreme also shall be shown.

(e) When deemed necessary, the Commission may require tests of frequency stability under conditions in addition to those specifically set out in paragraphs (a), (b), (c), and (d) of this section. (For example measurements showing the effect of proximity to large metal objects, or of various types of antennas, may be required for portable equipment.)

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90.213 FREQUENCY STABILITY

§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.

(b) For the purpose of determining the frequency stability limits, the power of a transmitter is considered to be the maximum rated output power as specified by the manufacturer.

Applies to EUT	Frequency range (MHz)	Fixed and base stations (ppm)	Mobile stations > 2 watts output power (ppm)	Mobile stations ≤ 2 watts output power (ppm)
☒	421-512	[7] [11] [14]2.5	[8]5	[8]5
☐	90.265(b)(3) Wireless Mics.	**When OBW < 54 kHz:** +/- 32.5 kHz tolerance		

[7]In the 421-512 MHz band, fixed and base stations with a 12.5 kHz channel bandwidth must have a frequency stability of 1.5 ppm. Fixed and base stations with a 6.25 kHz channel bandwidth must have a frequency stability of 0.5 ppm.

[8]In the 421-512 MHz band, mobile stations designed to operate with a 12.5 kHz channel bandwidth must have a frequency stability of 2.5 ppm. Mobile stations designed to operate with a 6.25 kHz channel bandwidth must have a frequency stability of 1.0 ppm.

[11]Paging transmitters operating on paging-only frequencies must operate with frequency stability of 5 ppm in the 150-174 MHz band and 2.5 ppm in the 421-512 MHz band.

[14]Control stations may operate with the frequency tolerance specified for associated mobile frequencies.

(b) For the purpose of determining the frequency stability limits, the power of a transmitter is considered to be the maximum rated output power as specified by the manufacturer.

☐ **§90.265 Assignment and use of frequencies in the bands allocated for Federal use.**

(b) The following frequencies are available for wireless microphone operations to eligibles in this part, subject to the provisions of this paragraph:

Frequencies (MHz)

169.445	169.505	169.545	169.575	169.605	169.995	170.025	170.05
170.245	170.305	171.045	171.075	171.105	171.845	171.875	171.90

(3) For emissions with a bandwidth not exceeding 54 kHz, the frequency stability of wireless microphones shall limit the total emission to within ±32.5 kHz of the assigned frequency. Emissions with a bandwidth exceeding 54 kHz shall comply with the emission mask in Section 8.3 of ETSI EN 300 422-1 v1.4.2 (2011-08).

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FREQUENCY STABILITY

Test Procedure: ANSI C63.26 S 5.6.3

5.6.3 Procedure for frequency stability testing

Frequency stability is a measure of the frequency drift due to temperature and supply voltage variations, with reference to the frequency measured at +20 °C and rated supply voltage.

The operating carrier frequency shall be set up in accordance with the manufacturer's published operation and instruction manual prior to the commencement of these tests. No adjustment of any frequency determining circuit element shall be made subsequent to this initial set-up. Frequency stability is tested:

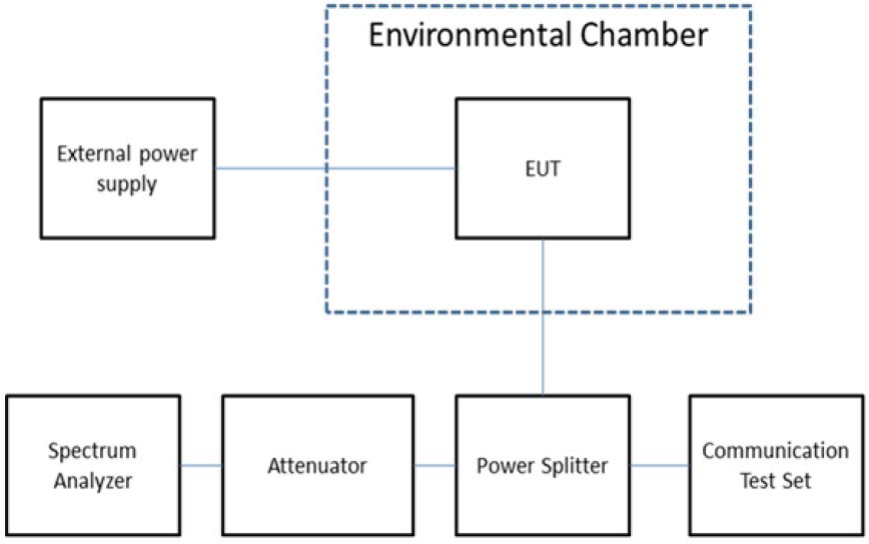
a) At 10 °C intervals of temperatures between −30 °C and +50 °C at the manufacturer's rated supply voltage, and

b) At +20 °C temperature and ±15% supply voltage variations. If a product is specified to operate over a range of input voltage then the −15% variation is applied to the lowermost voltage and the +15% is applied to the uppermost voltage.

During the test all necessary settings, adjustments and control of the EUT have to be performed without disturbing the test environment, i.e., without opening the environmental chamber. The frequency stabilities can be maintained to a lesser temperature range provided that the transmitter is automatically inhibited from operating outside the lesser temperature range. For handheld equipment that is only capable of operating from internal batteries and the supply voltage cannot be varied, the frequency stability tests shall be performed at the nominal battery voltage and the battery end point voltage specified by the manufacturer. An external supply voltage can be used and set at the internal battery nominal voltage, and again at the battery operating end point voltage which shall be specified by the equipment manufacturer.

If an unmodulated carrier is not available, the mean frequency of a modulated carrier can be obtained by using a frequency counter with gating time set to an appropriately large multiple of bit periods (gating time depending on the required accuracy). Full details on the choice of values shall be included in the test report.

Test Setup Block Diagram:



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90.214 TRANSIENT FREQUENCY RESPONSE

§90.214 Transient frequency behavior.

Transmitters designed to operate in the 150-174 MHz and 421-512 MHz frequency bands must maintain transient frequencies within the maximum frequency difference limits during the time intervals indicated:

150 - 174 MHz, 25 kHz Channel, 12.5 kHz Channel, & 6.25 kHz Channel			
Time intervals [1] [2]	t_1[4]	t_2	t_3[4]
Length (ms)	10 ms	25 ms	10 ms
Maximum Frequency Difference [3]	±1 Ch.	±0.5 Ch.	±1 Ch.

[1] $_{on}$ is the instant when a 1 kHz test signal is completely suppressed, including any capture time due to phasing.

t_1 is the time period immediately following t_{on}.

t_2 is the time period immediately following t_1.

t_3 is the time period from the instant when the transmitter is turned off until t_{off}.

t_{off} is the instant when the 1 kHz test signal starts to rise.

[2] During the time from the end of t_2 to the beginning of t_3, the frequency difference must not exceed the limits specified in §90.213.

[3] Difference between the actual transmitter frequency and the assigned transmitter frequency.

[4] If the transmitter carrier output power rating is 6 watts or less, the frequency difference during this time period may exceed the maximum frequency difference for this time period.

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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 EN TR 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
TR 100 028 PARAGRAPH 7.1.1 – FREQUENCY ERROR < 30 MHz	± 0.063 ppm	(1)
TR 100 028 PARAGRAPH 7.1.1 - FREQUENCY ERROR < 200 MHz	± 0.051 ppm	(1)
TR 100 028 PARAGRAPH 7.1.1 - FREQUENCY ERROR < 1 GHz	± 0.051 ppm	(1)
TR 100 028 PARAGRAPH 7.1.1 - FREQUENCY ERROR ≤ 18 GHz	± 0.051 ppm	(1)
TR 100 028 PARAGRAPH 7.1.1 - FREQUENCY ERROR ≤ 40 GHz	± 0.051 ppm	(1)
TR 100 028 PARAGRAPH 7.1.2 - CONDUCTED POWER MEASUREMENT	±0.643 dB	(1)
TR 100 028 PARAGRAPH 7.1.4.1 - CONDUCTED SPURIOUS EMISSIONS 9 kHz – 150 kHz	± 3.14 dB	(1)
TR 100 028 PARAGRAPH 7.1.4.1 - CONDUCTED SPURIOUS EMISSIONS 150 kHz – 30 MHz	± 3.08 dB	(1)
TR 100 028 PARAGRAPH 7.2 – RADIATED EMISSIONS < 200 MHz	± 2.16 dB	(1)
TR 100 028 PARAGRAPH 7.2 – RADIATED EMISSIONS < 1 GHz	± 2.15 dB	(1)
TR 100 028 PARAGRAPH 7.2 – RADIATED EMISSIONS < 18 GHz	± 2.14 dB	(1)
TR 100 028 PARAGRAPH 7.2 – RADIATED EMISSIONS ≤ 40 GHz	± 2.31 dB	(1)
FLUKE Multimeter AC Voltage Uncertainty	± 2.263 %	(1)
FLUKE Multimeter DC Voltage Uncertainty	± 0.453 %	(1)
Temperature (C°)	± 0.81 C°	

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

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EMC EQUIPMENT LIST

Device	Manufacturer	Model	SN	Calibration Date	Cal Due Date
EMI Test Receiver R & S ESU 40 firmware v 4.43 SP 3 BIOS v5.1-24-3	Rohde & Schwarz	ESU 40	100320	08/28/18	08/28/20
Software: Field Strength Program	Timco	N/A	Version 4.10.7.0	N/A	N/A
Coaxial Cable - Chamber 3 cable set (backup)	Micro-Coax	Chamber 3 cable set (backup)	KMKM-0244-02 KMKM-0670-01 KFKF-0197-00	02/27/19	02/27/21
CHAMBER	Panashield	3M	N/A	03/15/19	03/15/21
Antenna: Active Loop	ETS-Lindgren	6502	00062529	12/11/17	12/11/20
Antenna: Biconical 1057	Eaton	94455-1	1057	12/13/17	12/13/20
Antenna: Log-Periodic 1243	Electro-Metrics	96005	1243	04/20/18	04/20/21
Ant: Double-Ridged Horn/ETS Horn 1	ETS-Lindgren	3117	00035923	02/25/20	02/25/23
Noise Source 10 MHz – 18 GHz	Agilent	346B	MY44421884	n/a	n/a
Splitter 1-1000MHz	Mini-Circuits	ZFSC-4-1-BNC+	U115700825	11/19/17	11/19/20

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ANNEX I – MANUFACTURER-PROVIDED INFORMATION

Note: The accuracy and precision of the following information provided by the manufacturer of the equipment under test has not been verified using test methods, cannot be verified, or is not necessary to verify.

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ANNEX II – MEASUREMENT DATA

Modulation Characteristics

Test Engineer:_____
Test Date:_____

N/A. Device does not accept audio input.

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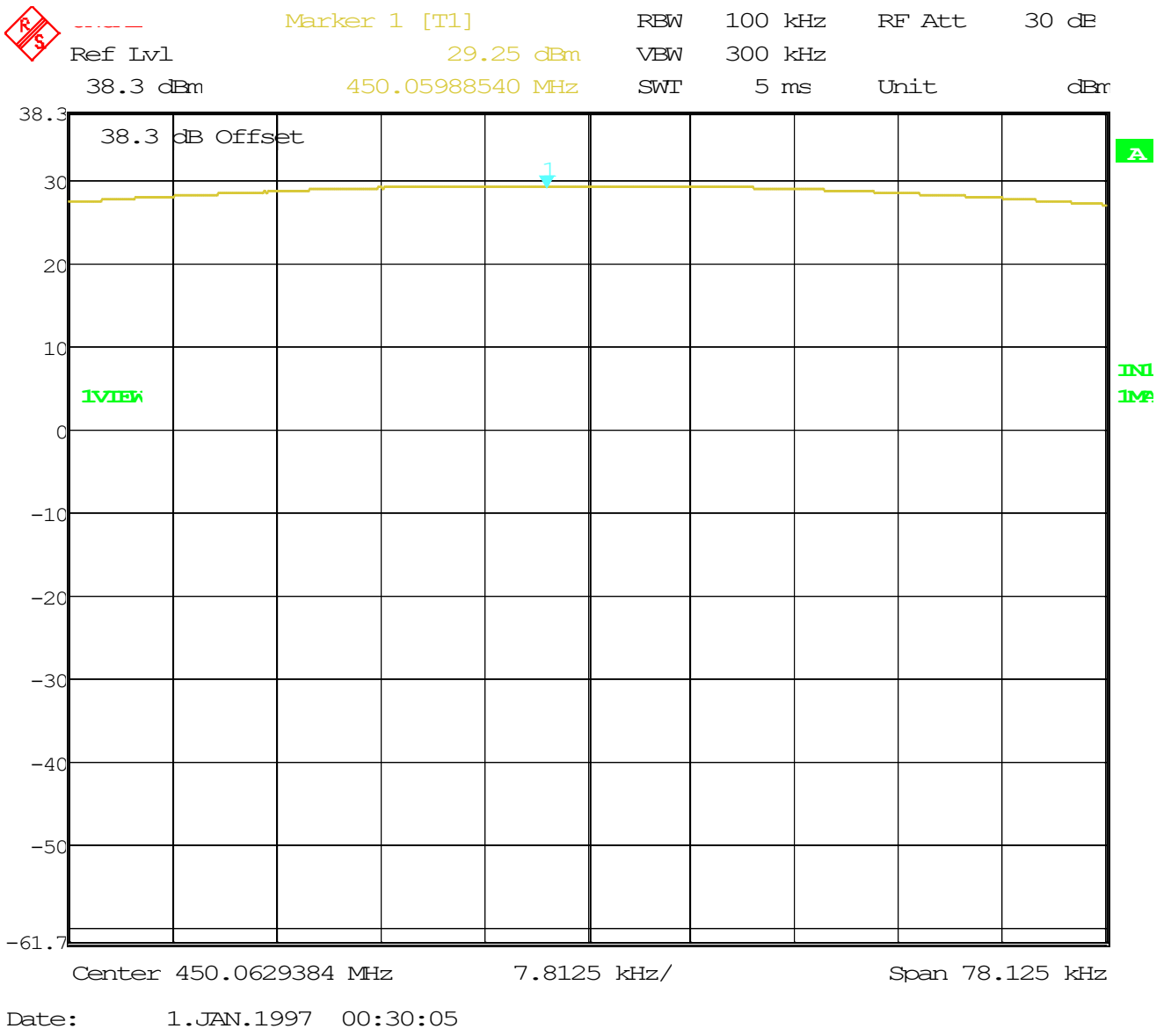
2.1046 RF POWER OUTPUT

Test Data: 450MHz, 30dBm

Test Engineer: TR
Test Date: Aug 7 2020



Max Power Output = 29.25 dBm (0.84 W)

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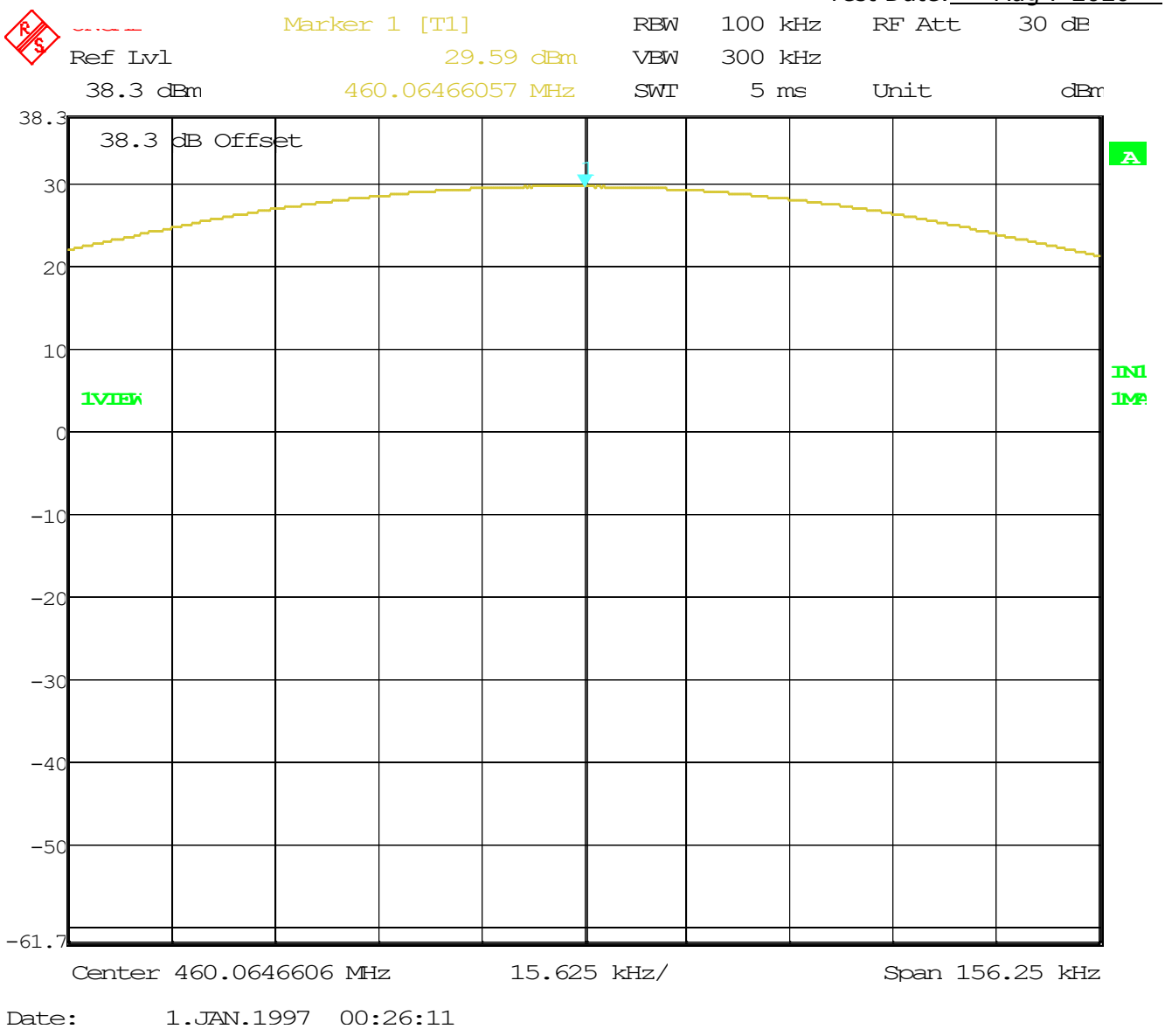
RF POWER OUTPUT

Test Data: 460MHz, 30dBm

Test Engineer: TR
Test Date: Aug 7 2020



Max Power Output = 29.59 dBm (0.9 W)

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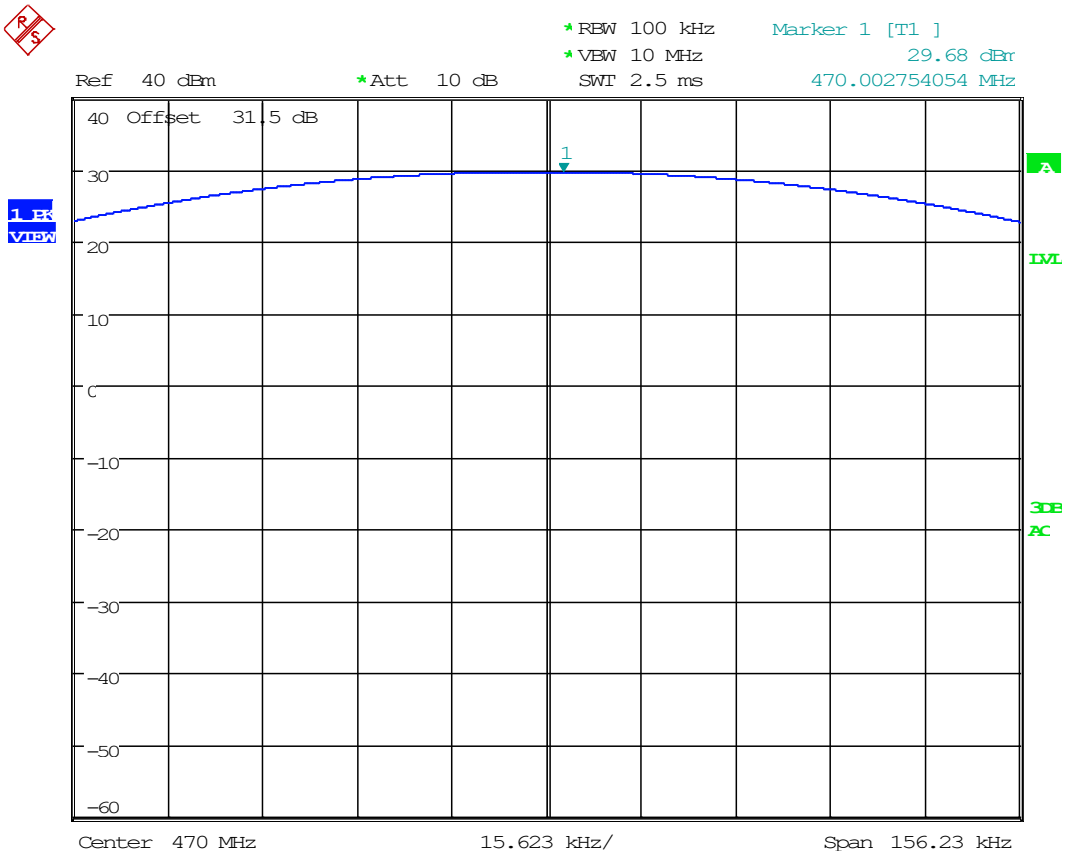
RF POWER OUTPUT

Test Data: 470MHz, 30dBm

Test Engineer: TR
Test Date: Aug 7 2020



Date: 2.SEP.2020 16:18:34

Max Power Output = 29.68 dBm (0.9 W)

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RF POWER OUTPUT

2.1047 AUDIO FREQUENCY RESPONSE

2.1047 LOW PASS FILTER RESPONSE

Test Engineer:_____
Test Date:_____

N/A. Device does not accept audio input.

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2.1047 MODULATION LIMITING

Test Engineer:_____
Test Date:_____

N/A. Device does not have means to limit modulation.

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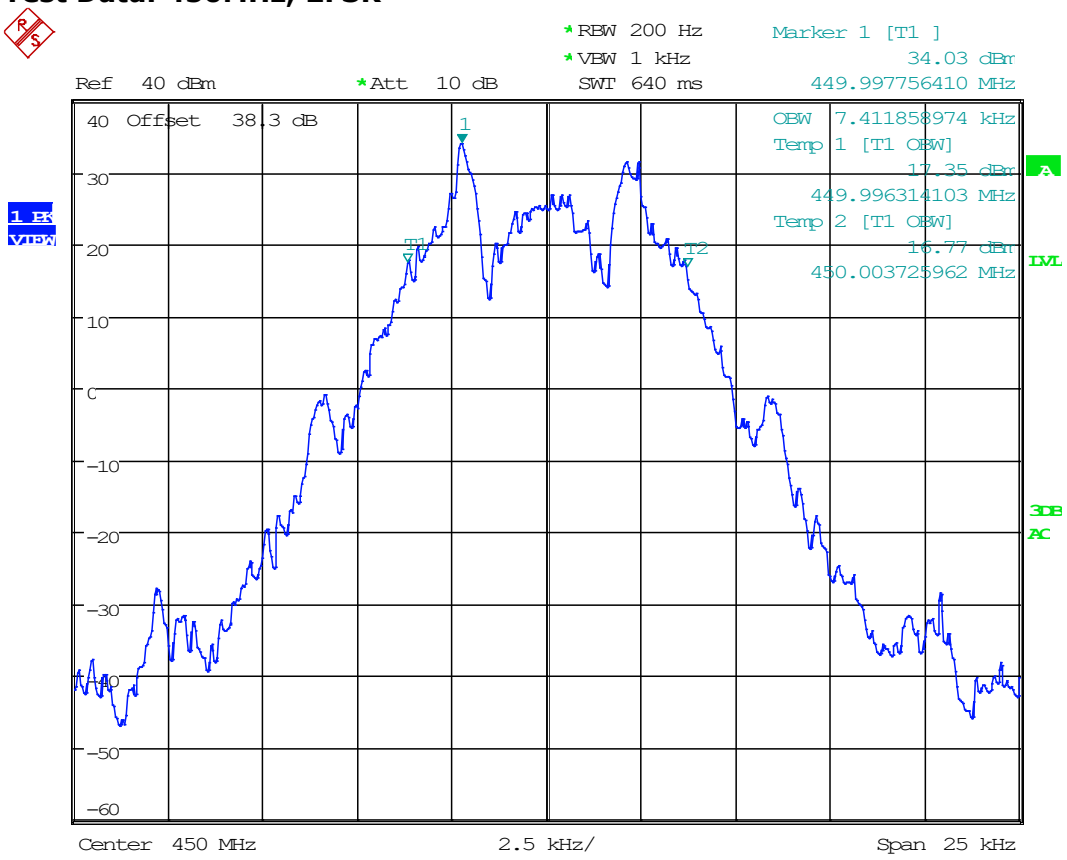
90.209 OCCUPIED BANDWIDTH

Test Engineer: TR
Test Date: AUG 7, 2020

Test Data: 450MHz, 2FSK

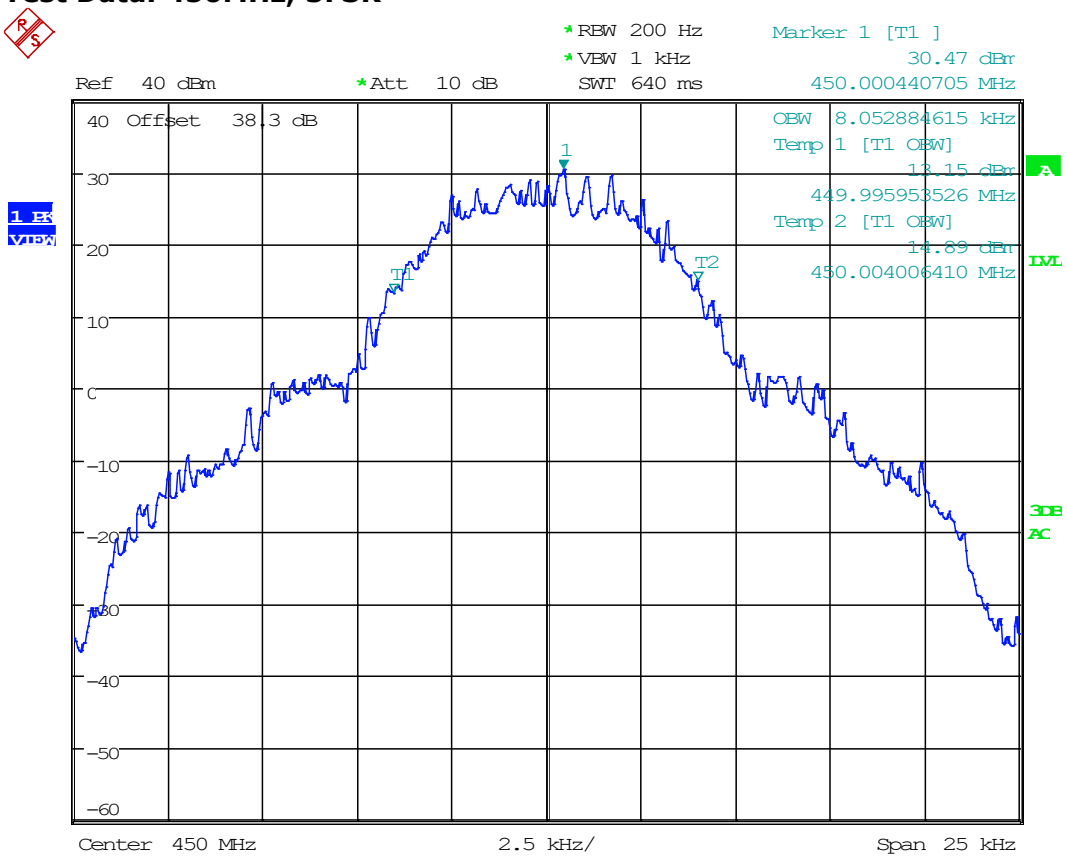


Date: 7.AUG.2020 16:12:26

OCCUPIED BANDWIDTH

Test Engineer: TR
Test Date: AUG 7, 2020

Test Data: 450MHz, 3FSK



Date: 7.AUG.2020 16:13:03

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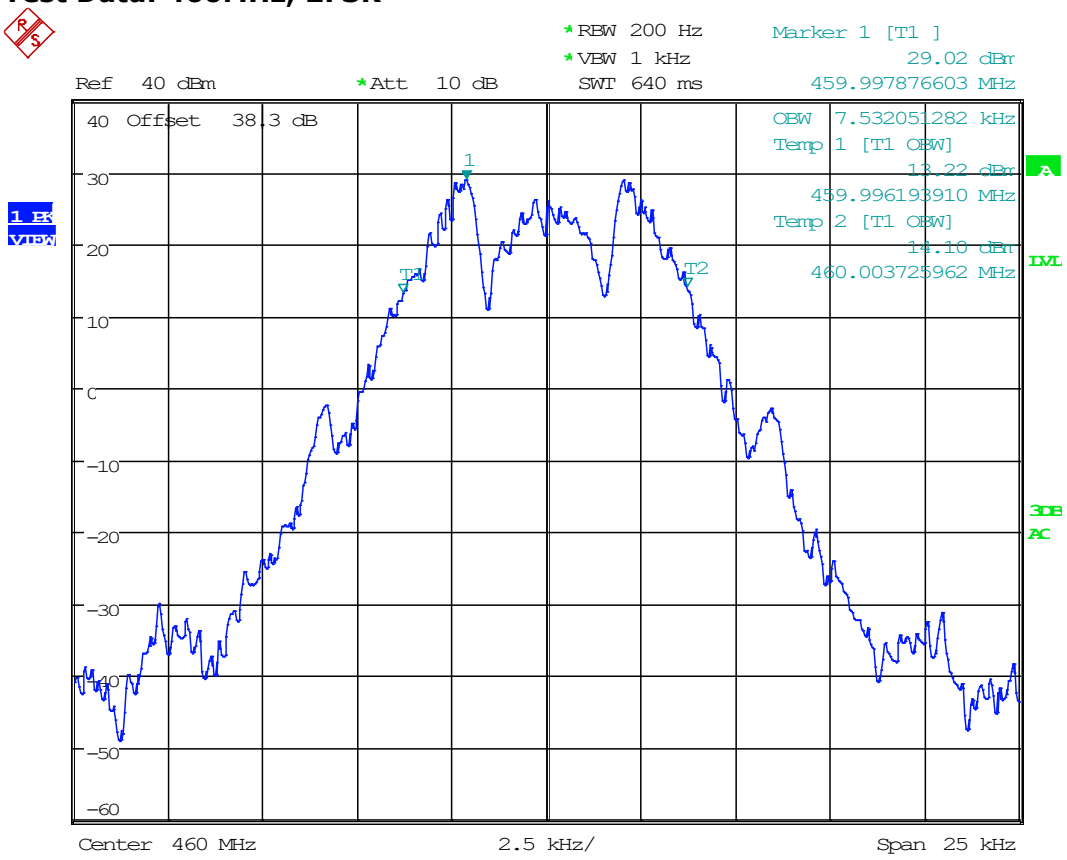
OCCUPIED BANDWIDTH

Test Engineer: TR
Test Date: AUG 7, 2020

Test Data: 460MHz, 2FSK



Date: 7.AUG.2020 16:11:49

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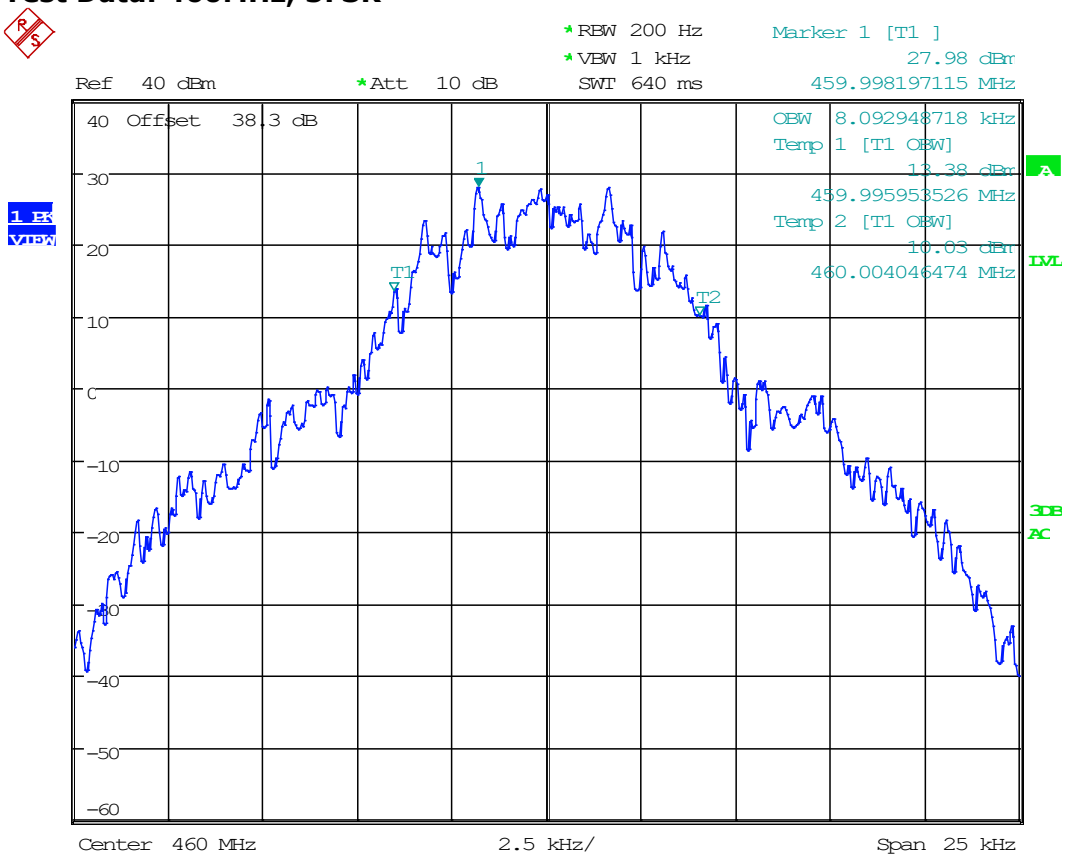
OCCUPIED BANDWIDTH

Test Engineer: TR
Test Date: AUG 7, 2020

Test Data: 460MHz, 3FSK



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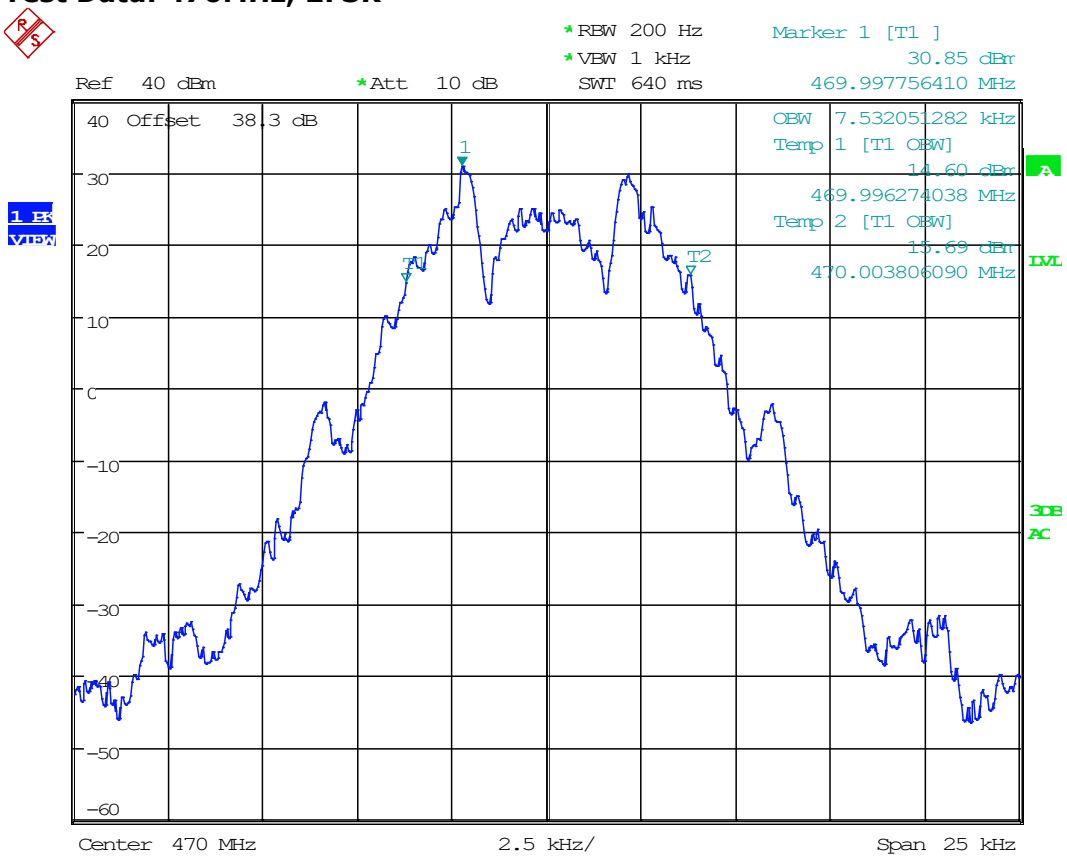
OCCUPIED BANDWIDTH

Test Engineer: TR
Test Date: AUG 7, 2020

Test Data: 470MHz, 2FSK



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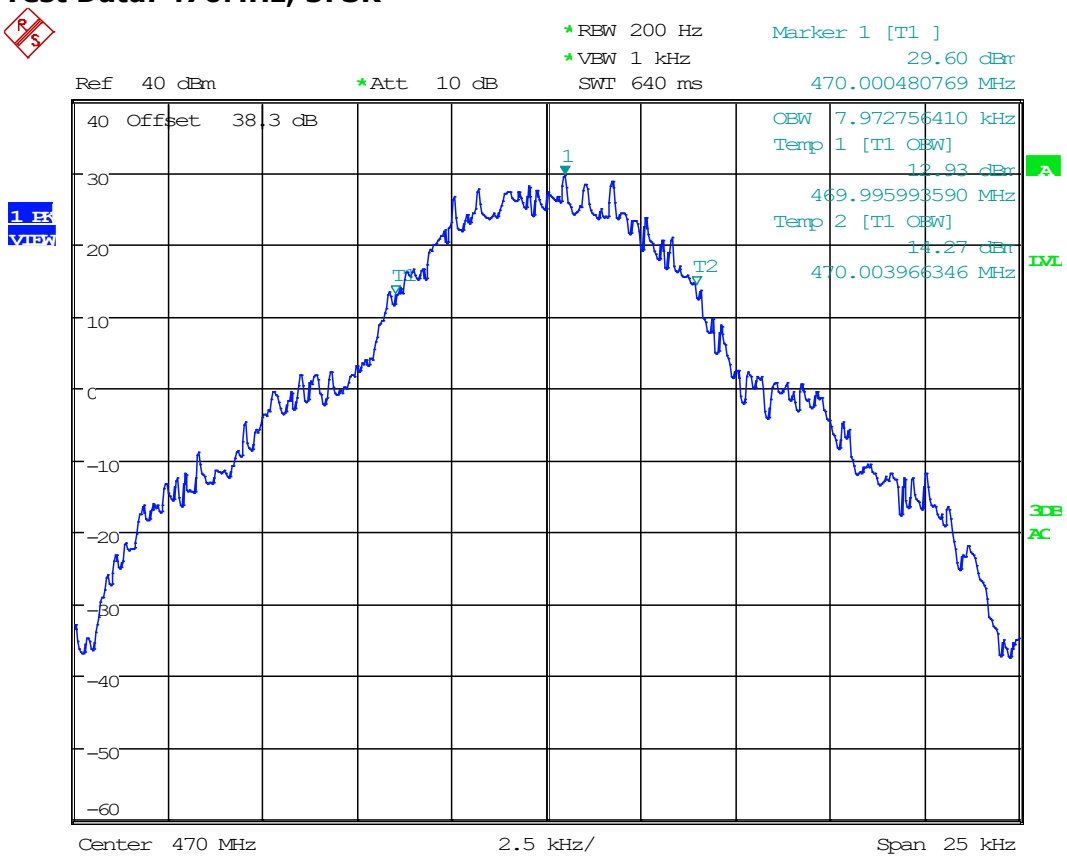
OCCUPIED BANDWIDTH

Test Engineer: TR
Test Date: AUG 7, 2020

Test Data: 470MHz, 3FSK

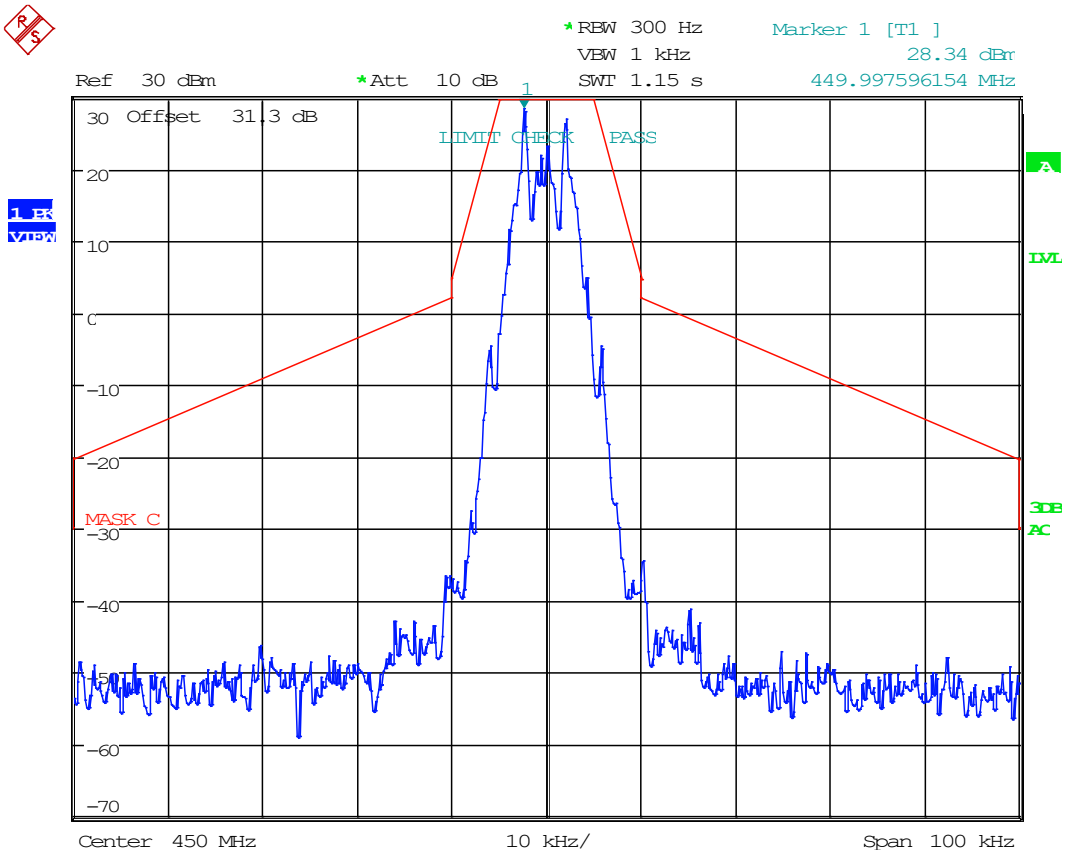


Date: 7.AUG.2020 16:10:13

90.210 EMISSION MASKS

Test Engineer: TR
Test Date: AUG 7, 2020

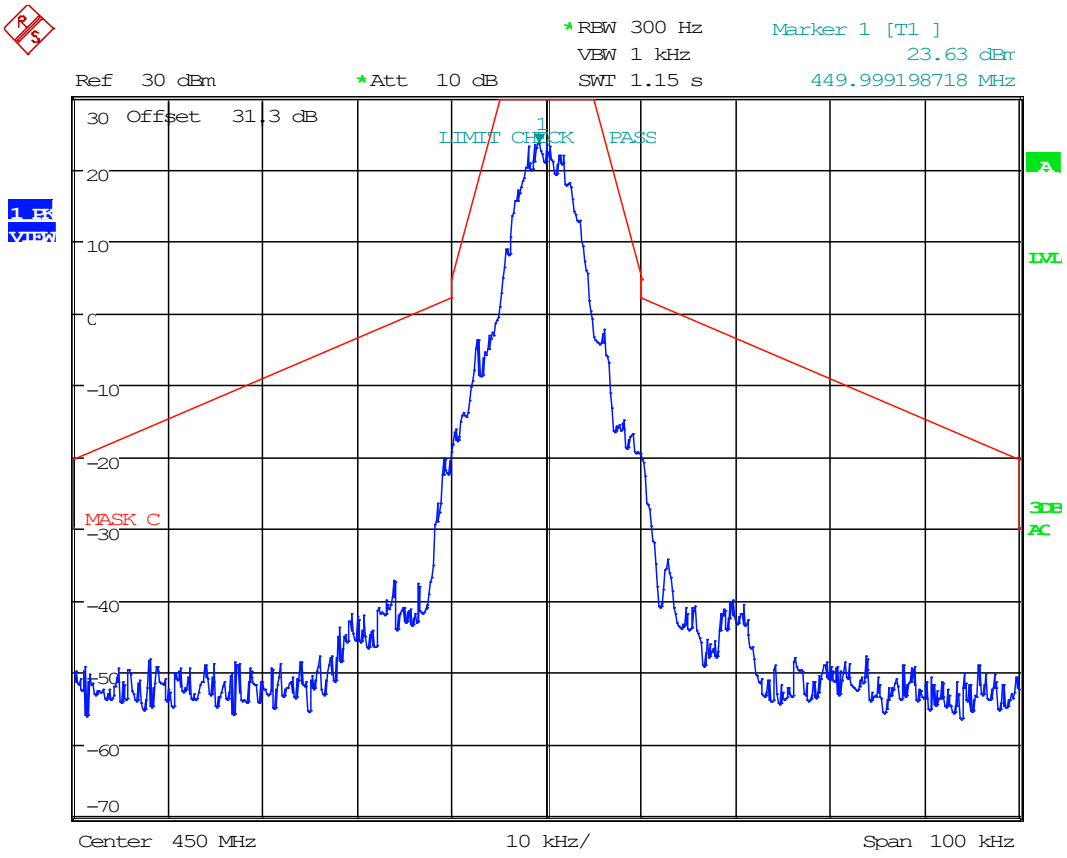
Test Data: 450MHz, 2FSK, Mask C



EMISSION MASKS

Test Engineer: TR
Test Date: AUG 7, 2020

Test Data: 450MHz, 3FSK, Mask C



Date: 12.AUG.2020 12:35:19

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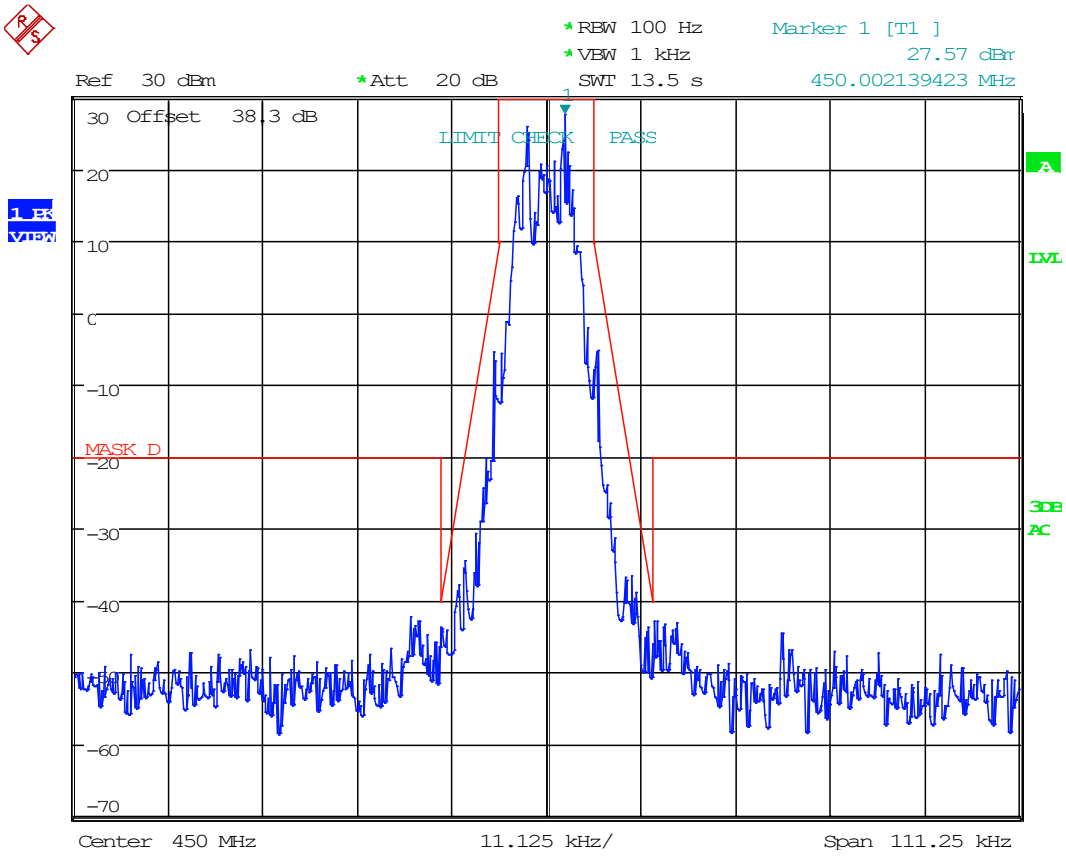
EMISSION MASKS

Test Data: 450MHz, 2FSK, Mask D



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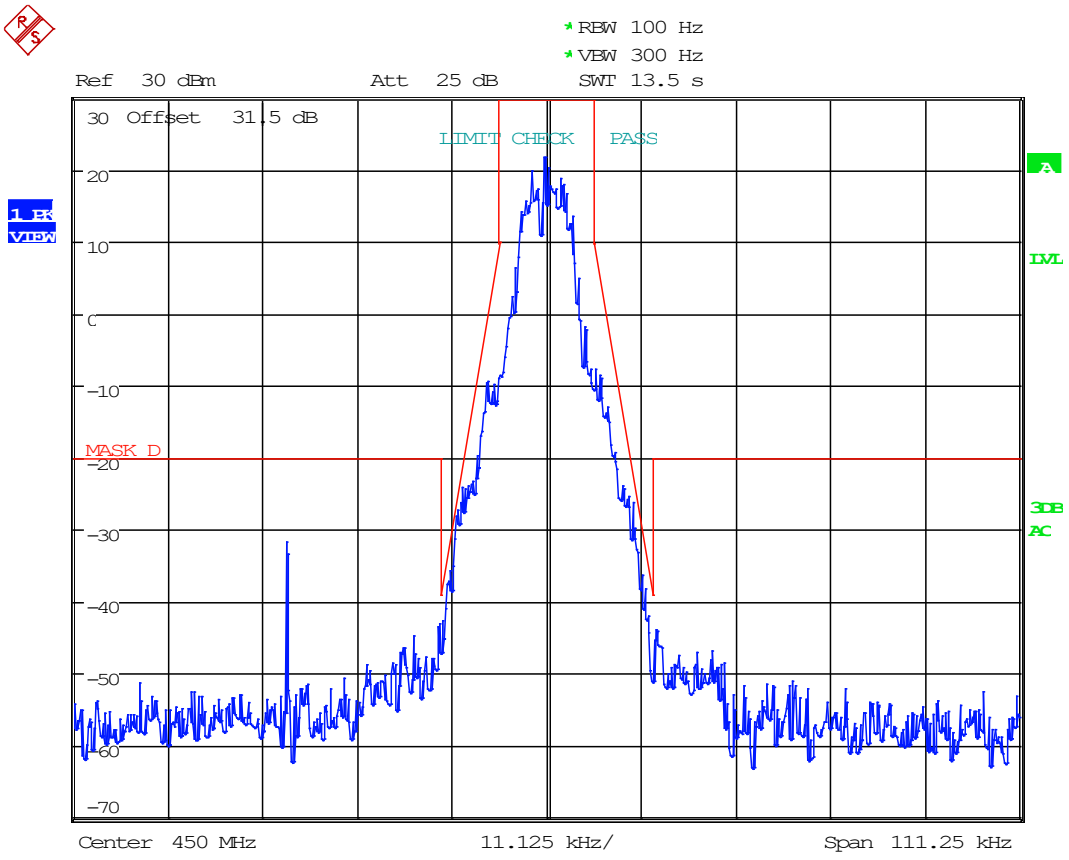
EMISSION MASKS

Test Engineer: TR
Test Date: AUG 7, 2020

Test Data: 450MHz, 3FSK, Mask D



Date: 31.AUG.2020 10:22:33

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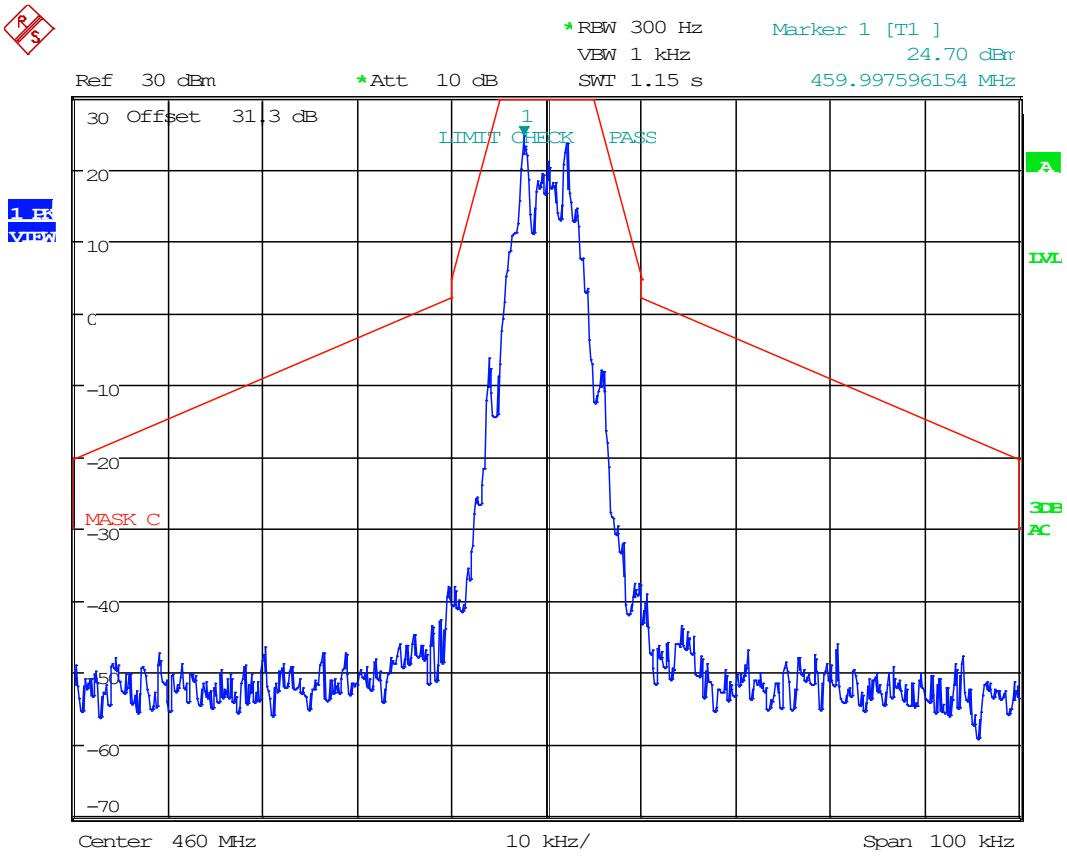
EMISSION MASKS

Test Engineer: TR
Test Date: AUG 7, 2020

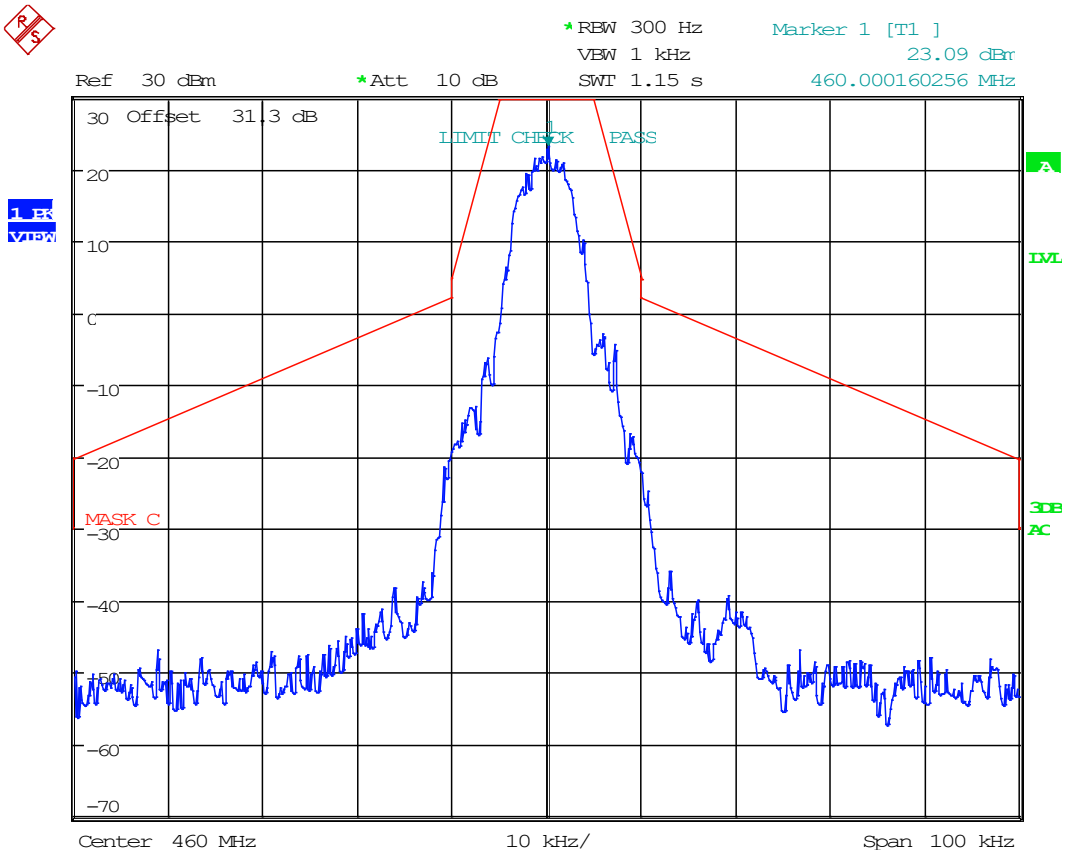
Test Data: 460MHz, 2FSK, Mask C



EMISSION MASKS

Test Engineer: TR
Test Date: AUG 7, 2020

Test Data: 460MHz, 3FSK, Mask C



Date: 12.AUG.2020 12:36:45

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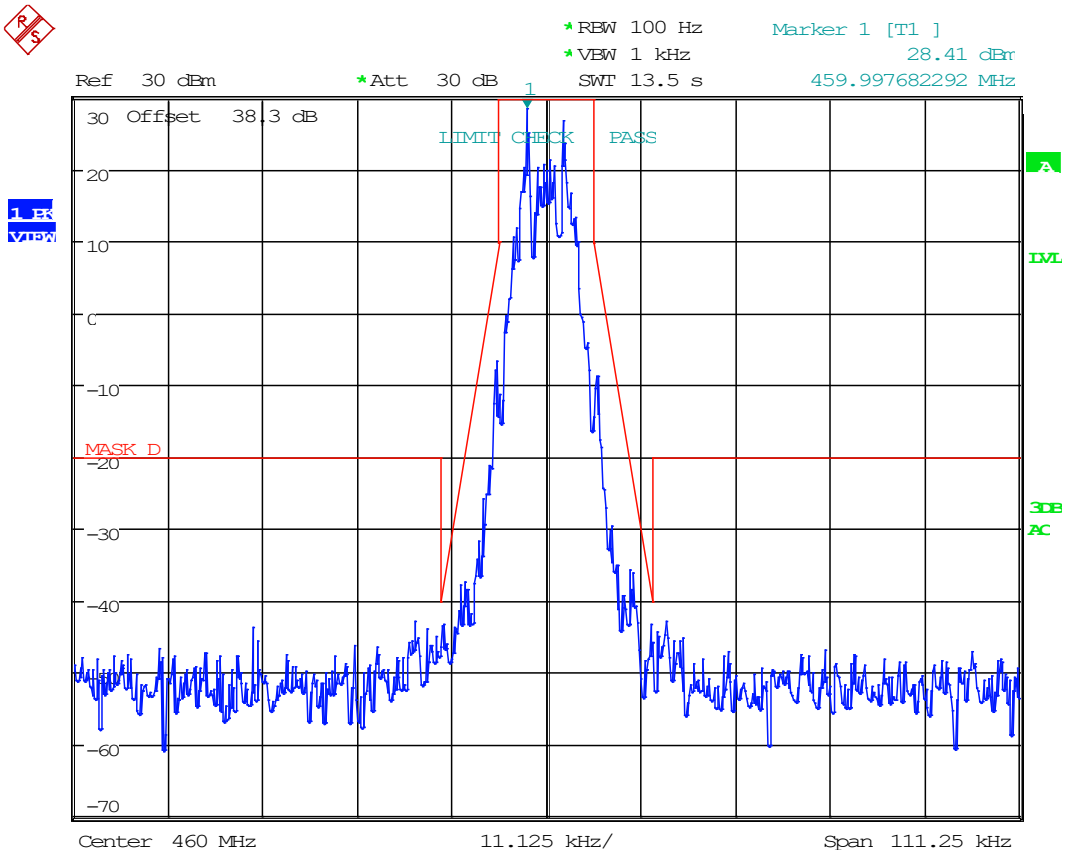
EMISSION MASKS

Test Engineer: TR
Test Date: AUG 7, 2020

Test Data: 460MHz, 2FSK, Mask D



Date: 7.AUG.2020 16:20:04

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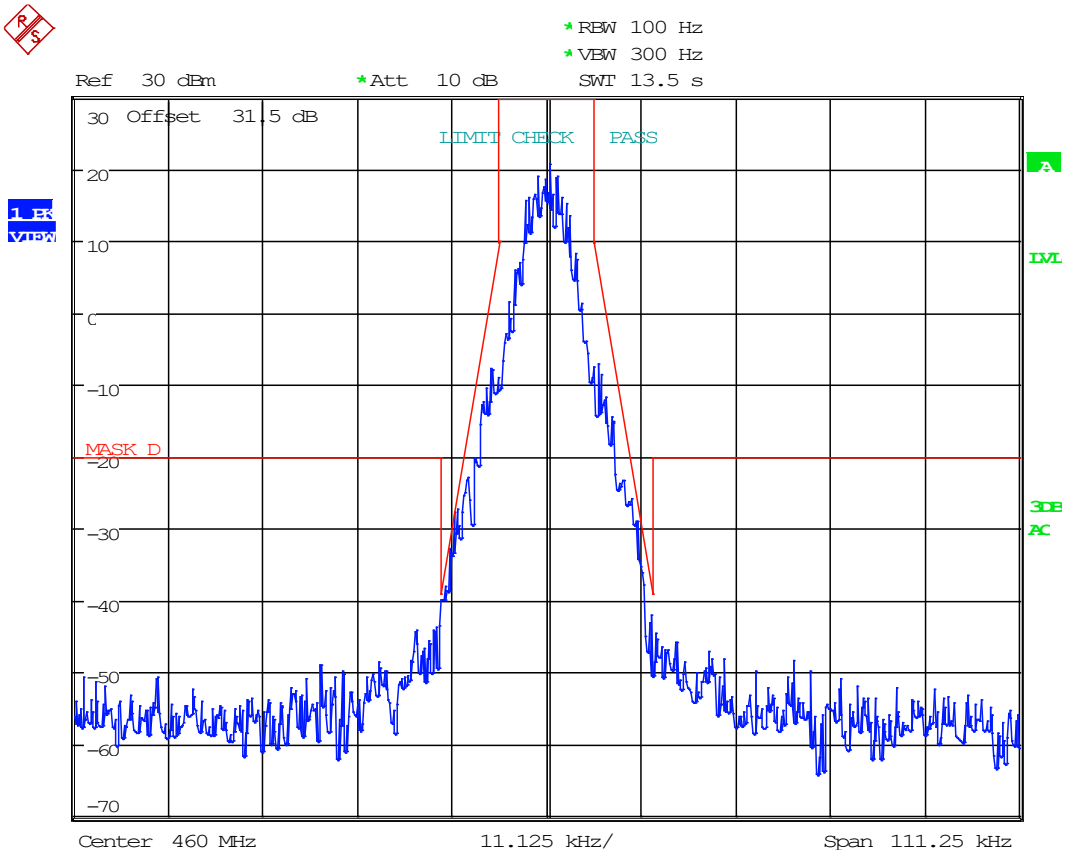
EMISSION MASKS

Test Engineer: TR
Test Date: AUG 7, 2020

Test Data: 460MHz, 3FSK, Mask D



Date: 2.SEP.2020 16:12:13

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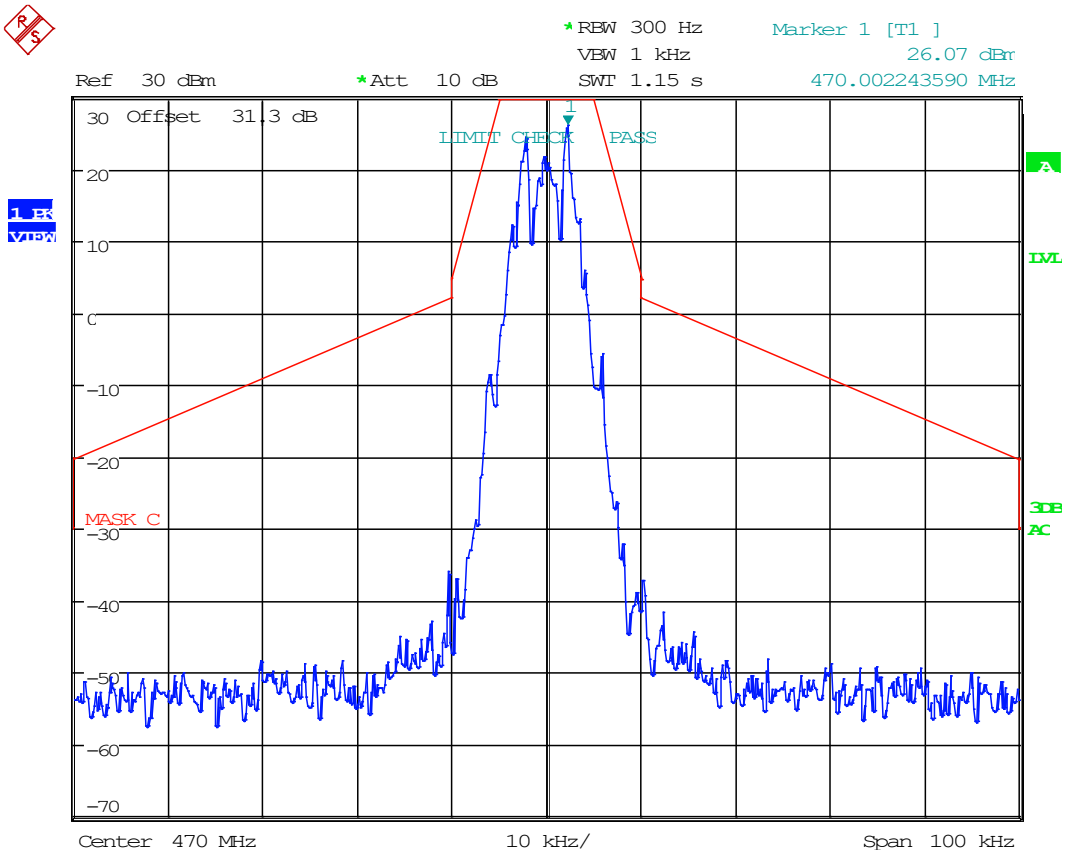
EMISSION MASKS

Test Engineer: TR
Test Date: AUG 7, 2020

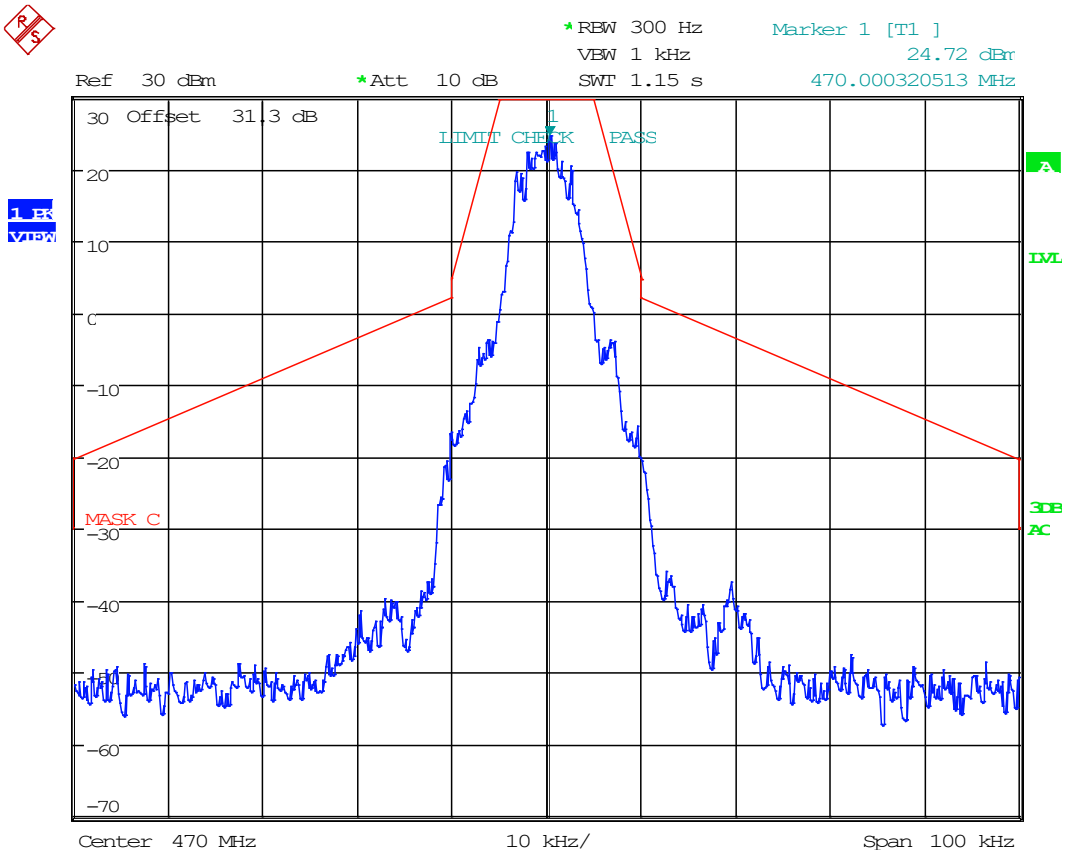
Test Data: 470MHz, 2FSK, Mask C



EMISSION MASKS

Test Engineer: TR
Test Date: AUG 7, 2020

Test Data: 470MHz, 3FSK, Mask C



Date: 12.AUG.2020 12:38:01

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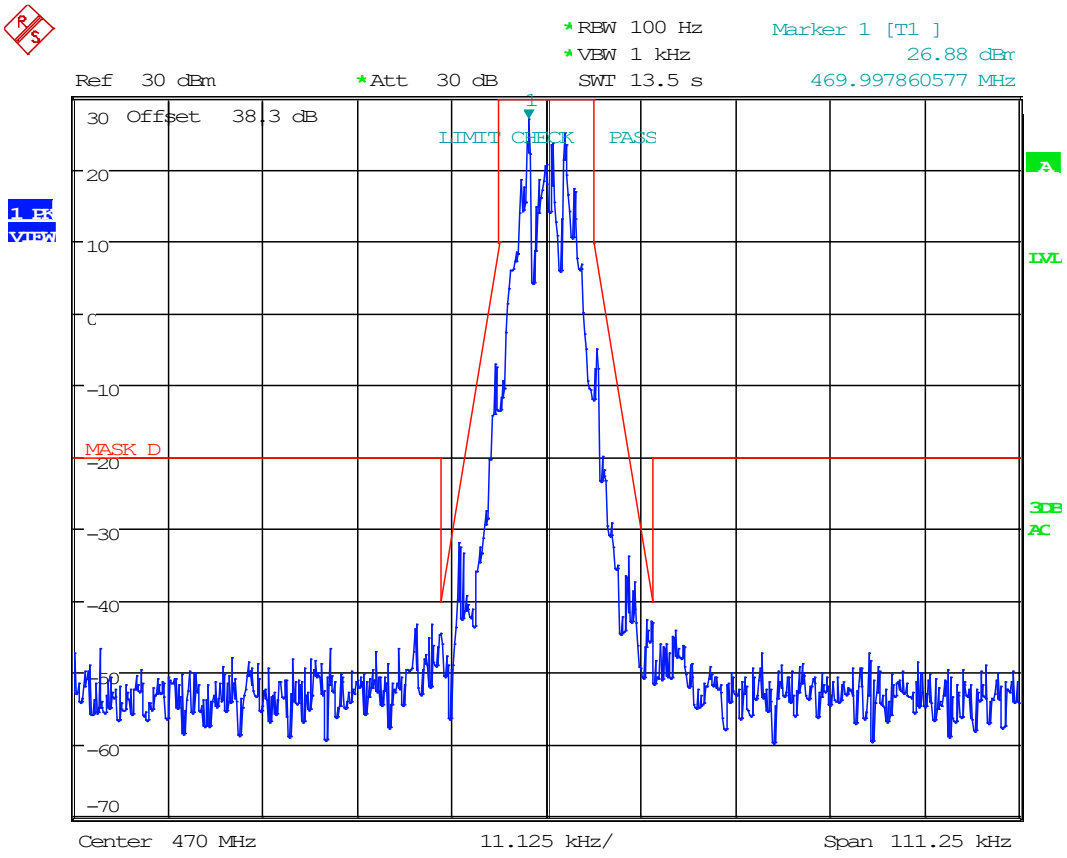
EMISSION MASKS

Test Engineer: TR
Test Date: AUG 7, 2020

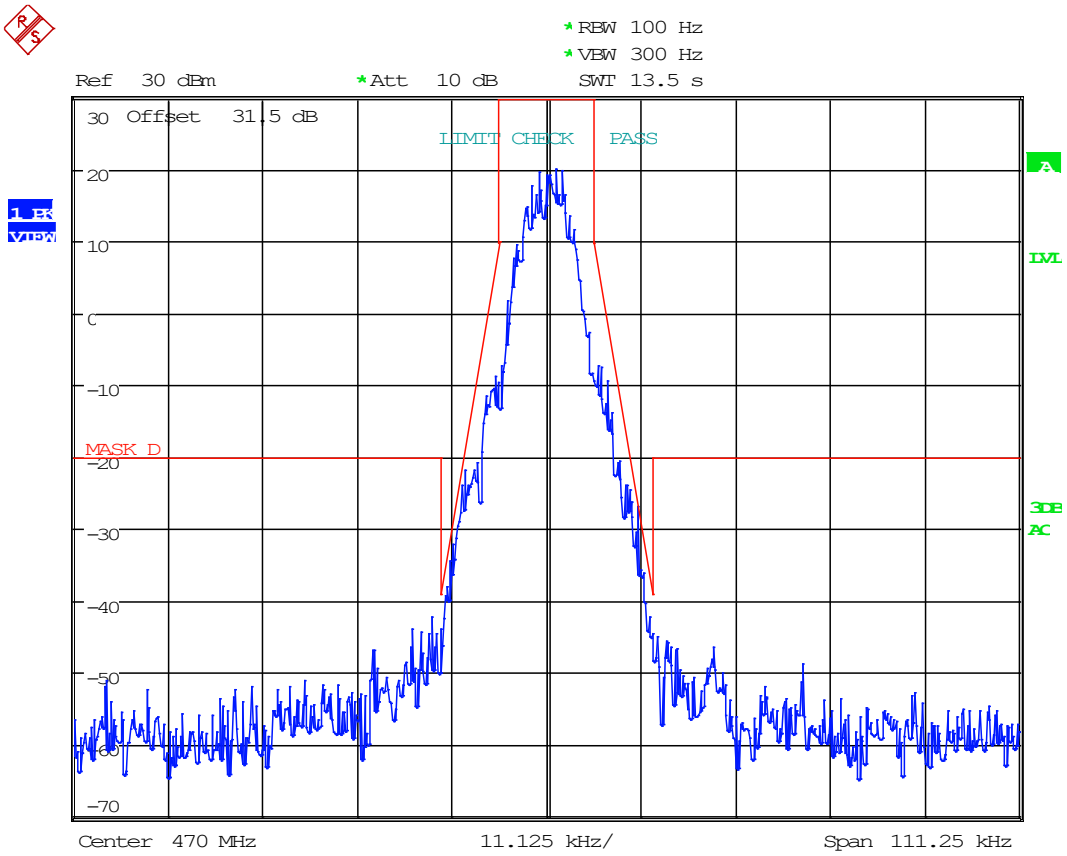
Test Data: 470MHz, 2FSK, Mask D



EMISSION MASKS

Test Engineer: TR
Test Date: AUG 7, 2020

Test Data: 470MHz, 3FSK, Mask D



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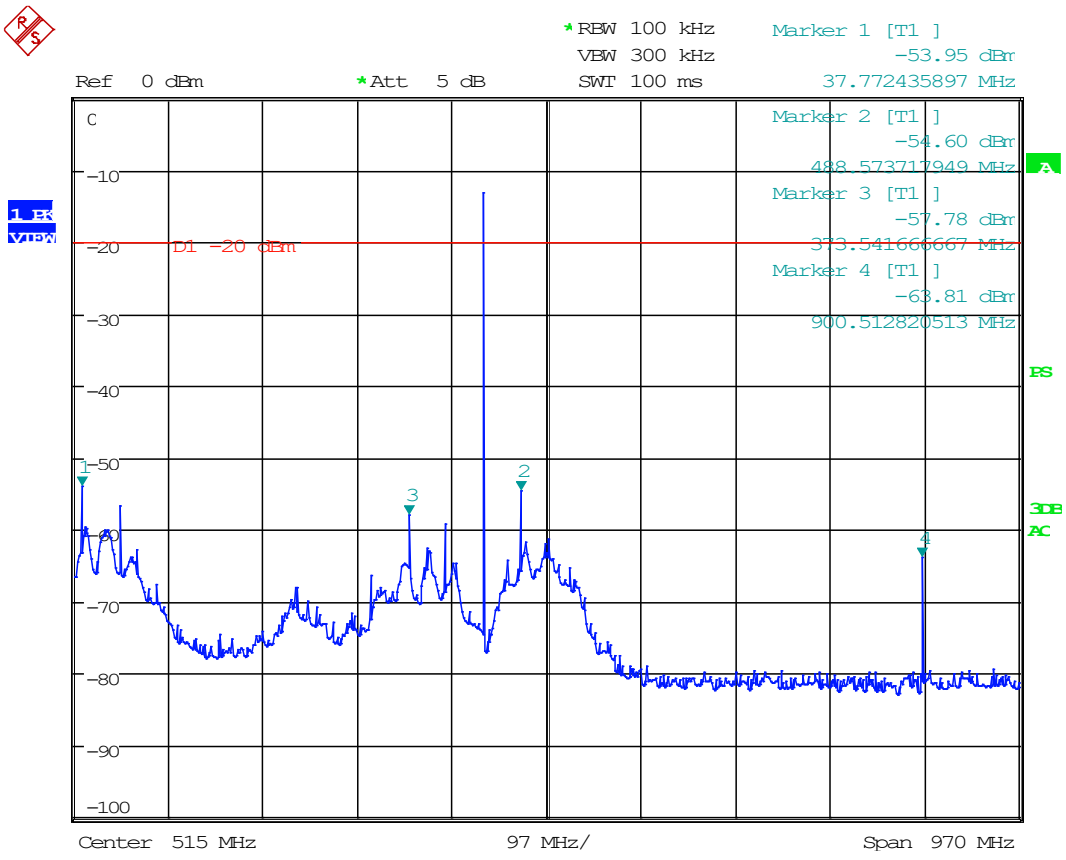
2.1051 CONDUCTED SPURIOUS EMISSIONS

Test Engineer: TR
Test Date: AUG 7, 2020

Test Data: 450MHz, 30dBm, Below 1 GHz

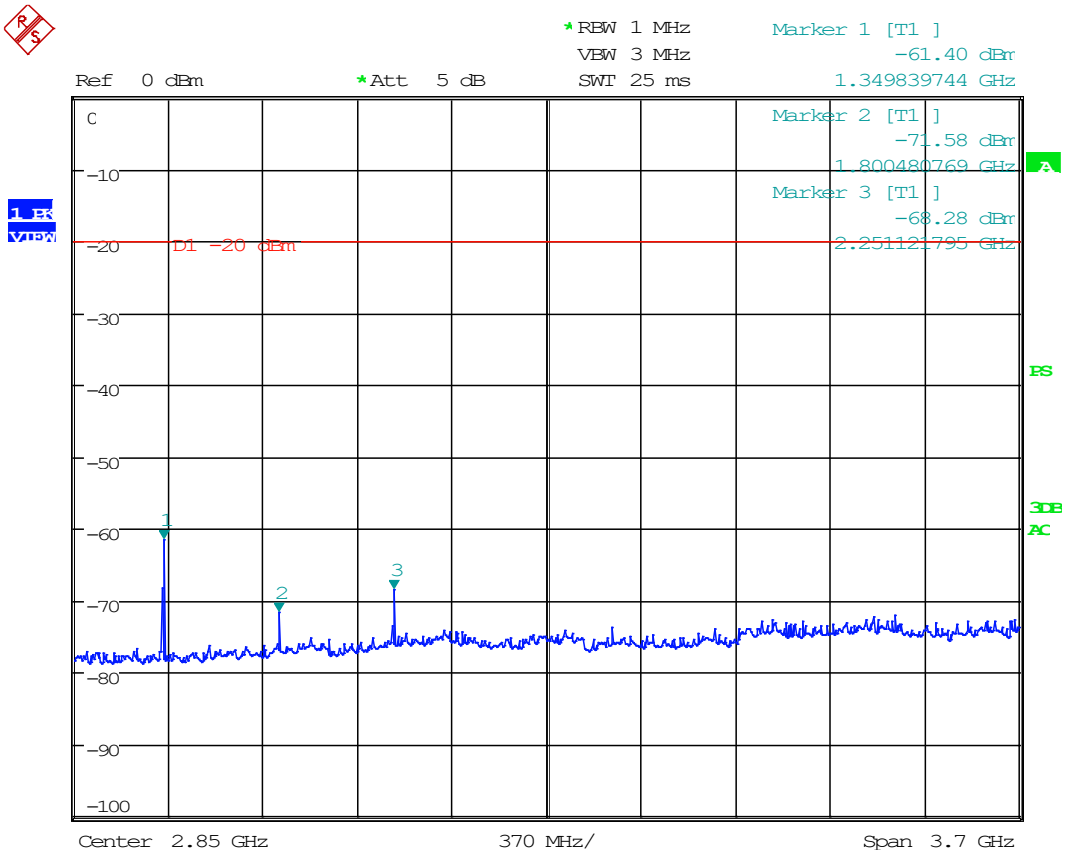


Date: 7.AUG.2020 16:45:00

CONDUCTED SPURIOUS EMISSIONS

Test Engineer: TR
Test Date: AUG 7, 2020

Test Data: 450MHz, 30dBm, Above 1 GHz



Date: 7.AUG.2020 16:42:43

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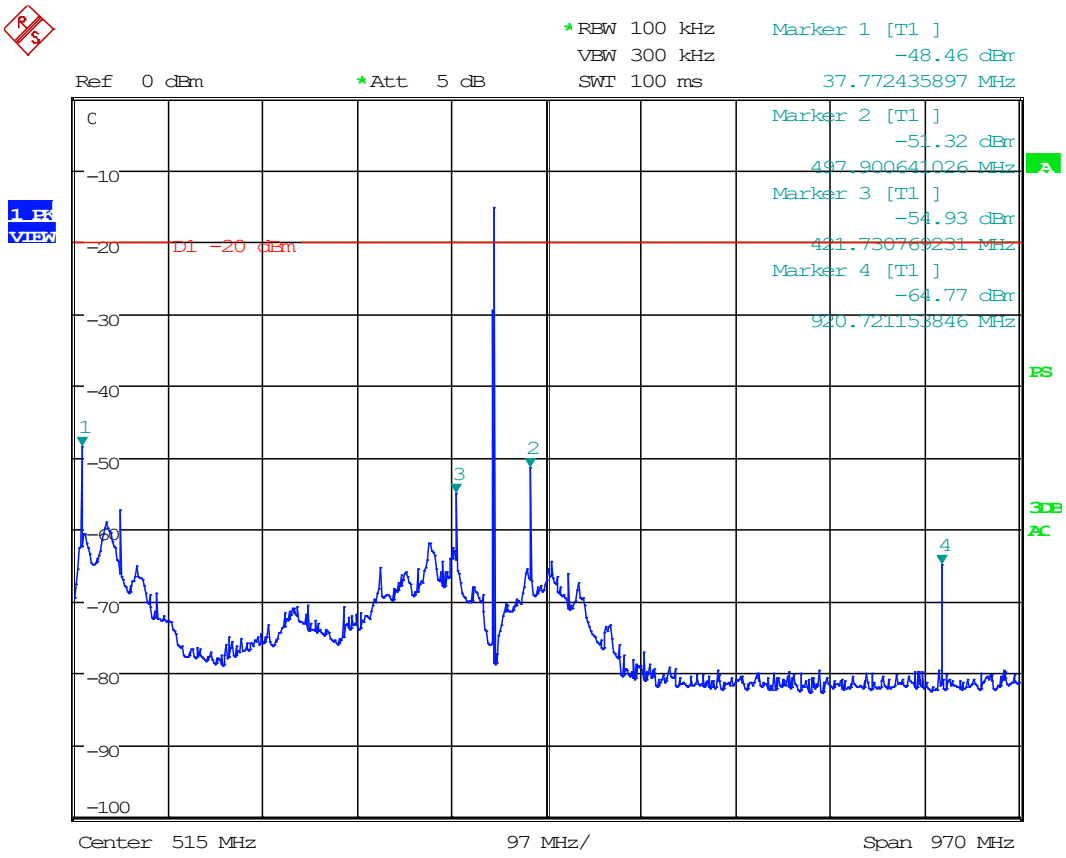
CONDUCTED SPURIOUS EMISSIONS

Test Engineer: TR
Test Date: AUG 7, 2020

Test Data: 460MHz, 30dBm, Below 1 GHz

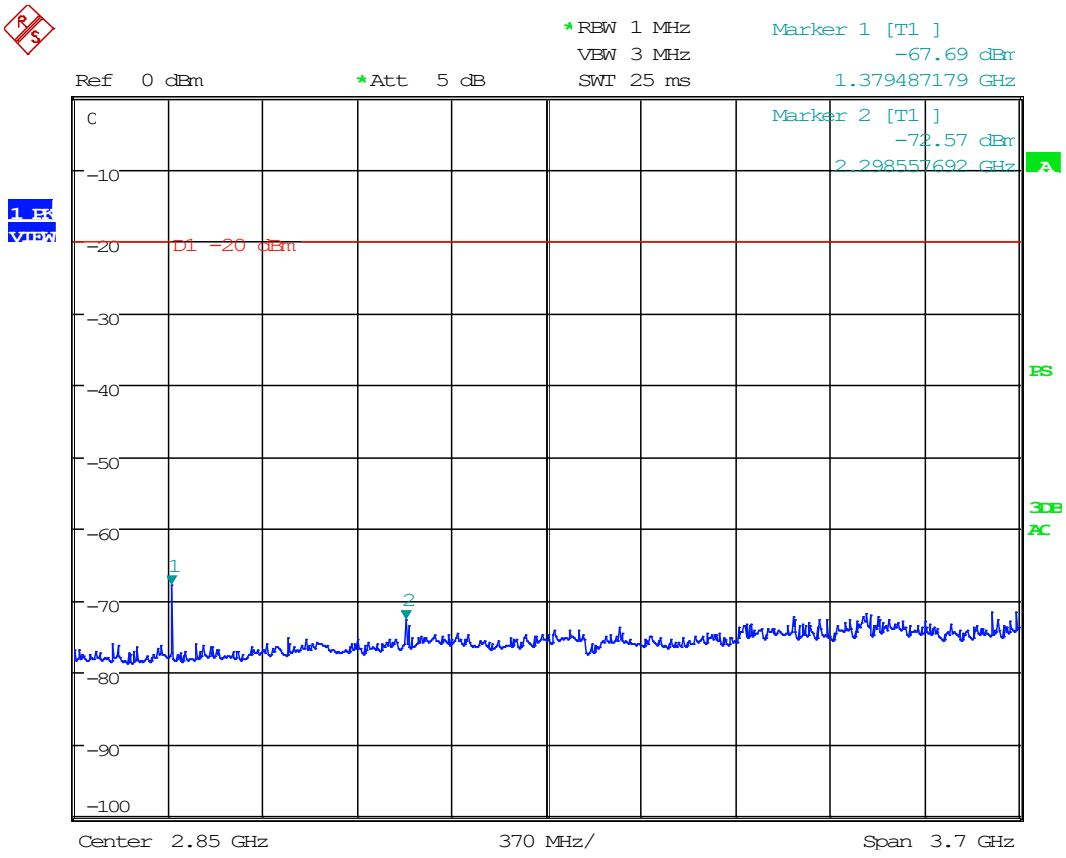


Date: 7.AUG.2020 16:39:29

CONDUCTED SPURIOUS EMISSIONS

Test Engineer: TR
Test Date: AUG 7, 2020

Test Data: 460MHz, 30dBm, Above 1 GHz



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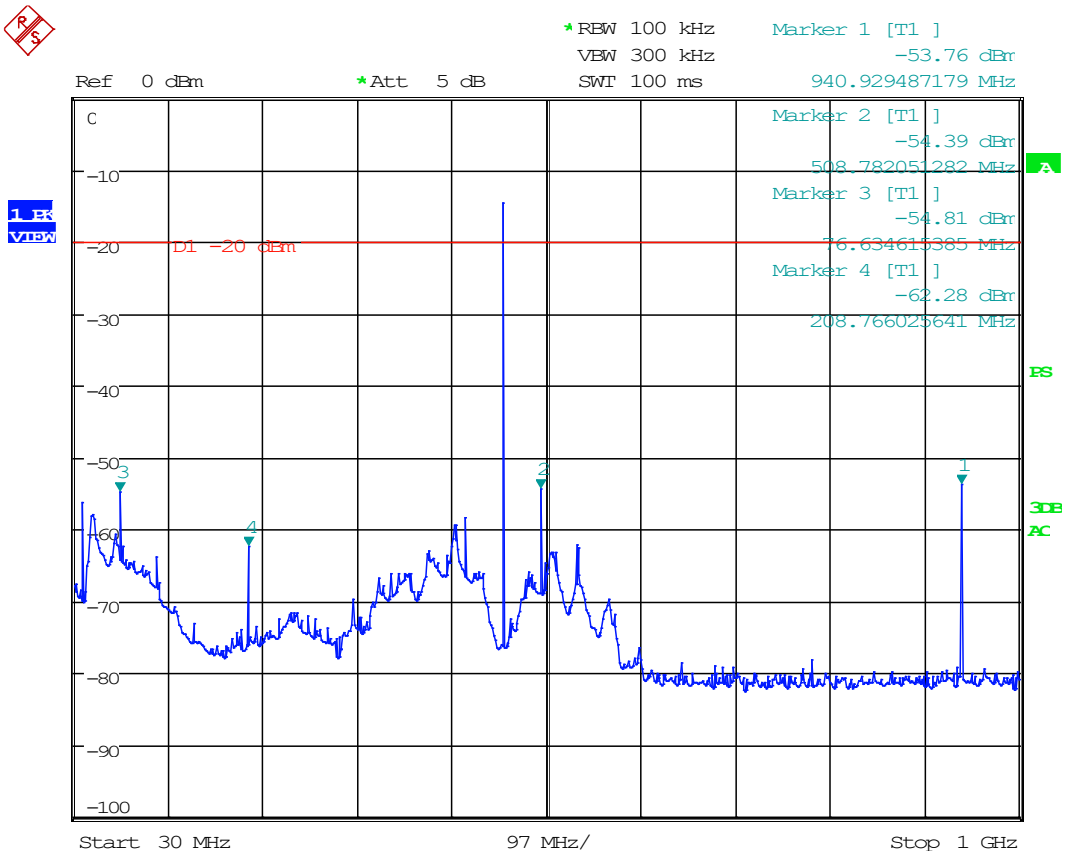
CONDUCTED SPURIOUS EMISSIONS

Test Engineer: TR
Test Date: AUG 7, 2020

Test Data: 470MHz, 30dBm, Below 1 GHz

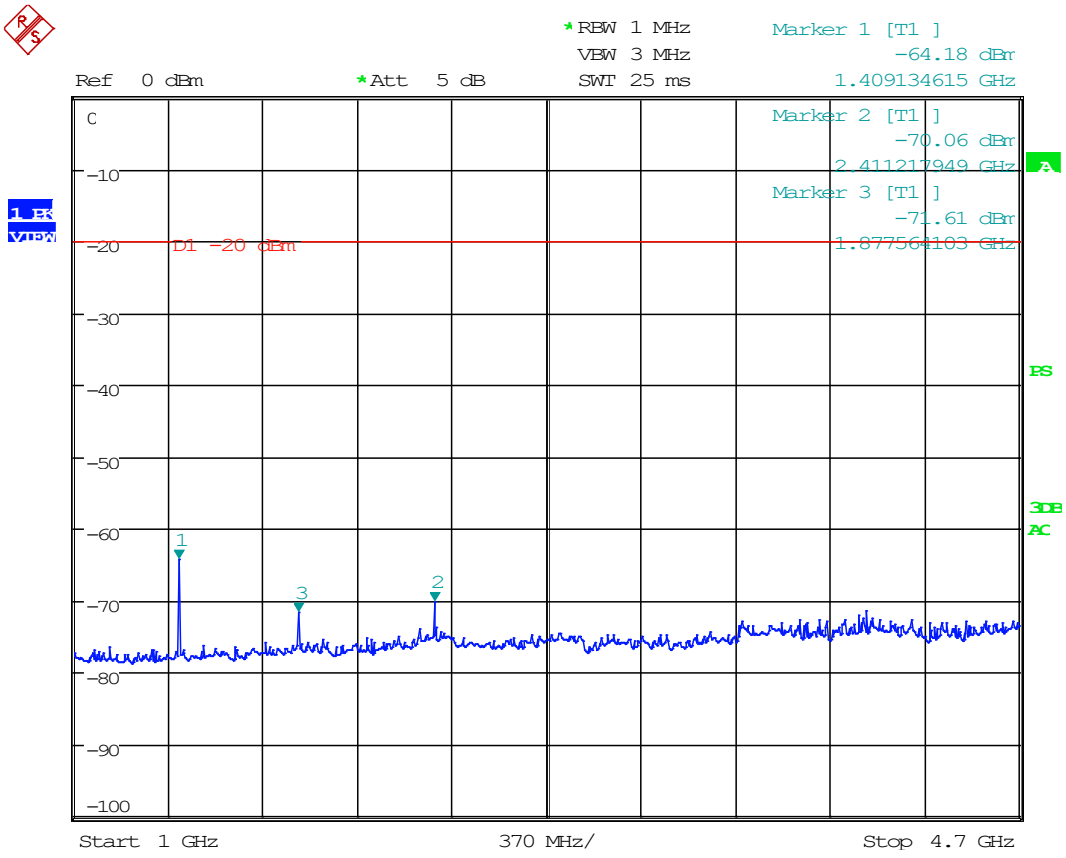


Date: 7.AUG.2020 16:31:10

CONDUCTED SPURIOUS EMISSIONS

Test Engineer: TR
Test Date: AUG 7, 2020

Test Data: 470MHz, 30dBm, Above 1 GHz



Date: 7.AUG.2020 16:35:02

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2.1053 FIELD STRENGTH OF SPURIOUS EMISSIONS

Test Engineer: TR
Test Date: AUG 7, 2020

Test Data: 450MHz, 30dBm, 2FSK

Tuned Frequency (MHz)	Antenna Polarity	Emission Frequency (MHz)	Meter Reading (dBm)	Detector	Coax Loss (dB)	Antenna Correction Factor (dB/m)	Distance (m)	Field Strength (dBµV/m)	ERP (dBm)	Spurious Limit (dBm)	Margin (dBm)
450.00	V	172.20	28.06	PK	1.53	14.96	3.00	44.55	-52.83	-20.00	32.83
450.00	V	172.20	33.86	PK	1.53	14.96	3.00	50.35	-47.03	-20.00	27.03
450.00	H	319.23	28.80	PK	2.09	14.01	3.00	44.90	-52.48	-20.00	32.48
450.00	V	417.94	24.43	PK	2.33	15.24	3.00	42.00	-55.38	-20.00	35.38
450.00	H	900.00	23.48	PK	3.54	21.70	3.00	48.72	-48.66	-20.00	28.66
450.00	V	900.00	26.32	PK	3.54	21.70	3.00	51.56	-45.82	-20.00	25.82

Tuned Frequency (MHz)	Antenna Polarity	Emission Frequency (MHz)	Meter Reading (dBm)	Detector	Coax Loss (dB)	Antenna Correction Factor (dB/m)	Distance (m)	Field Strength (dBµV/m)	ERP (dBm)	Spurious Limit (dBm)	Margin (dBm)
450.00	H	1350.00	14.64	PK	4.26	28.76	3.00	47.66	-49.72	-20.00	29.72
450.00	V	1350.00	15.43	PK	4.26	28.76	3.00	48.45	-48.93	-20.00	28.93
450.00	H	1800.00	15.33	PK	4.90	30.29	3.00	50.52	-46.86	-20.00	26.86
450.00	V	1800.00	15.79	PK	4.90	30.29	3.00	50.98	-46.40	-20.00	26.40
450.00	H	2250.00	11.08	PK	5.43	31.23	3.00	47.74	-49.64	-20.00	29.64
450.00	V	2250.00	15.33	PK	5.43	31.23	3.00	51.99	-45.39	-20.00	25.39
450.00	H	2700.00	13.94	PK	5.98	32.51	3.00	52.42	-44.95	-20.00	24.95
450.00	V	2700.00	14.55	PK	5.98	32.51	3.00	53.03	-44.34	-20.00	24.34
450.00	H	3150.00	9.68	PK	6.53	32.78	3.00	48.98	-48.40	-20.00	28.40
450.00	V	3150.00	11.90	PK	6.53	32.78	3.00	51.20	-46.18	-20.00	26.18
450.00	H	3600.00	10.92	PK	6.67	33.11	3.00	50.69	-46.68	-20.00	26.68
450.00	V	3600.00	9.80	PK	6.67	33.11	3.00	49.57	-47.80	-20.00	27.80
450.00	H	4050.00	9.68	PK	7.19	33.38	3.00	50.24	-47.13	-20.00	27.13
450.00	V	4050.00	14.40	PK	7.19	33.38	3.00	54.96	-42.41	-20.00	22.41
450.00	H	4500.00	9.94	PK	7.33	33.89	3.00	51.15	-46.22	-20.00	26.22
450.00	V	4500.00	11.30	PK	7.33	33.89	3.00	52.51	-44.86	-20.00	24.86

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FIELD STRENGTH OF SPURIOUS EMISSIONS

Test Engineer: TR
Test Date: AUG 7, 2020

Test Data: 450MHz, 30dBm, 3FSK

Tuned Frequency (MHz)	Antenna Polarity	Emission Frequency (MHz)	Meter Reading (dBm)	Detector	Coax Loss (dB)	Antenna Correction Factor (dB/m)	Distance (m)	Field Strength (dBµV/m)	ERP (dBm)	Spurious Limit (dBm)	Margin (dBm)
450.00	H	96.47	25.23	PK	1.15	10.90	3.00	37.29	-60.09	-20.00	40.09
450.00	V	122.90	25.58	PK	1.26	11.28	3.00	38.12	-59.26	-20.00	39.26
450.00	H	319.23	30.01	PK	2.09	14.01	3.00	46.11	-51.27	-20.00	31.27
450.00	V	417.94	32.32	PK	2.33	15.24	3.00	49.89	-47.49	-20.00	27.49
450.00	H	900.00	24.50	PK	3.54	21.70	3.00	49.74	-47.64	-20.00	27.64
450.00	V	900.00	25.82	PK	3.54	21.70	3.00	51.06	-46.32	-20.00	26.32

Tuned Frequency (MHz)	Antenna Polarity	Emission Frequency (MHz)	Meter Reading (dBm)	Detector	Coax Loss (dB)	Antenna Correction Factor (dB/m)	Distance (m)	Field Strength (dBµV/m)	ERP (dBm)	Spurious Limit (dBm)	Margin (dBm)
450.00	H	1350.00	23.04	PK	4.26	28.76	3.00	56.06	-41.32	-20.00	21.32
450.00	V	1350.00	15.08	PK	4.26	28.76	3.00	48.10	-49.28	-20.00	29.28
450.00	H	1800.00	14.68	PK	4.90	30.29	3.00	49.87	-47.51	-20.00	27.51
450.00	V	1800.00	15.17	PK	4.90	30.29	3.00	50.36	-47.02	-20.00	27.02
450.00	H	2250.00	14.75	PK	5.43	31.23	3.00	51.41	-45.97	-20.00	25.97
450.00	V	2250.00	13.34	PK	5.43	31.23	3.00	50.00	-47.38	-20.00	27.38
450.00	H	2700.00	16.50	PK	5.98	32.51	3.00	54.98	-42.39	-20.00	22.39
450.00	V	2700.00	14.57	PK	5.98	32.51	3.00	53.05	-44.32	-20.00	24.32
450.00	H	3150.00	12.36	PK	6.53	32.78	3.00	51.66	-45.72	-20.00	25.72
450.00	V	3150.00	12.14	PK	6.53	32.78	3.00	51.44	-45.94	-20.00	25.94
450.00	H	3600.00	12.68	PK	6.67	33.11	3.00	52.45	-44.92	-20.00	24.92
450.00	V	3600.00	10.07	PK	6.67	33.11	3.00	49.84	-47.53	-20.00	27.53
450.00	H	4050.00	9.48	PK	7.19	33.38	3.00	50.04	-47.33	-20.00	27.33
450.00	V	4050.00	10.16	PK	7.19	33.38	3.00	50.72	-46.65	-20.00	26.65
450.00	H	4500.00	9.36	PK	7.33	33.89	3.00	50.57	-46.80	-20.00	26.80
450.00	V	4500.00	10.44	PK	7.33	33.89	3.00	51.65	-45.72	-20.00	25.72

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FIELD STRENGTH OF SPURIOUS EMISSIONS

Test Engineer: TR
Test Date: AUG 7, 2020

Test Data: 460MHz, 30dBm, 2FSK

Tuned Frequency (MHz)	Antenna Polarity	Emission Frequency (MHz)	Meter Reading (dBm)	Detector	Coax Loss (dB)	Antenna Correction Factor (dB/m)	Distance (m)	Field Strength (dBµV/m)	ERP (dBm)	Spurious Limit (dBm)	Margin (dBm)
460.00	V	44.16	25.06	PK	0.75	12.68	3.00	38.49	-58.88	-20.00	38.88
450.00	H	145.24	24.52	PK	1.37	16.00	3.00	41.89	-55.49	-20.00	35.49
460.00	H	220.00	29.83	PK	1.70	10.30	3.00	41.83	-55.55	-20.00	35.55
460.00	V	318.72	29.03	PK	2.09	14.08	3.00	45.20	-52.18	-20.00	32.18
460.00	H	920.00	26.64	PK	3.58	22.30	3.00	52.52	-44.86	-20.00	24.86
460.00	V	920.00	29.18	PK	3.58	22.30	3.00	55.06	-42.32	-20.00	22.32

Tuned Frequency (MHz)	Antenna Polarity	Emission Frequency (MHz)	Meter Reading (dBm)	Detector	Coax Loss (dB)	Antenna Correction Factor (dB/m)	Distance (m)	Field Strength (dBµV/m)	ERP (dBm)	Spurious Limit (dBm)	Margin (dBm)
460.00	H	1380.00	19.05	PK	4.30	28.58	3.00	51.93	-45.44	-20.00	25.44
460.00	V	1380.00	19.11	PK	4.30	28.58	3.00	51.99	-45.38	-20.00	25.38
460.00	H	1840.00	13.74	PK	4.96	30.76	3.00	49.46	-47.91	-20.00	27.91
460.00	V	1840.00	11.98	PK	4.96	30.76	3.00	47.70	-49.67	-20.00	29.67
460.00	H	2300.00	15.01	PK	5.49	31.52	3.00	52.02	-45.36	-20.00	25.36
460.00	V	2300.00	16.04	PK	5.49	31.52	3.00	53.05	-44.33	-20.00	24.33
460.00	H	2760.00	12.30	PK	6.11	32.41	3.00	50.82	-46.55	-20.00	26.55
460.00	V	2760.00	11.94	PK	6.11	32.41	3.00	50.46	-46.91	-20.00	26.91
460.00	H	3220.00	12.23	PK	6.63	32.68	3.00	51.54	-45.84	-20.00	25.84
460.00	V	3220.00	10.92	PK	6.63	32.68	3.00	50.23	-47.15	-20.00	27.15
460.00	H	3680.00	10.23	PK	6.62	33.19	3.00	50.05	-47.33	-20.00	27.33
460.00	V	3680.00	9.66	PK	6.62	33.19	3.00	49.48	-47.90	-20.00	27.90
460.00	H	4140.00	10.36	PK	7.04	33.42	3.00	50.82	-46.56	-20.00	26.56
460.00	V	4140.00	9.55	PK	7.04	33.42	3.00	50.01	-47.37	-20.00	27.37
460.00	H	4600.00	10.91	PK	7.55	34.06	3.00	52.51	-44.86	-20.00	24.86
460.00	V	4600.00	10.51	PK	7.55	34.06	3.00	52.11	-45.26	-20.00	25.26

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FIELD STRENGTH OF SPURIOUS EMISSIONS

Test Engineer: TR
Test Date: AUG 7, 2020

Test Data: 460MHz, 30dBm, 3FSK

Tuned Frequency (MHz)	Antenna Polarity	Emission Frequency (MHz)	Meter Reading (dBm)	Detector	Coax Loss (dB)	Antenna Correction Factor (dB/m)	Distance (m)	Field Strength (dBµV/m)	ERP (dBm)	Spurious Limit (dBm)	Margin (dBm)
460.00	V	109.82	24.73	PK	1.20	10.20	3.00	36.13	-61.25	-20.00	41.25
460.00	V	134.62	26.10	PK	1.31	14.19	3.00	41.60	-55.78	-20.00	35.78
460.00	H	318.72	29.47	PK	2.09	14.08	3.00	45.64	-51.74	-20.00	31.74
460.00	V	417.43	28.99	PK	2.33	15.19	3.00	46.52	-50.86	-20.00	30.86
460.00	H	920.00	27.36	PK	3.58	22.30	3.00	53.24	-44.14	-20.00	24.14
460.00	V	920.00	26.70	PK	3.58	22.30	3.00	52.58	-44.80	-20.00	24.80

Tuned Frequency (MHz)	Antenna Polarity	Emission Frequency (MHz)	Meter Reading (dBm)	Detector	Coax Loss (dB)	Antenna Correction Factor (dB/m)	Distance (m)	Field Strength (dBµV/m)	ERP (dBm)	Spurious Limit (dBm)	Margin (dBm)
460.00	H	1380.00	20.55	PK	4.30	28.58	3.00	53.43	-43.94	-20.00	23.94
460.00	V	1380.00	12.12	PK	4.30	28.58	3.00	45.00	-52.37	-20.00	32.37
460.00	H	1840.00	12.38	PK	4.96	30.76	3.00	48.10	-49.27	-20.00	29.27
460.00	V	1840.00	11.77	PK	4.96	30.76	3.00	47.49	-49.88	-20.00	29.88
460.00	H	2300.00	15.35	PK	5.49	31.52	3.00	52.36	-45.02	-20.00	25.02
460.00	V	2300.00	17.42	PK	5.49	31.52	3.00	54.43	-42.95	-20.00	22.95
460.00	H	2760.00	13.11	PK	6.11	32.41	3.00	51.63	-45.74	-20.00	25.74
460.00	V	2760.00	12.16	PK	6.11	32.41	3.00	50.68	-46.69	-20.00	26.69
460.00	H	3220.00	12.76	PK	6.63	32.68	3.00	52.07	-45.31	-20.00	25.31
460.00	V	3220.00	11.45	PK	6.63	32.68	3.00	50.76	-46.62	-20.00	26.62
460.00	H	3680.00	10.56	PK	6.62	33.19	3.00	50.38	-47.00	-20.00	27.00
460.00	V	3680.00	10.87	PK	6.62	33.19	3.00	50.69	-46.69	-20.00	26.69
460.00	H	4140.00	10.83	PK	7.04	33.42	3.00	51.29	-46.09	-20.00	26.09
460.00	V	4140.00	9.82	PK	7.04	33.42	3.00	50.28	-47.10	-20.00	27.10
460.00	H	4600.00	10.21	PK	7.55	34.06	3.00	51.81	-45.56	-20.00	25.56
460.00	V	4600.00	9.84	PK	7.55	34.06	3.00	51.44	-45.93	-20.00	25.93

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FIELD STRENGTH OF SPURIOUS EMISSIONS

Test Engineer: TR
Test Date: AUG 7, 2020

Test Data: 470MHz, 30dBm, 2FSK

Tuned Frequency (MHz)	Antenna Polarity	Emission Frequency (MHz)	Meter Reading (dBm)	Detector	Coax Loss (dB)	Antenna Correction Factor (dB/m)	Distance (m)	Field Strength (dBµV/m)	ERP (dBm)	Spurious Limit (dBm)	Margin (dBm)
470.00	H	35.99	24.97	PK	0.67	13.40	3.00	39.04	-58.34	-20.00	38.34
470.00	V	77.40	24.65	PK	1.06	7.72	3.00	33.43	-63.95	-20.00	43.95
470.00	H	305.38	31.18	PK	2.08	14.44	3.00	47.70	-49.68	-20.00	29.68
470.00	V	319.49	28.15	PK	2.09	13.97	3.00	44.21	-53.17	-20.00	33.17
470.00	H	940.00	32.75	PK	3.59	22.60	3.00	58.94	-38.44	-20.00	18.44
470.00	V	940.00	37.80	PK	3.59	22.60	3.00	63.99	-33.39	-20.00	13.39

Tuned Frequency (MHz)	Antenna Polarity	Emission Frequency (MHz)	Meter Reading (dBm)	Detector	Coax Loss (dB)	Antenna Correction Factor (dB/m)	Distance (m)	Field Strength (dBµV/m)	ERP (dBm)	Spurious Limit (dBm)	Margin (dBm)
470.00	H	1410.00	15.33	PK	4.31	28.39	3.00	48.03	-49.35	-20.00	29.35
470.00	V	1410.00	20.98	PK	4.31	28.39	3.00	53.68	-43.70	-20.00	23.70
470.00	H	1880.00	11.06	PK	5.03	30.94	3.00	47.03	-50.34	-20.00	30.34
470.00	V	1880.00	12.30	PK	5.03	30.94	3.00	48.27	-49.10	-20.00	29.10
470.00	H	2350.00	15.12	PK	5.58	31.93	3.00	52.62	-44.76	-20.00	24.76
470.00	V	2350.00	17.02	PK	5.58	31.93	3.00	54.52	-42.86	-20.00	22.86
470.00	H	2820.00	13.00	PK	6.21	32.43	3.00	51.64	-45.74	-20.00	25.74
470.00	V	2820.00	10.10	PK	6.21	32.43	3.00	48.74	-48.64	-20.00	28.64
470.00	H	3290.00	10.97	PK	6.70	32.63	3.00	50.30	-47.08	-20.00	27.08
470.00	V	3290.00	11.30	PK	6.70	32.63	3.00	50.63	-46.75	-20.00	26.75
470.00	H	3760.00	10.76	PK	6.45	33.13	3.00	50.33	-47.04	-20.00	27.04
470.00	V	3760.00	10.98	PK	6.45	33.13	3.00	50.55	-46.82	-20.00	26.82
470.00	H	4230.00	10.55	PK	7.10	33.33	3.00	50.98	-46.40	-20.00	26.40
470.00	V	4230.00	12.67	PK	7.10	33.33	3.00	53.10	-44.28	-20.00	24.28
470.00	H	4700.00	10.56	PK	7.20	33.88	3.00	51.64	-45.74	-20.00	25.74
470.00	V	4700.00	11.01	PK	7.20	33.88	3.00	52.09	-45.29	-20.00	25.29

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FIELD STRENGTH OF SPURIOUS EMISSIONS

Test Engineer: TR
Test Date: AUG 7, 2020

Test Data: 470MHz, 30dBm, 3FSK

Tuned Frequency (MHz)	Antenna Polarity	Emission Frequency (MHz)	Meter Reading (dBm)	Detector	Coax Loss (dB)	Antenna Correction Factor (dB/m)	Distance (m)	Field Strength (dBµV/m)	ERP (dBm)	Spurious Limit (dBm)	Margin (dBm)
470.00	H	56.15	25.08	PK	0.88	8.96	3.00	34.91	-62.47	-20.00	42.47
470.00	V	122.26	25.90	PK	1.26	11.15	3.00	38.31	-59.07	-20.00	39.07
470.00	H	319.48	29.06	PK	2.09	13.97	3.00	45.12	-52.25	-20.00	32.25
470.00	V	368.20	26.29	PK	2.20	14.17	3.00	42.66	-54.71	-20.00	34.71
470.00	H	940.00	32.88	PK	3.59	22.60	3.00	59.07	-38.31	-20.00	18.31
470.00	V	940.00	33.98	PK	3.59	22.60	3.00	60.17	-37.21	-20.00	17.21

Tuned Frequency (MHz)	Antenna Polarity	Emission Frequency (MHz)	Meter Reading (dBm)	Detector	Coax Loss (dB)	Antenna Correction Factor (dB/m)	Distance (m)	Field Strength (dBµV/m)	ERP (dBm)	Spurious Limit (dBm)	Margin (dBm)
470.00	H	1410.00	15.82	PK	4.31	28.39	3.00	48.52	-48.86	-20.00	28.86
470.00	V	1410.00	21.70	PK	4.31	28.39	3.00	54.40	-42.98	-20.00	22.98
470.00	H	1880.00	11.03	PK	5.03	30.94	3.00	47.00	-50.37	-20.00	30.37
470.00	V	1880.00	10.08	PK	5.03	30.94	3.00	46.05	-51.32	-20.00	31.32
470.00	H	2350.00	11.32	PK	5.58	31.93	3.00	48.82	-48.56	-20.00	28.56
470.00	V	2350.00	16.77	PK	5.58	31.93	3.00	54.27	-43.11	-20.00	23.11
470.00	H	2820.00	11.56	PK	6.21	32.43	3.00	50.20	-47.18	-20.00	27.18
470.00	V	2820.00	12.23	PK	6.21	32.43	3.00	50.87	-46.51	-20.00	26.51
470.00	H	3290.00	11.45	PK	6.70	32.63	3.00	50.78	-46.60	-20.00	26.60
470.00	V	3290.00	12.14	PK	6.70	32.63	3.00	51.47	-45.91	-20.00	25.91
470.00	H	3760.00	10.89	PK	6.45	33.13	3.00	50.46	-46.91	-20.00	26.91
470.00	V	3760.00	10.88	PK	6.45	33.13	3.00	50.45	-46.92	-20.00	26.92
470.00	H	4230.00	10.56	PK	7.10	33.33	3.00	50.99	-46.39	-20.00	26.39
470.00	V	4230.00	10.79	PK	7.10	33.33	3.00	51.22	-46.16	-20.00	26.16
470.00	H	4700.00	10.37	PK	7.20	33.88	3.00	51.45	-45.93	-20.00	25.93
470.00	V	4700.00	10.37	PK	7.20	33.88	3.00	51.45	-45.93	-20.00	25.93

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2.1055 FREQUENCY STABILITY

90.213 FREQUENCY STABILITY

Test Engineer: TR
Test Date: AUG 7, 2020

Test Data: Test Table

FCC Part 90 Limit	5.0	ppm
FCC Part 90 Limit, as ppb	5000	ppb (Parts per Billion)
FCC Part 90 Limit, as %	0.00050	%
Strictest Combined Limit, as Hz	2249.999	Hz
Combined Lower Limit	449.997520	MHz
Combined Upper Limit	450.002020	MHz
Rated Supply Voltage	5.0	○ AC ◉ DC

Temperature / Voltage Variation

Temperature (°C)	Supplied Voltage (V)	Frequency (MHz)	Deviation (kHz)
-30	5.0	450.000040	-0.270
-20	5.0	450.000010	-0.240
-10	5.0	449.999900	-0.130
0	5.0	449.999650	0.120
+10	5.0	449.999680	0.090
+20 (reference)	5.0	449.999770	0.000
+20	4.3	449.999770	0.000
+20	5.8	449.999770	0.000
+30	5.0	449.999910	-0.140
+40	5.0	449.999910	-0.140
+50	5.0	449.999890	-0.120

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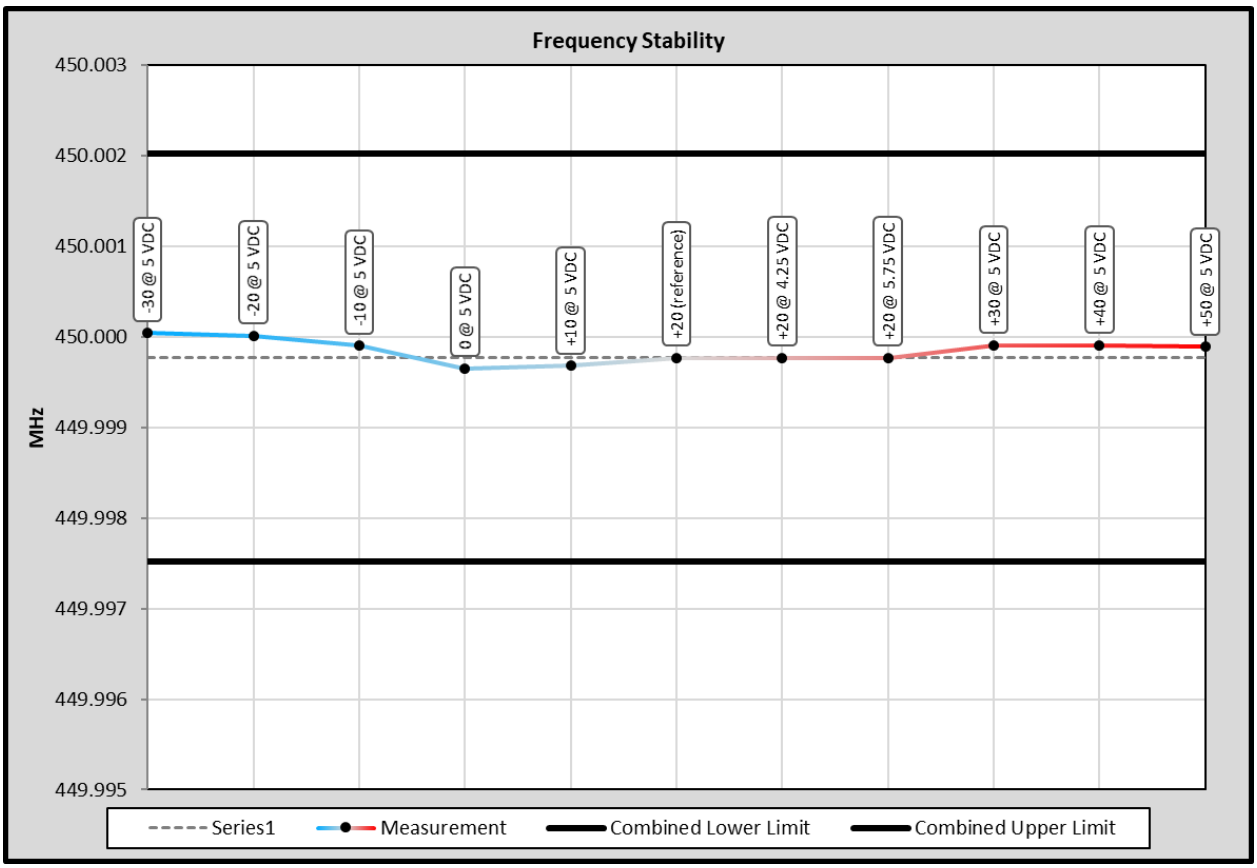
FREQUENCY STABILITY

Test Data: Test Plot



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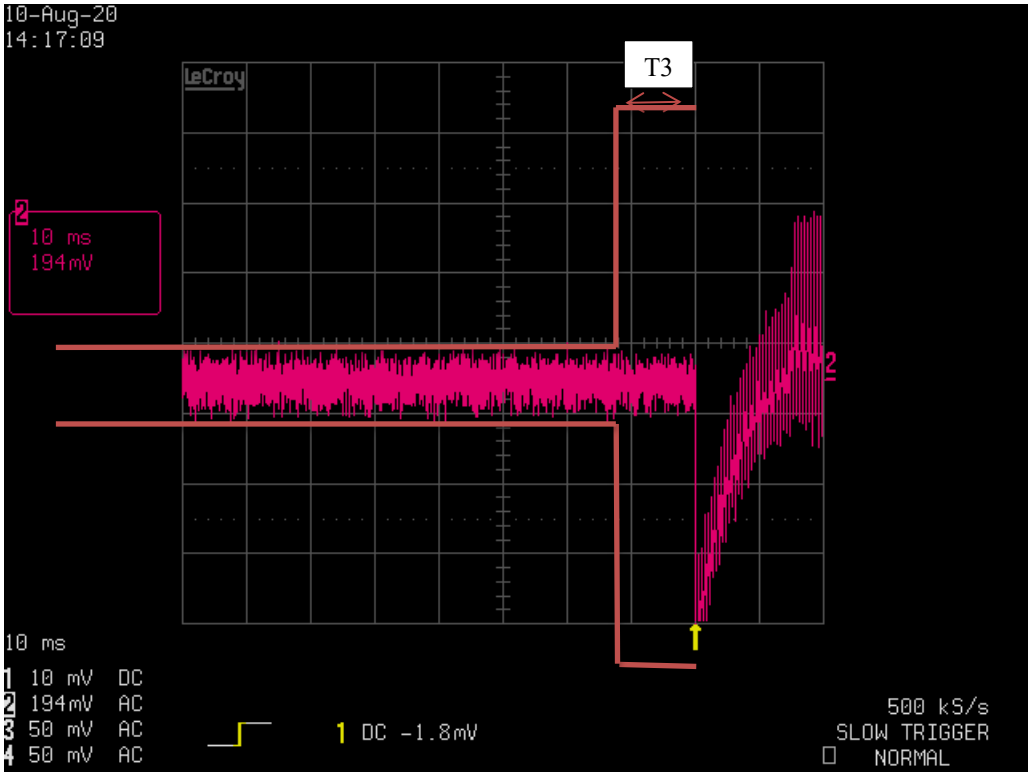
90.214 TRANSIENT FREQUENCY RESPONSE

Test Engineer: TR
Test Date: AUG 7, 2020



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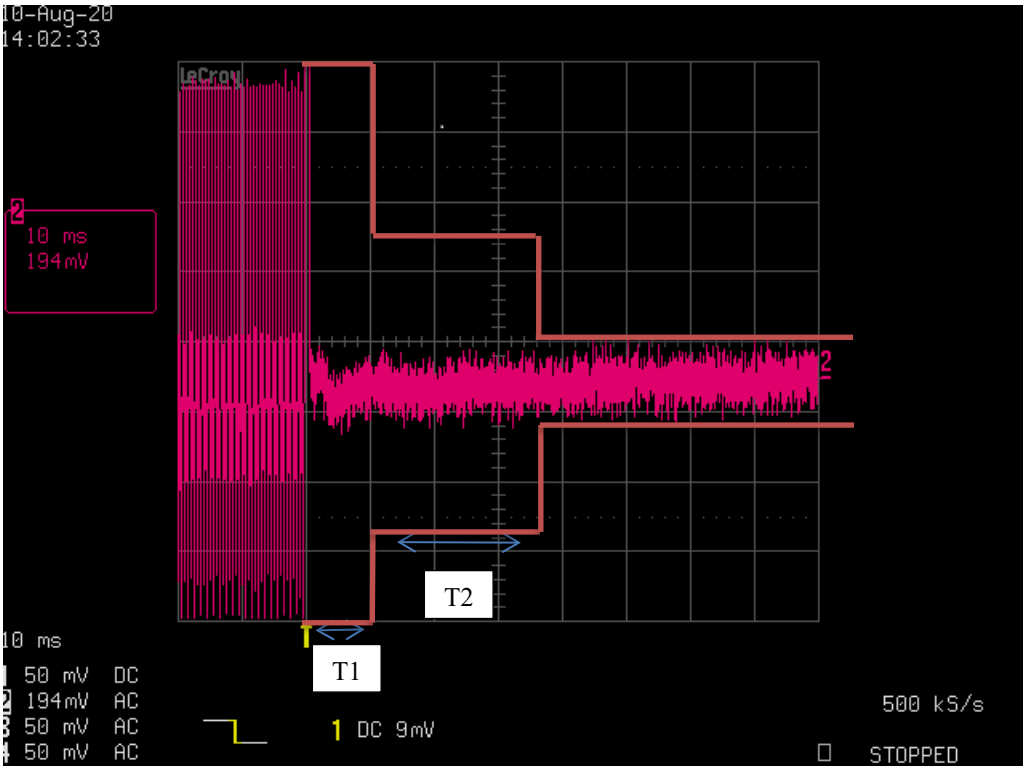

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END OF TEST REPORT

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