41039 Boyce Road
Fremont, CA. 94538
510-578-3500 Phone

Radio Test Report

FCC Part 90 and RSS-119
(USA: 435 MHz to 470 MHz)
(Canada: 450 MHz to 470 MHz)

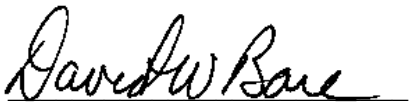
Model: LRS455C

IC CERTIFICATION #:	2329B-LRS455C
FCC ID:	KNYLRS455C
COMPANY:	FreeWave Technologies, Inc. 5395 Pearl Parkway, Suite 100 Boulder, CO 80301
TEST SITE(S):	NTS Labs LLC 41039 Boyce Road. Fremont, CA. 94538-2435
PROJECT NUMBER:	PR167383
REPORT DATE:	January 9, 2023
RE-ISSUED DATE:	September 25, 2023
FINAL TEST DATES:	December 28 and 29, 2022 and January 3 and 4, 2023
TOTAL NUMBER OF PAGES:	53

ACCREDITED
Testing Cert #0214.26

VALIDATING SIGNATORIES

PROGRAM MGR



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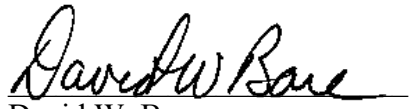

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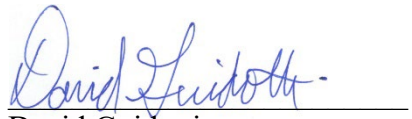

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REVISION HISTORY

Rev#	Date	Comments	Modified By
-	January 9, 2023	First release	
1	September 25, 2023	Updated to add interface impedance, spectrum efficiency and minimum data rate statements, remove highlights, correct the ERP calculations, separate FCC and ISED summary tables, change a reference to C63.10 to C63.26 and add additions annotations to the transient frequency behavior plots	David Bare
2	September 25, 2023	Corrected ERP values	David Bare

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SCOPE

Tests have been performed on the FreeWave Technologies, Inc. model LRS455C, pursuant to the relevant requirements of the following standard(s) in order to obtain device certification against the regulatory requirements of the Federal Communications Commission and Innovation Science and Economic Development Canada.

- Code of Federal Regulations (CFR) Title 47 Part 2
- RSS-Gen Issue 5, April 2018
- CFR 47 Part 90 (Private Land Mobile Radio Service) Subpart I
- RSS-119, Issue 12, May 2015 (Land Mobile and Fixed Equipment Operating in the Frequency Range 27.41-960 MHz)

Conducted and radiated emissions data has been collected, reduced, and analyzed within this report in accordance with measurement guidelines set forth in the following reference standards and as outlined in NTS Labs LLC test procedures:

ANSI C63.26:2015
FCC KDB 971168 Licensed Digital Transmitters

The intentional radiator above has been tested in a simulated typical installation to demonstrate compliance with the relevant Innovation Science and Economic Development Canada performance and procedural standards.

Every practical effort was made to perform an impartial test using appropriate test equipment of known calibration. All pertinent factors have been applied to reach the determination of compliance.

NTS Labs LLC is accredited by the A2LA, certificate number 0214.26, to perform the test(s) listed in this report, except where noted otherwise.

The test results recorded herein are based on a single type test of the FreeWave Technologies, Inc. model LRS455C and therefore apply only to the tested sample. The sample was selected and prepared by Ofer Fisher of FreeWave Technologies, Inc.

OBJECTIVE

The primary objective of the manufacturer is compliance with the regulations outlined in the previous section.

Prior to marketing in the USA, the device requires certification. Prior to marketing in Canada, Class I transmitters, receivers and transceivers require certification.

Certification is a procedure where the manufacturer submits test data and technical information to a certification body and receives a certificate or grant of equipment authorization upon successful completion of the certification body's review of the submitted documents. Once the equipment authorization has been obtained, the label indicating compliance must be attached to all identical units, which are subsequently manufactured.

Maintenance of compliance is the responsibility of the manufacturer. Any modification of the product which may result in increased emissions should be checked to ensure compliance has been maintained (i.e., printed circuit board layout changes, different line filter, different power supply, harnessing or I/O cable changes, etc.).

STATEMENT OF COMPLIANCE

The tested sample of FreeWave Technologies, Inc. model LRS455C complied with the requirements of the standards and frequency bands declared in the scope of this test report.

Maintenance of compliance is the responsibility of the manufacturer. Any modifications to the product should be assessed to determine their potential impact on the compliance status of the device with respect to the standards detailed in this test report.

DEVIATIONS FROM THE STANDARDS

No deviations were made from the published requirements listed in the scope of this report.

TEST RESULTS

FCC Part 90

		Description	Measured	Limit	Result
Transmitter Modulation, output power and other characteristics					
§2.1033 (c) (5) § 90.35		Frequency range(s)	450-470 MHz	450-470 MHz	Pass
§2.1033 (c) (6) §2.1033 (c) (7) § 2.1046 § 90.205		RF power output at the antenna terminals	20 to 32.9 dBm	57 dBm ERP	Pass
§2.1033 (c) (6) §2.1033 (c) (7) § 2.1046 § 90.205		EIRP / ERP	Max 10.0 W (40 dBm) ERP	57 dBm ERP	Pass
§2.1033 (c) (4) § 2.1047 § 90.210		Emission types	F1D	-	-
		Emission mask	Mask D	Within Mask	Pass
§ 2.1049 § 90.209		Occupied Bandwidth	2-level GFSK: 8.82kHz 4-level GFSK: 7.59kHz	11.25 kHz	Pass
§ 90.214		Transient Frequency Behavior	Within Limits	Refer to Standard	Pass
Transmitter spurious emissions					
§ 2.1051 § 2.1057		At the antenna terminals	-29.4 dBm @ 437.00 MHz (-9.4 dB)	-20 dBm	Pass
§ 2.1053 § 2.1057		Field strength	-51.1 dBm erp @ 900.86 MHz (-31.1 dB)	-20 dBm	Pass
Other details					
§ 2.1055 § 90.213		Frequency stability	1.5ppm	1.5 ppm	Pass
§ 2.1093		RF Exposure	See separate user manual and MPE calculation exhibits	-	Pass
§2.1033 (c) (8)		Final radio frequency amplifying circuit's dc voltages and currents for normal operation over the power range	5.5V, 1A	-	-
-	-	Antenna Gain	Maximum 9.25 dBi	-	-
Note 1 Pass/Fail criteria defined by standards listed above.					

RSS-119

		Description	Measured	Limit	Result
Transmitter Modulation, output power and other characteristics					
RSS-119		Frequency range(s)	450-470 MHz	450-470 MHz	Pass
RSS-119		RF power output at the antenna terminals	20 to 32.9 dBm	47.8 dBm ERP	Pass
RSS-119		EIRP / ERP	Max 10.0 W (40.0 dBm) ERP	47.8 dBm ERP	Pass
RSS-119		Emission types	F1D	-	-
		Emission mask	Mask D	Within Mask	Pass
RSS-GEN 6.7 RSS-119		Occupied Bandwidth	2-level GFSK: 8.82kHz 4-level GFSK: 7.59kHz	11.25 kHz	Pass
RSS-119		Transient Frequency Behavior	Within Limits	Refer to Standard	Pass
Transmitter spurious emissions					
RSS-119		At the antenna terminals	-29.4 dBm @ 437.00 MHz (-9.4 dB)	-20 dBm	Pass
RSS-119		Field strength	-51.1 dBm erp @ 900.86 MHz (-31.1 dB)	-20 dBm	Pass
Other details					
RSS-119		Frequency stability	1.5ppm	1.5 ppm	Pass
RSS-102		RF Exposure	See separate user manual and MPE calculation exhibits	-	Pass
-		Final radio frequency amplifying circuit's dc voltages and currents for normal operation over the power range	5.5V, 1A	-	-
-	-	Antenna Gain	Maximum 9.25 dBi	-	-
Note 2 Pass/Fail criteria defined by standards listed above.					

EXTREME CONDITIONS

Frequency stability is determined over extremes of temperature and voltage. The extremes of voltage were 85 to 115 percent of the nominal value.

The extremes of temperature were -30°C to +50°C as specified in FCC §2.1055(a)(1).

MEASUREMENT UNCERTAINTIES

ISO/IEC 17025 requires that an estimate of the measurement uncertainties associated with the emissions test results be included in the report. The measurement uncertainties given below are based on a 95% confidence level (based on a coverage factor (k=2) and were calculated in accordance with NAMAS document NIS 81 and M3003.

Measurement Type	Measurement Unit	Frequency Range	Expanded Uncertainty
RF frequency	Hz	25 to 7,000 MHz	0.7×10^{-7}
RF power, conducted	dBm	25 to 7,000 MHz	± 0.52 dB
Conducted emission of transmitter	dBm	25 to 40,000 MHz	± 0.7 dB
Conducted emission of receiver	dBm	25 to 40,000 MHz	± 0.7 dB
Radiated emission (substitution method)	dBm	25 to 40,000 MHz	± 2.5 dB
Radiated emission (field strength)	dBµV/m	25 to 1,000 MHz 1 to 40 GHz	± 3.6 dB ± 6.0 dB

EQUIPMENT UNDER TEST (EUT) DETAILS

GENERAL

The FreeWave Technologies, Inc. model LRS455C is a licensed radio module which is designed to operate in the 435-470 MHz bands. Since the host unit could be placed in any position during operation, the EUT was treated as tabletop equipment during testing to simulate the end-user environment. The electrical rating of the EUT is 6-27VDC, 0.8 Amps, nominally 12VDC.

The sample was received on December 19, 2022 and tested on December 28 and 29, 2022 and January 3 and 4, 2023. The EUT consisted of the following component(s):

Company	Model	Description	Serial Number	FCC ID
FreeWave Technologies, Inc.	LRS455C	Licensed radio module	463-1711	KNYLRS455C

OTHER EUT DETAILS

The EUT has a 50 ohm output impedance for connection of an antenna. The EUT uses 12.5 kHz channels using either 2-level GFSK or 4-level GFSK modulation. The minimum data rate is 9600 bps which meets the spectrum efficiency requirement of minimum 4800 bps per 6.25 kHz channel bandwidth.

ENCLOSURE

The EUT has no enclosure. It is designed to be installed within the enclosure of a host computer. It measures approximately 6 cm wide by 13 cm long.

MODIFICATIONS

No modifications were made to the EUT during the time the product was at NTS Labs LLC.

SUPPORT EQUIPMENT

The following equipment was used as support equipment for testing:

Company	Model	Description	Serial Number	FCC ID
Shenzhen Mingxin	MX15W-1200800UX	AC/DC Adapter	-	-

The following equipment was used as remote support equipment for emissions testing:

Company	Model	Description	Serial Number	FCC ID
HP	6530B	Laptop	CNU006LPL	-

EUT INTERFACE PORTS

The I/O cabling configuration during testing was as follows:

Port		Cable(s)		
From	To	Description	Shielded/Unshielded	Length(m)
10-pin connector	Serial DB9, Power, Reset Button	Multiwire	Unshielded	1.2
Serial DB9	Laptop USB	Multiwire	Shielded	1.8
Power	AC/DC Adapter	two wire	Unshielded	1.4
Antenna	Termination	Coax	Shielded	0.1

EUT OPERATION

During emissions testing the EUT was set to transmit a continuous modulated signal at maximum power on the selected frequency.

TESTING

GENERAL INFORMATION

Antenna port measurements were taken at the NTS Labs LLC test site located at 41039 Boyce Road, Fremont, CA 94538-2435.

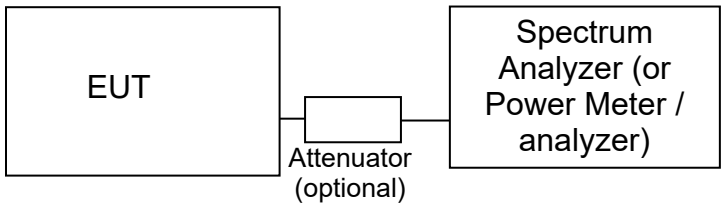
Final test measurements were taken at the test sites listed below. Pursuant to section 2.948 of the FCC's Rules and section 6.2 of RSS-GEN, NTS Labs LLC has been recognized as an accredited test laboratory by the Commission and Innovation, Science and Economic Development Canada. A description of the facilities employed for testing is maintained by NTS Labs LLC.

Site	Company / Registration Numbers		Location
	FCC	Canada	
Chamber 3	US1031	2845B (Wireless test lab #US0027)	41039 Boyce Road Fremont, CA 94538-2435
Chamber 4			
Chamber 5			
Chamber 7			

ANSI C63.4 recommends that ambient noise at the test site be at least 6 dB below the allowable limits. Ambient levels are below this requirement. The test site(s) contain separate areas for radiated and conducted emissions testing. Results from testing performed in this chamber have been correlated with results from an open area test site. Considerable engineering effort has been expended to ensure that the facilities conform to all pertinent requirements of ANSI C63.4.

RF PORT MEASUREMENT PROCEDURES

Conducted measurements are performed with the EUT's rf input/output connected to the input of a spectrum analyzer, power meter or modulation analyzer. When required an attenuator, filter and/or dc block is placed between the EUT and the spectrum analyzer to avoid overloading the front end of the measurement device. Measurements are corrected for the insertion loss of the attenuators and cables inserted between the rf port of the EUT and the measurement equipment.



Test Configuration for Antenna Port Measurements

For devices with an integral antenna the output power and spurious emissions are measured as a field strength at a test distance of (typically) 3m and then converted to an eirp using a substitution measurement (refer to RADIATED EMISSIONS MEASUREMENTS). All other measurements are made as detailed below but with the test equipment connected to a measurement antenna directed at the EUT.

OUTPUT POWER

Output power is measured using a power meter and an average sensor head, a spectrum analyzer or a power meter and peak power sensor head as required by the relevant rule part(s). Where necessary measurements are gated to ensure power is only measured over periods that the device is transmitting.

Power measurements made directly on the rf power port are, when appropriate, converted to an EIRP by adding the gain of the highest gain antenna that can be used with the device under test, as specified by the manufacturer.

BANDWIDTH MEASUREMENTS

The 6dB, 20dB and/or 26dB signal bandwidth is measured in using the bandwidths recommended by ANSI C63.4. When required, the 99% bandwidth is measured using the methods detailed in RSS-GEN. The measurement bandwidth is set to be at least 1% of the instrument's frequency span.

CONDUCTED SPURIOUS EMISSIONS

Initial scans are made using a peak detector (RBW=VBW) and using scan rates to ensure that the EUT transmits before the sweep moves out of each resolution bandwidth (for transmit mode measurements). Where the limits are expressed as an average power the spectrum analyzer is tunes to that frequency with a narrow span (wide enough to capture the emission and its sidebands) and the resolution and video bandwidths are adjusted as required by the reference measurement standards. For transmitter measurements the appropriate detector (average, peak, normal ,sample, quasi-peak) is used when making measurements for licensed devices. For receiver conducted spurious measurements the detector is set to peak.

TRANSMITTER MASK MEASUREMENTS

The transmitter mask measurements are made using resolution bandwidths as specified in the pertinent rule part(s). Where narrower bandwidths are used the measurement is corrected to account for the reduced bandwidth by either using the adjacent channel power function of the spectrum analyzer to sum the power across the required measurement bandwidth. The frequency span of the analyzer is set to ensure the fundamental signal and all significant sidebands are displayed.

The top of the mask may be set by the total output power of the signal, the power of the unmodulated signal or the peak value of the signal in the reference bandwidth being used for the mask measurement.

FREQUENCY STABILITY

The EUT is placed inside a temperature chamber with all support and test equipment located outside of the chamber. The temperature is varied across the specified frequency range in 10 degree increments with frequency measurements made at each temperature step. The EUT is allowed enough time to stabilize at each temperature variation.

The spectrum analyzer is configured to give a 5- or 6-digit display for the marker-frequency function. The spectrum analyzer's built-in frequency counter is used to measure the maximum deviation of the fundamental frequency at each temperature. Where possible the device is set to transmit an unmodulated signal. Where this is not possible the frequency drift is determined by finding a stable point on the signal (e.g. the null at the centre of an OFDM signal) or by calculating a centre frequency based on the upper and lower XdB points (where X is typically 6dB or 10dB) on the signal's skirts.

TRANSIENT FREQUENCY BEHAVIOR:

The TIA/EIA 603 procedure is used to determine compliance with transient frequency timing requirements as the radio is keyed on and off.

The EUTs rf output is connected via a combiner/splitter to the test receiver/spectrum analyzer and to a diode detector. The test receiver or spectrum analyzer video output is connected to an oscilloscope, which is triggered by the output from the diode detector.

Plots showing Ton, T1, and T2 are made when turning on the transmitter and showing T3 when turning off the transmitter.

RADIATED EMISSIONS MEASUREMENTS

Transmitter radiated spurious emissions are initially measured as a field strength. The eirp or erp limit as specified in the relevant rule part(s) is converted to a field strength at the test distance and the emissions from the EUT are then compared to that limit. Emissions within 20dB of this limit are the subjected to a substitution measurement.

All radiated emissions measurements are performed in two phases. A preliminary scan of emissions is conducted in either an anechoic chamber or on an OATS during which all significant EUT frequencies are identified with the system in a nominal configuration. At least two scans are performed across the complete frequency range of interest and at each operating frequency identified in the reference standard. One or more of these is with the antenna polarized vertically while the one or more of these is with the antenna polarized horizontally. Initial scans are made using a peak detector (RBW=VBW) and using scan rates to ensure that the EUT transmits before the sweep moves out of each resolution bandwidth (for transmit mode).

During the preliminary scans, the EUT is rotated through 360°, the antenna height is varied and cable positions are varied to determine the highest emission relative to the limit. This was repeated with the EUT oriented in the 2 other orthogonal orientations. For transmitter spurious emissions, where the limit is expressed as an effective radiated power, the eirp or erp is converted to a field strength limit.

Final measurements are made in a semi-anechoic chamber at the significant frequencies observed during the preliminary scan(s) using the same process of rotating the EUT and raising/lowering the measurement antenna to find the highest level of the emission. The field strength is recorded and, for receiver spurious emissions, compared to the field strength limit. For the final measurement the appropriate detectors (average, peak, normal, sample, quasi-peak) are used. For receiver measurements below 1GHz the detector is a Quasi-Peak detector, above 1GHz a peak detector is used and the peak value (RB=VB=1MHz) and average value (RB=1MHz, VB=10Hz) are recorded.

For transmitter spurious emissions, the radiated power of all emissions within 20dB of the calculated field strength limit are determined using a substitution measurement. The substitution measurement is made by replacing the EUT with an antenna of known gain (typically a dipole antenna or a double-ridged horn antenna), connected to a signal source. The output power of the signal generator is adjusted until the maximum field strength from the substitution antenna is similar to the field strength recorded from the EUT. The erp of the EUT is then calculated.

INSTRUMENTATION

An EMI receiver as specified in CISPR 16-1-1 is used for radiated emissions measurements. The receivers used can measure over the frequency range of 9 kHz up to 7000 MHz. These receivers allow both ease of measurement and high accuracy to be achieved. The receivers have Peak, Average, and CISPR (Quasi-peak) detectors built into their design so no external adapters are necessary.

For measurements above the frequency range of the receivers and for all conducted measurements a spectrum analyzer is utilized because it provides visibility of the entire spectrum along with the precision and versatility required to support engineering analysis.

Measurement bandwidths for the test instruments are set in accordance with the requirements of the standards referenced in this document.

Software control is used to correct the measurements for transducer factors (e.g. antenna) and the insertion loss of cables, attenuators and other series elements to obtain the final measurement value. This provides faster, more accurate readings by performing the conversions described under Sample Calculations within the Test Procedures section of this report. Results are exported in a graphic and/or tabular format, as appropriate.

FILTERS/ATTENUATORS

External filters and precision attenuators are often connected between the EUT antenna port or receiving antenna and the test receiver. This eliminates saturation effects and non-linear operation due to high amplitude transient events.

ANTENNAS

A combination of biconical, log periodic or bi-log antennas are used to cover the range from 30 MHz to 1000 MHz. Broadband antennas or tuned dipole antennas are used over the entire 25 to 1000 MHz frequency range as the reference antenna for substitution measurements.

Above 1000 MHz, a dual-ridge guide horn antenna or octave horn antenna are used as reference and measurement antennas.

The antenna calibration factors are included in site factors that are programmed into the test receivers and instrument control software when measuring the radiated field strength.

ANTENNA MAST AND EQUIPMENT TURNTABLE

The antennas used to measure the radiated electric field strength are mounted on a non-conductive antenna mast equipped with a motor-drive to vary the antenna height.

Table mounted devices are placed on a non-conductive table at a height of 80 centimeters above the floor. Floor mounted equipment is placed on the ground plane if the device is normally used on a conductive floor or separated from the ground plane by insulating material from 3 to 12 mm if the device is normally used on a non-conductive floor. The EUT is positioned on a motorized turntable to allow it to be rotated during testing to determine the angel with the highest level of emissions.

SAMPLE CALCULATIONS

SAMPLE CALCULATIONS - CONDUCTED SPURIOUS EMISSIONS

Measurements are compared directly to the conducted emissions specification limit (decibel form). The calculation is as follows:

$$R_r - S = M$$

where:

R_r = Measured value in dBm
S = Specification Limit in dBm
M = Margin to Specification in +/- dB

SAMPLE CALCULATIONS –RADIATED FIELD STRENGTH

Measurements of radiated field strength are compared directly to the specification limit (decibel form). The control software corrects for cable loss, preamplifier gain, and antenna factor. The calculations are in the reverse direction of the actual signal flow, thus cable loss is added and the amplifier gain is subtracted. The Antenna Factor converts the voltage at the antenna coaxial connector to the field strength at the antenna elements.

A distance factor is sued when measurements are made at a test distance that is different to the specified limit distance by using the following formula:

$$F_d = 20*LOG_{10} (D_m/D_s)$$

where:

F_d = Distance Factor in dB

D_m = Measurement Distance in meters

D_s = Specification Distance in meters

For electric field measurements below 30MHz the extrapolation factor is either determined by making measurements at multiple distances or a theoretical value is calculated using the formula:

$$F_d = 40*LOG_{10} (D_m/D_s)$$

The margin of a given emission peak relative to the limit is calculated as follows:

$$R_c = R_r + F_d$$

and

$$M = R_c - L_s$$

where:

R_r = Receiver Reading in dBuV/m

F_d = Distance Factor in dB

R_c = Corrected Reading in dBuV/m

L_s = Specification Limit in dBuV/m

M = Margin in dB Relative to Spec

SAMPLE CALCULATIONS –RADIATED POWER

The erp/eirp limits for transmitter spurious measurements are converted to a field strength in free space using the following formula:

$$E = \frac{\sqrt{30\ P\ G}}{d}$$

where:

E = Field Strength in V/m
P = Power in Watts
G = Gain of isotropic antenna (numeric gain) = 1
D = measurement distance in meters

The field strength limit is then converted to decibel form (dBuV/m) and the margin of a given emission peak relative to the limit is calculated (refer to SAMPLE CALCULATIONS –RADIATED FIELD STRENGTH).

When substitution measurements are required (all signals with less than 20dB of margin relative to the calculated field strength limit) the eirp of the spurious emission is calculated using:

$$P_{EUT} = P_S - (E_S - E_{EUT})$$

and

$$P_S = G + P_{in}$$

where:

P_S = effective isotropic radiated power of the substitution antenna (dBm)
P_{in} = power input to the substitution antenna (dBm)
G = gain of the substitution antenna (dBi)
E_S = field strength the substitution antenna (dBm) at eirp P_S
E_{EUT} = field strength measured from the EUT

Where necessary the effective isotropic radiated power is converted to effective radiated power by subtracting the gain of a dipole (2.2dBi) from the eirp value.

Appendix A Test Equipment Calibration Data

Manufacturer	Description	Model	Asset #	Calibrated	Cal Due
Radiated Emissions, 30 - 6,000 MHz, 28-Dec-22					
National Technical Systems	NTS EMI Software (rev 2.10)	N/A	WC022452	N/A	
Agilent Technologies	PSA Spectrum Analyzer	E4446A	WC055670	10/24/2022	10/31/2023
Filtek Filters	Filter, 1 GHz High Pass	HP12/1000-5BA	WC064427	2/1/2022	2/1/2023
EMCO	Antenna, Horn, 1-18 GHz (SA40-Red)	3115	WC064463	7/9/2022	7/9/2024
Sunol Sciences	Biconilog, 30-3000 MHz	JB3	WC064536	1/29/2021	3/23/2023
Com-Power	Preamplifier, 1-1000 MHz	PAM-103	WC064733	6/2/2022	6/2/2023
Rohde & Schwarz	EMI Test Receiver, 20Hz-40GHz	ESI	WC068000	7/21/2022	7/21/2023
MITEQ	Preamplifier, 1-18 GHz	AFS44	WC080962	7/18/2022	7/18/2023
Radio Antenna Port (Power and Spurious Emissions), 29-Dec-22, 03-Jan-23					
ETS-Lindgren	EMC Chamber #2, Inner Dimensions (LxWxH): 12' x 16' x 10'	CH 2	WC055564	N/A	
Tektronix	Oscilloscope (Digital)	TDS5104	WC055595	12/8/2022	12/8/2023
Agilent Technologies	PSA Spectrum Analyzer	E4446A	WC055650	8/30/2022	8/31/2023
Agilent Technologies	Signal Generator (Vector) (PSG)	E8267D	WC055673	4/26/2022	4/26/2023
Werlatone	Directional Coupler	C6021	WC062562	N/A	
Rohde & Schwarz	Power Meter	NRVS	WC064428	12/8/2022	12/8/2023
Rohde & Schwarz	Peak Power Sensor 100 uW - 2 Watts use with 20dB attenuator sn:1031.6959.00 only	NRV-Z32	WC064862	12/8/2022	12/8/2023
Mini-Circuits	2 way power divider, 50 MHz-2GHz	15542	WC065009	N/A	
Rohde & Schwarz	EMI Test Receiver, 20Hz-40GHz	ESI	WC068000	7/21/2022	7/21/2023
Radio Antenna Port (Frequency Stability), 04-Jan-23					
National Technical Systems	EMC Lab #3	None	WC055573	N/A	
Hewlett Packard	Spectrum Analyzer 9 KHz-26.5 GHz	8563E	WC064401	10/11/2022	10/31/2023
Fluke	Fluke Multimeter, True RMS	175	WC064448	10/9/2022	10/31/2023
Watlow	Environmental Chamber Controller	F4	WC066185	6/2/2022	6/2/2023

Appendix B Test Data

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Client:	FreeWave Technologies, Inc.	PR Number:	PR167383
Product	LRS455C	T-Log Number:	TL167383-RANA
System Configuration:	-	Project Manager:	Deepa Shetty
Contact:	Ofer Fisher	Project Engineer:	David Bare
Emissions Standard(s):	FCC Parts 15 & 90, RSS-119; EN55032	Class:	-
Immunity Standard(s):	-	Environment:	Radio

EMC Test Data

For The

FreeWave Technologies, Inc.

Product

LRS455C

Date of Last Test: 8/31/2023

Client:	FreeWave Technologies, Inc.	PR Number:	PR167383
Model:	LRS455C	T-Log Number:	TL167383-RANA
		Project Manager:	Deepa Shetty
Contact:	Ofer Fisher	Project Engineer:	David Bare
Standard:	FCC Parts 15 & 90, RSS-119; EN55032	Class:	N/A

RSS 119 and FCC Part 90

Power, Occupied Bandwidth, Frequency Stability and Spurious Emissions

Test Specific Details

Objective: The objective of this test session is to perform final qualification testing of the EUT with respect to the specification listed above.

General Test Configuration

With the exception of the radiated spurious emissions tests, all measurements are made with the EUT's rf port connected to the measurement instrument via an attenuator or dc-block if necessary. All amplitude measurements are adjusted to account for the attenuation between EUT and measuring instrument. For frequency stability measurements the EUT was placed inside an environmental chamber.

Radiated measurements are made with the EUT located on a non-conductive table, 3m from the measurement antenna.

Radiated emissions tests above 1 GHz to FCC Part 90 were performed with floor absorbers in place in accordance with the test methods of ANSI C63.4 and CISPR 16-1-4.

Ambient Conditions:

Temperature:	19-20 °C
Rel. Humidity:	48-50 %

Modifications Made During Testing

No modifications were made to the EUT during testing

Deviations From The Standard

No deviations were made from the requirements of the standard.

Client:	FreeWave Technologies, Inc.	PR Number:	PR167383
Model:	LRS455C	T-Log Number:	TL167383-RANA
		Project Manager:	Deepa Shetty
Contact:	Ofer Fisher	Project Engineer:	David Bare
Standard:	FCC Parts 15 & 90, RSS-119; EN55032	Class:	N/A

Summary of Results

Run #	Power Setting	Test Performed	Limit	Pass / Fail
1	10	Output Power	500W ERP	Pass, 26.853 W ERP
2	10	Spectral Mask	Within Mask	Pass, the signal was within the mask
3	10	99% or Occupied Bandwidth	11.25 kHz	2-level GFSK: 8.82kHz 4-level GFSK: 7.59kHz
4	10	Spurious Emissions (conducted)	-20dBm	All signals were below the limit
5	10	Spurious emissions (radiated)	-20dBm	-51.1 dBm erp @ 900.86 MHz (-31.1 dB)
6	10	Transient Frequency Behavior	t_1: 10ms t_2: 25ms	Pass
7	10	Modulation limitation	N/A	-
8	10	Frequency Stability	2.5 ppm / 1.5 ppm	1.5ppm/ 0.1ppm

Test Notes

RSS-119 and SRSP-501 only allow operation from 450-470 MHz. FCC §2.106 pages 28 and 29 and Part 90 allow operation over the full 435-470 MHz band.

Client:	FreeWave Technologies, Inc.	PR Number:	PR167383
Model:	LRS455C	T-Log Number:	TL167383-RANA
		Project Manager:	Deepa Shetty
Contact:	Ofer Fisher	Project Engineer:	David Bare
Standard:	FCC Parts 15 & 90, RSS-119; EN55032	Class:	N/A

Run #1: Output Power

Date of Test: 12/29/2022
Test Engineer: M. Birgani
Test Location: Chamber 2

Config. Used: 1
Config Change: None
EUT Voltage: 12 VDC

Cable Loss: 0.0 dB
Cable ID(s): None

Attenuator: 20.0 dB
Attenuator IDs: WC072174

Total Loss: 20.0 dB

Power Setting[2]	Frequency (MHz)	Output Power (dBm) [1]	Output Power mW	Max Ant Gain (dBi)	Result	ERP dBm	ERP W
10	435	32.9	1949.8	9.25	Pass	40.0	10.0
10	450	32.9	1949.8	9.25	Pass	40.0	10.0
10	460	32.8	1905.5	9.25	Pass	39.9	9.8
10	470	32.6	1819.7	9.25	Pass	39.7	9.3

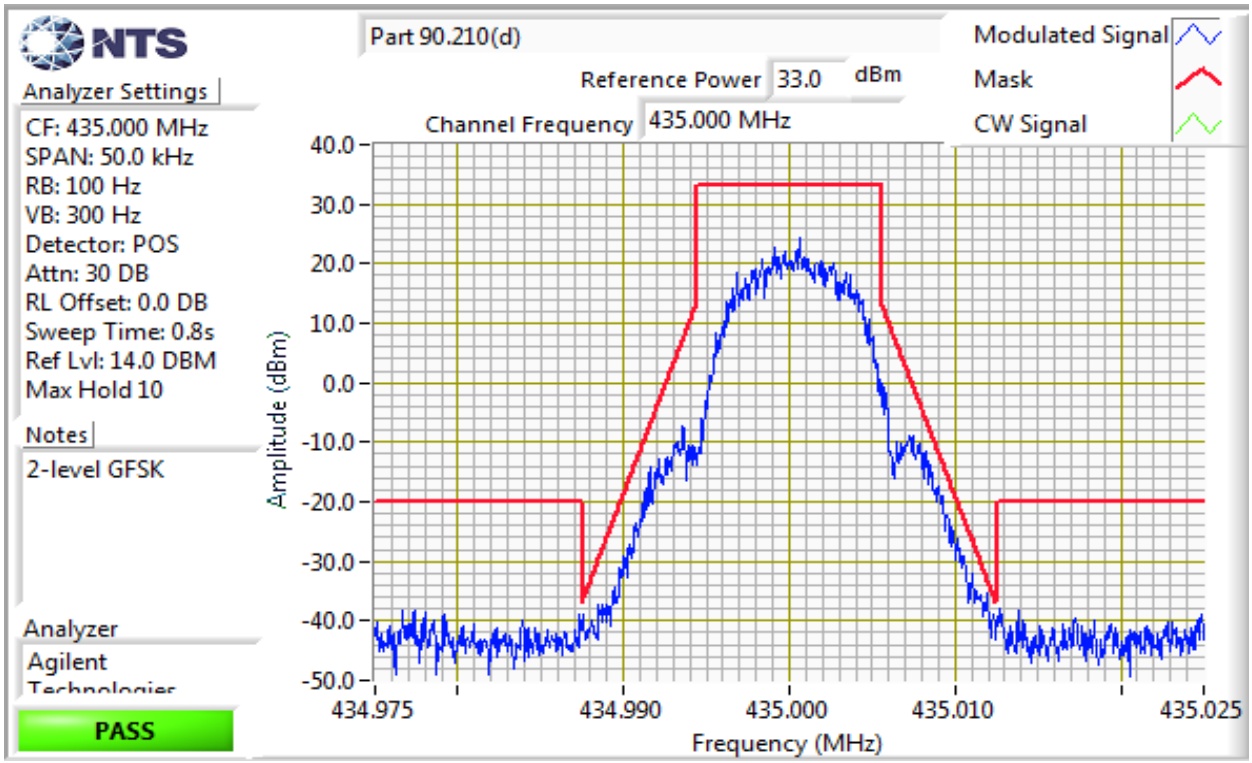
Note 1:	Output power measured using a peak power meter
Note 2:	Power setting - the software power setting used during testing, included for reference only
Note 3:	435 MHz not used in Canada

Client:	FreeWave Technologies, Inc.	PR Number:	PR167383
Model:	LRS455C	T-Log Number:	TL167383-RANA
		Project Manager:	Deepa Shetty
Contact:	Ofer Fisher	Project Engineer:	David Bare
Standard:	FCC Parts 15 & 90, RSS-119; EN55032	Class:	N/A

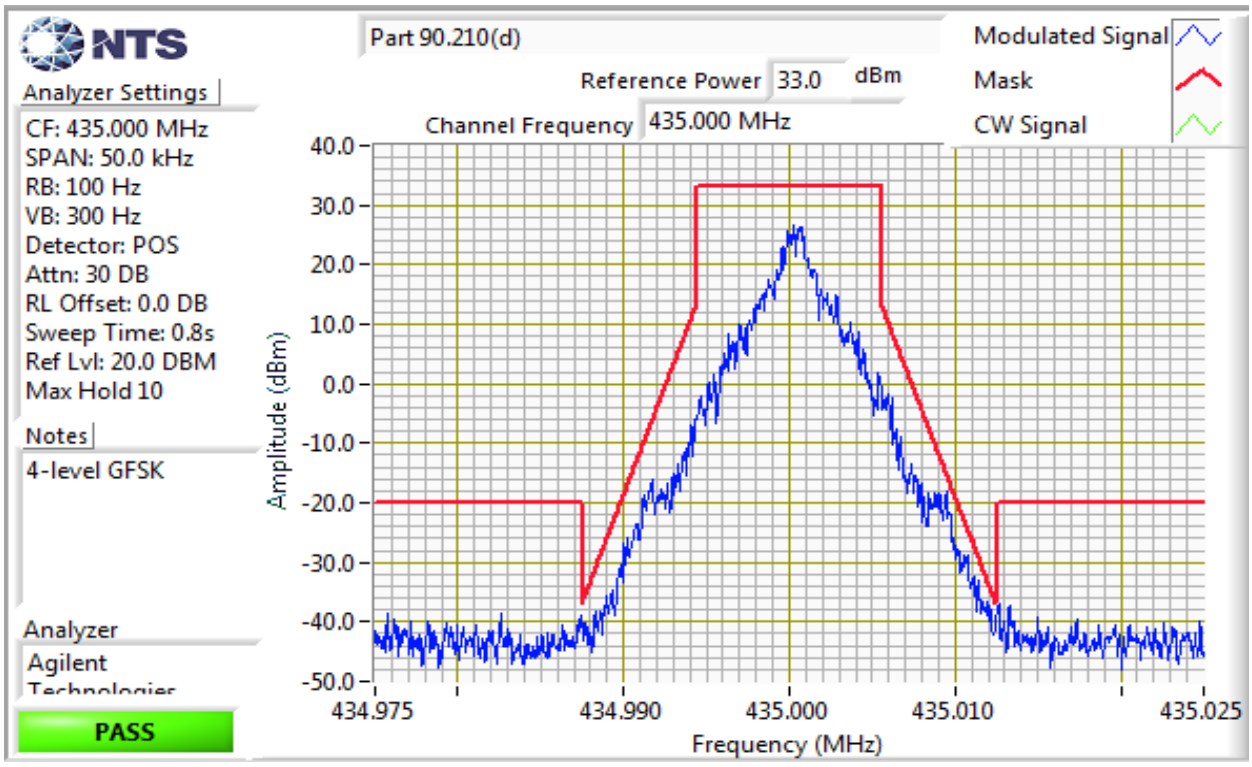
Run #2: Spectral Mask, FCC Part 90/RSS-119 Mask D

Date of Test: 12/29/2022 Config. Used: 1
Test Engineer: M. Birgani Config Change: None
Test Location: Chamber 2 EUT Voltage: 12 VDC

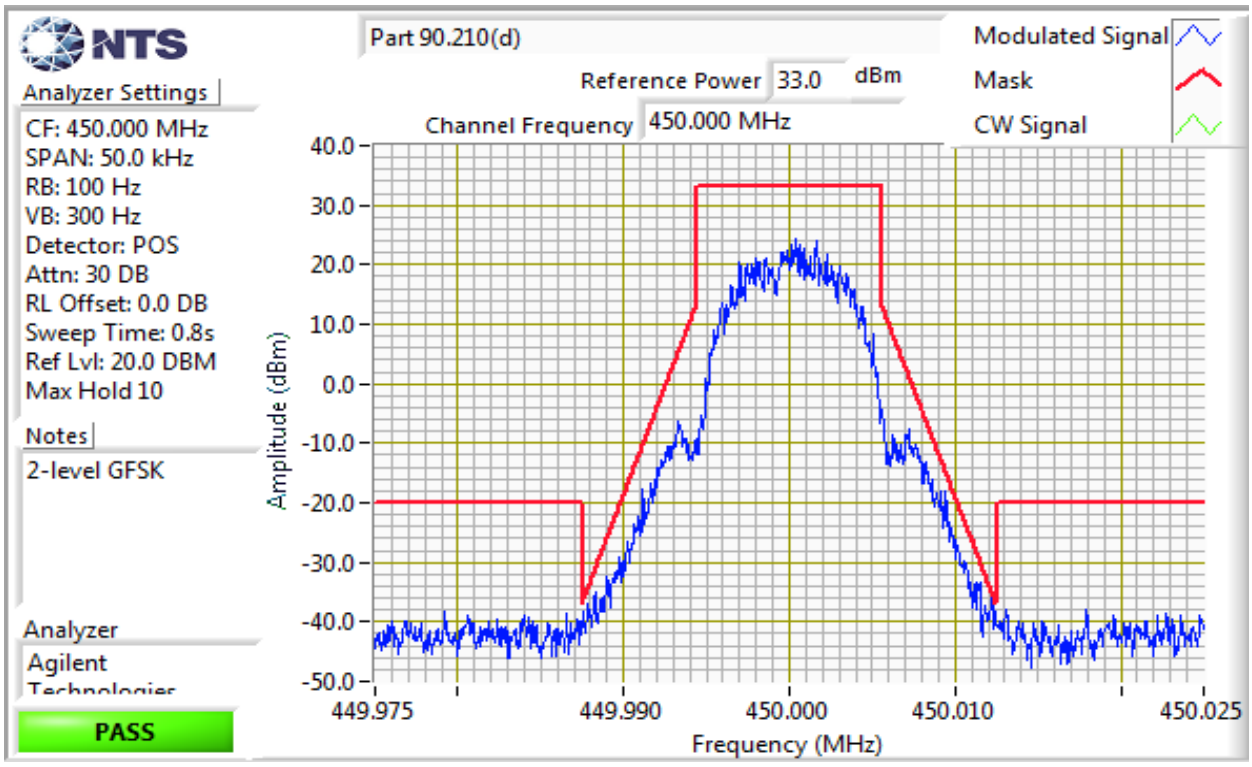
Note 1:	Reference level for Mask is equal to maximim peak power from Run 1
Note 2:	435 MHz not used in Canada



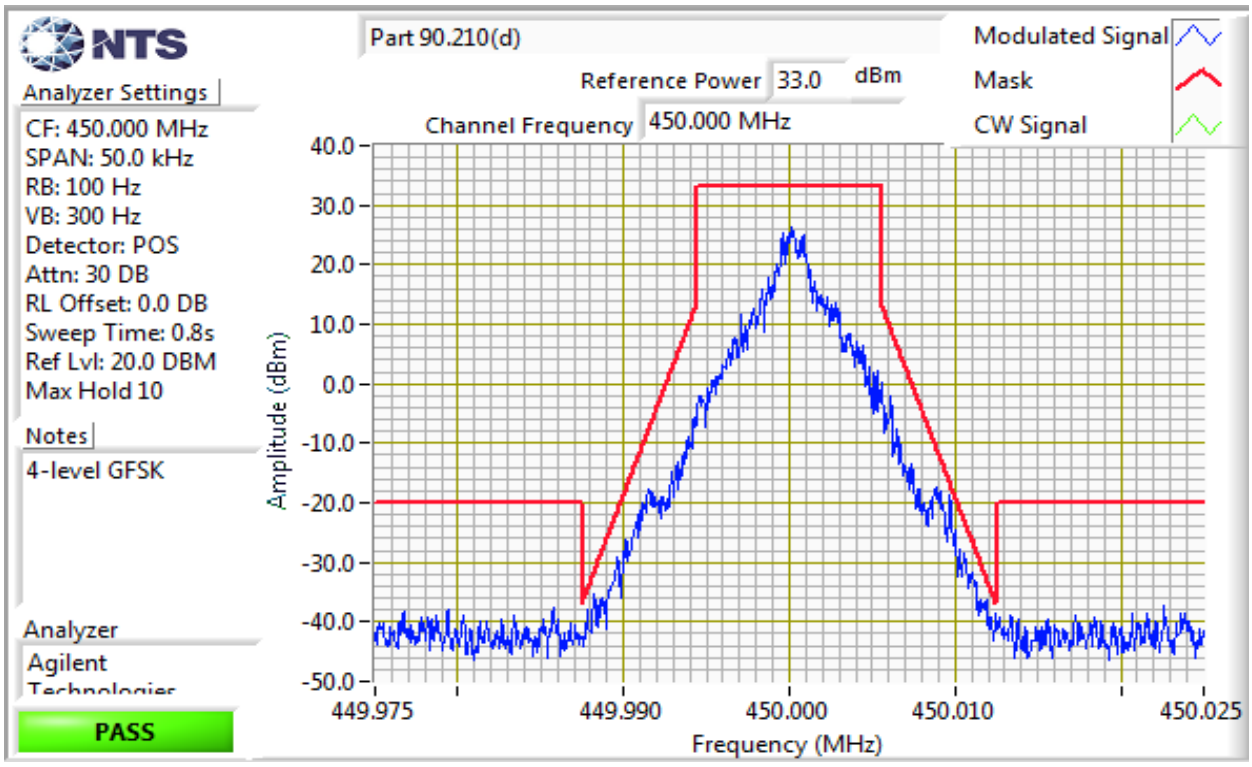
Client:	FreeWave Technologies, Inc.	PR Number:	PR167383
Model:	LRS455C	T-Log Number:	TL167383-RANA
		Project Manager:	Deepa Shetty
Contact:	Ofer Fisher	Project Engineer:	David Bare
Standard:	FCC Parts 15 & 90, RSS-119; EN55032	Class:	N/A



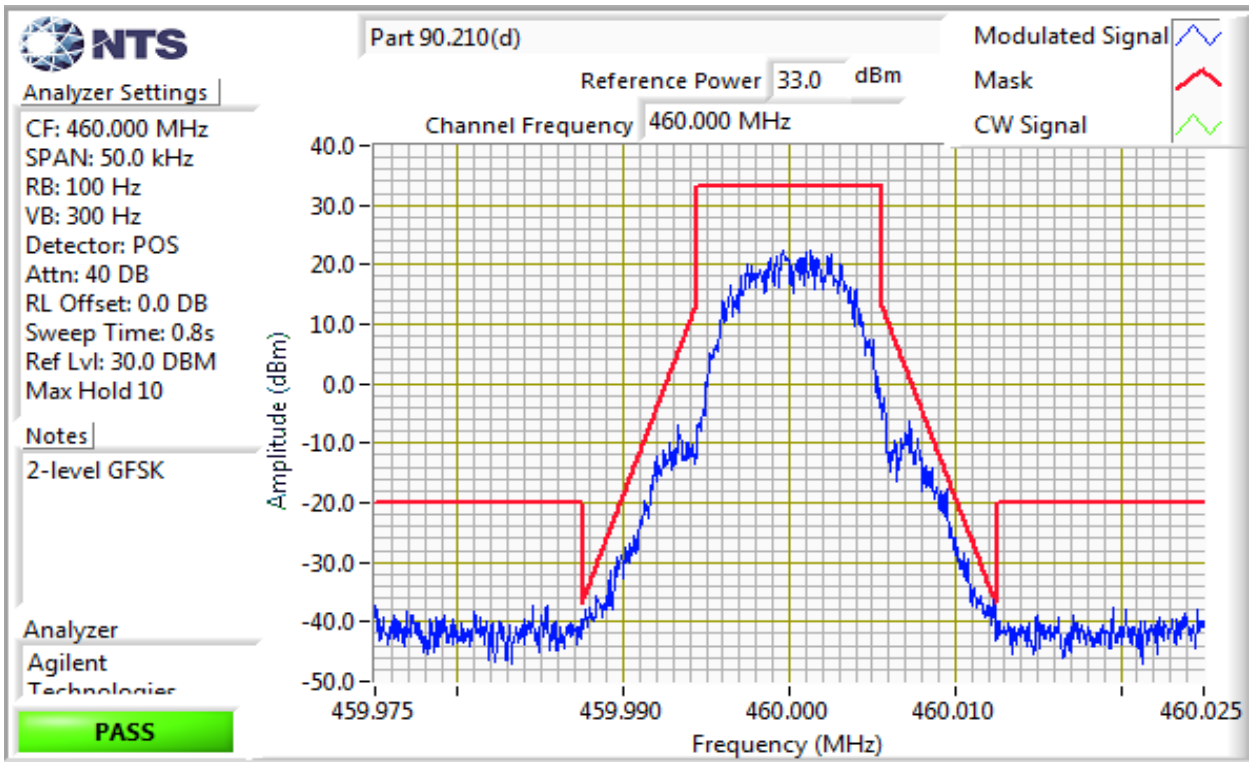
Client:	FreeWave Technologies, Inc.	PR Number:	PR167383
Model:	LRS455C	T-Log Number:	TL167383-RANA
		Project Manager:	Deepa Shetty
Contact:	Ofer Fisher	Project Engineer:	David Bare
Standard:	FCC Parts 15 & 90, RSS-119; EN55032	Class:	N/A



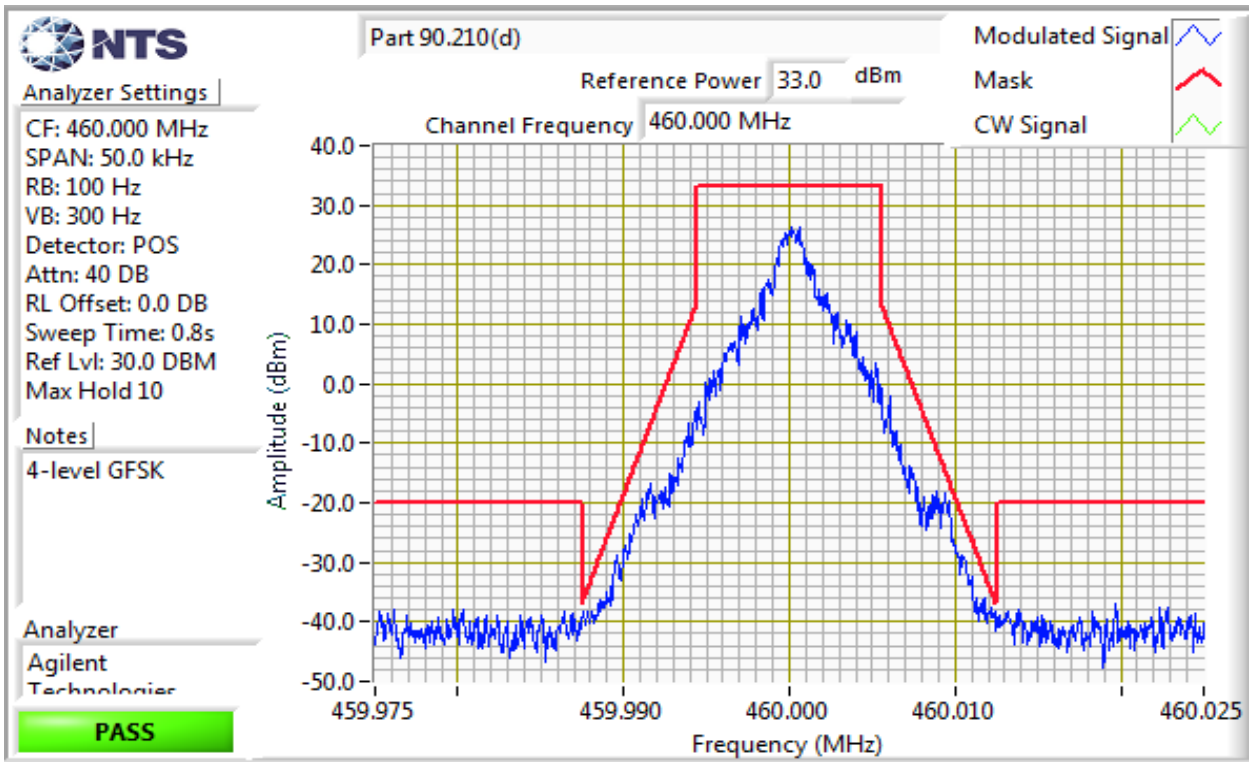
Client:	FreeWave Technologies, Inc.	PR Number:	PR167383
Model:	LRS455C	T-Log Number:	TL167383-RANA
		Project Manager:	Deepa Shetty
Contact:	Ofer Fisher	Project Engineer:	David Bare
Standard:	FCC Parts 15 & 90, RSS-119; EN55032	Class:	N/A



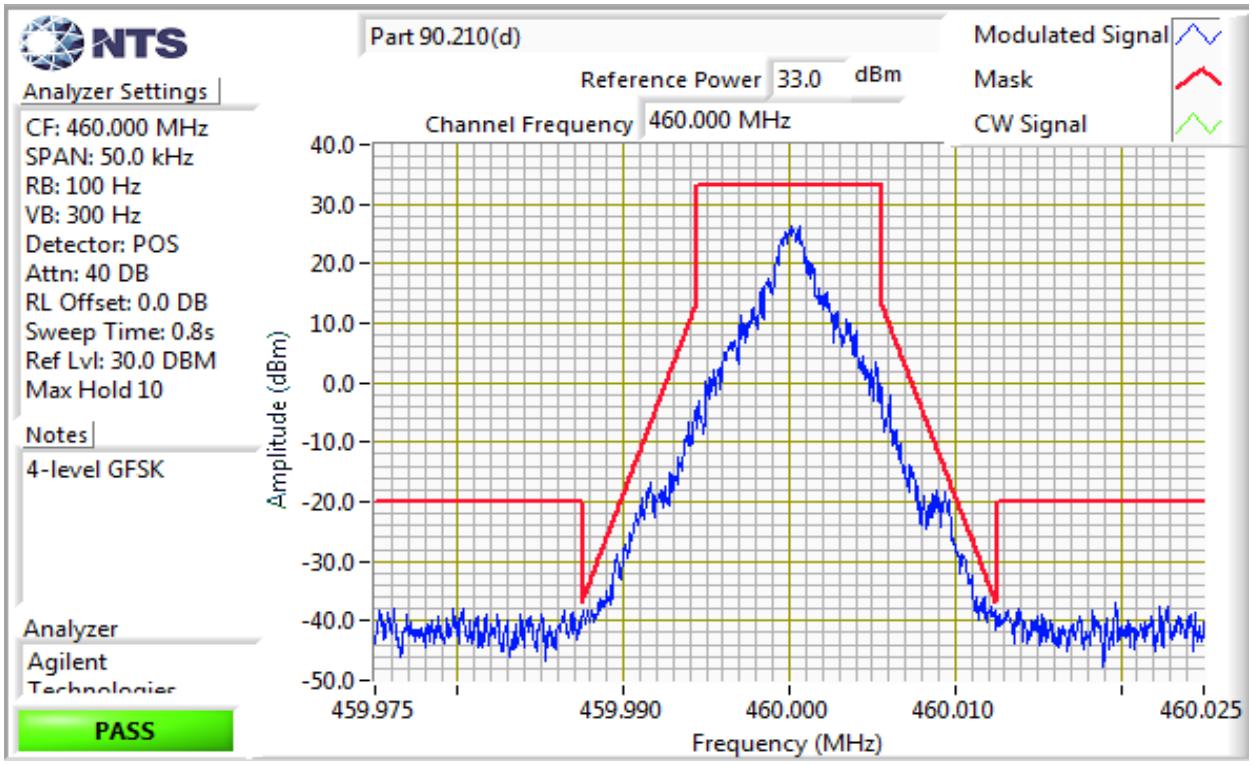
Client:	FreeWave Technologies, Inc.	PR Number:	PR167383
Model:	LRS455C	T-Log Number:	TL167383-RANA
		Project Manager:	Deepa Shetty
Contact:	Ofer Fisher	Project Engineer:	David Bare
Standard:	FCC Parts 15 & 90, RSS-119; EN55032	Class:	N/A



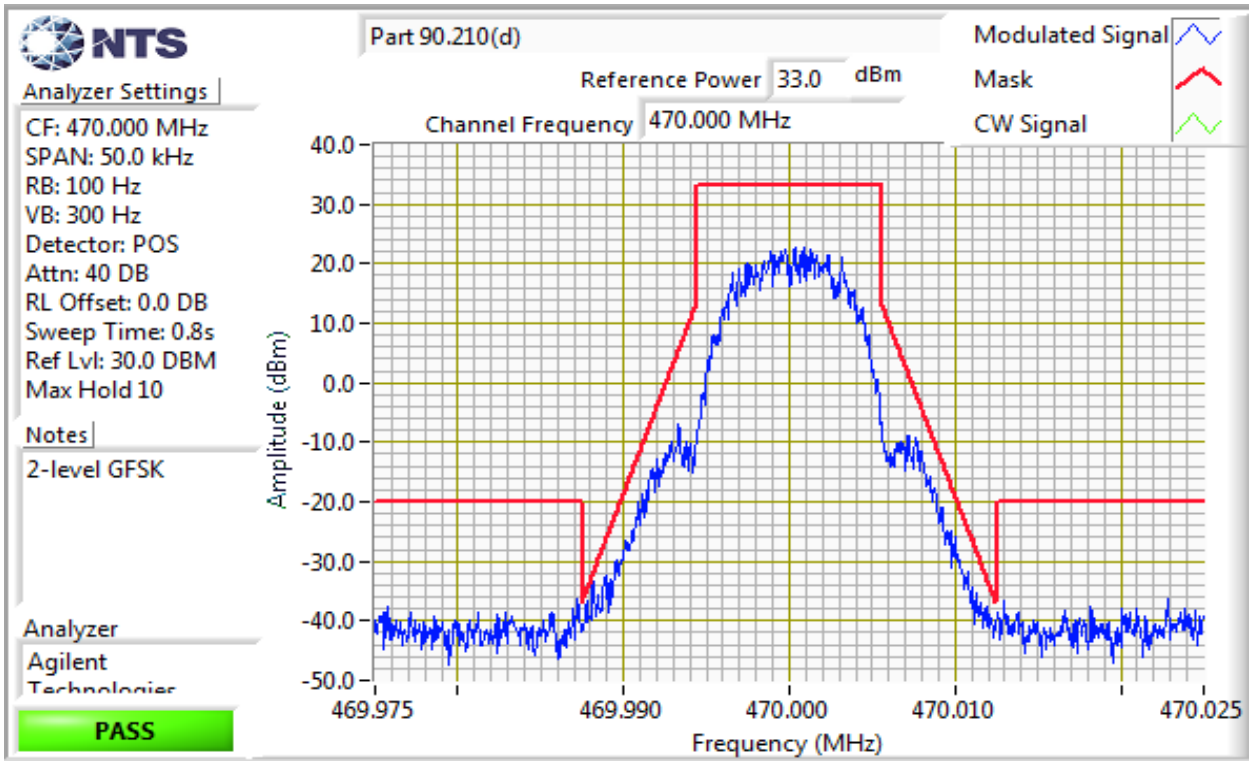
Client:	FreeWave Technologies, Inc.	PR Number:	PR167383
Model:	LRS455C	T-Log Number:	TL167383-RANA
		Project Manager:	Deepa Shetty
Contact:	Ofer Fisher	Project Engineer:	David Bare
Standard:	FCC Parts 15 & 90, RSS-119; EN55032	Class:	N/A



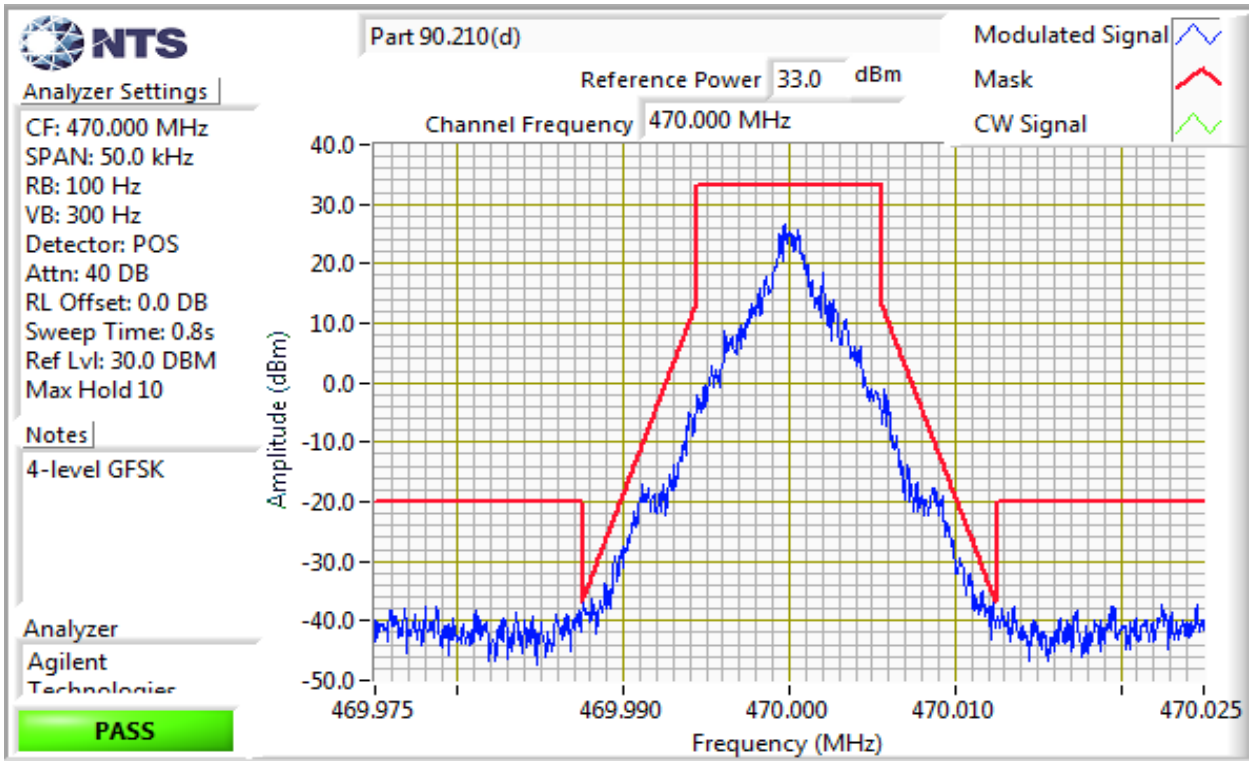
Client:	FreeWave Technologies, Inc.	PR Number:	PR167383
Model:	LRS455C	T-Log Number:	TL167383-RANA
		Project Manager:	Deepa Shetty
Contact:	Ofer Fisher	Project Engineer:	David Bare
Standard:	FCC Parts 15 & 90, RSS-119; EN55032	Class:	N/A



Client:	FreeWave Technologies, Inc.	PR Number:	PR167383
Model:	LRS455C	T-Log Number:	TL167383-RANA
		Project Manager:	Deepa Shetty
Contact:	Ofer Fisher	Project Engineer:	David Bare
Standard:	FCC Parts 15 & 90, RSS-119; EN55032	Class:	N/A



Client:	FreeWave Technologies, Inc.	PR Number:	PR167383
Model:	LRS455C	T-Log Number:	TL167383-RANA
		Project Manager:	Deepa Shetty
Contact:	Ofer Fisher	Project Engineer:	David Bare
Standard:	FCC Parts 15 & 90, RSS-119; EN55032	Class:	N/A



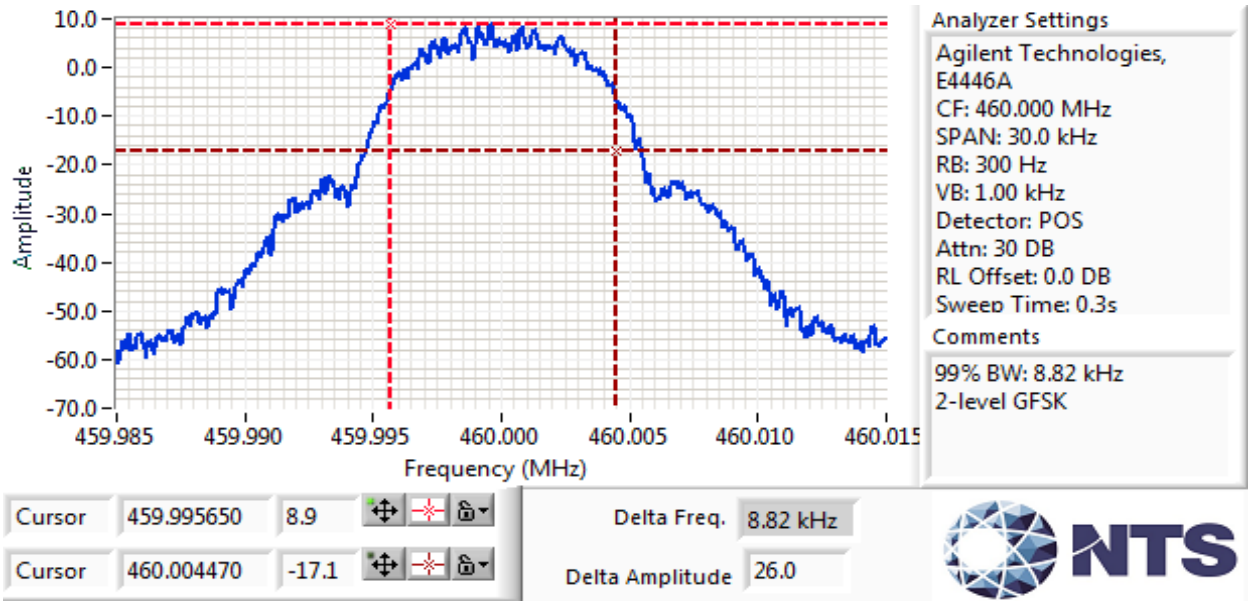
Client:	FreeWave Technologies, Inc.	PR Number:	PR167383
Model:	LRS455C	T-Log Number:	TL167383-RANA
		Project Manager:	Deepa Shetty
Contact:	Ofer Fisher	Project Engineer:	David Bare
Standard:	FCC Parts 15 & 90, RSS-119; EN55032	Class:	N/A

Run #3: Signal Bandwidth

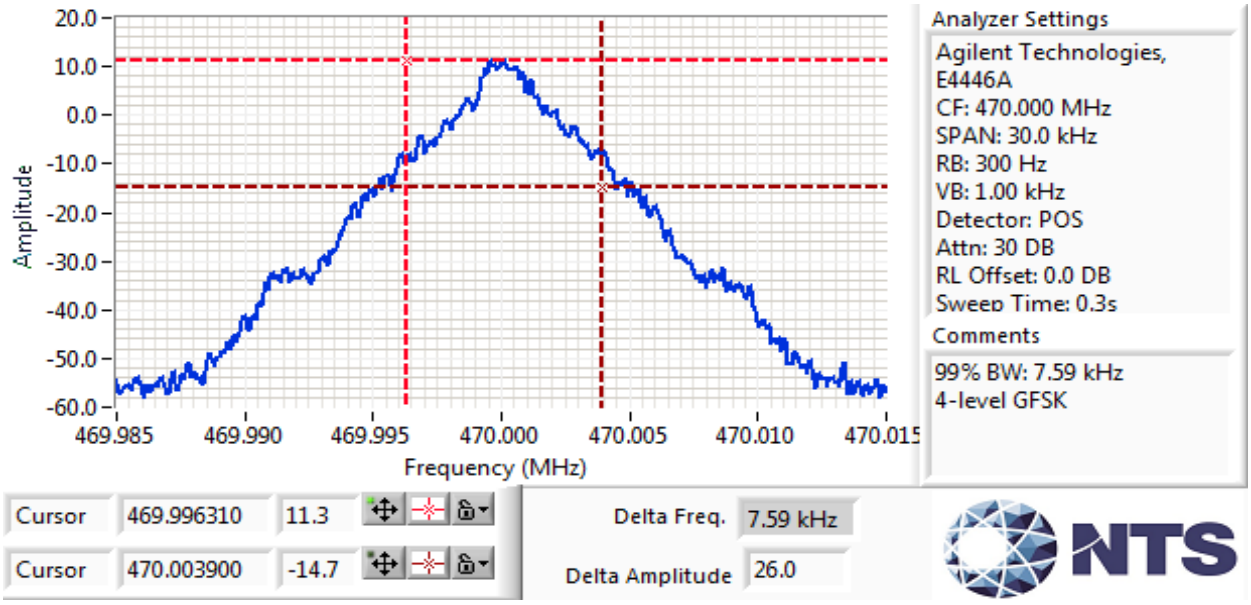
Date of Test: 12/29/2022 Config. Used: 1
Test Engineer: M. Birgani Config Change: None
Test Location: Chamber 2 EUT Voltage: 12 VDC

Power Setting	Frequency (MHz)	Resolution Bandwidth	Bandwidth (kHz)	99%	
10	435	300 Hz		8.94	2-level GFSK
10	450	300 Hz		8.82	2-level GFSK
10	460	300 Hz		8.82	2-level GFSK
10	470	300 Hz		8.79	2-level GFSK
10	435	300 Hz		7.71	4-level GFSK
10	450	300 Hz		7.53	4-level GFSK
10	460	300 Hz		7.53	4-level GFSK
10	470	300 Hz		7.59	4-level GFSK

Note 1:	99% bandwidth measured in accordance with ANSI C63.26, with RB between 1% and 5% of the measured bandwidth and VB ≥ 3*RB and Span ≥ 1.5% and ≤ 5% of measured bandwidth.
Note 2:	435 MHz not used in Canada



Client:	FreeWave Technologies, Inc.	PR Number:	PR167383
Model:	LRS455C	T-Log Number:	TL167383-RANA
		Project Manager:	Deepa Shetty
Contact:	Ofer Fisher	Project Engineer:	David Bare
Standard:	FCC Parts 15 & 90, RSS-119; EN55032	Class:	N/A



Client:	FreeWave Technologies, Inc.	PR Number:	PR167383
Model:	LRS455C	T-Log Number:	TL167383-RANA
		Project Manager:	Deepa Shetty
Contact:	Ofer Fisher	Project Engineer:	David Bare
Standard:	FCC Parts 15 & 90, RSS-119; EN55032	Class:	N/A

Run #4: Out of Band Spurious Emissions, Conducted

Date of Test: 12/29/2022 Config. Used: 1
Test Engineer: M. Birgani Config Change: None
Test Location: Chamber 2 EUT Voltage: 12 VDC

Frequency (MHz)	Limit	Result
435	-20 dBm	Pass
450	-20 dBm	Pass
460	-20 dBm	Pass
470	-20 dBm	Pass

The limit is taken from FCC Part 90 Mask D.
Plots 20 MHz wide centered on the signal frequency also provided for each channel bandwidth/spacing.

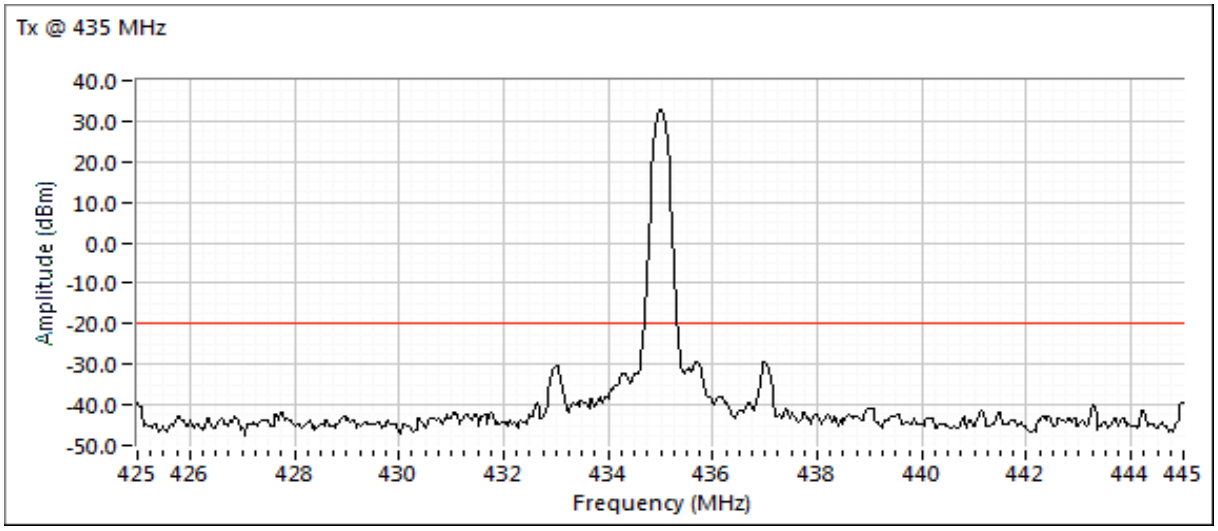
Final peak readings

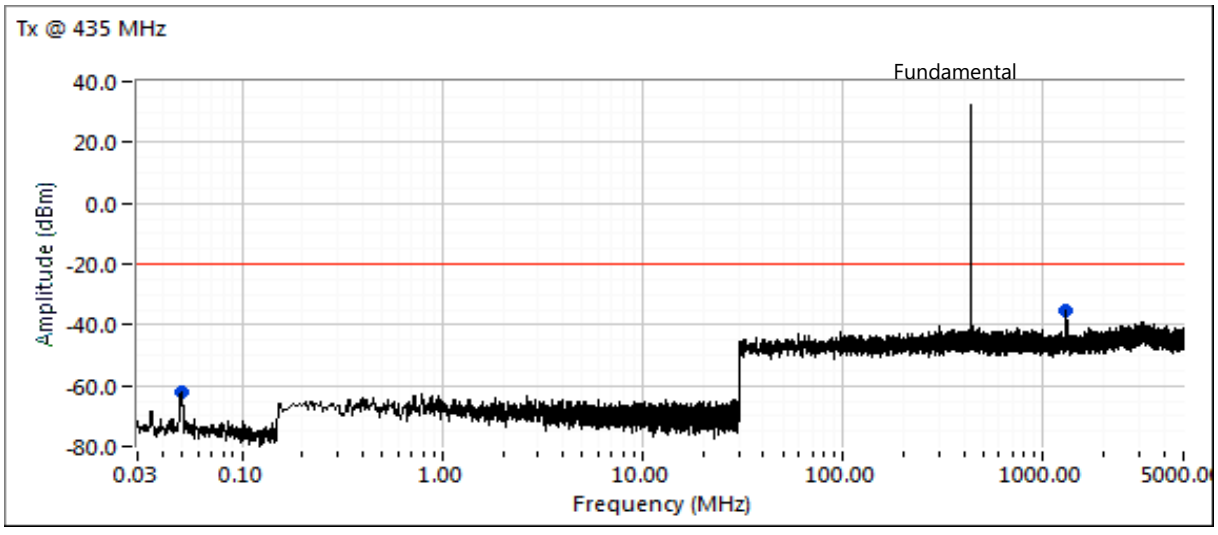
Frequency	Level		FCC 90.210		Detector	Comments	
MHz	dBm	Port	Limit	Margin	QP/Ave		Frequency
0.050	-62.4	RF Port	-20.0	-42.4	Peak	RB 1 kHz; VB: 3 kHz	435
433.000	-30.3	RF Port	-20.0	-10.3	Peak	RB 120 kHz; VB: 1 MHz	435
437.000	-29.4	RF Port	-20.0	-9.4	Peak	RB 120 kHz; VB: 1 MHz	435
1304.540	-35.4	RF Port	-20.0	-15.4	Peak	RB 1 MHz; VB: 3 MHz	435
0.050	-64.6	RF Port	-20.0	-44.6	Peak	RB 1 kHz; VB: 3 kHz	450
1350.040	-35.0	RF Port	-20.0	-15.0	Peak	RB 1 MHz; VB: 3 MHz	450
0.050	-57.5	RF Port	-20.0	-37.5	Peak	RB 1 kHz; VB: 3 kHz	460
1380.050	-34.9	RF Port	-20.0	-14.9	Peak	RB 1 MHz; VB: 3 MHz	460
0.050	-61.4	RF Port	-20.0	-41.4	Peak	RB 1 kHz; VB: 3 kHz	470
1410.050	-35.9	RF Port	-20.0	-15.9	Peak	RB 1 MHz; VB: 3 MHz	470

Note 1:	435 MHz not used in Canada
Note 2:	30-150kHz RB=1kHz VB=3kHz 150kHz to 30MHz RB=9kHz VB=30kHz 30-1000MHz RB=120kHz VB=1MHz 1-5GHz RB=1MHz VB=3MHz

Client:	FreeWave Technologies, Inc.	PR Number:	PR167383
Model:	LRS455C	T-Log Number:	TL167383-RANA
		Project Manager:	Deepa Shetty
Contact:	Ofer Fisher	Project Engineer:	David Bare
Standard:	FCC Parts 15 & 90, RSS-119; EN55032	Class:	N/A

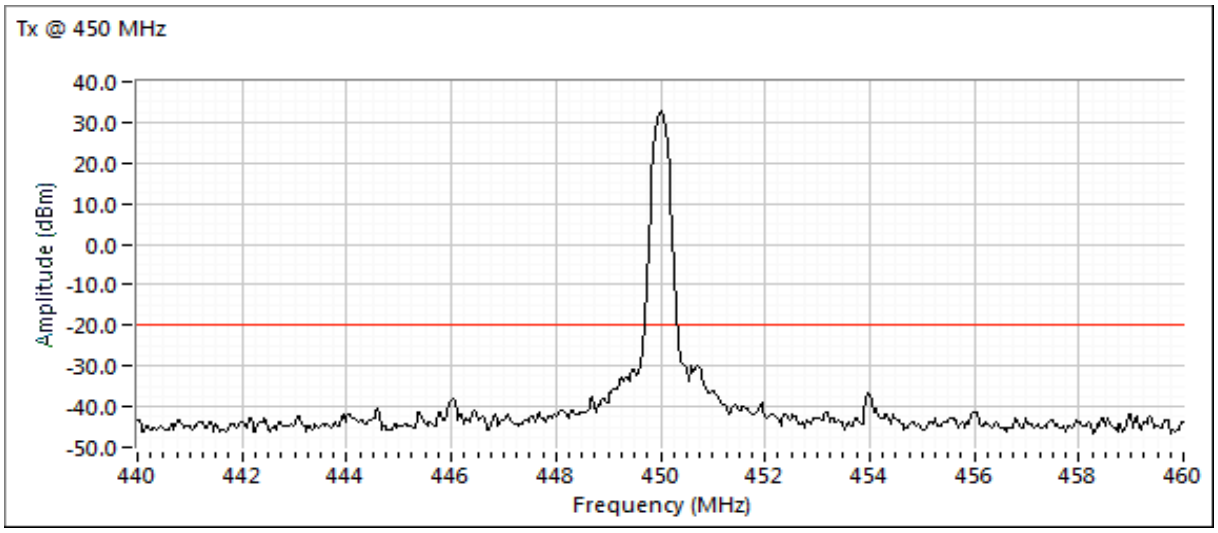
Plots for low channel, power setting(s) = 10

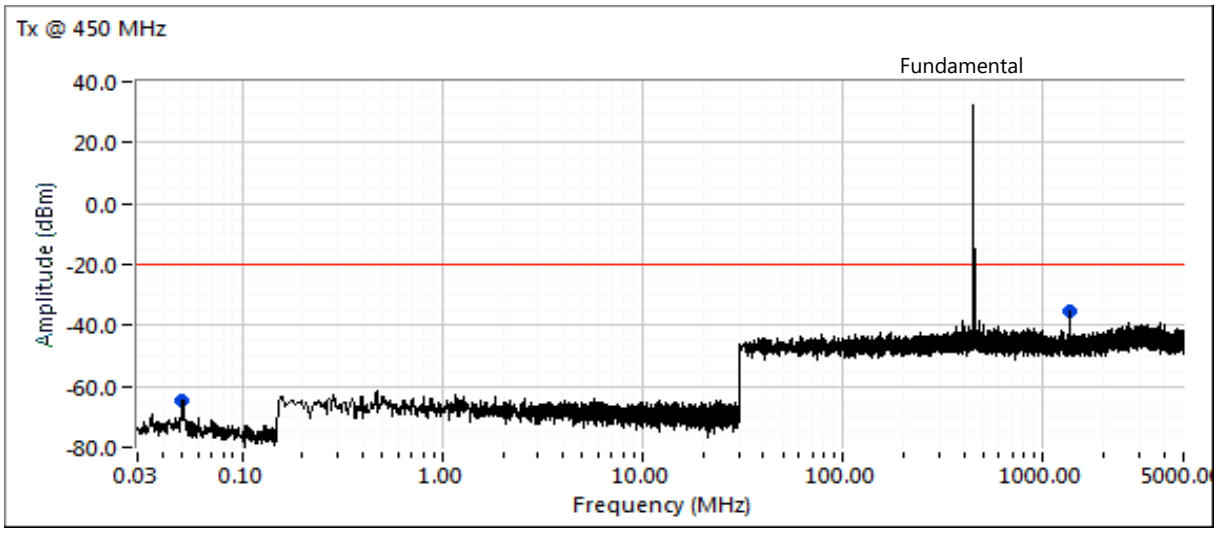




Client:	FreeWave Technologies, Inc.	PR Number:	PR167383
Model:	LRS455C	T-Log Number:	TL167383-RANA
		Project Manager:	Deepa Shetty
Contact:	Ofer Fisher	Project Engineer:	David Bare
Standard:	FCC Parts 15 & 90, RSS-119; EN55032	Class:	N/A

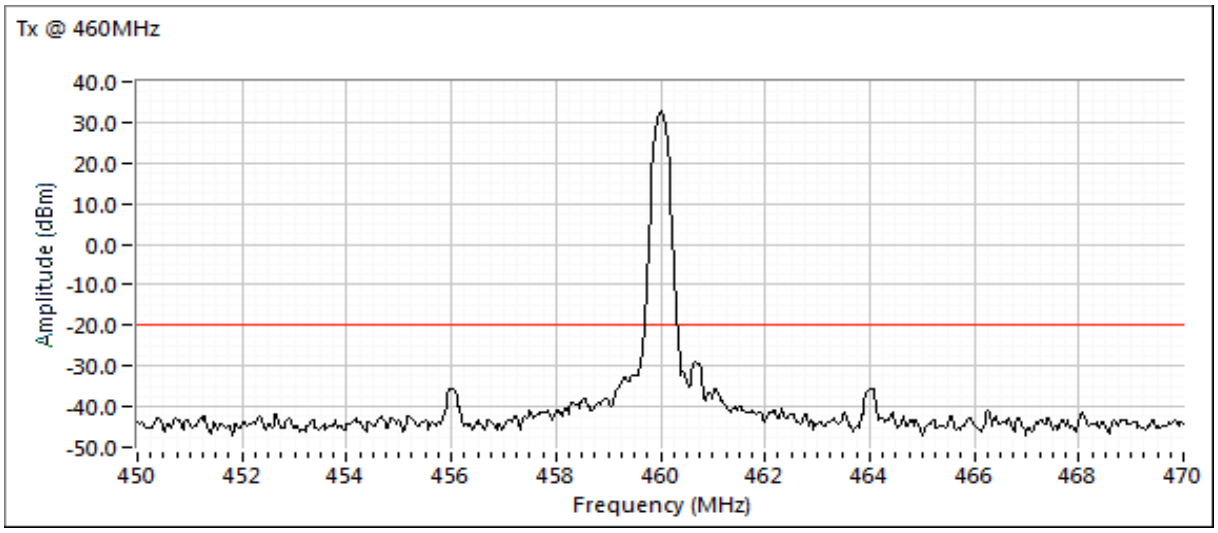
Plots for center channel, power setting(s) = 10

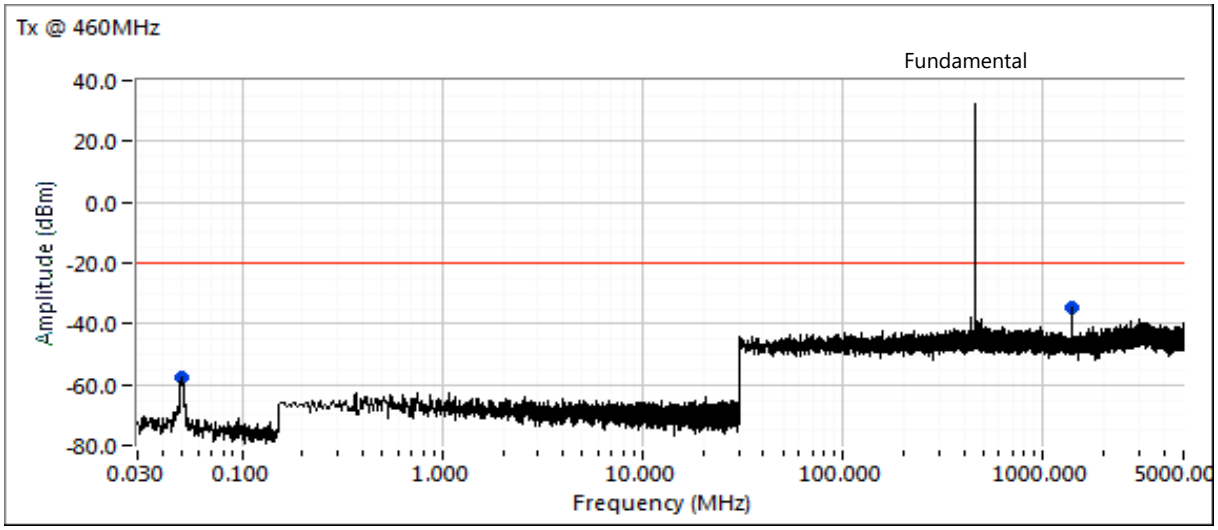




Client:	FreeWave Technologies, Inc.	PR Number:	PR167383
Model:	LRS455C	T-Log Number:	TL167383-RANA
		Project Manager:	Deepa Shetty
Contact:	Ofer Fisher	Project Engineer:	David Bare
Standard:	FCC Parts 15 & 90, RSS-119; EN55032	Class:	N/A

Plots for center channel, power setting(s) = 10





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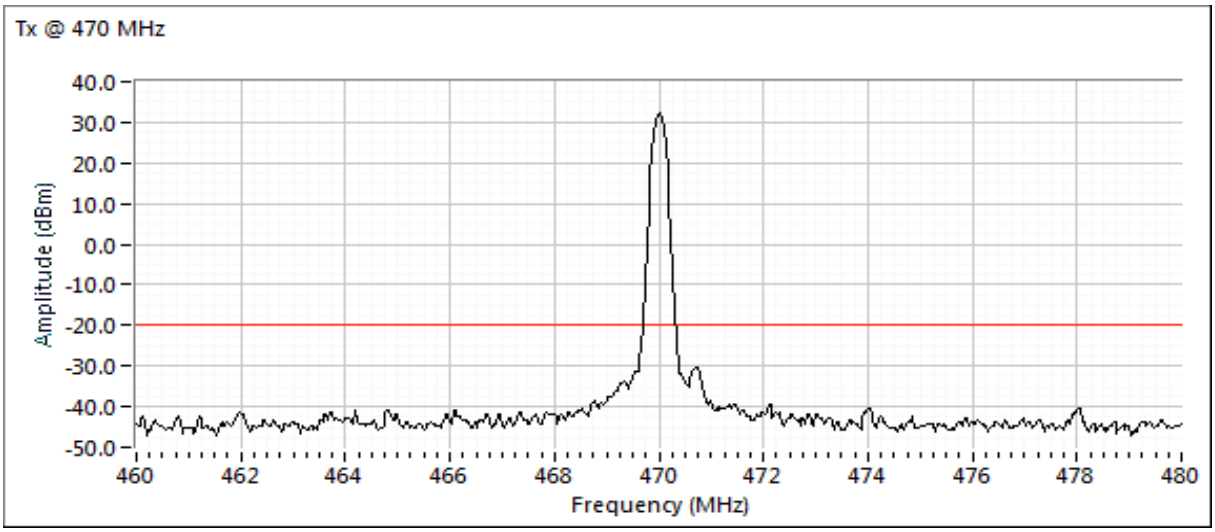
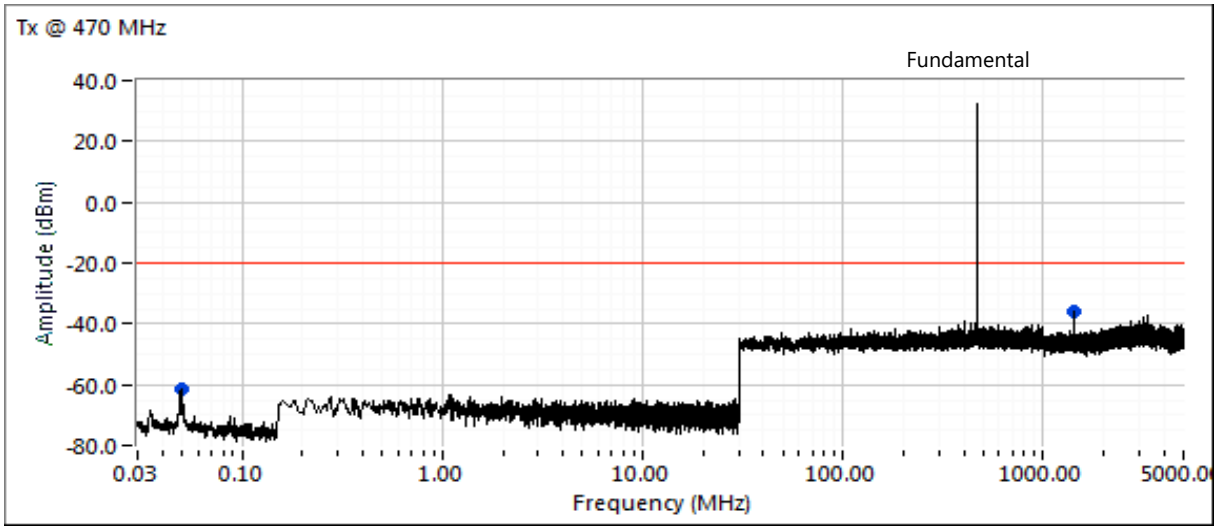
Model:	LRS455C	T-Log Number:	TL167383-RANA
		Project Manager:	Deepa Shetty
Contact:	Ofer Fisher	Project Engineer:	David Bare
Standard:	FCC Parts 15 & 90, RSS-119; EN55032	Class:	N/A

Plots for high channel, power setting(s) = 10





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		Project Manager:	Deepa Shetty
Contact:	Ofer Fisher	Project Engineer:	David Bare
Standard:	FCC Parts 15 & 90, RSS-119; EN55032	Class:	N/A

Run #5: Out of Band Spurious Emissions, Radiated

Conducted limit (dBm): -20
Approximate field strength limit @ 3m: 75.3

The limit is taken from FCC Part 90 Mask D

Run #5a - Preliminary measurements

Date of Test: 12/28/2022 Config. Used: 1
Test Engineer: M. Birgani Config Change: None
Test Location: Chamber 7 EUT Voltage: 12VDC

Frequency	Level	Pol	FCC Part 90		Detector	Azimuth	Height	Comments	Channel
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters		
45.551	28.8	V	75.3	-46.5	Peak	311	1.0		435
280.762	25.1	H	75.3	-50.2	Peak	106	1.0		435
434.829	79.9	H	-	-	Peak	59	1.0	Fundamental	435
613.166	24.1	V	75.3	-51.2	Peak	26	3.0		435
871.703	35.3	H	75.3	-40.0	Peak	55	1.0		435
1200.000	27.4	H	75.3	-47.9	Peak	72	1.6		435
1305.010	29.1	V	75.3	-46.2	Peak	223	2.2		435
41.663	30.3	V	75.3	-45.0	Peak	340	1.0		450
162.184	26.2	V	75.3	-49.1	Peak	152	1.0		450
449.880	75.4	H	-	-	Peak	276	2.5	Fundamental	450
900.862	44.5	H	75.3	-30.8	Peak	230	1.0		450
928.076	33.3	V	75.3	-42.0	Peak	125	1.5		450
1200.020	27.6	H	75.3	-47.7	Peak	288	1.6		450
1350.010	28.8	V	75.3	-46.5	Peak	29	2.2		450
45.551	28.9	V	75.3	-46.4	Peak	344	1.0		460
280.762	23.0	H	75.3	-52.3	Peak	271	1.5		460
459.599	78.2	H	-	-	Peak	60	1.0	Fundamental	460
620.942	25.8	H	75.3	-49.5	Peak	68	3.0		460
920.301	39.3	H	75.3	-36.0	Peak	60	1.0		460
1200.020	27.6	H	75.3	-47.7	Peak	288	1.6		460
1350.010	28.8	V	75.3	-46.5	Peak	29	2.2		460

Client:	FreeWave Technologies, Inc.	PR Number:	PR167383
Model:	LRS455C	T-Log Number:	TL167383-RANA
		Project Manager:	Deepa Shetty
Contact:	Ofer Fisher	Project Engineer:	David Bare
Standard:	FCC Parts 15 & 90, RSS-119; EN55032	Class:	N/A

Run #5a - Continue

Frequency	Level	Pol	FCC Part 90		Detector	Azimuth	Height	Comments	Channel
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters		
41.663	28.5	V	75.3	-46.8	Peak	315	1.0		470
276.874	23.0	H	75.3	-52.3	Peak	91	1.5		470
470.263	74.2	H	-	-	Peak	121	2.0	Fundamental	470
611.222	25.0	H	75.3	-50.3	Peak	107	2.0		470
941.683	40.0	H	75.3	-35.3	Peak	148	1.5		470
1200.000	28.1	H	75.3	-47.2	Peak	233	1.6		470
1415.090	31.4	H	75.3	-43.9	Peak	319	1.0		470
3760.000	34.4	V	75.3	-40.9	Peak	190	1.9		470

Note 1:	The field strength limit in the tables above was calculated from the erp/eirp limit detailed in the standard using the free space propagation equation: $E=\sqrt{(30PG)}/d$. This limit is conservative - it does not consider the presence of the ground plane and, for erp limits, the dipole gain (2.2dBi) has not been included. The erp or eirp for all signals with less than **20dB** of margin relative to this field strength limit is determined using substitution measurements.
Note 2:	Measurements are made with the antenna port terminated.
Note 3:	Based on preliminary measurements, no difference was observed when the EUT was oriented in the 3 orthogonal axis.

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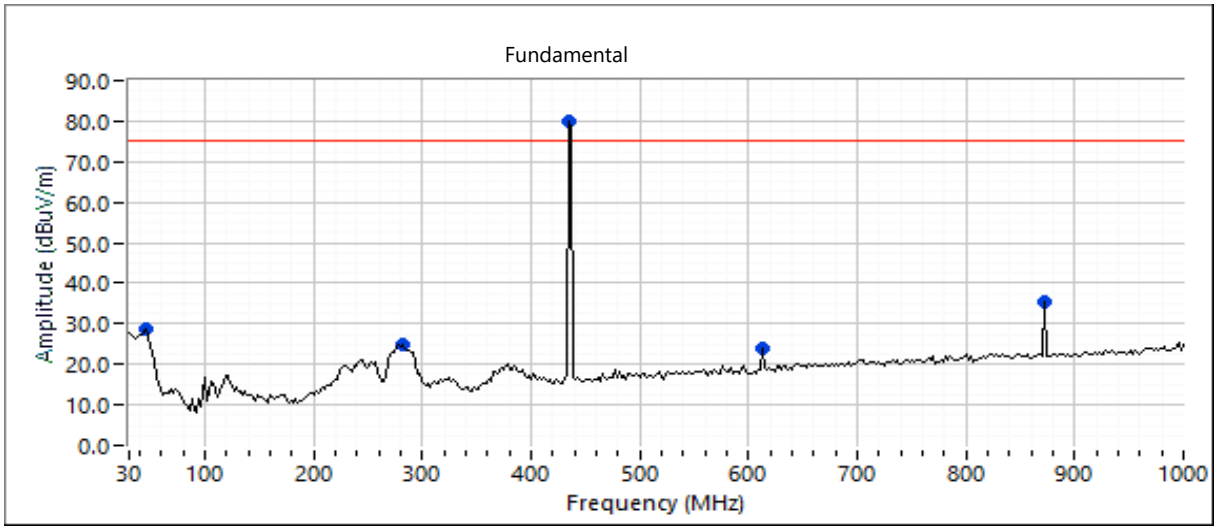
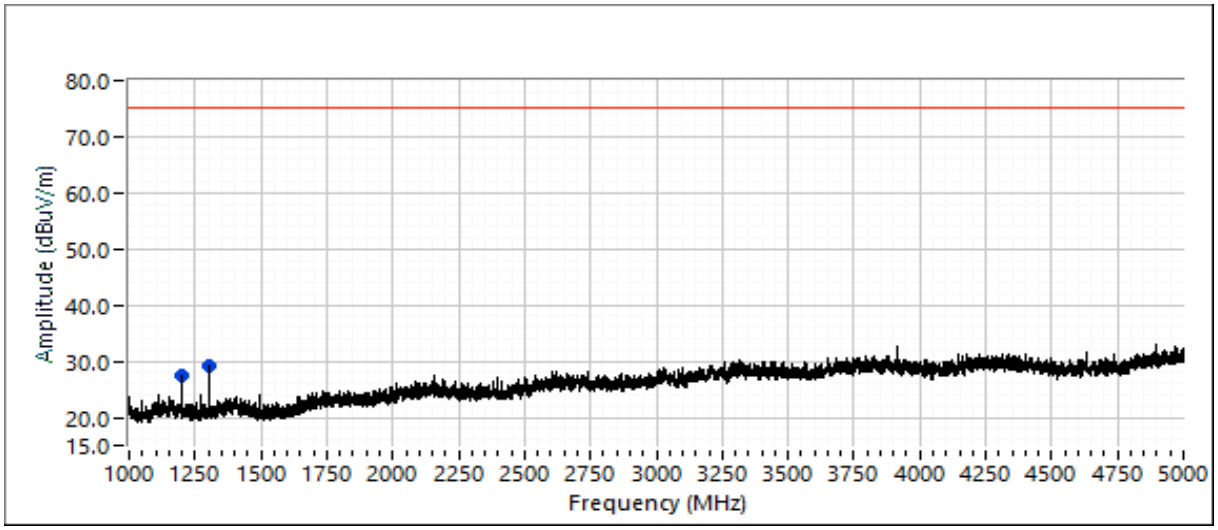
Model:	LRS455C	T-Log Number:	TL167383-RANA
		Project Manager:	Deepa Shetty
Contact:	Ofer Fisher	Project Engineer:	David Bare
Standard:	FCC Parts 15 & 90, RSS-119; EN55032	Class:	N/A

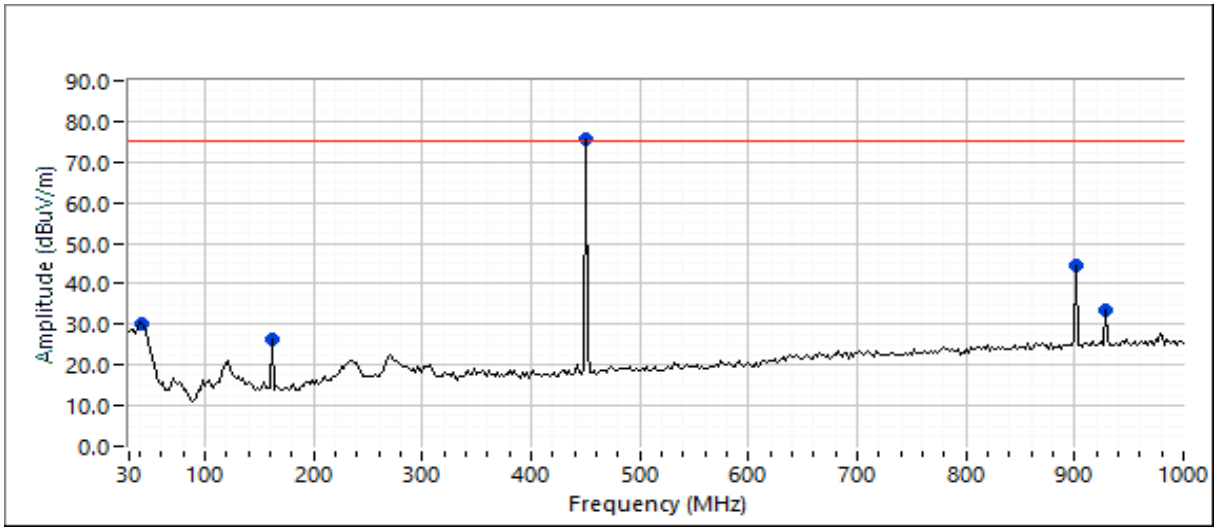
Plots for low channel (435 MHz), power setting(s) = 10

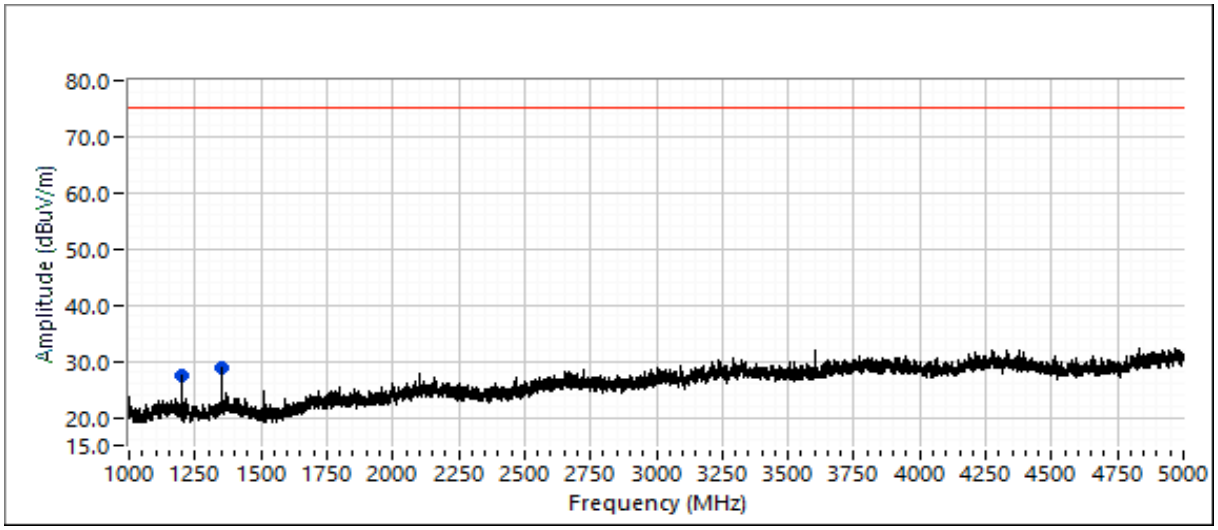




Client:	FreeWave Technologies, Inc.	PR Number:	PR167383
Model:	LRS455C	T-Log Number:	TL167383-RANA
		Project Manager:	Deepa Shetty
Contact:	Ofer Fisher	Project Engineer:	David Bare
Standard:	FCC Parts 15 & 90, RSS-119; EN55032	Class:	N/A

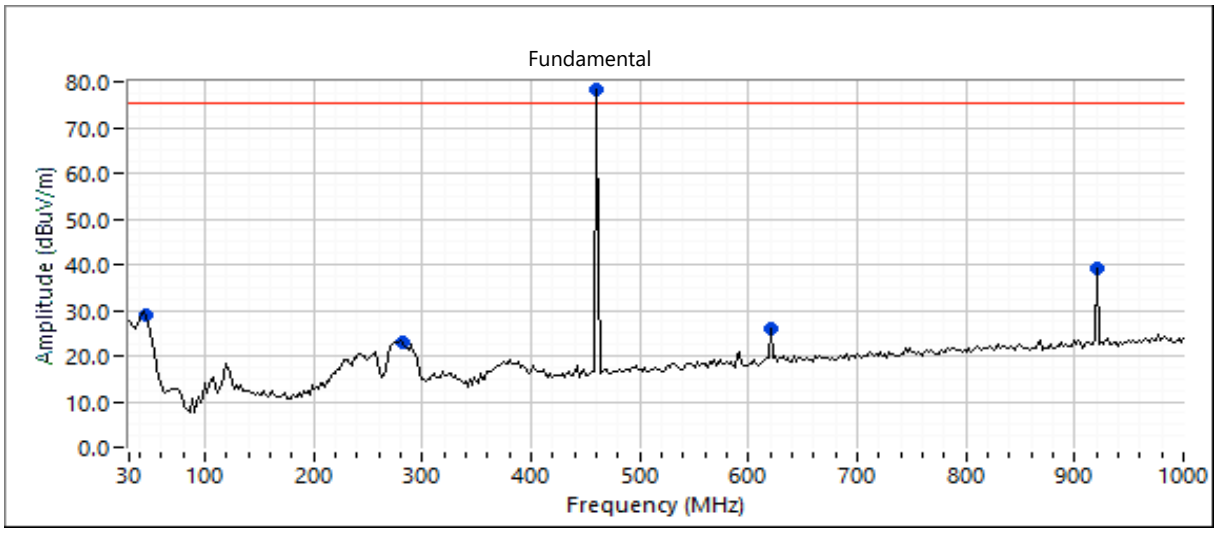
Plots for center channel (450 MHz), power setting(s) = 10

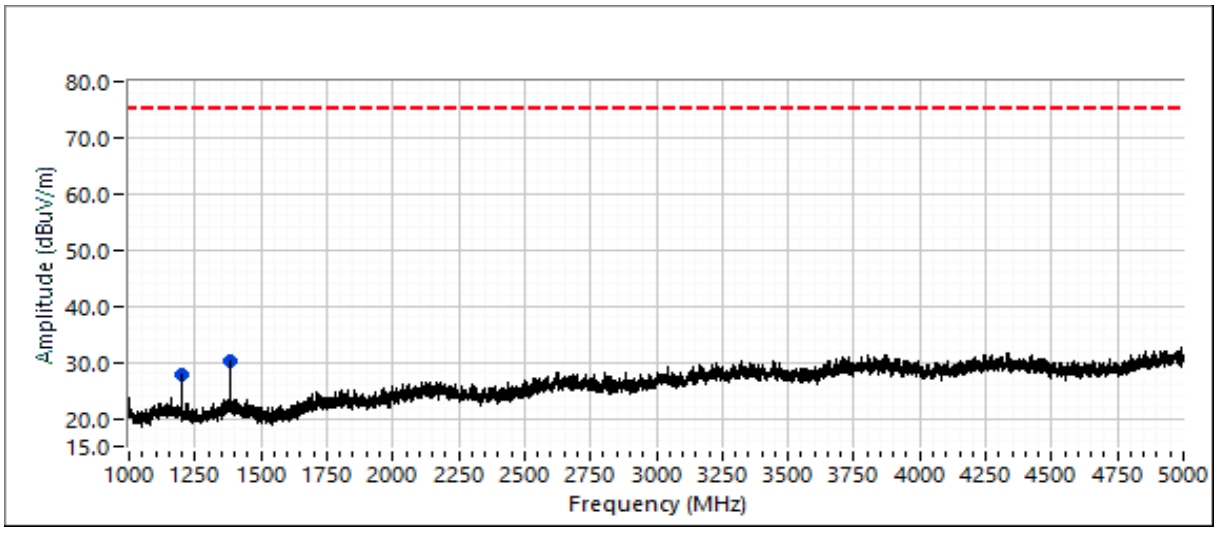




Client:	FreeWave Technologies, Inc.	PR Number:	PR167383
Model:	LRS455C	T-Log Number:	TL167383-RANA
		Project Manager:	Deepa Shetty
Contact:	Ofer Fisher	Project Engineer:	David Bare
Standard:	FCC Parts 15 & 90, RSS-119; EN55032	Class:	N/A

Plots for center channel (460 MHz), power setting(s) = 10





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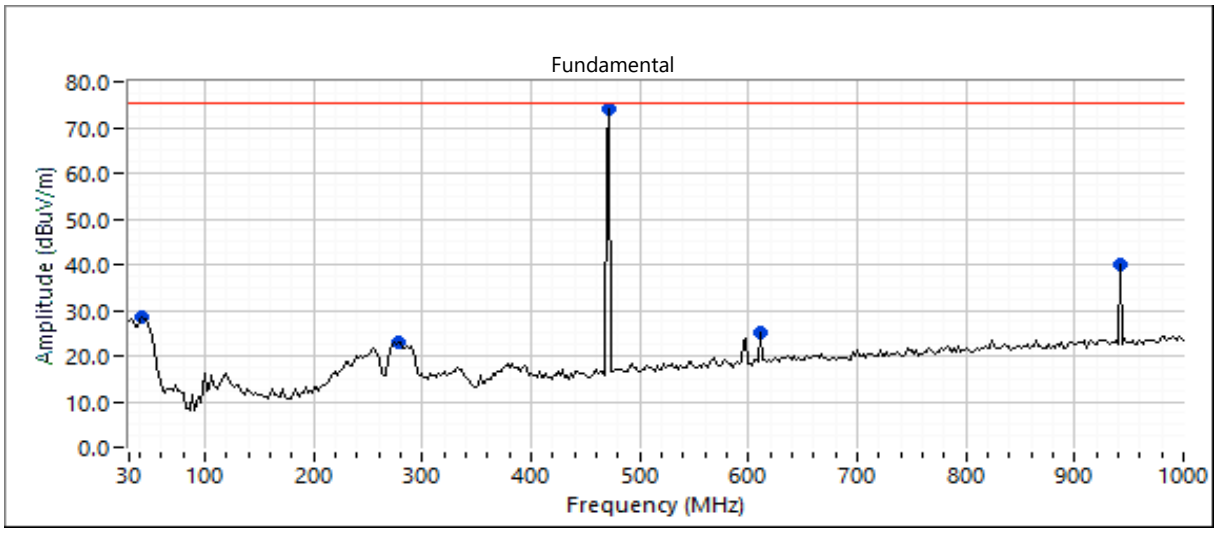
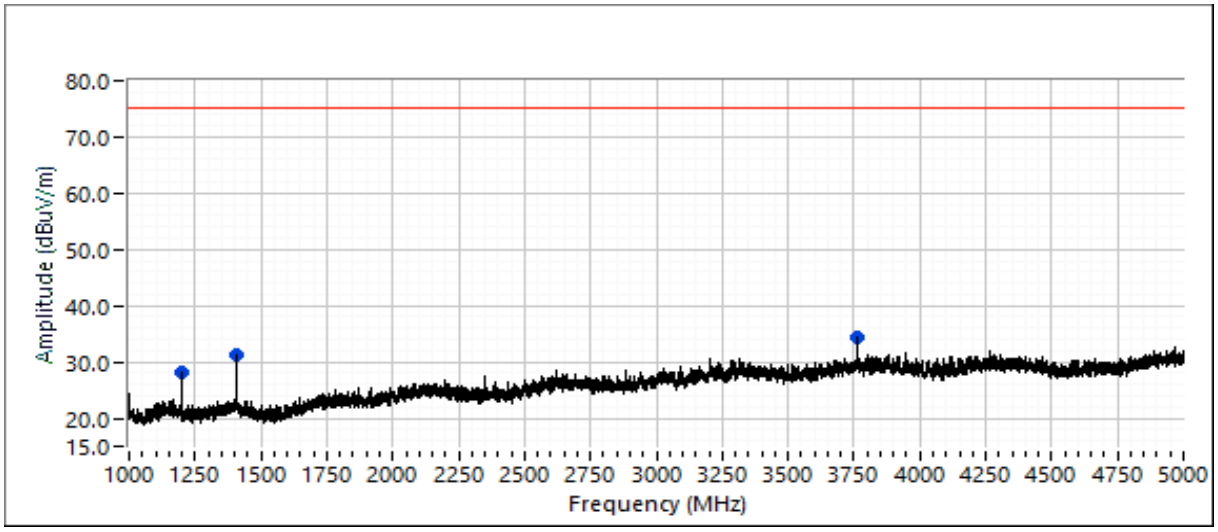
		Project Manager:	Deepa Shetty
Contact:	Ofer Fisher	Project Engineer:	David Bare
Standard:	FCC Parts 15 & 90, RSS-119; EN55032	Class:	N/A

Plots for high channel (470 MHz), power setting(s) = 10





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Model:	LRS455C	T-Log Number:	TL167383-RANA
		Project Manager:	Deepa Shetty
Contact:	Ofer Fisher	Project Engineer:	David Bare
Standard:	FCC Parts 15 & 90, RSS-119; EN55032	Class:	N/A

Run #5b: - Final Field Strength Measurements and Substitution Measurements

Date of Test: 12/19/2022 Config. Used: 1

Test Engineer: M. Birgani Config Change: None

Test Location: Chamber #4 EUT Voltage: 12VDC

EUT Field Strength

Frequency	Level	Pol	FCC Part 90		Detector	Azimuth	Height	Comments	Channel
MHz	dBµV/m	v/h	Limit	Margin	Pk/QP/Avg	degrees	meters		Freq
900.862	**44.2**	H	75.3	**-31.1**	PK	230	1.0	RB 1 MHz; VB: 3 MHz	450
3760.070	41.7	V	75.3	-33.6	PK	190	1.9	RB 1 MHz; VB: 3 MHz	470
1379.980	34.1	H	75.3	-41.2	PK	266	1.9	RB 1 MHz; VB: 3 MHz	460
1200.270	33.7	H	75.3	-41.6	PK	72	1.6	RB 1 MHz; VB: 3 MHz	435
1350.140	33.2	V	75.3	-42.1	PK	29	2.2	RB 1 MHz; VB: 3 MHz	450
1200.120	33.0	H	75.3	-42.3	PK	288	1.6	RB 1 MHz; VB: 3 MHz	450
1199.980	32.6	H	75.3	-42.7	PK	233	1.6	RB 1 MHz; VB: 3 MHz	470
1199.830	32.3	H	75.3	-43.0	PK	138	1.6	RB 1 MHz; VB: 3 MHz	460
41.663	31.4	V	75.3	-43.9	PK	340	1.0	RB 1 MHz; VB: 3 MHz	450
1414.890	31.2	H	75.3	-44.1	PK	319	1.0	RB 1 MHz; VB: 3 MHz	470
1304.740	30.9	V	75.3	-44.4	PK	223	2.2	RB 1 MHz; VB: 3 MHz	435
162.184	28.6	V	75.3	-46.7	PK	152	1.0	RB 1 MHz; VB: 3 MHz	450
928.076	25.4	V	75.3	-49.9	PK	125	1.5	RB 1 MHz; VB: 3 MHz	450

Note 1:	The field strength limit in the tables above was calculated from the erp/eirp limit detailed in the standard using the free space propagation equation: E=√(30PG)/d. This limit is conservative - it does not consider the presence of the ground plane and, for erp limits, the dipole gain (2.2dBi) has not been included. The erp or eirp for all signals with less than **20dB** of margin relative to this field strength limit is determined using substitution measurements.
Note 2:	Measurements are made with the antenna port terminated.

Substitution measurements

Note 1:	As none of the emissions were within 20 dB of the calculated field strength limit, no substitution measurements are required.

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		Project Manager:	Deepa Shetty
Contact:	Ofer Fisher	Project Engineer:	David Bare
Standard:	FCC Parts 15 & 90, RSS-119; EN55032	Class:	N/A

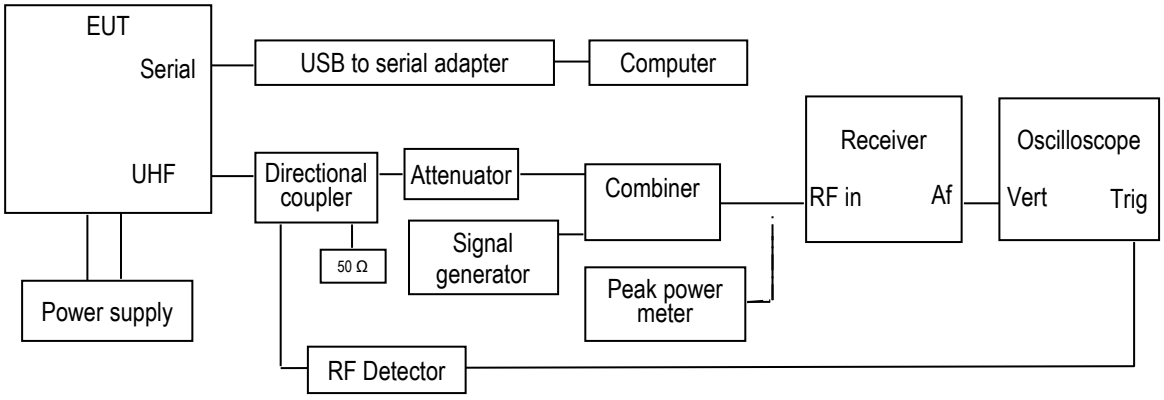
Run #6: Transient Frequency Behavior

Date of Test: 1/3/2023
Test Engineer: M. Birgani
Test Location: Chamber 2

Config. Used: 1
Config Change: None
EUT Voltage: 12 VDC

Transient frequency Behaviour measurements setup

Note: The test has been performed with the method given in ANSI / TIA 603-C (2.2.19)and ANSI C63.26-2015 section 6.5.2.3



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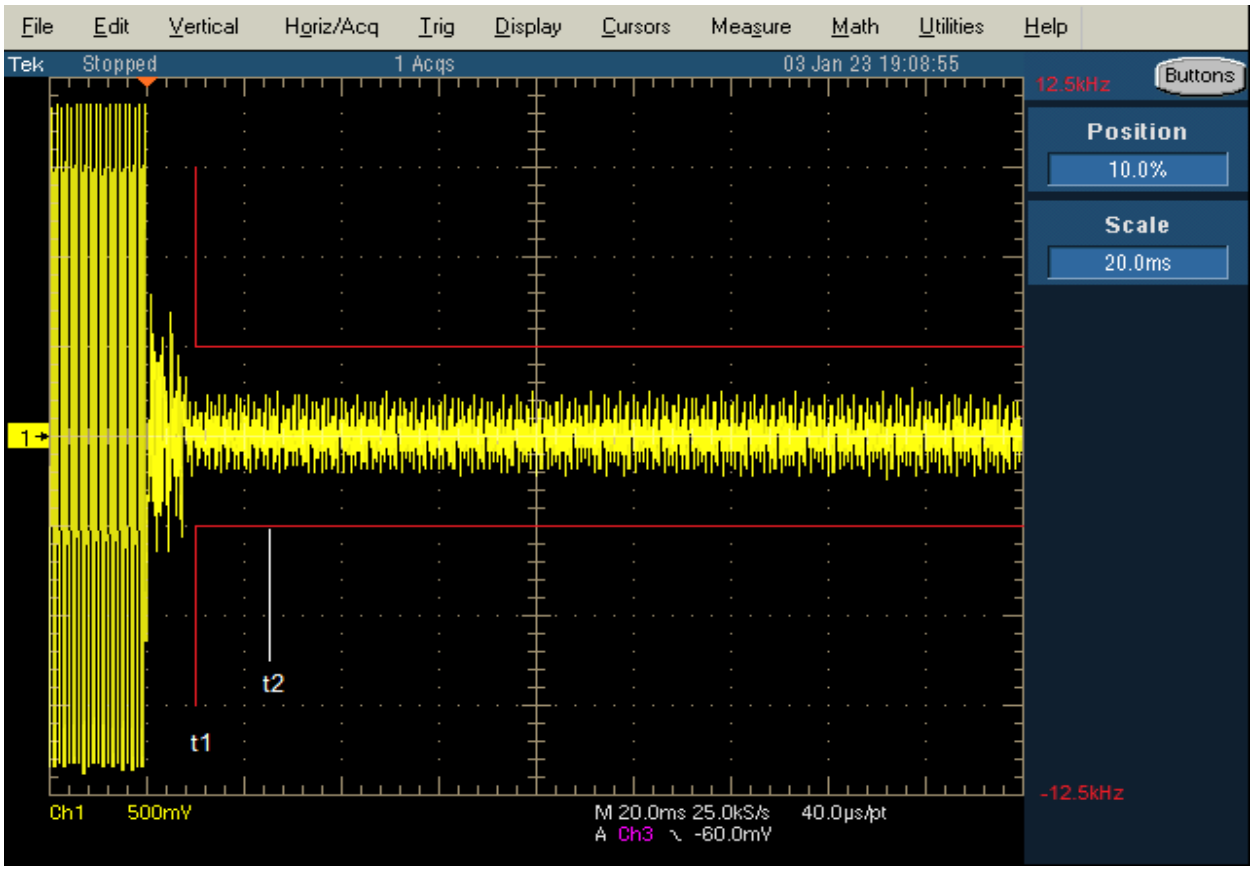
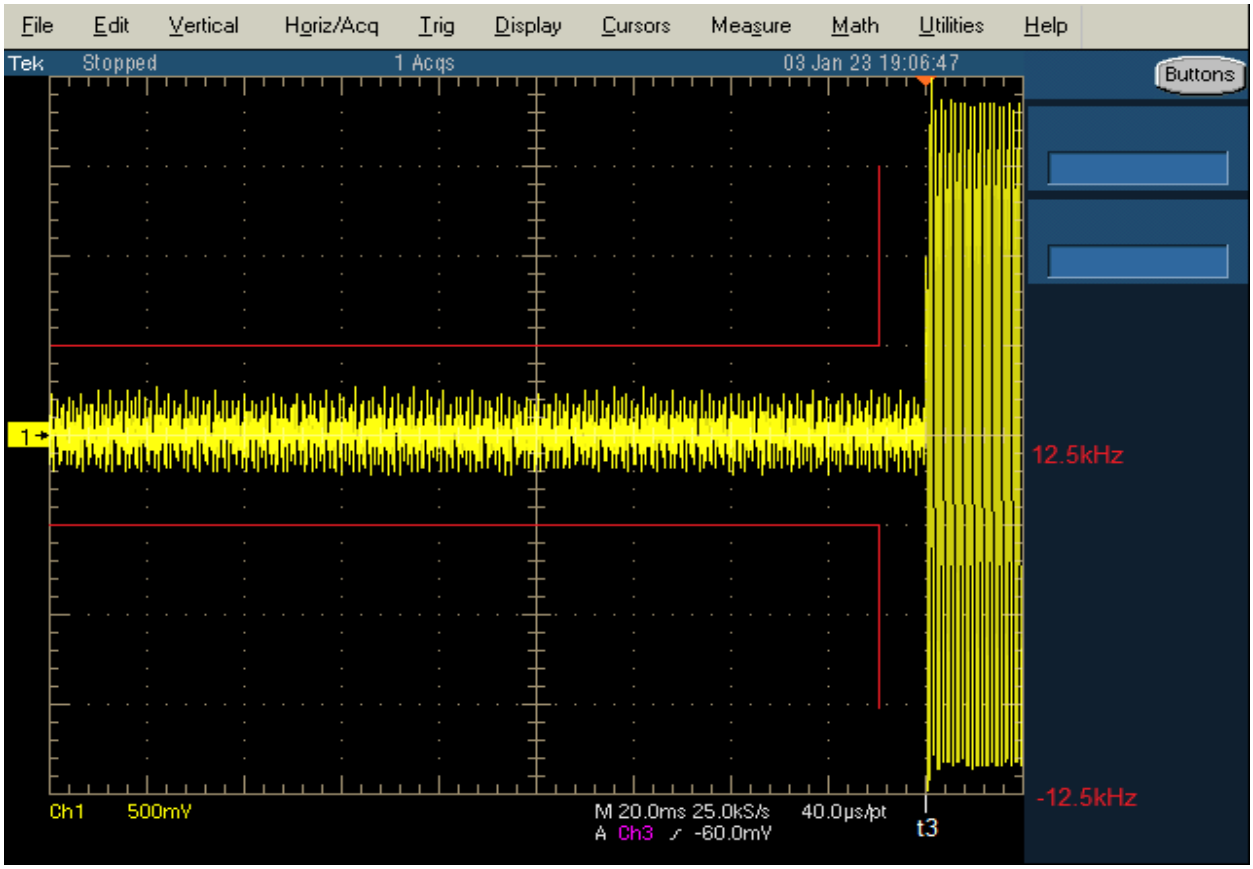
Model:	LRS455C	T-Log Number:	TL167383-RANA
		Project Manager:	Deepa Shetty
Contact:	Ofer Fisher	Project Engineer:	David Bare
Standard:	FCC Parts 15 & 90, RSS-119; EN55032	Class:	N/A

Run #6a
Carrier Frequency: 450 MHz
Channel Spacing: 12.5 kHz
Modulation: 2-level GFSK (CW)
Description: Switch on condition ton, t1, and t2



Client:	FreeWave Technologies, Inc.	PR Number:	PR167383
Model:	LRS455C	T-Log Number:	TL167383-RANA
		Project Manager:	Deepa Shetty
Contact:	Ofer Fisher	Project Engineer:	David Bare
Standard:	FCC Parts 15 & 90, RSS-119; EN55032	Class:	N/A

Run #6b
Carrier Frequency: 450 MHz
Channel Spacing: 12.5 kHz
Modulation: 2-level GFSK (CW)
Description: Switch off condition t3 and toff



Client:	FreeWave Technologies, Inc.	PR Number:	PR167383
Model:	LRS455C	T-Log Number:	TL167383-RANA
		Project Manager:	Deepa Shetty
Contact:	Ofer Fisher	Project Engineer:	David Bare
Standard:	FCC Parts 15 & 90, RSS-119; EN55032	Class:	N/A

Run #8: Frequency Stability

Date of Test: 1/4/2023 & 8/31/2023 — Config. Used: 1
Test Engineer: M.Birgani & D. Bare — Config Change: None
Test Location: Lab #3 — EUT Voltage: 6-27 VDC

Nominal Frequency: 459.996942 MHz

Frequency Stability Over Temperature

The EUT was soaked at each temperature for a minimum of 30 minutes prior to making the measurements to ensure the EUT and chamber had stabilized at that temperature.

Temperature	Frequency Measured	Drift	
(Celsius)	(MHz)	(Hz)	(ppm)
-30	459.997632	690	1.5
-20	459.997652	710	1.5
-10	459.997462	520	1.1
0	459.997312	370	0.8
10	459.997052	110	0.2
20	459.996942	0	0.0
30	459.996922	-20	0.0
40	459.997182	240	0.5
50	459.997332	390	0.8
	Worst case:	710	1.5

Frequency Stability Over Input Voltage

Nominal Voltage is 12Vdc.

Voltage	Frequency Measured	Drift	
(DC)	(MHz)	(Hz)	(ppm)
6.0	459.997003	61	0.1
85%	459.996967	25	0.1
115%	459.996977	35	0.1
27.0	459.997115	173	0.4
	Worst case:	35	0.4

Note 2:	Spectrum analyzer was set to RB: 100 Hz, VB: 300Hz Span: 3kHz

End of Report

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