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TEST REPORT

Mimomax MWL-TORNADO-BACA
Digital Linking Radio (400-430MHz)

tested to the

Code of Federal Regulations (CFR) 47

Part 90 –Private Land Mobile Services

for

Mimomax Wireless Ltd

This Test Report is issued with the authority of:

Andrew Cutler- General Manager

ACCREDITED
IANZ
TESTING LABORATORY

All tests reported herein have been performed in accordance with the laboratory's scope of accreditation

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1. COMPLIANCE STATEMENT

The **Mimomax MWL-TORNADO–BACA Digital Linking Radio** complies with the limits defined in 47 CFR Part 90 and 47 CFR Part 2 when tested in-accordance with the test methods described in 47 CFR Part 2, ANSI / TIA-603-E: 2016 and ANSI C63.26: 2015.

The client has requested for the addition of variants to this test report based on their technical assessment. At the end of the test report, the request letter has been appended for reference. The below models are equivalent to the MWL-TORNADO-BACA:

MWL-TORNADO-AAAA, MWL-TORNADO-AABA, MWL-TORNADO-AACA, MWL-TORNADO-BAAA, MWL-TORNADO-BABA, MWL-TORNADO-AAAB, MWL-TORNADO-AABB, MWL-TORNADO-AACB, MWL-TORNADO-BAAB, MWL-TORNADO-BABB, MWL-TORNADO-BACB

2. RESULT SUMMARY

The results of testing carried out between January and April 2024 are summarised below.

Clause	Description	Result	Page no
90.203	Certification required	Noted.	9
2.1046 90.205	RF power output Power and antenna height limits	Noted Complies	11
2.1049 2.202 90.207 90.209 90.210	Occupied bandwidth Bandwidths Types of emissions Bandwidth limitations Emission masks	Noted Noted Complies Complies Complies	 12 12 20
2.1051	Spurious emissions at antenna terminals	Complies	27
2.1053	Field strength of spurious radiation	Complies	30
2.1055 90.213	Frequency stability Frequency stability	Noted Complies	 33
90.214	Transient frequency behaviour	Complies	35
1.1310	Radio frequency exposure limits	Complies	40

3. ATTESTATION

This report describes the tests and measurements performed for the purpose of determining compliance with the specification.

The client selected the test sample.

This report relates only to the sample tested.

Any corrections or erasures to the report are indicated in the report revision table.

Measurement uncertainties with statistical confidence intervals of 95% are shown below test results. Both Class A and Class B uncertainties have been accounted for, as well as influence uncertainties where appropriate.

All compliance statements have been made with respect of the specification limit with no reference to the measurement uncertainty.

All testing was carried out as per the standard in the worst-case configuration with no deviations being applied.

In addition this equipment has been tested in accordance with the requirements contained in the appropriate Commission regulations.

All compliance statements have been made with respect of the specification limit with no reference to the measurement uncertainty.

To the best of my knowledge, these tests were performed using measurement procedures that are consistent with industry or Commission standards and demonstrate that the equipment complies with the appropriate standards.

I further certify that the necessary measurements were made by EMC Technologies NZ Ltd, 47 MacKelvie Street, Grey Lynn, Auckland, New Zealand.

Andrew Cutler
General Manager
EMC Technologies NZ Ltd

Report Revision Table

Version	Change Made	Date
231205.2	Initial Issue.	01/05/2024

4. CLIENT INFORMATION

Company Name	MiMOMax Wireless Ltd
Address	540 Wairakei Rd Burnside Christchurch 8053
Country	New Zealand
Contact	James Dowle

5. TEST SAMPLE DESCRIPTION

Brand Name	MiMOMax
Model Number	MWL-TORNADO-BACA
Product	Digital Linking Radio
Manufacturer	MiMOMax Wireless Ltd
Serial Number	UUT for Transmitter testing: 23004892
Firmware ID	4.8.4.1
RF Connectors	2 X 50 Ohm N Type Connectors
FCC ID	XMK-MMXTRNB008
FCC Certification range	400-430 MHz

Rated Transmitter Output Power

1 mW (0.0 dBm) to 0.25 watts (+24.0 dBm)

RMS power: +24.0 dBm (across all modulations)

The typical theoretical PARP (dB) for the modulations supported by the product is as in the range of 6 dB to 8 dB.

Product Description (From user manual):

The Mimomax Tornado Digital Link is an ultra-spectrally efficient, long range point to multipoint remote radio.

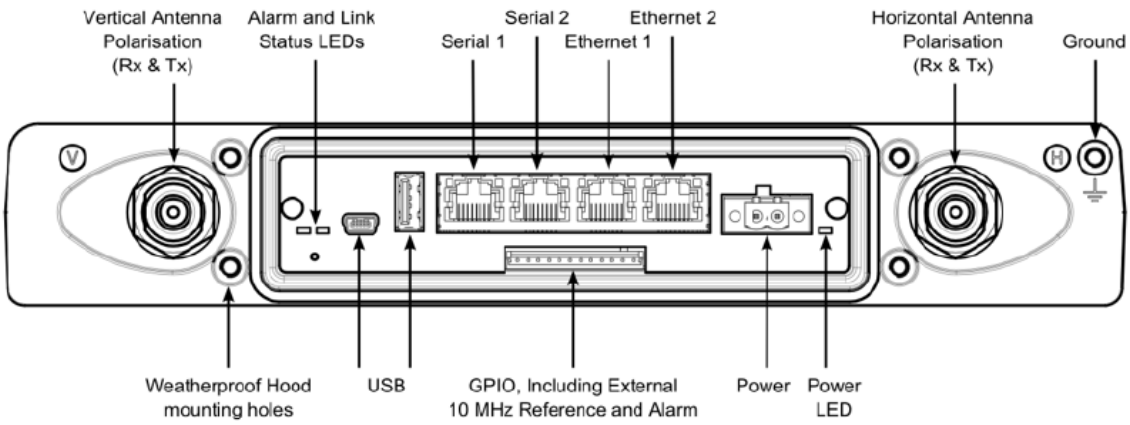
The radio unit has built in intelligent network features for Critical Network Infrastructure, providing economic SCADA and telemetry solutions for critical network infrastructure.

The Mimomax Tornado utilises multiple input, multiple output technology (2X2 MIMO). The multiple input/ outputs consist of 2 or 4 antenna connections depending on the duplexer configuration.

Antenna connections provide simultaneous Tx/Rx on orthogonal antenna polarisations.

Tornado radios provide a radio wireless infrastructure for connecting devices used by various applications to form a network through which IP data, RS-232 serial data or RS485 synchronous serial data can seamlessly flow.

Features include isolated power supply with low power consumption, full duplex operation with built in duplexers and supporting a combination of interfaces, with very high scalable data rates, remote over the air network management, optional SNMP, ModBus and DNP3 support and a random-access protocol.



Product connector diagram from the user manual

Test Power Source

The test power source used for this report is identified in the equipment list at the end of this report. The test voltage was measured at the point of connection of the power cable to the test sample equipment.

Normal test conditions

Normal Temperature and Humidity

Temperature: +25 °C ± 4 °C maintained.
Relative Humidity: 60 % ± 10 % observed.

Normal Test Power Source

The equipment is powered using an external DC supply.

Other Power Source

Test Voltage: 24.0 VDC

Extreme Test Conditions

Extreme Temperature
High Temperature: + 50 °C maintained.
Low Temperature: - 30 °C maintained.

Extreme Voltage (Noted as per the user manual)

High Voltage: 60.0 VDC
Low Voltage: 10.5 VDC

Test frequencies

Frequency (MHz)	Channel Spacing (kHz)	Modulation Type	Test Type	UUT ID
407.9500 412.9500 427.9125	12.5 & 25.0	QPSK	Transmit	23004892
	12.5 & 25.0	16QAM	Transmit	
	12.5 & 25.0	64QAM	Transmit	
	12.5 & 25.0	256QAM	Transmit	

Note: Change of Duplexers inside the product was required to test each frequency mentioned in the above table.

Setup Description:

Transmitter Testing Setup:

The device was connected to the laptop via an Ethernet cable. A static IP address was used to connect to the device.

Google chrome with this IP in the address bar was used to access the product setup.

For Transient Adjacent channel power test RRU style burst mode was selected.

The product has 2 antenna ports labelled as V and H. Both the ports were tested with one port terminated at a time by an attenuator capable of handling >20 Watt power.

Changing the modulation type and enabling/disabling the transmitter was performed remotely using the web server running the client application.

Snapshot of the software used to control the product

6. TEST RESULTS

Certification required

Part 90.203(j)

Except where otherwise specially provided for, transmitters operating on frequencies in the 150-174 MHz and 406-512 MHz bands must comply with the following:

(1) Applications for certification of mobile and portable equipment designed to transmit voice on public safety frequencies in the 150-174 MHz or 450-470 MHz band will be granted only if the mobile/portable equipment is capable of operating in the analog FM mode on the nationwide public safety interoperability channels in the 150-174 MHz band or 450-470 MHz band, as appropriate. (See § 90.20(c), (d)(80) of this part.)

- The product is a base station transmitter. This clause is not applicable.

(4) Applications for part 90 certification of transmitters designed to operate on frequencies in the 150.8-162.0125 MHz, 173.2-173.4 MHz, and/or 421-512 MHz bands, received on or after January 1, 2011, except for hand-held transmitters with an output power of two watts or less, will only be granted for equipment with the following channel bandwidths:

- The product tested operates within 421.0-512.0 MHz band and hence certification is required.

(i) 6.25 kHz or less for single bandwidth mode equipment;

(ii) 12.5 kHz for multi-bandwidth mode equipment with a maximum channel bandwidth of 12.5 kHz if it is capable of operating on channels of 6.25 kHz or less;

(iii) 25 kHz for multi-bandwidth mode equipment with a maximum channel bandwidth of 25 kHz if it is capable of operating on channels of 6.25 kHz or less; and

(iv) Up to 25 kHz if the equipment meets the efficiency standard of paragraph (j)(5) of this section.

- The product is a base station transmitter which supports channel bandwidths of 12.5 kHz and 25.0 kHz. Spectrum efficiency details have been provided in this test report.

(5) Applications for part 90 certification of transmitters designed to operate on frequencies in the 150.8-162.0125 MHz, 173.2-173.4 MHz, and/or 421-512 MHz bands, received on or after January 1, 2011, must include a certification that the equipment meets a spectrum efficiency standard of one voice channel per 6.25 kHz of channel bandwidth.

Additionally, if the equipment is capable of transmitting data, has transmitter output power greater than 500 mW, and has a channel bandwidth of more than 6.25 kHz, the equipment must be capable of supporting a minimum data rate of 4800 bits per second per 6.25 kHz of channel bandwidth.

- The product does not support voice capability and 6.25 kHz channel bandwidth. Compliance to Part 90.203(j) (10) has been applied.

(7) Transmitters designed only for one-way paging operations may be certified with up to a 25 kHz bandwidth and are exempt from the spectrum efficiency requirements of paragraphs (j)(3) and (j)(5) of this section.

- Not applicable.

(10) Except as provided in this paragraph, single-mode and multi-mode transmitters designed to operate in the 150-174 MHz and 421-512 MHz bands that operate with a maximum channel bandwidth greater than 12.5 kHz shall not be manufactured in, or imported into, the United States after January 1, 2011, except as follows:

(i) To the extent that the equipment meets the efficiency standard of paragraph (j)(3) of this section, or

(ii) Where operation with a bandwidth greater than 12.5 kHz is specified elsewhere.

- Noted and Applied. Spectrum efficiency details have been provided in this test report.

§2.1046, § 90.205 RF power output

Measurements were carried out at the RF output terminals of the transmitter using a 60 dB power attenuator and a 50 Ω dummy load.

Measurements were carried out when the transmitter was not being modulated. Testing was carried out at maximum power output on a wide band power meter.

Maximum transmitter power (CW) - Rated 0.25W (+24.0 dBm)

Frequency: 407.950 MHz

Port Tested	Temp (°C)	10.5 VDC (dBm)	24.0 VDC (dBm)	60.0 VDC (dBm)
V	**+25**	23.6	23.6	23.6
H	**+25**	23.6	23.6	23.6

Frequency: 427.9125 MHz

Port Tested	Temp (°C)	10.5 VDC (dBm)	24.0 VDC (dBm)	60.0 VDC (dBm)
V	**+25**	23.9	23.9	23.9
H	**+25**	23.9	23.9	23.9

Frequency: 412.950 MHz

Port Tested	Temp (°C)	Low VDC (dBm)	Mid VDC (dBm)	High VDC (dBm)
V	**+55**	24.8	24.8	24.8
	+25	24.1	24.1	24.1
	-30	24.6	24.6	24.6
H	**+55**	24.8	24.8	24.8
	+25	24.0	24.0	24.0
	-30	24.6	24.6	24.6

Limits:

Part 90 does not specify the transmitter output power

Result: Complies.

Measurement Uncertainty: ± 0.5 dB

§90.207 Emission types and §90.209 bandwidth limitations:

The following emission types are used: W1W, these have been elaborated as under:

The modulations tested are QPSK, 16QAM, 64QAM and 256 QAM for 12.5 kHz and 25.0 kHz channel bandwidths

The authorised bandwidth is taken to be the necessary bandwidth.

Measurements have been made to verify this declared bandwidth using the various modulation types and data rates that the device under test can support at each test frequency.

Measurements were made using a spectrum analyser that was operating in occupied bandwidth mode with the 99% power points being determined automatically.

The analyser was set up with a resolution bandwidth video bandwidth as per 47 CFR Part 2, ANSI / TIA-603-E-2016 and ANSI C63.26: 2015.

Attached to the input of the spectrum analyser was an external high power attenuator.

All the measurements that have been tabulated were made but only the representative plots have been included in the test report in order to simplify the test report.

Result: Complies

Measurement Uncertainty: ± 1.5 dB

Measurement results:

Ports V and Port H have shown identical measurements.

Emission Type- 12.5 kHz spacing.

Modulation Type	Frequency (MHz)	Measured (kHz)	Authorised Bandwidth
256QAM	407.950	10.311	11.200 kHz
QPSK	412.950	10.441	
16QAM	412.950	10.419	
64QAM	412.950	10.358	
256QAM	412.950	10.302	
256QAM	427.9125	10.434	

Emission Type- 25.0 kHz spacing.

Modulation Type	Frequency (MHz)	Measured (kHz)	Authorised Bandwidth
256QAM	407.950	18.694	20.000 kHz
QPSK	412.950	18.867	
16QAM	412.950	18.838	
64QAM	412.950	18.805	
256QAM	412.950	18.811	
256QAM	427.9125	18.786	

***** The Authorized bandwidth has been listed as per §90.209(b)(5)

Result: Complies.

Table 1 to § 90.209(b)(5)—Standard Channel Spacing/Bandwidth

Frequency band (MHz)	Channel spacing (kHz)	Authorized bandwidth (kHz)
Below 25[2]		
25–50	20	20
72–76	20	20
150–174	[1]7.5	[1 3] 20/11.25/6
216–220[5]	6.25	20/11.25/6
220–222	5	4
406–512[2]	[1] 6.25	[1 3 6] 20/11.25/6

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

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

[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).

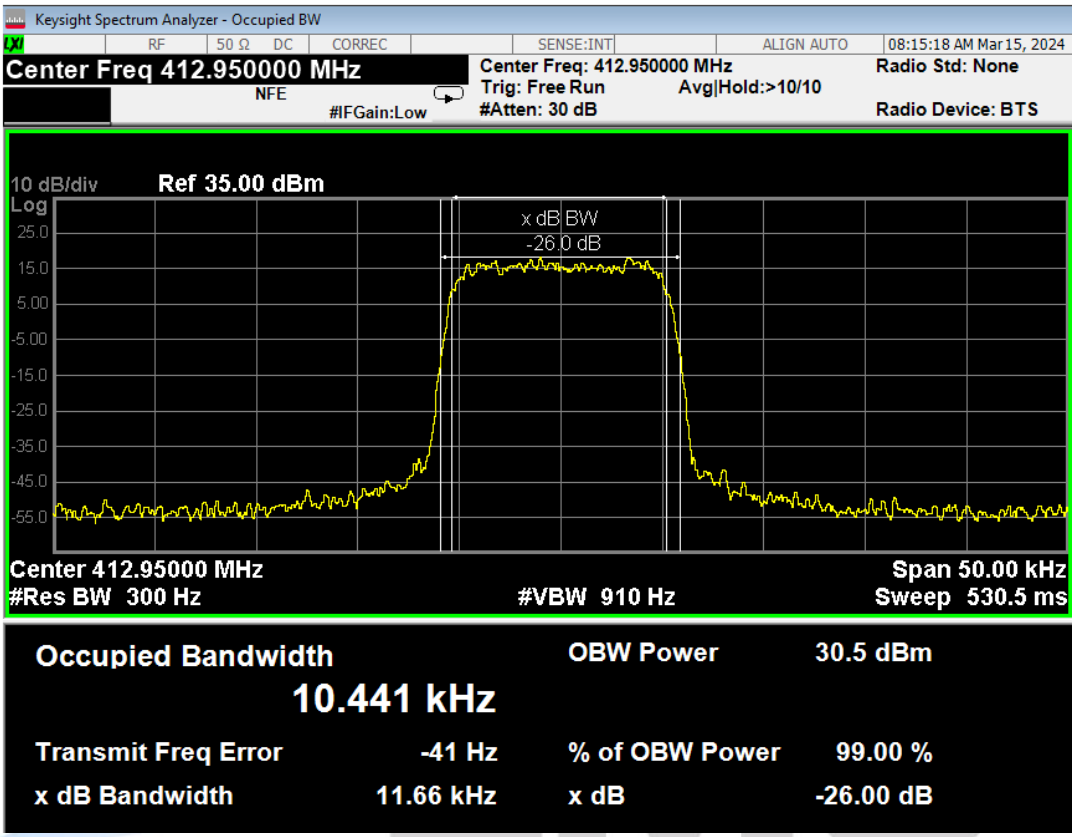
[4] The maximum authorized bandwidth shall be 12 MHz for non-multilateration LMS operations in the band 909.75–921.75 MHz and 2 MHz in the band 902.00–904.00 MHz. The maximum authorized bandwidth for multilateration LMS operations shall be 5.75 MHz in the 904.00–909.75 MHz band; 2 MHz in the 919.75–921.75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

[5] See § 90.259.

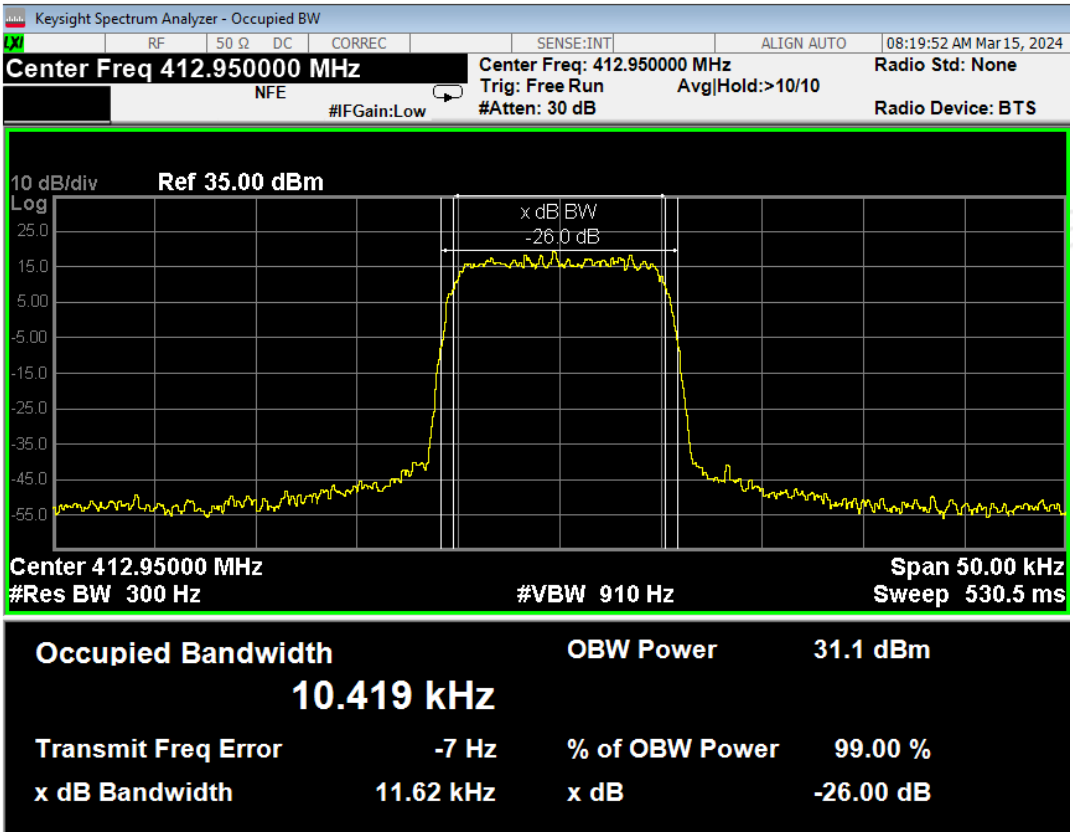
[6] Operations using equipment designed to operate with a 25 kilohertz channel bandwidth may be authorized up to a 20 kilohertz bandwidth unless the equipment meets the Adjacent Channel Power limits of § 90.221 in which case operations may be authorized up to a 22 kilohertz bandwidth. Operations using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

Occupied Bandwidth Measurement Plots:

Port V/ QPSK/12.5 kHz

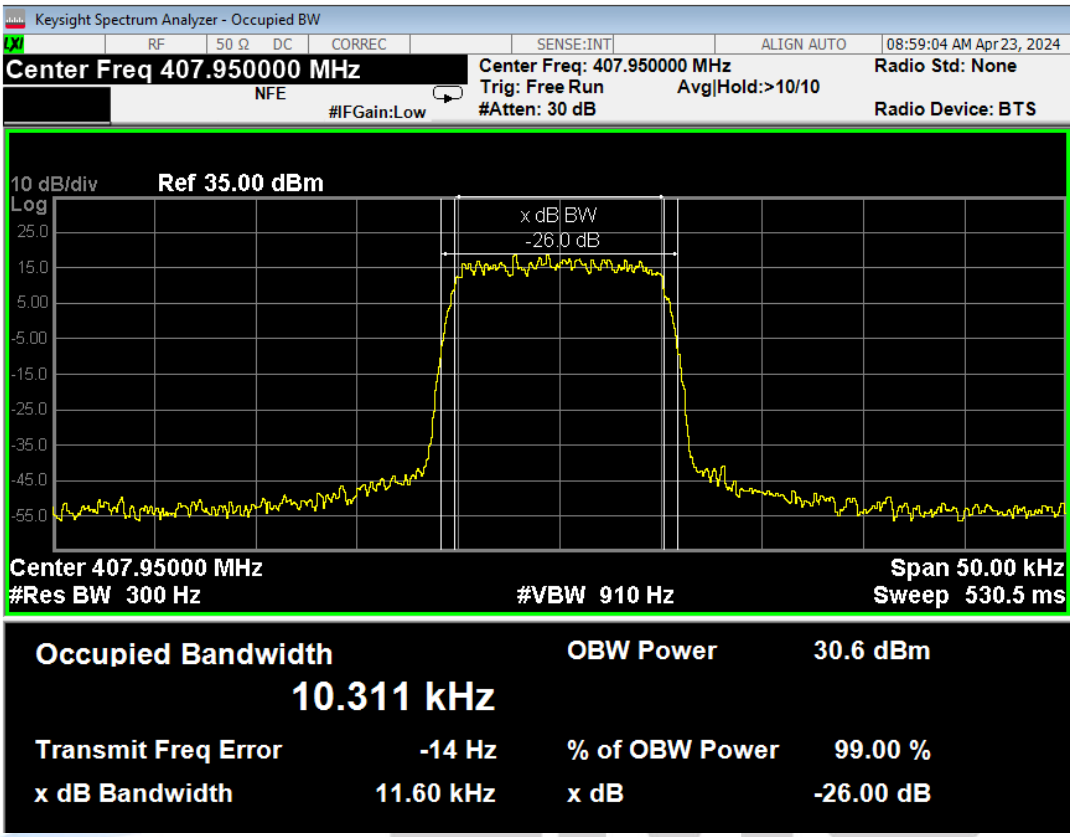


Port V/ 16QAM/12.5 kHz

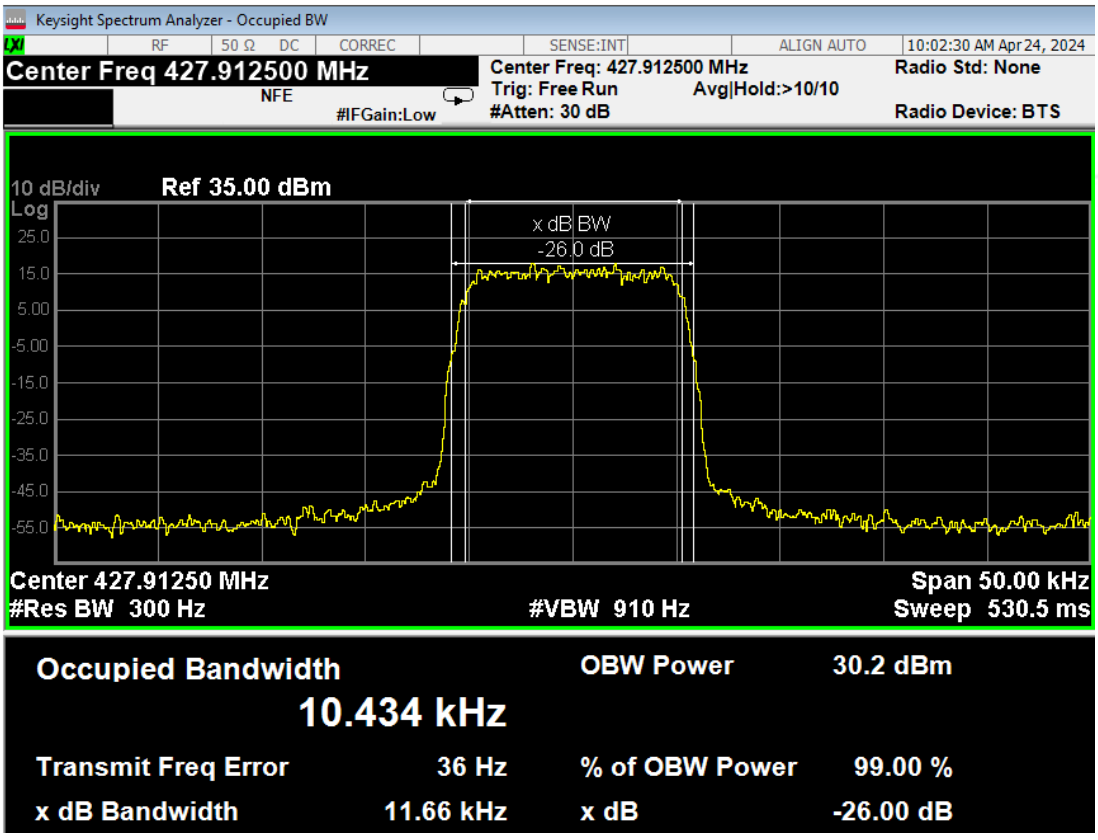


Occupied Bandwidth Measurement Plots:

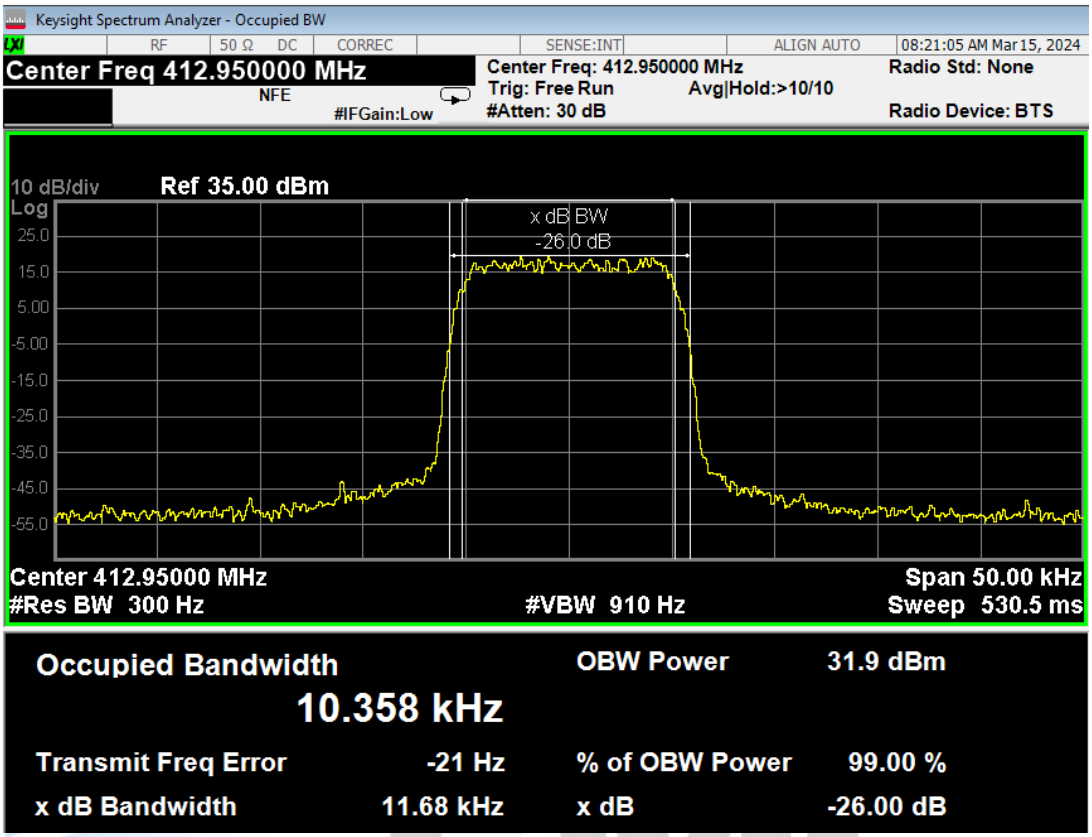
Port V/ 256QAM/12.5 kHz



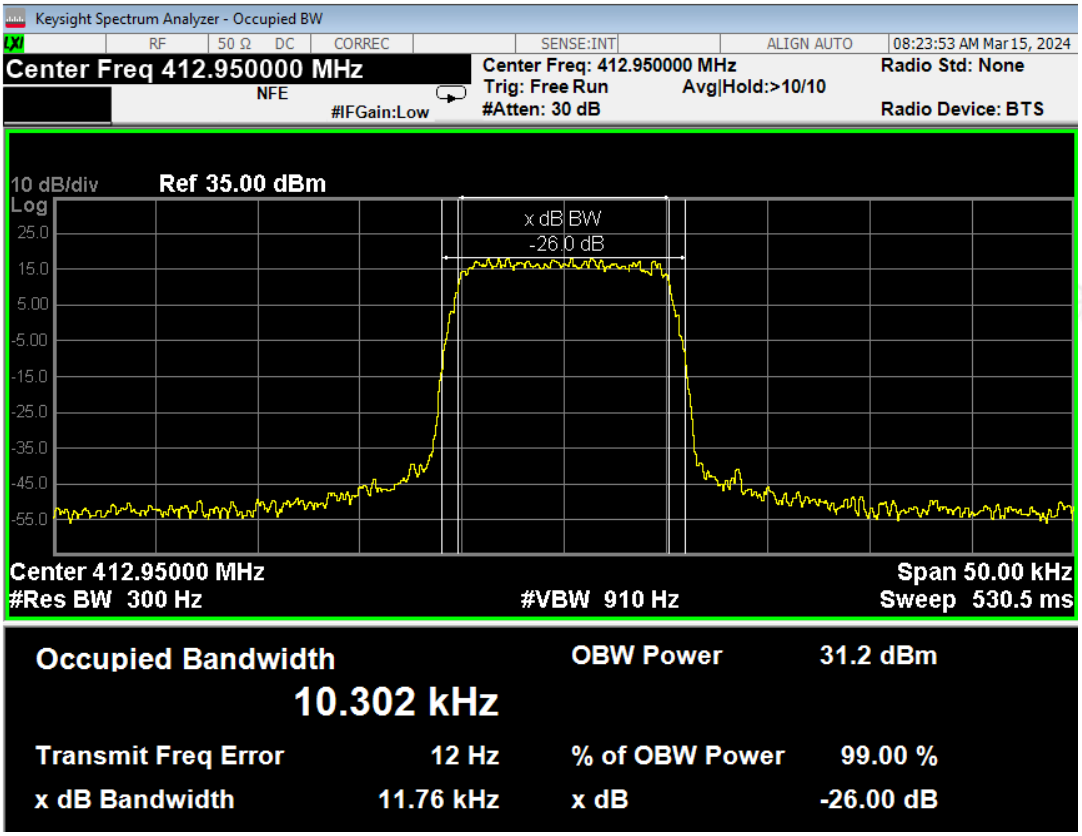
Port V/ 256QAM/12.5 kHz



Port V/ 64QAM/12.5 kHz

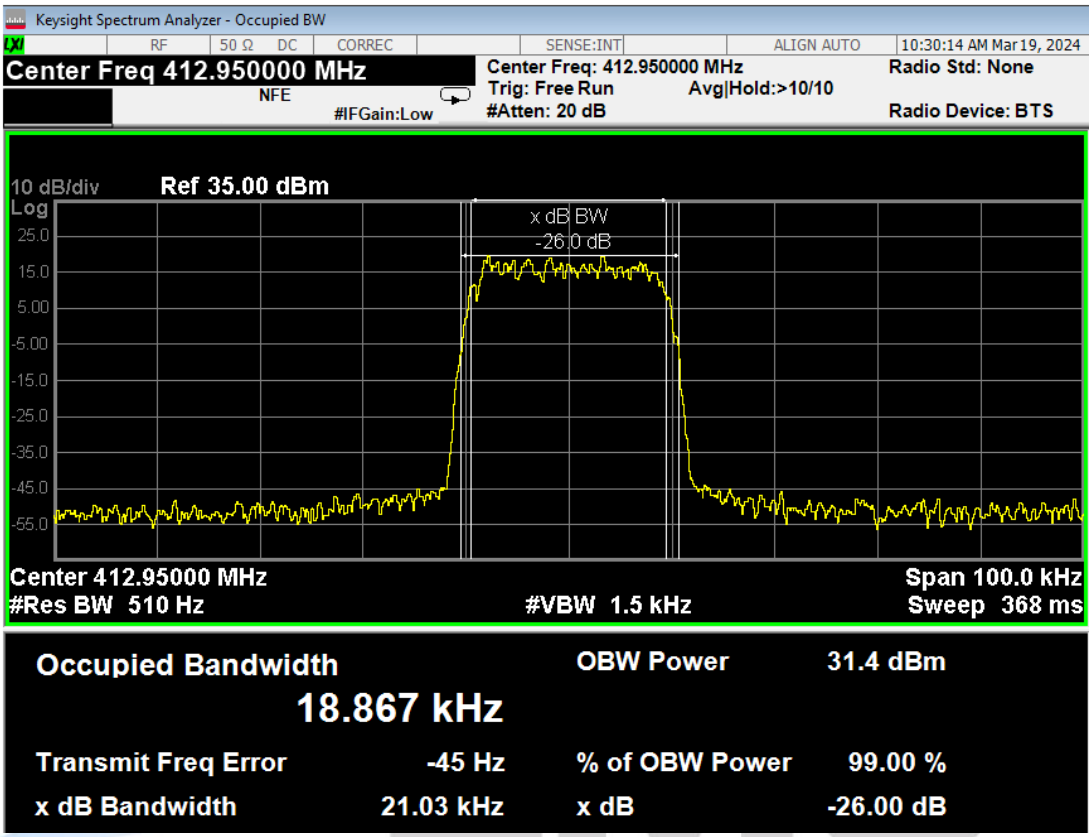


Port V/ 256QAM/12.5 kHz

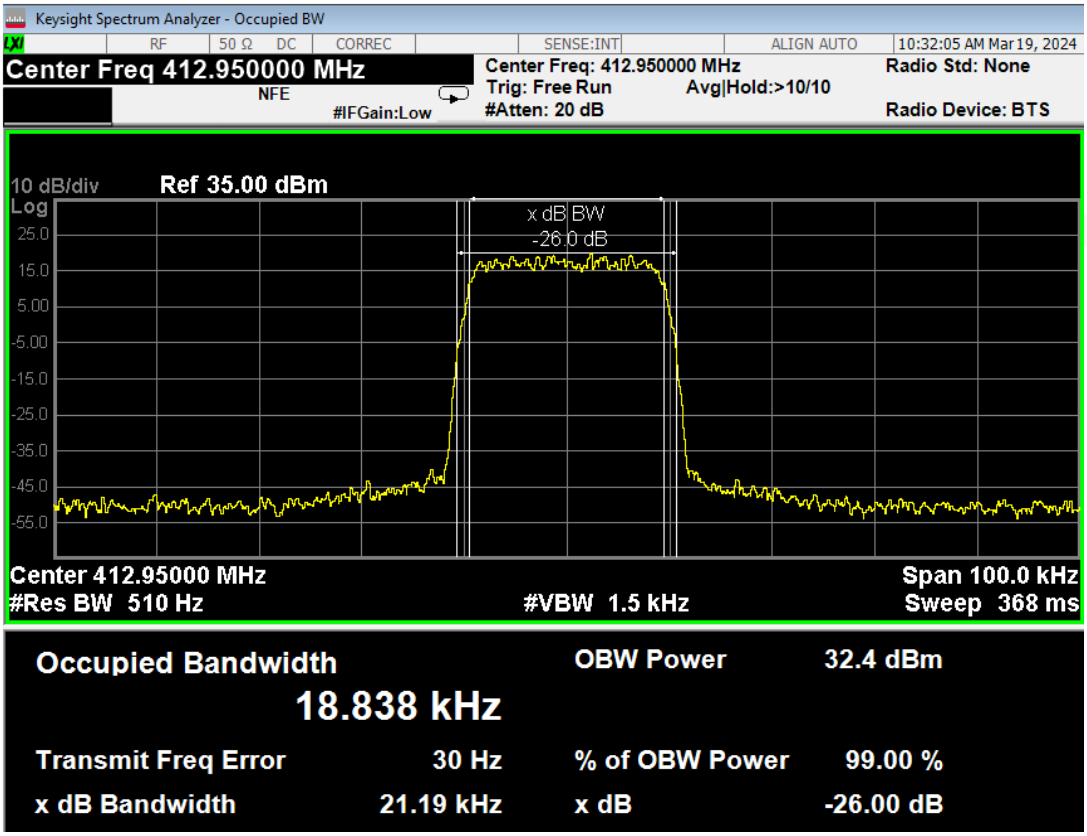


Occupied Bandwidth Measurement Plots:

Port V/ QPSK/25.0 kHz

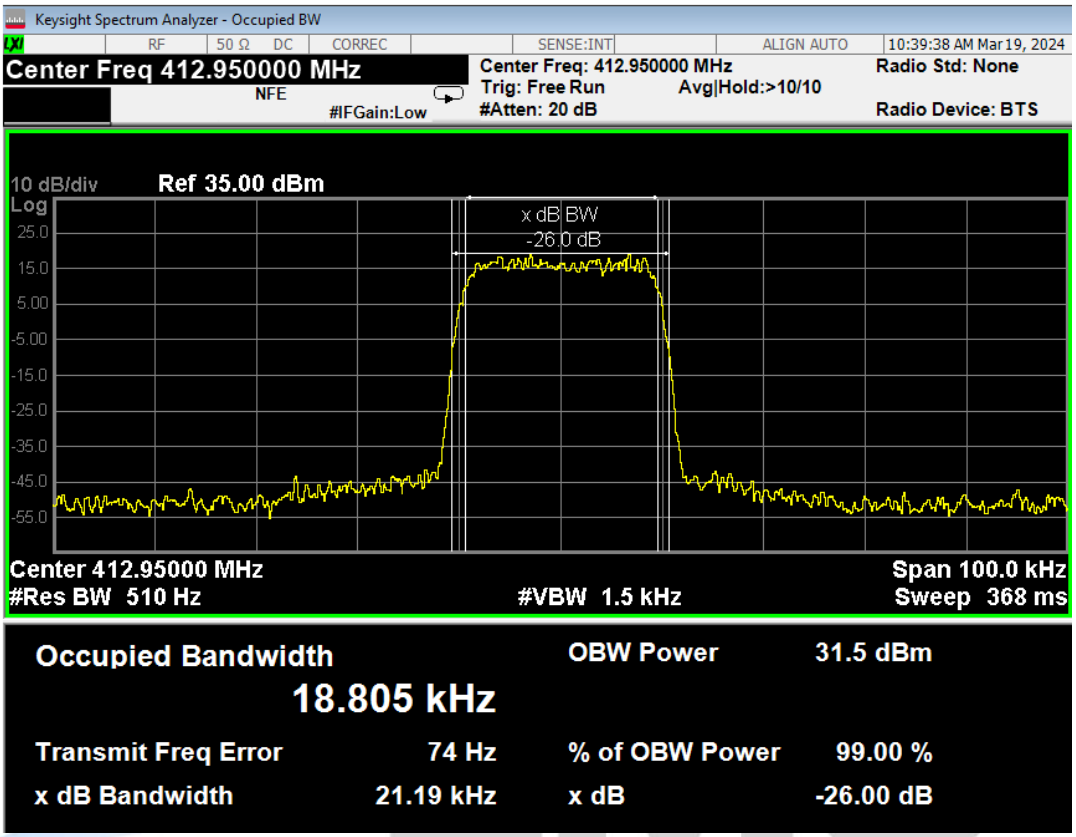


Port V/ 16QAM/25.0 kHz

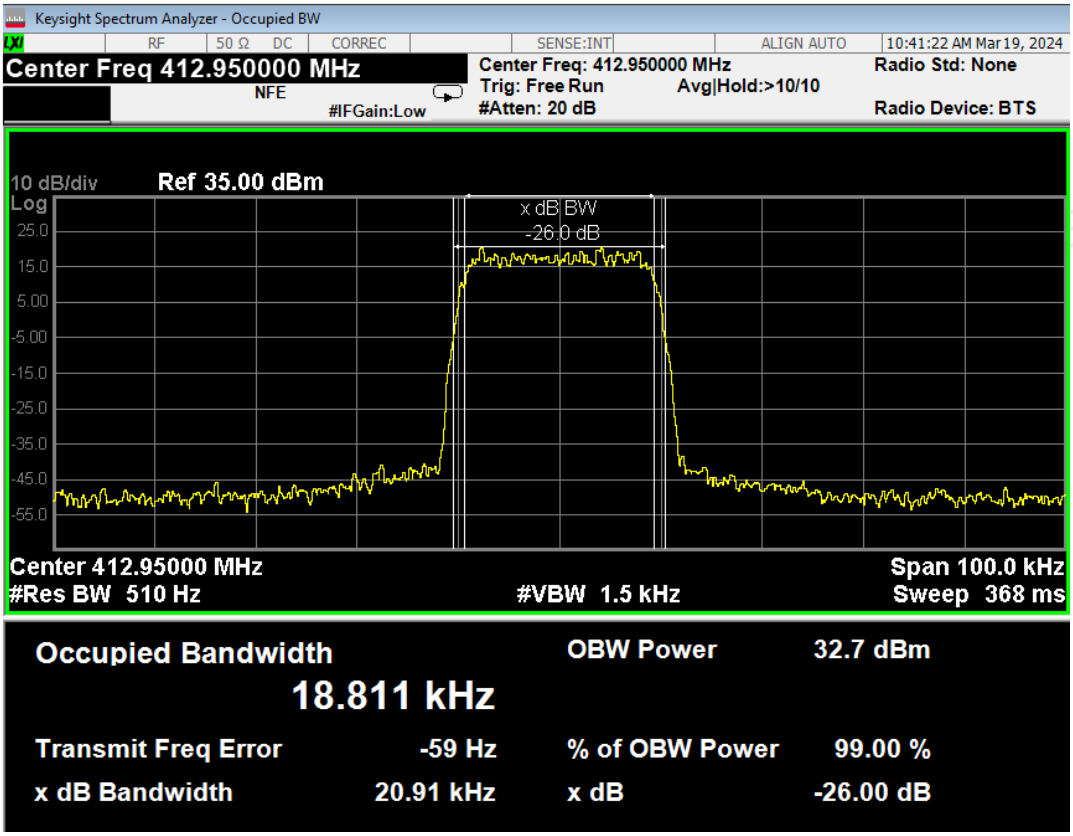


Occupied Bandwidth Measurement Plots:

Port V/ 64QAM/25.0 kHz



Port V/ 256QAM/25.0 kHz



§90.210 Spectrum Emission Masks

As per the client, the product does not have audio filters, Section 90.210(d) – Mask D and Mask C have been applied as the transmitter can operate in the band 400.000-430.000 MHz using an authorised bandwidth of 12.5 kHz and 25.0 kHz respectively as per Section 90.209(b)(5).

For all measurements a high power attenuator is placed between the transmitter and the spectrum analyser. Measurements were made in peak hold.

For showing compliance of the product to emission masks plots at various modulation and channel bandwidths when the product was operating in the 400.000-430.000 MHz frequency range have been presented in the test report.

All the measurements were performed when the product was operating at a high power setting (0.25 Watts).

During peak detector measurement performed using Peak detector in the spectrum analyser and trace maxhold, the reference level was set to the modulated emissions PARP obtained using a wide resolution bandwidth (>120 kHz).

During Average detector measurement performed using Avg detector in the spectrum analyser and trave Avg, the reference level was set to the RMS value of the emission as observed using a wide resolution bandwidth (>120 kHz).

12.5 kHz channel mask measurements were performed using both Peak and Average detector measurement method. Both the methods have been found to given similar results.

25.0 kHz channel mask measurement has been carried out using Average detector measurement with up to 100 trace averaging performed.

Result: Complies.
Measurement Uncertainty: 1.5 dB

§90.210- Applicable Emission Masks

Frequency band (MHz)	Mask for equipment with audio low pass filter	Mask for equipment without audio low pass filter
Below 25[1]	A or B	A or C
25–50	B	C
72–76	B	C
150–174[2]	B, D, or E	C, D or E
150 paging only	B	C
220–222	F	F
421–512[2 5]	B, D, or E	C, D, or E
450 paging only	B	G
806–809/851–854[6]	B	H
809–824/854–869[35]	B, D	D, G.
896–901/935–940	I	J

[1] Equipment using single sideband J3E emission must meet the requirements of Emission Mask A. Equipment using other emissions must meet the requirements of Emission Mask B or C, as applicable.

[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.

[3] Equipment used in this licensed to EA or non-EA systems shall comply with the emission mask provisions of § 90.691 of this chapter.

[4] DSRCS Roadside Units in the 5895–5925 MHz band are governed under subpart M of this part.

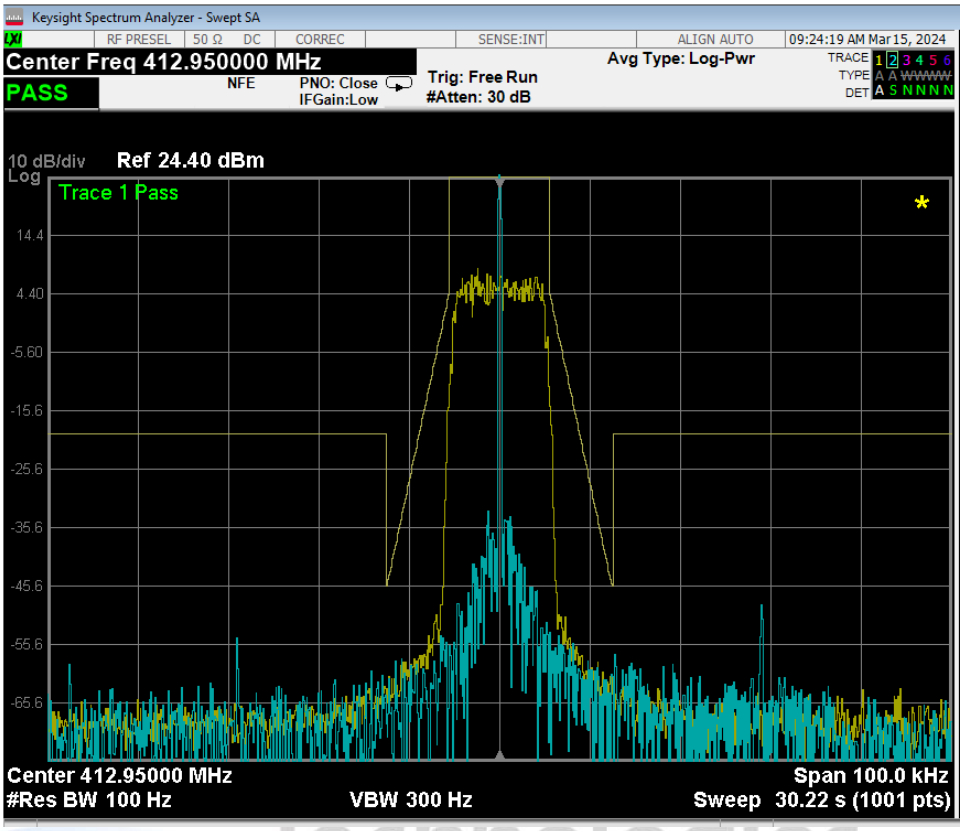
[5] Equipment designed to operate on 25 kilohertz bandwidth channels must meet the requirements of either Emission Mask B or G, whichever is applicable, while equipment designed to operate on 12.5 kilohertz bandwidth channels must meet the requirements of Emission Mask D. Equipment designed to operate on 25 kilohertz bandwidth channels may alternatively meet the Adjacent Channel Power limits of § 90.221.

[6] Transmitters utilizing analog emissions that are equipped with an audio low-pass filter must meet Emission Mask B. All transmitters utilizing digital emissions and those transmitters using analog emissions without an audio low-pass filter must meet Emission Mask H.

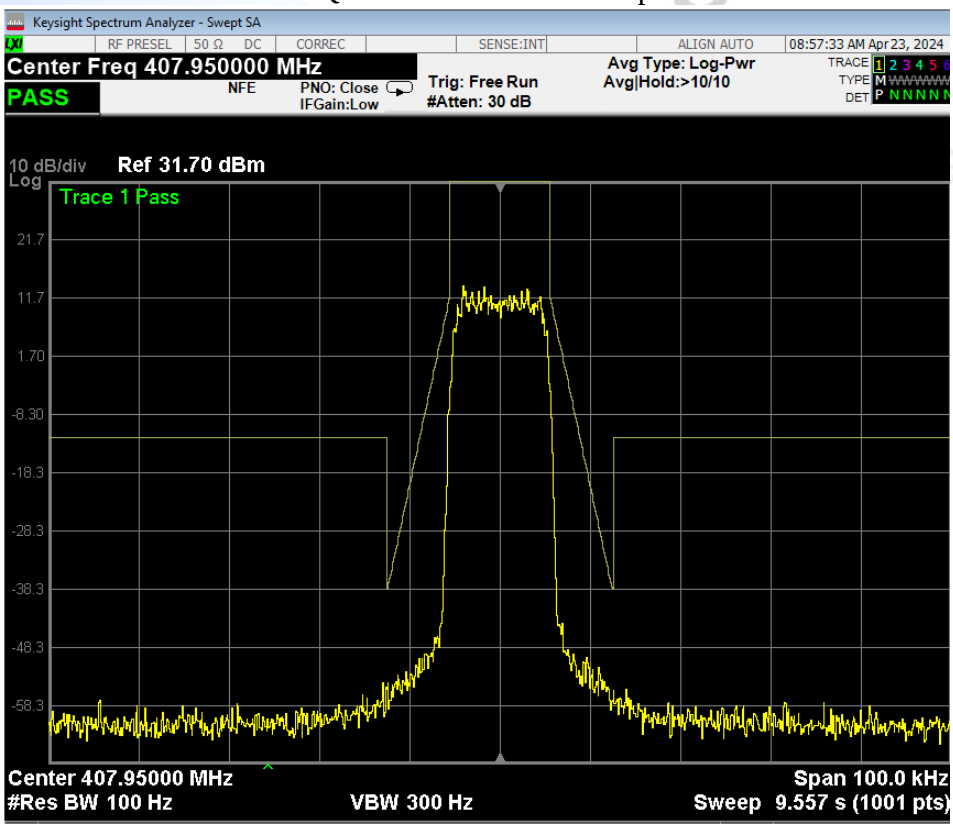
12.5 kHz Channel bandwidth emission mask-D

The measurements using peak and average detector methods have shown similar results for compliance

Port-V/256QAM/12.5 kHz/Mask D/RMS mode

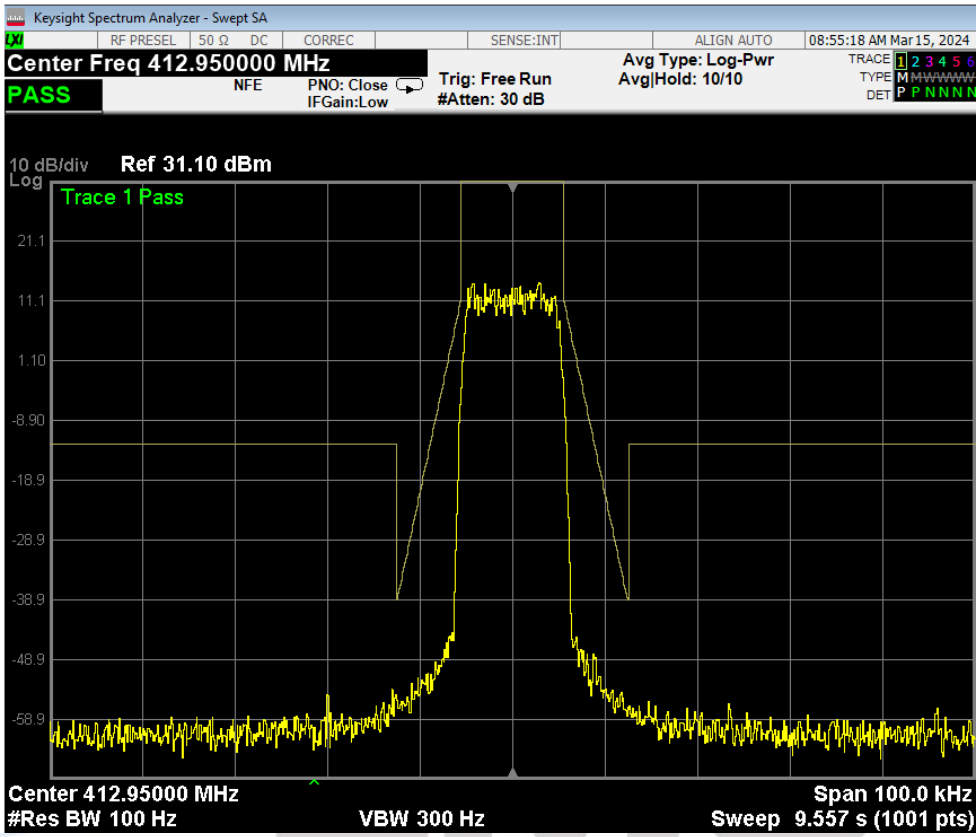


Port-V/256QAM/12.5 kHz/Mask D/peak mode

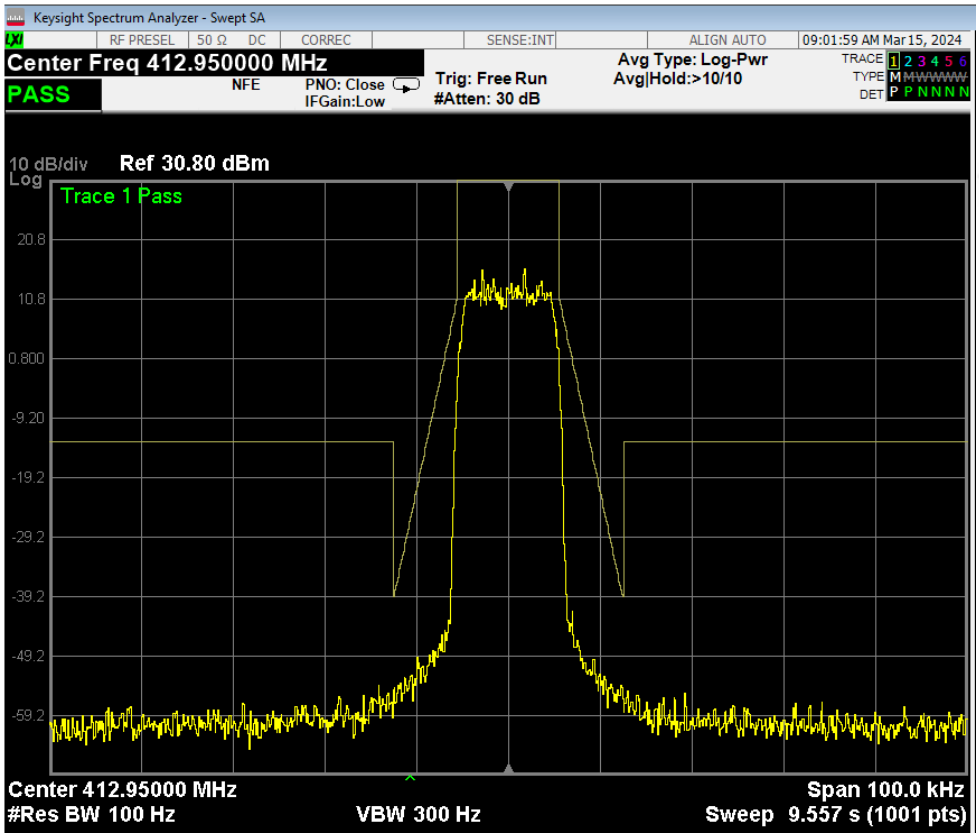


12.5 kHz Channel bandwidth emission mask-D

Port-V/16QAM/12.5 kHz/Mask D

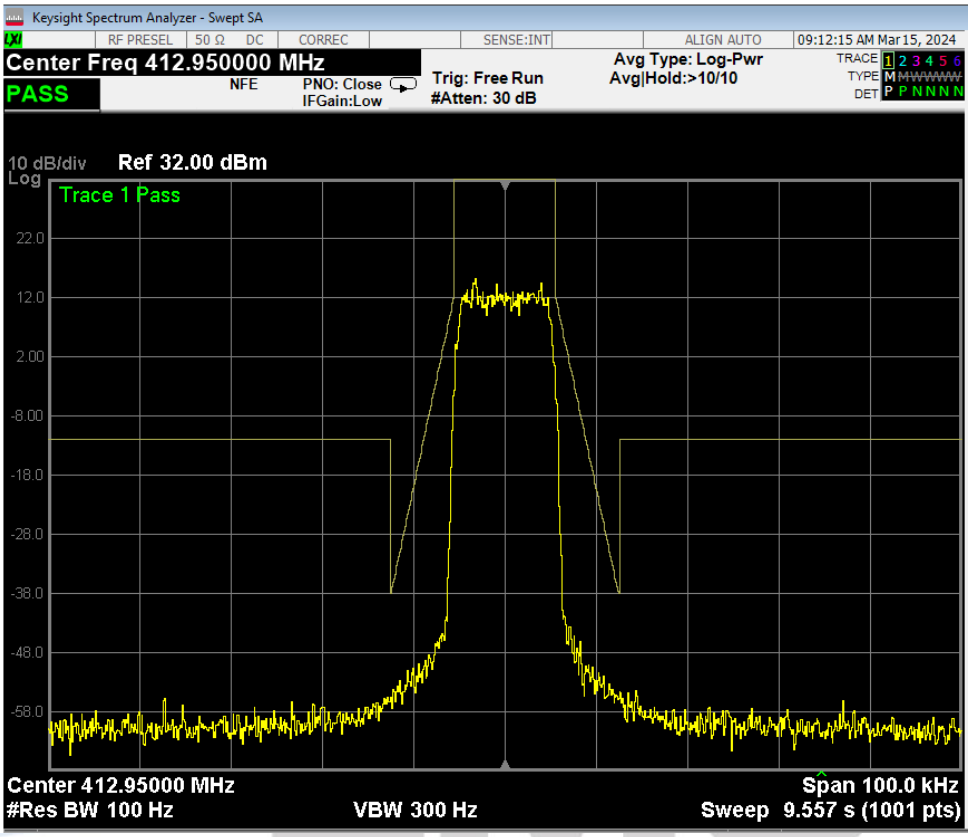


Port-V/64QAM/12.5 kHz/Mask D



12.5 kHz Channel bandwidth emission mask-D

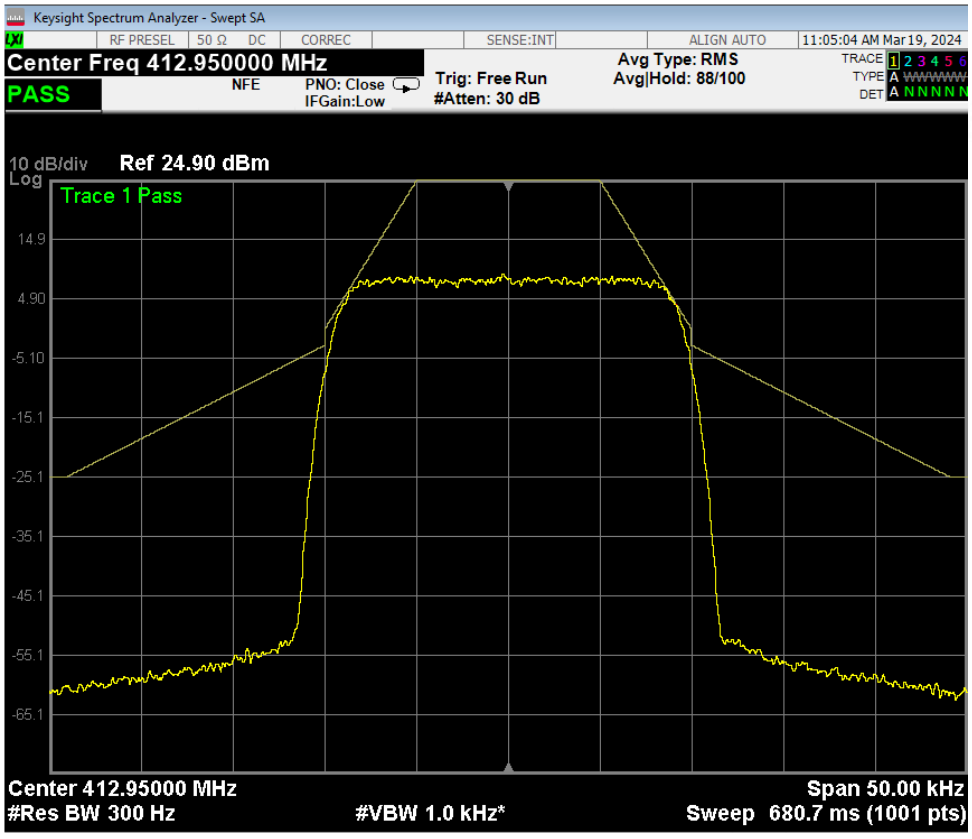
Port-V/256QAM/12.5 kHz/Mask D



25.0 kHz Channel bandwidth-Mask C

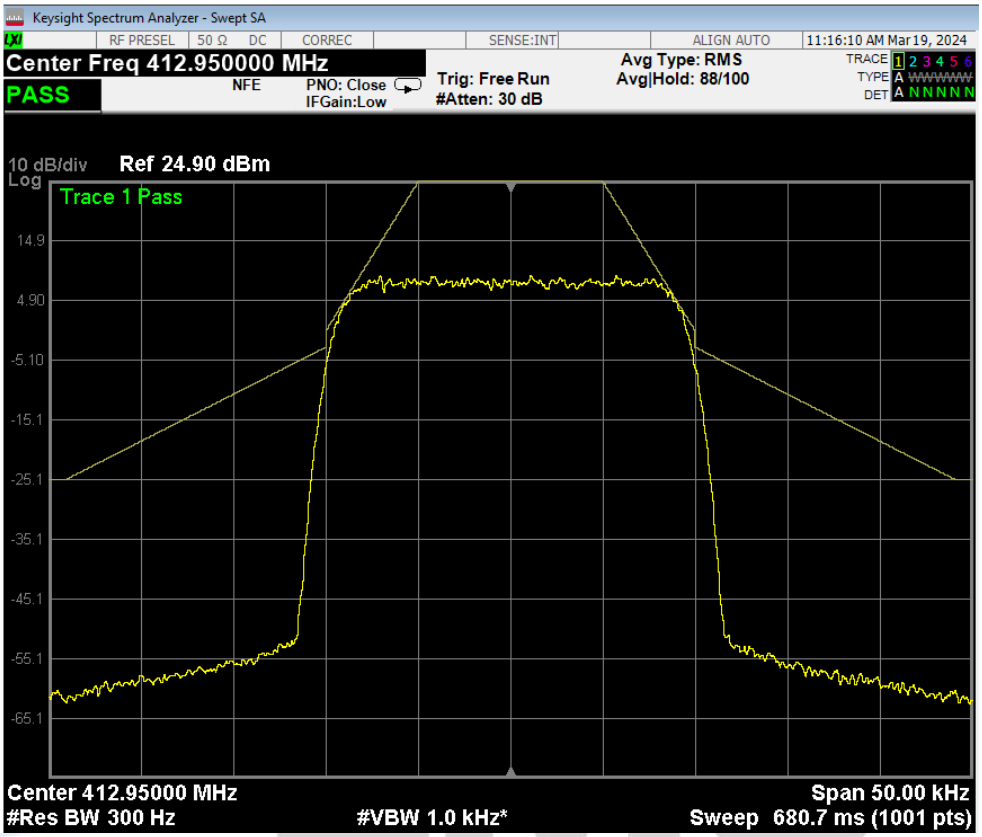
(The plots have been shown in the report with a 50 kHz span to zoom the signal)

Port-H/QPSK/25.0 kHz/Mask C

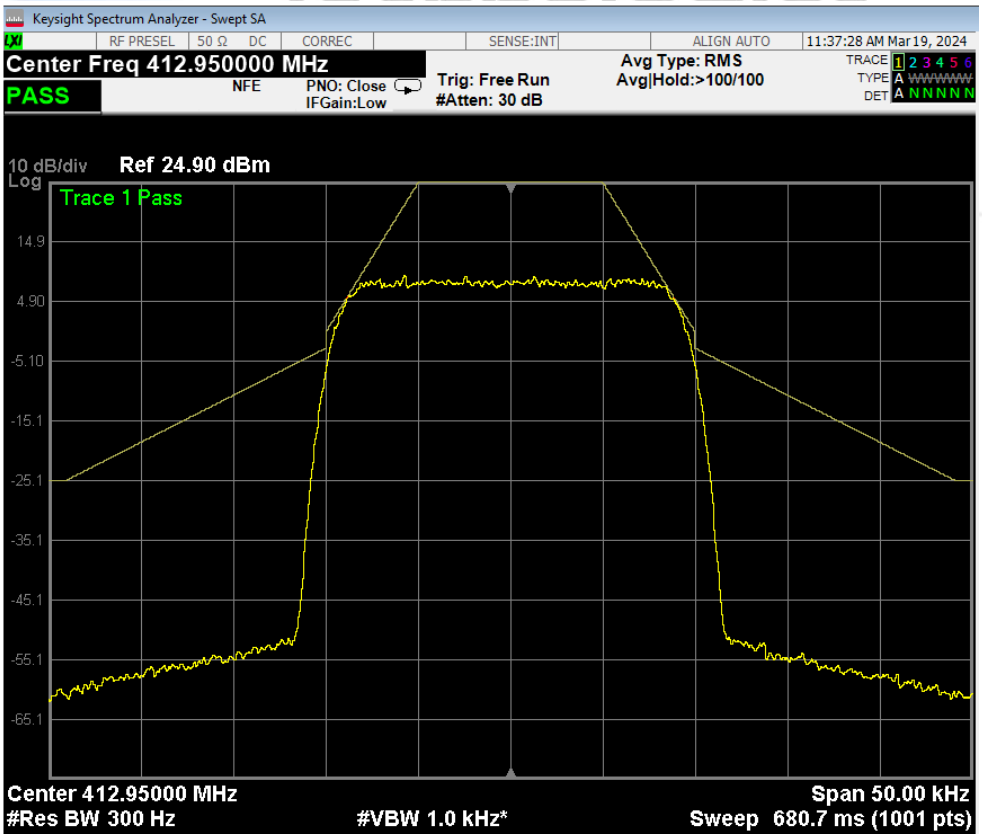


25.0 kHz Channel bandwidth-Mask C

Port-H/16QAM/25.0 kHz/Mask C

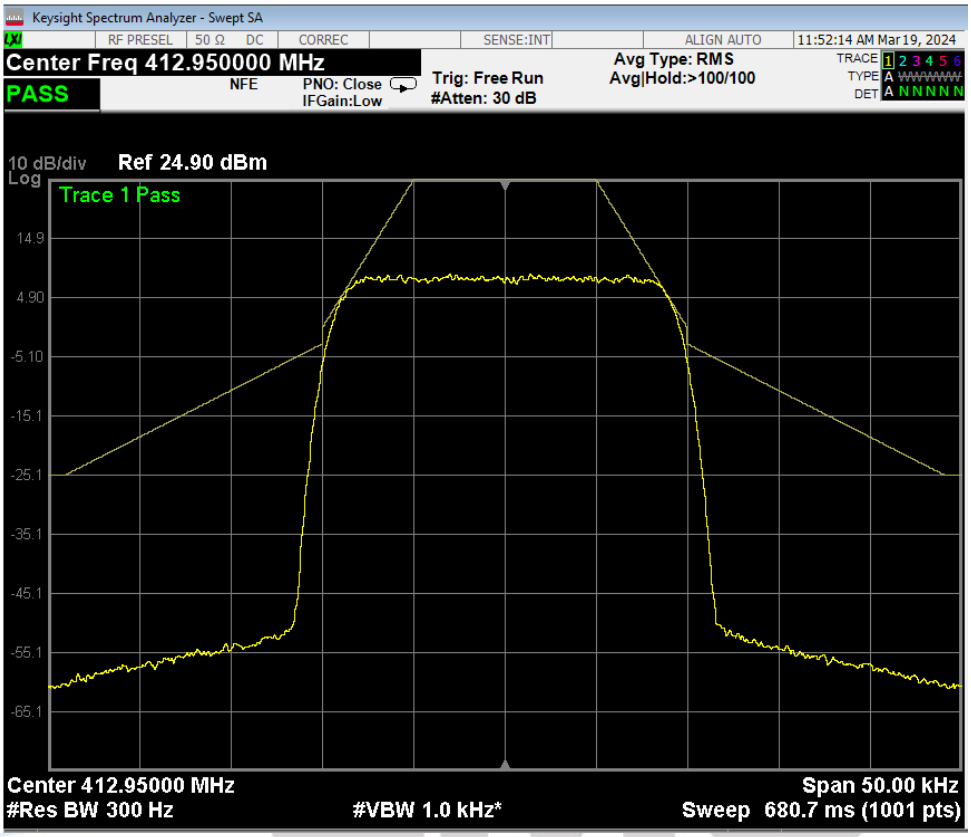


Port-H/64QAM/25.0 kHz/Mask C

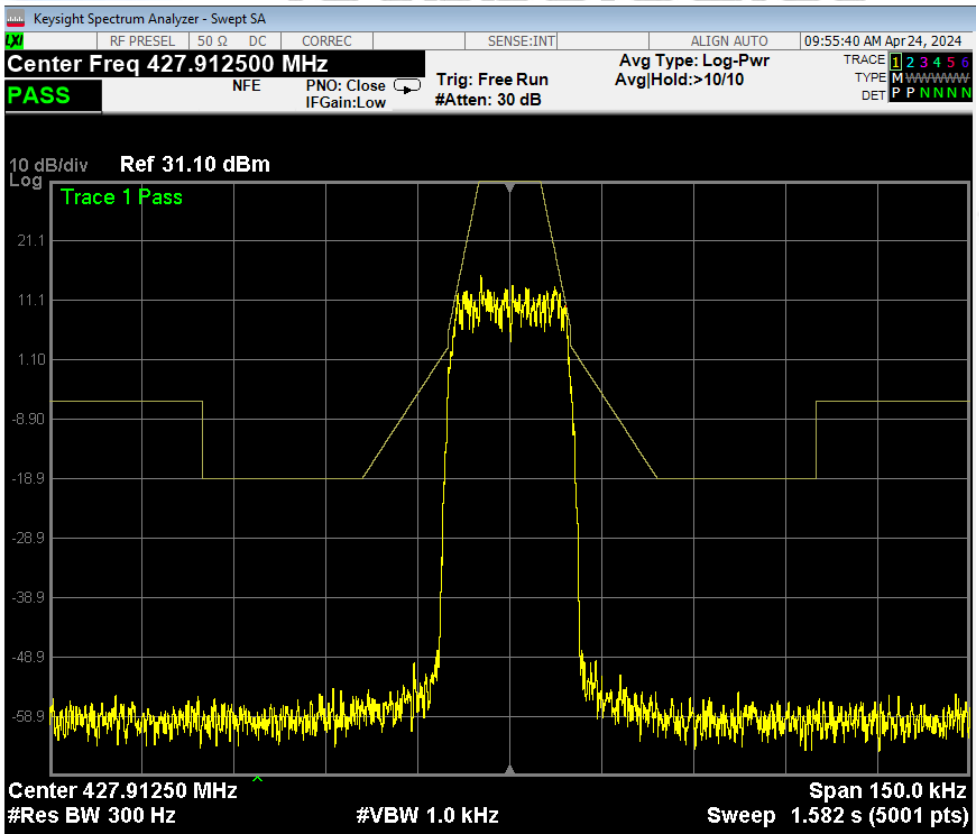


25.0 kHz Channel bandwidth-Mask C

Port-H/256QAM/25.0 kHz/Mask C



Port-V/256QAM/25.0 kHz/Mask C



§2.1051 Transmitter spurious emissions at the antenna terminals

The test was conducted at standard and extreme test conditions and the worst case has been tabulated as below:

Rated output power level: +24dBm

Frequency: 407.950 MHz/QPSK

Spurious emission (MHz)	Emission level (dBm)		Limit (dBm)
	V	H	
815.900	<-45.0	<-45.0	-20.0
1223.850	<-45.0	<-45.0	-20.0
1631.800	<-45.0	<-45.0	-20.0
2039.750	<-45.0	<-45.0	-20.0

Frequency: 412.950 MHz/QPSK

Spurious emission (MHz)	Emission level (dBm)		Limit (dBm)
	V	H	
825.900	<-45.0	<-45.0	-20.0
1238.850	<-45.0	<-45.0	-20.0
1651.800	<-45.0	<-45.0	-20.0
2064.750	<-45.0	<-45.0	-20.0

Frequency: 412.950 MHz /16QAM

Spurious emission (MHz)	Emission level (dBm)		Limit (dBm)
	V	H	
825.900	<-45.0	<-45.0	-20.0
1238.850	<-45.0	<-45.0	-20.0
1651.800	<-45.0	<-45.0	-20.0
2064.750	<-45.0	<-45.0	-20.0

Frequency: 412.950 MHz /64QAM

Spurious emission (MHz)	Emission level (dBm)		Limit (dBm)
	V	H	
825.900	<-45.0	<-45.0	-20.0
1238.850	<-45.0	<-45.0	-20.0
1651.800	<-45.0	<-45.0	-20.0
2064.750	<-45.0	<-45.0	-20.0

Frequency: 412.950 MHz /256QAM

Spurious emission (MHz)	Emission level (dBm)		Limit (dBm)
	V	H	
825.900	<-45.0	<-45.0	-20.0
1238.850	<-45.0	<-45.0	-20.0
1651.800	<-45.0	<-45.0	-20.0
2064.750	<-45.0	<-45.0	-20.0

Frequency: 427.9125 MHz/QPSK

Spurious emission (MHz)	Emission level (dBm)		Limit (dBm)
	V	H	
855.825	<-45.0	<-45.0	-20.0
1283.738	<-45.0	<-45.0	-20.0
1711.650	<-45.0	<-45.0	-20.0
2139.563	<-45.0	<-45.0	-20.0

When operating in transmit mode no other emissions were detected between the harmonic emissions.

Limit:

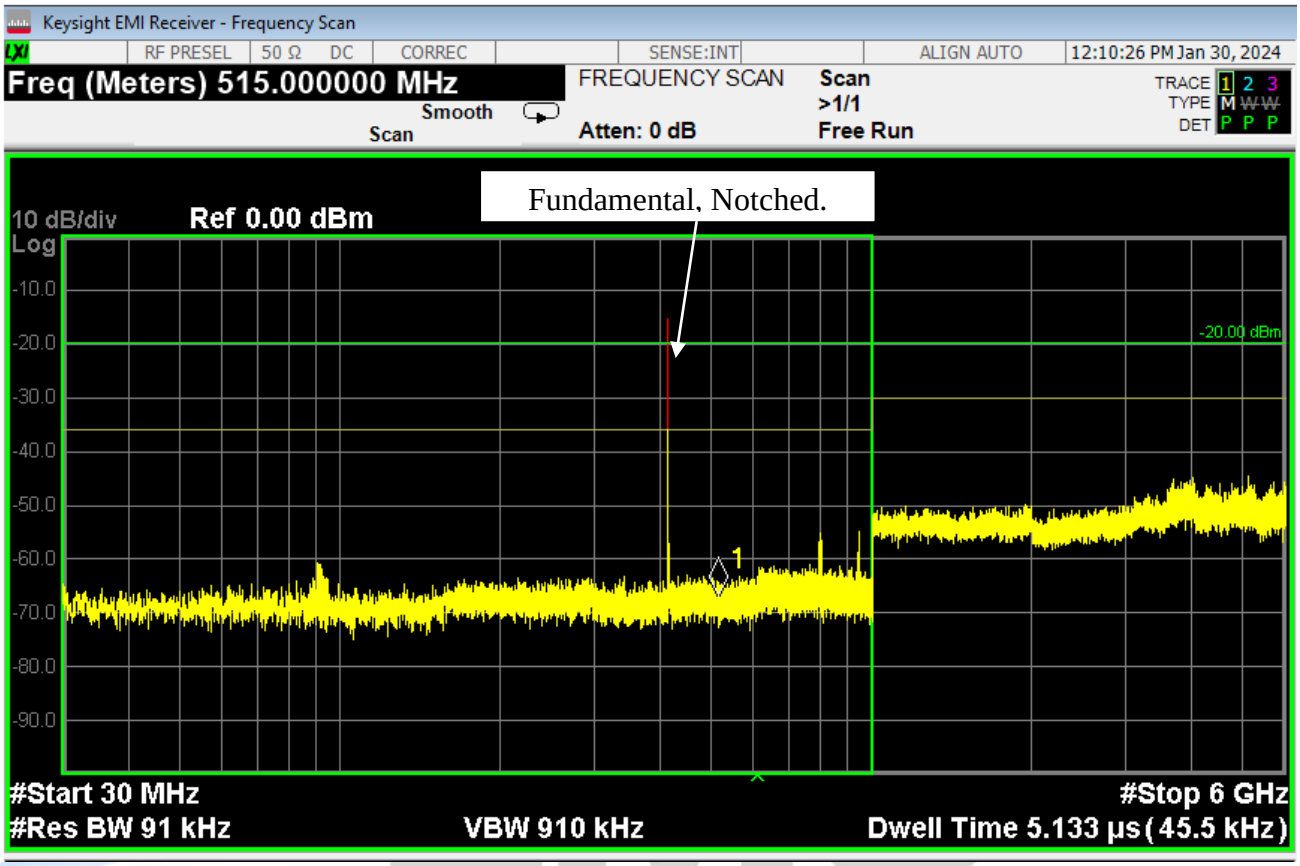
The limit of 50+10 log (P) attenuation from unmodulated power has been applied, which calculates to (+24 dBm -44 dB) = -20.0 dBm

No measurements were made above the 10th harmonic.

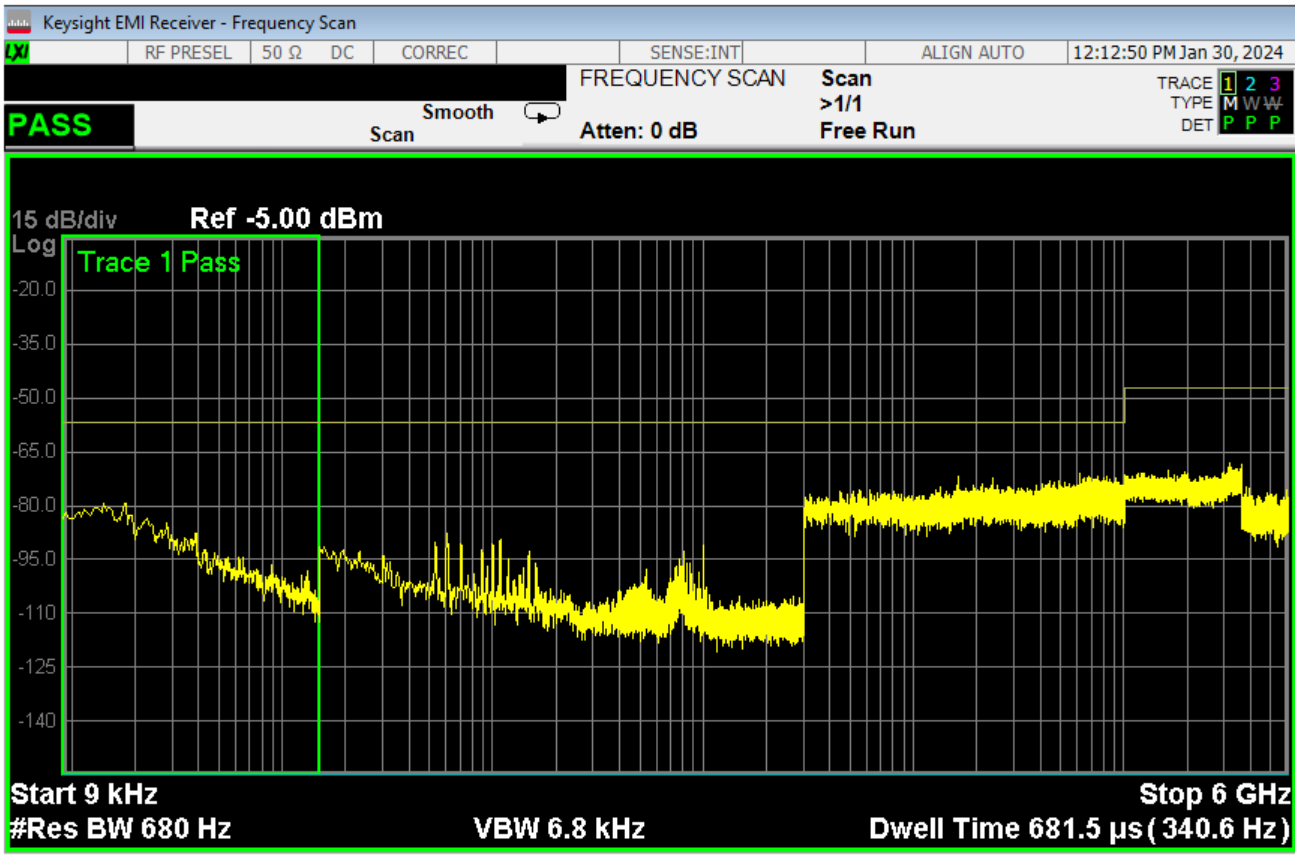
Result: Complies.

Measurement Uncertainty: ± 1.5 dB

V port Transmit emission plot with carrier frequency notched.



V port receive/standby emission plot



§2.1053 Field strength of the transmitter spurious emissions

Field strength transmitter spurious emission testing was carried out over the range of 30 – 6000 MHz which covered the 10th harmonic of the transmitter fundamental emission.

Before testing was carried out a receiver self-calibration was undertaken along with a check of all cables and programmed antenna factors was carried out.

The device tested when placed in the centre of the test table flat 0.8 m above the test site ground plane.

All interconnecting cables were bundled in 40 cm long bundles.

The device was powered at 24 VDC using lead acid batteries.

Attached to the device was a test laptop using a 2 meter long Ethernet cable that facilitated product control using software.

When operating in transmit mode no significant emissions were detected between the harmonic emissions that were detected.

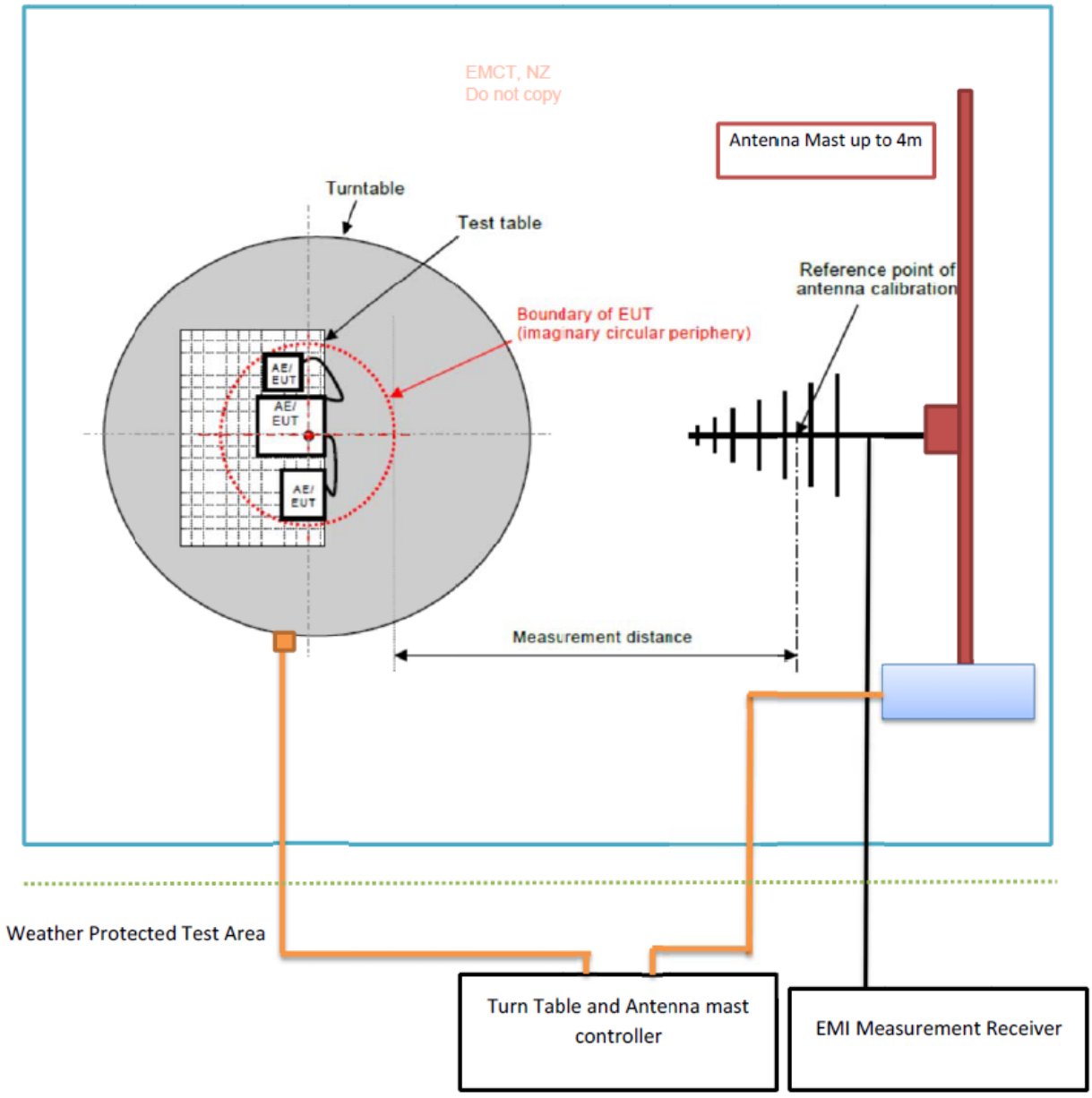
The transmitter was tested while transmitting continuously on high power (0.25 watts) while attached to a dummy load.

The device was tested on an open area test site at a distance of 3 metres.

Testing was carried out at EMC Technologies NZ Ltd Open Area Test Site which is located at Driving Creek, Orere Point, Auckland.

The level recorded is the signal generator output level in dBm less any gains / losses due to the coax cable and the dipole antenna.

Radiated Emissions Test setup at Open area test site



30 MHz-300 MHz: Bi conical Antenna; Measurement distance: 3 m

300 MHz- 1000 MHz: Log Periodic Antenna; Measurement distance: 3 m

Above 1 GHz: Horn Antenna; Measurement distance: 3 m

EMI Receiver Used: ESIB40

Nominal Frequency: 412.950 MHz

Frequency (MHz)	Level (dBuV/m)	Level (dBm)	Limit (dBm)	Polarity	Margin (dB)	Result
825.9000	35.0	-62.4	-20.0	Vertical	42.4	Pass*
825.9000	35.0	-62.4	-20.0	Horizontal	42.4	Pass*
1238.8500	47.0	-50.4	-20.0	Vertical	30.4	Pass*
1238.8500	47.0	-50.4	-20.0	Horizontal	30.4	Pass*
1651.8000	51.0	-46.4	-20.0	Vertical	26.4	Pass*
1651.8000	51.0	-46.4	-20.0	Horizontal	26.4	Pass*
2064.7500	60.0	-37.4	-20.0	Vertical	17.4	Pass*
2064.7500	60.0	-37.4	-20.0	Horizontal	17.4	Pass*
2477.7000	60.0	-37.4	-20.0	Vertical	17.4	Pass*
2477.7000	60.0	-37.4	-20.0	Horizontal	17.4	Pass*
2890.6500	50.0	-47.4	-20.0	Vertical	27.4	Pass*
2890.6500	50.0	-47.4	-20.0	Horizontal	27.4	Pass*
3303.6000	50.0	-47.4	-20.0	Vertical	27.4	Pass*
3303.6000	50.0	-47.4	-20.0	Horizontal	27.4	Pass*
3716.5500	50.0	-47.4	-20.0	Vertical	27.4	Pass*
3716.5500	50.0	-47.4	-20.0	Horizontal	27.4	Pass*
4129.5000	50.0	-47.4	-20.0	Vertical	27.4	Pass*
4129.5000	50.0	-47.4	-20.0	Horizontal	27.4	Pass*
4542.4500	50.0	-47.4	-20.0	Vertical	27.4	Pass*
4542.4500	50.0	-47.4	-20.0	Horizontal	27.4	Pass*
4955.4000	50.0	-47.4	-20.0	Vertical	27.4	Pass*
4955.4000	50.0	-47.4	-20.0	Horizontal	27.4	Pass*

* Noise floor measurement.

Limit:

A limit of -20 dBm has been applied to the measurements.

No measurements were made above the 10th harmonic.

Result: Complies.
Measurement Uncertainty: ± 4.1 dB

§90.213 Frequency Stability

Frequency stability measurements were between - 30 °C and + 50°C in 10°C increments.

At each temperature the transmitter was given a period of 30 minutes to stabilise.

The transmitter was then turned on and the frequency error measured after a period of 1 minute.

Test Frequency: 412.950 MHz

Temperature (°C)	Low (VDC) Error (Hz)	Nominal (VDC) Error (Hz)	High (VDC) Error (Hz)
+50	+20	+20	+20
+40	+10	+10	+10
+30	-20	-20	-20
+20	-20	-20	-20
+10	-60	-60	-60
0	-40	-40	-40
-10	-20	-20	-20
-20	+20	+20	+20
-30	+30	+30	+30

Port-V

Frequency (MHz)	Voltage (VDC)	Frequency Error (Hz) +22˚ C
407.9500	Low	-20
	Mid	-20
	High	-10

Port-H

Frequency (MHz)	Voltage (VDC)	Frequency Error (Hz) +22° C
427.9125	Low	-20
	Mid	-20
	High	-20

Limits: The limits for this test is selected as per §90.213 Table (a)

For the frequency range 400.000 to 430.000 MHz a limit has not been specified.

A worst case error of 0.15 ppm (-60 Hz / 412.950 MHz) was observed.

Result: Complies.
Measurement Uncertainty: ± 30 Hz

§90.214 Transient frequency behaviour

Measurements were carried out using the method described in TIA-603 and EN 300-086.

The modulation analyser produces an amplitude difference signal and a frequency difference signal, which are applied to the input of a storage oscilloscope.

The unmodulated transmitter is then keyed which produces a trigger pulse that is AC coupled to the oscilloscope that produces a display on the screen.

The result of the change in the ratio of power between the test signal from the signal generator and the transmitter output will produce 2 separate sides on the oscilloscope picture. One will show the 1000 Hz test modulation and the other will be the frequency difference of the transmitter versus time.

Channel Spacing (kHz)	Transient Period t_1	Frequency Period t_2	Deviation (kHz) Period t_3
6.25	Nil	Nil	Nil
12.5	Nil	Nil	Nil
25.0	Nil	Nil	Nil

Limits:

Time Interval	Period (ms)		6.25 kHz Deviation (kHz)	12.5 kHz Deviation (kHz)	25 kHz Deviation (kHz)
	VHF	UHF			
t_1	10	5	± 6.25	± 12.5	± 25.0
t_2	25	20	± 3.125	± 6.25	± 12.5
t_3	10	5	± 6.25	± 12.5	± 25.0

Result: Complies.

Measurement Uncertainty: Frequency difference ± 1.6 kHz,
Time period ±1 ms.

12.5 kHz transmitter turn on (412.950 MHz)

Trace = 1 kHz tone with FM deviation of 12.5 kHz.

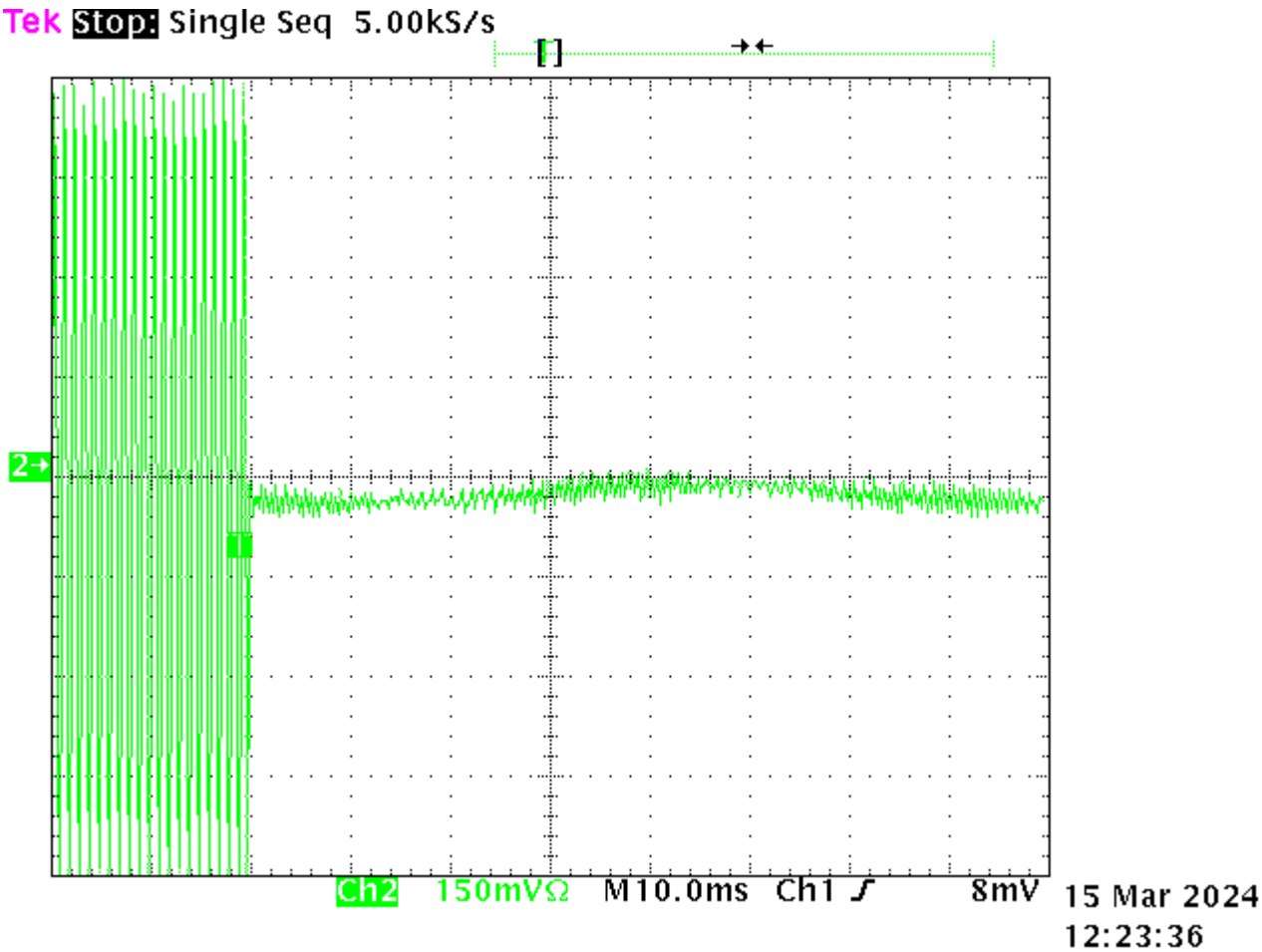
The trace has been maximised to give full screen indication of +/- 12.5 kHz.
The X axis has been set to a sweep rate of 10 ms/division.

Triggering has been set to occur 2 divisions from the left hand edge (20 ms).

*t*on occurs at 20 ms.

*t*1 occurs between 2.0 and 3.0 divisions from the left hand edge.
t2 occurs between 3.0 and 5.5 divisions from the left hand edge.

Transient response can be observed during t1 and t2.



12.5 kHz transmitter turn off (412.950 MHz)

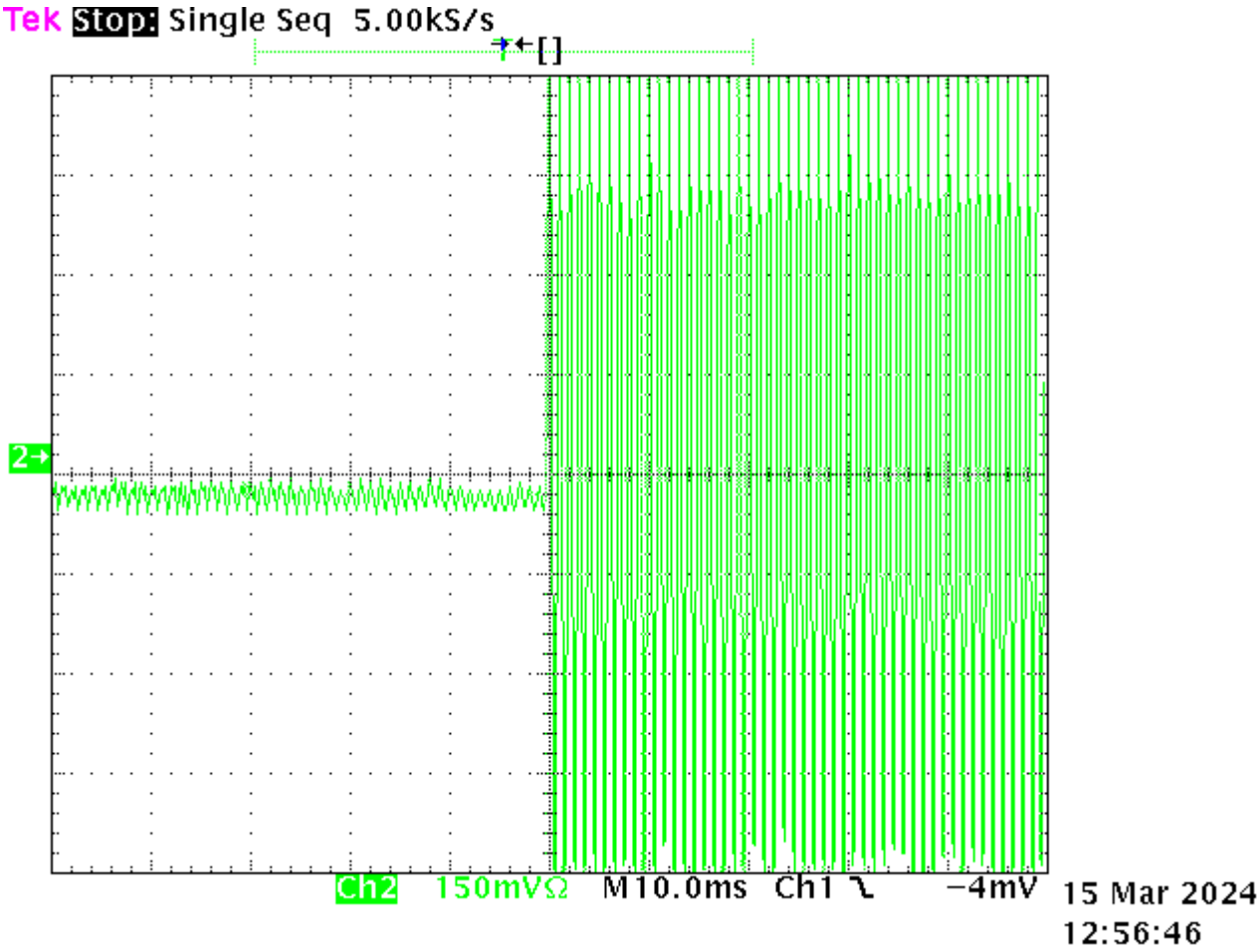
Trace = 1 kHz tone with FM deviation of 12.5 kHz.

The trace has been maximised to give full screen indication of +/- 12.5 kHz.
The X axis has been set to a sweep rate of 10 ms/division

The display of the 1 kHz signal rising has been positioned 5 divisions from the left hand edge (50 ms). This is position *t*off.

*t*3 occurs between 4.0 and 5.0 divisions from the left hand edge.

Transient response can be observed before *t*off.



25.0 kHz Transmitter turn on (412.950 MHz)

Green Trace = 1 kHz tone with FM deviation of 25.0 kHz.

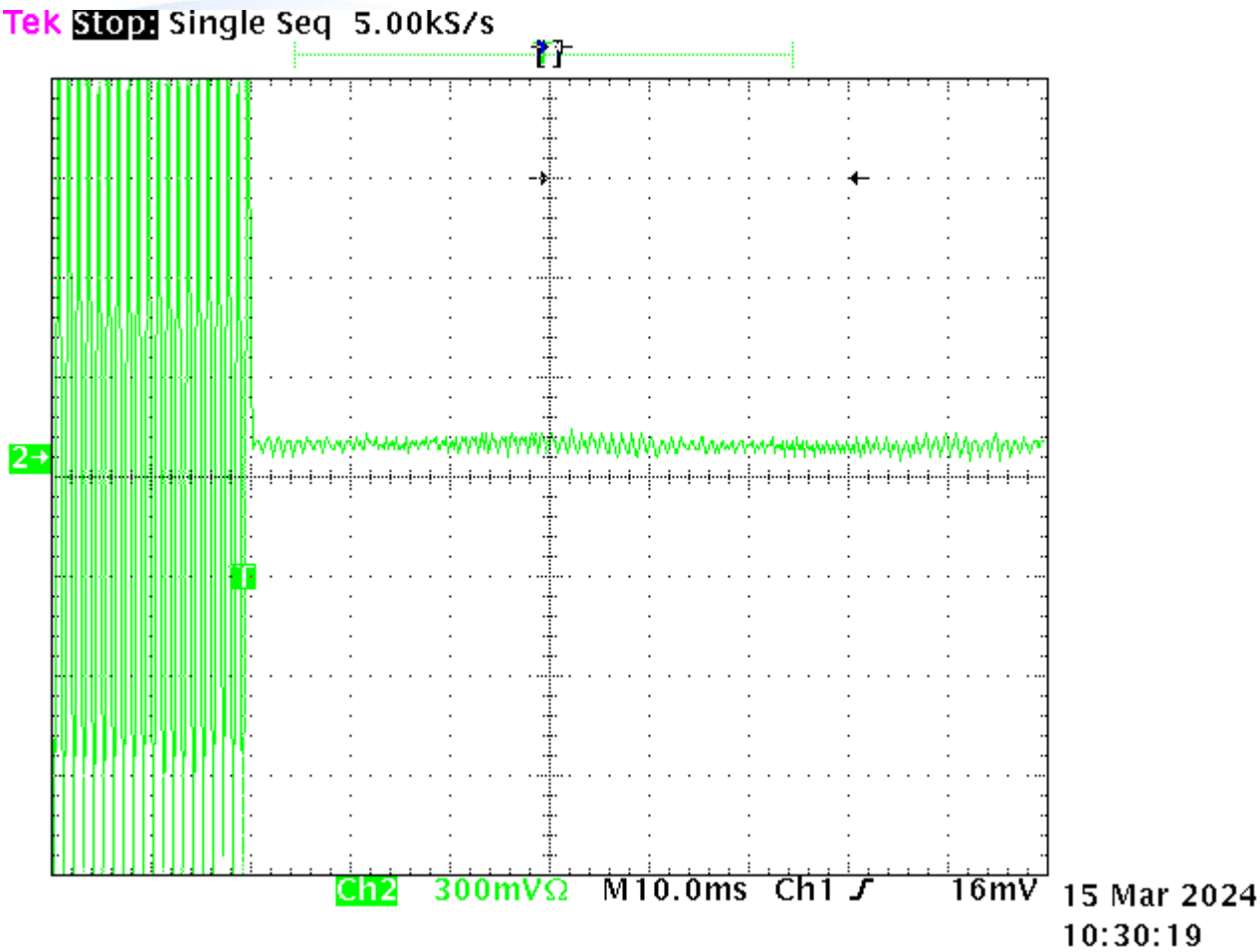
Green trace has been maximised to give full screen indication of +/- 25.0 kHz.
The X axis has been set to a sweep rate of 10 ms/division.

Triggering has been set to occur 2 divisions from the left hand edge (20 ms).

*t*on occurs at 20 ms

*t*1 occurs between 2.0 and 2.5 divisions from the left hand edge.
t2 occurs between 2.5 and 4.5 divisions from the left hand edge.

Transient response can be observed during *t*1 and *t*2.



25.0 kHz transmitter turn off (412.950 MHz)

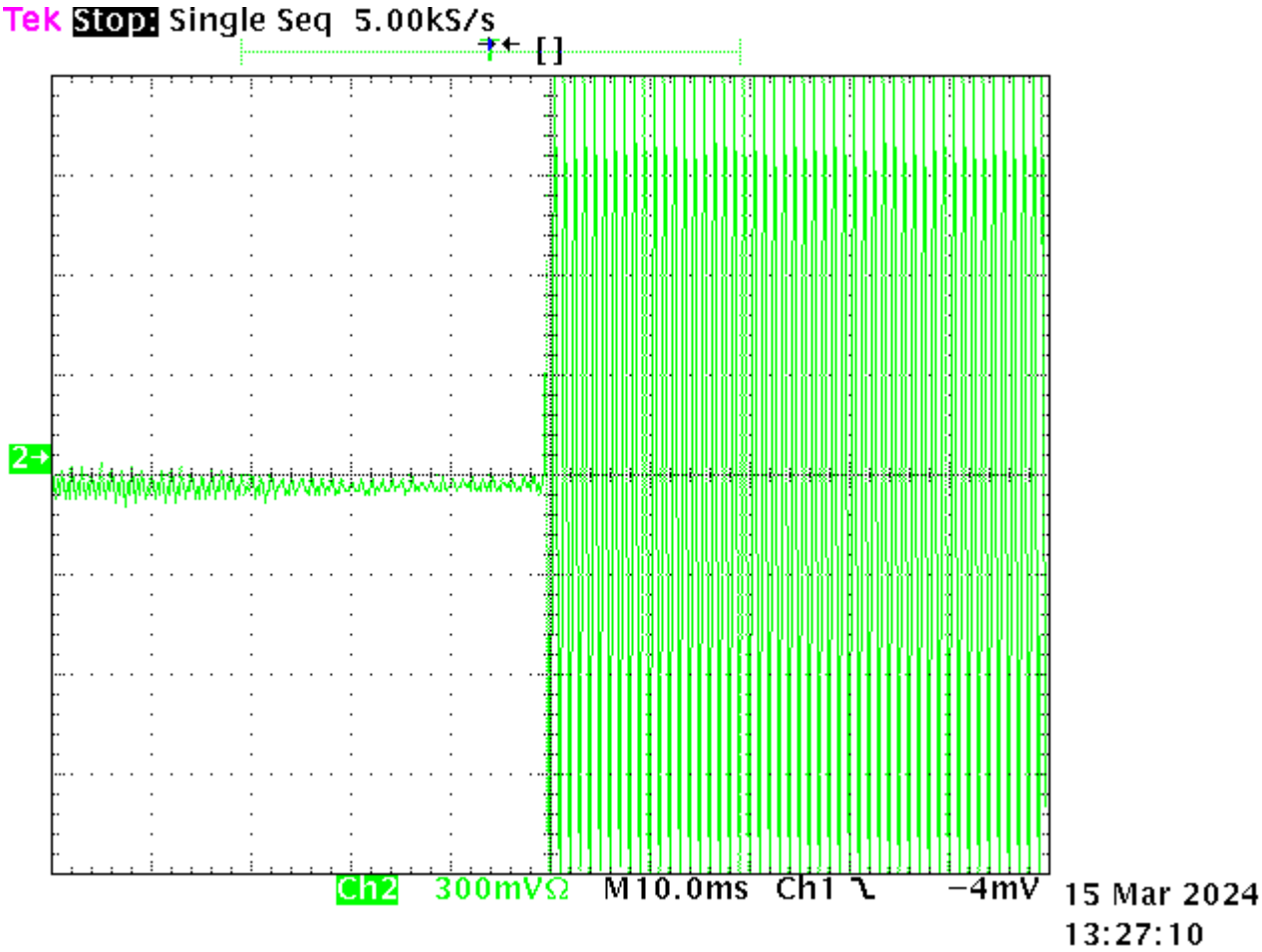
Green Trace = 1 kHz tone with FM deviation of 25.0 kHz.

Green trace has been maximised to give full screen indication of +/- 25.0 kHz.
The X axis has been set to a sweep rate of 10 ms/division

The display of the 1 kHz signal rising has been positioned 5 divisions from the left hand edge (50 ms). This is position *t*off.

*t*3 occurs between 4.5 and 5.0 divisions from the left hand edge.

A transient response can be observed before *t*off.



Exposure of humans to RF fields

As per FCC KDB 447498 D01 and Section 2.1091 radio frequency transmitters are required to be operated in a manner that ensures the public is not exposed to RF energy levels.

Calculations have been made using the General Public/Uncontrolled Exposure limits that are defined in Section 1.1310.

For worst case MPE calculations, 400 MHz has been selected.

Frequency range (MHz)	Electric field strength (V/m)	Magnetic field strength (A/m)	Power density (mW/cm^2)	Averaging time (minutes)
(A) Limits for Occupational/Controlled Exposure				
0.3–3.0	614	1.63	*100	6
3.0–30	1842/f	4.89/f	*900/f^2	6
30–300	61.4	0.163	1.0	6
300–1,500			f/300	6
1,500–100,000			5	6
(B) Limits for General Population/Uncontrolled Exposure				
0.3–1.34	614	1.63	*100	30
1.34–30	824/f	2.19/f	*180/f^2	30
30–300	27.5	0.073	0.2	30
300–1,500			f/1500	30
1,500–100,000			1.0	30

f = frequency in MHz * = Plane-wave equivalent power density

Limits for maximum permissible exposure (MPE)

- General Population / Uncontrolled exposure is f/1500. At 400.0 MHz, the calculated limit is 0.27 mW/cm^2

- Occupational /Controlled exposure is f/300. At 400.0 MHz, the calculated limit is 1.33 mW/cm^2

Minimum safe distances have been calculated below.

For Uncontrolled Environment

At 400 MHz, Power Density = 0.27 mW/cm^2 = $E^2/3770$

E= √ 0.27*3770

E = 31.9 V/m

For Controlled Environment

At 400.0 MHz, Power Density = 1.33 mW/cm^2 = $E^2/3770$

E= √ 1.33*3770

E = 70.8 V/m

The rated maximum transmitter power (CW) = 0.25 W (+24 dBm).

A worst case scenario duty cycle of 100% has been used for the calculations.

The following information about the antenna type and gain has been obtained from the client:

Antenna Type	Gain (dBi)
Omni	10 dBi
Panel	10 dBi
Panel	15 dBi

The minimum distance from the antenna at which the MPE is met is calculated from the following

Field strength in V/m (FS),
Transmit power in watts (P)
Transmit antenna gain (G)
Transmitter duty cycle (DC)
Separation distance in metres (D)

The calculation is as follows:

FS = (√ (30 * P * G * DC)) / D

The calculations have been shown with following scenarios:

- MPE calculations for the product with both ports terminated in a 50 Ohm load
- Using 10 dBi gain antenna
- Using 15 dBi gain antenna

a) For Uncontrolled environments, the minimum distance is:

D = (√ (30 * P * G * DC)) / FS

P = 0.25 W

FS = 31.9 V/m

Frequency (MHz)	Antenna Gain (dBi)	Antenna Gain Numeric	Duty cycle	Safe distance (metres)
400.000	No gain (0)	1.0	100%	0.09
400.000	10.0	10.0	100%	0.27
400.000	15.0	31.6	100%	0.48

a) For Controlled environments, the minimum distance is:

D = (√ (30 * P * G * DC)) / FS

P = 0.25 W

FS = 70.8 V/m

Frequency (MHz)	Antenna Gain (dBi)	Antenna Gain Numeric	Duty cycle	Safe distance (metres)
400.000	No gain (0)	1.0	100%	0.04
400.000	10.0	10.0	100%	0.12
400.000	15.0	31.6	100%	0.22

Result: Complies if the safe distances shown in the calculations above are followed.

7. TEST EQUIPMENT USED

Instrument	Manufacturer	Model	Serial/ID #	Cal Due	Interval
Aerial Controller	EMCO	1090	9112-1062	N/a	N/a
Aerial Mast	EMCO	1070-1	9203-1661	N/a	N/a
Biconical Antenna	Schwarzbeck	BBA 9106	11042021A	22/11/24	3.0 years
Log Periodic	Schwarzbeck	VUSLP 9111	9111-112	15/11/24	3.0 years
Horn Antenna	EMCO	3115	9511-4629	03/03/25	3.0 years
Modulation Analyzer	Rohde & Schwarz	FMA	837807/020	13/04/25	3.0 year
Power Attenuator	Tenuline	8322	-	N/a	N/a
Power Attenuator	DTS	-	-	N/a	N/a
Modulation Analyser	Hewlett Packard	8901B	SN2608A00782	30/04/25	2.0 years
Level Generator	Anritsu	MG443B	M61689	7/08/25	2.0 years
Power meter	Hewlett Packard	436A	2512A22439	19/04/25	2.0 years
Power Sensor	Hewlett Packard	8482A	2237A07036	19/04/25	2.0 years
Oscilloscope	Tektronics	745A	B010643	4/10/24	2.0 Years
Signal Generator	Rohde & Schwarz	SMHU	E1493	27/05/24	2.0 Years
Heliax Cable	L6PNM-RPD	OATS	22869	22/12/24	2.0 Years
Receiver	Rohde & Schwarz	ESIB-40	100295	06/10/24	2.0 years
Spectrum Analyzer	Keysight	N9038A	MY57290153	21/11/24	1.0 year
Thermal chamber	Contherm	M180F	86025	N/a	N/a
Thermometer	DSIR	RT200	35	11/04/27	5.0 years
Turntable	EMCO	1080-1-2.1	9109-1578	N/a	N/a
VHF Balun	Schwarzbeck	VHA9103	-	N/a	N/a

At the time of testing all test equipment was within calibration.

8. ACCREDITATIONS

Testing was carried out in accordance with EMC Technologies NZ Ltd designation as a FCC Accredited Laboratory by International Accreditation New Zealand, designation number: NZ0002 under the APEC TEL MRA.

All testing was carried out in accordance with the terms of EMC Technologies (NZ) Ltd International Accreditation New Zealand (IANZ) Accreditation to NZS/ISO/IEC 17025.

All measurement equipment has been calibrated in accordance with the terms of the EMC Technologies (NZ) Ltd International Accreditation New Zealand (IANZ) Accreditation to NZS/ISO/IEC 17025.

International Accreditation New Zealand has International Laboratory Accreditation Council (ILAC) Mutual Recognition Arrangements for testing and calibration with various accreditation bodies in a number of economies.

This includes NATA (Australia), UKAS (UK), SANAS (South Africa), NVLAP (USA), A2LA (USA), SWEDAC (Sweden). Further details can be supplied on request.

Letter supplied by the client for addition of Variants:

Mimomax Wireless Ltd, trading as Ubiik Mimomax
540 Wairakei Road
PO Box 20003
Christchurch, New Zealand

26 April 2024

To whom it may concern

Equivalence for FCC-ID: XMK-MMXTRNB008

Mimomax 400-430 MHz Tornado radios have been certification tested with during April 2024, Testing was carried out on an Encryption capable radio fitted with internal duplexers and 50kHz receiver filters. Equivalent radios with and without encryption capability, with internal vs external duplexers and with different bandwidth receiver filters are available in the Tornado Radios.

Encryption capability or lack of encryption capability makes no impact on the signal transmitted from the Radio. Internal duplexers radios have less rejection of unwanted signals and are consequently the worst case for the signals out of the radio. A radio with a 50 kHz receiver filter was tested as it can support all the bandwidths required for testing and the receiver filter bandwidth has no impact on the signals out of the radio.

Certification testing was complete on a MWL-TORNADO-BACA model radio.

The below models are equivalent to the MWL-TORNADO-BACA:

MWL-TORNADO-AAAA, MWL-TORNADO-AABA, MWL-TORNADO-AACA, MWL-TORNADO-BAAA,

MWL-TORNADO-BABA, MWL-TORNADO-AAAB, MWL-TORNADO-AABB, MWL-TORNADO-AACB,

MWL-TORNADO-BAAB, MWL-TORNADO-BABB, MWL-TORNADO-BACB

Model numbering follows the format

MWL-TORNADO-1234

Where 1 = A for non-encryption capable radios, and B for encryption capable radios.

Where 2 = A for 400-430 MHz Frequency band radios.

Where 3 = A for 12.5kHz bandwidth Receiver filters, B for 25kHz bandwidth receiver filters and C for 50kHz bandwidth receiver filters.

Where 4 = A for internal duplexer radios and B for external duplexer radios.

Regards

James Dowle

James Dowle, R&D Manager

9. PHOTOGRAPHS

Top Face

Connector Face

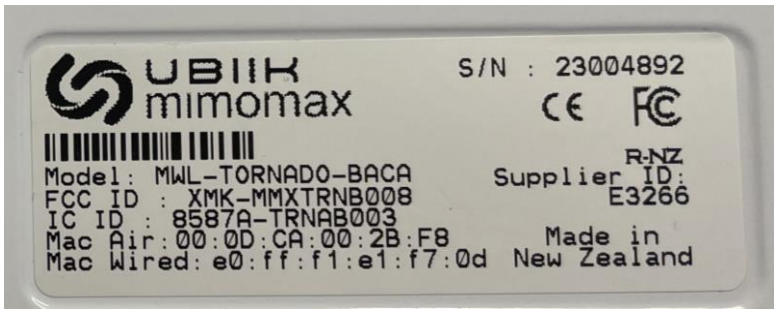
Side face with top face

Side Face

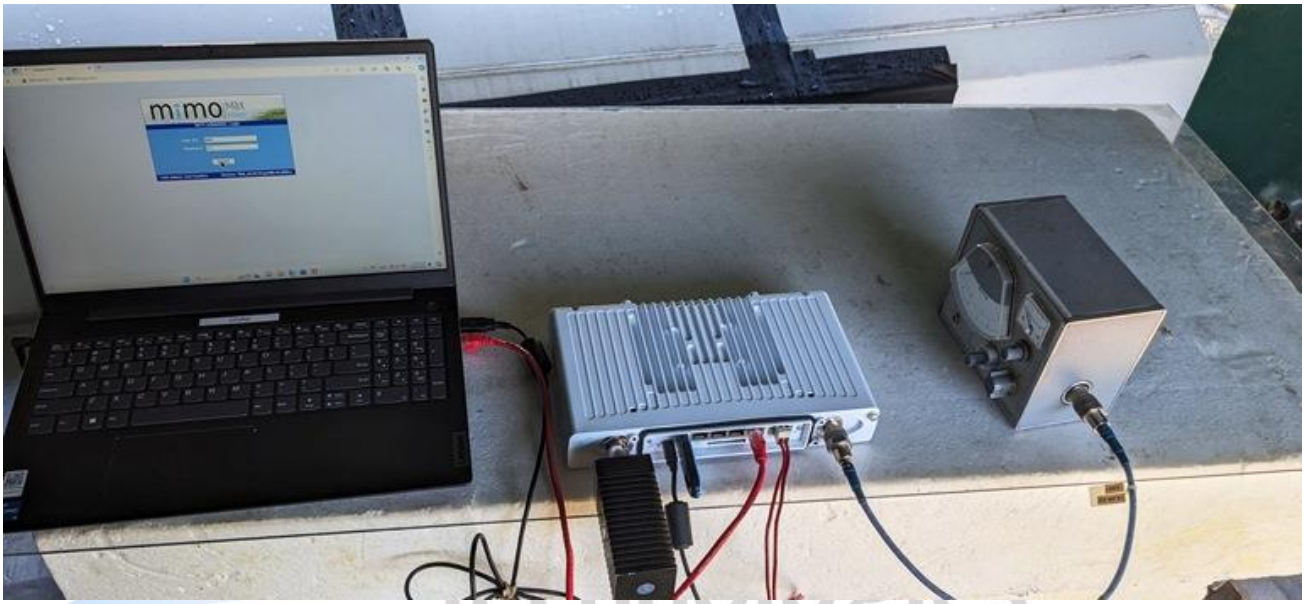
Side Face

Bottom side of the product showing label location

Labels



Radiated Emissions Test Setup



Radiated Emissions Test Setup

Biconical Antenna pointing towards Test Enclosure.

Log Periodic Antenna pointing towards Test Enclosure.

Horn Antenna pointing towards Test Enclosure.