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TEST REPORT

Spectra MX940-100 Watt
Digital Base Station Transceiver

tested to the

Code of Federal Regulations (CFR) 47

Part 90 –Private Land Mobile Services
&
Part 22-Public Mobile Services

for

Spectra Engineering Pty 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 **Spectra MX940-100 Watt Digital Base Station Transceiver** complies with the limits defined in 47 CFR Part 90, Part 22 and 47 CFR Part 2 when tested in-accordance with the test methods described in 47 CFR Part 2 and ANSI / TIA-603-E: 2016.

2. RESULT SUMMARY

The results of testing carried out between April 2022 and June 2022 are summarised below.

Clause	Description	Result
90.203	Certification required	Noted
2.1046 90.205	RF power output Power and antenna height limits	Noted Complies
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
2.1051	Spurious emissions at antenna terminals	Complies
2.1053	Field strength of spurious radiation	Not tested
2.1055 90.213	Frequency stability Frequency stability	Noted Complies
90.214	Transient frequency behaviour	Complies
-	Audio filter response	Included.
1.1310	Radio frequency exposure limits	Complies

3. ATTESTATION

This report describes the tests and measurements performed for the purpose of determining compliance with the specification with the following conditions:

The client selected the test sample.

The report relates only to the sample tested.

This report does not contain erasures.

This report contains following corrections:
Accreditation section has been updated.

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.

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.

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

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

4. CLIENT INFORMATION

Company Name	Spectra Engineering Pty Ltd
Postal Address	731 Marshall Road Malaga Perth, Western Australia 6057
Country	Australia
Contact	Gary Jacobs & Anthony Chadd

5. TEST SAMPLE DESCRIPTION

Brand Name	Spectra Engineering
Model Number	MX940N5V
Product	UHF Transceiver
Manufacturer	Spectra Engineering Pty Ltd
Manufactured in	Australia
Serial Number	211100003
FCC ID	OKRMX940N5V
Controller Firmware Version:	0.1.04
DMR Logic Firmware Version:	1.1.29

Configuration Application Serial communication tool-Putty used for product control during testing.

Antenna connector N type (Female) connector is available on the product.

Rated Transmitter Output Power

The power can be varied up to 100 Watts (50.0 dBm) using the client software.

Transmitter Certification Range

Part 90: 406.0-512.0 MHz

Test frequencies

Frequency (MHz)	Power (Watts)	Channel Bandwidth (kHz)	Emission
408.750	100 (50 dBm)	12.5, 25.0	Analog FM and DMR modulations
435.000	100 (50 dBm)	12.5, 25.0	
452.500	100 (50 dBm)	12.5, 25.0	
461.250	100 (50 dBm)	12.5, 25.0	

Standard Temperature and Humidity

Temperature: +15 °C to + 30 °C maintained.
Relative Humidity: 20% to 75% observed.

Standard Test Power Source

Standard Test Voltage: 13.8 Vdc

Extreme Temperature

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

Extreme Test Voltages

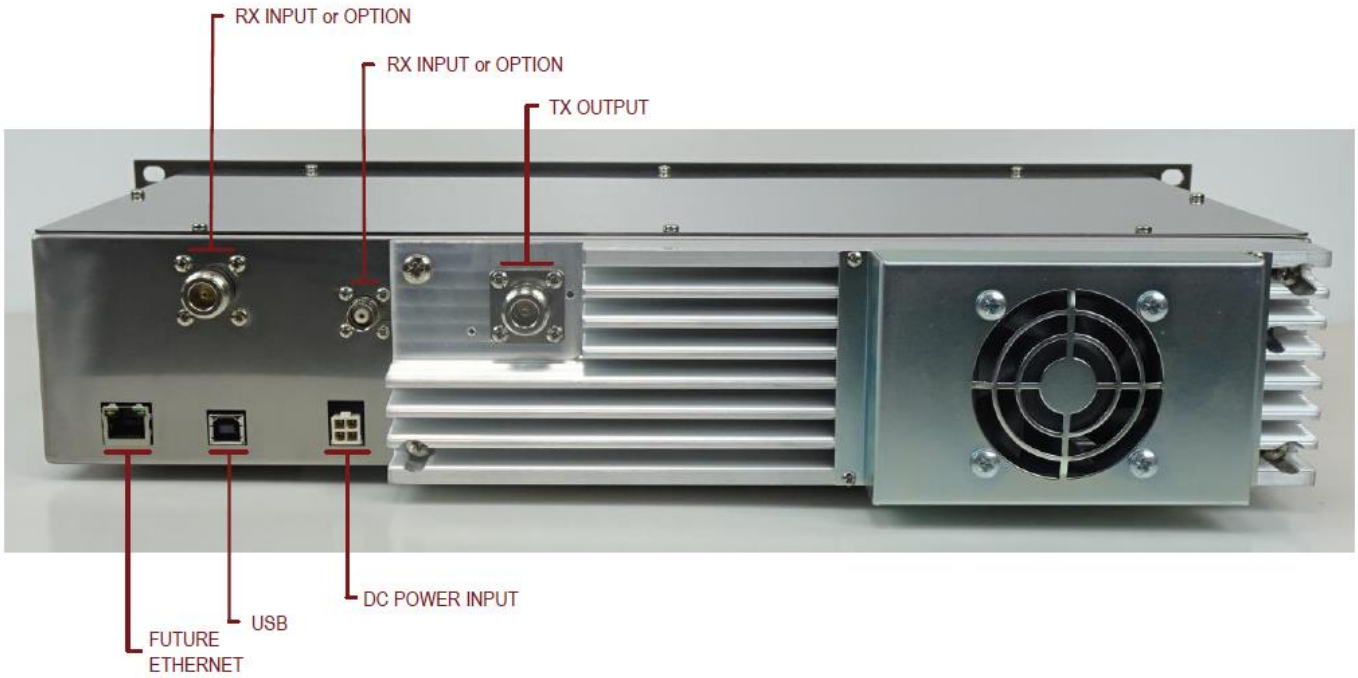
High Voltage: 16.0 Vdc
Low Voltage: 11.5 Vdc

Product Overview (from user manual):

The product under test is a 100 Watt base station and repeater which has a purpose of meeting the requirements for fixed site DMR digital radio communications applications.
The product is packaged in a 2RU size chassis and suitable for DMR applications using 6.25e kHz TDMA Tier 2, conventional mode Repeater or IP linked Repeater. As per the client, the operating modes can be software upgraded to cater for feature and system release updates.
The product can operate at a full 100 Watts of RF power with a 100% duty rating.

As per the user manual supplied by the client:
The MX940 can operate in a number of different modes. The primary alternatives are DMR Repeat, which is the default mode, and future options for Duplex and simplex systems.
There are a number of features that also can be enable/disabled to suit the individual system needs. This is done thought the radio configuration menu system, with a Personal Computer (PC) with terminal software.

Rear panel of the product showing the connections:



Test Setup

Serial open source communication tool (Putty) was used to control the product during testing.

The product's USB port was connected to the test laptop using a 2 m long cable to send commands to receive the product status.

The commands necessary for testing were supplied by the client. These commands were used to change frequency, power levels, modulation type and channel spacing etc.

After changing the product configuration, verification was done using "DIAG1" command to read the product status and to confirm that it has been configured correctly for the test.

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:

- The product tested operates in the frequency range 406.1 MHz to 470 MHz which falls within 406.1 MHz – 512.0 MHz band and hence certification is required

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

- Requirement not applicable, product under test is a base station/repeater.

2) Applications for certification received on or after February 14, 1997 but before January 1, 2005 will only be granted for equipment with the following channel bandwidths:

(i) 12.5 kHz or less for single bandwidth mode equipment or multi-bandwidth mode equipment with a maximum channel bandwidth of 12.5 kHz;

(ii) 25 kHz for multi-bandwidth mode equipment with a maximum channel bandwidth of 25 kHz if it is capable of operating on channels of 12.5 kHz or less; and

(iii) 25 kHz if the equipment meets the efficiency standard of paragraph (j)(3) of this section.

- Requirement not applicable, certification is being applied after June 2022.

3) 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 February 14, 1997 must include a certification that the equipment meets a spectrum efficiency standard of one voice channel per 12.5 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 complies with the spectrum efficiency requirement of one voice channel per 12.5 kHz of channel bandwidth.
- The product under test operates as a digital mobile radio supporting digital voice and data operating with 4 state FSK modulations, which creates four possible symbols over the air at a rate of 4800 symbols/s, corresponding to 9600 bit/s.
- In reference to 579009 D03 Applications Part 90 Reframing Bands v01 dated April 10, 2015, the product meets the following condition:

III. SPECIAL CASES:

The efficiency standard for digitized voice can be satisfied either by having multiple emissions such as four separate emissions on a 25 kHz channel, or having multiple voice channels on a single emission (e.g., TDMA). The Ritron Waiver (DA 13-431) permits one voice channel per 12.5 kHz bandwidth and waives the multi-bandwidth mode requirement of § 90.203(j)(4)(ii). The efficiency standard for data for single bandwidth mode or multi-bandwidth mode devices requires at least 4800 bps per 6.25 kHz of bandwidth or 9600 bps per 12.5 kHz channel. A 25 kHz single mode device must have a single emission rated at 4 × 4800 bps or a mode that has four individual but simultaneous emissions at 4800 bps per emission. Radios designed to operate on a 6.25 kHz channel do not need to meet the 4800 bps efficiency standard

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:

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

- Requirement not applicable, the product operates over multi bandwidth mode.

(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;

- The product complies and supports 12.5 kHz channel bandwidth.

(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 complies with the spectrum efficiency requirement for 25 kHz channel bandwidth.

(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, 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;

- The product tested supports DMR voice/data modulations operating with a channel bandwidth of 12.5 kHz with TDMA implemented. It has shown to meet spectrum efficiency masks for 12.5 kHz channel bandwidth. Exclusion to this requirement is requested based on reference to FCC KDB, 579009 D03 Applications Part 90 Reframing Bands v01 dated April 10, 2015.

SPECIAL CASES: cont.

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 under test operates as a digital mobile radio supporting digital voice and data operating with 4 state FSK modulations, which creates four possible symbols over the air at a rate of 4800 symbols/s, corresponding to 9600 bit/s.

Result: Complies.

RF power output

Measurements were carried out at the RF output terminals of the transmitter using a power attenuator and a RF Power meter.

Measurements were carried out when the transmitter was not being modulated.

Testing was carried out at maximum power output.

Maximum transmitter power (CW) - Rated 100 W (+50.0 dBm)

Frequency (MHz)	Voltage (Vdc)	Carrier Power (dBm)		
		+22˚ C	+50˚ C	-30˚ C
408.750	Low	47.8	47.5	48.3
	Mid	49.8	49.3	50.2
	High	50.7	50.7	50.3
461.250	Low	48.1	48.0	48.7
	Mid	50.0	49.6	50.1
	High	50.7	50.7	50.7

Limits:

Part 90 does not specify the transmitter output power

Result: Complies.

Measurement Uncertainty: ± 0.5 dB

Emission types and bandwidth limitations:

The following emission types are used:

Following emission designators have been declared by the client:

Analog FM mode:
11K0F3E for 12.5 kHz channel bandwidth
16K0F3E for 25.0 kHz channel bandwidth

Digital mobile radio mode: This mode operates using TDMA frames, the product will receive a TDMA signal and it activates both slots in the outbound.

Digital Voice DMR: 7K60FXE
Digital Data DMR: 7K60FXD
Digital Voice/Data DMR: 7K60FXW

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 this radio can support at each test frequency. For simplicity of the test report limited no of plots at representative test frequencies have been provided in the test report.

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 and ANSI / TIA-603-E-2016.

Testing of analog FM channels has been performed by modulating the product using 2500 Hz external audio signal at a level 16 dB higher than that causes 50% frequency deviation corresponding to the channel bandwidth under test.

Testing of digital channels has been performed using the products internal modulation.

Attached to the input of the spectrum analyser was an external power attenuator. The attenuation factor of the power attenuator has been included as a correction in the plots Peak detector has been employed with max hold to capture the worst case results.

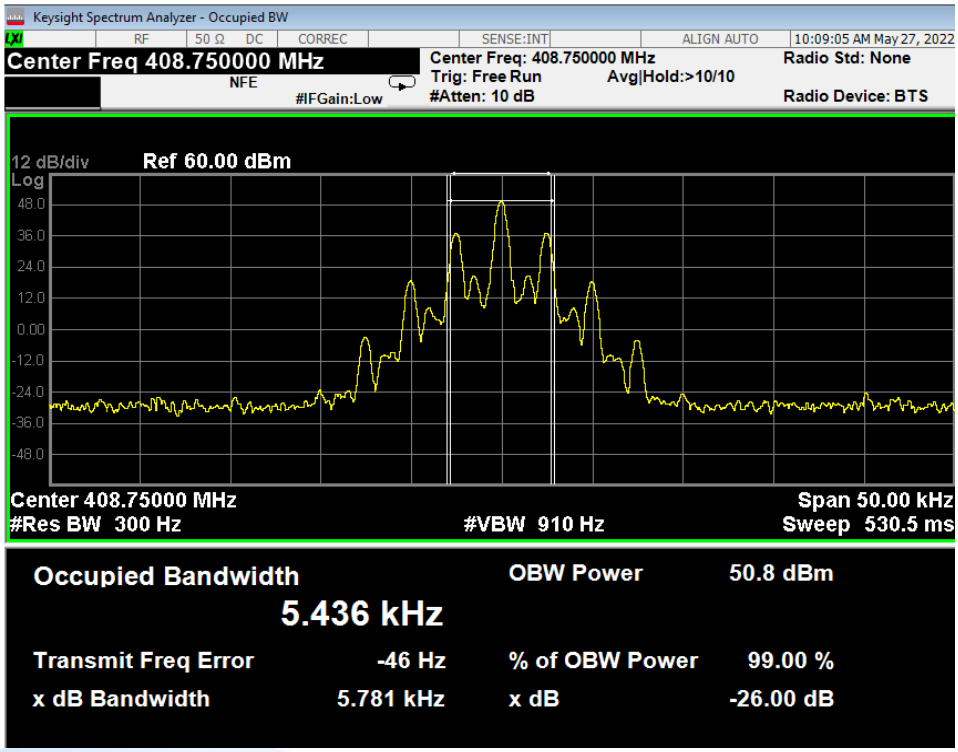
All the measurements that have been tabulated were made but only the representative plots have been included in the test report in order to simplify the test report.

Result: Complies

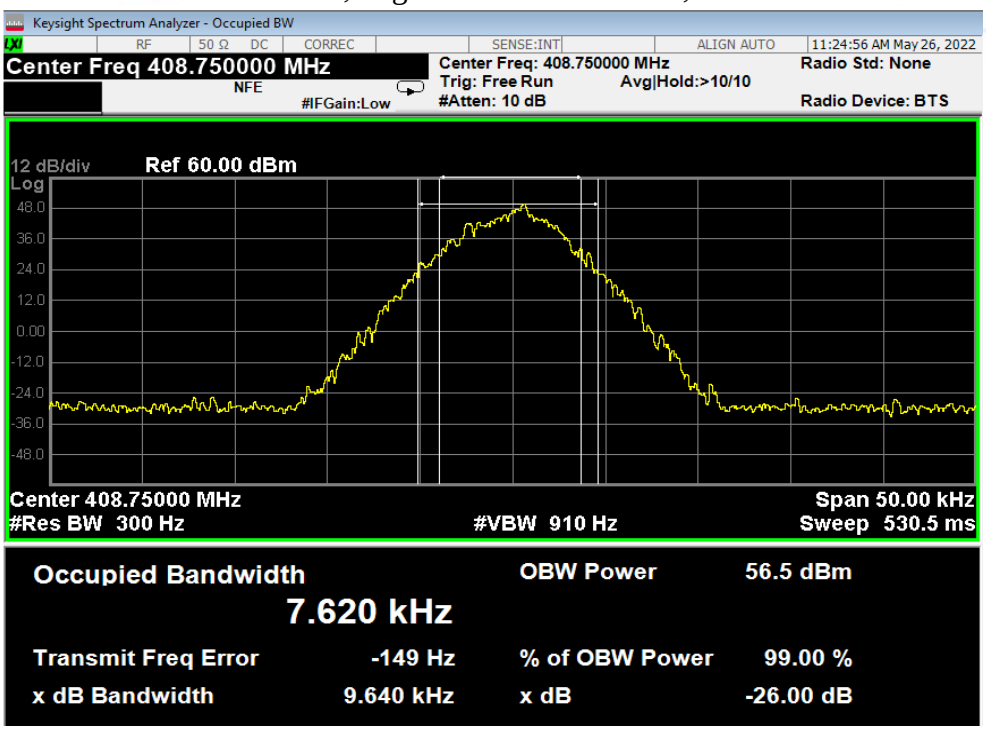
Emission-12.5 kHz spacing.

Mode tested	Frequency (MHz)	Measured (kHz)	Designated
Analog FM/12.5 kHz	408.750	5.436	11.250 kHz
Analog FM/12.5 kHz	461.250	5.872	
Digital Voice DMR	408.750	7.620	
Digital Data DMR	408.750	7.620	

408.750 MHz, Analog FM, 12.5 kHz



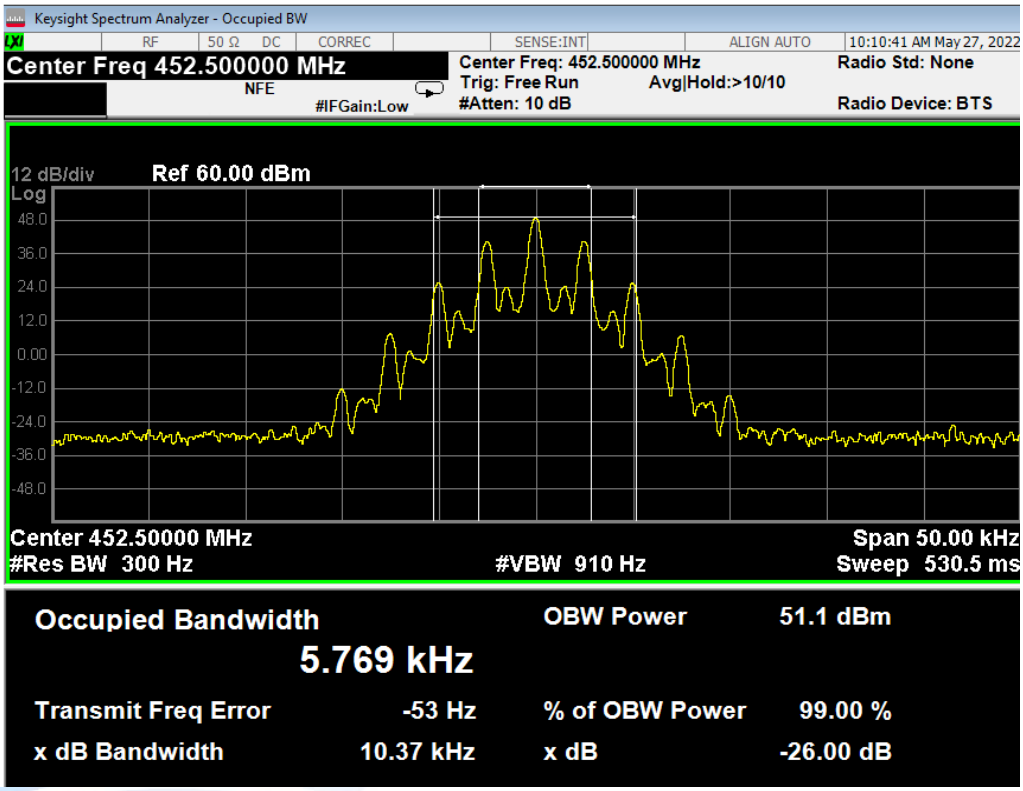
408.750 MHz, Digital Voice/Data DMR, 12.5 kHz



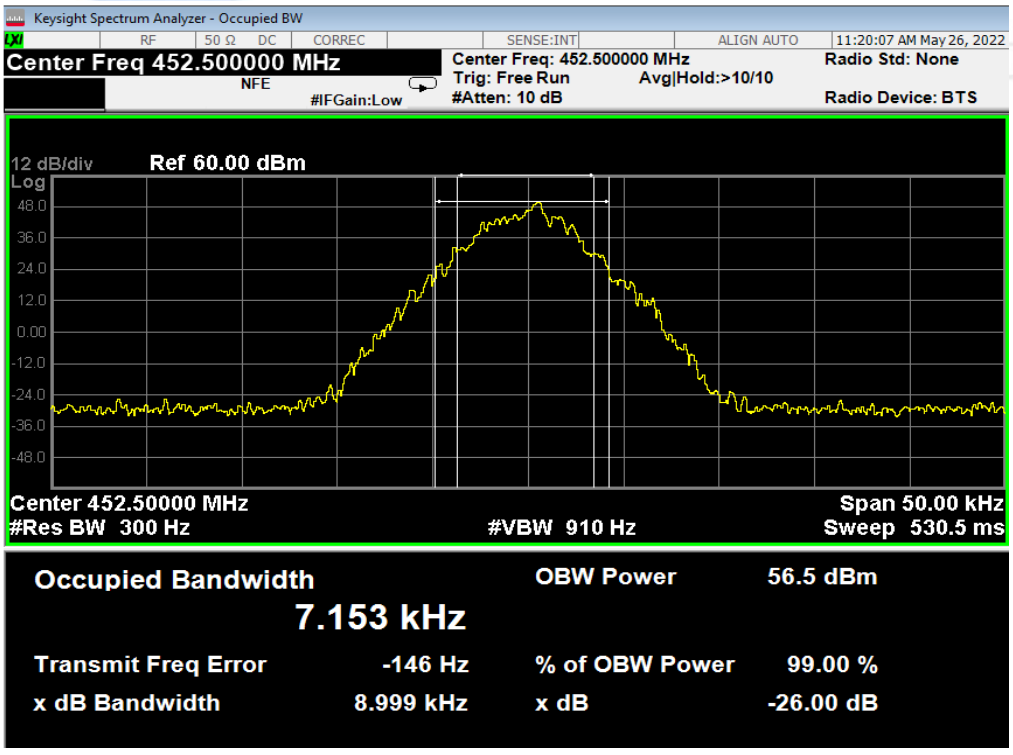
Emission-12.5 kHz spacing.

Mode tested	Frequency (MHz)	Measured (kHz)	Designated
Analog FM/12.5 kHz	452.500	5.769	11.250 kHz
Digital Voice/Data DMR	452.500	7.153	
Digital Voice/Data DMR	461.250	7.534	

452.500 MHz, Analog FM, 12.5 kHz



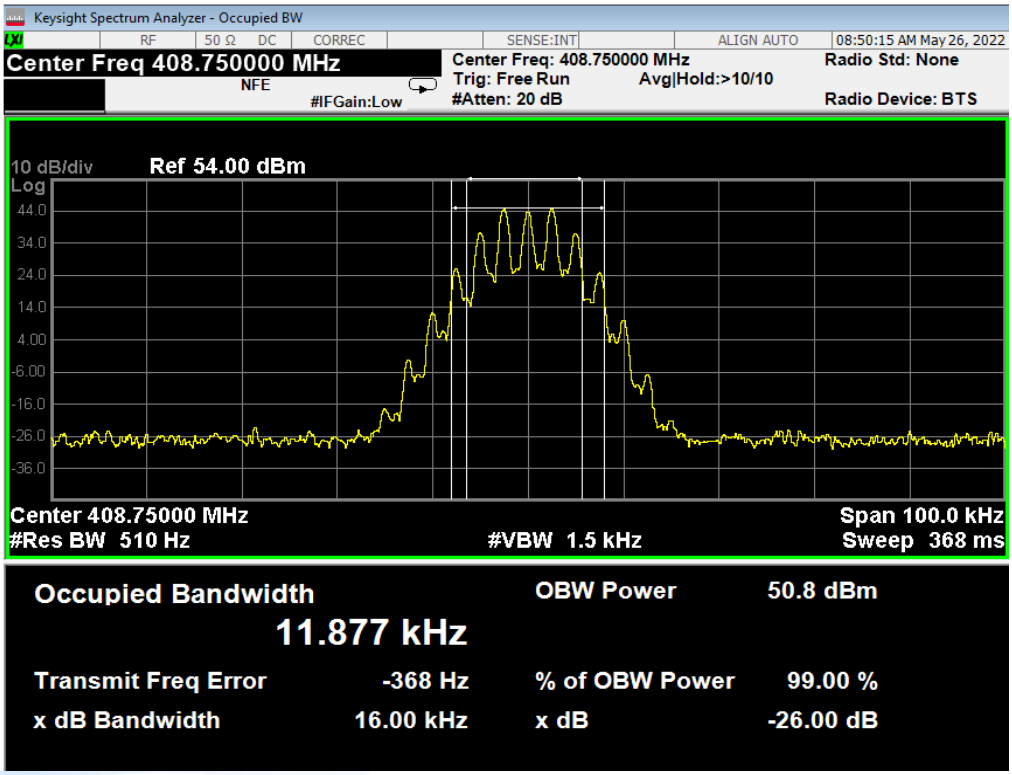
452.500 MHz, Digital Voice/Data DMR, 12.5 kHz



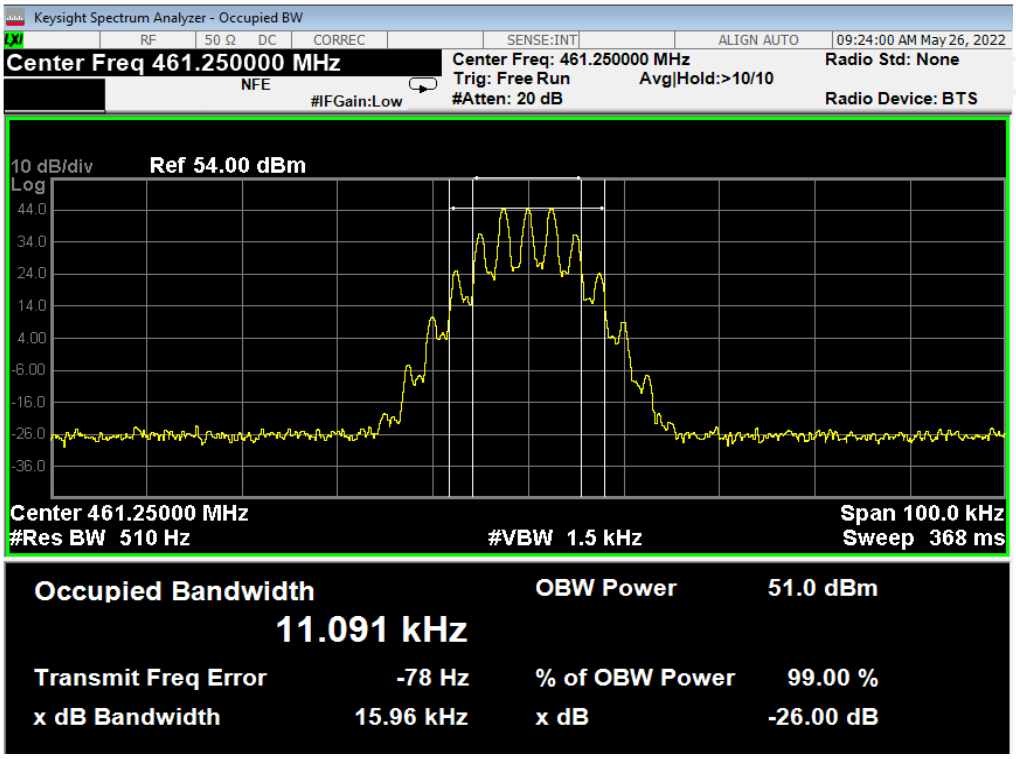
Emission-25.0 kHz spacing.

Mode tested	Frequency (MHz)	Measured (kHz)	Designated
Analog FM/25 kHz	408.750	11.877	20.000 kHz
Analog FM/25 kHz	452.500	11.091	
Analog FM/25 kHz	461.250	11.091	

408.750 MHz, Analog FM, 25.0 kHz



461.250 MHz, Analog FM, 25.0 kHz



Spectrum Masks

The product operates with an audio low pass filter, following masks have been applied:

Section 90.210(d) – Mask B and D have been applied as the transmitter can operate in the band 406.5 MHz to 470.0 MHz using an authorised bandwidth of 25.0 kHz and 12.5 kHz respectively as per Section 90.209(b)(5).

The reference level for the following emission mask measurements has been determined using a resolution bandwidth of 120 kHz with the transmitter modulated.

For all measurements a power attenuator is placed between the transmitter and the spectrum analyser, corresponding correction factors have been included in the measured plots. Measurements were made using a peak detector in max hold function.

Testing of analog FM channels has been performed by modulating the product using 2500 Hz external audio signal at a level 16 dB higher than that causes 50% frequency deviation corresponding to the channel bandwidth under test.

Testing of digital channels has been performed using the products internal modulation.

Attached to the input of the spectrum analyser was an external power attenuator. The attenuation factor of the power attenuator has been included as a correction in the plots Peak detector has been employed with max hold to capture the worst case results.

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.

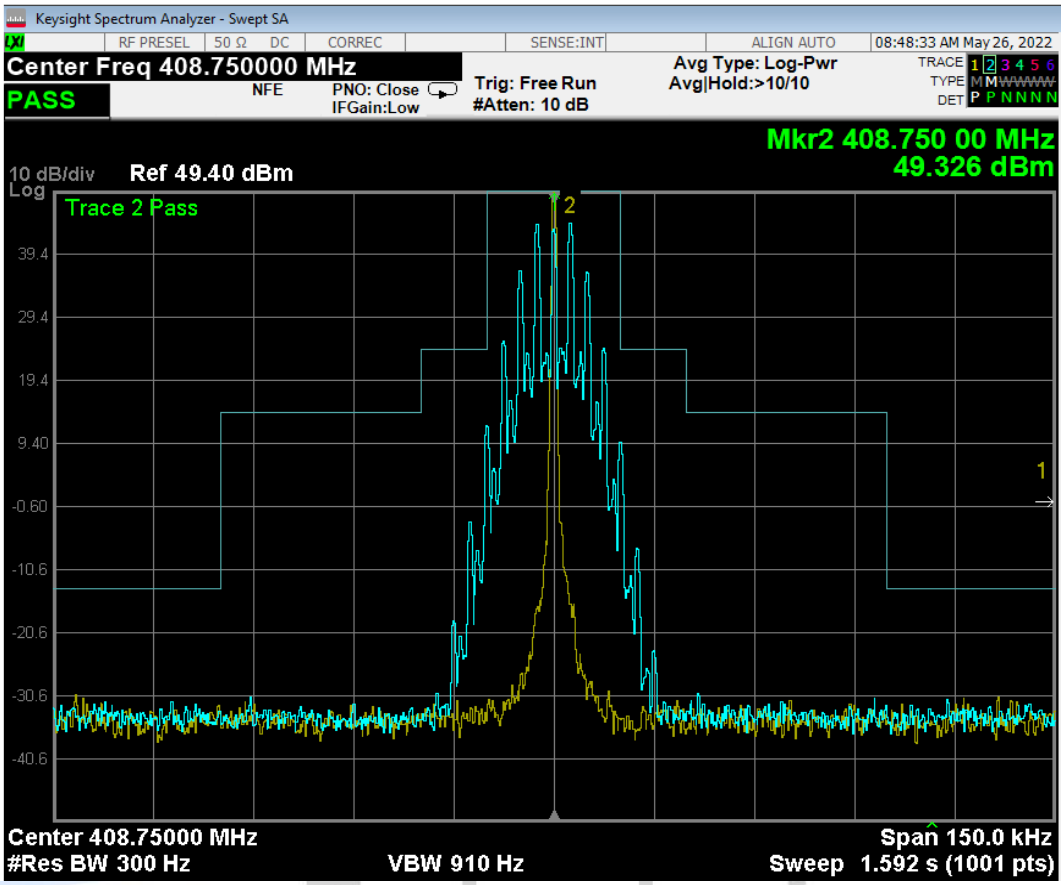
Yellow trace in the plots corresponds to unmodulated maximum power output. Blue trace corresponds to the modulated signal under test.

For the purpose of simplicity of the test report, only representative plots have been provided from the tested frequency band.

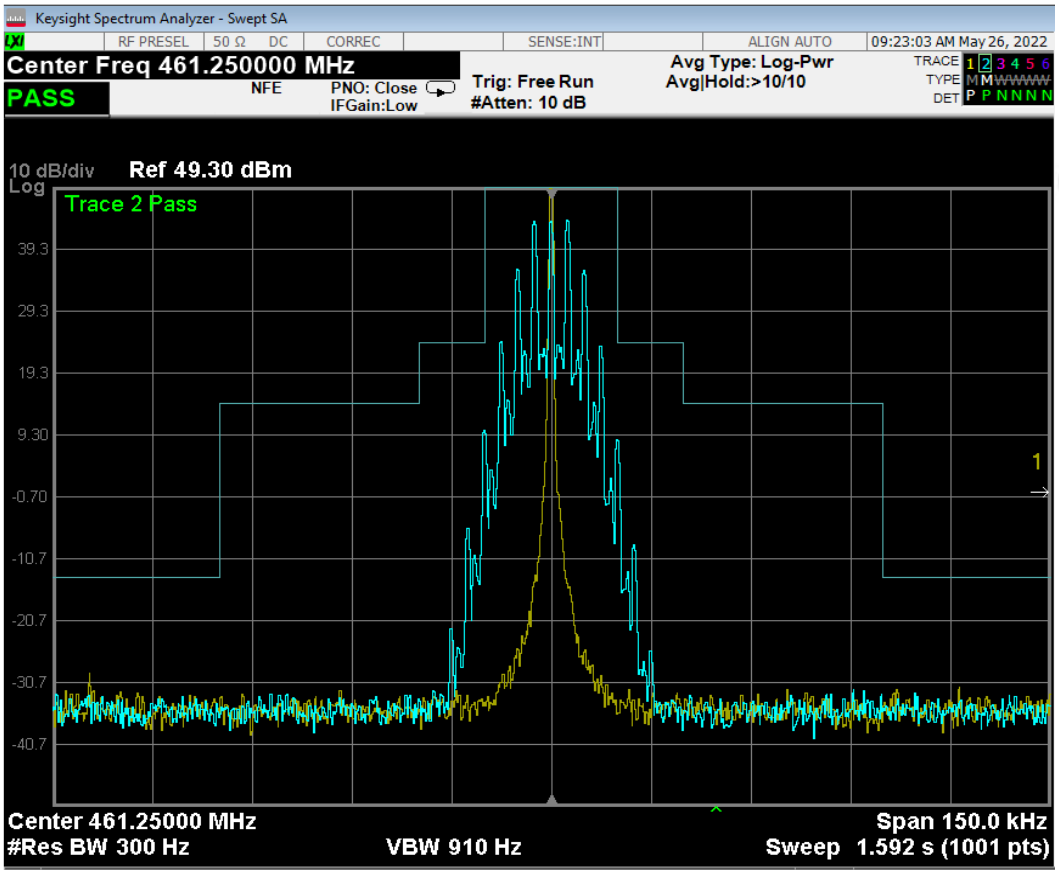
Result: Complies.

Spectrum Masks

Mask B, 408.750 MHz, FM 25 KHz, 100 W

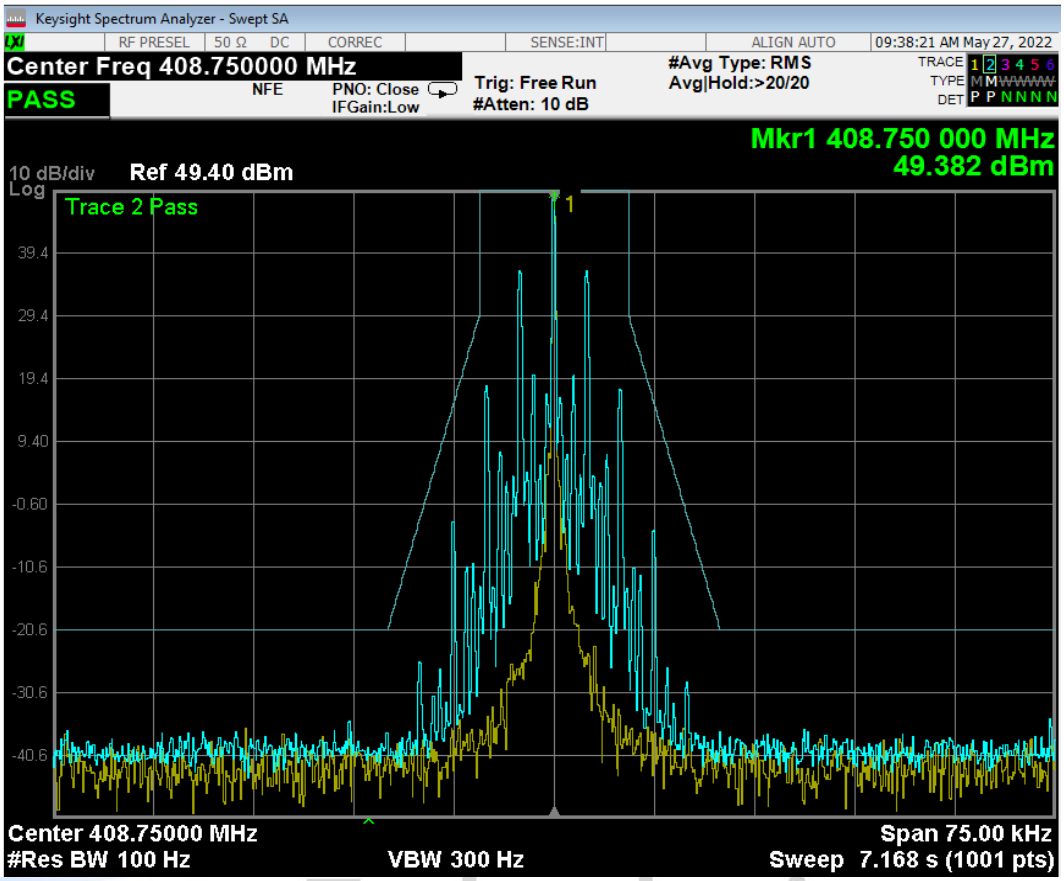


Mask B, 461.250 MHz, FM 25 KHz, 100 W

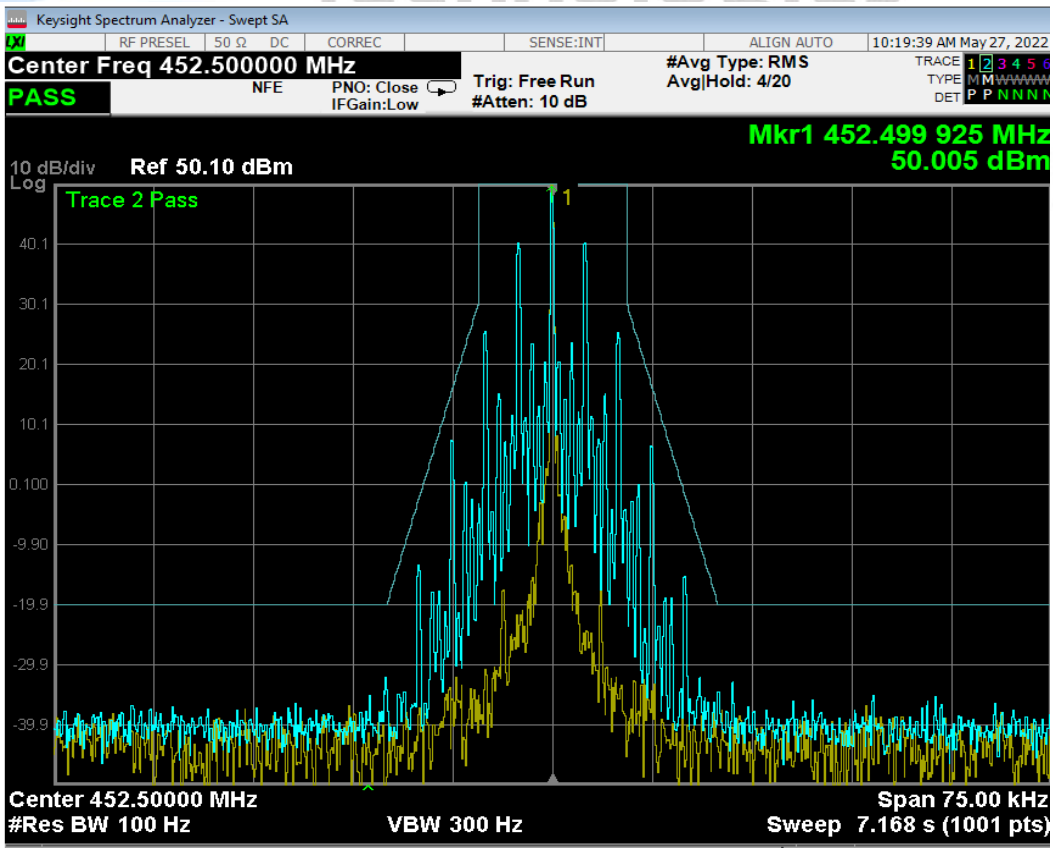


Spectrum Masks

Mask D, 408.750 MHz, FM 12.5 KHz, 100 W

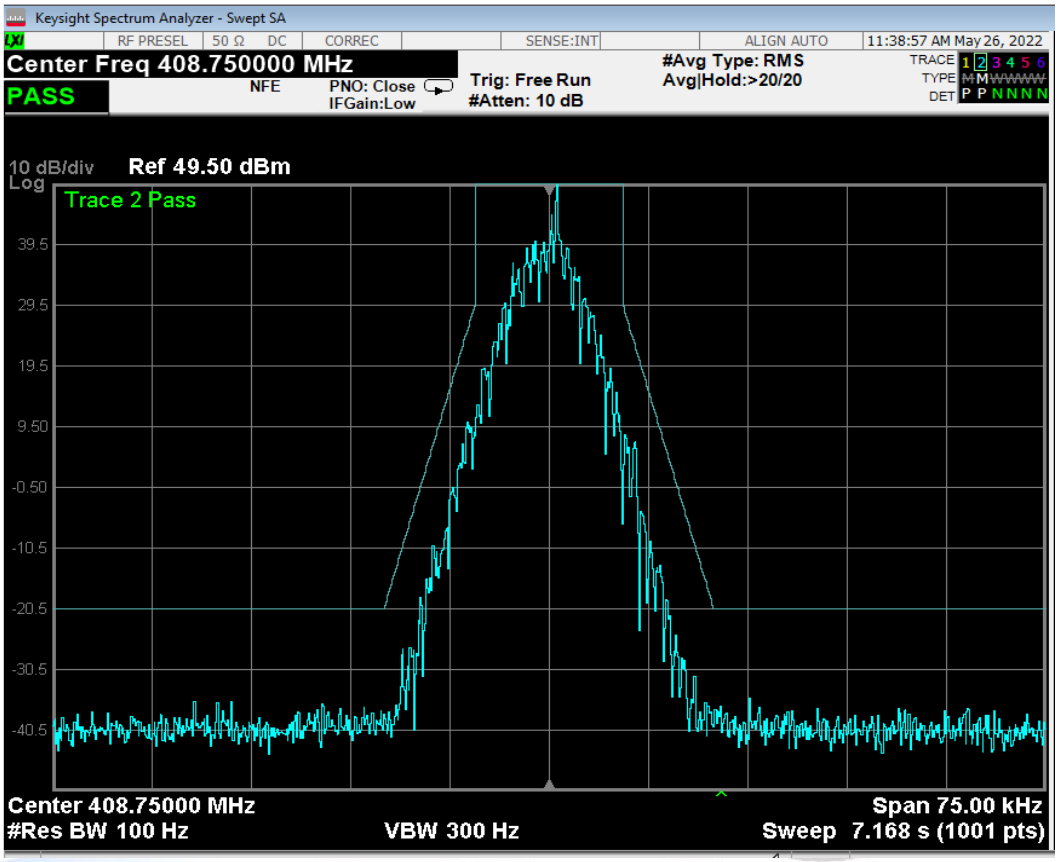


Mask D, 452.500 MHz, FM 12.5 KHz, 100 W

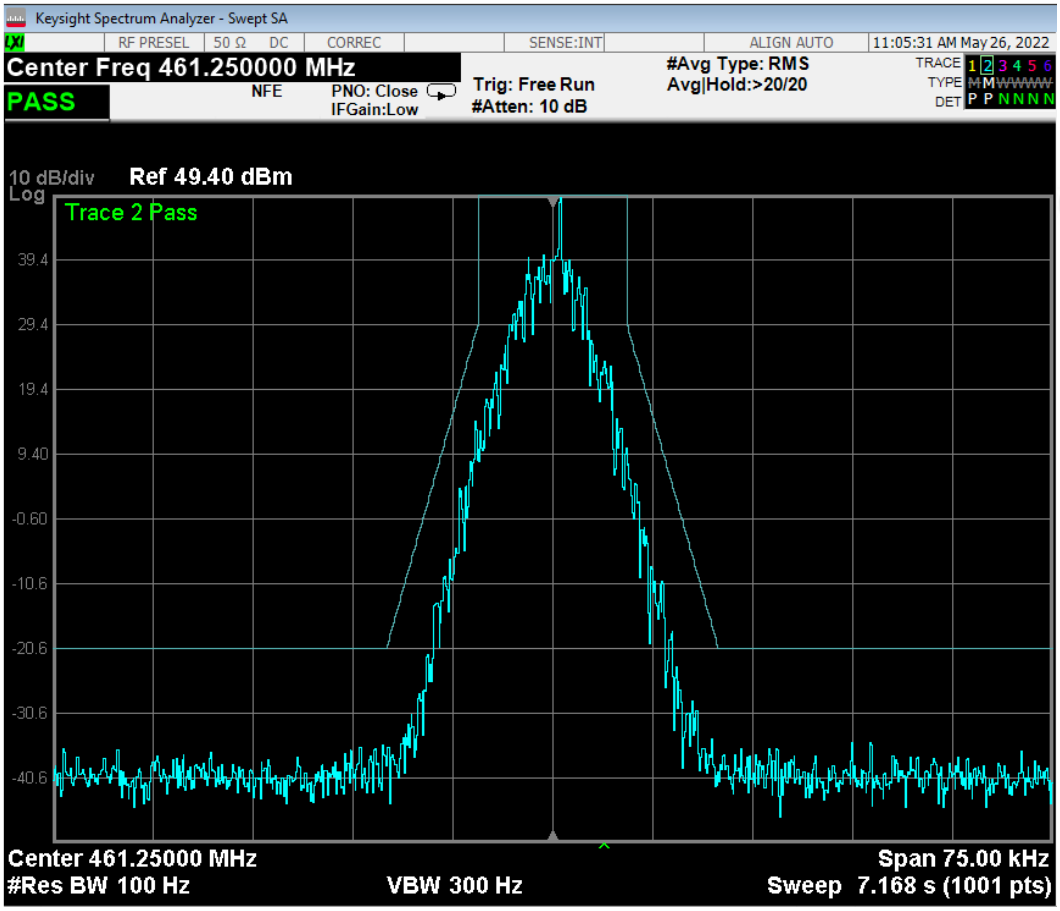


Spectrum Masks

Mask D, 408.750 MHz, DMR 12.5 KHz, 100 W



Mask D, 408.750 MHz, DMR 12.5 KHz, 100 W



Transmitter spurious emissions at the antenna terminals

Attached to the input of the spectrum analyser was an external power attenuator. The attenuation factor of the power attenuator has been included as a correction in the plots Peak detector has been employed with max hold to capture the worst case results.

The product was tested at unmodulated carrier output.

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

Frequency: 408.750 MHz

Spurious emission Harmonic (MHz)	Emission level (dBm)	Limit (dBm)
817.50	-36.2	-20.0
1226.25	-33.8	-20.0
1635.00	<-40.0	-20.0
2043.75	<-40.0	-20.0
2452.50	<-40.0	-20.0
2861.25	<-40.0	-20.0
3270.00	<-40.0	-20.0
3678.75	<-40.0	-20.0
4087.50	<-40.0	-20.0

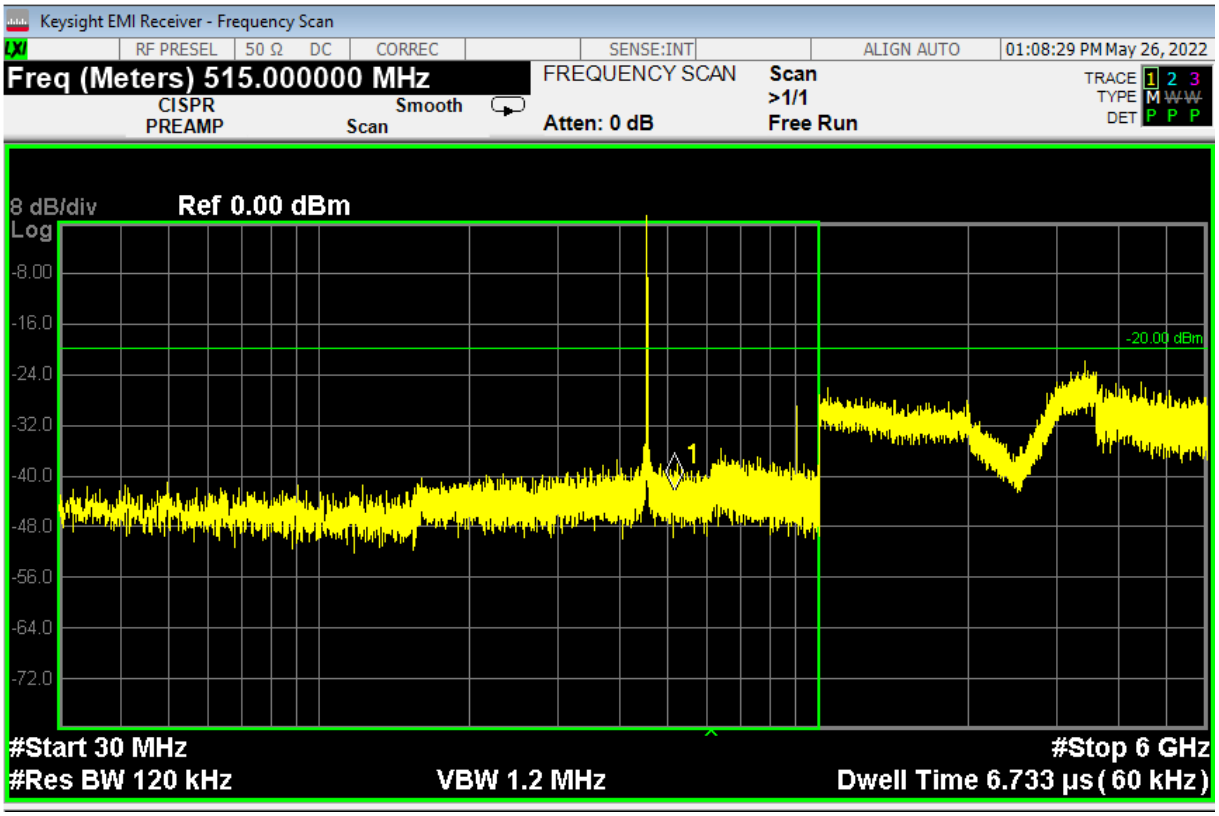
Frequency: 435.000 MHz

Spurious emission Harmonic (MHz)	Emission level (dBm)	Limit (dBm)
870.00	-39.7	-20.0
1305.00	<-39.0	-20.0
1740.00	<-40.0	-20.0
2175.00	<-40.0	-20.0
2610.00	<-40.0	-20.0
3045.00	<-40.0	-20.0
3480.00	<-40.0	-20.0
3915.00	<-40.0	-20.0
4350.00	<-40.0	-20.0

Transmitter spurious emissions at the antenna terminals cont.

Frequency: 461.250 MHz

Spurious emission Harmonic (MHz)	Emission level (dBm)	Limit (dBm)
922.50	-37.5	-20.0
1383.75	-39.2	-20.0
1845.00	<-40.0	-20.0
2306.25	<-40.0	-20.0
2767.50	<-40.0	-20.0
3228.75	<-40.0	-20.0
3690.00	<-40.0	-20.0
4151.25	<-40.0	-20.0
4612.50	<-40.0	-20.0



Transmitter spurious emissions at the antenna terminals cont.

Limit:

Part 90.210(d) Mask D, (3) on any frequency removed from the centre of the authorised bandwidth by a displacement frequency of more than 12.5 kHz shall be attenuated by at least 50 + 10 log (P) or 70 dB whichever is the lesser attenuation.

The spurious emission limit defined by Mask D has been applied as this transmitter can operate using channel spacing of 12.5 kHz.

Part 2.1051 states that emissions greater than 20 dB below the limit need not be specified.

Part 2.1057 states that the spectrum should be investigated up to the 10th harmonic if the transmitter operates below 10 GHz.

A rated power of 100 W gives a limit of –20.0 dBm.

No measurements were made above the 10th harmonic.

Result: Complies. **Measurement Uncertainty**: ± 0.5 dB

Field strength of the transmitter spurious emissions

Radiated emission testing was carried out over the frequency range of 30 MHz to 6000 MHz.

The measurements were carried out in transmit and standby/receive modes.

Testing was carried out at the laboratory's open area test site - located at Driving Creek Orere Point, RD5, Papakura, New Zealand.

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.

Testing was carried out using DC power supply.

Testing was carried out by manually scanning between 30 MHz and 6000 MHz in 100 kHz steps while aurally and visually monitoring for emissions.

When an emission is located, it is positively identified and its maximum level is found by rotating the automated turntable, and by varying the antenna height, where appropriate, with an automated antenna tower.

Between 30 - 1000 MHz the emission is measured in both vertical and horizontal antenna polarisations at a distance of 3 metres using a Quasi Peak detector with a 120 kHz bandwidth is used.

Between 1000 - 6000 MHz the emission is measured in both vertical and horizontal antenna polarisations at a distance of 3 metres using an Average detector and a Peak detector with bandwidths of 1 MHz.

The emission level was determined in field strength by taking the following into consideration:

Level (dBµV/m) = Receiver Reading (dBµV) + Antenna Factor (dB/m) + Coax Loss (dB)

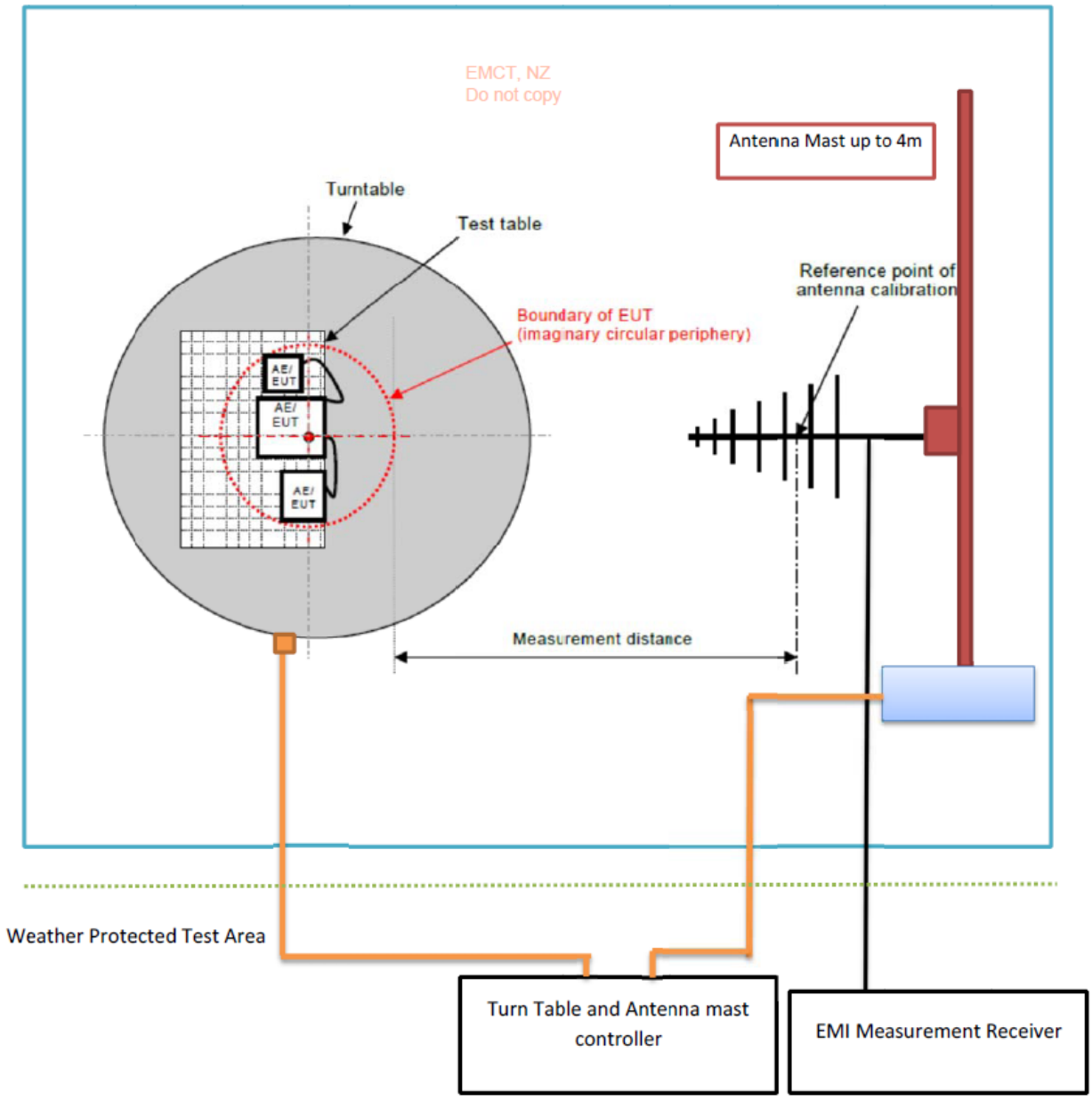
For example, if an emission of 30 dBµV was observed at 30 MHz.

45.5 dBµV/m = 30.0 dBµV + 14 dB/m + 1.5 dB

Result: Complies.

Measurement Uncertainty: ± 4.1 dB

Radiated Emissions Test setup at Open area test site



Transmitter spurious emissions results:

Nominal Frequency: 417.500 MHz

Frequency (MHz)	Level (dBuV/m)	Level (dBm)	Limit (dBm)	Polarity	Margin (dB)	Result
835.0000	41.2	-56.2	-20.0	Vertical	36.2	Pass
	44.6	-52.8	-20.0	Horizontal	32.8	Pass
1252.5000	52.3	-45.0	-20.0	Vertical	25.0	Pass
	53.5	-43.9	-20.0	Horizontal	23.9	Pass
1670.0000	43.0	-54.4	-20.0	Vertical	34.4	Pass
	54.1	-43.3	-20.0	Horizontal	23.3	Pass
2087.5000	47.5	-49.9	-20.0	Vertical	29.9	Pass
	-	-	-20.0	Horizontal	-	Pass
2505.0000	48.0	-49.4	-20.0	Vertical	29.4	Pass
	-	-	-20.0	Horizontal	-	Pass
2922.5000	49.0	-48.4	-20.0	Vertical	28.4	Pass
	-	-	-20.0	Horizontal	-	Pass
3340.0000	<50.0	<-47.4	-20.0	Vertical	>27.4*	Pass
	-	-	-20.0	Horizontal	-	Pass
3757.5000	<50.0	<-47.4	-20.0	Vertical	>27.4*	Pass
	-	-	-20.0	Horizontal	-	Pass

Nominal Frequency: 435.000 MHz

Frequency (MHz)	Level (dBuV/m)	Level (dBm)	Limit (dBm)	Polarity	Margin (dB)	Result
870.0000	45.2	-52.2	-20.0	Vertical	32.2	Pass
	44.0	-53.4	-20.0	Horizontal	33.4	Pass
1305.0000	50.5	-46.9	-20.0	Vertical	26.9	Pass
	50.4	-47.0	-20.0	Horizontal	27.0	Pass
1740.0000	54.6	-42.8	-20.0	Vertical	22.8	Pass
	55.0	-42.4	-20.0	Horizontal	22.4	Pass
2175.0000	49.0	-48.4	-20.0	Vertical	28.4	Pass
	49.0	-48.4	-20.0	Horizontal	28.4	Pass
2610.0000	<50.0	<-47.4	-20.0	Vertical	>27.4*	Pass
	<50.0	<-47.4	-20.0	Horizontal	>27.4*	Pass
3045.0000	<50.0	<-47.4	-20.0	Vertical	>27.4*	Pass
	<50.0	<-47.4	-20.0	Horizontal	>27.4*	Pass
3480.0000	<50.0	<-47.4	-20.0	Vertical	>27.4*	Pass
	<50.0	<-47.4	-20.0	Horizontal	>27.4*	Pass

*** Noise floor measurement**

Transmitter spurious emissions results: cont.

Nominal Frequency: 470.000 MHz

Frequency (MHz)	Level (dBuV/m)	Level (dBm)	Limit (dBm)	Polarity	Margin (dB)	Result
940.0000	44.0	-53.4	-20.0	Vertical	33.4	Pass
	42.8	-54.6	-20.0	Horizontal	34.6	Pass
1410.0000	43.7	-53.7	-20.0	Vertical	33.7	Pass
	50.8	-46.6	-20.0	Horizontal	26.6	Pass
1880.0000	51.5	-45.9	-20.0	Vertical	25.9	Pass
	55.2	-42.2	-20.0	Horizontal	22.2	Pass
2350.0000	49.4	-48.0	-20.0	Vertical	28.0	Pass
	49.0	-48.4	-20.0	Horizontal	28.4	Pass
2820.0000	49.3	-48.1	-20.0	Vertical	28.1	Pass
	49.3	-48.1	-20.0	Horizontal	28.1	Pass
3290.0000	<50.0	>-47.4	-20.0	Vertical	>27.4*	Pass
	<50.0	>-47.4	-20.0	Horizontal	>27.4*	Pass
3760.0000	<50.0	>-47.4	-20.0	Vertical	>27.4*	Pass
	<50.0	>-47.4	-20.0	Horizontal	>27.4*	Pass

* Noise floor measurement

Limit:

All spurious emissions are to be attenuated by at least 50 + 10 log (P) from below the mean power of the transmitter. The rated power of 100 W gives a limit of -20.0 dBm.

No measurements were made above the 10th harmonic.

Result: Complies.

Measurement Uncertainty: ± 4.1 dB

General/Standby emissions:

Results: 30 – 6000 MHz

Measurements between 30 – 6000 MHz have been made at a distance of 3 metres.
The Class B limits been applied.

Frequency (MHz)	Vertical (dBµV/m)	Horizontal (dBµV/m)	Limit (dBµV/m)	Margin (dB)	Antenna Polarisation	Result
32.0000	32.45	-	40.0	7.6	Vertical	Pass
32.4000	34.5	-	40.0	5.5	Vertical	Pass
32.600	32.8	-	40.0	7.2	Vertical	Pass
34.440	31.3	-	40.0	8.7	Vertical	Pass
39.760	27.3	-	40.0	12.7	Vertical	Pass
44.560	30.8	-	40.0	9.2	Vertical	Pass
67.520	21.1	-	40.0	18.9	Vertical	Pass
68.920	19.3	-	40.0	20.7	Vertical	Pass
75.960	31.8	-	40.0	8.2	Vertical	Pass
115.600	23.0	-	40.0	17.0	Vertical	Pass
120.000	25.2	-	40.0	14.8	Vertical	Pass
124.280	30.5	-	40.0	9.5	Vertical	Pass
141.320	31.4	-	40.0	8.6	Vertical	Pass
190.400	30.3	-	43.5	13.2	Vertical	Pass
249.800	33.7	-	43.5	9.8	Vertical	Pass
333.280	-	32.7	46.0	13.3	Horizontal	Pass
343.840	-	33.5	46.0	12.5	Horizontal	Pass
350.360	-	30.8	46.0	15.2	Horizontal	Pass
360.880	-	29.6	46.0	16.4	Horizontal	Pass
438.760	-	29.5	46.0	16.5	Horizontal	Pass
503.560	-	30.5	46.0	15.5	Horizontal	Pass
607.640	-	32.5	46.0	13.5	Horizontal	Pass
710.760	-	33.9	46.0	12.0	Horizontal	Pass
1593.600	48.8	-	74.0	25.2	Vertical	Pass Peak detector
1593.600	32.0	-	54.0	22.0	Vertical	Pass Average detector
1785.200	-	35.5	54.0	18.5	Horizontal	Pass Average detector
1994.800	49.6	47.2	74.0	24.4	Vertical	Pass Peak detector
1994.800	41.9	35.5	54.0	12.1	Vertical	Pass Average detector
2399.600	54.2	49.9	74.0	19.8	Vertical	Pass Peak detector
2399.600	44.6	35.9	54.0	9.4	Vertical	Pass Average detector
3054.000	-	52.3	74.0	21.7	Horizontal	Pass Peak detector

All other emissions were observed to have a margin to the limit that exceed at least 15 dB of the limit when the measurements were carried out between 30 - 6000 MHz using both vertical and horizontal polarisations.

Result: Complies.

Measurement uncertainty with a confidence interval of 95% is:

- Free radiation tests (30 - 6000 MHz) ± 4.1 dB

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: 408.750 MHz

Temperature (°C)	Low Vdc Error (Hz)	Nominal Vdc Error (Hz)	High Vdc Error (Hz)
+50	-90	-90	-89
+40	-68	-68	-68
+30	-64	-64	-68
+20	-88	-68	-69
+10	+19	+20	+20
0	+14	+15	+15
-10	+32	+32	+32
-20	+38	+38	+38
-30	-10	-11	-11

Test Frequency: 461.250 MHz

Temperature (°C)	Low Vdc Error (Hz)	Nominal Vdc Error (Hz)	High Vdc Error (Hz)
+50	-90	-90	-89
+40	-68	-68	-69
+30	-70	-70	-71
+20	-90	-70	-70
+10	+25	+25	+25
0	+19	+19	+19
-10	+41	+41	+41
-20	+46	+46	+47
-30	-14	-11	-9

Limits:

Part 90.213 states that fixed station transmitters operating between 421.000-512.000 MHz with 6.25 kHz channelling are required to have a frequency tolerance of 1.0 ppm.

A worst case error of 0.220 ppm (-90 Hz / 408.750 MHz) was observed.

Result: Complies.
Measurement Uncertainty: ± 30 Hz

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.

Limits:

Time Interval	Period (ms)	6.25 kHz Deviation (kHz)	12.5 kHz Deviation (kHz)	25 kHz Deviation (kHz)
t_1	10	± 6.25	± 12.5	± 25.0
t_2	25	± 3.125	± 6.25	± 12.5
t_3	10	± 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 (435.000 MHz)

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

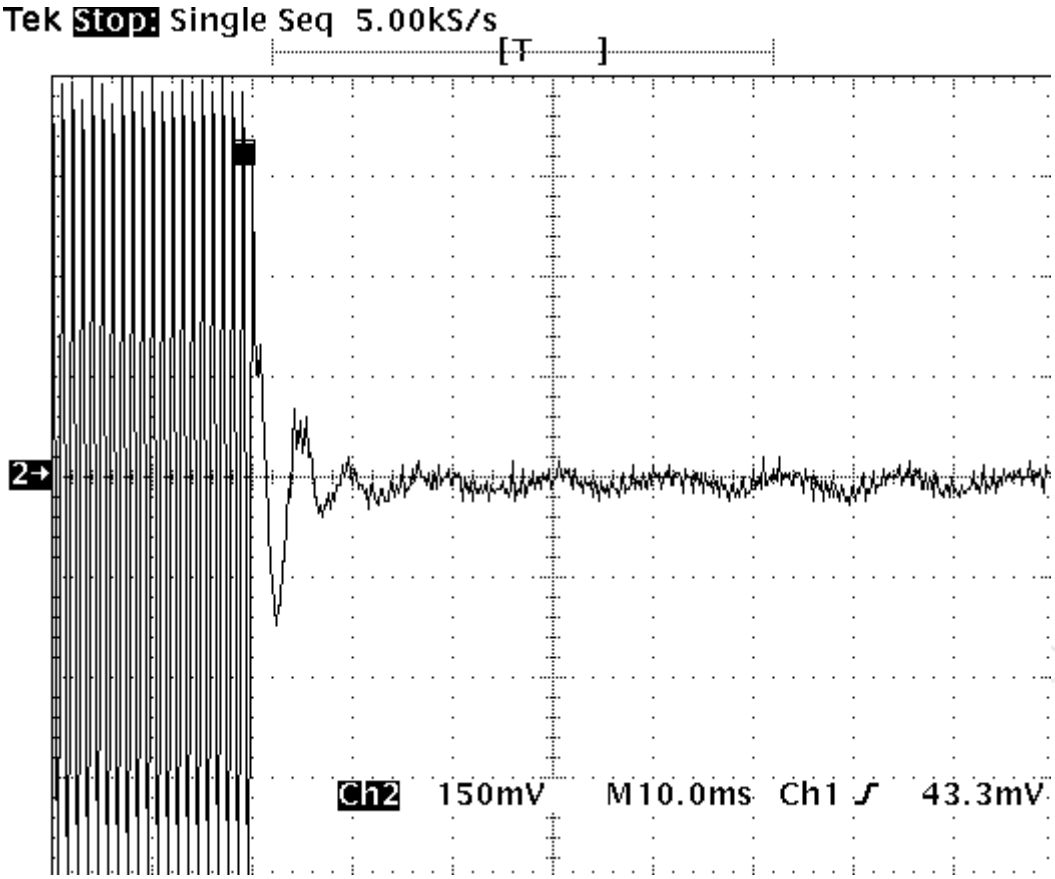
Green trace has been maximised to give full screen indication of +/- 12.5 kHz.
The X axis has been set to a sweep rate of 10 ms/division.

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.



Result: Complies.

12.5 kHz transmitter turn off (435.000 MHz)

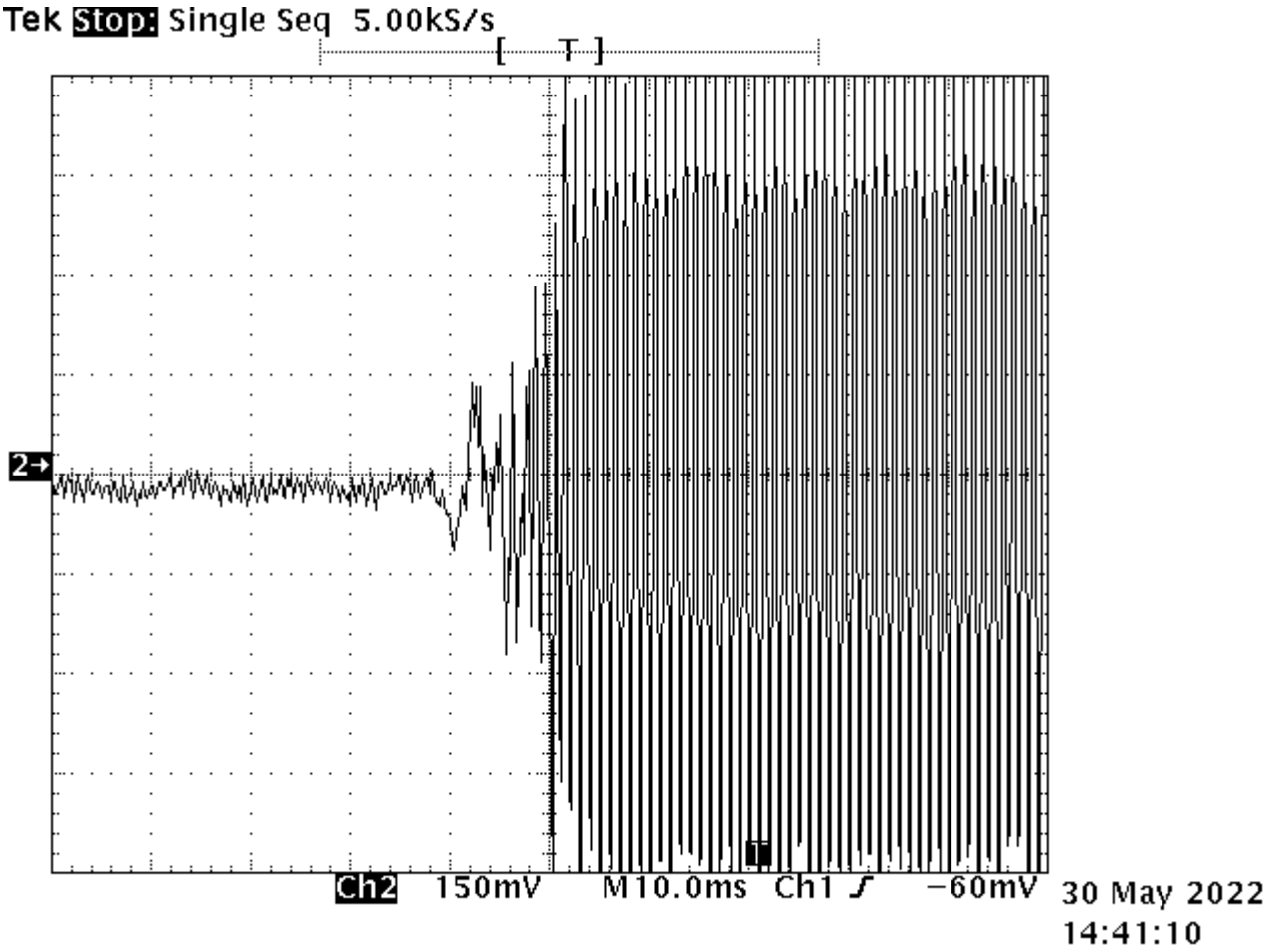
Green Trace = 1 kHz tone with FM deviation of 12.5 kHz.

Green 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.



Result: Complies.

25.0 kHz Transmitter turn on (435.000 MHz)

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

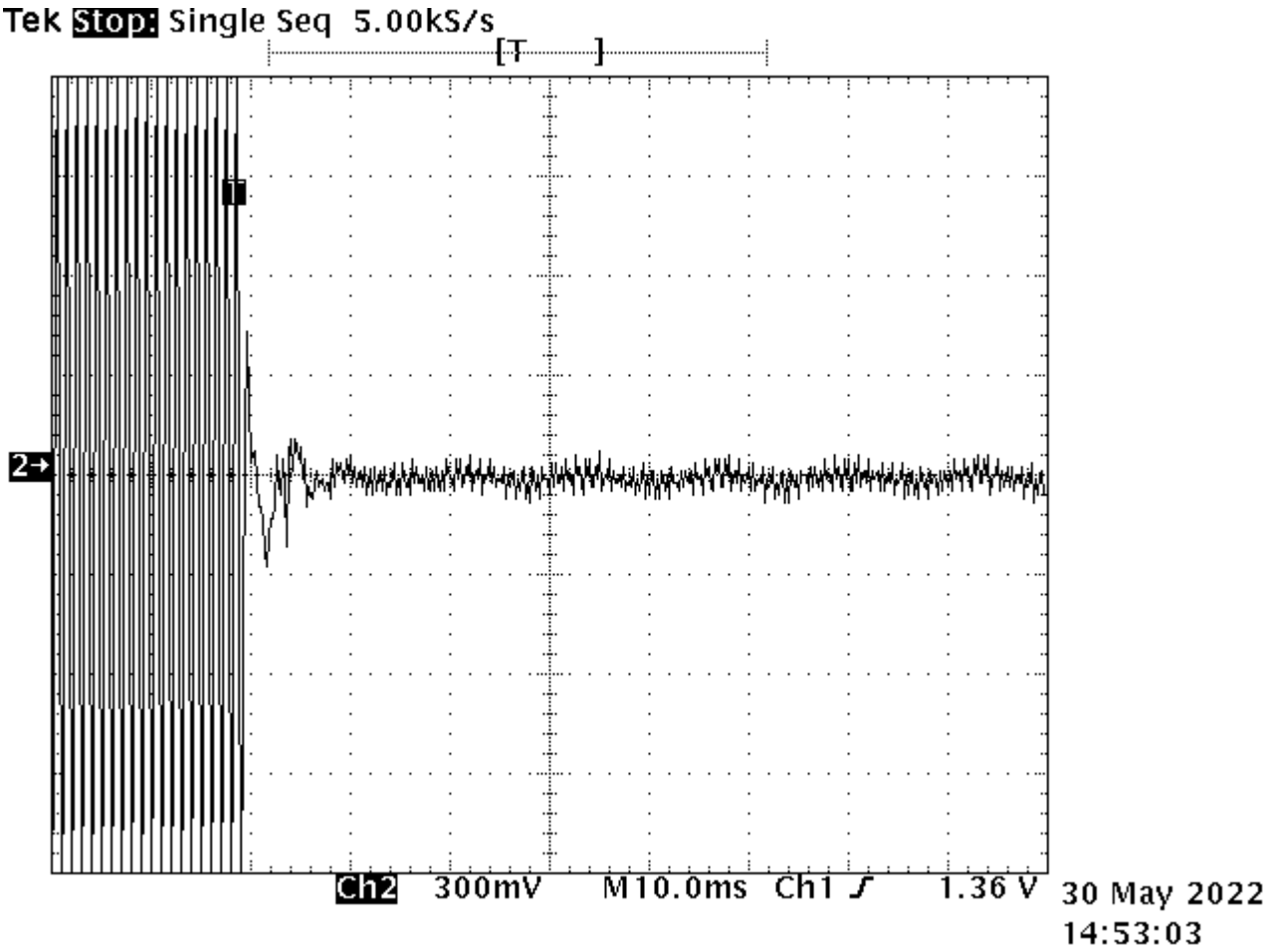
Green trace has been maximised to give full screen indication of +/- 25.0 kHz.
The X axis has been set to a sweep rate of 10 ms/division.

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.



Result: Complies.

25.0 kHz transmitter turn off (435.000 MHz)

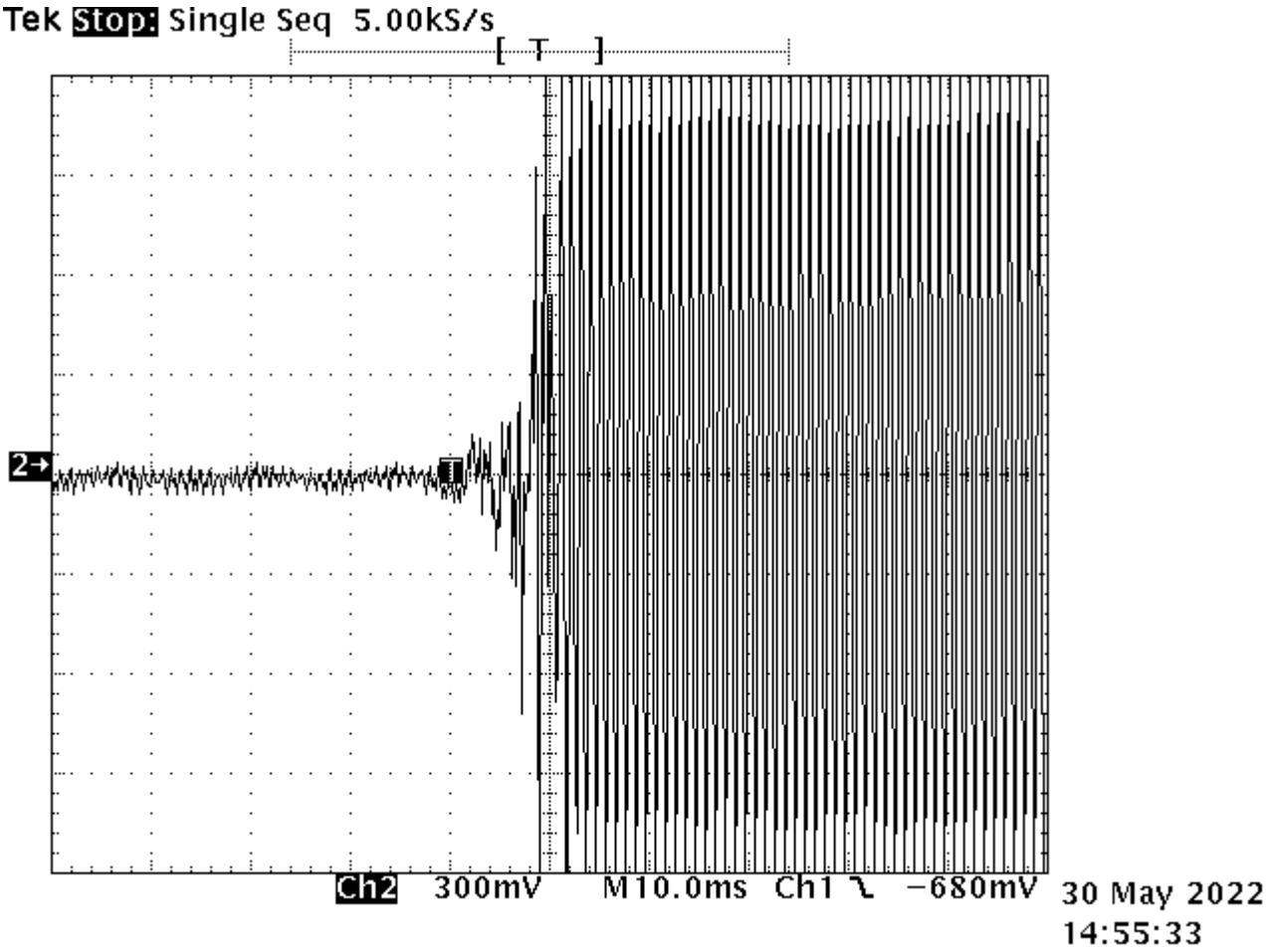
Green Trace = 1 kHz tone with FM deviation of 25.0 kHz.

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.



Result: Complies.

Modulation Characteristics

a) This transmitter is capable of producing analogue speech modulation.

Frequency response of the audio frequency low pass filter between 100 Hz and 15 kHz.

This measurement was carried out using an audio signal generator and an audio modulation analyser.

At 1 kHz an audio signal was applied which was used as a 0 dB response reference.

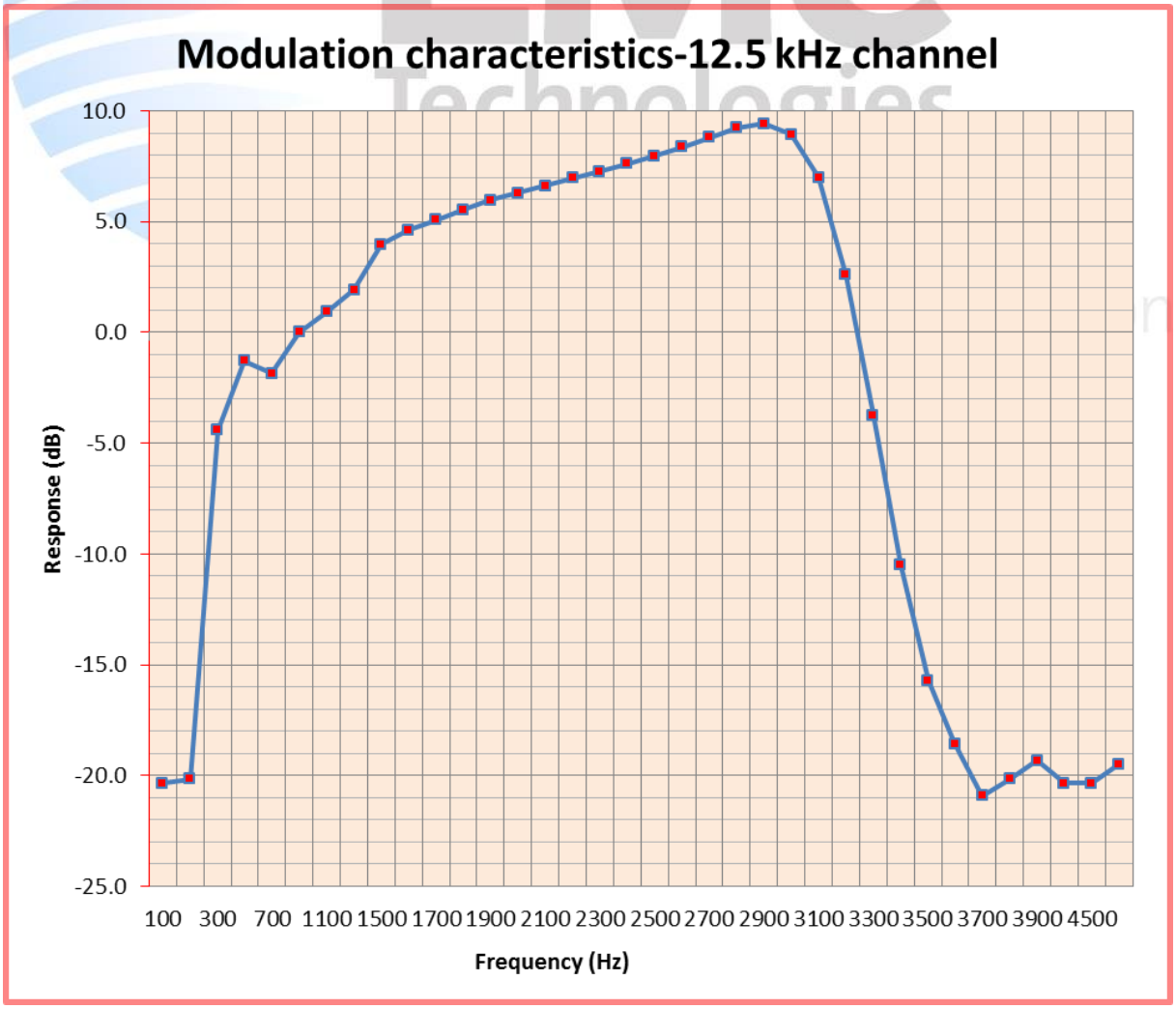
The frequency of the input signal was then varied and the output response noted.

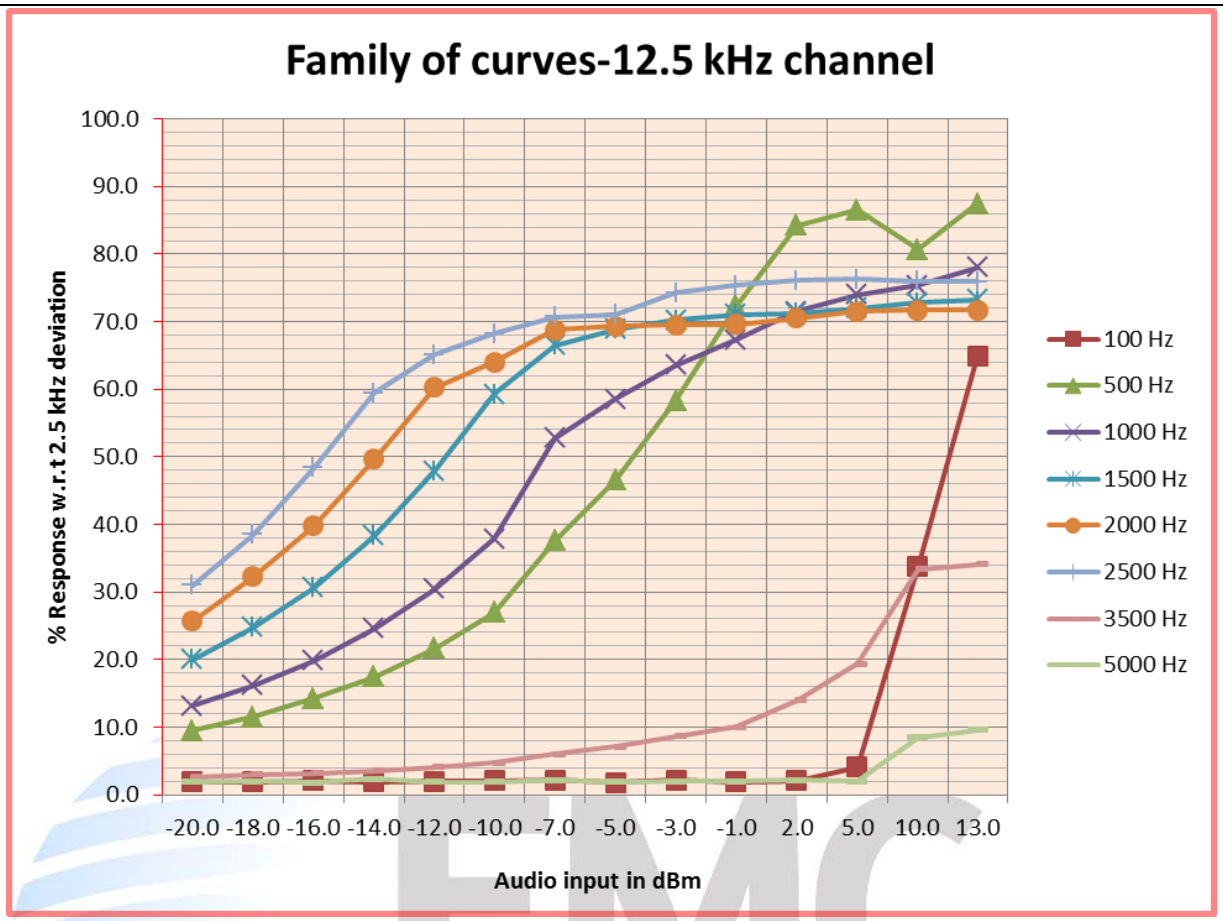
This measurement was carried out from 100 Hz to 5000 Hz as required by Part 2 with further measurements carried out in order to show the full range of this filter.

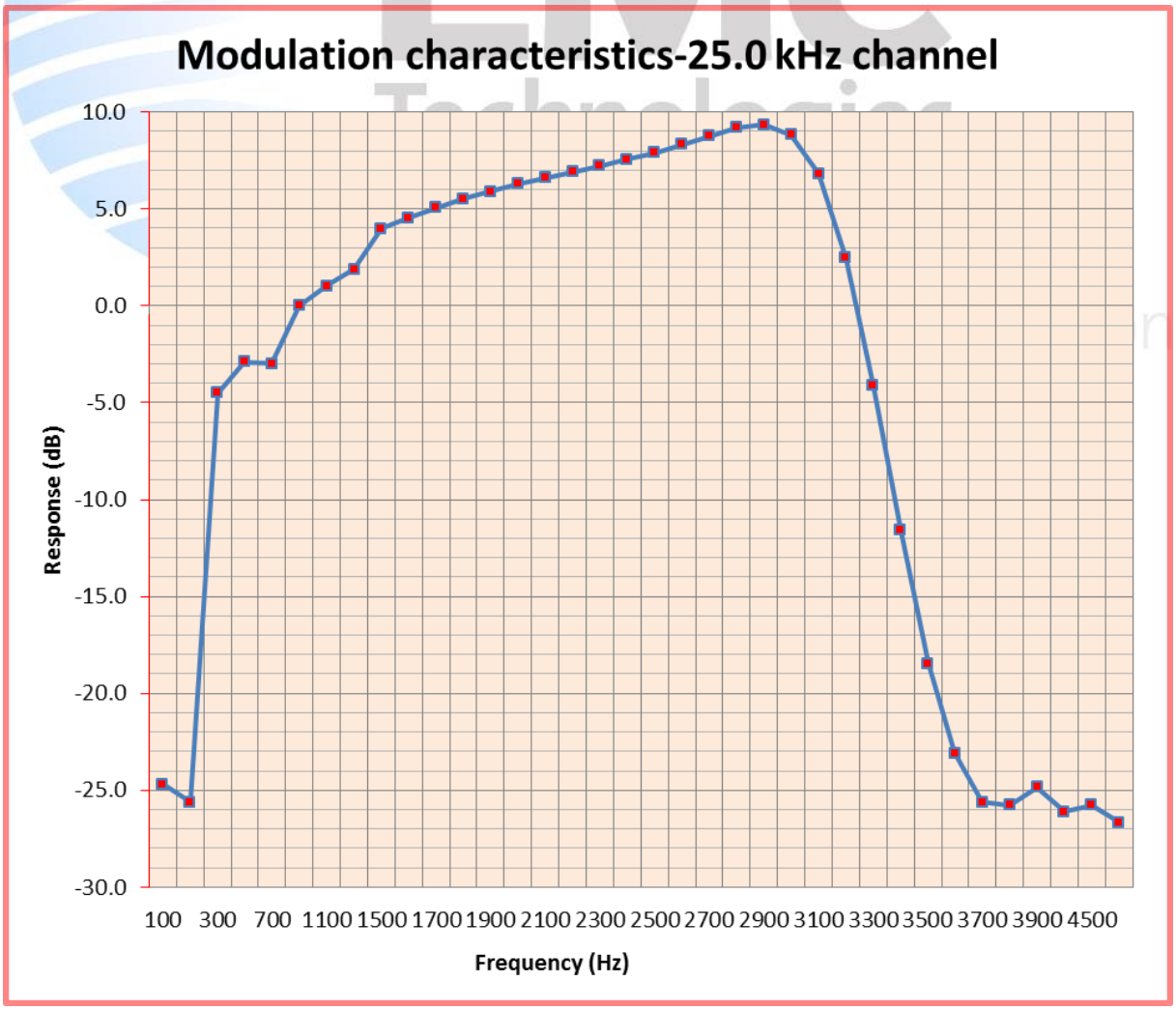
b) A family of curves showing the percentage of modulation versus the modulation input voltage.

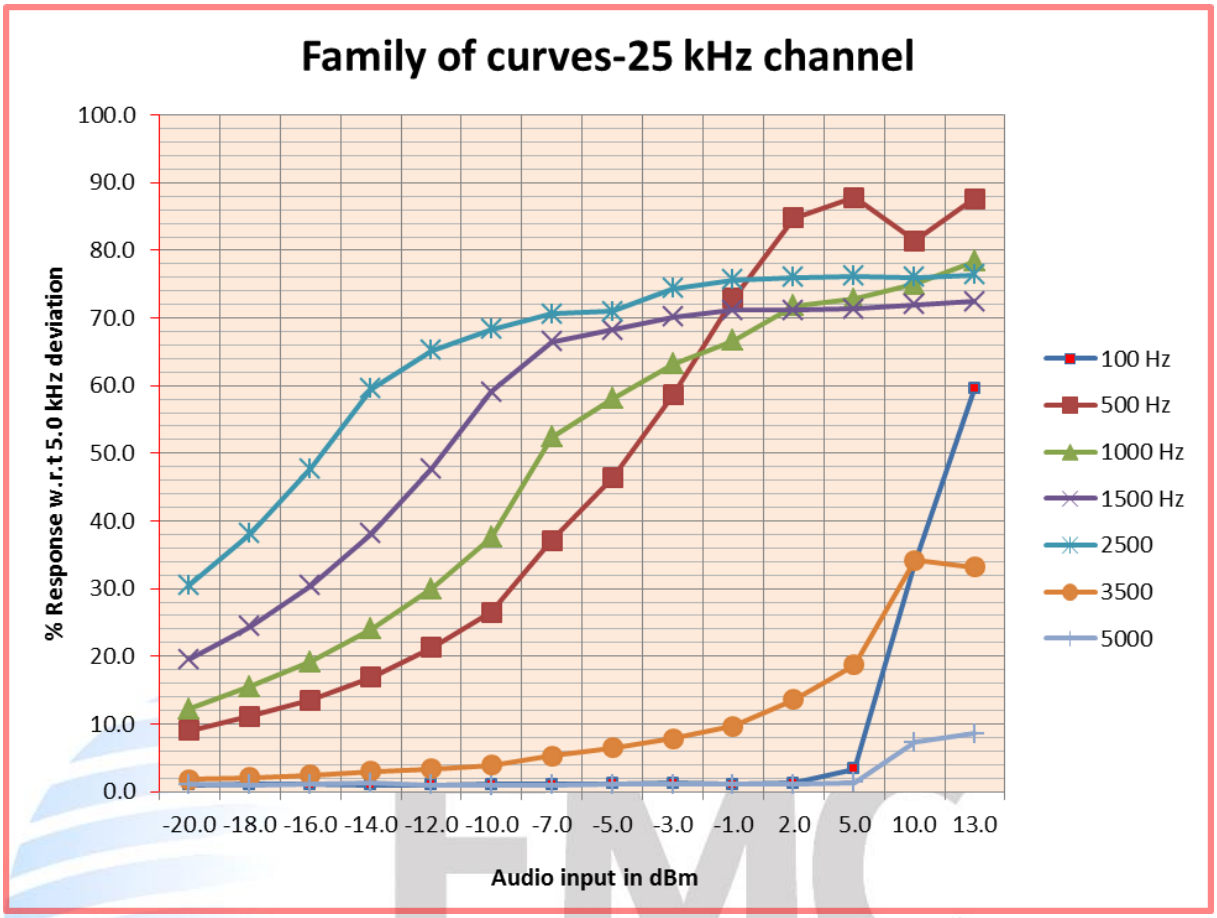
Measurements were made between 100 Hz to 5 kHz.

At each frequency the input voltage was slowly increased with the resulting frequency deviation of the transmitter being recorded.









Exposure of humans to RF fields

As per FCC KDB 447498 D04 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 both the Occupational (Controlled Exposure) and General Population (Uncontrolled Exposure) limits that are defined in Section 1.1310.

FCC 1.1310 Limits for Maximum Permissible Exposure (MPE)

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

Minimum safe distances have been calculated below.

- Occupational / Controlled exposure is (f/300) mW/cm^2

- General Population / Uncontrolled exposure is (f/1500) mW/cm^2

As this radio can operate over the range of 406.0 to 470.0 MHz the lowest frequency of operation which will give the worst case result, would be 406.0 MHz.

The power density (Power density = $E^2/3770$ mW/cm^2) at 406.0 MHz comes out to be as follows:

- For Occupational / Controlled exposure: 1.35 mW/cm^2

- General Population / Uncontrolled exposure: 0.27 mW/cm^2

The rated maximum transmitter power = 100 W (+50 dBm).

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

Exposure of humans to RF fields cont.

As per the client, the antenna(s) used for this transmitter must be fixed-mounted on outdoor permanent structures.

Typical antenna used in the calculation for maximum permissible exposure is a 1 dipole antenna which is bi-directional with typical gain of 3.6 dBi.

$$Gain_{(num)} = 10^{(Gain_{(dBi)}/10)}$$

Numeric gain calculated using formula above gives a value of 2.3 which is used in calculations.

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 Therefore D = (√ (30 * P * G * DC)) / FS

Alternative formula that can be applied as per OET Bulletin 65 is:

$$S = \frac{PG}{4\pi R^2}$$

Where:
S = power density (in appropriate units, e.g. mW/cm2)
P = power input to the antenna (in appropriate units, e.g., mW)
G = power gain of the antenna in the direction of interest relative to an isotropic radiator
R = distance to the centre of radiation of the antenna (appropriate units, e.g., cm)

For Controlled Environment
Power Density = 1.35 mW/cm^2 = E^2/3770

E= √ 1.35*3770

E = 71.3 V/m
D = (√ (30 * 100 * 2.3 * 1)) / 71.3
D = 1.16 m

For Uncontrolled Environment
Power Density = 0.270 mW/cm^2 = E^2/3770

E= √ 0.270*3770

E = 31.9 V/m
D = (√ (30 * 100* 2.3 * 1)) / 31.9
D = 2.6 m
Result: Complies if a safe distance of at least (D) calculated above is applied to this device.

7. TEST EQUIPMENT USED

Instrument	Manufacturer	Model	Serial #	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	9594	28/09/22	5 years
Log Periodic Antenna	Schwarzbeck	VUSLP 91111	9111-112	16/11/23	2 years
Horn Antenna	EMCO	3115	9511-4629	08/08/22	5 years
Measurement Receiver	Rohde & Schwarz	ESHS 10	828404/005	23/11/23	2 years
Modulation Analyzer	Rohde & Schwarz	FMA	837807/020	13/04/23	1.0 year
Power Attenuator	Tenuline	8322	-	N/a	N/a
Power Attenuator	DTS	-	-	N/a	N/a
Modulation Analyser	Hewlett Packard	8901B	SN2608A00782	13/01/23	3.0 years
Signal Generator	Rohde & Schwarz	SMHU	E1493	28/05/23	2.0 years
Power meter	Hewlett Packard	436A	2512A22439	17/06/22	2.5 years
Oscilloscope	Tektronics	745A	B010643	-	-
Receiver	Rohde & Schwarz	ESIB-40	100295	03/06/23	2.0 years
Spectrum Analyzer	Keysight	N9038A	MY57290153	29/07/22	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
Software	Rohde & Schwarz	ES-K1 140	-	N/a	N/a
ISN	TESEQ, ISN T8-Cat6	59957	3809	02/08/23	2 years

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, which expires on the 02/12/2022.

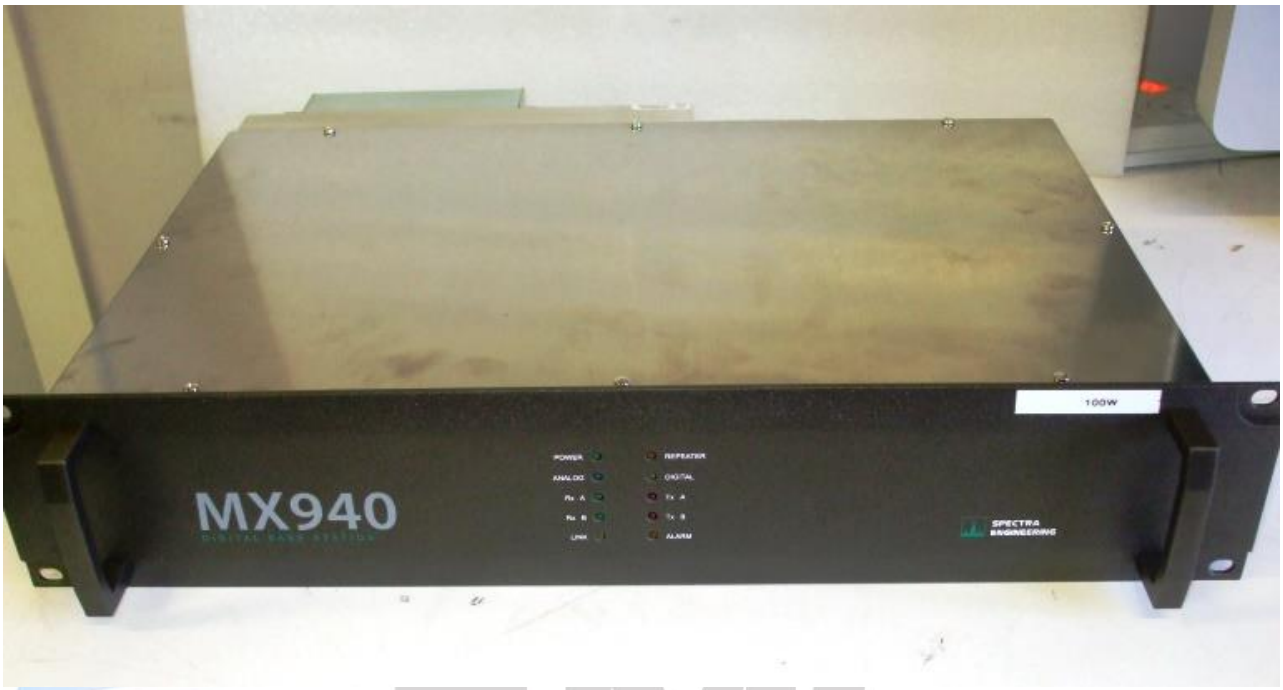
All testing was carried out in accordance with the terms of EMC Technologies (NZ) Ltd International Accreditation New Zealand (IANZ) Accreditation to NZS/ISO/IEC 17025.

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.

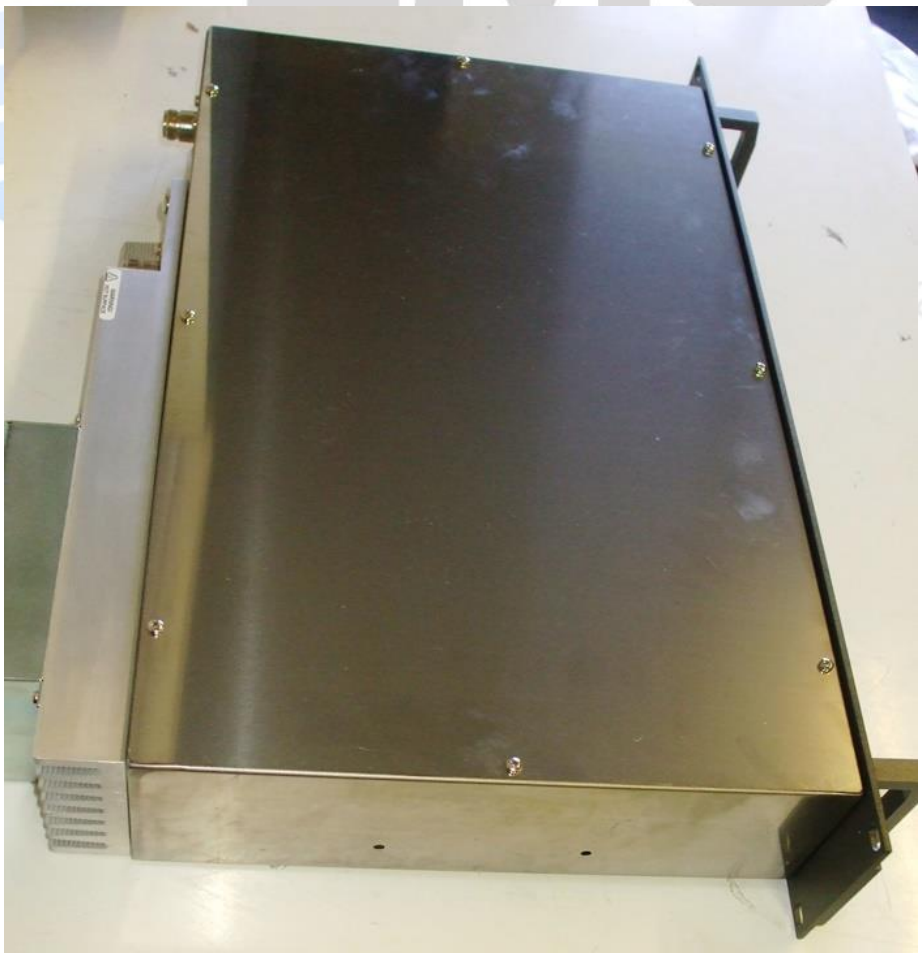
International Accreditation New Zealand has Mutual Recognition Arrangements for testing and calibration with various accreditation bodies in a number of economies. This includes NATA (Australia), UKAS (UK), SANAS (South Africa), NVLAP (USA), A2LA (USA), SWEDAC (Sweden). Further details can be supplied on request.

11. PHOTOGRAPHS

Front Face showing LED's



Side Face



Side Face showing label

Rear Face showing the antenna ports and other connections

Label-1

Label showing FCC ID

Radiated Emissions Test Setup