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TEST REPORT

Salcom 20-62-0450
(421.5-475.0 MHz)
UHF POCSAG Paging Transmitter

tested to the

Code of Federal Regulations (CFR) 47

Part 90 –Private Land Mobile Services

for

Sea Air and Land Communications (SALCOM) Ltd

This Test Report is issued with the authority of:

Andrew Cutler- General Manager

IANZ ACCREDITED 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 **Salcom 20-62-0450 (421.5-475.0 MHz) UHF POCSAG Paging Transmitter** 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 and ANSI / TIA-603-D-2010.

2. RESULT SUMMARY

The results of testing carried out between the 12th December 2019 and the 27th February 2020 are summarised below.

Clause	Description	Result
90.203	Certification required	Noted
2.1046	RF power output	Noted
90.205	Power and antenna height limits	Complies
2.1049	Occupied bandwidth	Noted
2.202	Bandwidths	Noted
90.207	Types of emissions	Complies
90.209	Bandwidth limitations	Complies
90.210	Emission masks	Complies
2.1051	Spurious emissions at antenna terminals	Complies
2.1053	Field strength of spurious radiation	Not tested
2.1055	Frequency stability	Noted
90.213	Frequency stability	Complies
90.214	Transient frequency behaviour	Complies
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 corrections or erasures.

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.

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 Sea, Air and Land Communications Ltd

Address 10 Vanadium place
Addington
Christchurch 8024

Country New Zealand

Contact Mr Alan Jacks

5. TEST SAMPLE DESCRIPTION

Brand Name Salcom

Model Number 20-62-0450

Product UHF (421.5-475.0 MHz) POCSAG Transmitter

Manufacturer Sea Air Land Communications Ltd

Manufactured in New Zealand

Serial Number DEMO-0012

FCC ID O87-20620450

Rated Transmitter Output Power

The power can be varied from 50 mW (17.0 dBm) to 5.0 W (37.0 dBm) using the client software.

Transmitter Certification Range

Part 90: 421.5-475.0 MHz

Test frequencies

Frequency (MHz)	Power (Watts)	Channel Bandwidth (kHz)	Emission
427.5	5.0	12.5, 25.0	F1D
451.0	5.0	12.5, 25.0	F1D
475.0	5.0	12.5, 25.0	F1D

- Frequencies of the switching range as per the FCC frequency allocation 47 C.F.R. § 2.106 were selected for testing.

The product uses POCSAG as internal modulation scheme which is an asynchronous protocol used to transmit data to pagers.

The modulation used is FSK with a ±4.5 kHz shift on the carrier. The high frequency represents a 0 and the low frequency a 1.

The ±4.5 kHz frequency shift is used along with a 25.0 kHz channel spacing, known as "wideband".

A "narrowband" configuration, using 12.5 kHz channel spacing and ±2.5 kHz frequency shifts is supported by the product.

512 and 1200 baud rates are supported by the product.

Transmitter Type

This equipment has been classed as one way paging transmitter.

Emission designators

7k20F1D for 12.5 kHz channel bandwidth

12k0F1D for 25.0 kHz channel bandwidth

Channel Spacing

Equipment designed to operate using 12.5 kHz and 25.0 kHz channel spacing.

Transmitter Duty Cycle

100% till time out is activated.

Standard Temperature and Humidity

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

Standard Test Power Source

Standard Test Voltage:	13.0 Vdc

Extreme Temperature

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

Extreme Test Voltages as per the product manual

High Voltage:	15.0 Vdc
Low Voltage:	11.0 Vdc

External Connector

The radio has the following permanent connectors:

- External 50 ohm connector
- Serial Port (RS232)
- Input/ Output RJ45 port
- Ethernet/ TCP IP port
- Programming, mini USB port

Product Overview:

The Product is available in VHF or UHF, with user-programmable power outputs ranging from 50 mW to 5 watts.

Using programming software, each model can be tuned across its full frequency range with no hardware adjustments.

All models can be programmed remotely or be used to message remotely using TCP/IP.

Test Setup

The client has provided Sacato tool which runs in a laptop and allows customers to set up some functions of their transmitter, a test plan was provided by the client that was used as assistance in testing. Sacato allows configuration of the following:

- Transmit carrier frequency, deviation, and power level to pre-calibrated values.
- Various message formats (protocols)
- Transmission of automatic messages in response to inputs or battery level, or for periodic status updates.
- TCP/IP configuration
- Various other parameters

For testing, this tool is used to set the carrier frequency, deviation and power level. The unit was **turned off and on** again for any configuration changes to take effect. Sacato was used to set up a ***periodic message transmission,*** which allows a short message with a delay of a few seconds between messages to be transmitted.

In addition to Sacato (Tool for evaluation only), a terminal program with predefined macros was used for making changes in the device configuration.

6. TEST RESULTS

Certification required

Part 90.203(j)

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;

The product tested operates in the frequency range 427.5-475.0 MHz which falls within 421–512 MHz band and hence certification is required

(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.

The multi bandwidth mode product tested is capable of operating using channel bandwidths of 25 kHz and 12.5 kHz.

(7) Transmitters designed only for one-way paging operations may be certificated 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.

The product complies with the definitions of (7) as it is classified as a one way paging transmitter.

Result: Complies.

RF power output

Measurements were carried out at the RF output terminals of the transmitter using a 30 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.

Maximum transmitter power (CW) - Rated 5 W (+37.0 dBm)

Frequency (MHz)	Voltage (Vdc)	Carrier Power (dBm)		
		+22˚ C	+55˚ C	-30˚ C
427.500	11.0	36.9	36.8	36.7
	13.0	37.5	37.3	36.8
	15.0	37.0	36.9	36.8
451.000	11.0	36.2	36.1	36.4
	13.0	36.7	36.6	36.5
	15.0	36.7	36.5	36.6
475.000	11.0	35.7	35.6	35.6
	13.0	36.0	35.9	35.9
	15.0	36.0	35.9	35.9

Limits:

Part 90 does not specify the transmitter output power

Result: Complies.
Measurement Uncertainty: ± 0.5 dB

Emission types and bandwidth limitations:

The authorised bandwidth for the 400.0-480.0 MHz band is 11.25 kHz and 20.0 kHz respectively when a 12.5 kHz and 25.0 kHz channel bandwidth is used.

The following emission type is used:

- F1D: Digital Modulation with a channel bandwidth of 12.5 kHz and 25.0 kHz.

Part 2.202 (g) (III-A) (1) gives the following formula to determine the Necessary Bandwidth (Bn) of a single channel of FM modulation (FSK) will be

Bn = Baud + 2 * Deviation * 1.2

For 1200 baud with 4.5 kHz deviation: Bn = 12 kHz
For 1200 baud with 2.5 kHz deviation Bn = 7.2 kHz

An emission designator of 7k20F1D and 12k0F1D has been declared respectively by the client for 12.5 kHz channels and 25.0 kHz channels.

Measurements have been made to verify this declared bandwidth using the various data rates that this radio 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 span, resolution bandwidth and video bandwidth as per the methods described in 47 CFR Part 2 while operating in peak hold mode.

Attached to the input of the spectrum analyser was an external 30 dB attenuator.

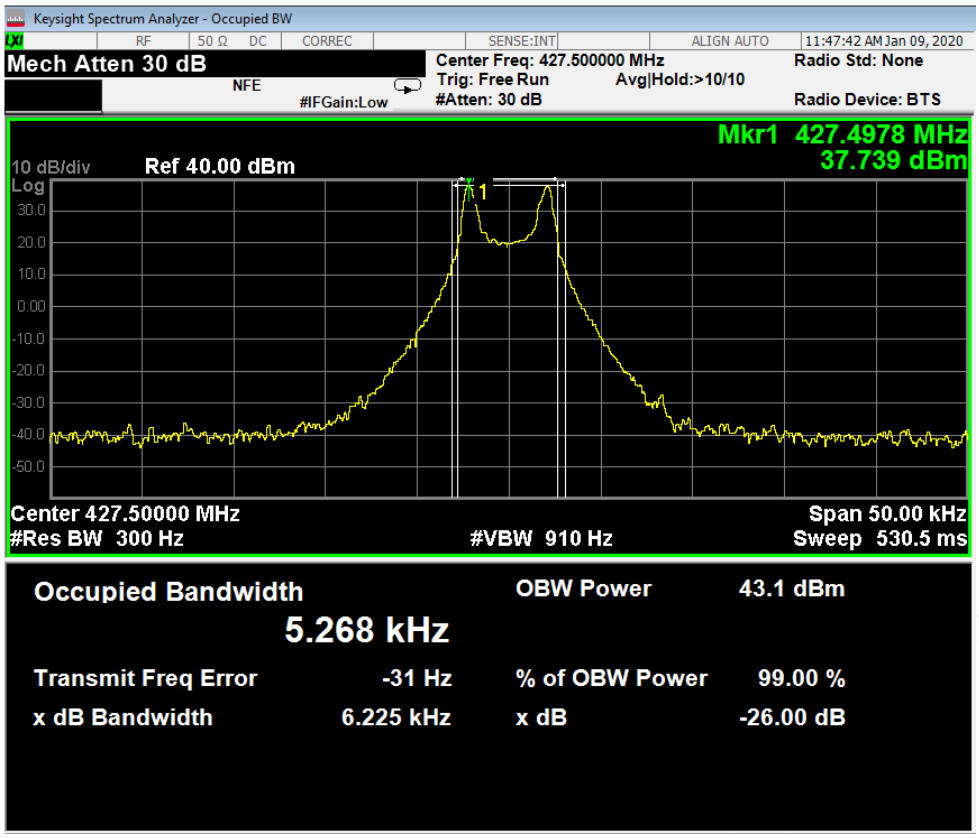
Representative plots of the measurements are provided in the report.

Result: Complies

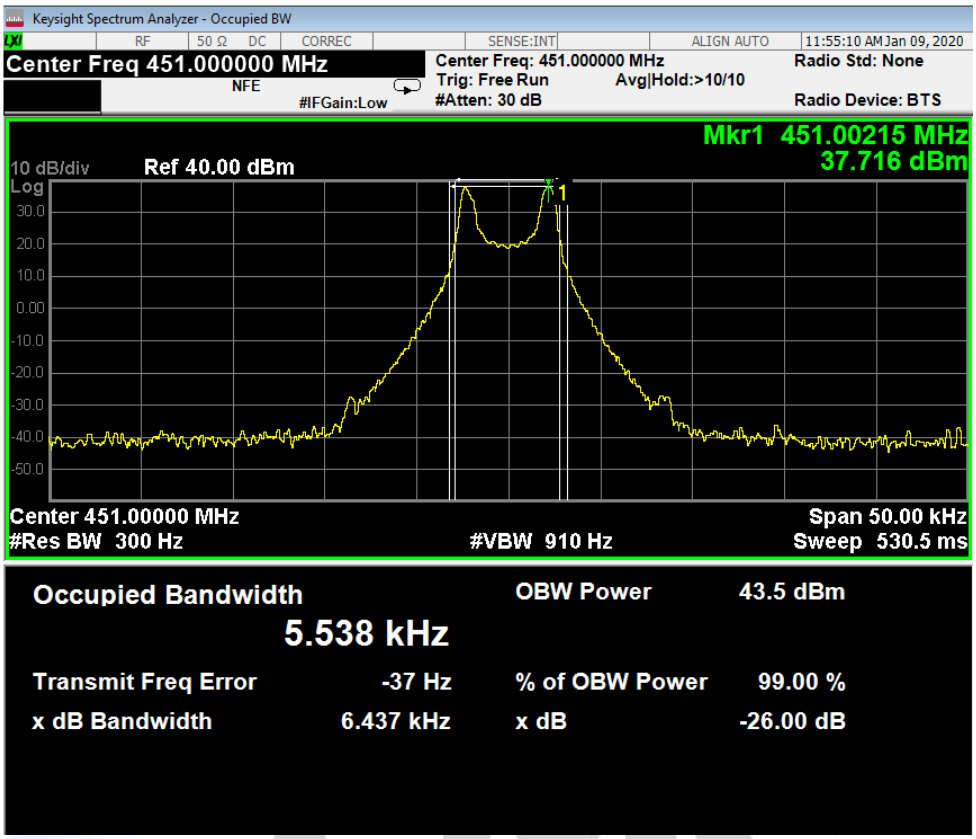
Channel Bandwidth: 12.5 kHz

Frequency (MHz)	Baud rate	Measured (kHz)	Bn Calculated (kHz)	Plot No
427.500	512	5.268	7.200	Plot-1
	1200	5.575	7.200	-
451.000	512	5.527	7.200	-
	1200	5.538	7.200	Plot-2
475.000	512	5.969	7.200	-
	1200	5.925	7.200	Plot-3

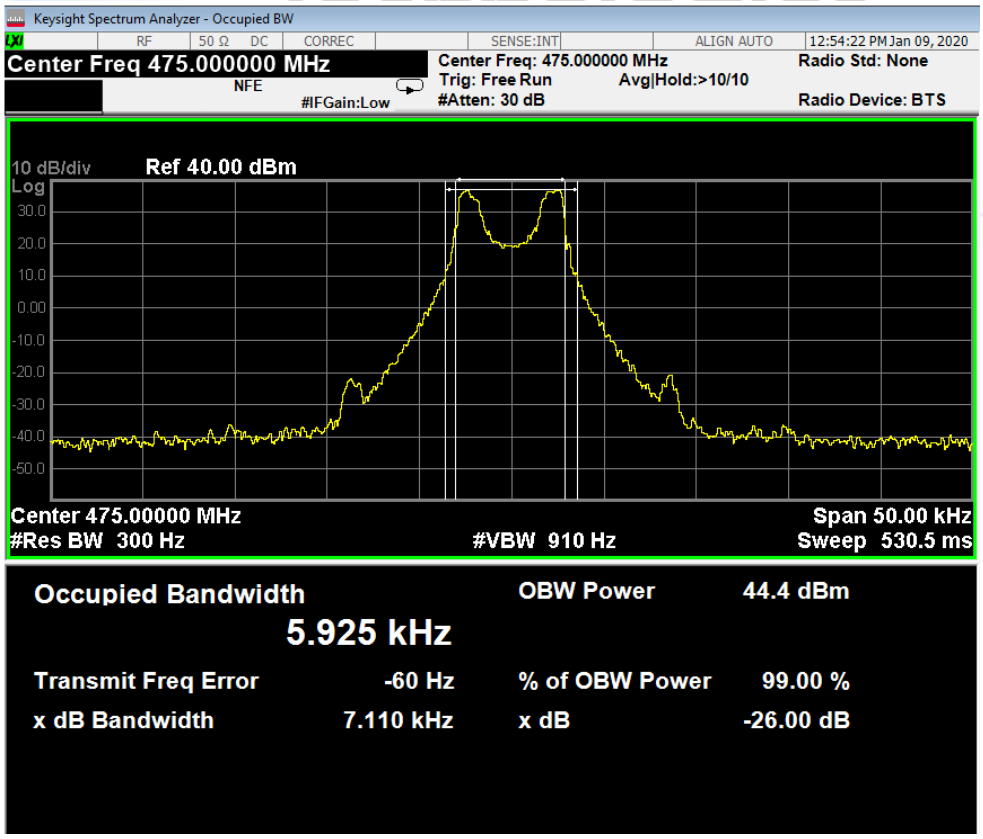
Plot 1: OBW- 427.5 MHz/12.5 kHz/512b



Plot 2: OBW- 451.0 MHz/12.5 kHz/1200b



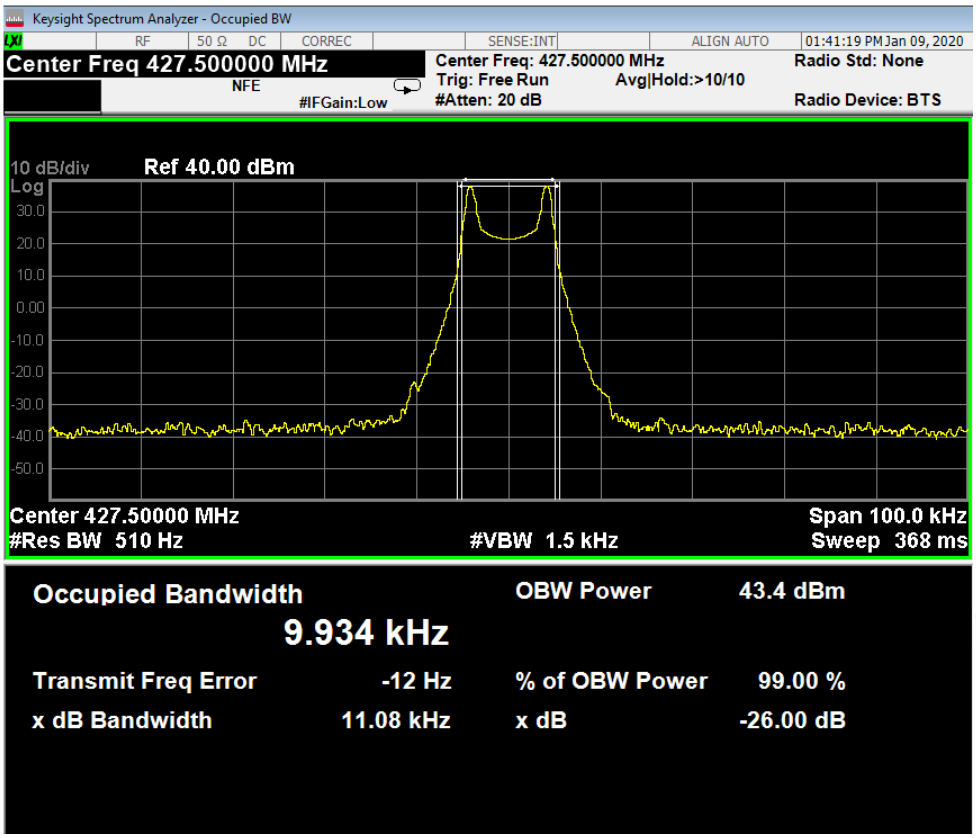
Plot 3: OBW- 475.0 MHz/12.5 kHz/1200b



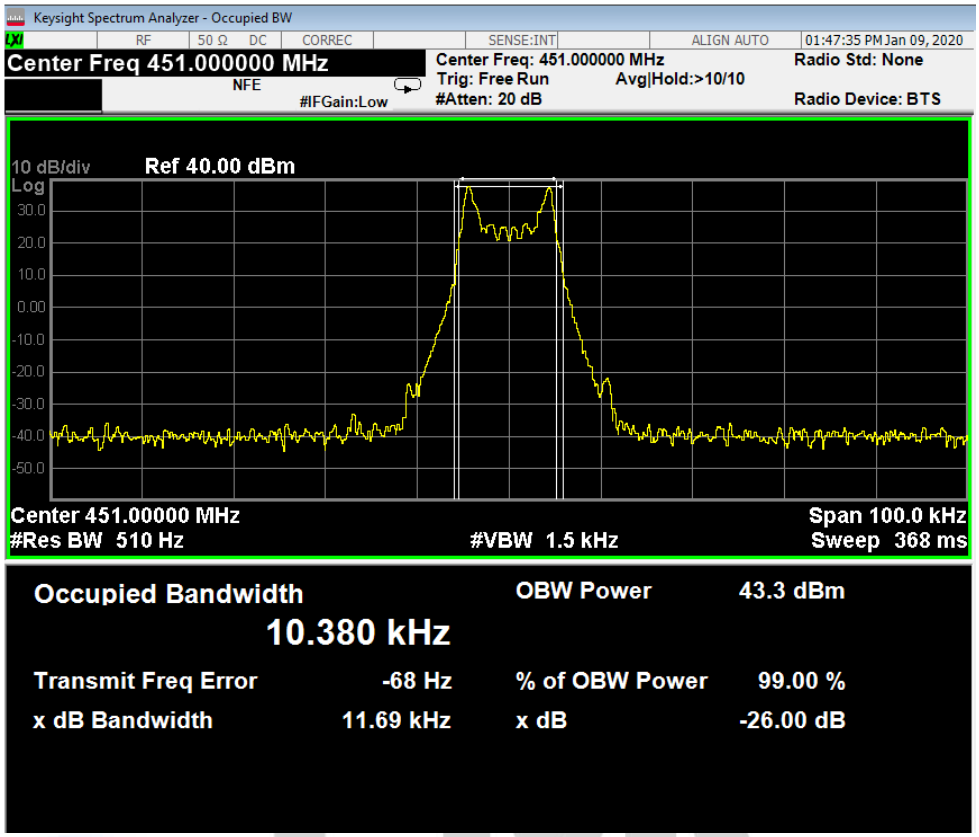
Channel Bandwidth: 25.0 kHz

Frequency (MHz)	Baud rate	Measured (kHz)	Bn Calculated (kHz)	Plot No
427.500	512	9.934	12.000	Plot-4
	1200	10.102	12.000	-
451.000	512	10.326	12.000	-
	1200	10.380	12.000	Plot-5
475.000	512	11.148	12.000	-
	1200	10.865	12.000	Plot-6

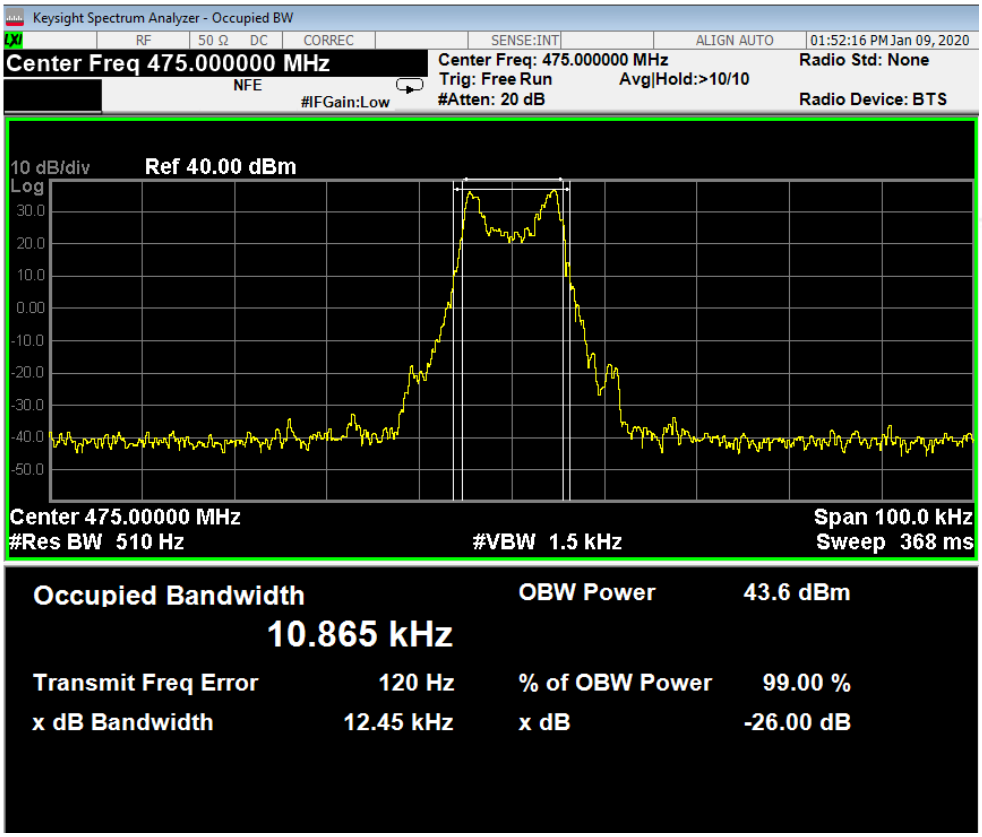
Plot 4: OBW- 427.5 MHz/25.0 kHz/512b



Plot 5: OBW- 451.0 MHz/25.0 kHz/1200b



Plot 6: OBW- 475.0 MHz/25.0 kHz/1200b



Spectrum Masks

The spectrum masks are defined in:

Section 90.210(d) – Mask B and D have been applied as the transmitter can operate in the band 406.0 MHz–512.000 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 an un-modulated carrier which is shown in the FXD mask measurements.

All measurements have been made when a 30 dB attenuator is placed between the transmitter and the spectrum analyser.

A correction file to account for the path loss from Transmitter to the spectrum analyser was included in the measurements.

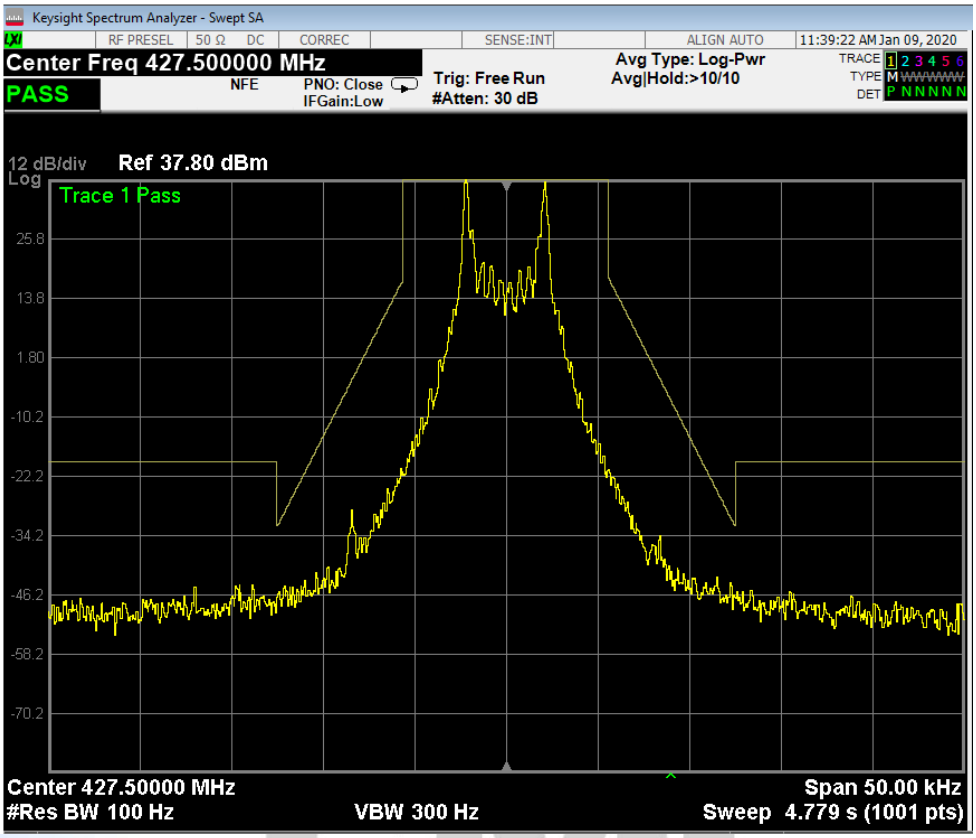
The Reference level was set equal to the power level of the unmodulated carrier.

Measurements were made in peak hold with the transmitter operating on 427.500 MHz, 451.000 MHz and 475.000 MHz.

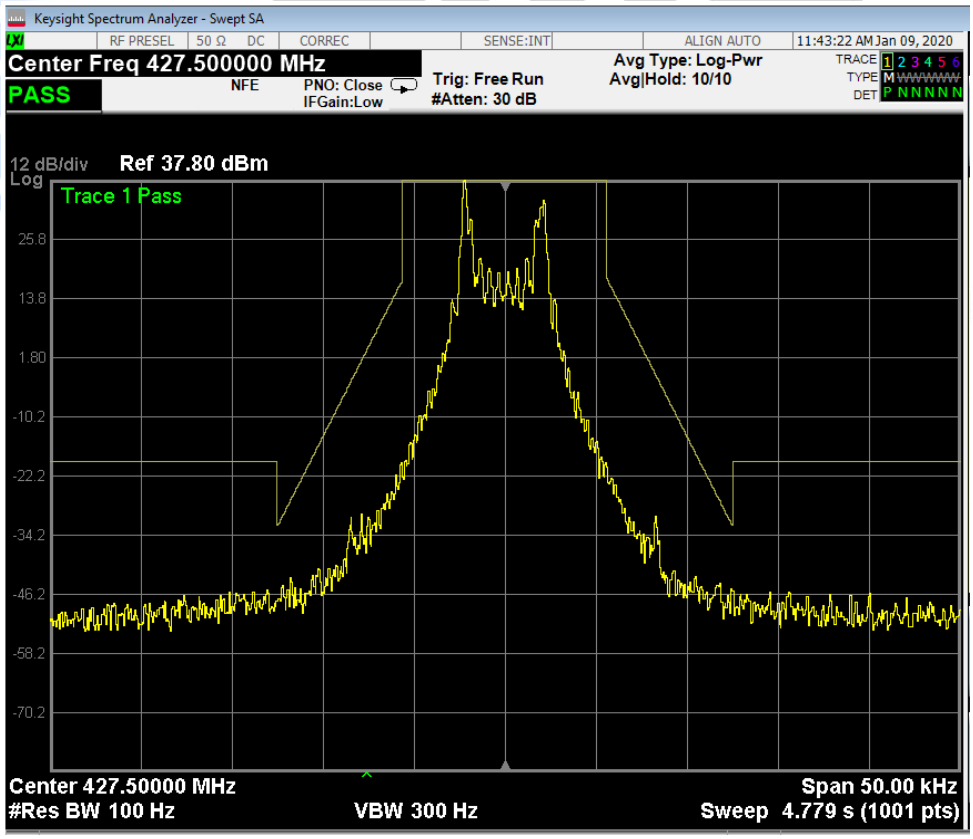
The transmitter was modulated using modulation sources internal to the transmitter as supplied by the client.

Result: Complies.

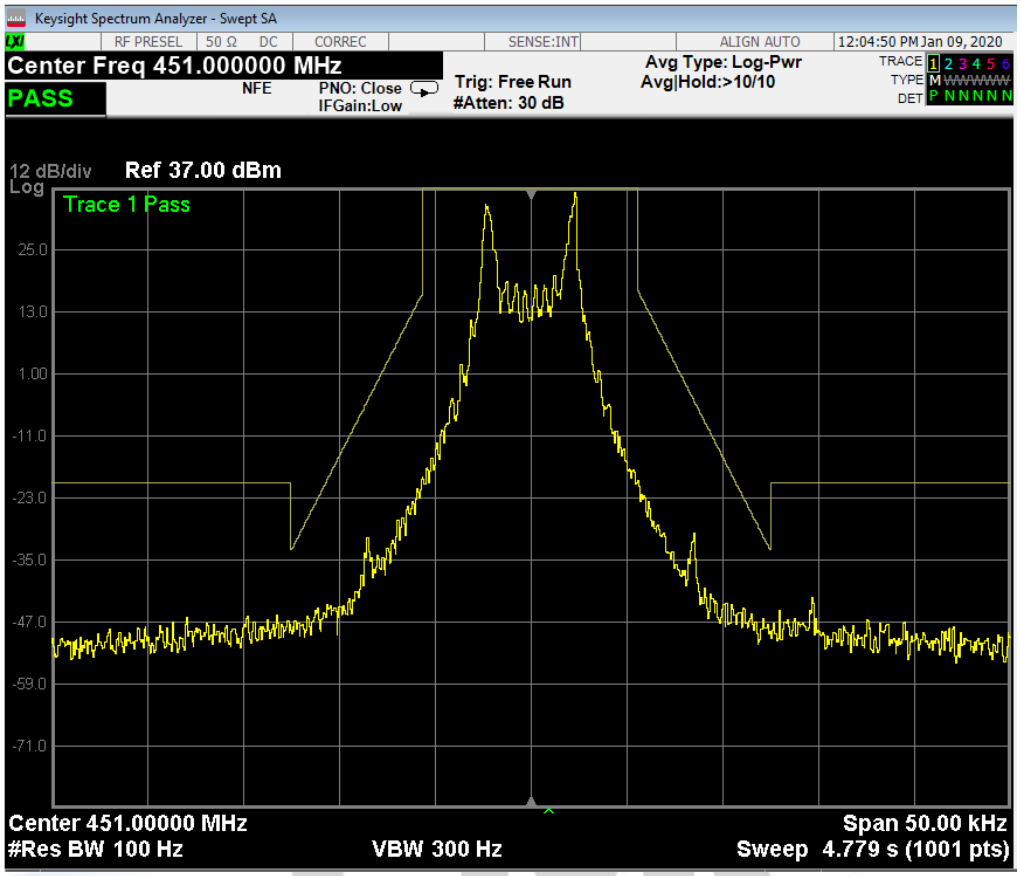
Plot 7: Emission mask D-421.500 MHz/512 baud



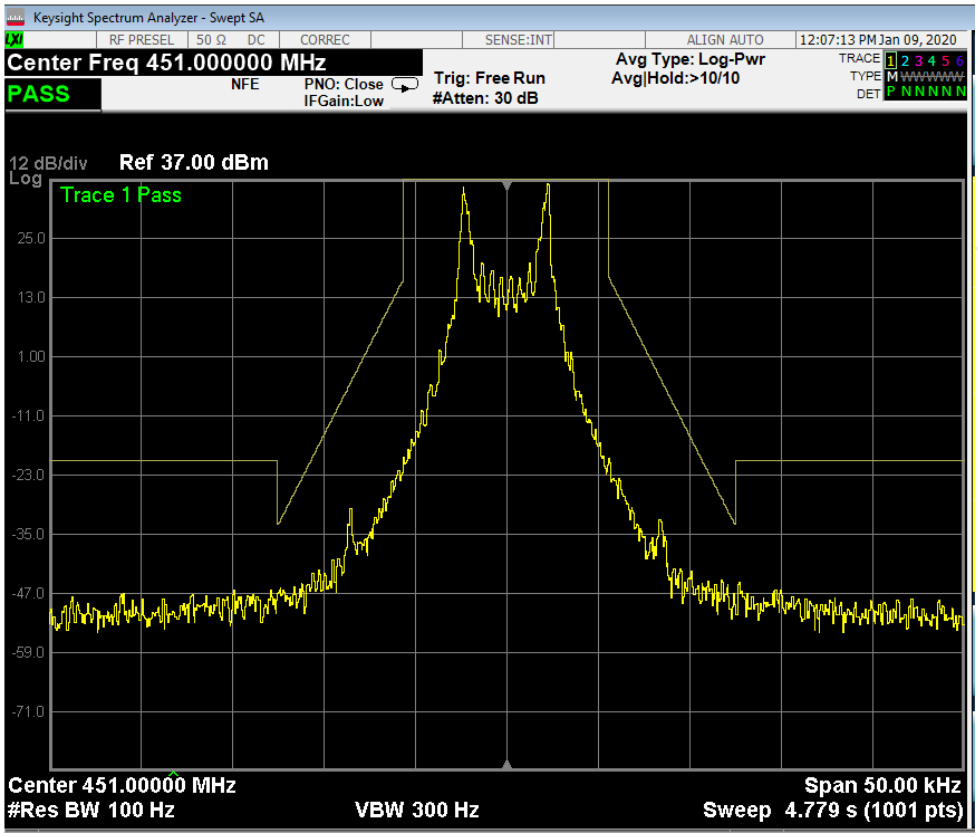
Plot 8: Emission mask D-421.500 MHz/1200 baud



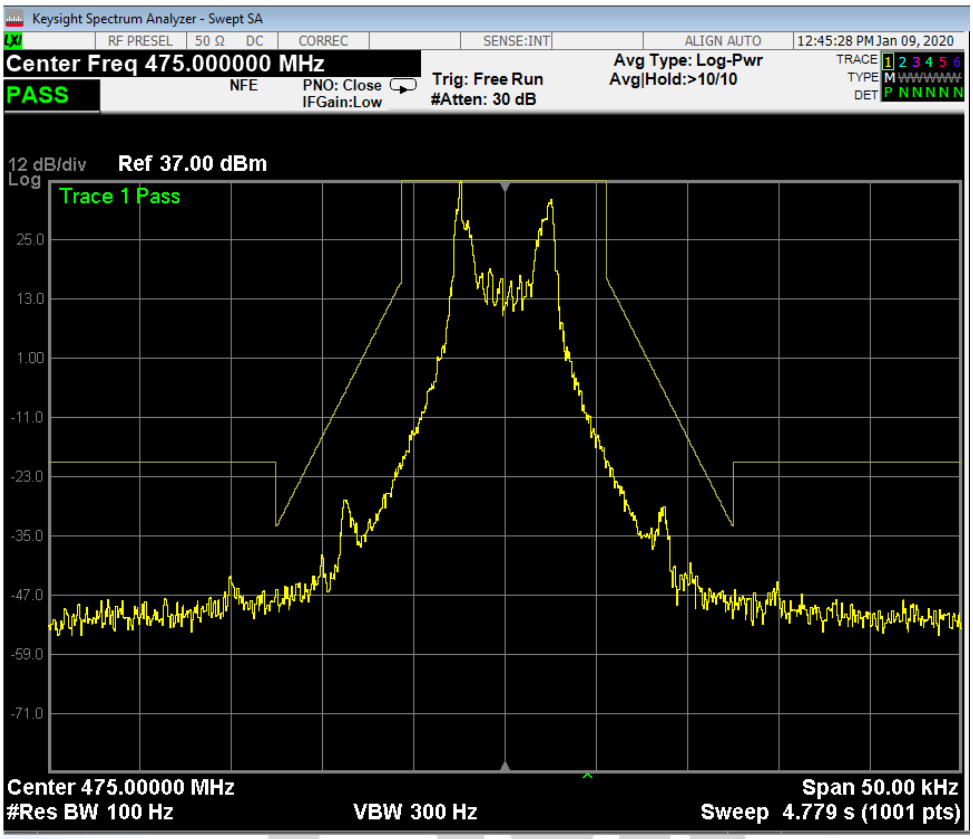
Plot 9: Emission mask D-451.000 MHz/512 baud



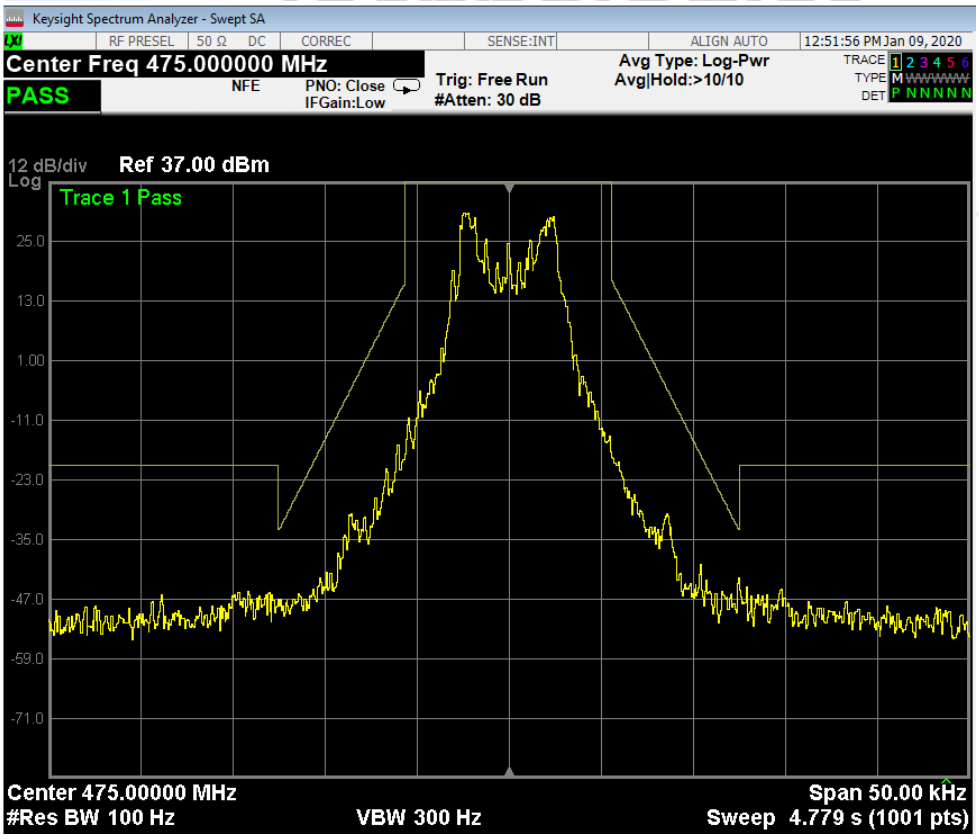
Plot 10: Emission mask D-451.000 MHz/1200 baud



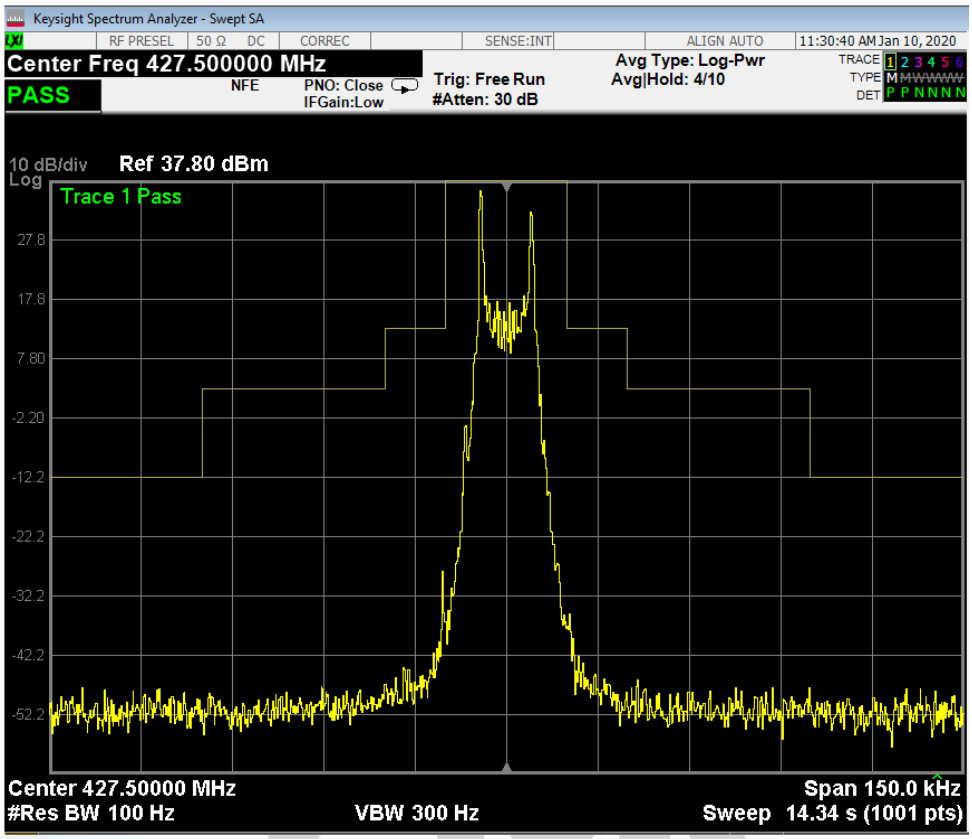
Plot 11: Emission mask D-475.000 MHz/512 baud



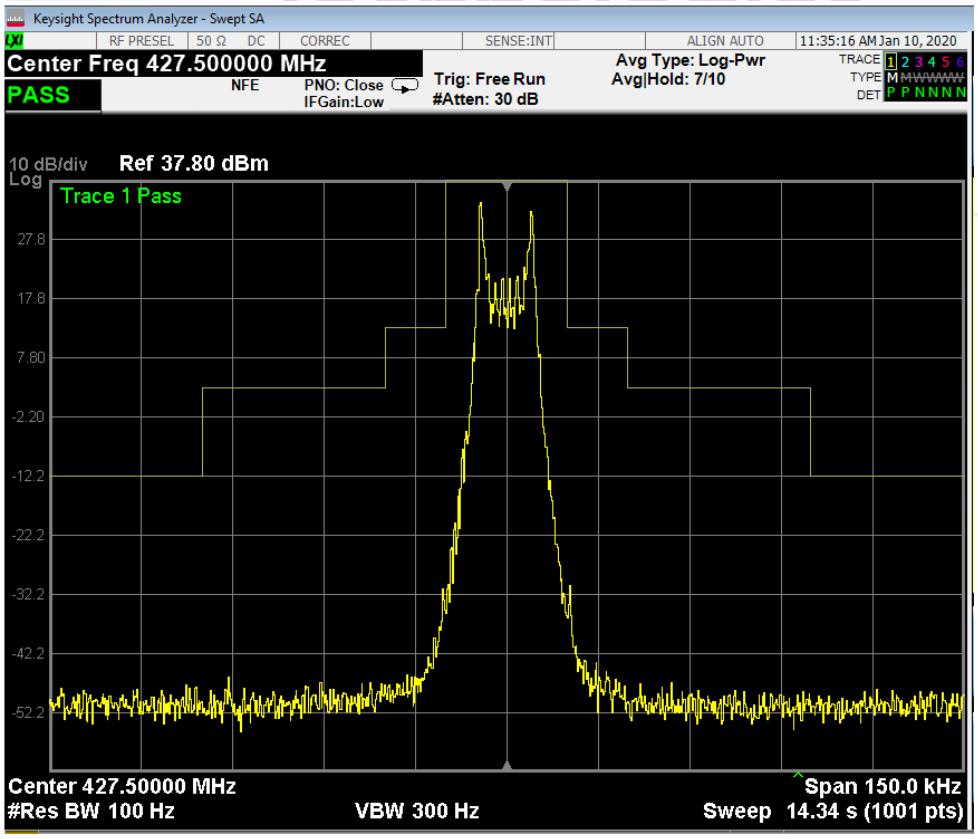
Plot 12: Emission mask D-475.000 MHz/1200 baud



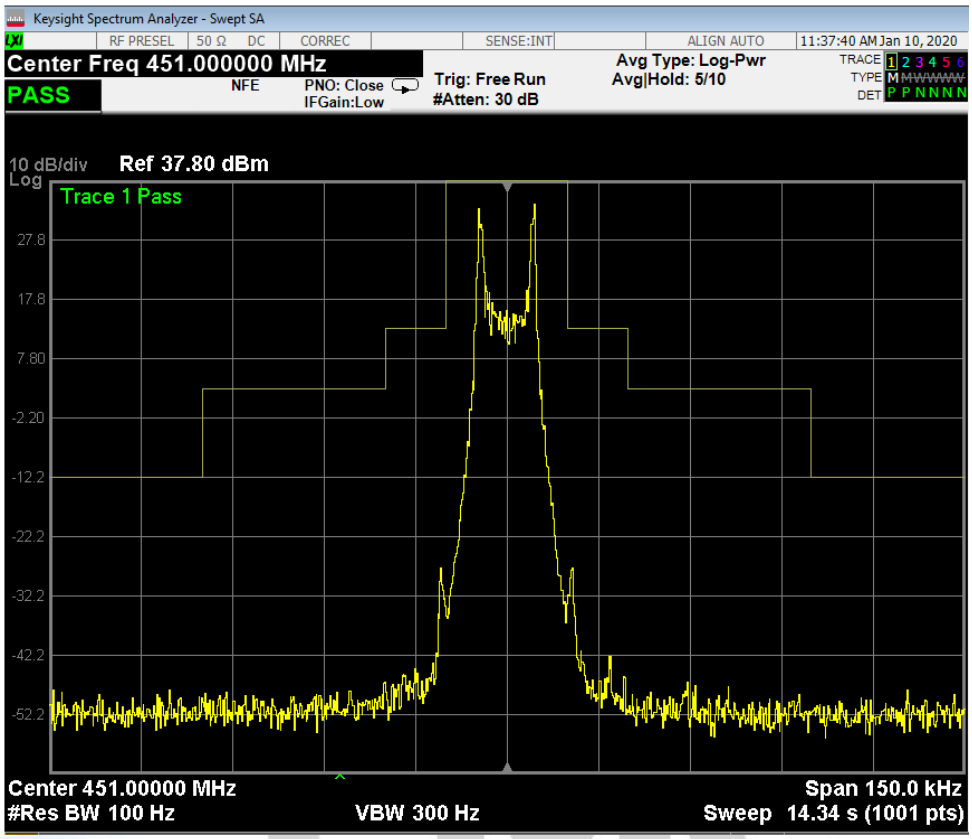
Plot 13: Emission mask B-427.500 MHz/512 baud



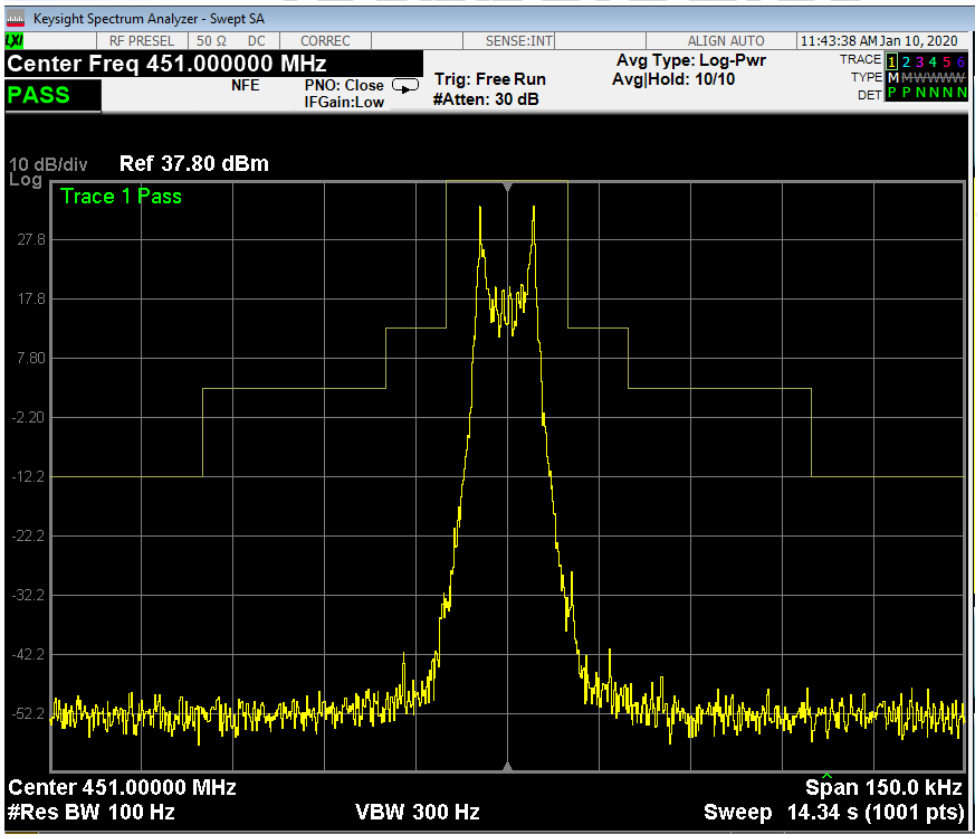
Plot 14: Emission mask B-427.500 MHz/1200 baud



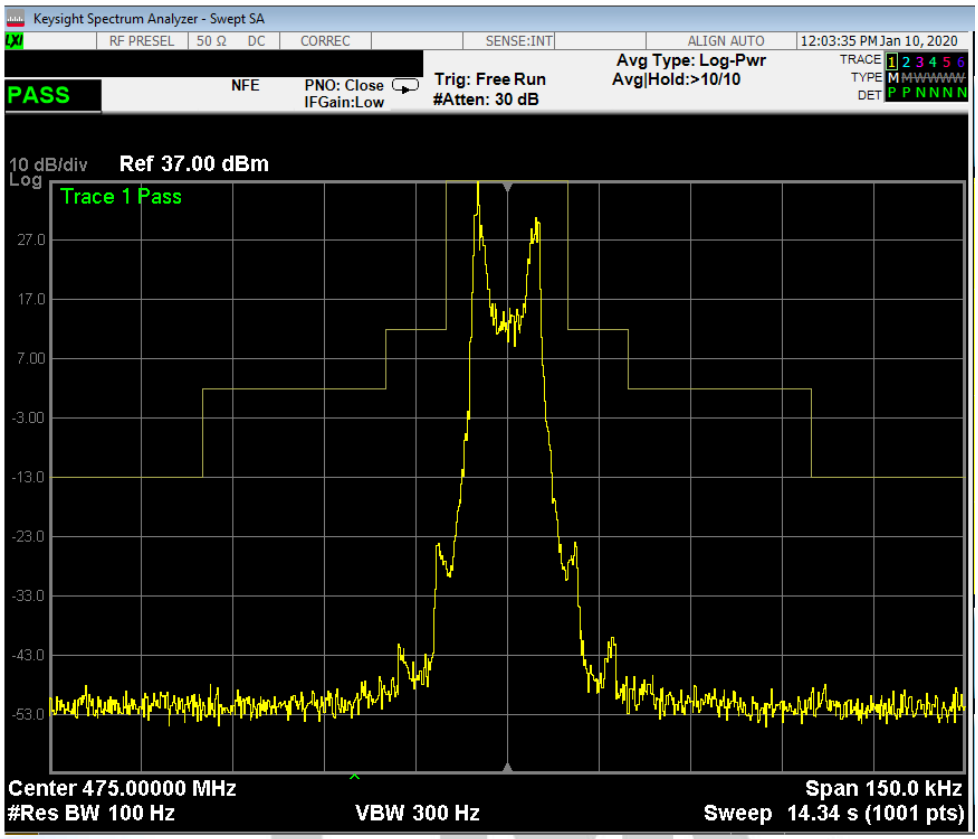
Plot 15: Emission mask B-451.000 MHz/512 baud



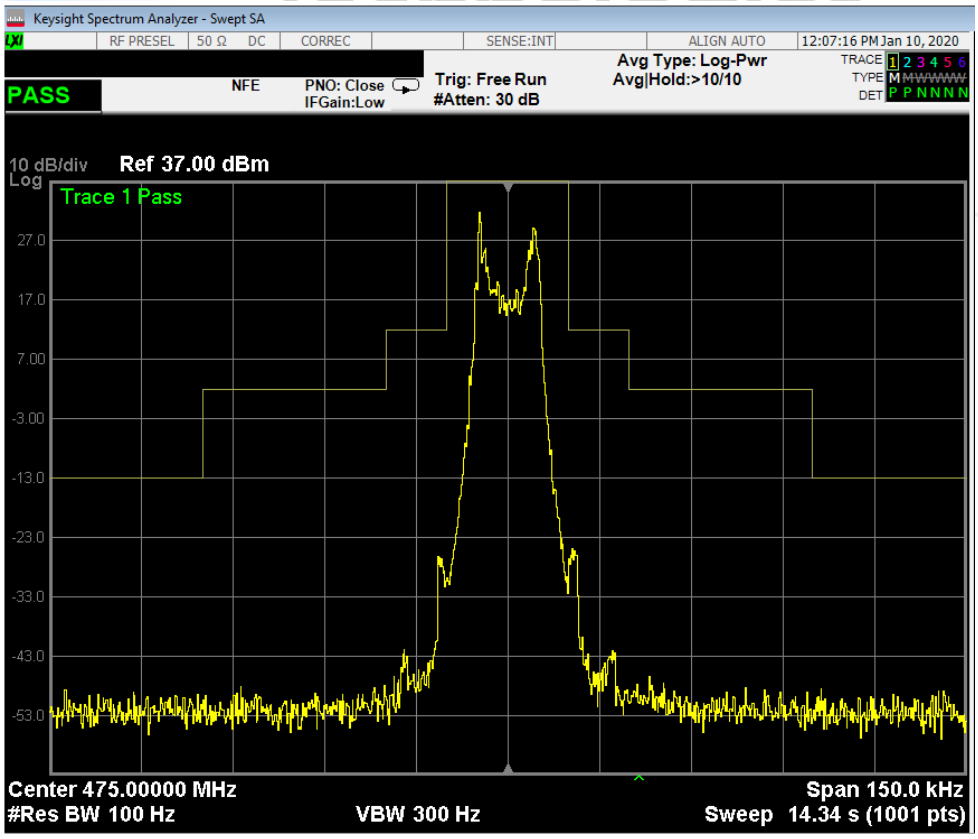
Plot 16: Emission mask B-451.000 MHz/1200 baud



Plot 17: Emission mask B-475.000 MHz/512 baud



Plot 18: Emission mask B-475.000 MHz/1200 baud



Transmitter spurious emissions at the antenna terminals

All measurements have been made when a 30 dB attenuator is placed between the transmitter and the spectrum analyser.

A correction file to account for the path loss from the device under test to the spectrum analyser was included in the measurements.

The measurement was made with an un-modulated carrier output.

Frequency: 427.500 MHz

Frequency of the Spurious emission (MHz)	Emission level (dBm)	Limit (dBm)
854.995	-51.2	-20.0
1282.500	-51.1	-20.0
1710.000	<-50.0	-20.0
2137.500	<-50.0	-20.0
2565.000	<-50.0	-20.0
2992.500	<-50.0	-20.0

Frequency: 451.000 MHz

Frequency of the Spurious emission (MHz)	Emission level (dBm)	Limit (dBm)
902.000	-50.0	-20.0
1353.000	-49.0	-20.0
1804.000	<-50.0	-20.0
2255.000	<-50.0	-20.0
2706.000	<-50.0	-20.0
3157.000	<-50.0	-20.0

Frequency: 475.000 MHz

Frequency of the Spurious emission (MHz)	Emission level (dBm)	Limit (dBm)
950.0	-49.4	-20.0
1425.0	-50.1	-20.0
1900.0	<-50.0	-20.0
2375.0	<-50.0	-20.0
2850.0	<-50.0	-20.0
3325.0	<-50.0	-20.0

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 5.0 watts gives a limit of –20.0 dBm.

No measurements were made above the 10th harmonic.

Result: Complies.
Measurement Uncertainty: ± 3.0 dB

Field strength of the transmitter spurious emissions

The device was powered using a 12 Vdc lead acid battery.

Attached to the transceiver were the following cables / devices:

- A 1.2 metre long serial cable that was terminated with a laptop computer that was running a Client supplied control programme.

- A 2 metre long Ethernet cable that was terminated with a laptop computer that was running a Client supplied control programme.

- A resistive dummy load that was attached to the antenna port.

Transmitter testing was carried out when the device was transmitting continuously on 427.500 MHz, 451.000 MHz and 475.000 MHz.

The transmitter was tested while transmitting continuously while attached to a dummy load.

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

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.

Testing was carried out with an un-modulated carrier and with digital modulation applied.

Testing with an un-modulated carrier gave worst case results which have been recorded below.

Limit:

All spurious emissions are to be attenuated by at least 50 + 10 log (P).

The rated power of 5 watts gives a limit of –20 dBm.

No measurements were made above the 10th harmonic

Result: Complies.

Measurement Uncertainty: ± 4.1 dB

Transmitter spurious emissions results:

Nominal Frequency: 427.500 MHz

Frequency (MHz)	Level (dBuV/m)	Level (dBm)	Limit (dBm)	Polarity	Margin (dB)	Result
855.000	54.3	-43.1	-20.0	Vertical	23.1	Pass
	55.0	-42.4	-20.0	Horizontal	22.4	Pass
1282.500	55.0	-42.4	-20.0	Vertical	22.4	Pass
	63.4	-34.0	-20.0	Horizontal	14.0	Pass
1710.000	55.9	-41.5	-20.0	Vertical	21.5	Pass
	55.5	-41.9	-20.0	Horizontal	21.9	Pass
2137.500	60.4	-37.0	-20.0	Vertical	17.0	Pass
	53.7	-43.7	-20.0	Horizontal	23.7	Pass
2565.000	52.1	-45.3	-20.0	Vertical	25.3	Pass
	<50.0	<-47.4	-20.0	Horizontal	>27.4	Pass
2992.500	<50.0	<-47.4	-20.0	Vertical	>27.4	Pass
	<50.0	<-47.4	-20.0	Horizontal	>27.4	Pass
3420.000	<50.0	<-47.4	-20.0	Vertical	>27.4	Pass
	<50.0	<-47.4	-20.0	Horizontal	>27.4	Pass

Nominal Frequency: 451.000 MHz

Frequency (MHz)	Level (dBuV/m)	Level (dBm)	Limit (dBm)	Polarity	Margin (dB)	Result
902.000	51.5	-45.9	-20.0	Vertical	25.9	Pass
	52.0	-45.4	-20.0	Horizontal	25.4	Pass
1353.000	58.5	-38.9	-20.0	Vertical	18.9	Pass
	57.3	-40.1	-20.0	Horizontal	20.1	Pass
1804.000	64.5	-32.9	-20.0	Vertical	12.9	Pass
	65.8	-31.6	-20.0	Horizontal	11.6	Pass
2255.000	58.8	-38.6	-20.0	Vertical	18.6	Pass
	58.4	-39.0	-20.0	Horizontal	19.0	Pass
2706.000	52.5	-44.9	-20.0	Vertical	24.9	Pass
	53.0	-44.4	-20.0	Horizontal	24.4	Pass
3157.000	<50.0	<-47.4	-20.0	Vertical	>27.4	Pass
	<50.0	<-47.4	-20.0	Horizontal	>27.4	Pass
3608.000	<50.0	<-47.4	-20.0	Vertical	>27.4	Pass
	<50.0	<-47.4	-20.0	Horizontal	>27.4	Pass

(Cont…) Transmitter spurious emissions results:

Nominal Frequency: 475.000 MHz

Frequency (MHz)	Level (dBuV/m)	Level (dBm)	Limit (dBm)	Polarity	Margin (dB)	Result
950.000	58.8	-38.6	-20.0	Vertical	18.6	Pass
	59.7	-37.7	-20.0	Horizontal	17.7	Pass
1425.000	54.5	-42.9	-20.0	Vertical	22.9	Pass
	55.2	-42.2	-20.0	Horizontal	22.2	Pass
1900.000	58.9	-38.5	-20.0	Vertical	18.5	Pass
	59.5	-37.9	-20.0	Horizontal	17.9	Pass
2375.000	60.2	-37.2	-20.0	Vertical	17.2	Pass
	63.4	-34.0	-20.0	Horizontal	14.0	Pass
2850.000	49.8	-47.6	-20.0	Vertical	27.6	Pass
	50.0	-47.4	-20.0	Horizontal	27.4	Pass
3325.000	51.0	-46.4	-20.0	Vertical	26.4	Pass
	<53.0	<-44.4	-20.0	Horizontal	>24.4	Pass
3800.000	< 53.0	<-44.4	-20.0	Vertical	>24.4	Pass
	< 53.0	<-44.4	-20.0	Horizontal	>24.4	Pass

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.

Frequency: 427.500 MHz

Temperature (°C)	11.0 Vdc (Hz)	13.0 Vdc (Hz)	15.0 Vdc (Hz)
+50	-50	-50	-50
+40	-50	-50	-50
+30	-30	+10	-10
+20	+20	+40	+20
+10	-110	-110	-110
0	-130	-140	-140
-10	-20	+50	-40
-20	-20	+50	-40
-30	+70	+60	+50

Frequency: 451.000 MHz

Temperature (°C)	11.0 Vdc (Hz)	13.0 Vdc (Hz)	15.0 Vdc (Hz)
+50	-50	-50	-50
+40	-80	-80	-80
+30	-30	+10	-10
+20	+10	+10	+10
+10	-30	-40	-100
0	-160	-160	-150
-10	-30	+30	-20
-20	-30	+30	-20
-30	+70	+60	+40

Frequency: 475.000 MHz

Temperature (°C)	11.0 Vdc (Hz)	13.0 Vdc (Hz)	15.0 Vdc (Hz)
+50	-30	-30	-30
+40	-90	-90	-90
+30	-40	+30	-30
+20	-10	+10	+10
+10	-60	-60	-70
0	-160	-170	-170
-10	-40	+20	+10
-20	-40	+20	+10
-30	+70	+50	+50

Limits:

Part 90.213 states that fixed station transmitters operating between 421.000-512.000 MHz with 12.5 kHz channelling are required to have a frequency tolerance of 1.5 ppm.

A worst case error of 0.358 ppm (170 Hz / 475.000 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.

Channel Spacing (kHz)	Transient Period t_1	Frequency Period t_2	Deviation (kHz) Period t_3
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)
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 (451.000 MHz)

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

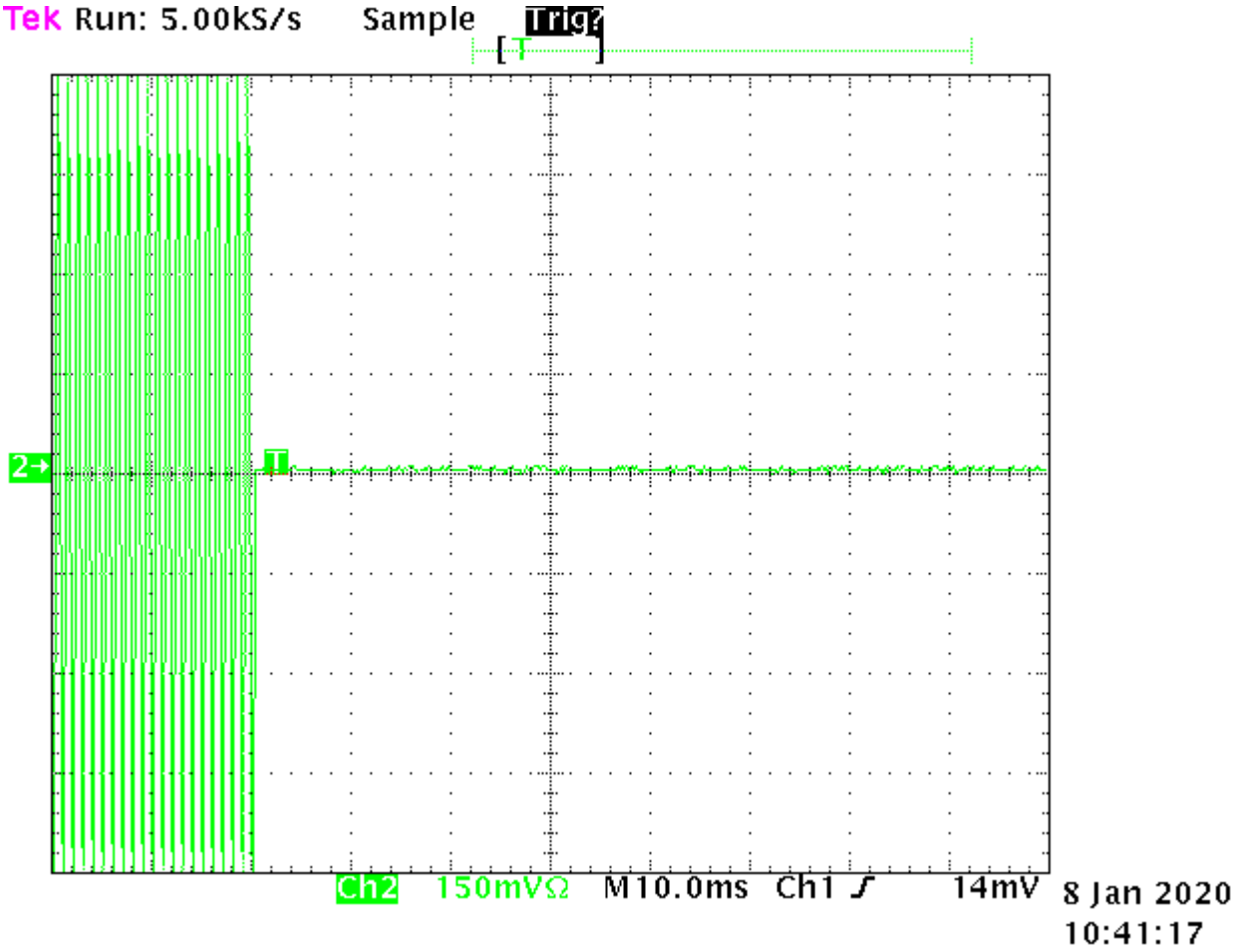
Green trace has been maximised to give full screen indication of +/- 12.5 kHz.
Therefore each Y axis division = 3.125 kHz per division.
The X axis has been set to a sweep rate of 10 ms/division.

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.

No transient response can be observed during t1 and t2.



12.5 kHz transmitter turn off (451.000 MHz)

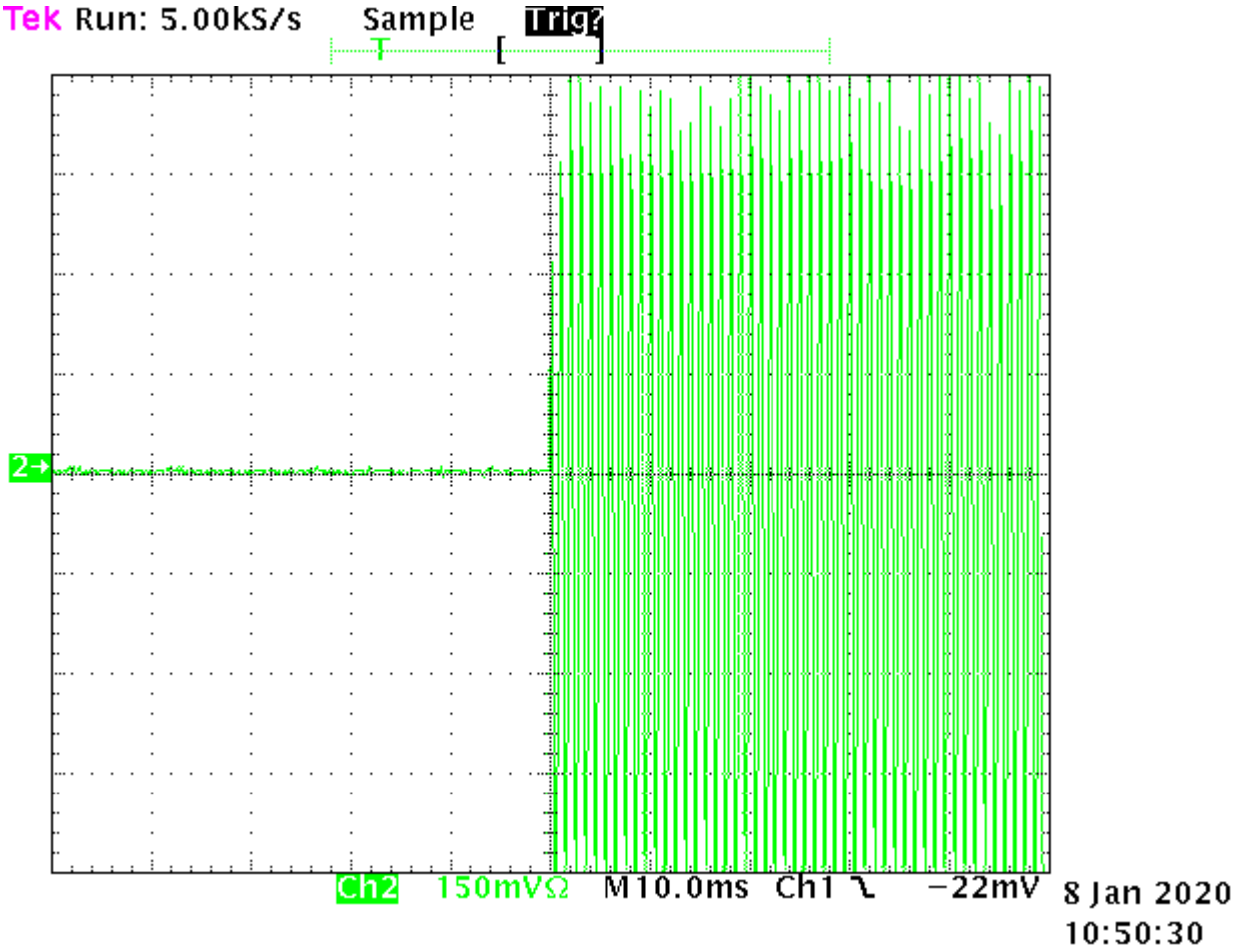
Green Trace = 1 kHz tone with FM deviation of 12.5 kHz.

Green trace has been maximised to give full screen indication of +/- 12.5 kHz.
Therefore each Y axis division = 3.125 kHz per division.
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.

No transient response can be observed before *t*off.



25.0 kHz Transmitter turn on (451.000 MHz)

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

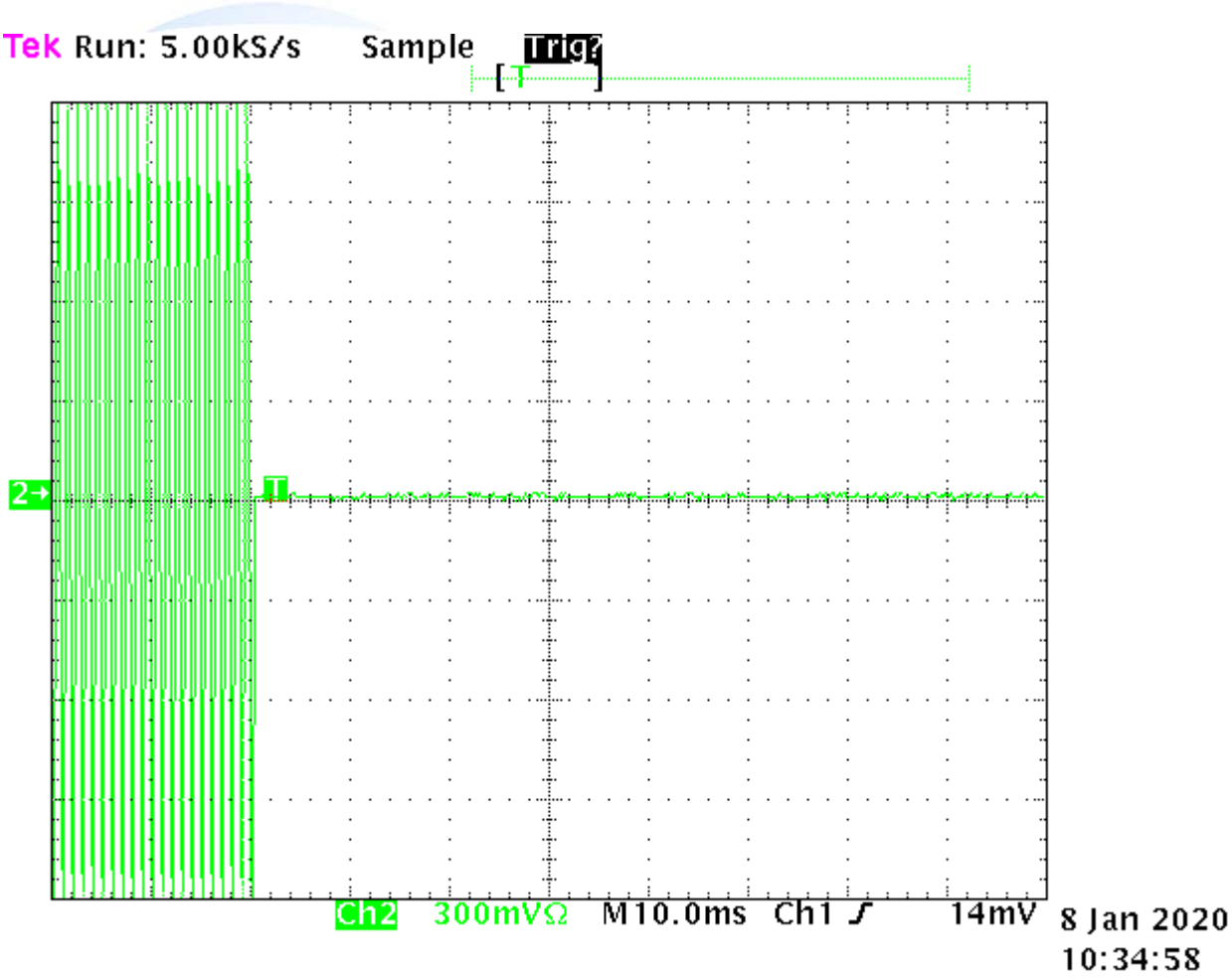
Green trace has been maximised to give full screen indication of +/- 25.0 kHz.
Therefore each Y axis division = 6.25 kHz per division.
The X axis has been set to a sweep rate of 10 ms/division.

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.

No transient response can be observed during *t*1 and *t*2.



25.0 kHz transmitter turn off (451.000 MHz)

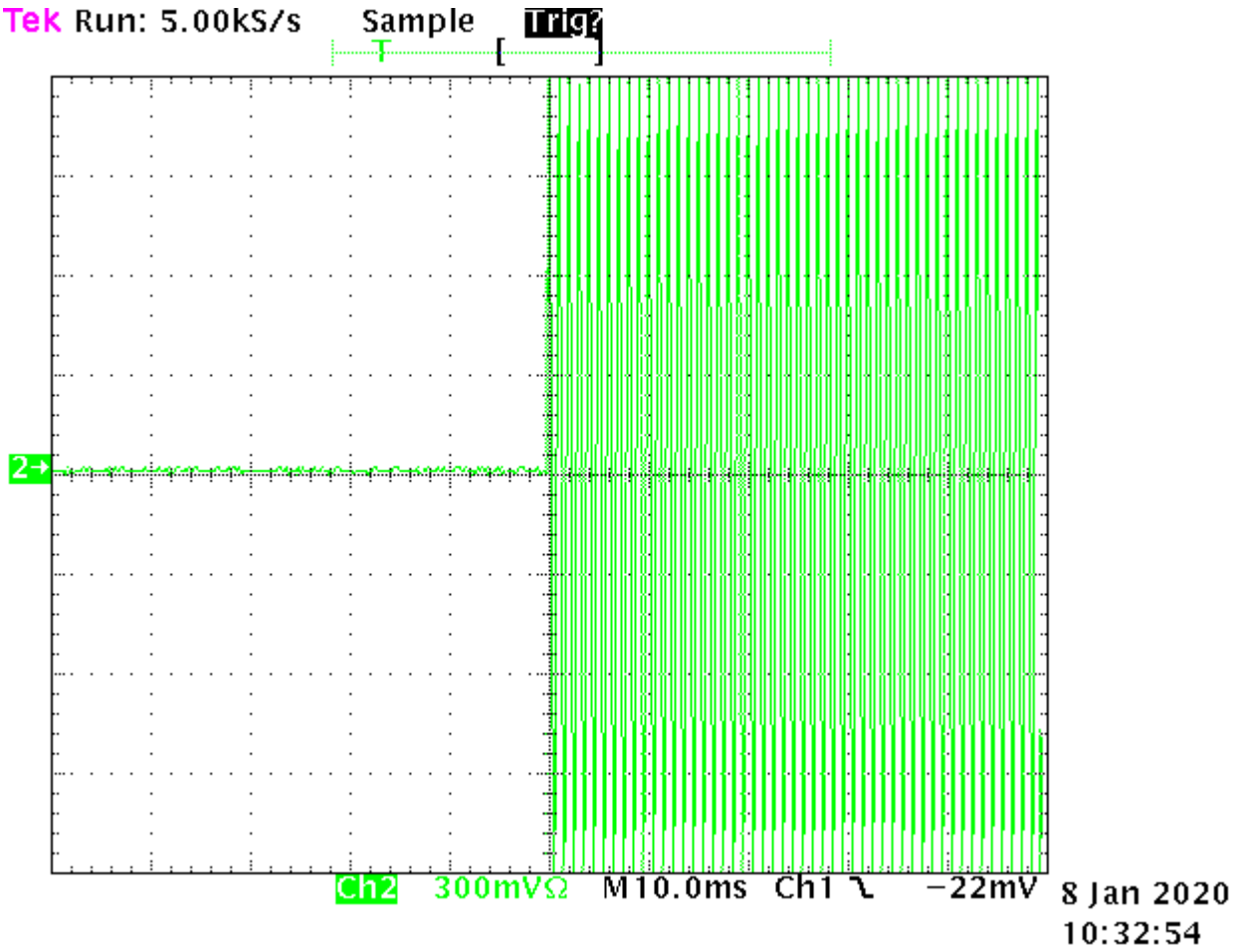
Green Trace = 1 kHz tone with FM deviation of 25.0 kHz.

Green trace has been maximised to give full screen indication of +/- 25.0 kHz.
Therefore each Y axis division = 6.25 kHz per division.
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 small 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.

Minimum safe distances have been calculated below.

Power density, $mW/cm^2 = E^2/3770$

Limits for General Population / Uncontrolled Exposure				
Frequency Range (MHz)	**Electric Field Strength (E) (V/m)**	**Magnetic Field Strength (H) (A/m)**	**Power Density (S) (mW/ cm²)**	**Averaging Time |E|²,|H|² or S (minutes)**
0.3-1.34	614	1.63	(100)*	30
1.34-30	824/f	2.19/f	(180/f)*	30
30-300	27.5	0.073	0.2	30
300-1500			F/1500	30
1500-100,000			1.0	30
Note 1: f = frequency in MHz ; *Plane-wave equivalent power density Note 2: For the applicable limit, see FCC 1.1310				

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

As this radio can operate over the range of 427.5 to 475.0 MHz the lowest frequency of operation which will give the worst case result, would be 427.5 MHz.

The power density at 427.5 MHz comes out to be 0.285 mW/cm^2.

For Uncontrolled Environment

Power Density = 0.285 $mW/cm^2 = E^2/3770$

$E = \sqrt{0.285*3770}$

E = 32.77 V/m

The rated maximum transmitter power = 5 watts (+37 dBm).

A worst case duty cycle (DC) of 100% (1.0) has been applied to the calculations.

The client has suggested that a standard 3 dBi antenna type would be used by customers with the transmitter.

Calculations of the safe distance for these types of antenna are detailed as below.

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

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

The calculation is as follows:

$D = \sqrt{\ } (30 * P * G*DC) / E$

Calculations for the safe distance would be as follows:

$D = \sqrt{\ } (30 * P * G*DC) / E$
$D = \sqrt{\ } (30 * 5*2) / 32.77$
D = 0.52 metres or 52 cm

Result: Complies if the safe distances defined for this environment is applied.

7. TEST EQUIPMENT USED

Instrument	Manufacturer	Model	Serial #	Last Cal	Cal Due	Interval
Aerial Controller	EMCO	1090	9112-1062	N/a	N/a	N/a
Aerial Mast	EMCO	1070-1	9203-1661	N/a	N/a	N/a
Biconical Antenna	Schwarzbeck	BBA 9106	-	28/09/2017	28/09/2020	3 years
Horn Antenna	EMCO	3115	9511-4629	08/08/2017	08/08/2020	3 years
Log Periodic Antenna	Schwarzbeck	VUSLP 91111	9111-112	24/09/2017	24/09/2020	3 years
Modulation Analyzer	Rohde & Schwarz	FMA	837807/020	08/05/2018	08/05/2021	3 years
Power Attenuator	JFW	50FH-030-100	-	N/a	N/a	N/a
Power Supply	Hewlett Packard	6032A	2743A-02859	N/a	N/a	N/a
Receiver	Rohde & Schwarz	ESIB-40	100295	12/09/18	11/09/2020	2 years
Selective Level Meter	Anritsu	ML422C	M35386	22/05/2018	22/05/2020	2 years
Signal Generator	Rohde & Schwarz	SMHU	838923/028	21/05/2019	20/05/2021	2 years
Spectrum Analyzer	Keysight	N9038A	MY57290153	11/01/2019	11/04/2020	1 year
Thermal chamber	Contherm	M180F	86025	N/a	N/a	N/a
Thermometer	DSIR	RT200	35	10/10/2016	10/10/2021	5 years
Turntable	EMCO	1080-1-2.1	9109-1578	N/a	N/a	N/a
VHF Balun	Schwarzbeck	VHA9103	-	N/a	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, 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.

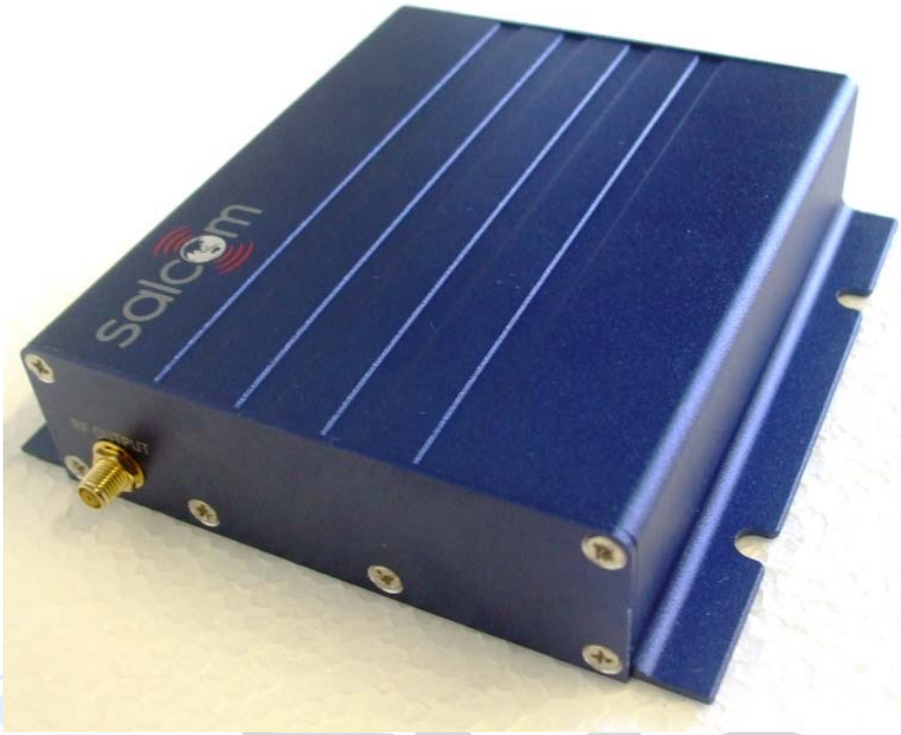
International Accreditation New Zealand has Mutual Recognition Arrangements for testing and calibration with various accreditation bodies in a number of economies. This includes NATA (Australia), UKAS (UK), SANAS (South Africa), NVLAP (USA), A2LA (USA), SWEDAC (Sweden). Further details can be supplied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

11. PHOTOGRAPHS

Front Face

Right Face

Left Face



Back Face

Radiated Emission photos