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TEST REPORT

MiMOMax MWL-TORNADO-*G?A
Fixed Digital Microwave Transceiver

tested to the

Code of Federal Regulations (CFR) 47

Part 101 –Fixed Microwave 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. STATEMENT OF COMPLIANCE

The **MiMOMax MWL-TORNADO-*G?A Fixed Digital Microwave Transceiver** complies with CFR 47 Part 101 and 47 CFR Part 2, as detailed below, when tested in-accordance with the test methods described in 47 CFR Part 2 and ANSI / TIA-603-E: 2016 and ANSI C63.26 – 2015.

Note: Please refer to Client's letter appended to the test report for more details about the product's model number nomenclature.

2. RESULTS SUMMARY

The results of testing carried out between 23rd July and 5th September 2024 are summarised below.

Clause	Description	Result	Page No
101.107	Frequency tolerance	Complies	10
101.109	Bandwidth	Complies	12
101.111	Emission limitations	Complies	22
	Spurious emission at antenna port	Complies	35
	Standby/Receive emissions	Complies	38
	Spurious emissions field strength	Complies	40
101.113	Transmitter power limitations	Complies	44
-	Radiation Hazard Assessment	Noted	47

3. INTRODUCTION

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.

The corrections or erasures in the test 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.

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

To the best of my knowledge, these tests were performed using measurement procedures that are consistent with industry or Industry Canada 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
240207.1	Initial Issue.	25th September 2024
240207.1a	Band of Operation changed on Page 6 Radiation Hazard Modification on Page 47	27th September 2024

4. CLIENT INFORMATION

Company Name MiMOMax Wireless Ltd

Address 540 Wairakei Road
Burnside
Christchurch

Country New Zealand

Contact James Dowle, Sha Luo

5. DESCRIPTION OF TEST SAMPLE

Brand Name MiMOMax

Model Number MWL-TORNADO-BGCA (Tested Sample)
MWL-TORNADO-*G?A (Nomenclature as per Client)

Product Fixed Digital Microwave Transceiver

Manufacturer MiMOMAX Wireless Ltd

Manufactured in New Zealand

Serial Numbers 23004892

FCC ID XMK-MMXTRNB009

Hardware version P001

S**oftware version** TRN_04.08.05

Rated Transmitter Output Power

Two transmitters each outputting +24 dBm (0.25 Watt) average

Transmitter FCC Frequency Bands

928.000 – 929.000 MHz
932.000 – 935.000 MHz
941.000 – 960.000 MHz

Testing was performed on low, mid and high frequency in the product operating range.

Test frequencies

Modulations	Transmit Frequency	Receive Frequency
QPSK, QAM16, QAM64, QAM256	928.5375	952.5375
	933.5000	942.5000
	942.5000	933.5000
	952.5375	928.5375

Full testing was carried out when product was tuned to 928.5375 MHz. At other frequencies, the testing was carried out suitably on limited test modes to cover the compliance requirements.

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

Channel bandwidths

12.5 kHz, 25.0 kHz, 50.0 kHz, 75 kHz

Declared Bandwidths

10.5 kHz, 20.0 kHz, 42.0 kHz, 63.0 kHz

Modulation Types

QPSK, QAM16, QAM64, QAM256

Emission Designators / Modes of operation

10k5W1W digital speech and data
20k0W1W digital speech and data
42K0W1W digital speech and data
63K0W1W digital speech and data

Power Supply

DC voltage supply over the range of 10.5 Vdc to 60 Vdc

Typically 12.0 Vdc or 24.0 Vdc using lead acid batteries

Standard Temperature and Humidity

Temperature: +15°C to + 30°C maintained.

Relative Humidity: 20% to 75% observed.

Standard Test Power Source

Standard Test Voltage: 24.0 Vdc

Extreme Test Voltages

High Voltage: 60.0 Vdc
Low Voltage: 10.5 Vdc

Extreme Temperature

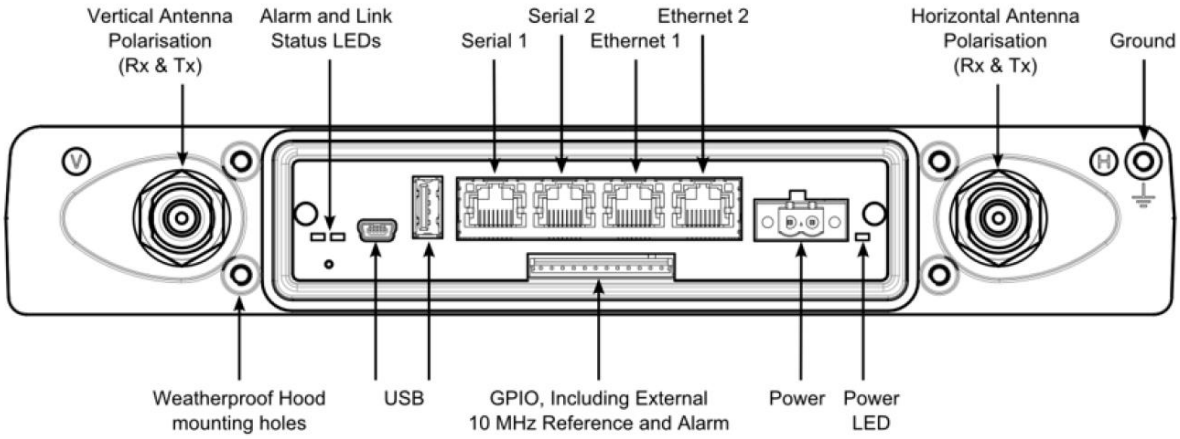
High Temperature: + 50°C maintained.
Low Temperature: - 30 °C maintained.

Product Description (From user manual)

The Product is used in SCADA, Protection and Linking applications. These 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.

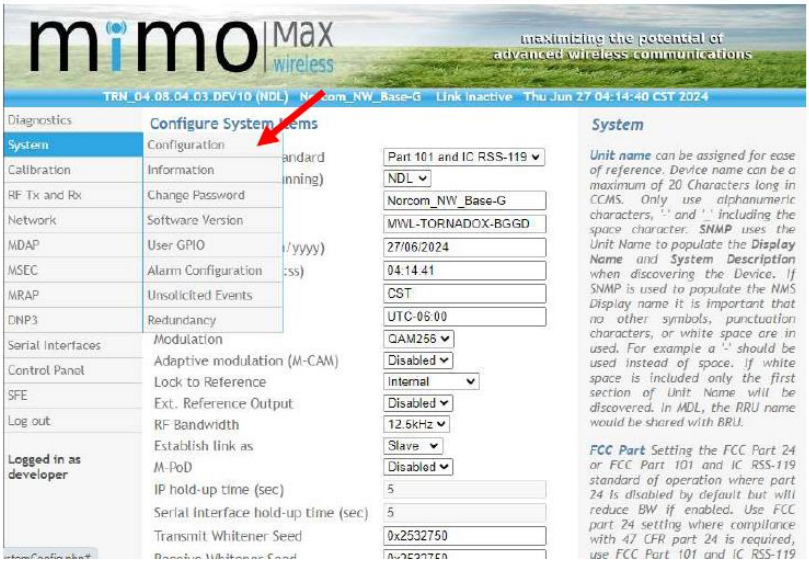
Features include isolated power supply with low power consumption, full duplex operation with built in duplexers and supporting a combination of interfaces, with scalable data rates, remote over the air network management, optional SNMP, ModBus and DNP3 support and a very efficient random-access protocol.

For testing on multiple test frequencies, the duplexers were changed inside the product a per the client test instructions.



Connection diagram of the product

The product control was performed using the CLI commands and Putty interface. Shown below is the software interface which can be alternatively used for product control.



6. TESTING OVERVIEW

The product under test operates on 4 bandwidths-12.5 kHz, 25.0 kHz, 50.0 kHz and 75.0 kHz and supports various modulations like QPSK, 16QAM, 64QAM and 256 QAM.

The product has Vertical and Horizontal ports which have similarity in operation and a letter suggesting the same has been affixed at the end of this test report.

The testing at both ports has been suitably covered while avoiding duplicity and increased scope of testing.

50.0 kHz and 75.0 kHz channels were tested for compliance to emission masks using Mask a(5) and Mask a(6) using the concept of channel aggregation.

The testing was carried out across the certification band with complete testing performed on one frequency, while limited testing per selected mode was performed at the low and high frequency of the certification band.

In order to reduce the complexity of the test report, limited number of plots has been supplied in this test report to ease readability.

Shown below is an example of the CLI commands supplied by the client which were used in product control.

```
-----------------------------------------------------
FCC Part 101
-----------------------------------------------------

DUT1> configure sys radio txtest disable
DUT1> configure sys radio txstate tx1 on
DUT1> configure sys radio txstate tx2 on

DUT1> configure sys radio fcc p101

DUT1> configure sys radio bw 12.5
DUT1> configure sys radio txtest modulation qam256
DUT1> configure sys radio txtest disable

DUT1> configure sys radio txtest modulation qam64
DUT1> configure sys radio txtest disable
```

7. TEST RESULTS

Part 101.107 Frequency Tolerance

Frequency tolerance measurements were between - 30 °C and + 50°C.

The testing was performed on a modulation analyser.

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: 896.000 MHz / Port H

Temperature (°C)	Voltage 10.5 Vdc	Voltage 24.0 Vdc	Voltage 60.0 Vdc
+20	-60	-60	-60

Frequency: 928.5375 MHz / Port V

Temperature (°C)	Voltage 10.5 Vdc	Voltage 24.0 Vdc	Voltage 60.0 Vdc
+50	+10	+10	+10
+40	-30	-30	-30
+30	-90	-90	-90
+20	-50	-60	-50
+10	-170	-170	-170
0	-120	-120	-120
-10	-80	-80	-80
-20	-140	-140	-140
-30	-130	-130	-130

Frequency: 933.5000 MHz / Port V

Temperature (°C)	Voltage 10.5 Vdc	Voltage 24.0 Vdc	Voltage 60.0 Vdc
+20	-80	-80	-80

Frequency: 942.500 MHz / Port H

Temperature (°C)	Voltage 10.5 Vdc	Voltage 24.0 Vdc	Voltage 60.0 Vdc
+20	-70	-70	-70

Frequency: 953.5375 MHz / Port H

Temperature (°C)	Voltage 10.5 Vdc	Voltage 24.0 Vdc	Voltage 60.0 Vdc
+20	-40	-40	-40

Limit:

Part 101.107 (a) states that for multiple address master stations a frequency tolerance of +/- 0.00015 % will apply.

Transmitter was tested highest frequency of 953.5375 MHz: +/- 0.00015 % = +/- 1430 Hz.

Result: Complies

Measurement Uncertainty: ±30 Hz

Part 101.109 Bandwidth limitations:

The transmitter tested has been designed to operate using four modulation types: QPSK, 16QAM, 64QAM and 256QAM.

An emission designator of W1W has been applied by the client with the transmitter being capable of operating on the given authorised bandwidths 12.5 kHz, 25 kHz, 50 kHz and 75 kHz.

Full set of measurements were carried out when the product was operating on 928.5375 MHz. On other test frequencies, on one modulation mode testing was carried out on all the declared channel bandwidths to state compliance across the entire testing range.

The occupied bandwidth has been measured and compared against the occupied bandwidth declared by the client.

Measurements have been made of each modulation type using a spectrum analyser operating in peak hold mode and an external 30 dB attenuator applied which has been accounted for in the spectrum plots below.

The measurement of occupied bandwidth was conducted using 99% occupied bandwidth function available in the spectrum analyser.

The product has Vertical port and Horizontal port which are similar in performance characteristics. For some test frequencies, V port was used to measure masks and OBW and for other frequencies H port was used, this was done to make sure compliance to both ports can be suitably demonstrated in the test report.

The resolution bandwidth for this measurement was maintained between 1% to 5 % of the authorized bandwidth, which is in accordance with TIA-603-E.

Result: Complies
Measurement Uncertainty: +/-1.5 dB

Port Tested: H

Frequency: 928.5375 MHz

Modulation	Emission	Measured (kHz)	Authorised (kHz)
QPSK	W1W	10.376	12.5 kHz
16QAM	W1W	10.455	12.5 kHz
64QAM	W1W	10.420	12.5 kHz
256QAM	W1W	10.411	12.5 kHz

Modulation	Emission	Measured (kHz)	Authorised (kHz)
QPSK	W1W	18.809	25.0 kHz
16QAM	W1W	18.829	25.0 kHz
64QAM	W1W	18.686	25.0 kHz
256QAM	W1W	18.805	25.0 kHz

Modulation	Emission	Measured (kHz)	Authorised (kHz)
QPSK	W1W	41.568	50.0 kHz
16QAM	W1W	41.574	50.0 kHz
64QAM	W1W	41.462	50.0 kHz
256QAM	W1W	41.462	50.0 kHz

Modulation	Emission	Measured (kHz)	Authorised (kHz)
QPSK	W1W	62.808	75.0 kHz
16QAM	W1W	62.956	75.0 kHz
64QAM	W1W	62.677	75.0 kHz
256QAM	W1W	62.643	75.0 kHz

*The plots are provided in this report to show compliance with combination of port tested, channel bandwidth and test frequency. Limited number of plots has been provided in the test report for readability

Port Tested: V

Frequency: 933.5000 MHz

Modulation	Emission	Measured (kHz)	Authorised (kHz)
256QAM	12.5 kHz	10.403	12.5 kHz
64QAM	25.0 kHz	18.624	25.0 kHz
256QAM	50.0 kHz	41.400	50.0 kHz
256QAM	75.0 kHz	62.390	75.0 kHz

Port Tested: H

Frequency: 942.5000 MHz

Modulation	Emission	Measured (kHz)	Authorised (kHz)
16QAM	75.0 kHz	62.877	75.0 kHz

Port Tested: V

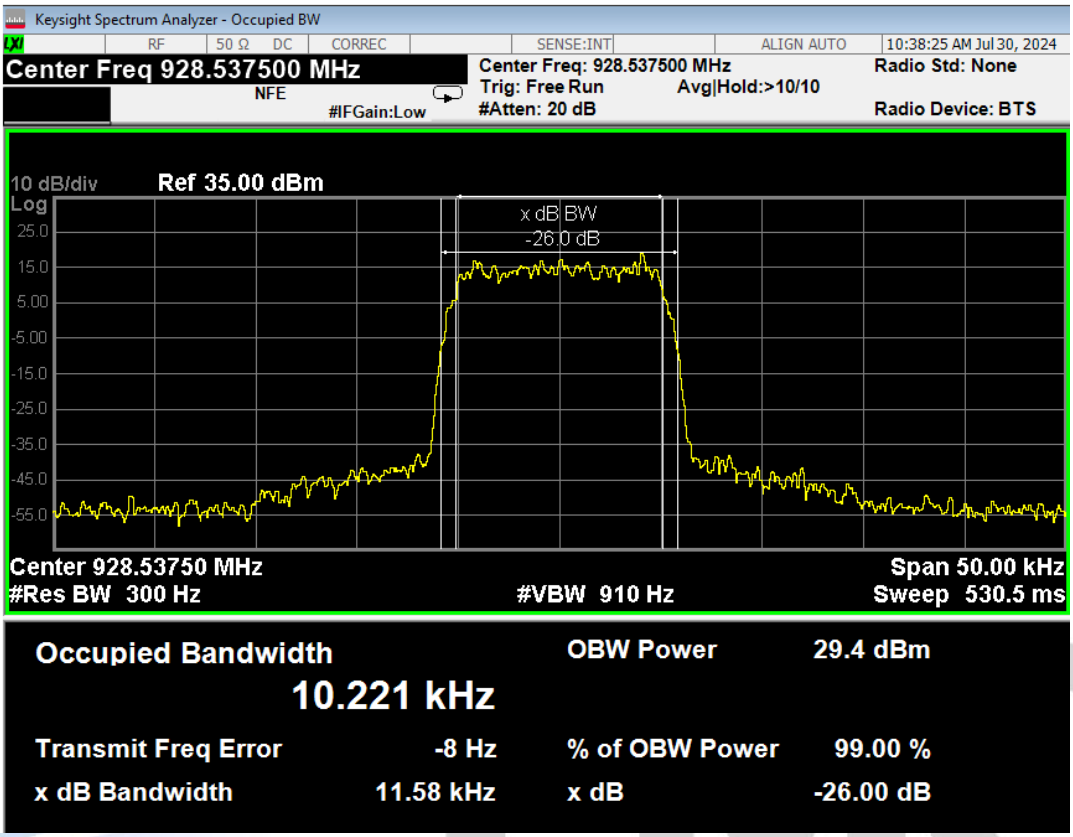
Frequency: 952.5375 MHz

Modulation	Emission	Measured (kHz)	Authorised (kHz)
256QAM	12.5 kHz	10.441	12.5 kHz
256QAM	25.0 kHz	18.653	25.0 kHz
256QAM	50.0 kHz	41.459	50.0 kHz
256QAM	75.0 kHz	62.936	75.0 kHz

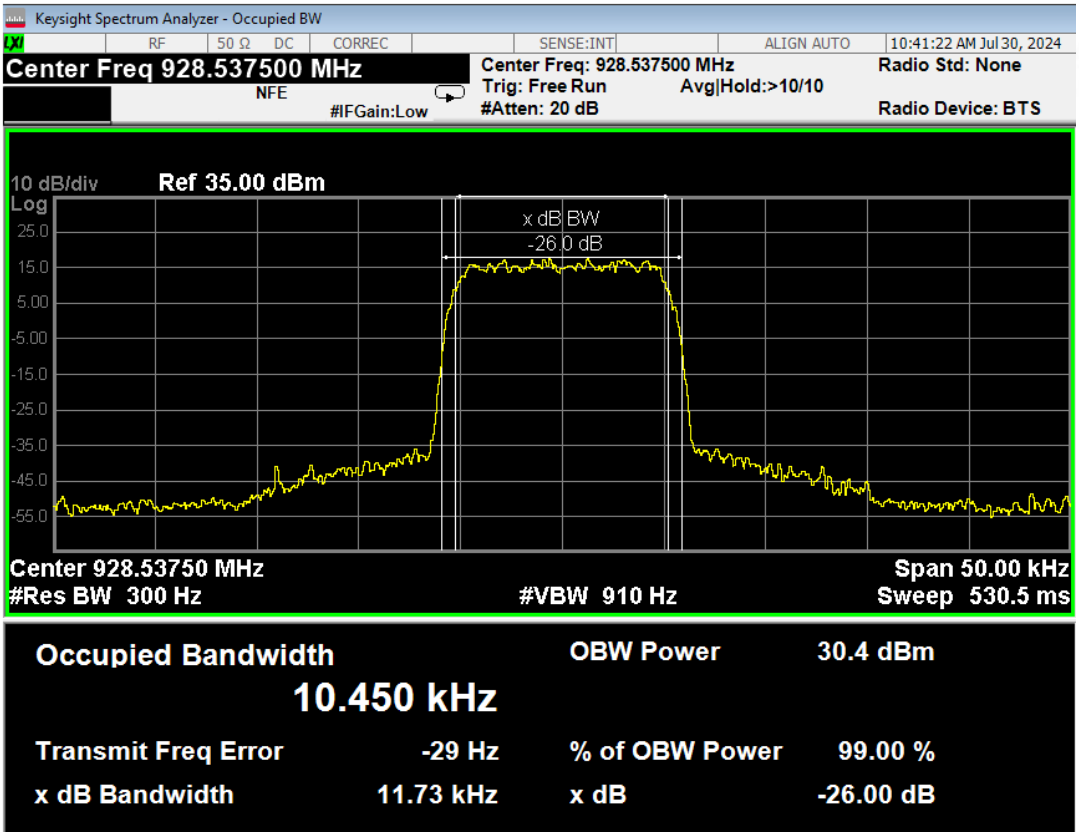
*The plots are provided in this report to show compliance with combination of port tested, channel bandwidth and test frequency. Limited number of plots has been provided in the test report for readability

Test Frequency: 928.5375 MHz

12.5k OBW QPSK

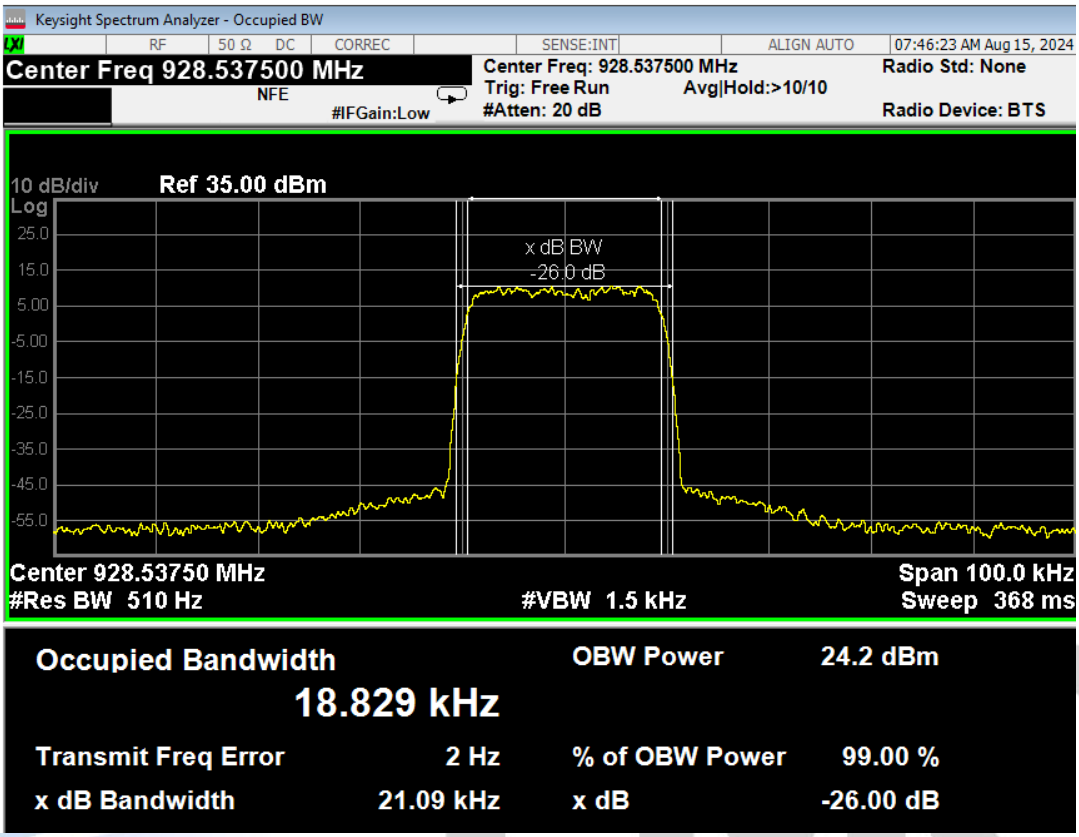


12.5k OBW 16QAM

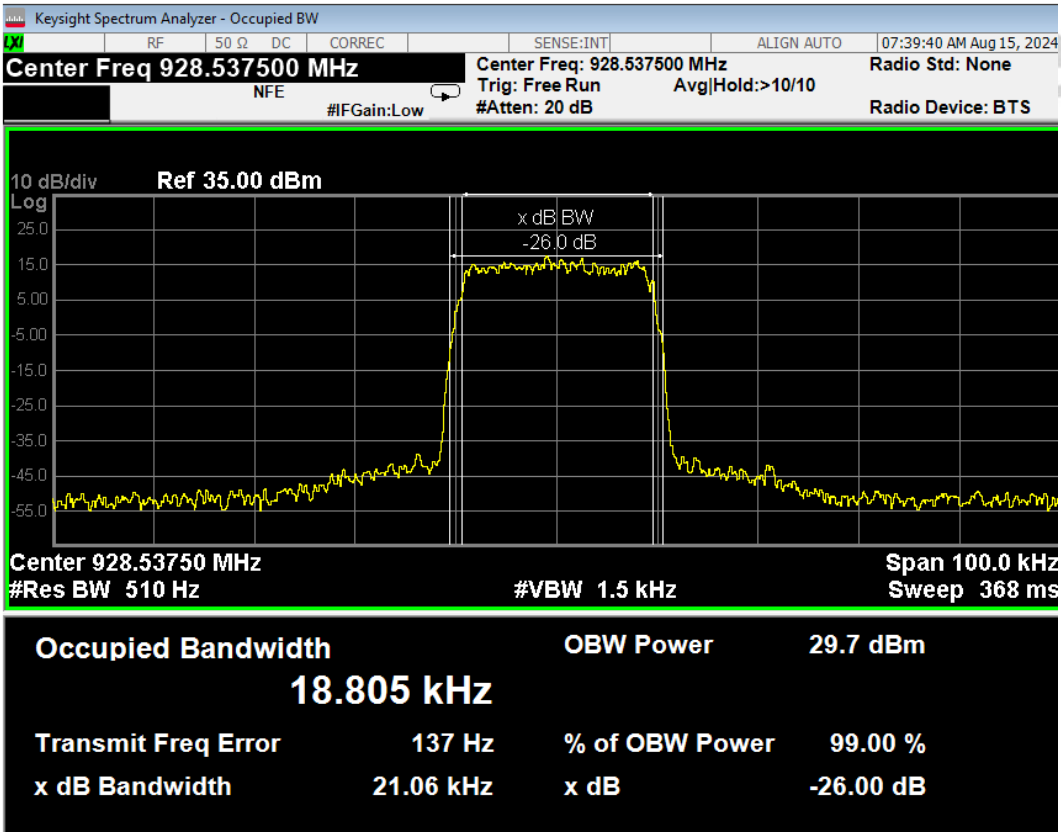


Test Frequency: 928.5375 MHz

25k OBW 16QAM

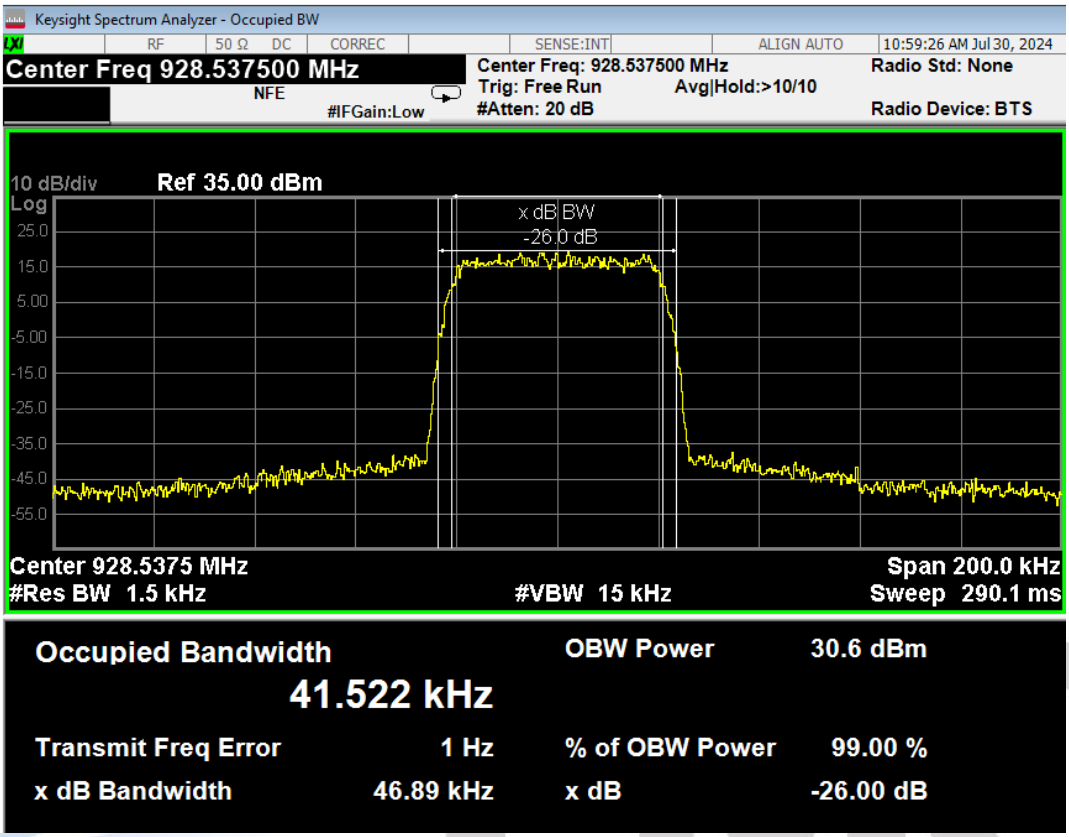


25k OBW 256QAM

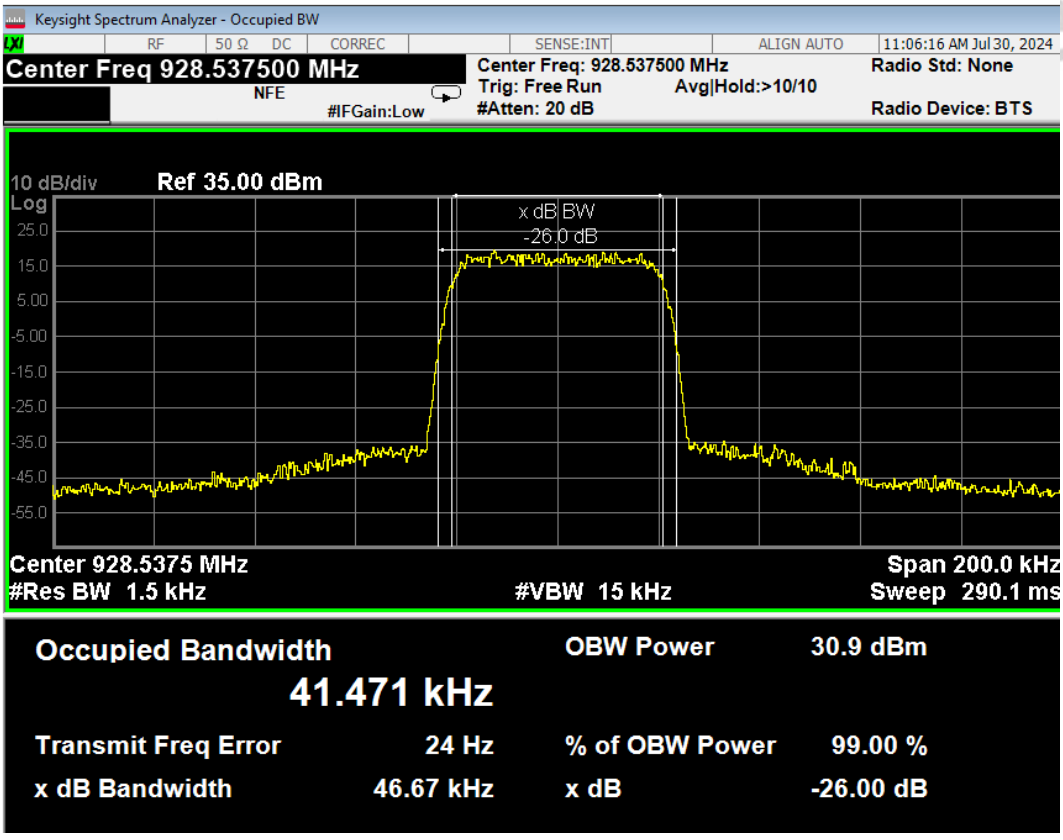


Test Frequency: 928.5375 MHz

50k OBW QPSK

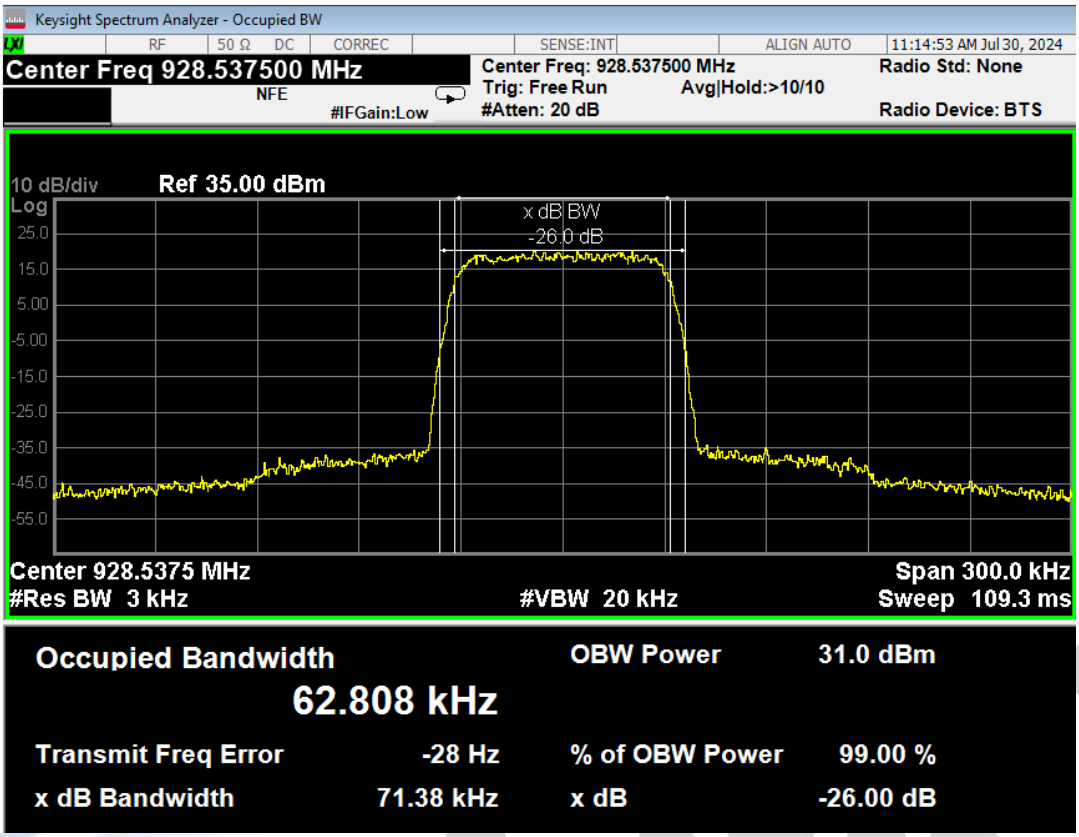


50k OBW 64QAM

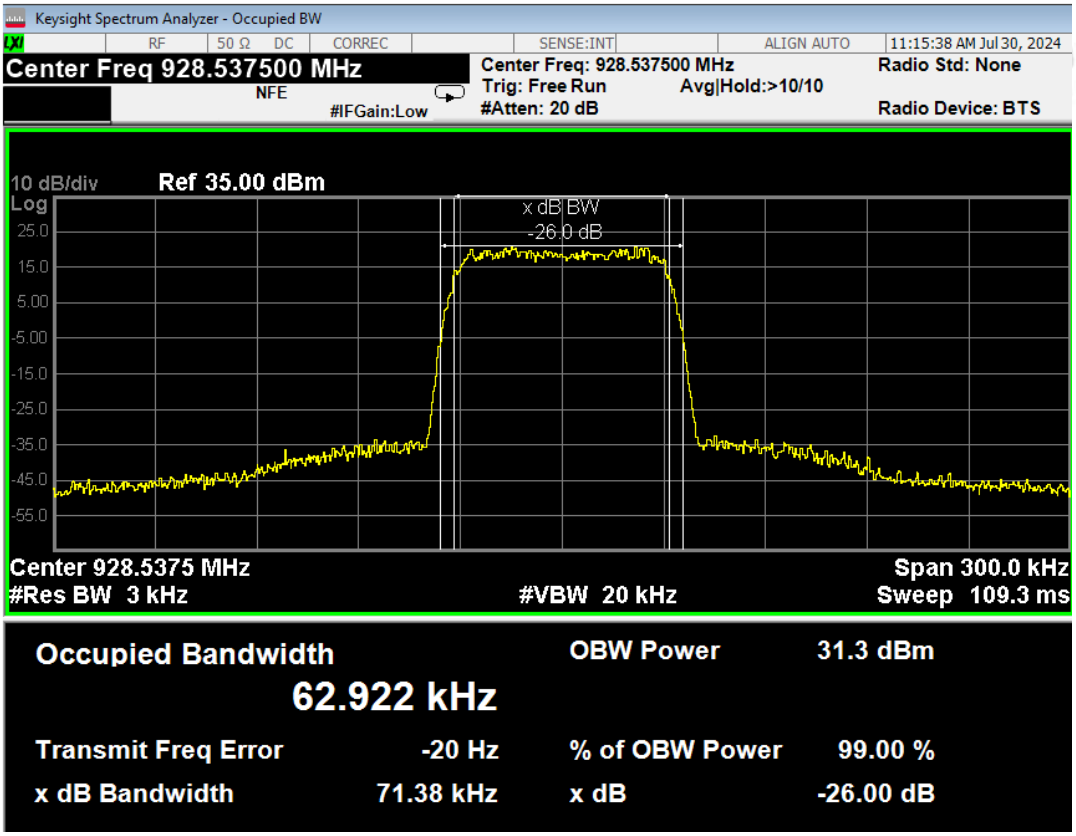


Test Frequency: 928.5375 MHz

75k OBW QPSK

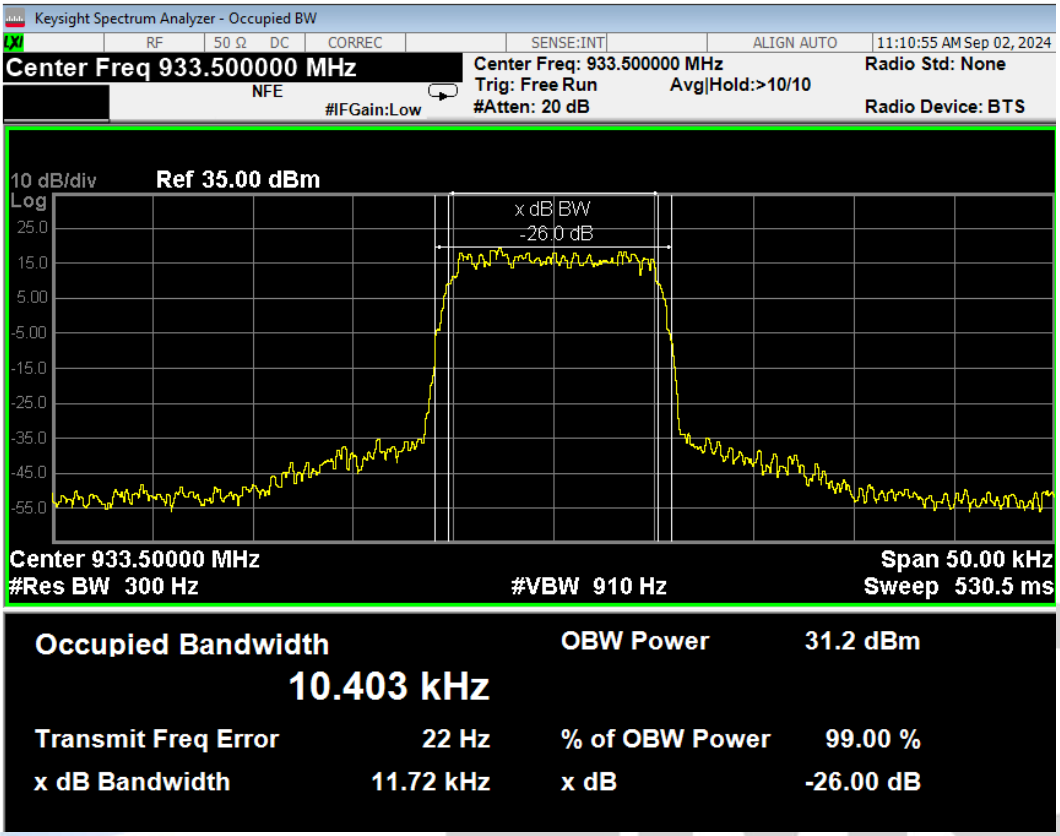


75k OBW 16QAM

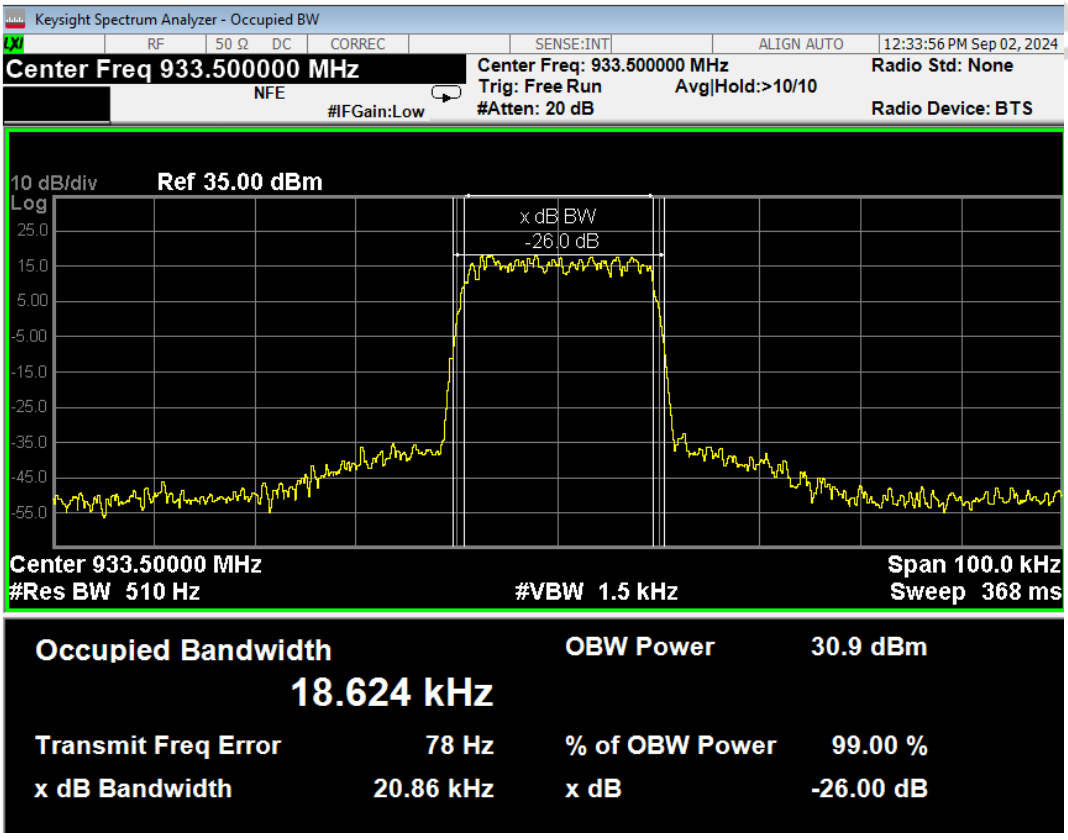


Test Frequency: 933.5000 MHz

12.5k OBW 256QAM

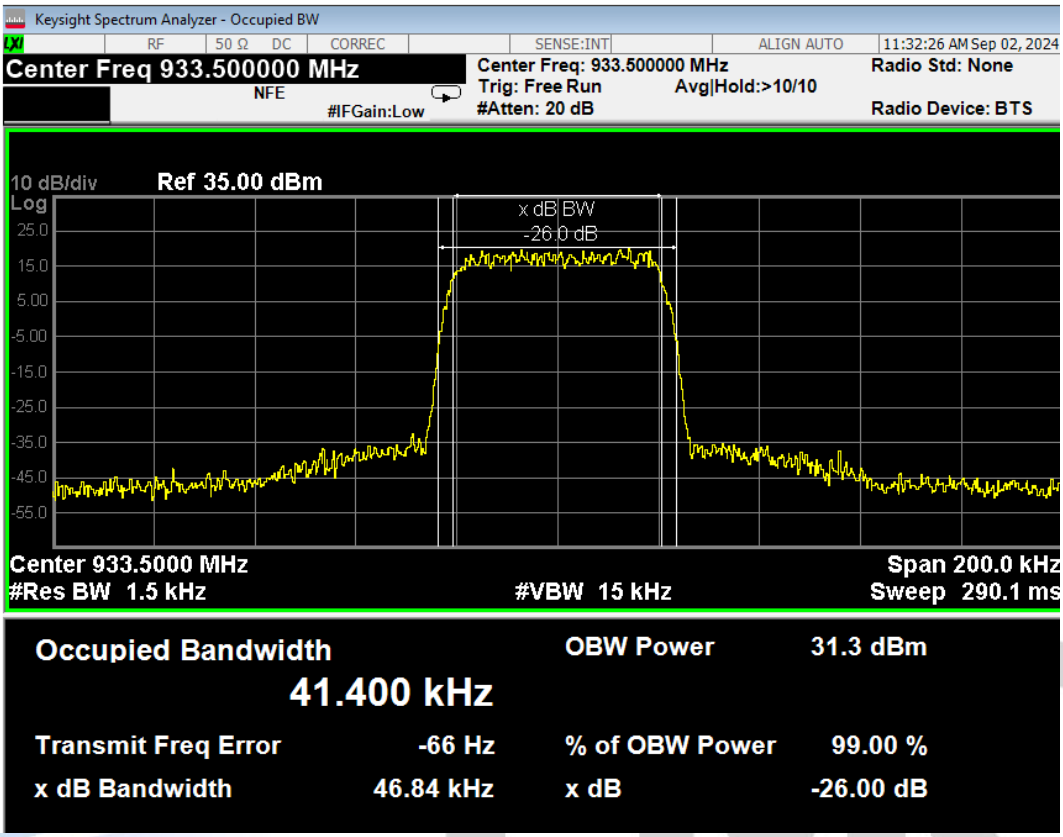


25k OBW 64QAM

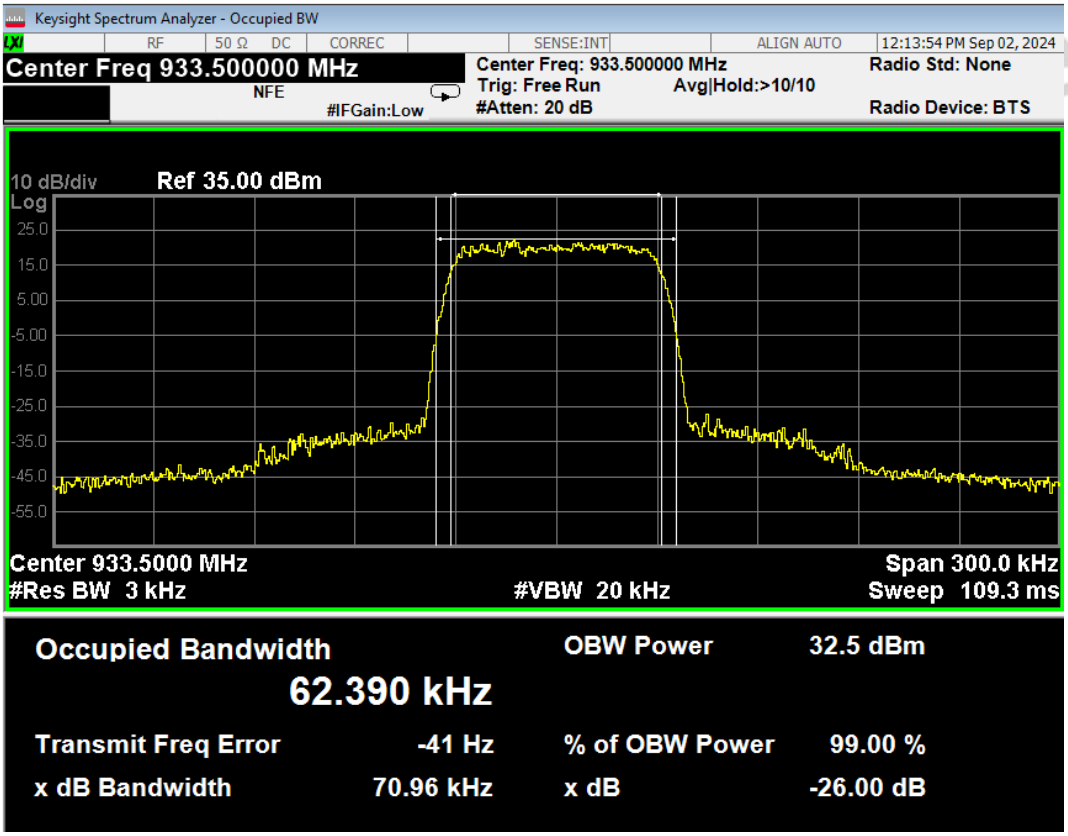


Test Frequency: 933.5000 MHz

50k OBW 256QAM

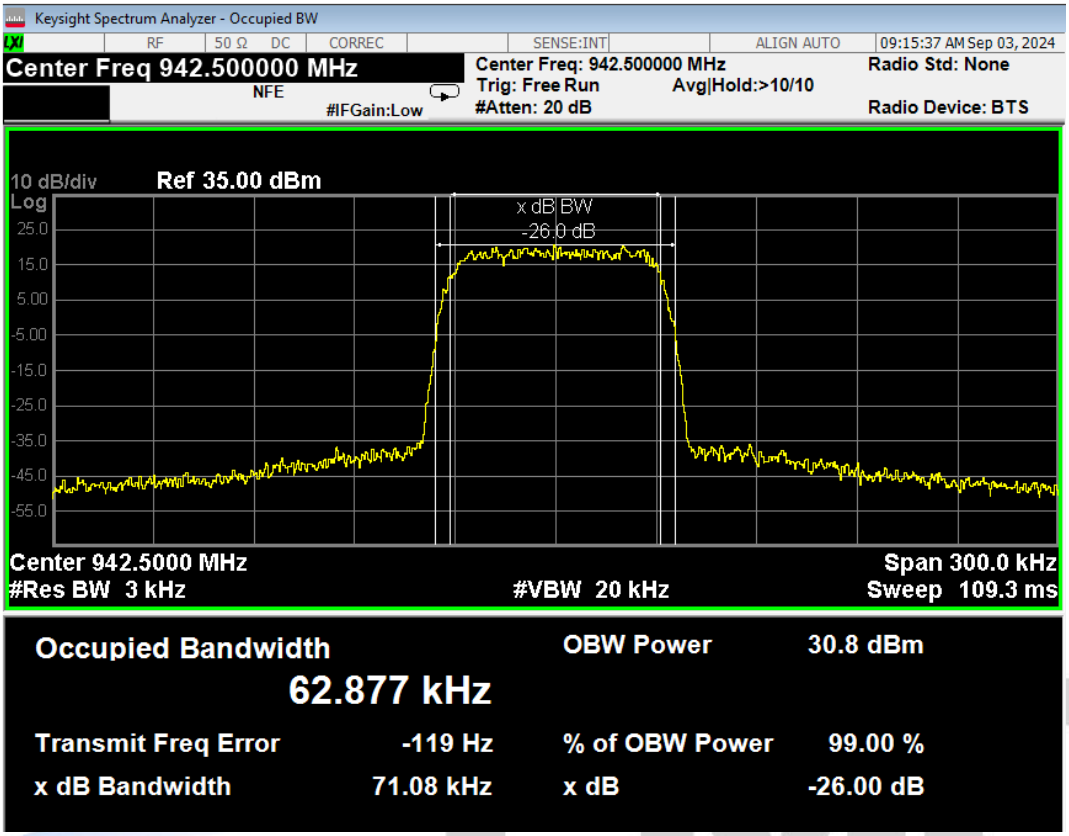


75k OBW 256QAM



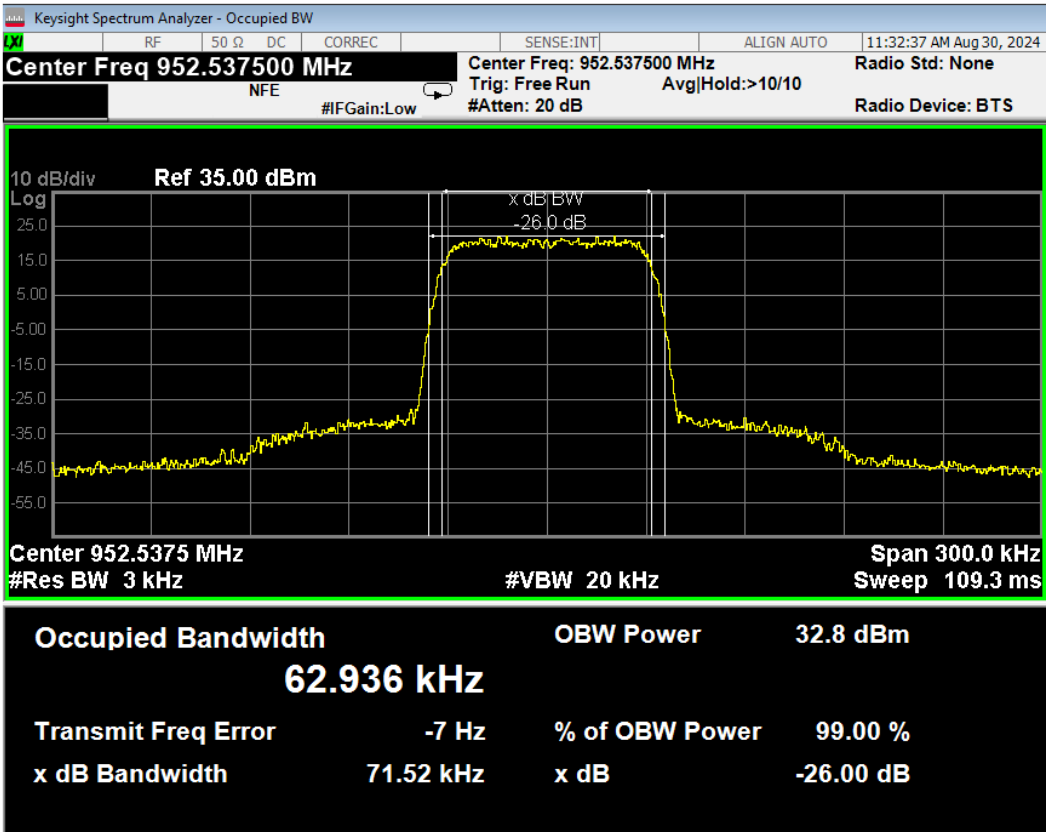
Test Frequency: 942.5000 MHz

H port-75 kHz OBW 16QAM



Test Frequency: 952.5375 MHz

V port-75k OBW 256QAM



101.111 Emission limitations

As this transmitter uses digital modulation in the 900 MHz band using 12.5 kHz, 25 kHz, 50 kHz and 75 kHz authorised bandwidths the emission masks as per section 101.111 (a) (5) and (6) have been applied.

The measurements were carried out using peak spectrum analyser method and RMS analyser method selectively across selected modulations for the purpose of completeness of the test.

When the Peak SA method was used, the reference level was determined using a 120 kHz resolution bandwidth and peak detector function for the modulation under test.

When the Average SA method was used, the reference level was determined using a 120 kHz resolution bandwidth and RMS detector with trace averaging for the modulation under test.

A 30 dB power attenuator was placed between the output of transmitter and the input of spectrum analyser. The correction factor has been included in the measurement results.

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

For the 12.5 kHz bandwidth, mask (a)(5) was applied.

For the 25.0 kHz bandwidth, mask (a)(6) was applied.

For the 50.0 kHz and 75.0 kHz bandwidth, mask (a)(5) was applied to show compliance when using aggregated 12.5 kHz channels.

Additionally for 50.0 kHz and 75.0 kHz bandwidth, mask G was applied to show compliance when using aggregated 25.0 kHz channels.

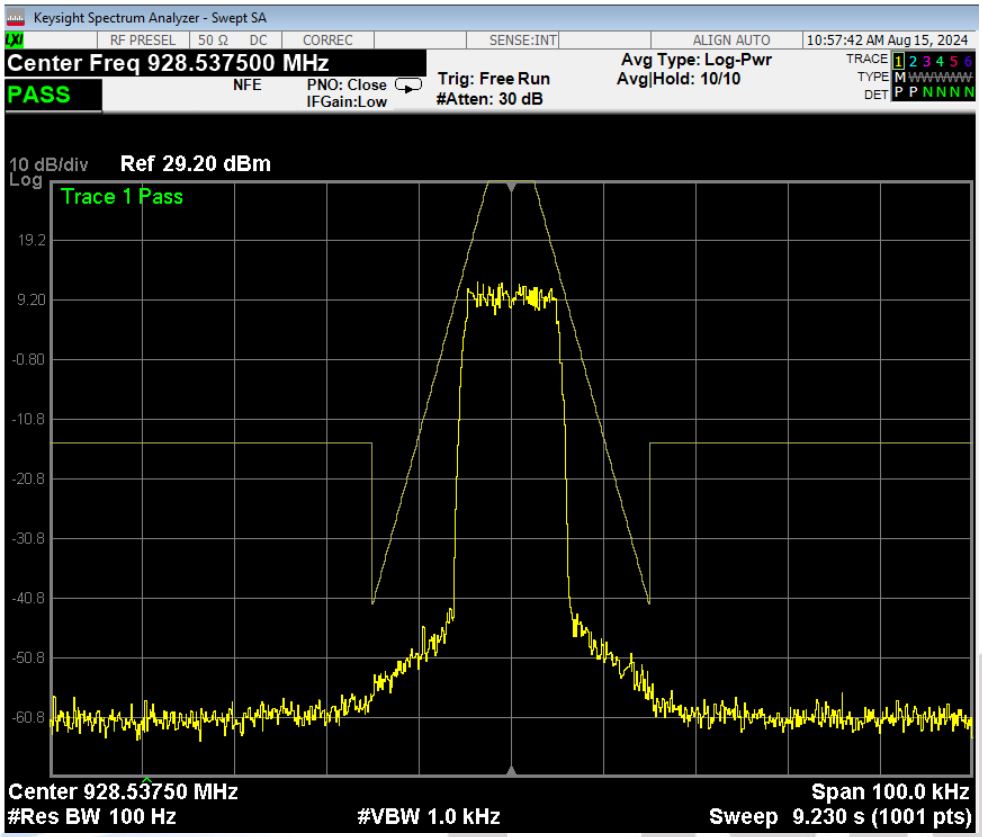
The mask measurement was performed on one port and is representative of compliance for port V and port H of the product.

The plots are provided in this report to show compliance with combination of port tested, channel bandwidth and test frequency. Limited number of plots has been provided in the test report for readability.

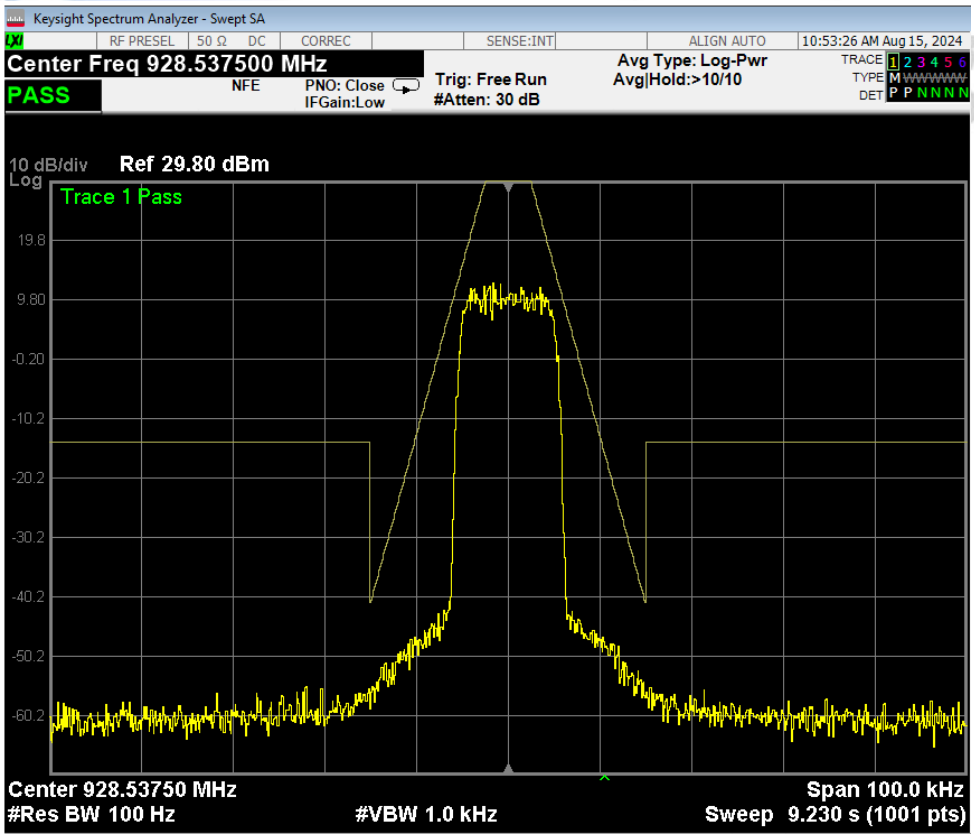
Result: Complies.
Measurement Uncertainty: +/-1.5 dB

Test Frequency: 928.5375 MHz

12.5k QPSK FCC mask (a) (5)

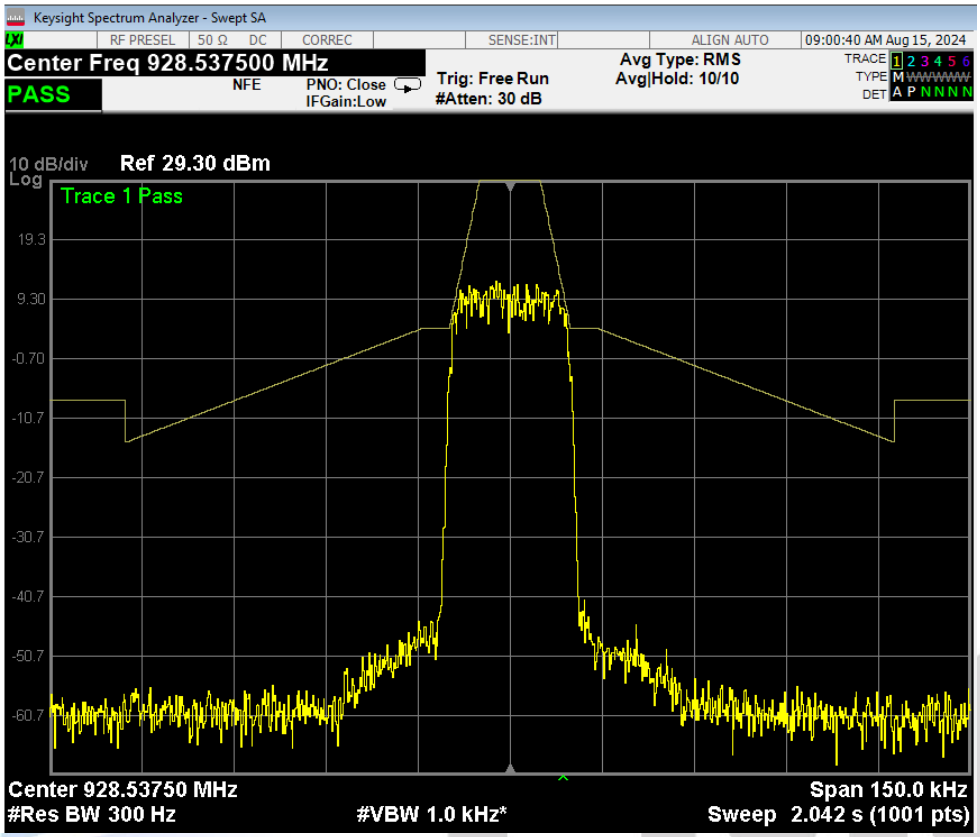


12.5k 16QAM FCC mask (a) (5)

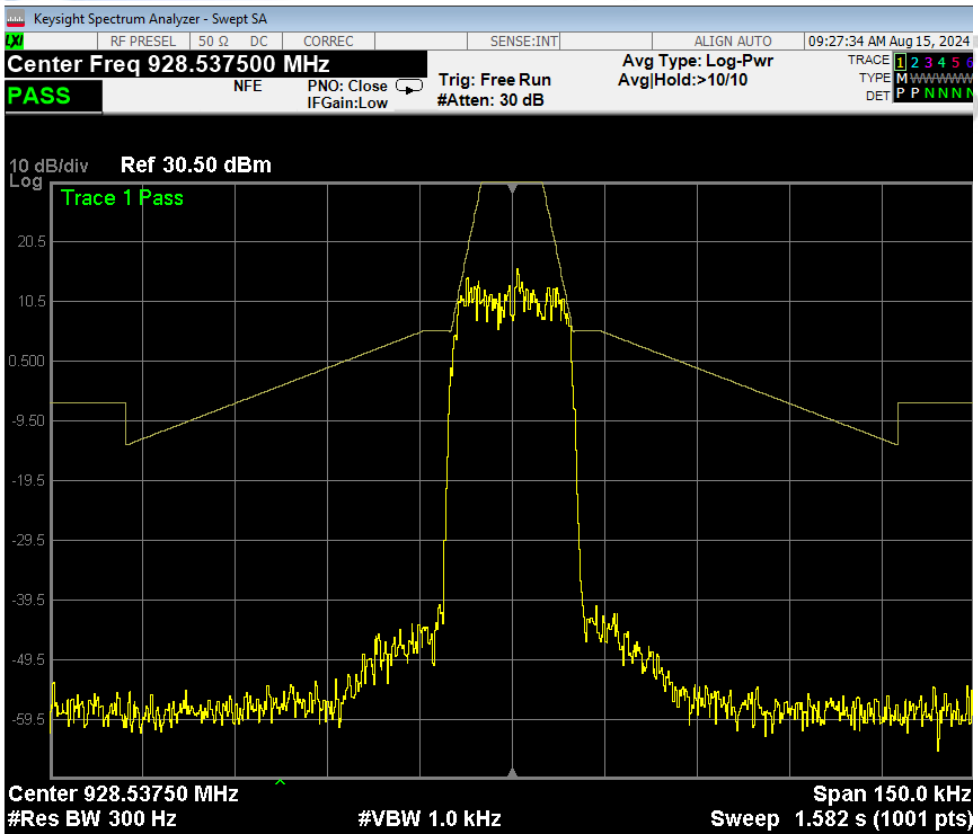


Test Frequency: 928.5375 MHz

25.0k QPSK FCC mask (a) (6)

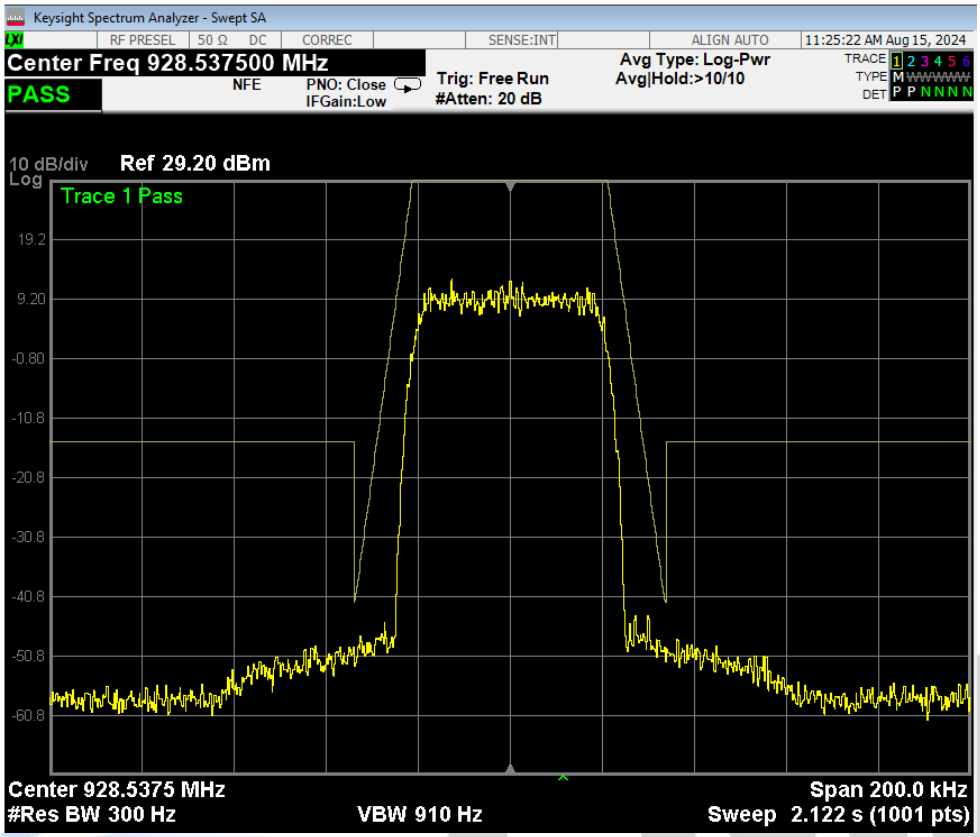


25.0k 64QAM FCC mask (a) (6)

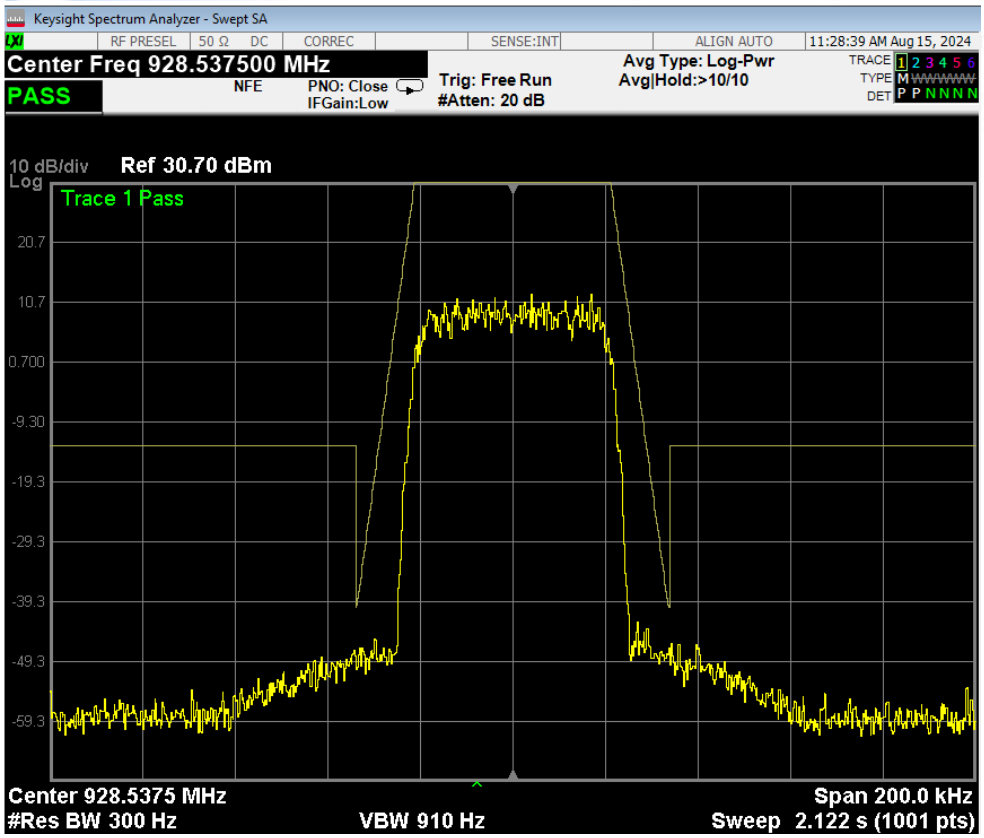


Test Frequency: 928.5375 MHz

50.0k QPSK FCC aggregated mask (a) (5)

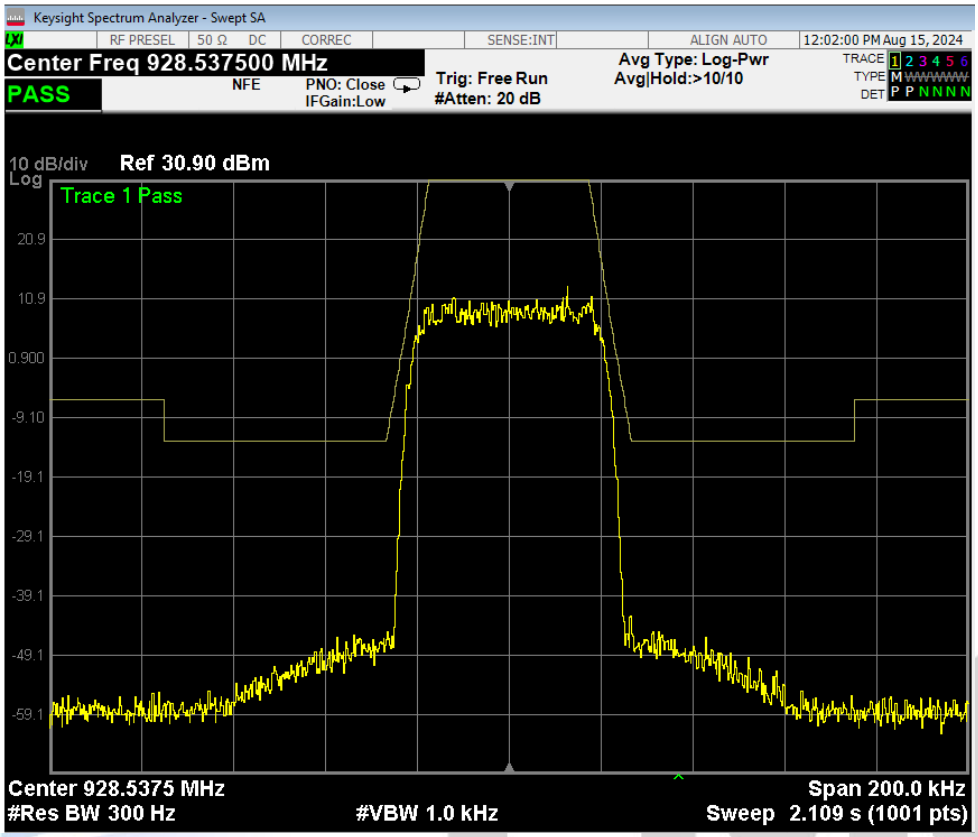


50.0k 256QAM FCC aggregated mask (a) (5)

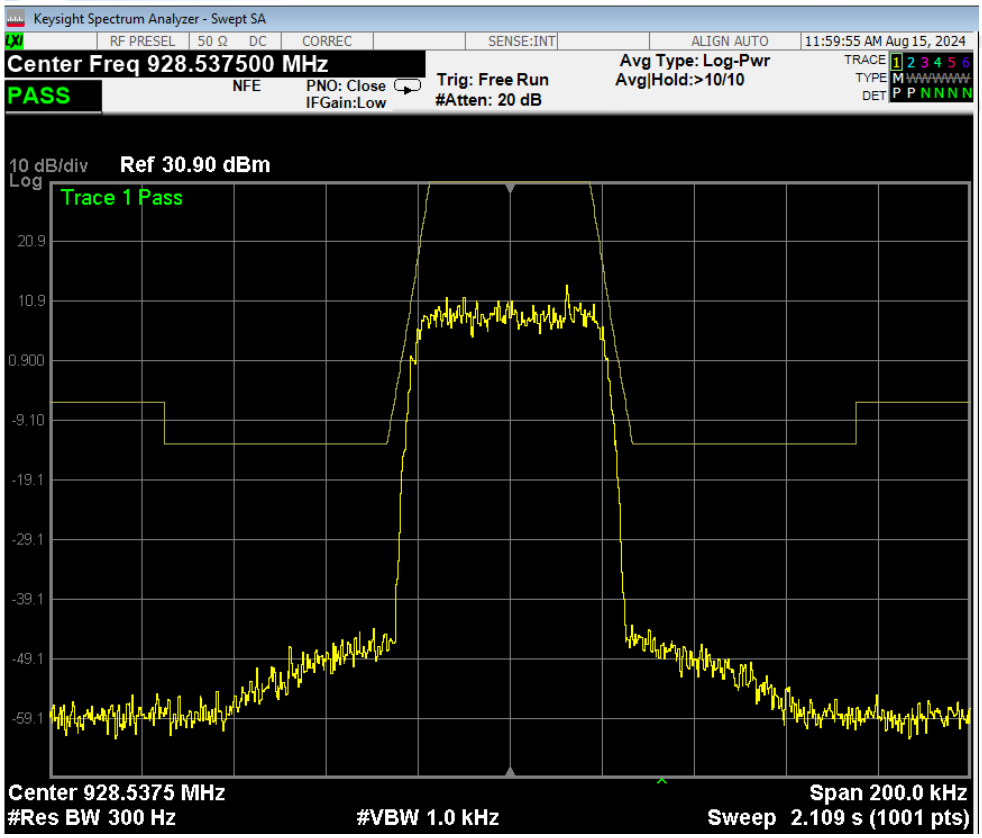


Test Frequency: 928.5375 MHz

50.0k 16QAM FCC aggregated mask (a) (6)

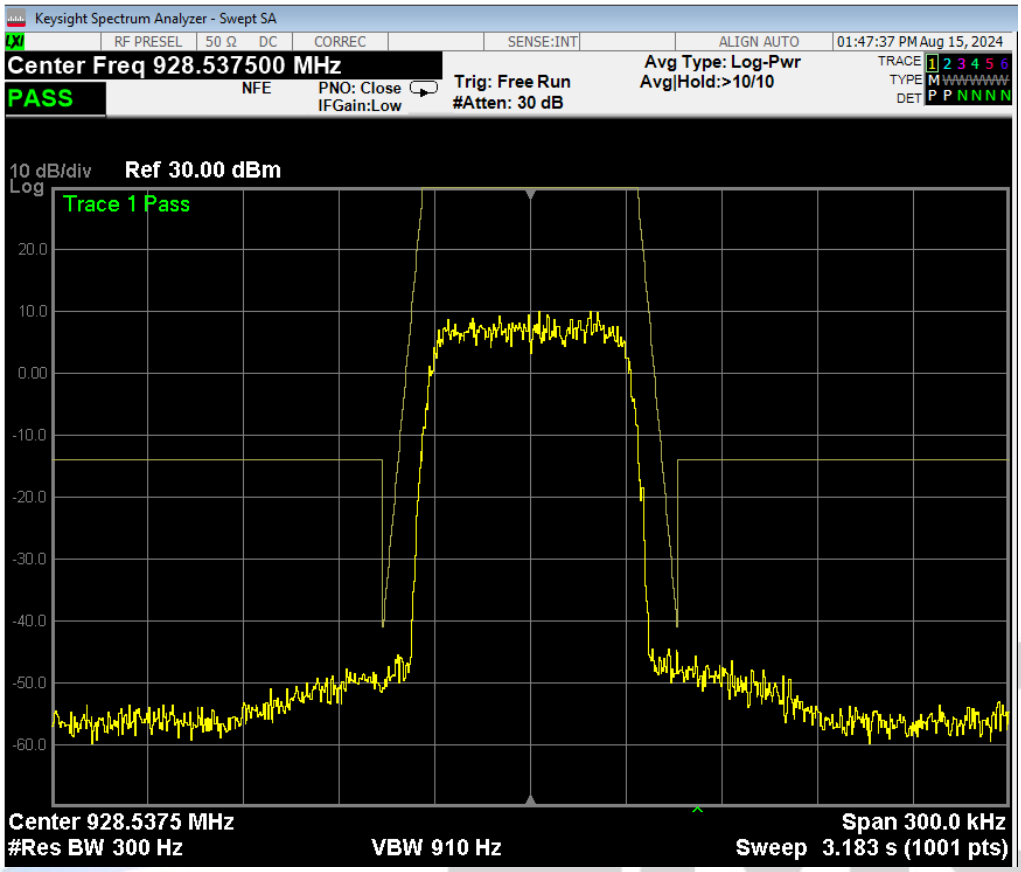


50.0k 64QAM FCC aggregated mask (a) (6)

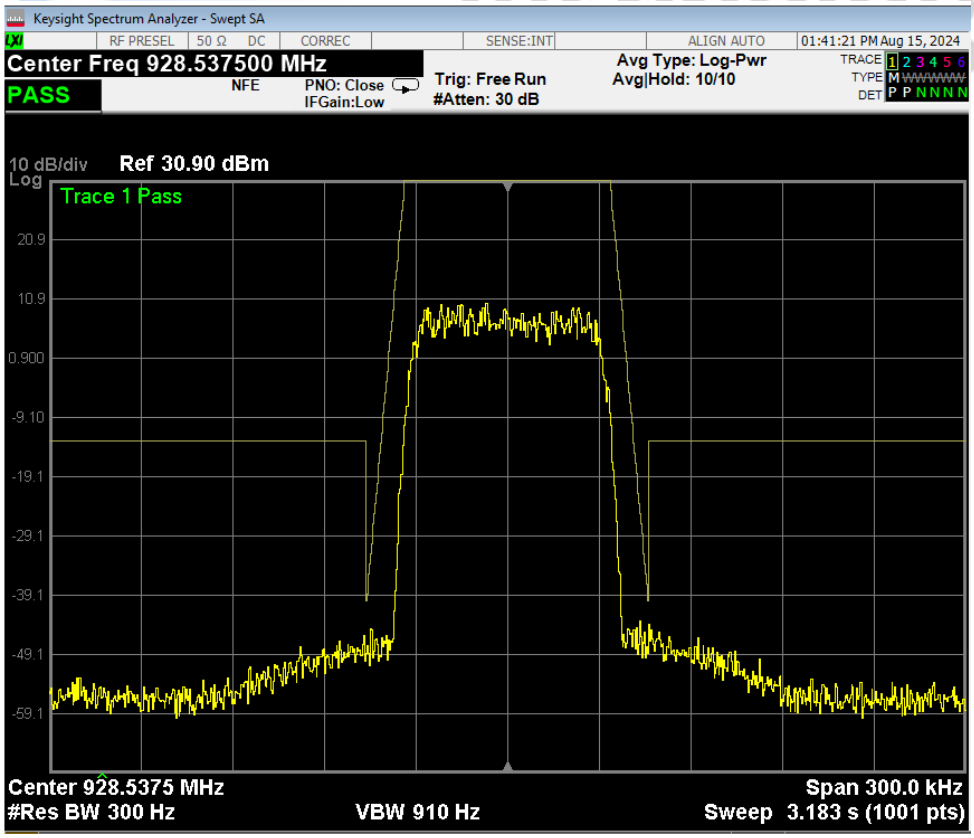


Test Frequency: 928.5375 MHz

75.0k 16QAM FCC aggregated mask (a) (5)

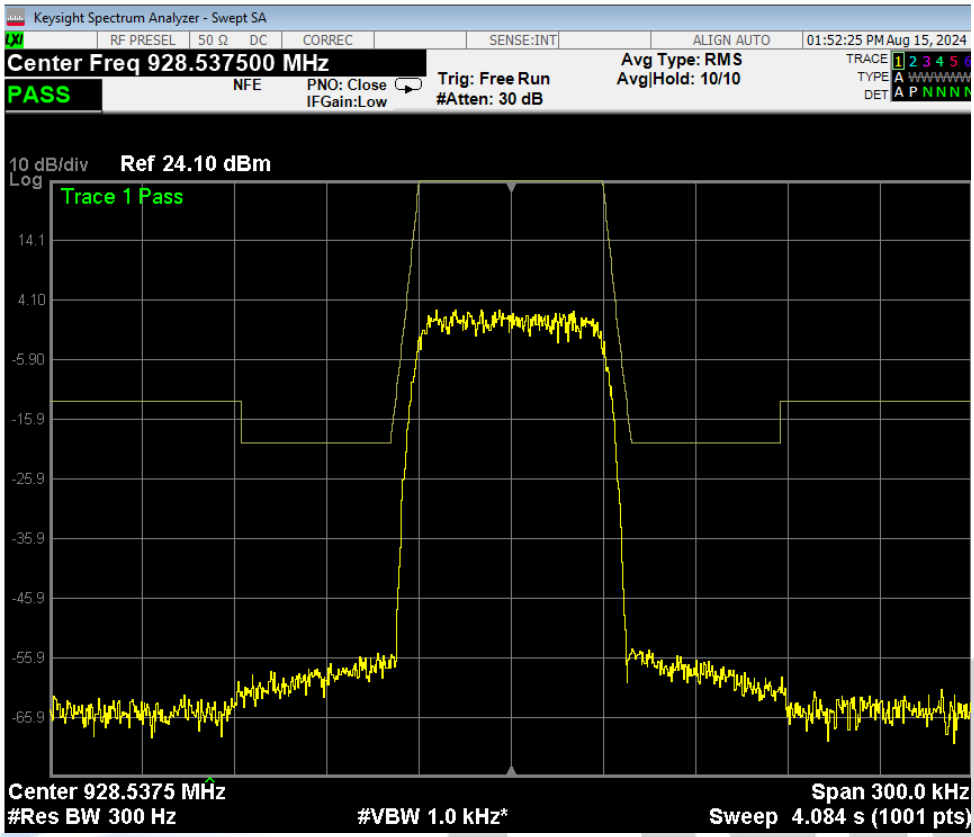


75.0k 256QAM FCC aggregated mask (a) (5)

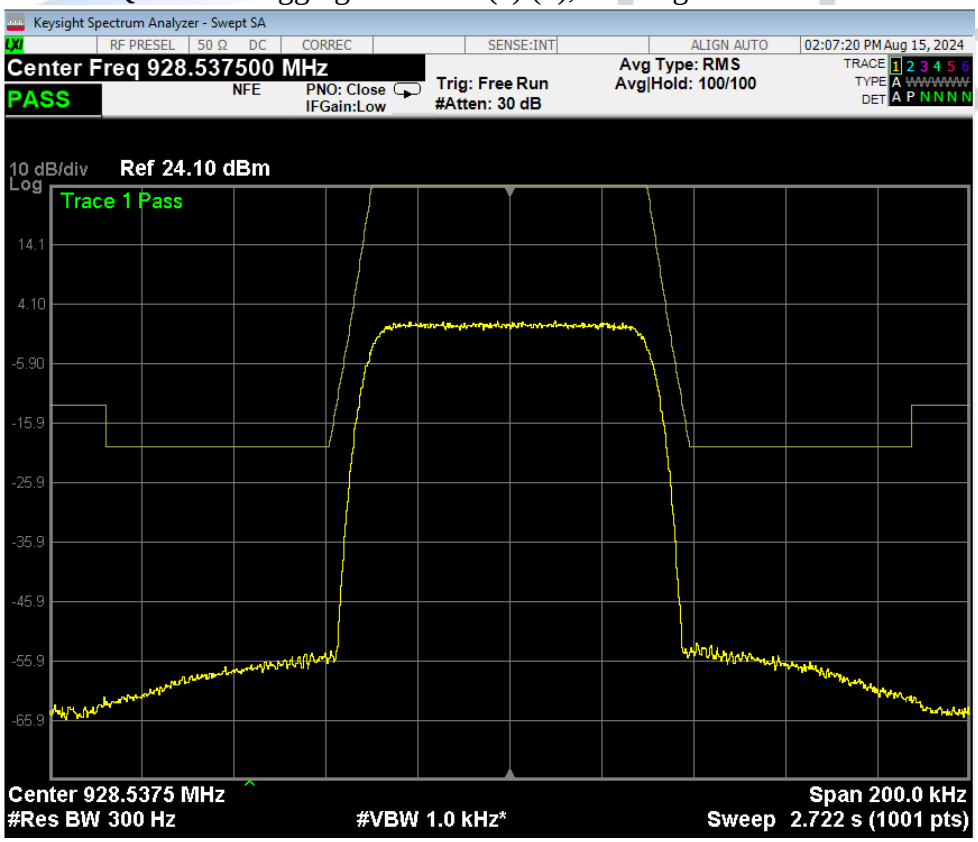


Test Frequency: 928.5375 MHz

75.0k QPSK FCC aggregated mask (a) (6), SA Avg method

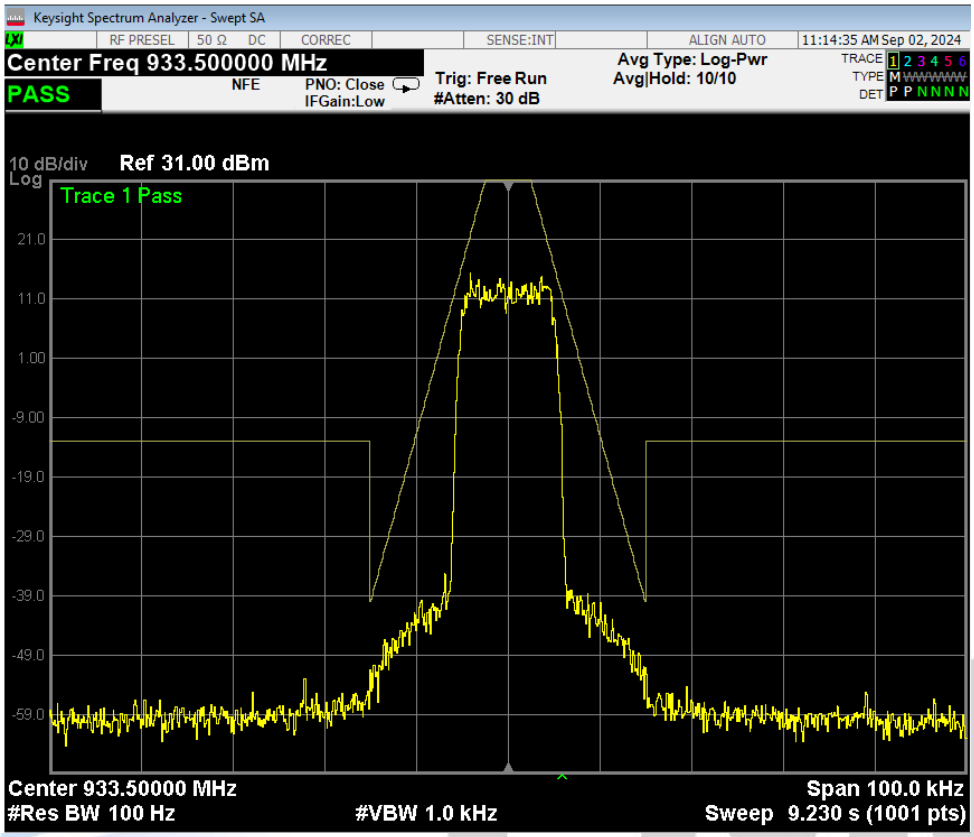


75.0k 64QAM FCC aggregated mask (a) (6), SA Avg method

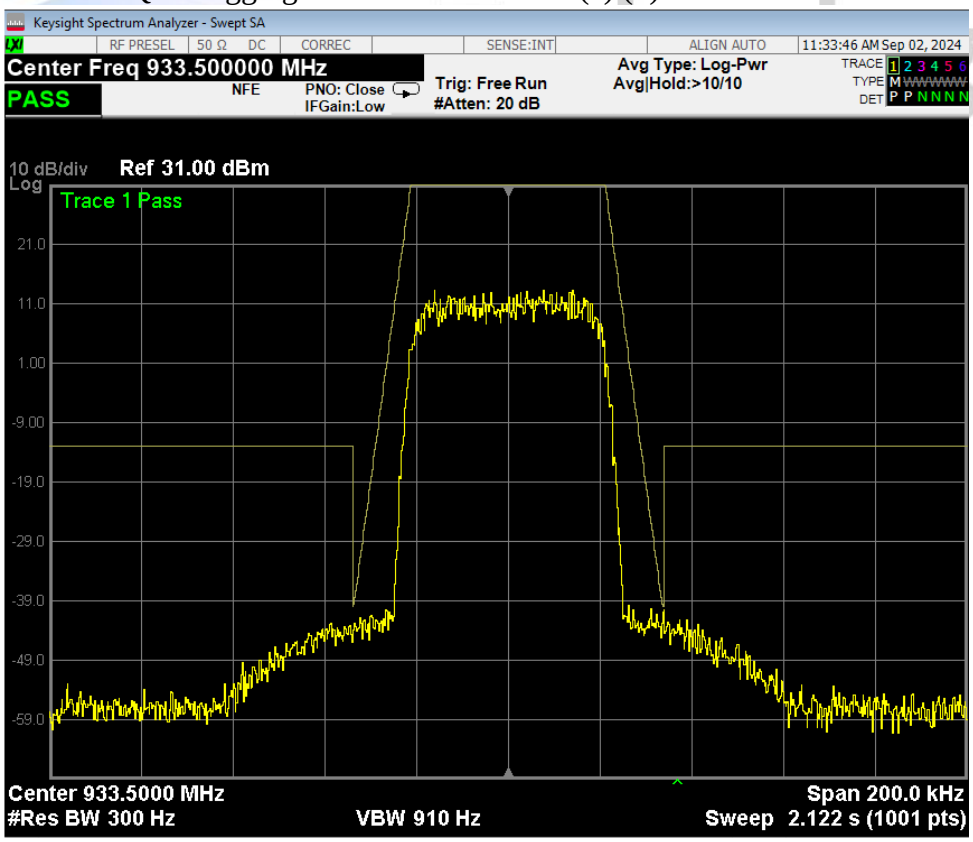


Test Frequency: 933.5000 MHz

12.5k 256QAM FCC mask (a) (5)

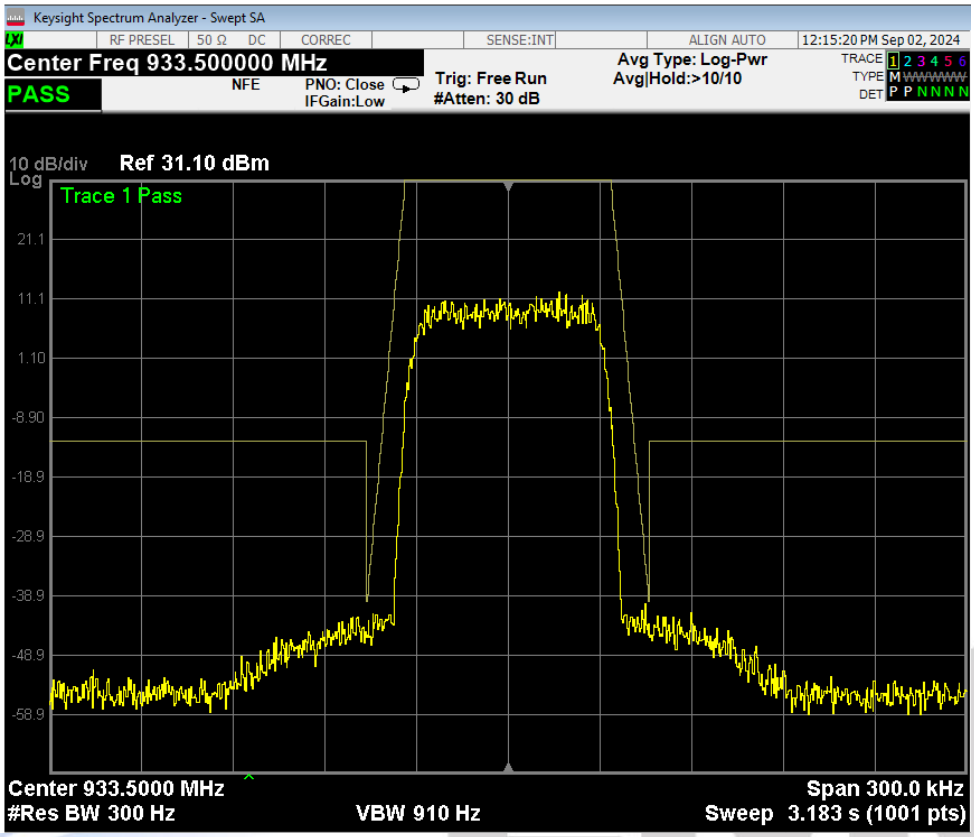


50.0k 256QAM aggregated mask FCC mask (a) (5)

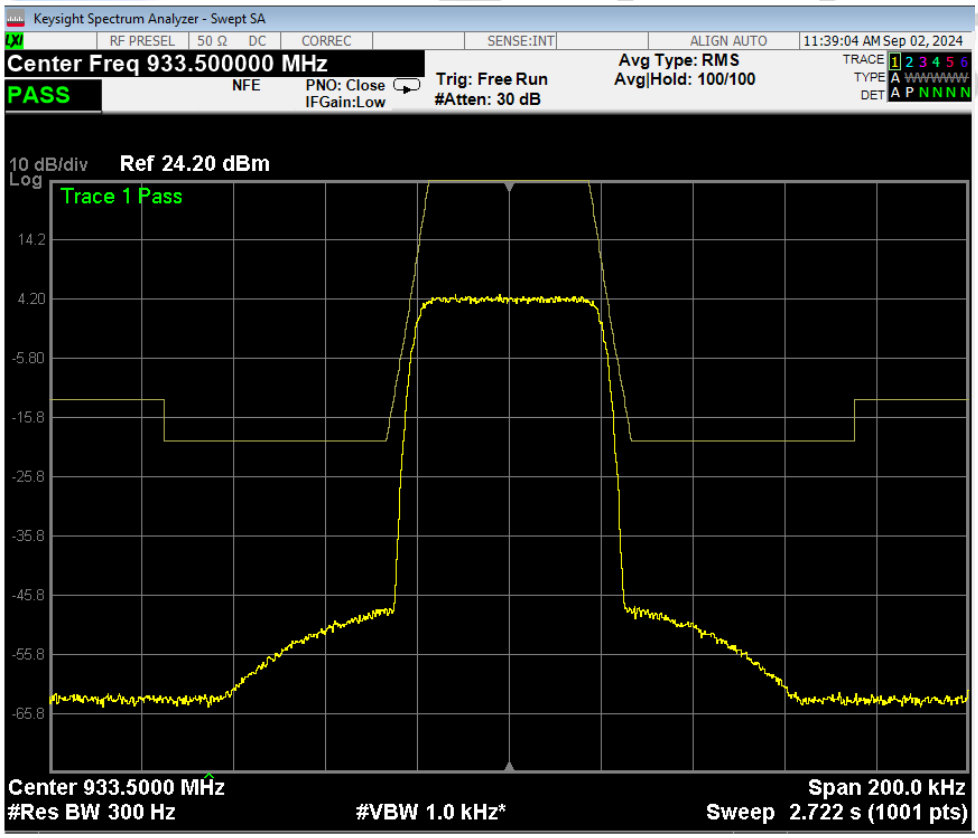


Test Frequency: 933.5000 MHz

75.0k 256QAM aggregated mask FCC mask (a) (5)

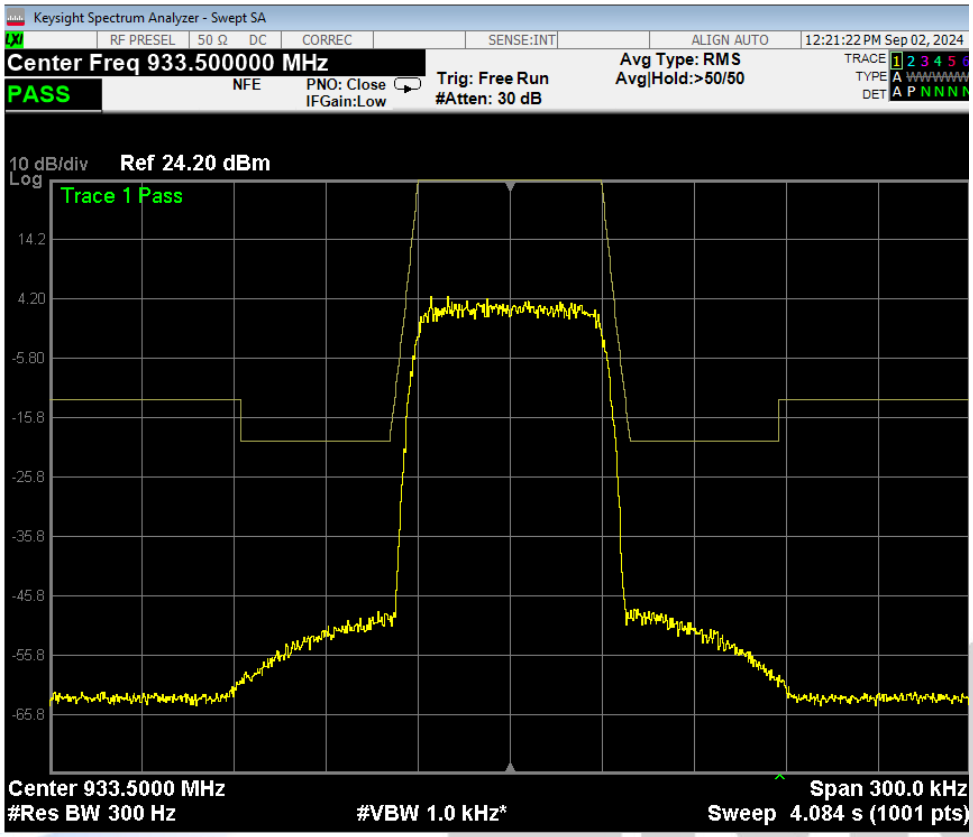


50.0k 256QAM aggregated mask FCC mask (a) (6), SA Avg method



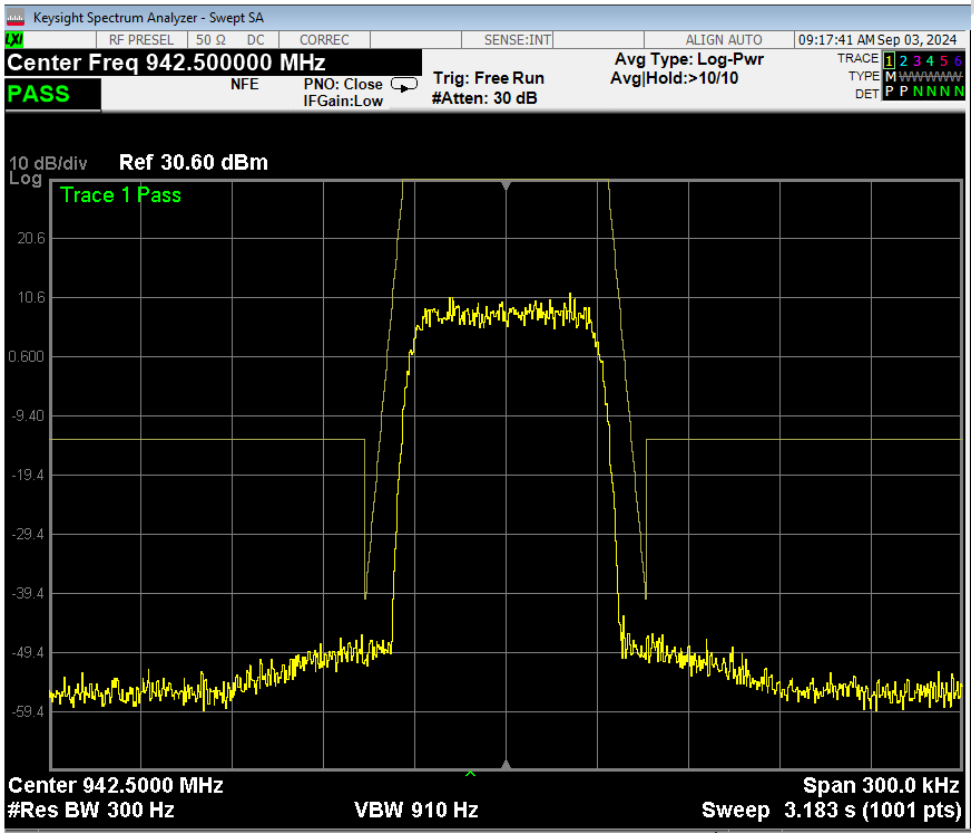
Test Frequency: 933.5000 MHz

75.0k 256QAM aggregated mask FCC mask (a) (6), SA Avg method



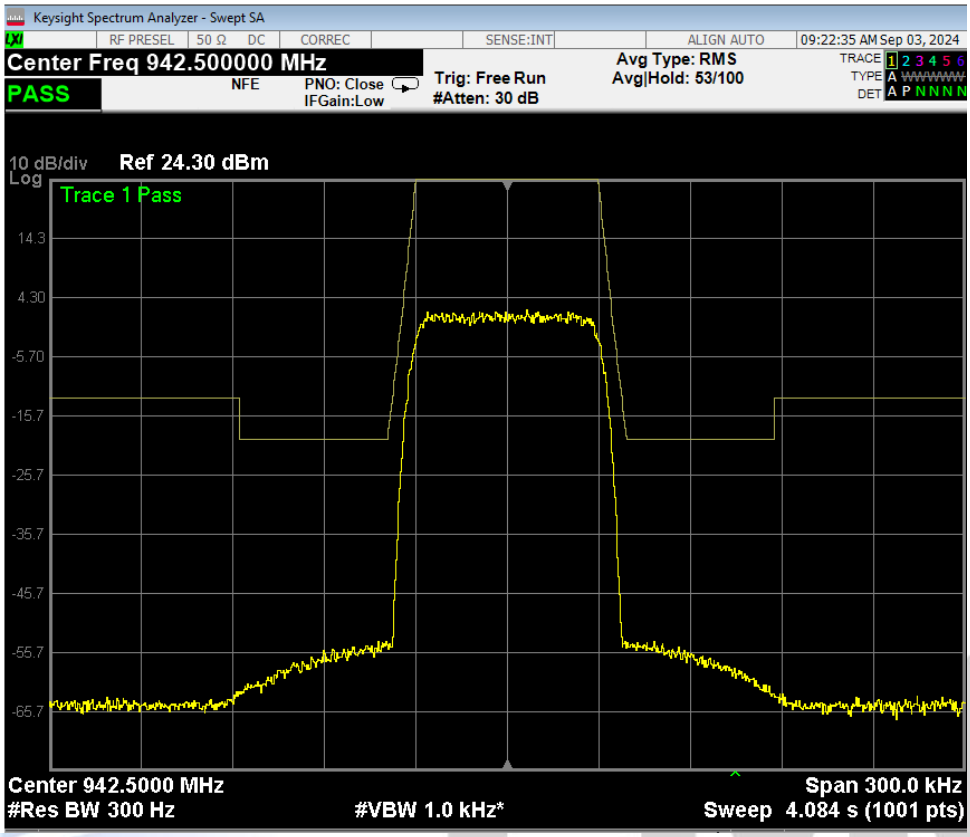
Test Frequency: 942.5000 MHz

75.0k 16QAM aggregated mask FCC mask (a) (5)



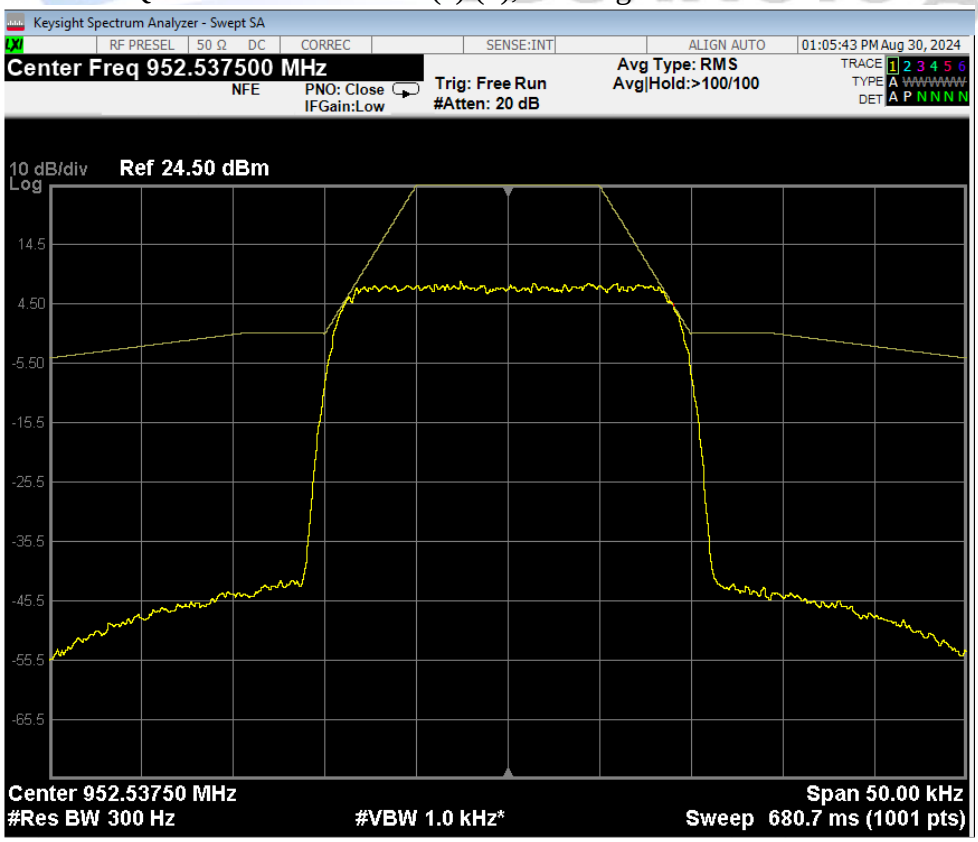
Test Frequency: 942.5000 MHz

75.0k 16QAM aggregated mask FCC mask (a) (6), SA Avg method



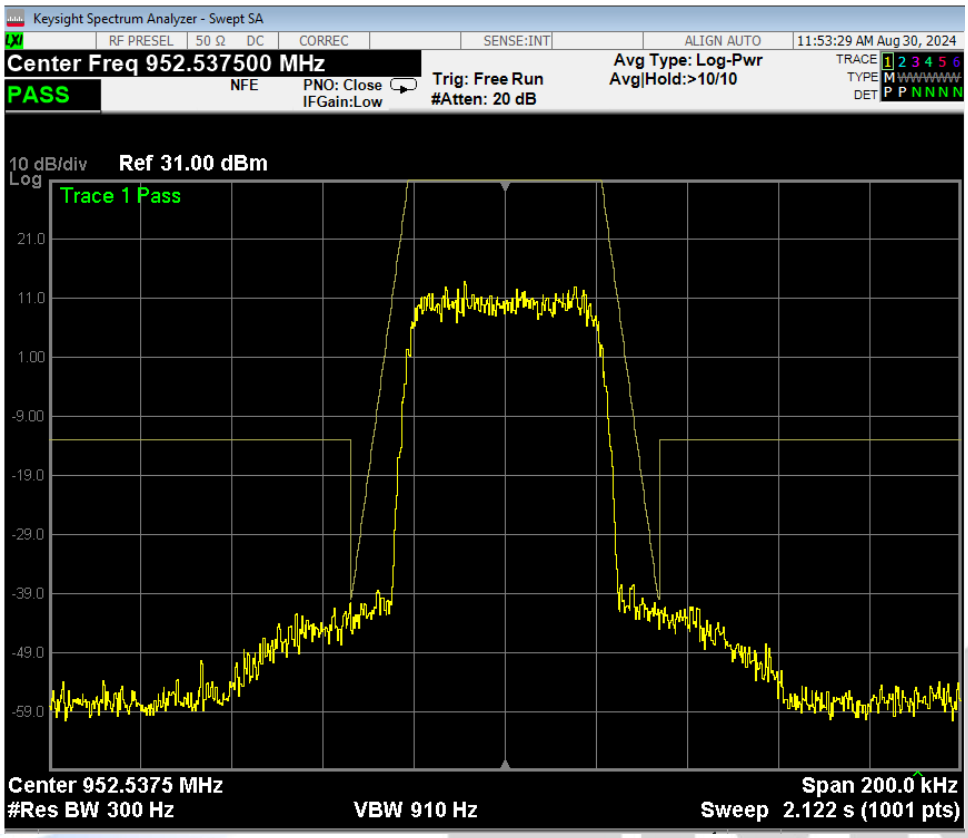
Test Frequency: 952.5375 MHz

25.0k 256QAM mask FCC mask (a) (6), SA Avg method

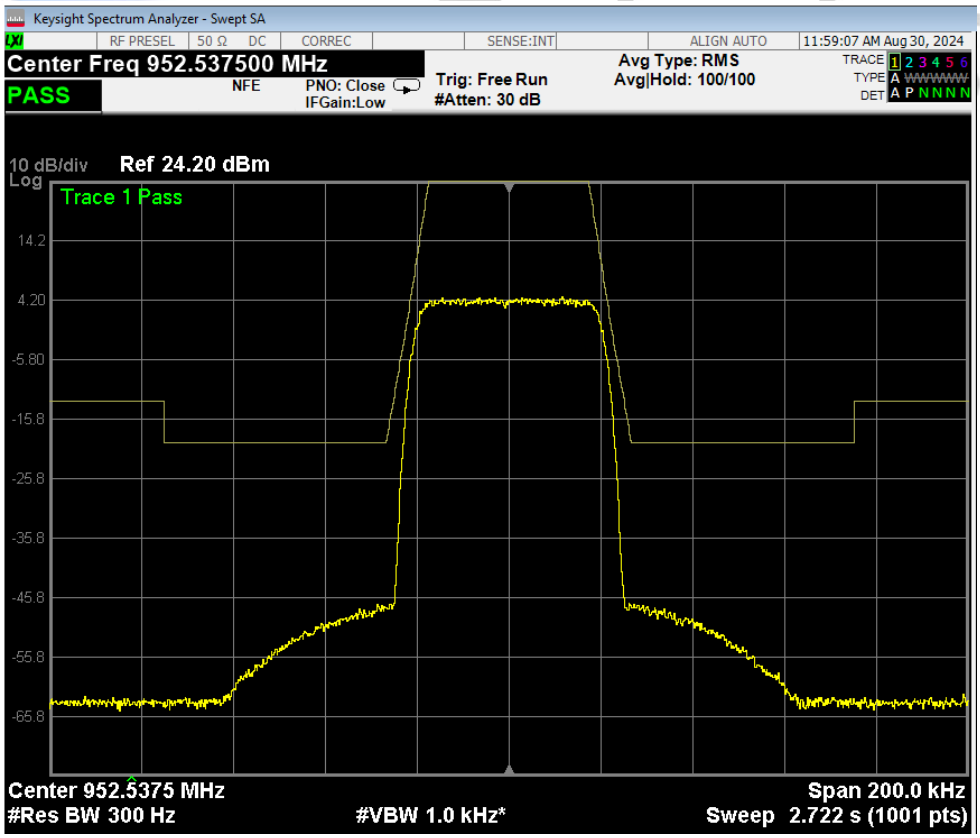


Test Frequency: 952.5375 MHz

50.0k 256QAM aggregated mask FCC mask (a) (5)

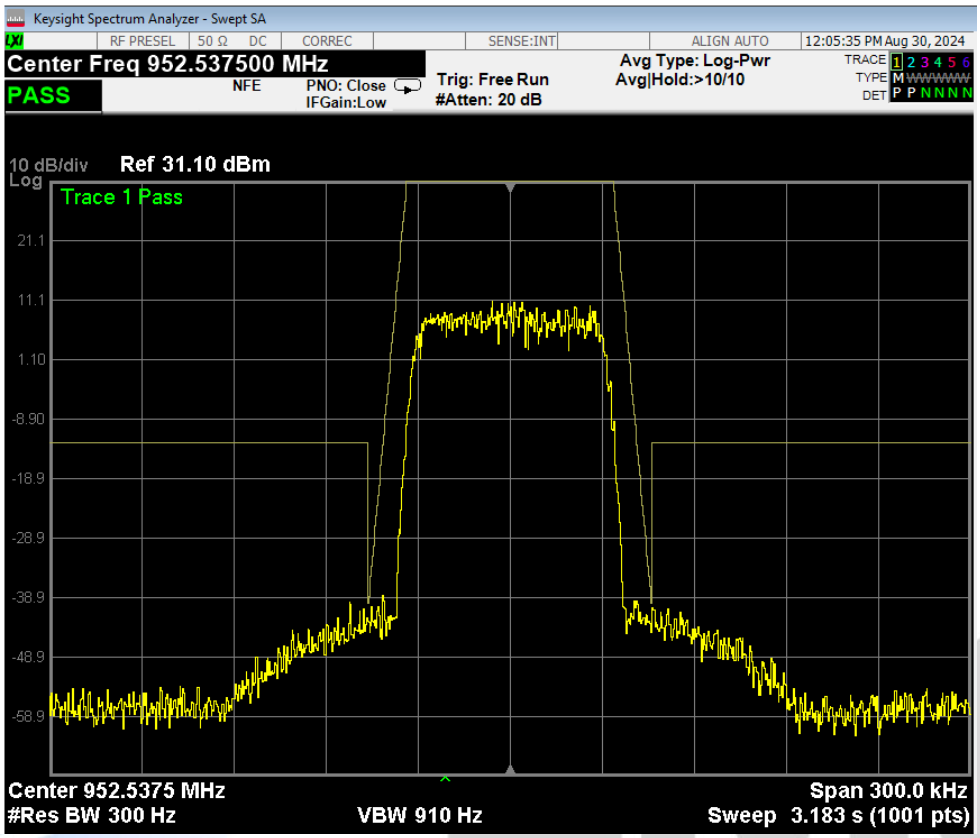


50.0k 256QAM aggregated mask FCC mask (a) (6), SA Avg method

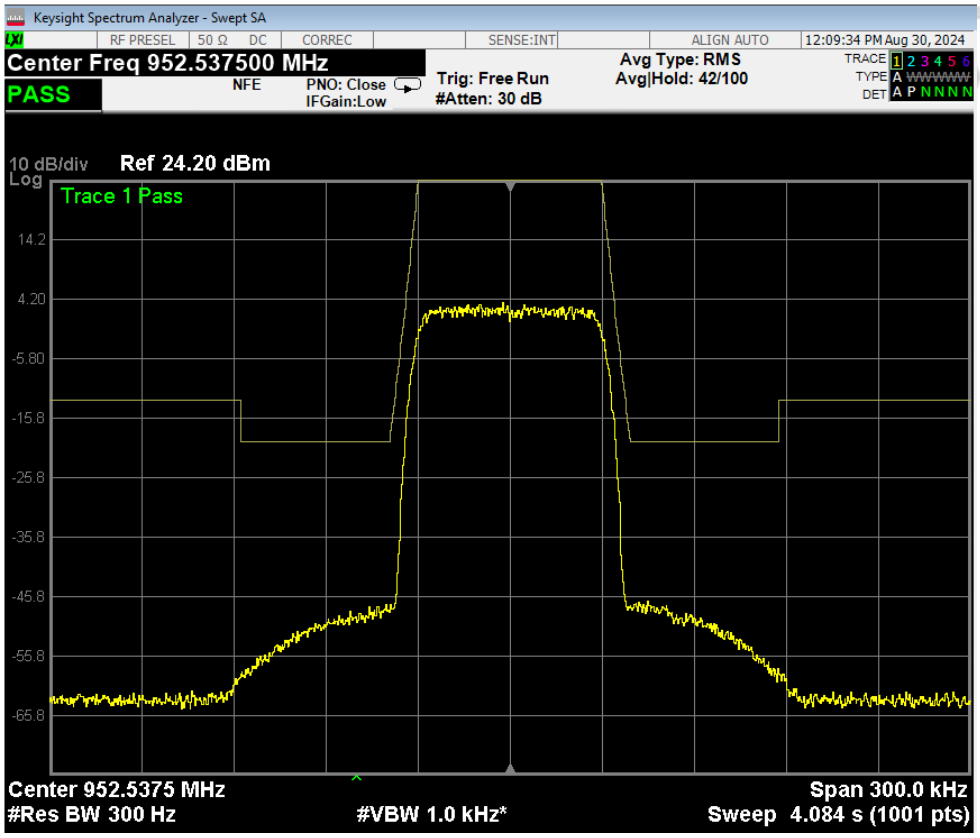


Test Frequency: 952.5375 MHz

75.0k 256QAM aggregated mask FCC mask (a) (5)



75.0k 256QAM aggregated mask FCC mask (a) (6), SA Avg method



Transmitter unwanted emissions – antenna terminal

As per section 2.1051 spurious emission measurements were made at the antenna port of the transmitter.

The spectrum analyser bandwidth was set to 100 kHz for measurements below 1 GHz and 1 MHz for measurements above 1 GHz.

Frequency (fc)**:** 928.5375 MHz/ Port-V

Spurious emission (Harmonic)	Emission level (dBm)	Limit (dBm)
1857.075	-47.9	-20.0
2785.613	<-50.0	-20.0
3714.150	<-45.0	-20.0
4642.688	<-45.0	-20.0
5571.225	<-45.0	-20.0
6499.763	<-45.0	-20.0
7428.300	<-45.0	-20.0
8356.838	<-45.0	-20.0
9285.375	<-45.0	-20.0
10213.913	<-45.0	-20.0

Limit:

Section 101.111 (a)(5) states that 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.

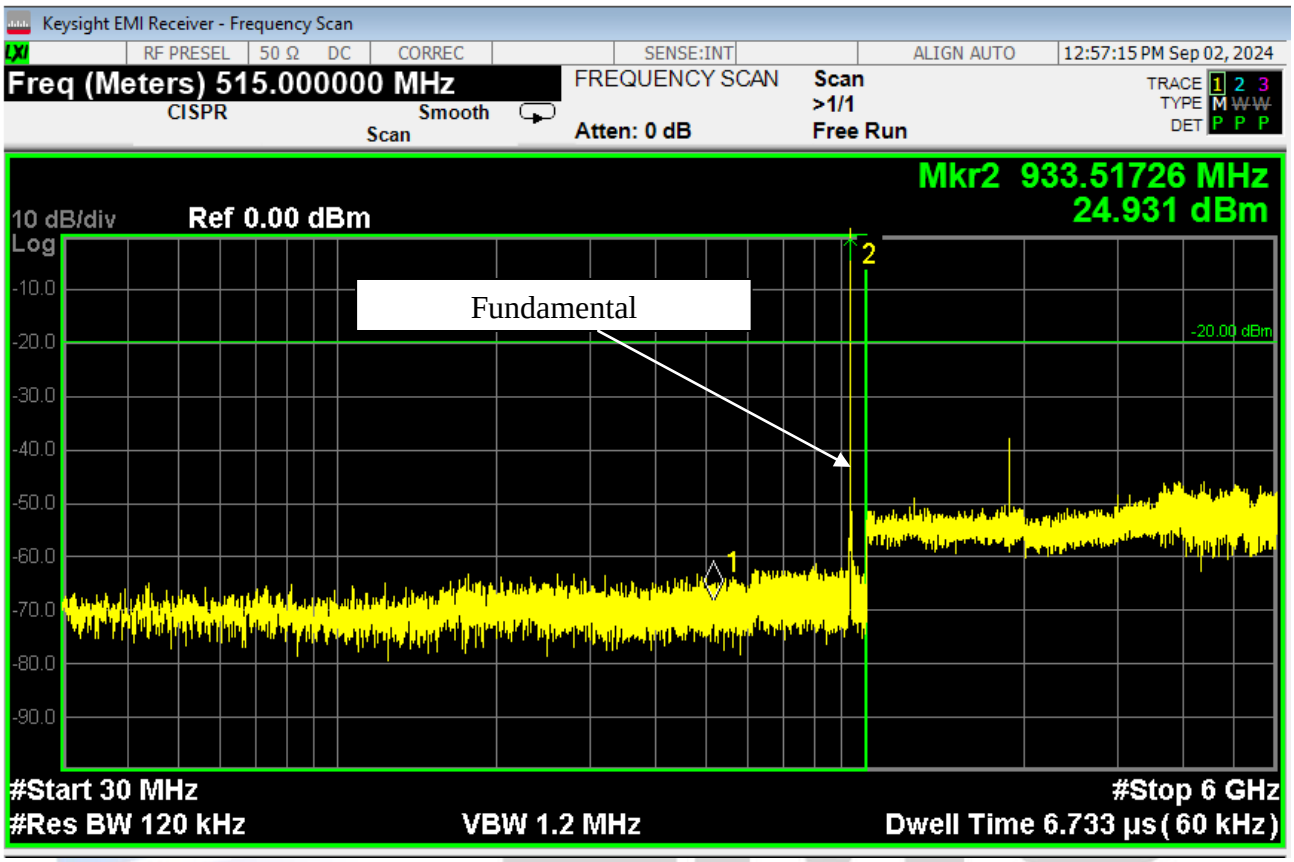
All spurious emissions are to be attenuated by at least 50 + 10 log (P). The rated power of +24 dBm gives a limit of –20 dBm.

The spectrum has been investigated up to the 10^{th} harmonic of the transmitter.

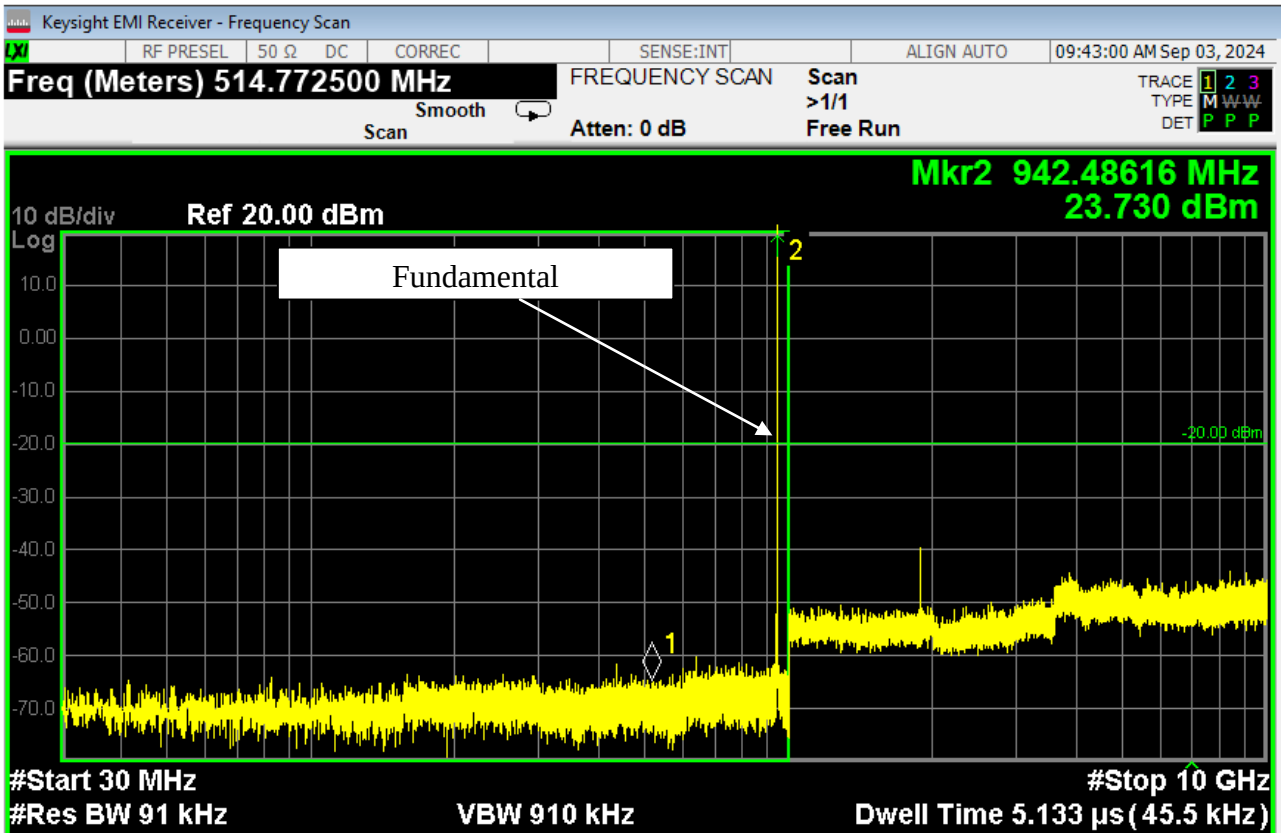
Result: Complies
Measurement Uncertainty: ± 3.3 dB

Transmit emissions plot

Test Frequency: 933.5000 MHz

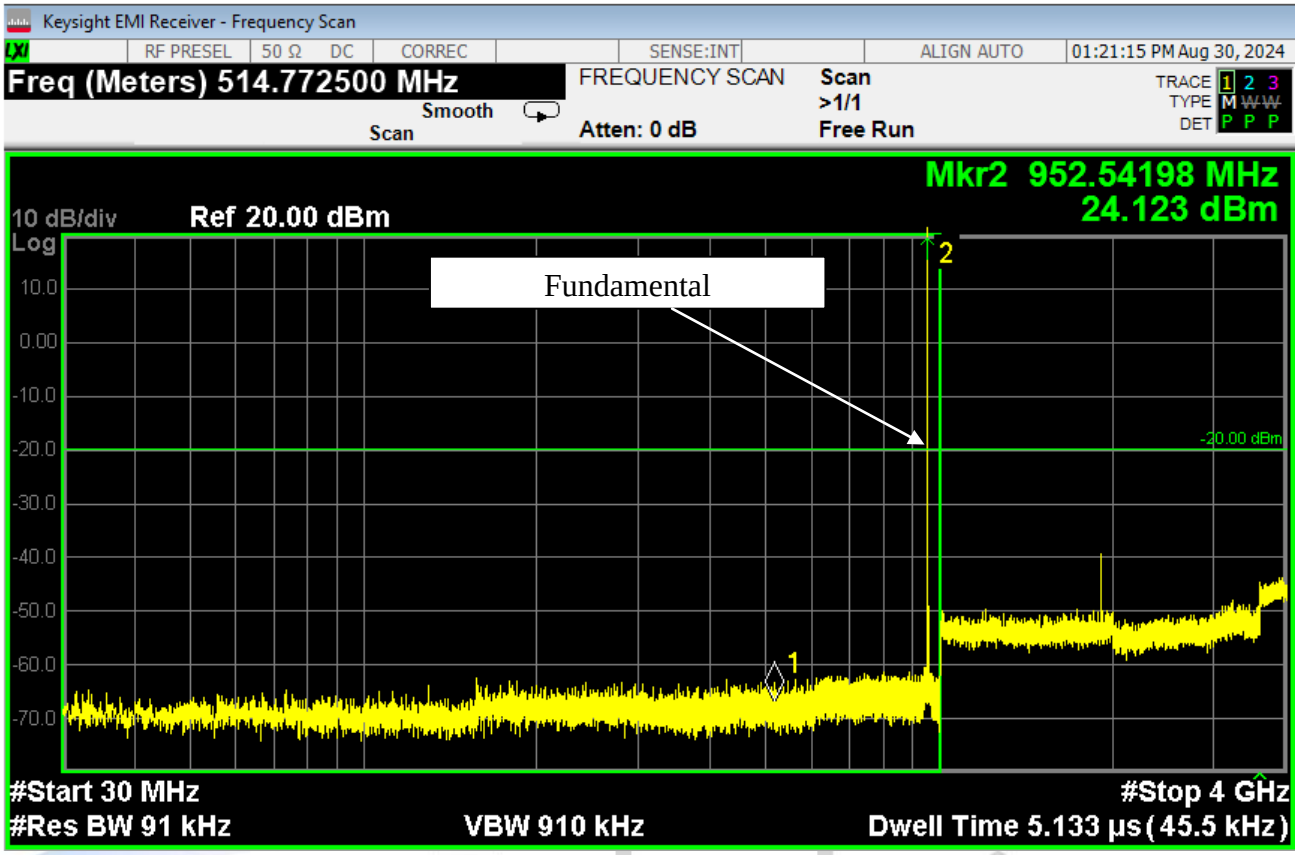


Test Frequency: 942.5000 MHz



Transmit emissions plot

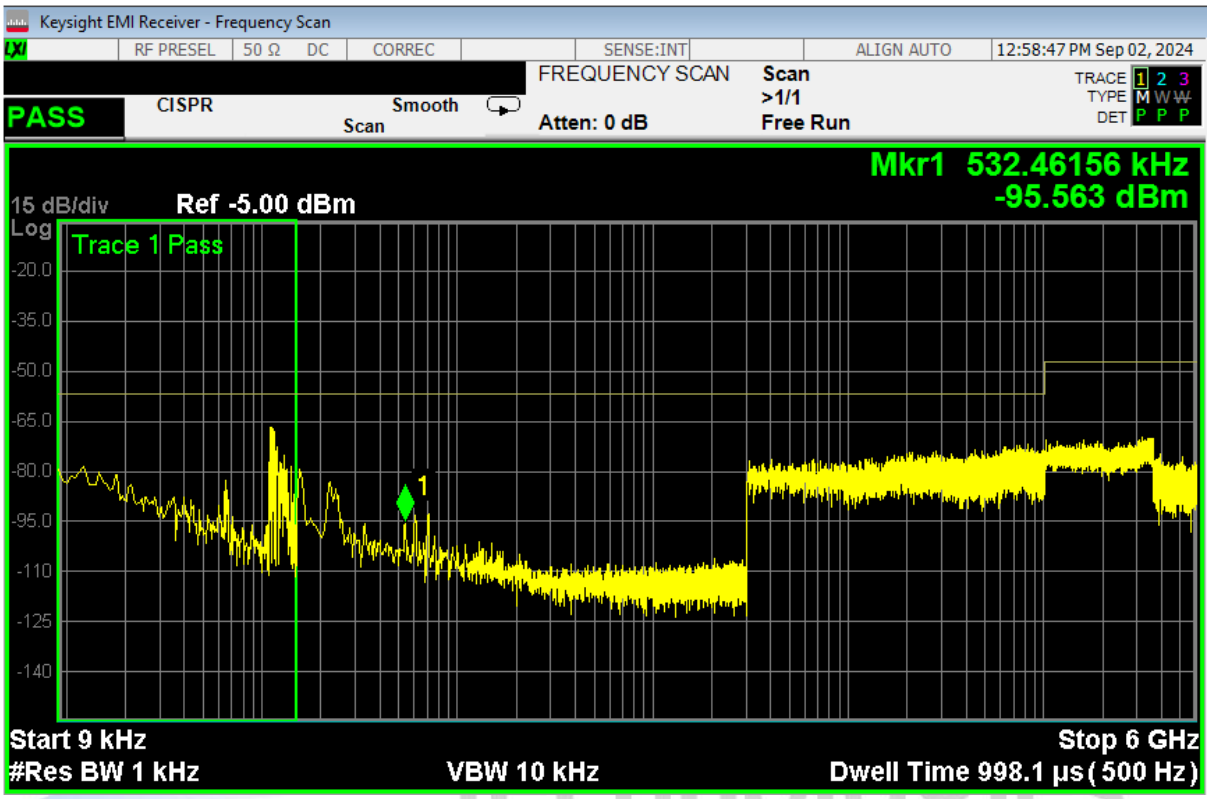
Test Frequency: 952.5375 MHz



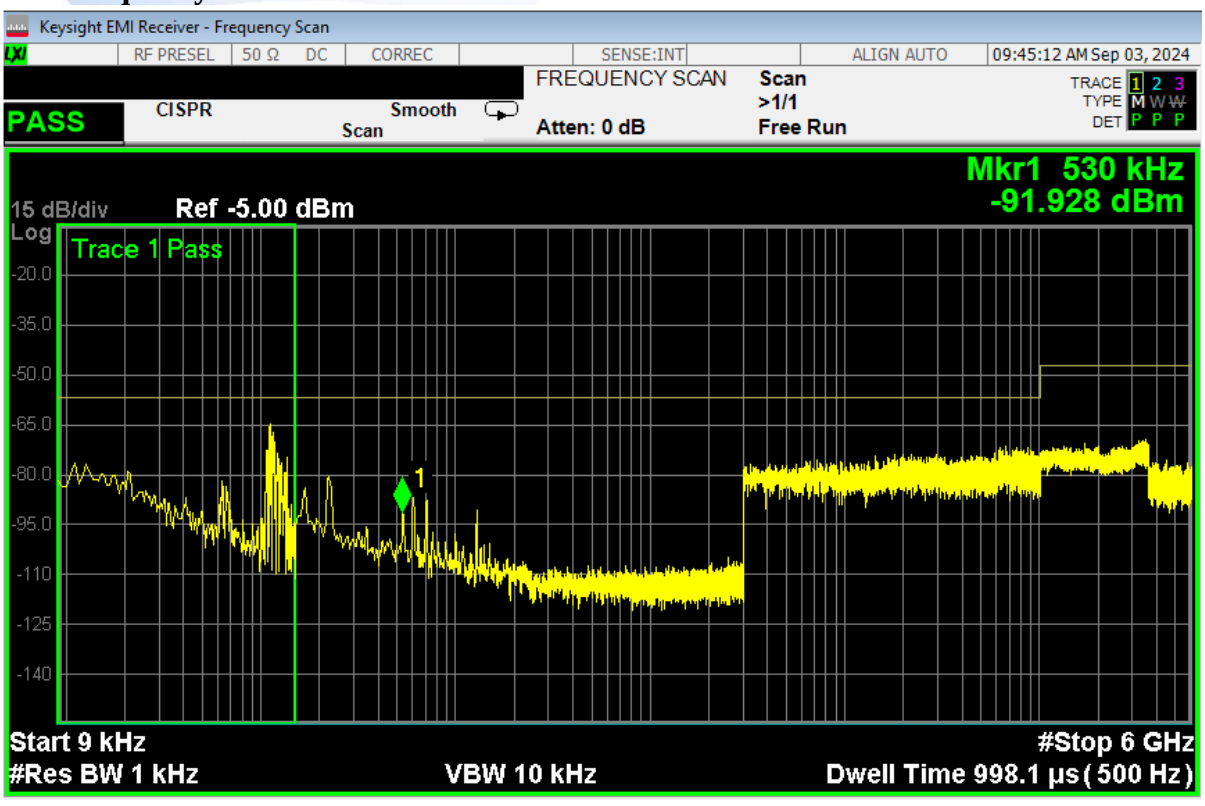
Receiver Spurious emissions- antenna terminal

The device was put in standby mode and the emissions were measured up to the 10th harmonic of the receive frequency. The testing was carried out on 4 test frequencies and the results have been plotted as below:

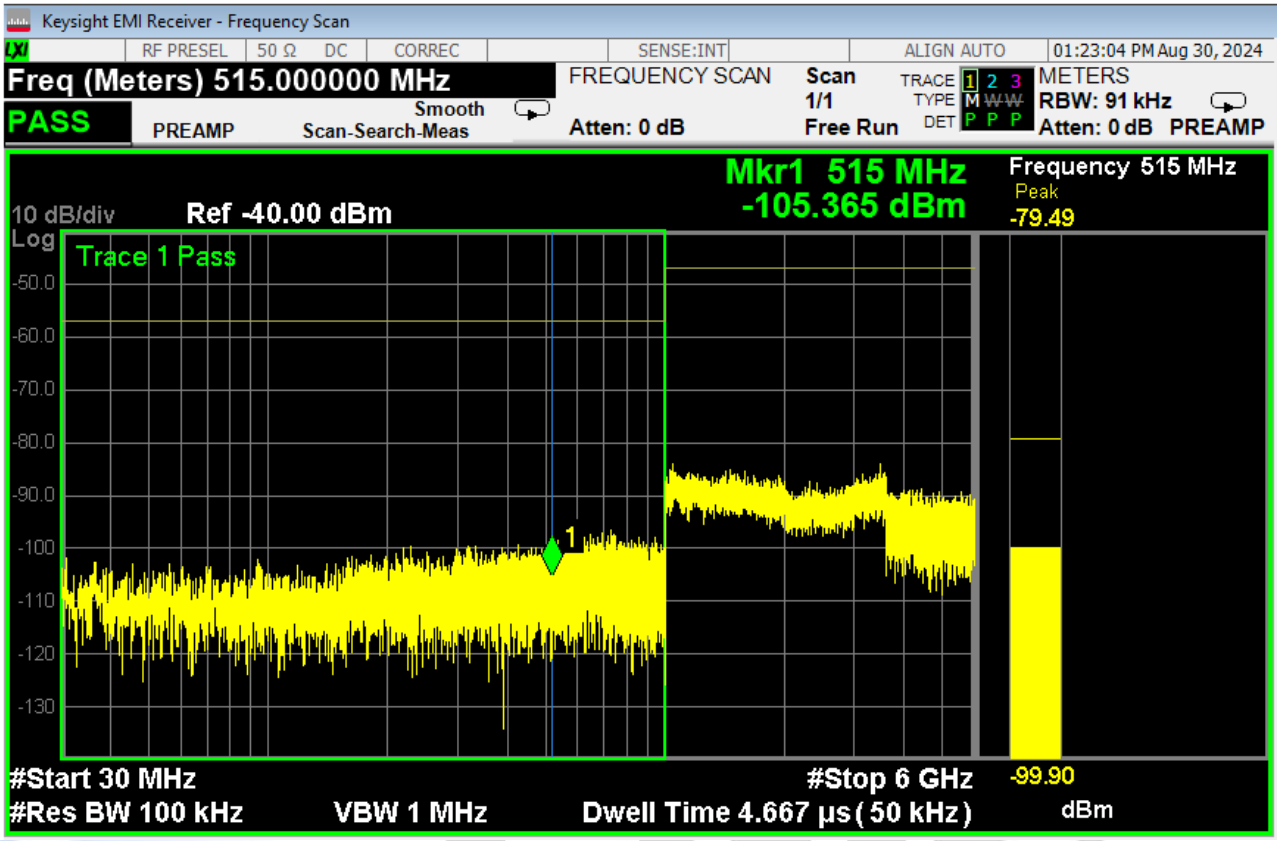
Test Frequency: 933.5000 MHz



Test Frequency: 942.5000 MHz



Test Frequency: 952.5375 MHz



Result: Complies
Measurement Uncertainty: ±3.3 dB

Field strength of the transmitter spurious emissions

Field strength transmitter spurious emission testing was carried out over the range of 30 – 10000 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 12 VDC using lead acid batteries.

Attached to the device was a test laptop using a 2 meter long Ethernet cable, A USB and a 1.5 meter long USB-C cable that facilitated product control using software.

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

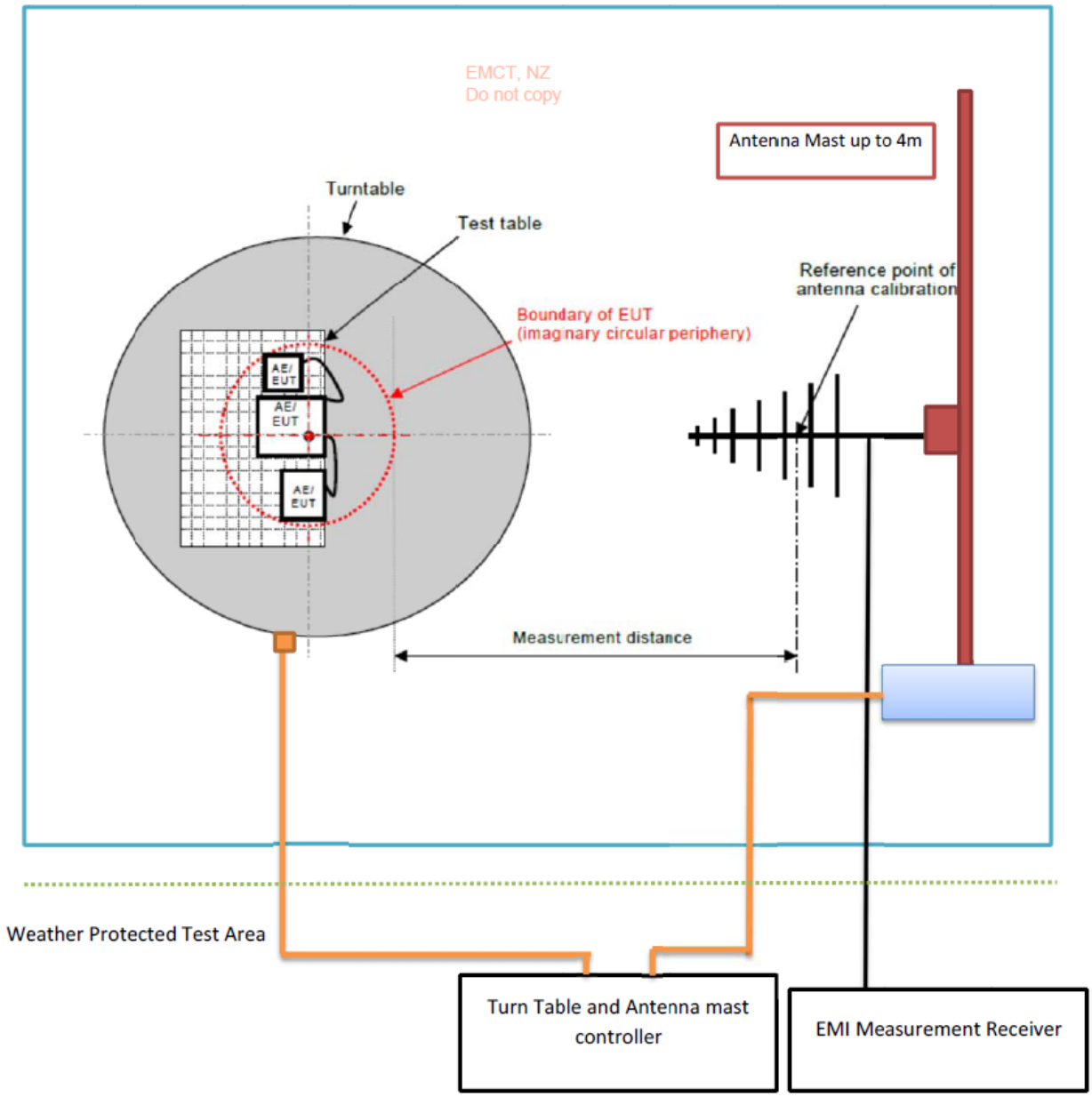
The transmitter was tested while transmitting continuously on high power (0.25 watts) while attached to a dummy load.

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

Spurious emissions (Radiated):

Nominal Frequency: 935.000 MHz

Frequency (MHz)	Level (dBuV/m)	Level (dBm)	Limit (dBm)	Polarity	Margin (dB)	Result
1870.0000	46.8	-50.6	-20.0	Vertical	30.6	Pass
1870.0000	47.7	-49.7	-20.0	Horizontal	29.7	Pass
2805.0000	48.1	-49.3	-20.0	Vertical	29.3	Pass
2805.0000	50.1	-47.3	-20.0	Horizontal	27.3	Pass*
3740.0000	52.2	-45.2	-20.0	Vertical	25.2	Pass*
3740.0000	52.0	-45.4	-20.0	Horizontal	25.4	Pass*
4675.0000	54.0	-43.4	-20.0	Vertical	23.4	Pass*
4675.0000	54.0	-43.4	-20.0	Horizontal	23.4	Pass*
5610.0000	57.0	-40.4	-20.0	Vertical	20.4	Pass*
5610.0000	57.0	-40.4	-20.0	Horizontal	20.4	Pass*
6545.0000	60.0	-37.4	-20.0	Vertical	17.4	Pass*
6545.0000	60.0	-37.4	-20.0	Horizontal	17.4	Pass*
7480.0000	60.0	-37.4	-20.0	Vertical	17.4	Pass*
7480.0000	60.0	-37.4	-20.0	Horizontal	17.4	Pass*
8415.0000	60.0	-37.4	-20.0	Vertical	17.4	Pass*
8415.0000	60.0	-37.4	-20.0	Horizontal	17.4	Pass*
9350.0000	60.0	-37.4	-20.0	Vertical	17.4	Pass*
9350.0000	60.0	-37.4	-20.0	Horizontal	17.4	Pass*
10285.0000	60.0	-37.4	-20.0	Vertical	17.4	Pass*
10285.0000	60.0	-37.4	-20.0	Horizontal	17.4	Pass*

* Noise floor measurement.

Other Transmit emissions:

Frequency (MHz)	Level (dBuV/m)	Level (dBm)	Limit (dBm)	Polarity	Margin (dB)	Result
364.4000	50.9	-46.5	-20.0	Vertical	26.5	Pass
596.9600	55.9	-41.5	-20.0	Vertical	21.5	Pass
1060.0800	51.5	-45.9	-20.0	Horizontal	25.9	Pass
1111.2000	54.0	-43.4	-20.0	Horizontal	23.4	Pass
1620.4000	46.5	-50.9	-20.0	Horizontal	30.9	Pass

Receiver/Standby emissions:

Frequency (MHz)	Level (dBuV/m)	Level (dBm)	Limit (dBm)	Polarity	Margin (dB)	Result
30.400	32.9	-64.5	-57.0	Vertical	7.5	Pass
30.400	24.7	-72.7	-57.0	Horizontal	15.7	Pass
31.960	32.1	-65.3	-57.0	Vertical	8.3	Pass
31.960	24.8	-72.6	-57.0	Horizontal	15.6	Pass
32.760	26.0	-71.4	-57.0	Horizontal	14.4	Pass
40.720	26.8	-70.6	-57.0	Vertical	13.6	Pass
47.960	27.0	-70.4	-57.0	Vertical	13.4	Pass
72.360	23.3	-74.1	-57.0	Vertical	17.1	Pass
75.960	31.6	-65.8	-57.0	Vertical	8.8	Pass
118.720	32.3	-65.1	-57.0	Vertical	8.1	Pass
123.680	30.0	-67.4	-57.0	Vertical	10.4	Pass
136.400	37.4	-60.0	-57.0	Vertical	3.0	Pass
136.400	25.3	-72.1	-57.0	Horizontal	15.1	Pass
143.200	34.5	-62.9	-57.0	Vertical	5.9	Pass
143.200	29.3	-68.1	-57.0	Vertical	11.1	Pass
145.920	35.7	-61.7	-57.0	Horizontal	4.7	Pass
243.760	31.3	-66.1	-57.0	Vertical	9.1	Pass
243.760	31.6	-65.8	-57.0	Horizontal	8.8	Pass
325.600	37.7	-59.7	-57.0	Vertical	2.7	Pass
325.600	28.1	-69.3	-57.0	Horizontal	12.3	Pass
462.560	31.2	-66.2	-57.0	Vertical	9.2	Pass
462.560	32.1	-65.3	-57.0	Horizontal	8.3	Pass

Limit:

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

A limit of -57.0 dBm has been applied for receive/standby measurements.

Result: Complies.

Measurement Uncertainty: ± 4.1 dB

101.113 Transmitter power limitations

Output power test

The RMS / Average power measurements were carried out using a spectrum analyser and a calibrated attenuator and sucoflex cable.

Measurements were made at the RF output terminals of the transmitter using a spectrum analyser with 1 MHz resolution bandwidth when the transmitter was modulated using the various modulation modes.

The rated output power is 0.25 Watt (+24 dBm) average to each of the transmitter output ports.

Testing was carried out on both output ports with the supply voltage being varied with the levels being recorded directly in dBm.

Test Frequency: 896.000 MHz
Horizontal Output port power (dBm) in RMS / Average mode/Unmodulated Carrier

Frequency (MHz)	Voltage (Vdc)		
	10.5	24.0	60.0
	Average Power in dBm		
896.000	24.3	24.3	24.3

Test Frequency: 928.5375 MHz

Vertical output port power (dBm) in RMS / Average mode

Channel Spacing	Modulation	Voltage (Vdc)		
		10.5	24.0	60.0
		Average Power in dBm		
75.0 kHz	QPSK	23.8	23.8	23.8
75.0 kHz	16QAM	23.7	23.7	23.7
75.0 kHz	64QAM	23.9	23.9	23.9
75.0 kHz	256QAM	24.0	24.0	23.9

Unmodulated output power/Port-V

Temp (˚C)	Average Power in dBm		
	10.5 Vdc	24.0 Vdc	60.0 Vdc
+50	23.3	23.4	23.2
-30	24.1	24.2	24.1

Test Frequency: 928.5375 MHz

Horizontal output port power (dBm) in RMS / Average when powered at 24.0 Vdc input voltage

Channel Spacing	Modulation	Average Power (dBm)
75.0 kHz	QPSK	23.9
75.0 kHz	16QAM	23.8
75.0 kHz	64QAM	24.0
75.0 kHz	256QAM	24.1

Horizontal output port power (dBm) in Peak power when powered at 24.0 Vdc input voltage

Channel Spacing	Modulation	Peak Power (dBm)
25.0 kHz	QPSK	29.1
25.0 kHz	16QAM	29.8
25.0 kHz	64QAM	30.5
25.0 kHz	256QAM	30.7

Test Frequency: 933.5000 MHz
Horizontal Output port power (dBm) in RMS / Average mode/Unmodulated Carrier

Frequency (MHz)	Voltage (Vdc)		
	10.5	24.0	60.0
	Average Power in dBm		
933.5000	24.5	24.5	24.5

Test Frequency: 942.500 MHz
Horizontal Output port power (dBm) in RMS / Average mode/Unmodulated Carrier

Frequency (MHz)	Voltage (Vdc)		
	10.5	24.0	60.0
	Average Power in dBm		
942.500	24.3	24.3	24.3

Test Frequency: 952.5375 MHz

Output port power (dBm) in RMS / Average mode/Unmodulated Carrier

Frequency (MHz)	Voltage (Vdc)		
	10.5	24.0	60.0
	Average Power in dBm		
Port-V			
952.5375	24.2	24.2	24.2
Port-H			
952.5375	24.4	24.4	24.4

Measurements were made to show that the declared power output of the transmitter measured power was within +/- 1 dB of the measured output power (+24.0 dBm).

A power limit of +40.0 dBW EIRP per polarisation applies to Fixed Equipment operating in the 952.0 - 960.0 MHz band.

Result: Complies

Measurement Uncertainty: ±0.5 dB

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 MPE calculations, 960.000 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 928.000 MHz, the calculated limit is 0.62 mW/cm^2

- Occupational /Controlled exposure is f/300. At 928.000 MHz, the calculated limit is 3.10 mW/cm^2

Minimum safe distances have been calculated below.

For Uncontrolled Environment

At 928.000 MHz, Power Density = 0.62 mW/cm^2 = $E^2/3770$

E= √ 0.62*3770

E = 49.3 V/m

For Controlled Environment

At 960.000 MHz, Power Density = 3.10 mW/cm^2 = E^2/3770

E= √ 3.10*3770

E = 108.1 V/m

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

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

Shown below is the typical list of antennas (Information supplied by the client) that would be used with the product:

Dual Polarized Omni-Directional Antenna	8dBi, 2xN Female
Dual Polarized Compact Panel Antenna	8dBi, 2xN Female
Dual Polarized, MIMO Directional Panel Antenna	9dBi, 2xN Female
Compact Panel Antenna	9dBi, 2xN Female / 2x4.3-10 Female
Compact Panel Antenna	11dBi, 2xN Female / 2x4.3-10 Female
MIMO Low Profile Panel Antenna	12dBi, 2xN Female
MIMO Panel Antenna	16dBi, 2xN Female / 2x4.3-10 Female
MIMO Yagi Antenna (with optional Radome available)	12dBi, 2xN Female
MIMO Yagi Antenna (with optional Radome available)	15dBi, 2xN Female

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 8 dBi gain antenna
- Using 9 dBi gain antenna
- Using 11 dBi gain antenna
- Using 12 dBi gain antenna
- Using 15 dBi gain antenna
- Using 16 dBi gain antenna

a) For Uncontrolled environments, the minimum distance is:

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

$P = 0.25$ W

$FS = E = 49.3$ V/m

Frequency (MHz)	Antenna Gain (dBi)	Antenna Gain Numeric	Duty cycle	Safe distance (metres)
928.000	No gain (0)	1.0	100%	0.06
	8.0	6.3	100%	0.14
	9.0	7.9	100%	0.16
	11.0	12.6	100%	0.20
	12.0	15.8	100%	0.22
	15.0	31.6	100%	0.31
	16.0	39.8	100%	0.35

a) For Controlled environments, the minimum distance is:

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

$P = 0.25$ W

$FS = E = 108.1$ V/m

Frequency (MHz)	Antenna Gain (dBi)	Antenna Gain Numeric	Duty cycle	Safe distance (metres)
928.000	No gain (0)	1.0	100%	0.02
	8.0	6.3	100%	0.06
	9.0	7.9	100%	0.07
	11.0	12.6	100%	0.09
	12.0	15.8	100%	0.10
	15.0	31.6	100%	0.14
	16.0	39.8	100%	0.16

Result: Complies if a safe distance shown in the calculations above is followed.

8. TEST EQUIPMENT USED

Instrument	Manufacturer	Model	Serial/ID #	Cal Due	Interval
Power Supply	Hewlett Packard	6654A	-	N/a	N/a
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	28/11/24	2.5 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

9. 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 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.

10. PHOTOGRAPHS

Top face

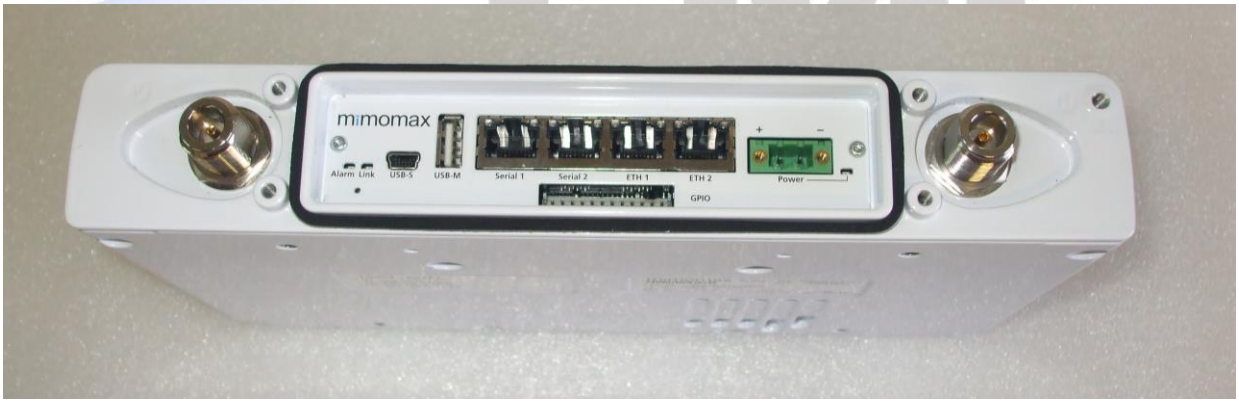
Side face

Side face

Back face

Bottom face

Connector face



Label

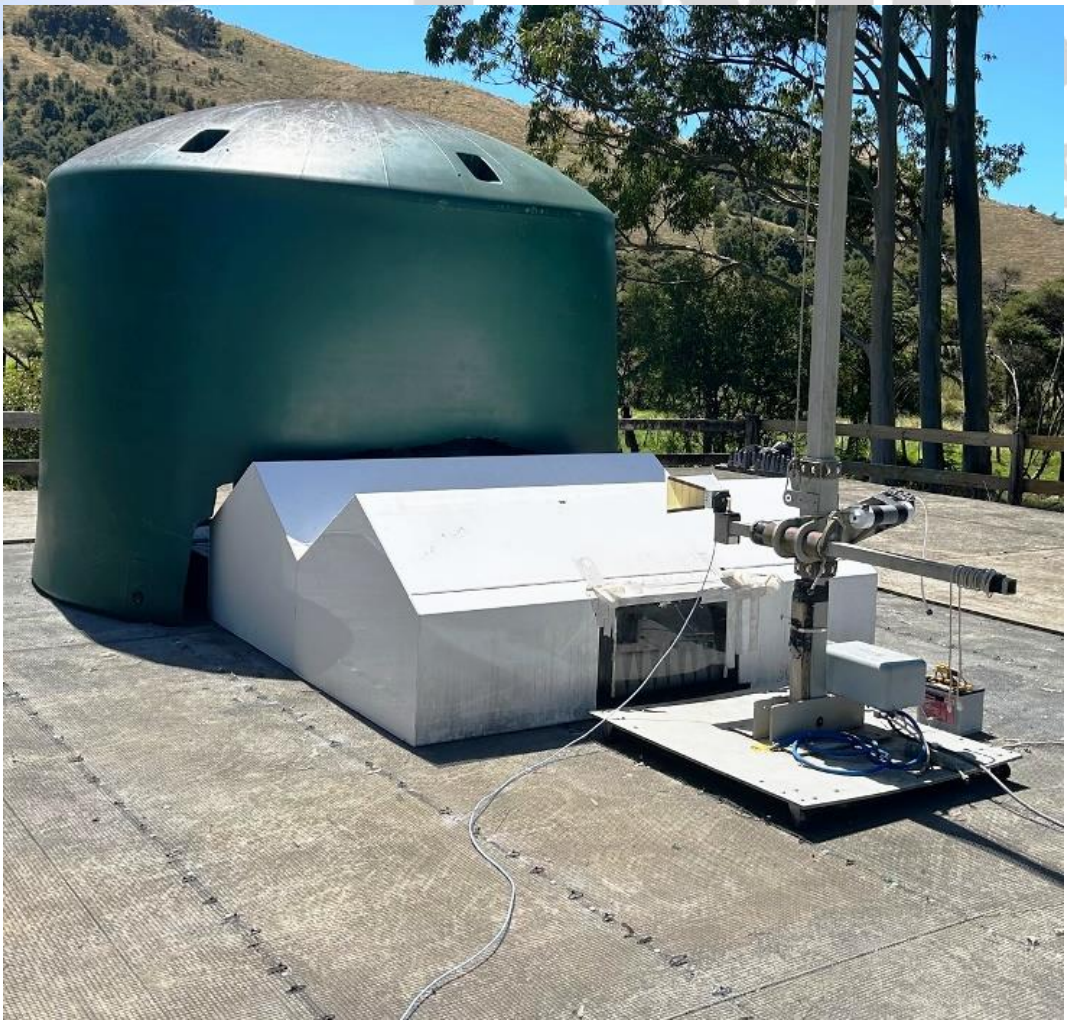
Radiated Emissions Test Setup

Radiated Emissions Test Setup

Biconical Antenna pointing towards Test Enclosure

Log Periodic Antenna pointing towards Test Enclosure

Horn Antenna pointing towards Test Enclosure



APPENDIX 1 – CLIENT LETTER's

Letter Stating similarity of RF performances at two ports

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

Date: 2024-09-11

To Whom It May Concern:

There are two RF transmitting output ports, named horizontal and vertical ports, in each of 900MHz Tornado radio MWL-TORNADO-BGCA. There are slight differences in layout design between these two transmitters. In order to compensate for the layout differences, some values of passive components used in these two transmitters are different, aiming to achieve the same RF performances. All the active components used in both transmitters are the same. Therefore, the RF performances out from the horizontal and vertical ports are very similar.

Thank you for your attention to this matter.

Yours Sincerely,

Signatory

James Dowle

Name: James Dowle

Title: R&D Manager

Company name: Mimomax Wireless Limited (Trading as Ubiik Mimomax)

Letter explaining the product's model number nomenclature used by the client.

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

Date: 25th September 2024

To: Federal Communications Commission,
Authorization & Evaluation Division,
7435 Oakland Mills Road,
Columbia, MD 21046

Re: Variants for FCC ID: XMK-MMXTRNB009

Model number for Approval

MWL-TORNADO-*G?A, The * and ? are wildcards and are explained below.

The * can be B or A, when the * = B this means the radio is encryption capable, when the * = A this means the radio is not encryption capable.

For Example: The MWL-TORNADO-AGCA and MWL-TORADNO-BGCA differ only in that the MWL-TORNADO-BGCA radio uses a processor with a hardware encryption co-processor, whereas MWL-TORNADO-AGCA radio does not have this hardware encryption co-processer, all other parts and radio configuration parameters are identical.

All Tornado radios use a strong whitener in the physical layer signal processing which ensures that the spectrum is not affected by the data regardless of the whiteness of the data, this also ensures that encryption or lack of encryption also has no effect on the spectrum and emissions from the product.

The ? can be a A, B or C, when the ? = C this means the radio is fitted with a 60kHz bandwidth receiver filter, when the ? = B this means the radio is fitted with a 30kHz bandwidth receiver filter, when the ? = A this means the radio is fitted with a 15kHz bandwidth receiver filter

For Example: The MWL-TORNADO-AGCA, MWL-TORADNO-AGBA and MWL-TORADNO-AGAA differ only in that the bandwidth of the crystal filter in the receiver intermediate frequency stage, all other parts and radio configuration parameters are identical.

The bandwidth of the receiver intermediate frequency filter being 15kHz, 30kHz or 60kHz makes no difference to the spectrum and emissions from the product.

Sincerely,

James Dowle

James Dowle

MiMOMax Wireless Limited (Trading as Ubiik Mimomax)