

RADIO TEST REPORT

Report ID:

REP012031

Project number:

PRJ0033926

Type of assessment:

Class II Permissive Change

Applicant:

ORBCOMM License Corp.

Product:

**ST6000 Mobile Satellite Earth Station
Module**

Model:

ST6000

FCC identifier:

FCC ID: XGS-ST6000

ISED certification number:

IC: 11881A-ST6000

Specification:

- ◆ FCC 47 CFR Part 25
- ◆ RSS-170, Issue 4, September 29, 2022

Date of issue: July 20, 2023

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Tested by



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ANAB File Number: AT-3195 (Ottawa/Almonte); AT-3193 (Pointe-Claire); AT-3194 (Cambridge)

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Test site identifier	Organization	Ottawa/Almonte	Montreal	Cambridge
	FCC:	CA2040	CA2041	CA0101
	ISED:	2040A-4	2040G-5	24676
Website	www.nemko.com			

Limits of responsibility

Note that the results contained in this report relate only to the items tested and were obtained in the period between the date of initial receipt of samples and the date of issue of the report.

This test report has been completed in accordance with the requirements of ISO/IEC 17025. All results contained in this report are within Nemko Canada's ISO/IEC 17025 accreditation.

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Section 1. Report summary

1.1 Test specifications

FCC 47 CFR Part 25	Satellite communications
RSS-170, Issue 4, September 29, 2022	Mobile Earth Stations and Ancillary Terrestrial Component Equipment Operating in the Mobile-Satellite Service Bands

1.2 Test methods

273109 D01 Equip Auth Guide Part 25 TX Receiver v02r02 (2011)	Equipment Authorization Guidance for Part 25 Transceivers
RSS-Gen, Issue 5, April 2018	General Requirements for Compliance of Radio Apparatus
ANSI C63.26 v2015	American National Standard for Compliance Testing of Transmitters Used in Licensed Radio Services

1.3 Exclusions

As per test plan (see section 2.2 technical judgement), partial testing was performed on the ST6000 module with the transmitter operating to confirm that the updated module meets the FCC/ISED requirements.

1.4 Statement of compliance

In the configuration tested, the EUT was found compliant.

Testing was performed against all relevant requirements of the test standard except as noted in section 1.4 below. Results obtained indicate that the product under test complies in full with the requirements tested. The test results relate only to the items tested.

See "Summary of test results" for full details.

1.5 Test report revision history

Table 1.5-1: Test report revision history

Revision #	Date of issue	Details of changes made to test report
REP012031	July 20, 2023	Original report issued

Section 2. Engineering considerations

2.1 Modifications incorporated in the EUT for compliance

There were no modifications performed to the EUT during this assessment.

2.2 Technical judgment

The ST6000 module was updated with new firmware which adds more transmitting signals with different channel structure (different data rate, different channel bandwidth, different spectrum etc.).

For each channel which has the same data/symbol rate, the channel bandwidth (CBW) and the spectrum shaping are the same, the TX power is the same. The difference is mainly on data bits number in each transmitting burst, therefore it impacts the transmitting time period.

The updated channel chart as below table,

Waveform	Symbol rate	Min. CBW(Hz)	Modulation
J	800	1250	OQPSK
K	1600	2000	OQPSK
N	800	1250	OQPSK
R	800	1250	OQPSK
S	1600	2000	OQPSK
T	3200	4000	OQPSK
X	3200	4000	OQPSK
Y	6400	8000	OQPSK
Z	12800	16000	OQPSK

For C2PC (FCC) and C3PC (ISED), the following test plan was performed on the waveform which has different symbol rate and longer transmitting burst

Test name	Channel BW (Hz) and symbol rate		Channels to test
Occupied Bandwidth (conducted)	1250	800	Low, mid, high
Transmitter EIRP (conducted)	2000	1600	
	4000	3200	
	8000	6400	
	12500	8000	
Spurious emissions (conducted)	Single Worst case from all		Single Worst case
Mask (ACP) (conducted) adding the guard band	3250	800	Single Worst case
	4000	1600	
	6000	3200	
	10000	6400	
	18000	8000	
Emissions within 1559–1610 MHz (conducted)	1250	800	Low
	2000	1600	
	4000	3200	
	8000	6400	
	12500	8000	
Spurious emissions (radiated)	1250	800	Single Worst case
	12500	8000	

2.3 Model variant declaration

There were no model variants declared by the applicant.

2.4 Deviations from laboratory tests procedures

No deviations were made from laboratory procedures.

Section 3. Test conditions

3.1 Atmospheric conditions

Temperature	15 °C – 35 °C
Relative humidity	20 % – 75 %
Air pressure	86 kPa (860 mbar) – 106 kPa (1060 mbar)

When it is impracticable to carry out tests under these conditions, a note to this effect stating the ambient temperature and relative humidity during the tests shall be recorded and stated.

3.2 Power supply range

The normal test voltage for equipment to be connected to the mains shall be the nominal mains voltage. For the purpose of the present document, the nominal voltage shall be the declared voltage, or any of the declared voltages $\pm 5\%$, for which the equipment was designed.

Section 4. Information provided by the applicant

4.1 Disclaimer

This section contains information provided by the applicant and has been utilized to support the test plan. Inaccurate information provided by the applicant can affect the validity of the results contained within this test report. Nemko accepts no responsibility for the information contained within this section and the impact it may have on the test plan and resulting measurements.

4.2 Applicant / Manufacturer

Applicant name	ORBCOMM License Corp.
Applicant address	395 W Passaic Street, Suite 325, Rochelle Park, NJ 07662 USA
Manufacturer name	Same as applicant
Manufacturer address	Same as applicant

4.3 EUT information

Product description	ST6000 Mobile Satellite Earth Station Module
Model / HVIN	ST6000
Serial number	None
Power supply requirements	5.8 V _{DC}
Product description and theory of operation	The EUT is a low data rate land mobile satellite earth station (LMES) that operates in microwave L-band (1.5/1.6 GHz) and it is designed to be used within Inmarsat global satellite network for asset tracking and management systems.

4.4 Radio technical information

Frequency band	1626.5–1660.5 MHz				
Symbol rate	800	1600	3200	6400	12800
Frequency Min	1626.500625 MHz	1626.501 MHz	1626.502 MHz	1626.504 MHz	1626.508 MHz
Frequency Max	1660.499375 MHz	1660.499 MHz	1660.498 MHz	1660.496 MHz	1660.492 MHz
RF power Max (W), Conducted	1.820 (32.6 dBm)	1.905 (32.8 dBm)	1.862 (32.7 dBm)	1.738 (32.4 dBm)	1.413 (31.5 dBm)
Measured BW (kHz), 99% OBW	1.135	1.917	3.806	7.661	15.022
Measured BW (kHz), 26 dB BW	1.39	2.85	5.84	12.37	25.57
Type of modulation	OQPSK				
Emission classification (F1D, G1D, D1D)	G1D				
Antenna information	3.9 dBi internal antenna The EUT uses a unique antenna coupling/ non-detachable antenna to the intentional radiator.				
Stated EIRP	Inmarsat's requirement: 7 dBW (37 dBm)				

4.5 EUT setup details

4.5.1 Radio exercise details

Operating conditions	ST6000 satellite modular was installed in a ST6100 platform and controlled by TeraTerm Pro session from Laptop to transmit a modulated signal.
Transmitter state	Transmitter set into transmitting mode with 40% TX duty cycle.

4.5.2 EUT setup configuration

Table 4.5-1: Support equipment

Description	Brand name	Model, Part number, Serial number, Revision level
Satellite terminal (Radiated sample)	ORBCOMM	MN: ST6100
Satellite terminal (Conducted sample)	ORBCOMM	MN: ST6100

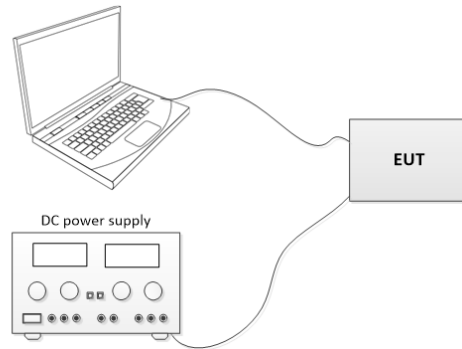


Figure 4.5-1: Block diagram

Section 5. Summary of test results

5.1 Testing location

Test location (s) Cambridge

5.2 Testing period

Test start date June 19, 2023 Test end date July 13, 2023

5.3 Sample information

Receipt date May 19, 2023 Nemko sample ID number(s) PRJ00339260001, PRJ00339260002

5.4 FCC test results

Table 5.4-1: FCC Part 25 results

Part	Test description	Verdict
2.1046	Occupied bandwidth	Pass
25.204	Power limits for earth station	Pass
25.202(f)	Spurious emissions at the antenna terminal	Pass
25.202(f)	Field strength of spurious emissions	Pass
25.216	Limits for emissions from mobile earth stations for protection of aeronautical radionavigation satellite service	Pass

Notes: Only tests required as test plan have been included in this table

5.5 ISED test results

Table 5.5-2: RSS-Gen, Issue 5 test results

Part	Test description	Verdict
6.7	Occupied bandwidth	Pass

Notes: Only tests required as test plan have been included in this table

Table 5.5-3: RSS-170, Issue 4 test results

Part	Test description	Verdict
5.2	Frequency bands	Pass
5.5	Transmitter output power for mobile earth stations (MESs)	Pass
5.7.2	Transmitter unwanted emissions for ATC Mobile Equipment within 1626.5–1660.5 MHz band	Pass
5.8	Transmitter unwanted emissions for MESs in all frequency bands	Pass
5.9	Additional unwanted emission limits for MESs to protect radionavigation-satellite service	Pass

Notes: Only tests required as test plan have been included in this table

Section 6. Test equipment

6.1 Test equipment list

Table 6.1-1: Equipment list

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
3 m EMI test chamber	TDK	SAC-3	FA003012	1 year	January 31, 2024
Flush mount turntable	SUNAR	FM2022	FA003006	—	NCR
Controller	SUNAR	SC110V	FA002976	—	NCR
Antenna mast	SUNAR	TLT2	FA003007	—	NCR
Receiver/spectrum analyzer	Rohde & Schwarz	ESR26	FA002969	1 year	February 10, 2024
Bilog antenna (30–2000 MHz)	SUNAR	JB1	FA003010	1 year	June 21, 2023
Horn antenna (1–18 GHz)	EMCO	3115	FA000649	1 year	March 27, 2024
Preamplifier (1–18 GHz)	ETS Lindgren	124334	FA002956	1 year	March 27, 2024
Signal and Spectrum Analyzer	Rohde & Schwarz	FSW43	FA002971	1 year	December 31, 2023
50 Ω coax cable	Huber + Suhner	None	FA003402	1 year	January 18, 2024
50 Ω coax cable	Huber + Suhner	None	FA003046	1 year	January 18, 2024
50 Ω coax cable	Huber + Suhner	None	FA003047	1 year	January 18, 2024

Notes: NCR - no calibration required

Table 6.1-2: Automation software details

Test description	Manufacturer of Software	Details
Radiated emissions	Rohde & Schwarz	EMC32, Software for EMC Measurements, Version 10.60.00

Table 6.1-3: Measurement uncertainty calculations based on equipment list

Measurement	Measurement uncertainty, ±dB
Radiated spurious emissions (30 MHz to 1 GHz)	4.27
Radiated spurious emissions (1 GHz to 6 GHz)	4.74
Radiated spurious emissions (6 GHz to 18 GHz)	5.04
RF Output power measurement using Spectrum Analyzer	0.85
Conducted spurious emissions	1.13
Other antenna port measurements	0.94
Notes: UKAS Lab 34, TIA-603 and ETSI TR 100 028-1&2 have been used as guidance for measurement uncertainty reasonable estimations with regards to previous experience and validation of data. Nemko Canada Inc. follows these test methods in order to satisfy ISO/IEC 17025 requirements for estimation of uncertainty of measurement for wireless products. Measurement uncertainty calculations assume a coverage factor of K = 2 with 95% certainty.	

Section 7. Testing data

7.1 FCC 2.1049 and RSS-Gen 6.7 Occupied Bandwidth

7.1.1 References, definitions and limits

FCC §2.1049

The occupied bandwidth, that is the frequency bandwidth such that, below its lower and above its upper frequency limits, the mean powers radiated are each equal to 0.5 percent of the total mean power radiated by a given emission.

RSS-Gen 6.7

The emission bandwidth (×dB) is defined as the frequency range between two points, one above and one below the carrier frequency, at which the maximum power level of the transmitted emission is attenuated × dB below the maximum in-band spectral density of the modulated signal. Spectral density (power per unit bandwidth) is to be measured with a detector of resolution bandwidth in the range of 1% to 5% of the anticipated emission bandwidth, and a video bandwidth at least 3× the resolution bandwidth.

When the occupied bandwidth limit is not stated in the applicable RSS or reference measurement method, the transmitted signal bandwidth shall be reported as the 99% emission bandwidth, as calculated or measured.

7.1.2 Test summary

Verdict	Pass		
Test date	May 31, 2023 – June 5, 2023	Temperature	23 – 24 °C
Tested by	Alvin Liu	Air pressure	940 – 980 mbar
Test location	Cambridge	Relative humidity	35 – 38 %

7.1.3 Observations, settings and special notes

Measurements performed with reference to ANSI 63.26 section 5.4.4

Spectrum analyser settings:

Resolution bandwidth:	≥ 1 % of OBW
Video bandwidth:	≥ 3 × RBW
Detector mode:	Peak
Trace mode:	Max Hold

7.1.4 Test data

Table 7.1-1: 99 % occupied bandwidth results – Waveform R

Frequency, MHz	99 % occupied bandwidth, kHz
1626.500625	1.133
1643.500625	1.083
1660.499375	1.135

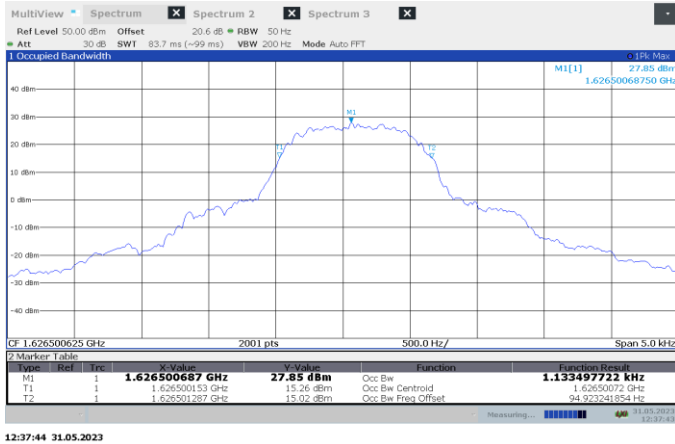


Figure 7.1-1: 99 % bandwidth on low channel – Waveform R

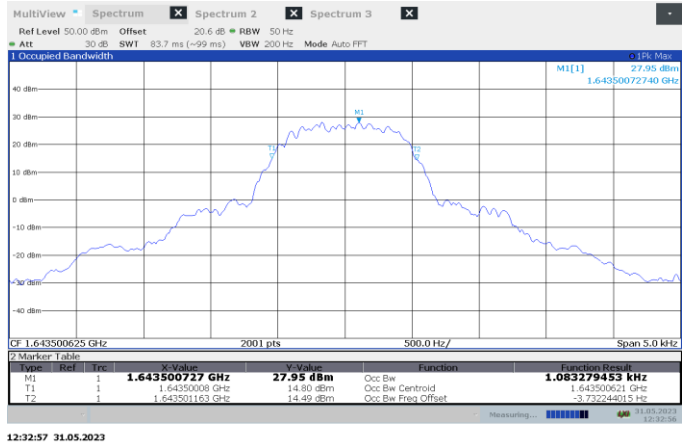


Figure 7.1-2: 99 % bandwidth on mid channel – Waveform R



Figure 7.1-3: 99 % bandwidth on high channel – Waveform R

Test data, continued

Table 7.1-2: 26 dB bandwidth results – Waveform R

Frequency, MHz	26 dB bandwidth, kHz
1626.500625	1.34
1643.500625	1.36
1660.499375	1.39

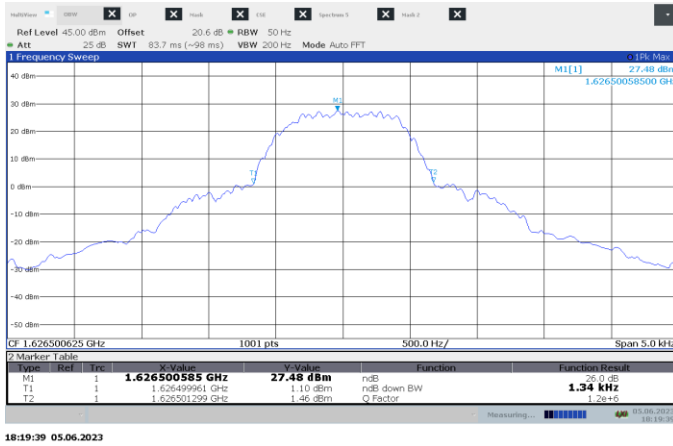


Figure 7.1-4: 26 dB bandwidth on low channel – Waveform R

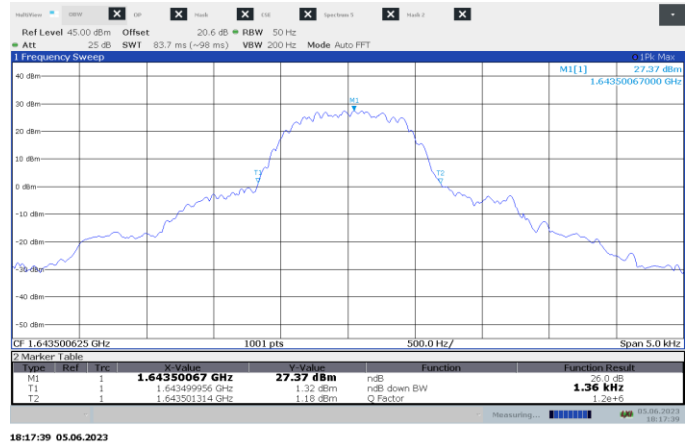


Figure 7.1-5: 26 dB bandwidth on mid channel – Waveform R

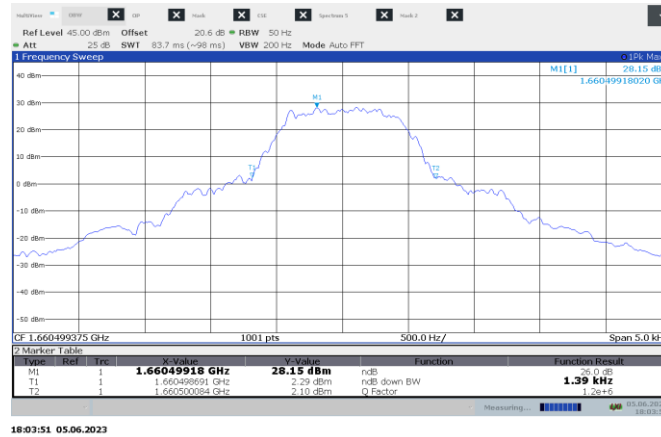


Figure 7.1-6: 26 dB bandwidth on high channel – Waveform R

Test data, continued

Table 7.1-3: 99 % occupied bandwidth results – Waveform S

Frequency, MHz	99 % occupied bandwidth, kHz
1626.501	1.903
1643.501	1.917
1660.499	1.915

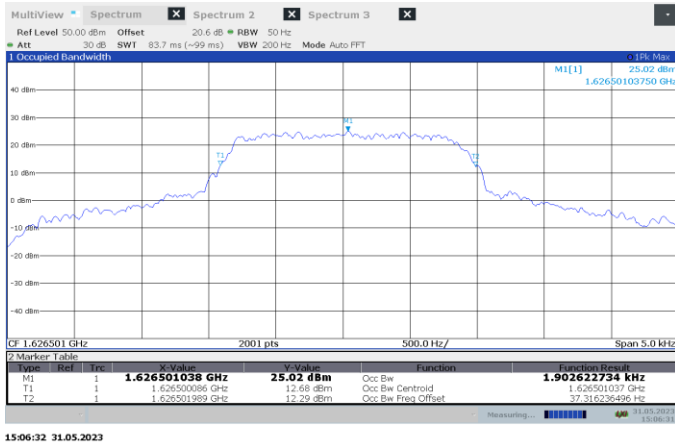


Figure 7.1-7: 99 % bandwidth on low channel – Waveform S

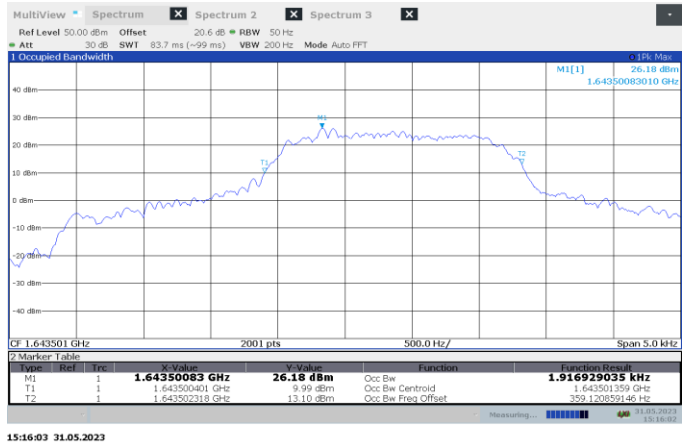


Figure 7.1-8: 99 % bandwidth on mid channel – Waveform S

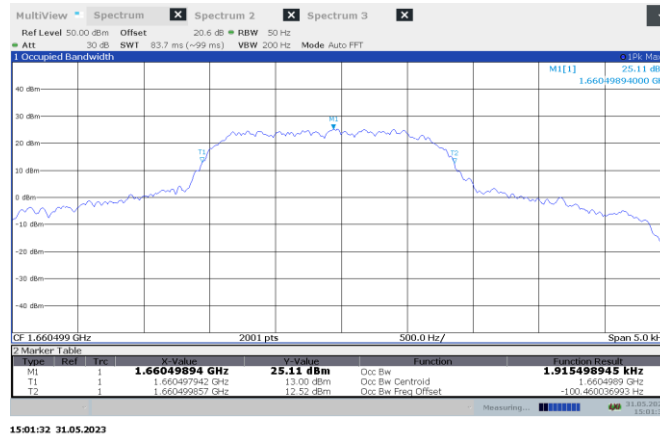


Figure 7.1-9: 99 % bandwidth on high channel – Waveform S

Test data, continued

Table 7.1-4: 26 dB bandwidth results – Waveform S

Frequency, MHz	26 dB bandwidth, kHz
1626.501	2.79
1643.501	2.81
1660.499	2.85

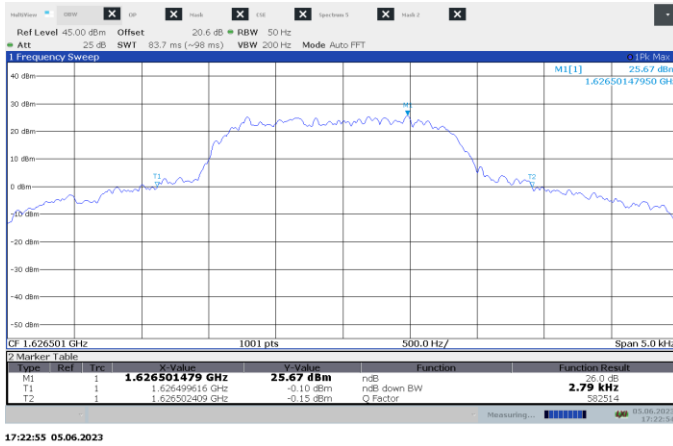


Figure 7.1-10: 26 dB bandwidth on low channel – Waveform S

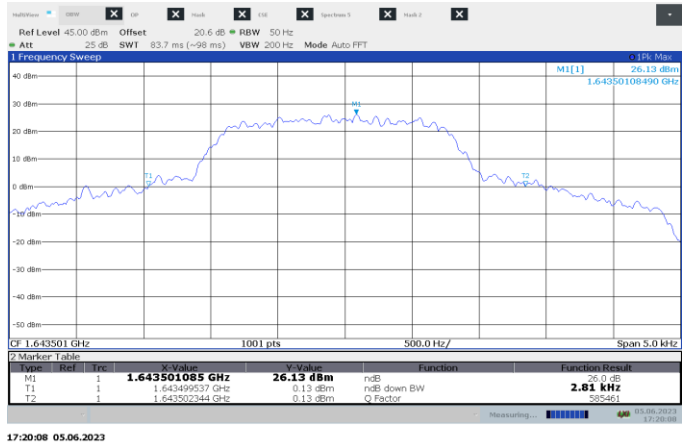


Figure 7.1-11: 26 dB bandwidth on mid channel – Waveform S

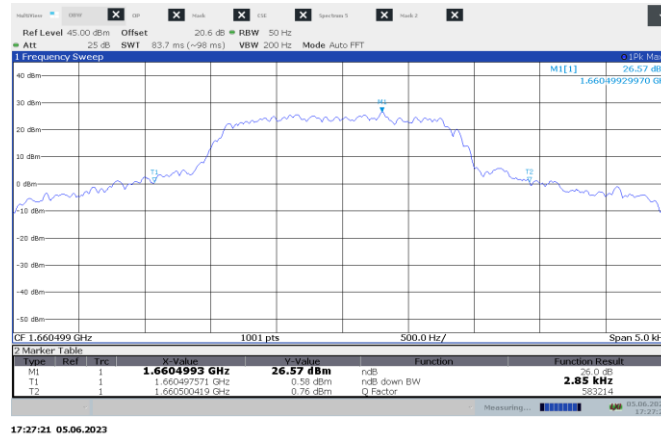


Figure 7.1-12: 26 dB bandwidth on high channel – Waveform S

Test data, continued

Table 7.1-5: 99 % occupied bandwidth results – Waveform X

Frequency, MHz	99 % occupied bandwidth, kHz
1626.502	3.806
1643.502	3.772
1660.498	3.802

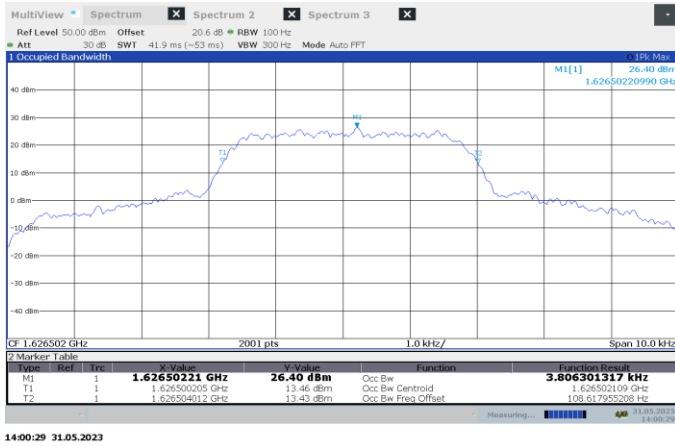


Figure 7.1-13: 99 % bandwidth on low channel – Waveform X

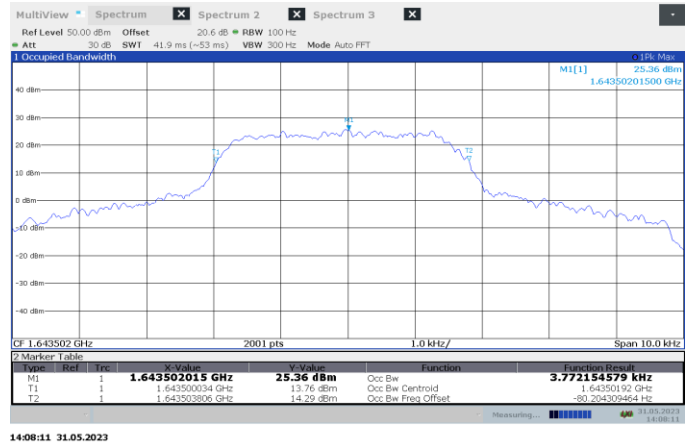


Figure 7.1-14: 99 % bandwidth on mid channel – Waveform X

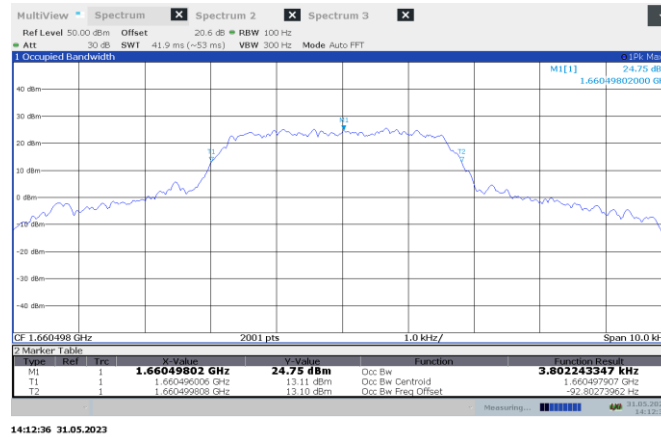


Figure 7.1-15: 99 % bandwidth on high channel – Waveform X

Test data, continued

Table 7.1-6: 26 dB bandwidth results – Waveform X

Frequency, MHz	26 dB bandwidth, kHz
1626.502	5.81
1643.502	5.60
1660.498	5.84

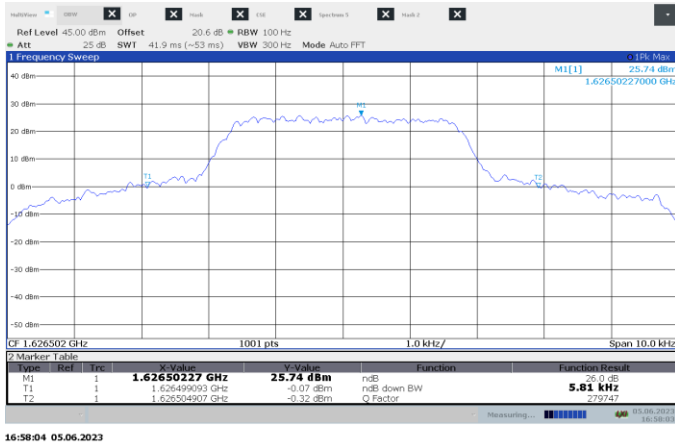


Figure 7.1-16: 26 dB bandwidth on low channel – Waveform X

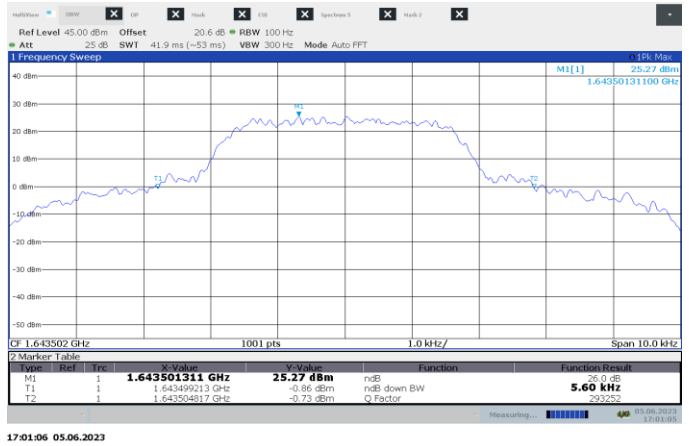


Figure 7.1-17: 26 dB bandwidth on mid channel – Waveform X

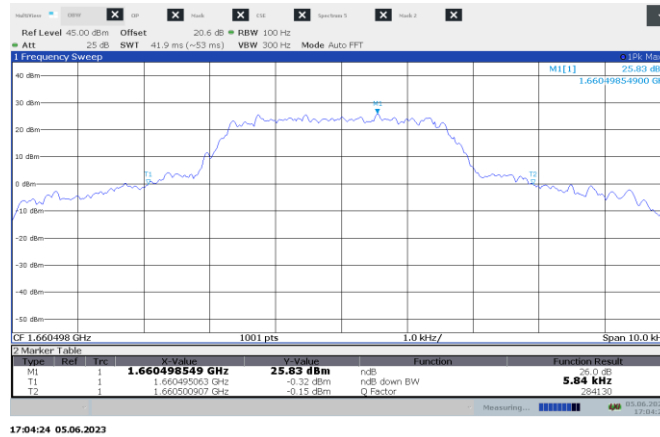


Figure 7.1-18: 26 dB bandwidth on high channel – Waveform X

Test data, continued

Table 7.1-7: 99 % occupied bandwidth results – Waveform Y

Frequency, MHz	99 % occupied bandwidth, kHz
1626.504	7.604
1643.504	7.661
1660.496	7.627

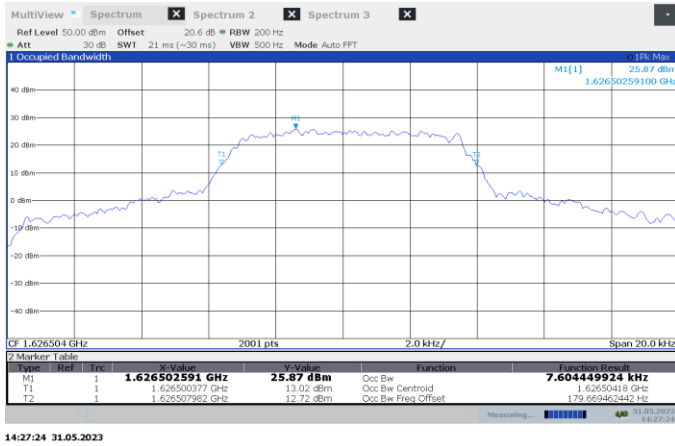


Figure 7.1-19: 99 % bandwidth on low channel – Waveform Y

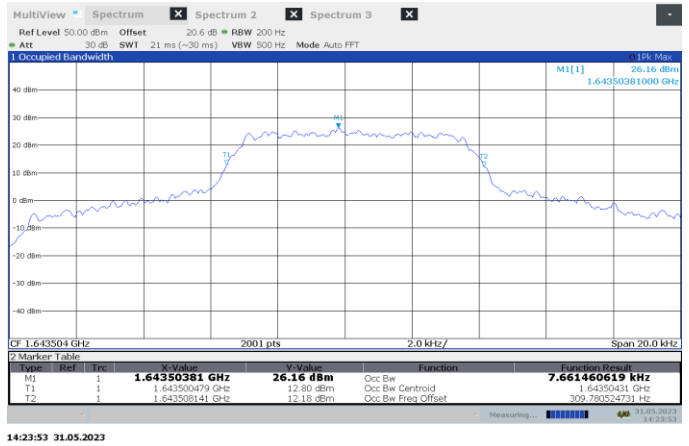


Figure 7.1-20: 99 % bandwidth on mid channel – Waveform Y

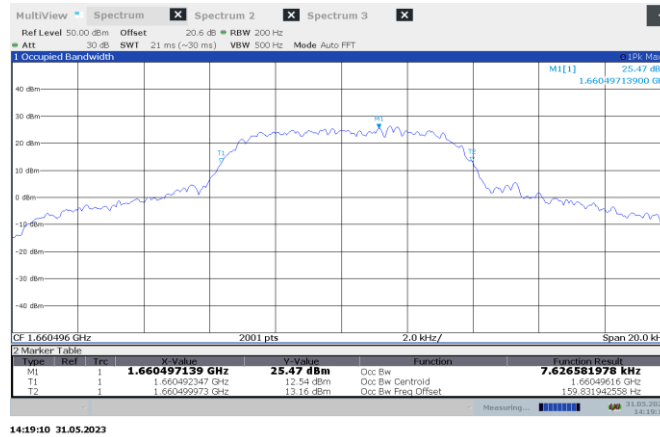


Figure 7.1-21: 99 % bandwidth on high channel – Waveform Y

Test data, continued

Table 7.1-8: 26 dB bandwidth results – Waveform Y

Frequency, MHz	26 dB bandwidth, kHz
1626.504	11.47
1643.504	11.75
1660.496	12.37

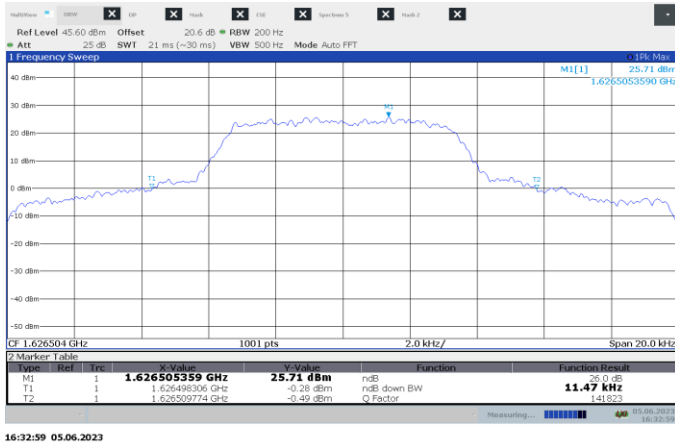


Figure 7.1-22: 26 dB bandwidth on low channel – Waveform Y

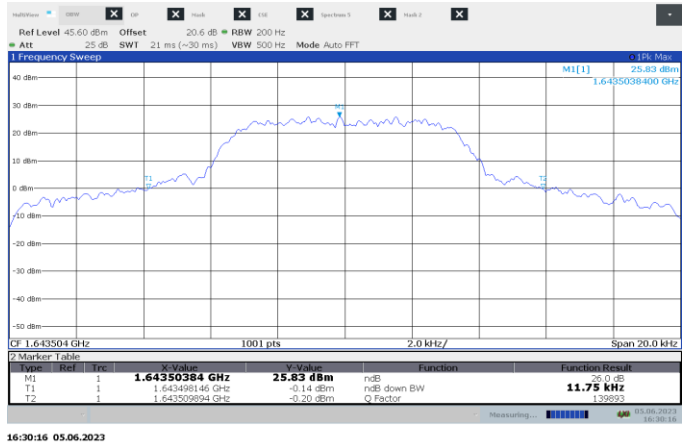


Figure 7.1-23: 26 dB bandwidth on mid channel – Waveform Y

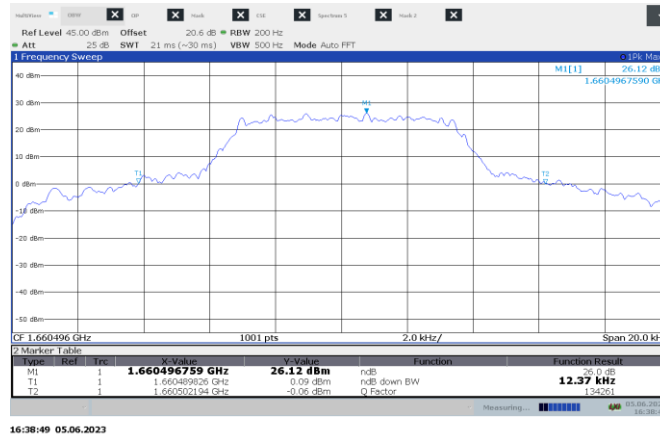


Figure 7.1-24: 26 dB bandwidth on high channel – Waveform Y

Test data, continued

Table 7.1-9: 99 % occupied bandwidth results – Waveform Z

Frequency, MHz	99 % occupied bandwidth, kHz
1626.508	14.981
1643.500	14.901
1660.492	15.022

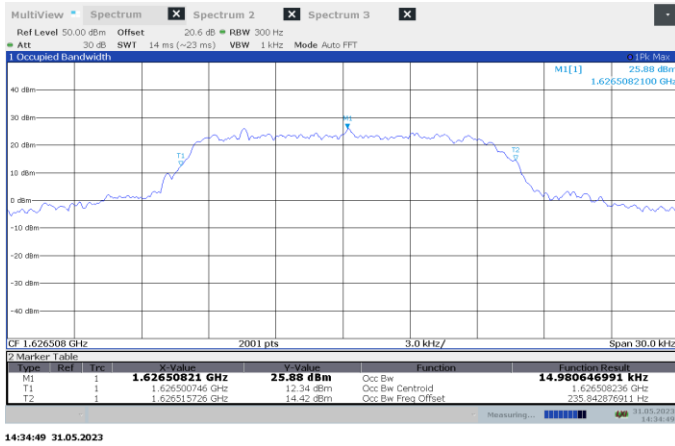


Figure 7.1-25: 99 % bandwidth on low channel – Waveform Z

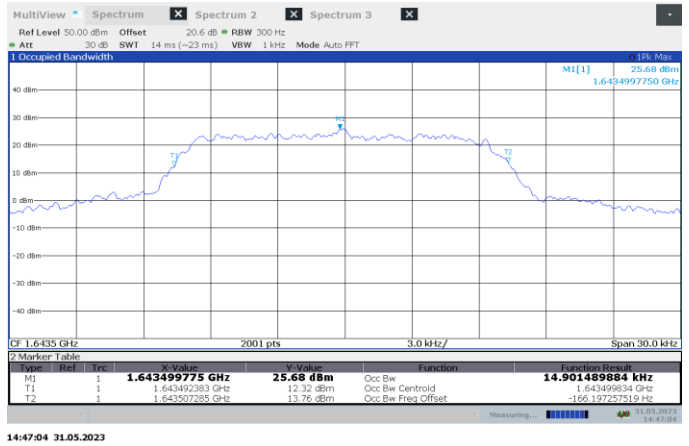


Figure 7.1-26: 99 % bandwidth on mid channel – Waveform Z

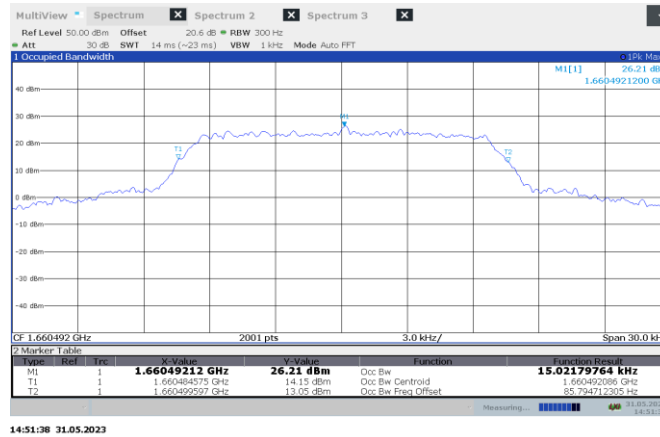


Figure 7.1-27: 99 % bandwidth on high channel – Waveform Z

Test data, continued

Table 7.1-10: 26 dB bandwidth results – Waveform Z

Frequency, MHz	26 dB bandwidth, kHz
1626.508	21.88
1643.500	22.48
1660.492	25.57

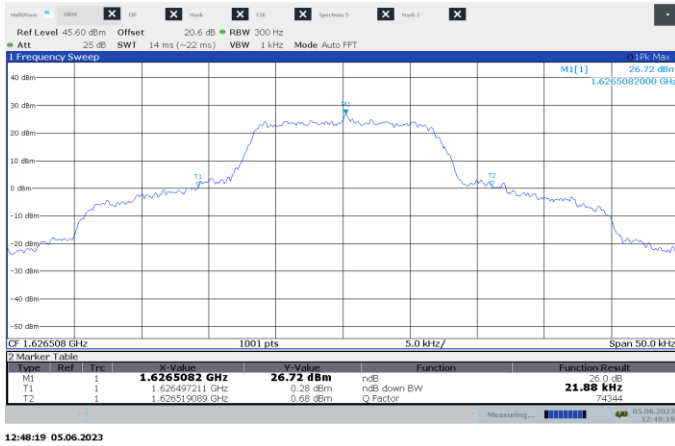


Figure 7.1-28: 26 dB bandwidth on low channel – Waveform Z

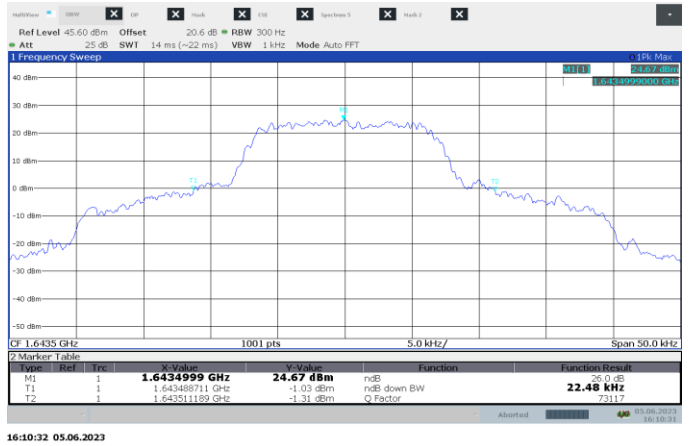


Figure 7.1-29: 26 dB bandwidth on mid channel – Waveform Z

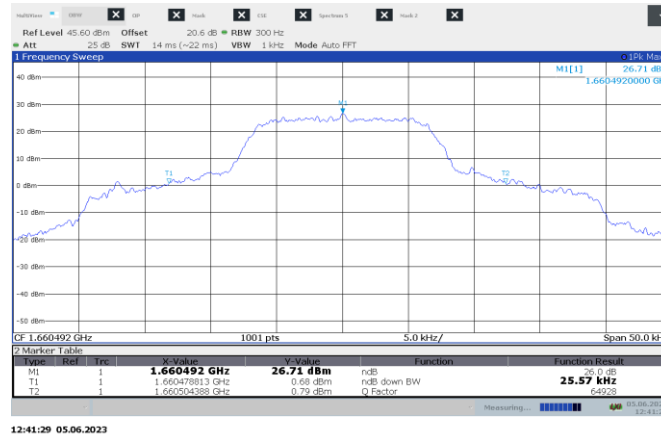


Figure 7.1-30: 26 dB bandwidth on high channel – Waveform Z

7.2 FCC 25.204 and RSS-170 5.5 Transmitter e.i.r.p. for mobile earth stations

7.2.1 References, definitions and limits

FCC §25.204:

- (a) In bands shared coequally with terrestrial radio communication services, the equivalent isotropically radiated power transmitted in any direction towards the horizon by an earth station, other than an ESV, operating in frequency bands between 1 and 15 GHz, shall not exceed the following limits except as provided for in paragraph (c) below:
+40 dBW (70 dBm) in any 4 kHz band for $\Theta \leq 0^\circ$
+40 + 3 Θ dBW in any 4 kHz band for $0^\circ < \Theta \leq 5^\circ$
where Θ is the angle of elevation of the horizon viewed from the center of radiation of the antenna of the earth station and measured in degrees as positive above the horizontal plane and negative below it.
- (b) In bands shared coequally with terrestrial radiocommunication services, the equivalent isotropically radiated power transmitted in any direction towards the horizon by an earth station operating in frequency bands above 15 GHz shall not exceed the following limits except as provided for in paragraph (c) below:
+64 dBW (94 dBm) in any 1 MHz band for $\Theta \leq 0^\circ$
+64 + 3 Θ dBW in any 1 MHz band for $0^\circ < \Theta \leq 5^\circ$
where Θ is as defined in paragraph (a) above.
- (c) For angles of elevation of the horizon greater than 5° there shall be no restriction as to the equivalent isotropically radiated power transmitted by an earth station towards the horizon.
- (d) Notwithstanding the e.i.r.p. and e.i.r.p. density limits specified in the station authorization, each earth station transmission shall be conducted at the lowest power level that will provide the required signal quality as indicated in the application and further amended by coordination agreements.

RSS-170, clause 5.5:

The application for MES certification shall state the MES e.i.r.p. that is necessary for satisfactory communication. The maximum permissible e.i.r.p. will be the stated e.i.r.p. plus a 2 dB margin. If a detachable antenna is used, the certification application shall state the recommended antenna type and manufacturer, the antenna gain and the maximum transmitter output power at the antenna terminal.

7.2.2 Test summary

Verdict	Pass		
Test date	May 31, 2023	Temperature	24 °C
Tested by	Alvin Liu	Air pressure	940 mbar
Test location	Cambridge	Relative humidity	38 %

7.2.3 Observations, settings and special notes

Measurement performed with reference to ANSI C63.26 section 5.2.3 for peak power of narrowband signal using spectrum analyzer.
Resolution bandwidth of 5 kHz selected in lieu of 4 kHz to satisfy FCC requirements.

Spectrum analyser settings:

Resolution bandwidth:	5 kHz
Video bandwidth:	20 kHz
Detector mode:	Peak
Trace mode:	Max Hold

7.2.4 Test data

Table 7.2-1: Conducted peak output power measurement results for ISSED – Waveform R

Frequency, MHz	Output power, dBm	Gain, dBi	EIRP, dBm	Stated EIRP, dBm	Maximum permissible EIRP, dBm	Margin, dB
1626.500625	32.4	3.9	36.3	37.0	39.0	2.7
1643.500625	32.4	3.9	36.3	37.0	39.0	2.7
1660.499375	32.6	3.9	36.5	37.0	39.0	2.5

Note: Maximum permissible EIRP, dBm = Stated EIRP + 2 dB

Table 7.2-2: Conducted peak output power measurement results for FCC – Waveform R

Frequency, MHz	Output power, dBm/5 kHz	Gain, dBi	EIRP, dBm/5 kHz	EIRP, dBm/4 kHz	EIRP limit, dBm/4kHz	Margin, dB
1626.500625	32.4	3.9	36.3	35.3	70.0	34.7
1643.500625	32.4	3.9	36.3	35.3	70.0	34.7
1660.499375	32.6	3.9	36.5	35.5	70.0	34.5

Note: EIRP limit [dBm/4kHz] = EIRP [dBm/5kHz] + 10×Log (4k / 5k) = EIRP [dBm/5kHz]

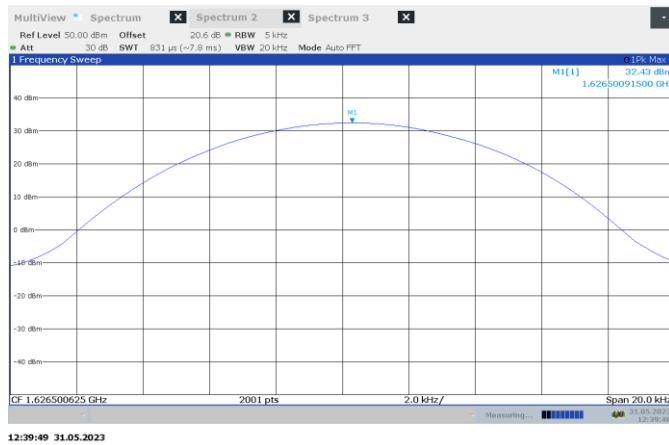


Figure 7.2-1: Conducted peak output power on low channel – Waveform R

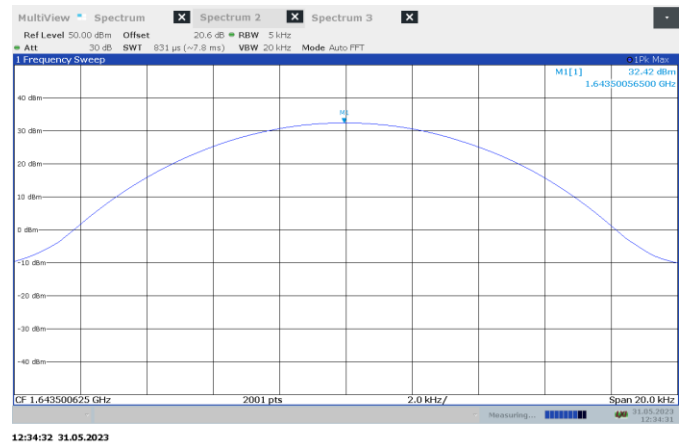


Figure 7.2-2: Conducted peak output power on mid channel – Waveform R

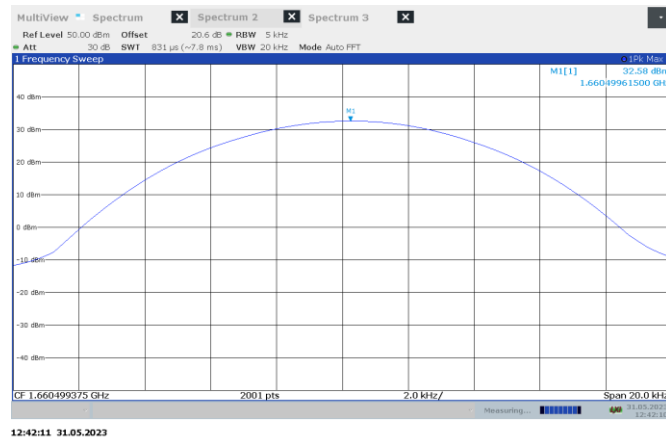


Figure 7.2-3: Conducted peak output power on high channel – Waveform R

Test data, continued

Table 7.2-3: Conducted peak output power measurement results for ISED – Waveform S

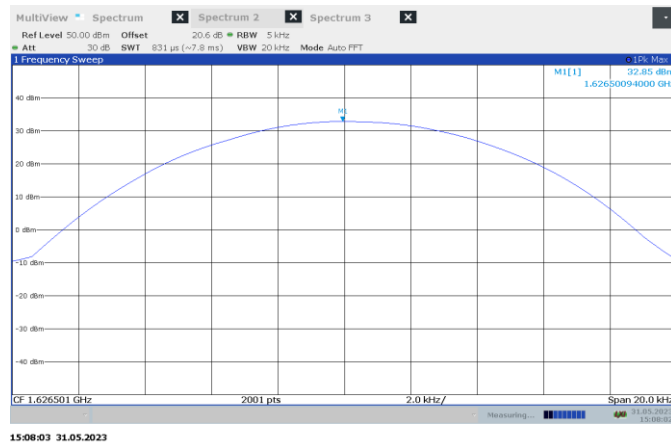
Frequency, MHz	Output power, dBm	Gain, dBi	EIRP, dBm	Stated EIRP, dBm	Maximum permissible EIRP, dBm	Margin, dB
1626.501	32.8	3.9	36.7	37.0	39.0	2.3
1643.501	32.7	3.9	36.6	37.0	39.0	2.4
1660.499	32.8	3.9	36.7	37.0	39.0	2.3

Note: Maximum permissible EIRP, dBm = Stated EIRP + 2 dB

Table 7.2-4: Conducted peak output power measurement results for FCC – Waveform S

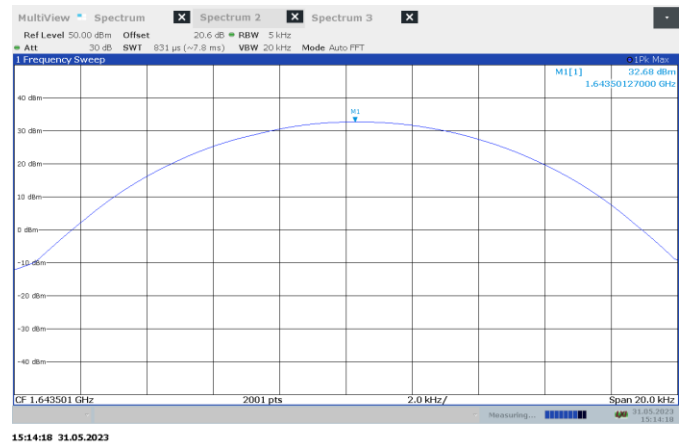
Frequency, MHz	Output power, dBm/5 kHz	Gain, dBi	EIRP, dBm/5 kHz	EIRP, dBm/4 kHz	EIRP limit, dBm/4kHz	Margin, dB
1626.501	32.8	3.9	36.7	35.7	70.0	34.3
1643.501	32.7	3.9	36.6	35.6	70.0	34.4
1660.499	32.8	3.9	36.7	35.7	70.0	34.3

Note: EIRP limit [dBm/4kHz] = EIRP [dBm/5kHz] + 10×Log (4k / 5k)



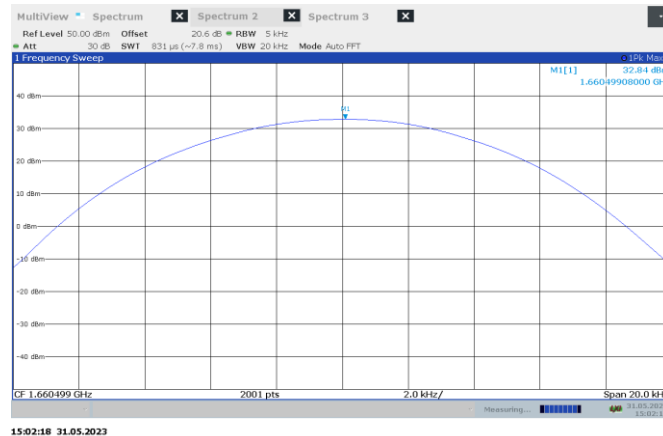
15:08:03 31.05.2023

Figure 7.2-4: Conducted peak output power on low channel – Waveform S



15:14:18 31.05.2023

Figure 7.2-5: Conducted peak output power on mid channel – Waveform S



15:02:18 31.05.2023

Figure 7.2-6: Conducted peak output power on high channel – Waveform S

Test data, continued

Table 7.2-5: Conducted peak output power measurement results for ISED – Waveform X

Frequency, MHz	Output power, dBm	Gain, dBi	EIRP, dBm	Stated EIRP, dBm	Maximum permissible EIRP, dBm	Margin, dB
1626.502	32.7	3.9	36.6	37.0	39.0	2.4
1643.502	32.6	3.9	36.5	37.0	39.0	2.5
1660.498	32.7	3.9	36.6	37.0	39.0	2.4

Note: Maximum permissible EIRP, dBm = Stated EIRP + 2 dB

Table 7.2-6: Conducted peak output power measurement results for FCC – Waveform X

Frequency, MHz	Output power, dBm/5 kHz	Gain, dBi	EIRP, dBm/5 kHz	EIRP, dBm/4 kHz	EIRP limit, dBm/4kHz	Margin, dB
1626.502	32.7	3.9	36.6	35.6	70.0	34.4
1643.502	32.6	3.9	36.5	35.5	70.0	34.5
1660.498	32.7	3.9	36.6	35.6	70.0	34.4

Note: EIRP limit [dBm/4kHz] = EIRP [dBm/5kHz] + 10×Log (4k / 5k)

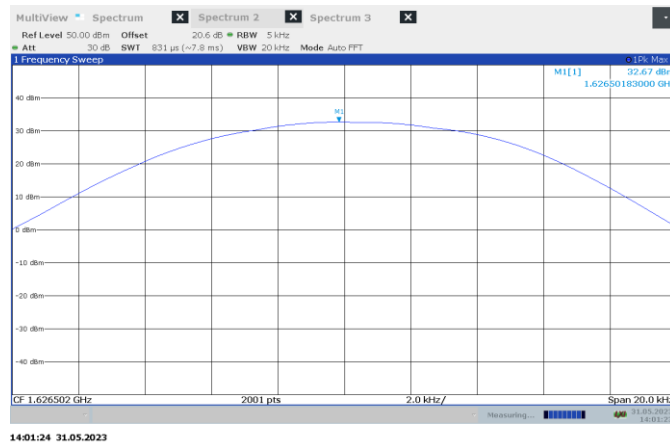


Figure 7.2-7: Conducted peak output power on low channel – Waveform X

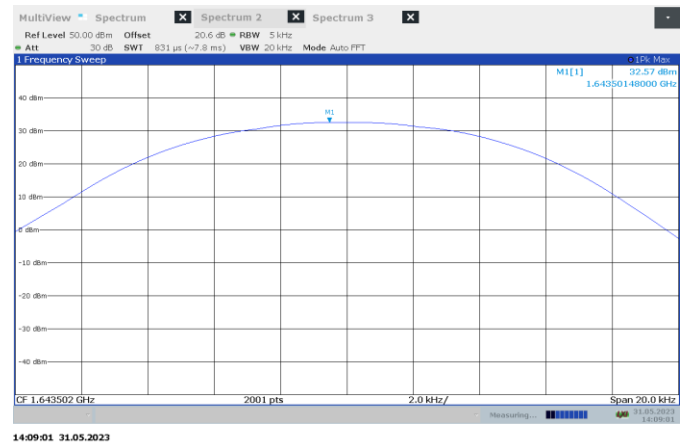


Figure 7.2-8: Conducted peak output power on mid channel – Waveform X

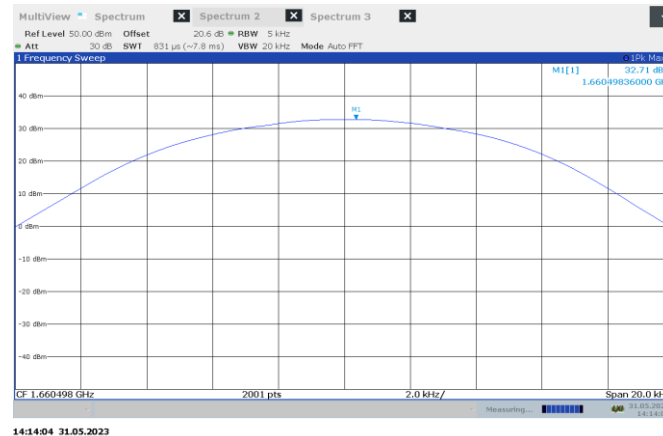


Figure 7.2-9: Conducted peak output power on high channel – Waveform X

Test data, continued

Table 7.2-7: Conducted peak output power measurement results for ISED – Waveform Y

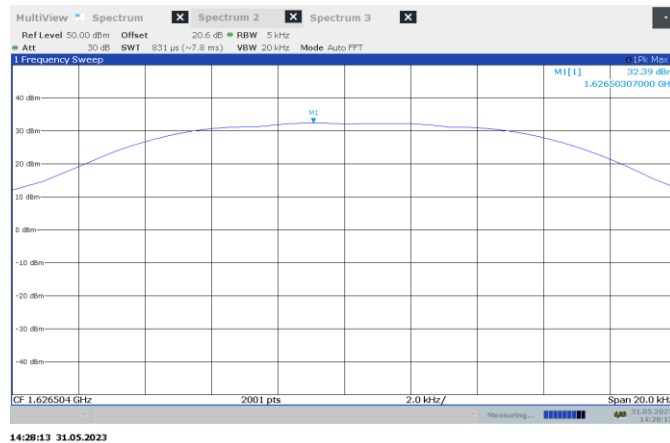
Frequency, MHz	Output power, dBm	Gain, dBi	EIRP, dBm	Stated EIRP, dBm	Maximum permissible EIRP, dBm	Margin, dB
1626.504	32.4	3.9	36.3	37.0	39.0	2.7
1643.504	32.3	3.9	36.2	37.0	39.0	2.8
1660.496	32.3	3.9	36.2	37.0	39.0	2.8

Note: Maximum permissible EIRP, dBm = Stated EIRP + 2 dB

Table 7.2-8: Conducted peak output power measurement results for FCC – Waveform Y

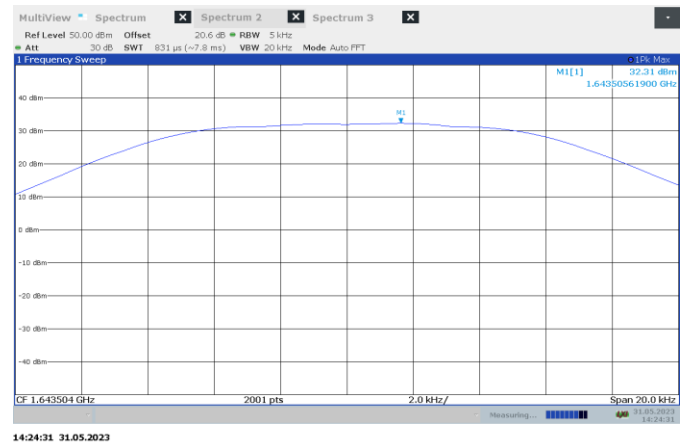
Frequency, MHz	Output power, dBm/5 kHz	Gain, dBi	EIRP, dBm/5 kHz	EIRP, dBm/4 kHz	EIRP limit, dBm/4kHz	Margin, dB
1626.504	32.4	3.9	36.3	35.3	70.0	34.7
1643.504	32.3	3.9	36.2	35.2	70.0	34.8
1660.496	32.3	3.9	36.2	35.2	70.0	34.8

Note: EIRP limit [dBm/4kHz] = EIRP [dBm/5kHz] + 10×Log (4k / 5k)



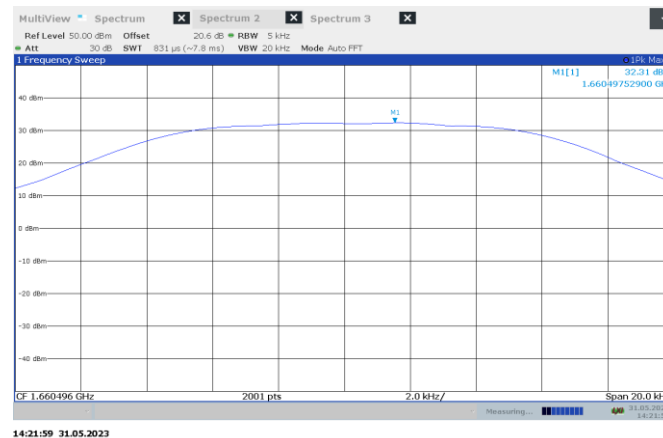
14:28:13 31.05.2023

Figure 7.2-10: Conducted peak output power on low channel – Waveform Y



14:24:31 31.05.2023

Figure 7.2-11: Conducted peak output power on mid channel – Waveform Y



14:21:59 31.05.2023

Figure 7.2-12: Conducted peak output power on high channel – Waveform Y

Test data, continued

Table 7.2-9: Conducted peak output power measurement results for ISED – Waveform Z

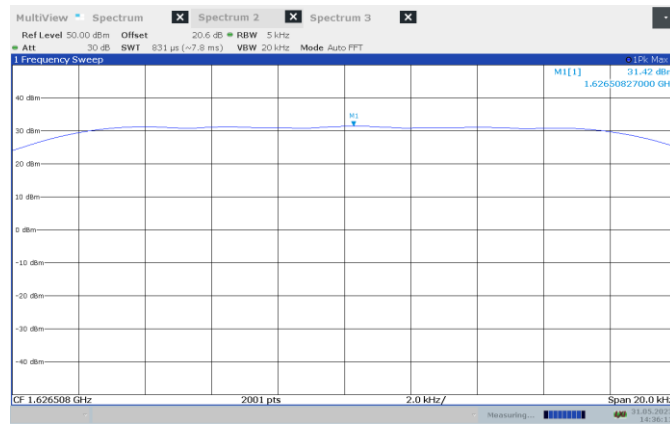
Frequency, MHz	Output power, dBm	Gain, dBi	EIRP, dBm	Stated EIRP, dBm	Maximum permissible EIRP, dBm	Margin, dB
1626.508	31.4	3.9	35.3	37.0	39.0	3.7
1643.500	31.5	3.9	35.4	37.0	39.0	3.6
1660.492	31.5	3.9	35.4	37.0	39.0	3.6

Note: Maximum permissible EIRP, dBm = Stated EIRP + 2 dB

Table 7.2-10: Conducted peak output power measurement results for FCC – Waveform Z

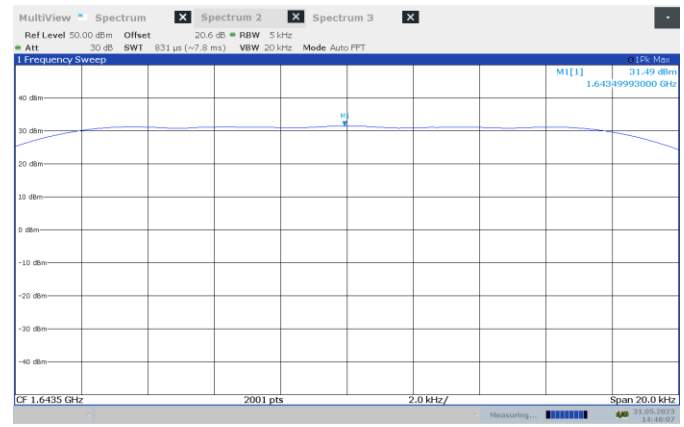
Frequency, MHz	Output power, dBm/5 kHz	Gain, dBi	EIRP, dBm/5 kHz	EIRP, dBm/4 kHz	EIRP limit, dBm/4kHz	Margin, dB
1626.508	31.4	3.9	35.3	34.3	70.0	35.7
1643.500	31.5	3.9	35.4	34.4	70.0	35.6
1660.492	31.5	3.9	35.4	34.4	70.0	35.6

Note: EIRP limit [dBm/4kHz] = EIRP [dBm/5kHz] + 10×Log (4k / 5k)



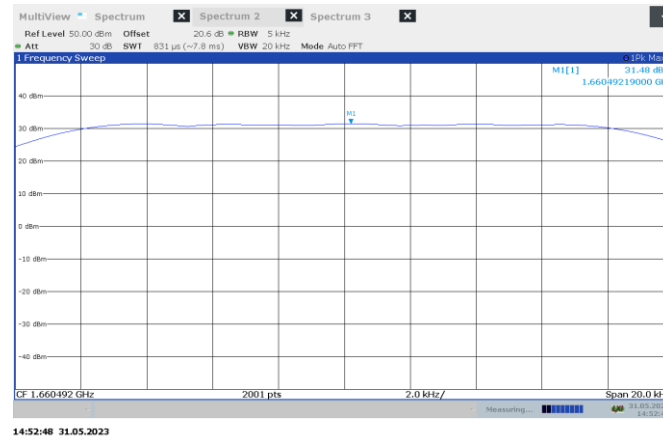
14:36:11 31.05.2023

Figure 7.2-13: Conducted peak output power on low channel – Waveform Z



14:48:08 31.05.2023

Figure 7.2-14: Conducted peak output power on mid channel – Waveform Z



14:52:48 31.05.2023

Figure 7.2-15: Conducted peak output power on high channel – Waveform Z

7.3 FCC 25.202(f) and RSS-170 5.8 Field strength of spurious emissions

7.3.1 References, definitions and limits

FCC §15.202:

- (f) Emission limitations. The mean power of emissions shall be attenuated below the mean output power of the transmitter in accordance with the following schedule:
- (1) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 50 percent up to and including 100 percent of the authorized bandwidth: 25 dB;
 - (2) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 100 percent up to and including 250 percent of the authorized bandwidth: 35 dB;
 - (3) In any 4 kHz band, the center frequency of which is removed from the assigned frequency by more than 250 percent of the authorized bandwidth: An amount equal to 43 dB plus 10 times the logarithm (to the base 10) of the transmitter power in watts (-13 dBm fixed);
 - (4) In any event, when an emission outside of the authorized bandwidth causes harmful interference, the Commission may, at its discretion, require greater attenuation than specified in paragraphs (f) (1), (2) and (3) of this section.

RSS-170

- 5.1 The transmitter unwanted emissions shall be measured with the carrier frequency set at both the highest and lowest channels in which the equipment is designed to operate.
The e.i.r.p. density of unwanted and carrier-off emissions in this section shall be averaged over any 2 ms active transmission using a power average detector with a resolution bandwidth of 1 MHz for broadband emissions and a resolution bandwidth of 1 kHz for discrete emissions, unless stated otherwise
- 5.8 **Unwanted emissions limits for Mobile Earth Stations in All Frequency Bands**
The average power of unwanted emissions shall be attenuated below the average output power, P(dBW), of the transmitter, as specified below:
- (1) 25 dB in any 4 kHz band, the centre frequency of which is offset from the channel frequency by more than 50%, up to and including 100% of the occupied bandwidth or necessary bandwidth, whichever is greater.
 - (2) 35 dB in any 4 kHz band, the centre frequency of which is offset from the channel frequency by more than 100%, up to and including 250% of the occupied bandwidth or necessary bandwidth, whichever is greater.
 - (3) 43 + 10 Log p (watts) in any 4 kHz band, the centre frequency of which is offset from the channel frequency by more than 250% of the occupied bandwidth or necessary bandwidth, whichever is greater.
- 5.10 **Carrier-off State Emissions**
Mobile equipment with transmitting frequencies between 1 GHz and 3 GHz shall have the e.i.r.p. density of carrier-off state emissions in the band 1559 – 1610 MHz not exceed -80 dBW/MHz.

7.3.2 Test summary

Verdict	Pass		
Test date	July 13, 2023	Temperature	22 – 24 °C
Tested by	Tarek Elkholy	Air pressure	940 – 980 mbar
Test location	Cambridge	Relative humidity	35 – 40 %

7.3.3 Observations, settings and special notes

The spectrum was searched from 30 MHz to the 10th harmonics.

Radiated measurements were performed at a distance of 3 m per ANSI 63.26, section 5.5.2 on a test site validated to the requirements of ANSI 63.10

Conducted spurious measurements were performed with reference to ANSI 63.26 section 5.7.4

Conducted out of band emissions measurements performed with using the power integration method per ANSI 63.26 section 5.7.2 (a); the measured value is scaled using $10 \log (\text{Reference bandwidth})/(\text{Measurement bandwidth})$.

As per declared by the applicant a guard band is added to the authorized bandwidths, accordingly all measurements were performed following the bandwidths listed in the table below.

Waveform code	Authorized bandwidth with 2 KHz guard band (Hz)
Z	18000
Y	10000
T,X	6000
K,S	4000
J,N,R	3250

Spectrum analyser settings for conducted spurious emissions measurements 30 MHz – 1 GHz:

Resolution bandwidth	100 kHz
Video bandwidth	300 kHz
Detector mode	Peak
Trace mode	Max Hold

Spectrum analyser settings for conducted spurious emissions measurements 1 GHz – 18 GHz:

Resolution bandwidth	1 MHz
Video bandwidth	3 MHz
Detector mode	Peak
Trace mode	Max Hold

Spectrum analyser settings for conducted bandedge spurious emission measurements outside assigned channel

Resolution bandwidth	$\geq 1\%$ of OBW
Video bandwidth	$\geq 3 \times \text{RBW}$
Detector mode	RMS
Trace mode	Power Average

Spectrum analyser settings for radiated spurious emissions measurements below 1 GHz:

Resolution bandwidth	120 kHz
Video bandwidth	300 kHz
Detector mode	Peak
Trace mode	Max Hold

Spectrum analyser settings for radiated spurious emissions measurements above 1 GHz:

Resolution bandwidth	1 MHz
Video bandwidth	3 MHz
Detector mode	Peak
Trace mode	Max Hold

7.3.4 Test data

Table 7.3-1: Emissions in 50 – 100% Authorized bandwidth – Waveform R

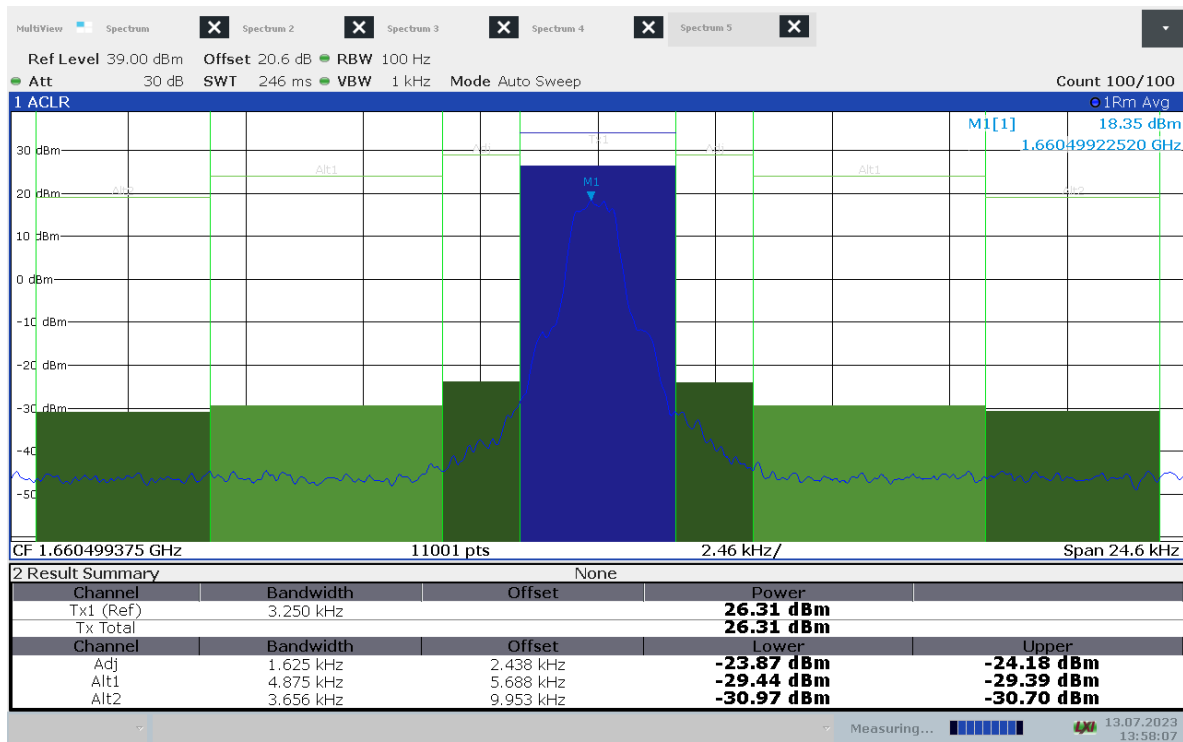
Frequency, (MHz)	Measured mean output power, (dBm/3.25 kHz)	Measured mean adjacent power 50–100% BW, (dBm/1.625 kHz)	Scaled mean adjacent power 50–100% BW, (dBm/4 kHz)	Limit, 50–100% (dBm/4 kHz)	Margin, (dB)
1660.499375	26.3	-23.9	-20.0	1.3	21.3

Note: Scaled power = measured power + 10×log (4 kHz/Measurement BW), Limit = scaled mean average power [dBm/4 kHz] – 25 dB

Table 7.3-2: Emissions in 100 – 250 % Authorized bandwidth – Waveform R

Frequency, (MHz)	Measured mean output power, (dBm/3.25 kHz)	Measured mean adjacent power 100–250% BW, (dBm/4.875 kHz)	Scaled mean adjacent power 100–250% BW, (dBm/4 kHz)	Limit, 100–250% (dBm/4 kHz)	Margin, (dB)
1660.499375	26.3	-29.4	-30.3	-8.7	21.6

Note: Scaled power = measured power + 10×log (4 kHz/Measurement BW), Limit = scaled mean average power [dBm/4 kHz] – 35 dB



13:58:08 13.07.2023

Figure 7.3-2: Conducted band edge spurious emissions outside assigned bandwidth – Waveform R, high channel

Test data, continued

Table 7.3-3: Emissions in 50 – 100% Authorized bandwidth – Waveform S

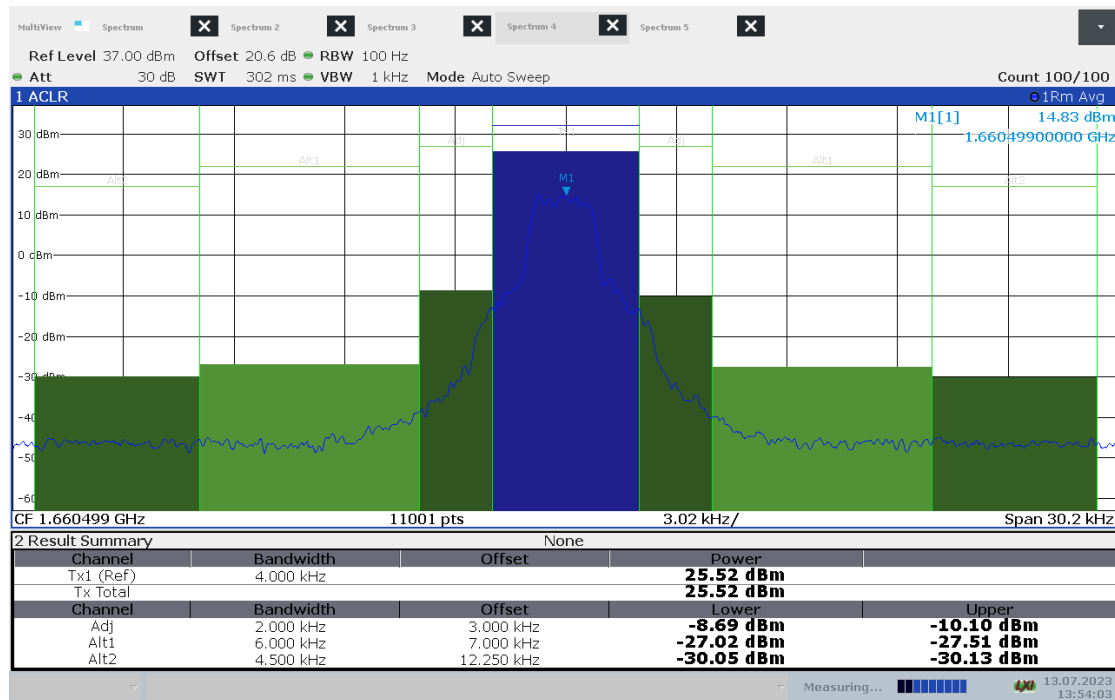
Frequency, (MHz)	Measured mean output power, (dBm/4 kHz)	Measured mean adjacent power 50–100% BW, (dBm/2 kHz)	Scaled mean adjacent power 50–100% BW, (dBm/4 kHz)	Limit, 50–100% (dBm/4 kHz)	Margin, (dB)
1660.499	25.5	-8.7	-5.7	0.5	6.2

Note: Scaled power = measured power + 10×log (4 kHz/Measurement BW), Limit = scaled mean average power [dBm/4 kHz] – 25 dB

Table 7.3-4: Emissions in 100 – 250 % Authorized bandwidth – Waveform S

Frequency, (MHz)	Measured mean output power, (dBm/4 kHz)	Measured mean adjacent power 100–250% BW, (dBm/6 kHz)	Scaled mean adjacent power 100–250% BW, (dBm/4 kHz)	Limit, 100–250% (dBm/4 kHz)	Margin, (dB)
1660.499	25.5	-27.0	-28.8	-9.5	19.3

Note: Scaled power = measured power + 10×log (4 kHz/Measurement BW), Limit = scaled mean average power [dBm/4 kHz] – 35 dB



13:54:03 13.07.2023

Figure 7.3-1: Conducted band edge spurious emissions outside assigned bandwidth – Waveform S, high channel

Test data, continued

Table 7.3-5: Emissions in 50 – 100% Authorized bandwidth – Waveform T

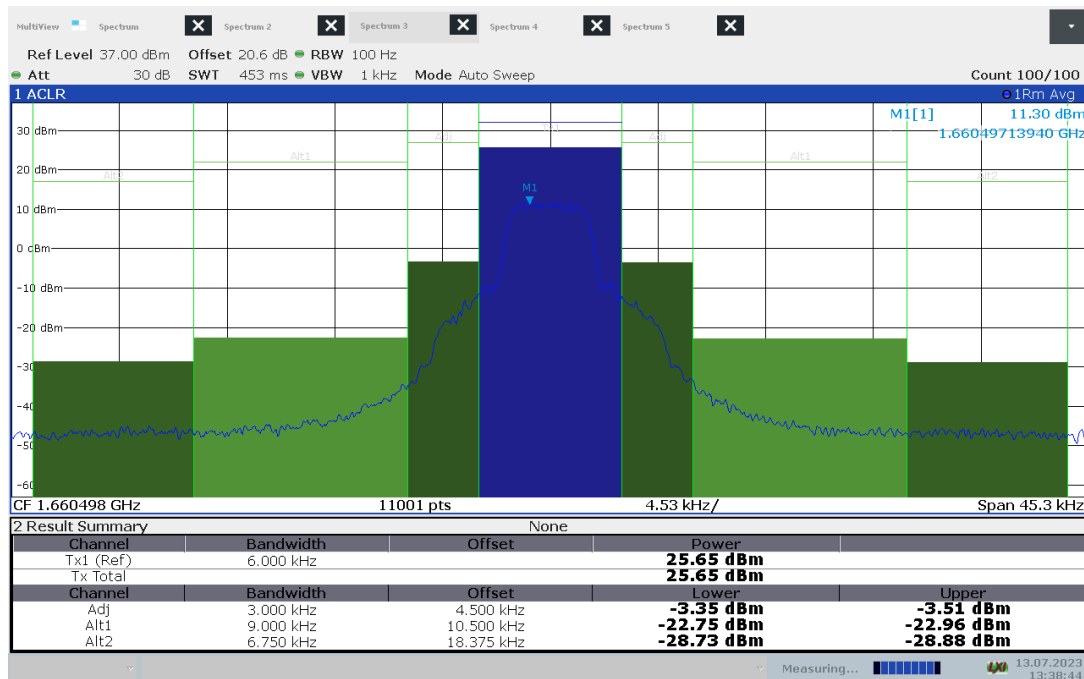
Frequency, (MHz)	Measured mean output power, (dBm/6 kHz)	Measured mean adjacent power 50–100% BW, (dBm/3 kHz)	Scaled mean adjacent power 50–100% BW, (dBm/4 kHz)	Limit, 50–100% (dBm/4 kHz)	Margin, (dB)
1660.498	25.7	-3.4	-2.2	0.7	-2.7

Note: Scaled power = measured power + 10×log (4 kHz/Measurement BW), Limit = scaled mean average power [dBm/4 kHz] – 25 dB

Table 7.3-6: Emissions in 100 – 250 % Authorized bandwidth – Waveform T

Frequency, (MHz)	Measured mean output power, (dBm/6 kHz)	Measured mean adjacent power 100–250% BW, (dBm/9 kHz)	Scaled mean adjacent power 100–250% BW, (dBm/4 kHz)	Limit, 100–250% (dBm/4 kHz)	Margin, (dB)
1660.498	25.7	-22.8	-26.3	-9.3	17.0

Note: Scaled power = measured power + 10×log (4 kHz/Measurement BW), Limit = scaled mean average power [dBm/4 kHz] – 35 dB



13:38:44 13.07.2023

Figure 7.3-2: Conducted band edge spurious emissions outside assigned bandwidth – Waveform T, high channel

Test data, continued

Table 7.3-7: Emissions in 50 – 100% Authorized bandwidth – Waveform Y

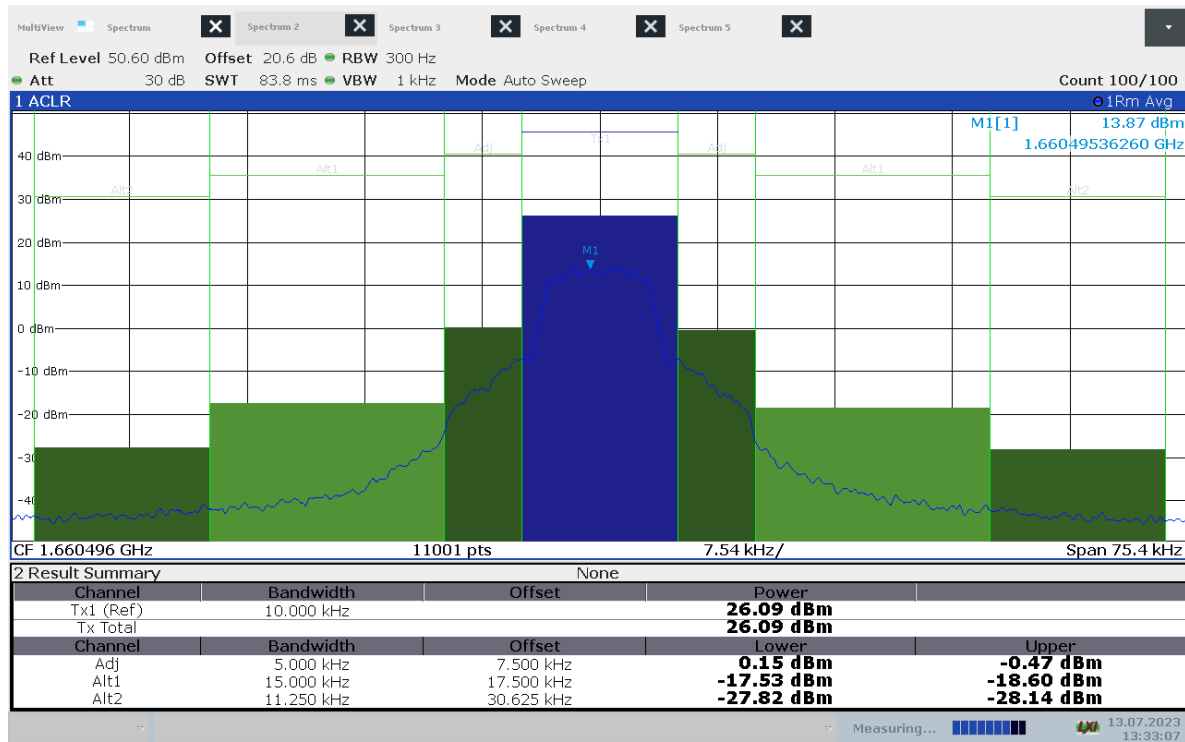
Frequency, (MHz)	Measured mean output power, (dBm/10 kHz)	Measured mean adjacent power 50–100% BW, (dBm/5 kHz)	Scaled mean adjacent power 50–100% BW, (dBm/4 kHz)	Limit, 50–100% (dBm/4 kHz)	Margin, (dB)
1660.496	26.1	0.2	-0.8	1.1	1.9

Note: Scaled power = measured power + 10×log (4 kHz/Measurement BW), Limit = scaled mean average power [dBm/4 kHz] – 25 dB

Table 7.3-8: Emissions in 100 – 250 % Authorized bandwidth – Waveform Y

Frequency, (MHz)	Measured mean output power, (dBm/10 kHz)	Measured mean adjacent power 100–250% BW, (dBm/15 kHz)	Scaled mean adjacent power 100–250% BW, (dBm/4 kHz)	Limit, 100–250% (dBm/4 kHz)	Margin, (dB)
1660.496	26.1	-17.5	-23.2	-8.9	14.3

Note: Scaled power = measured power + 10×log (4 kHz/Measurement BW), Limit = scaled mean average power [dBm/4 kHz] – 35 Db



13:33:07 13.07.2023

Figure 7.3-3: Conducted band edge spurious emissions outside assigned bandwidth – Waveform Y, High channel

Test data, continued

Table 7.3-9: Emissions in 50 – 100% Authorized bandwidth – Waveform Z

Frequency, (MHz)	Measured mean output power, (dBm/18 kHz)	Measured mean adjacent power 50–100% BW, (dBm/9 kHz)	Scaled mean adjacent power 50–100% BW, (dBm/4 kHz)	Limit, 50–100% (dBm/4 kHz)	Margin, (dB)
1660.492	26.0	0.5	-3.0	1.0	4.0

Note: Scaled power = measured power + 10×log (4 kHz/Measurement BW), Limit = scaled mean average power [dBm/4 kHz] – 25 dB

Table 7.3-10: Emissions in 100 – 250 % Authorized bandwidth – Waveform Z

Frequency, (MHz)	Measured mean output power, (dBm/18 kHz)	Measured mean adjacent power 100–250% BW, (dBm/27 kHz)	Scaled mean adjacent power 100–250% BW, (dBm/4 kHz)	Limit, 100–250% (dBm/4 kHz)	Margin, (dB)
1660.492	26.0	-13.1	-21.4	-9.0	12.4

Note: Scaled power = measured power + 10×log (4 kHz/Measurement BW), Limit = scaled mean average power [dBm/4 kHz] – 35 dB

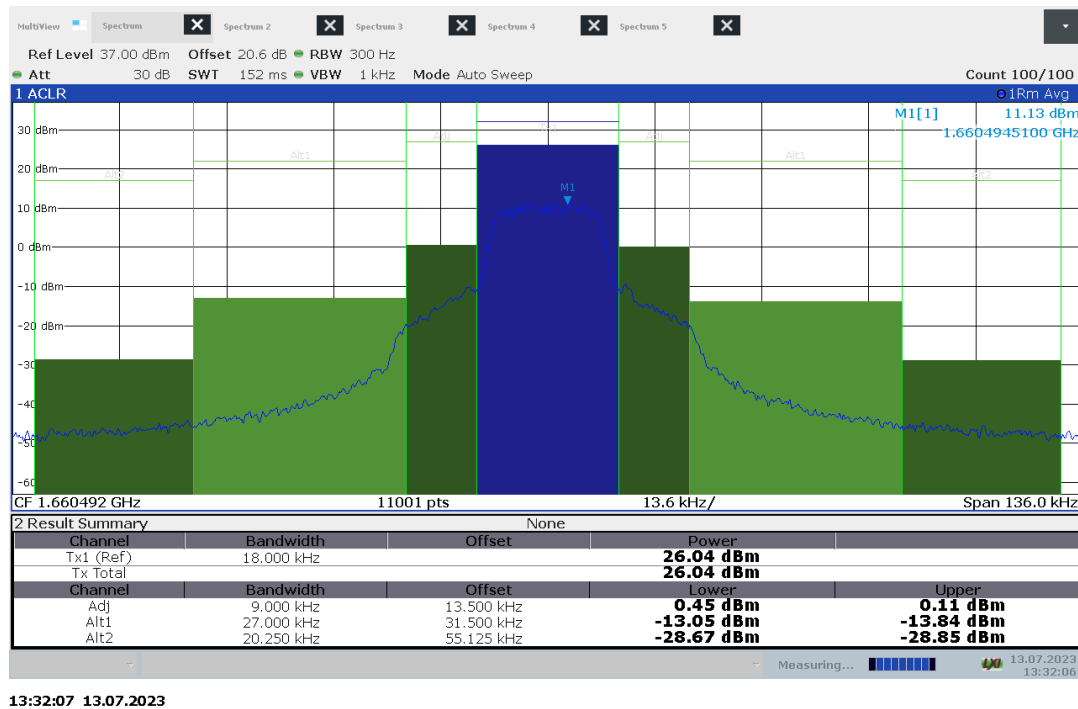


Figure 7.3-4: Conducted band edge spurious emissions outside assigned bandwidth – Waveform Z, high channel

Test data, continued

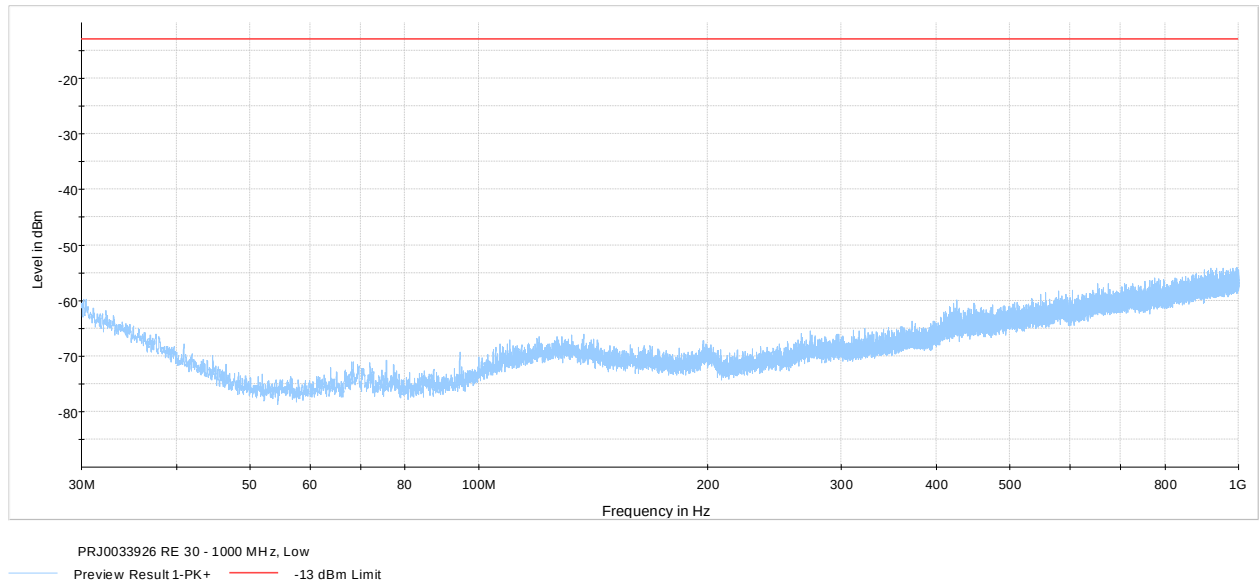


Figure 7.3-3: Radiated Spurious emissions 30 – 1000 MHz, low channel

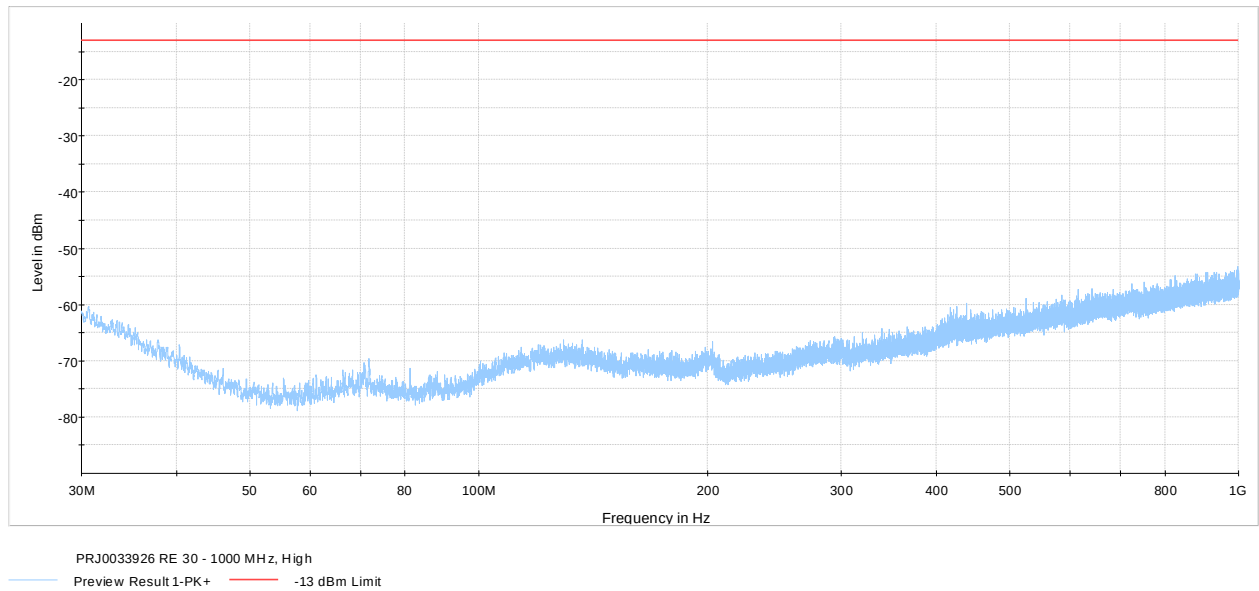


Figure 7.3-4: Radiated Spurious emissions 30 – 1000 MHz, high channel

Test data, continued

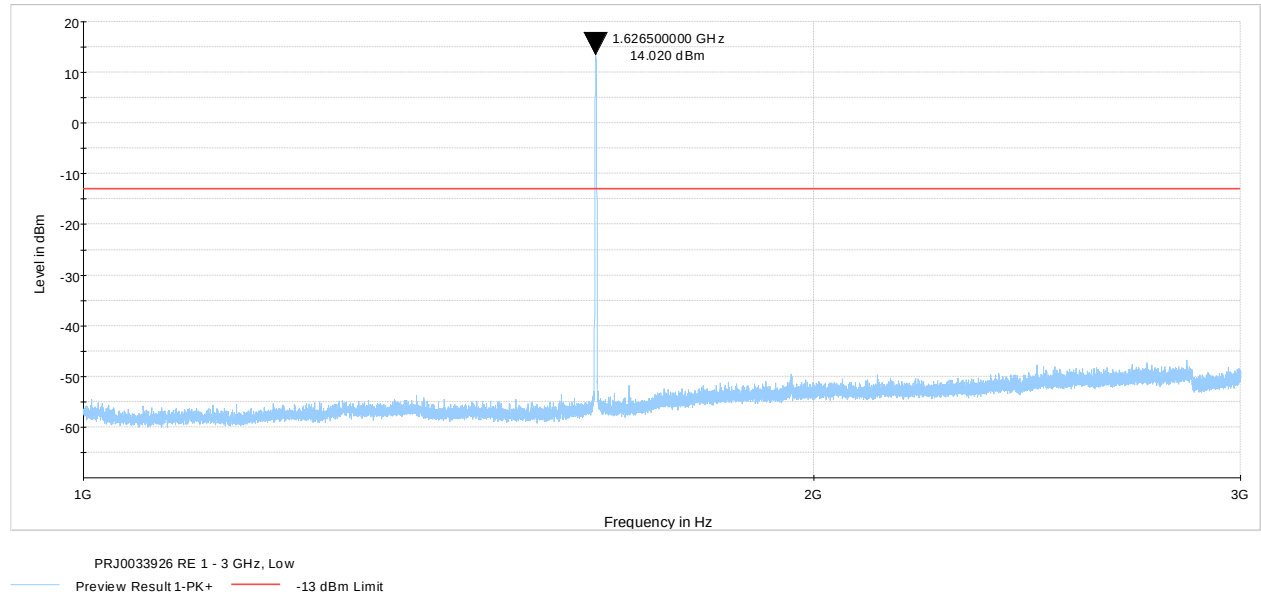


Figure 7.3-5: Radiated Spurious emissions 1 – 3 GHz, low channel

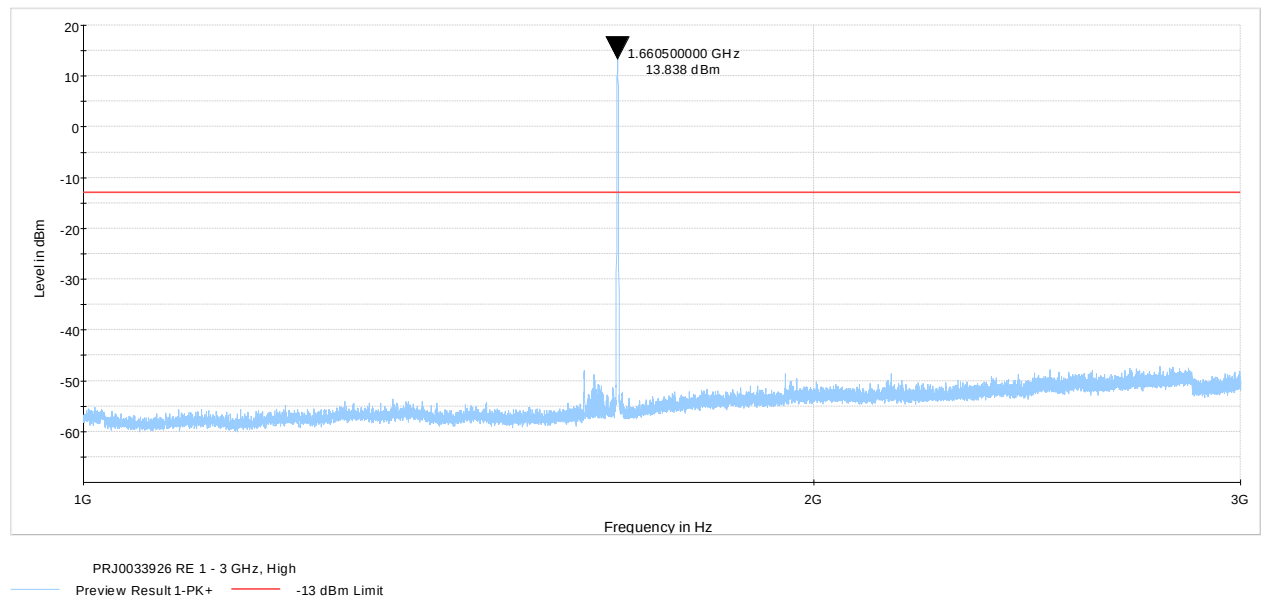


Figure 7.3-6: Radiated Spurious emissions 1 – 3 GHz, high channel

Test data, continued

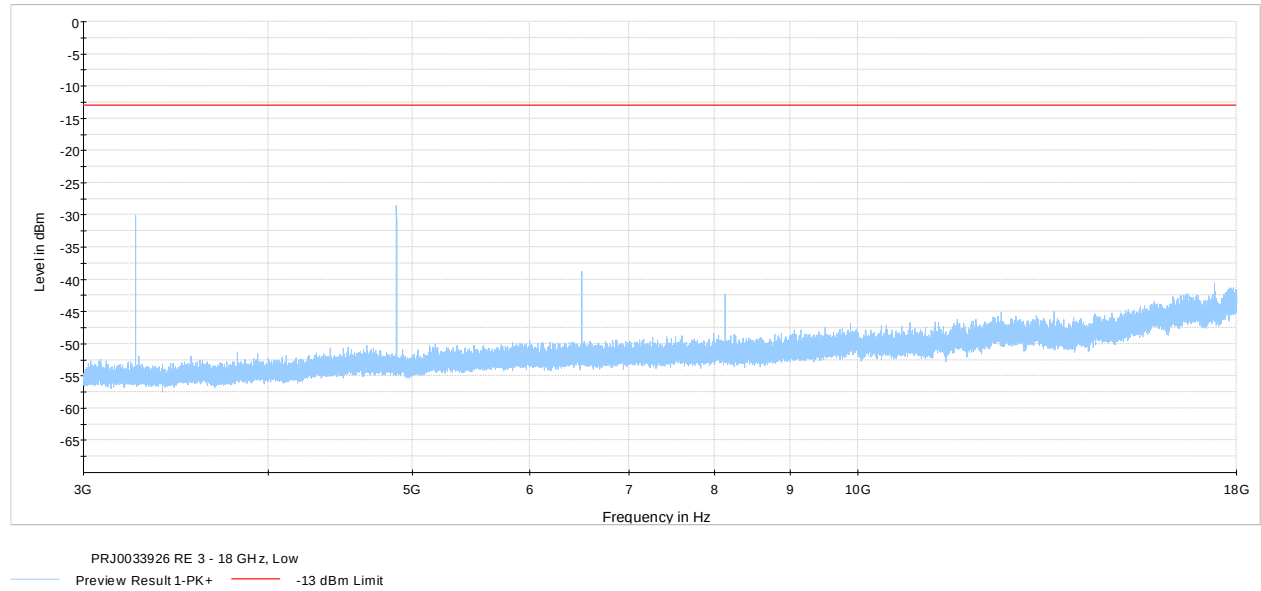


Figure 7.3-7: Radiated Spurious emissions 3 – 18 GHz, low channel

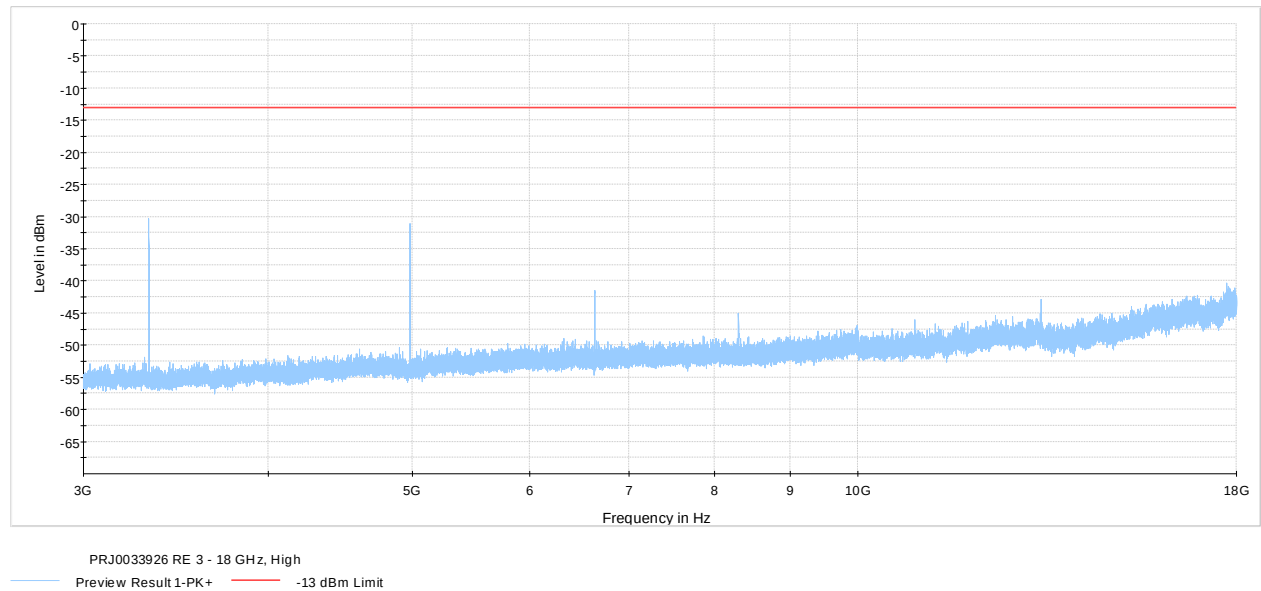


Figure 7.3-8: Radiated Spurious emissions 3 – 18 GHz, high channel

Test data, continued

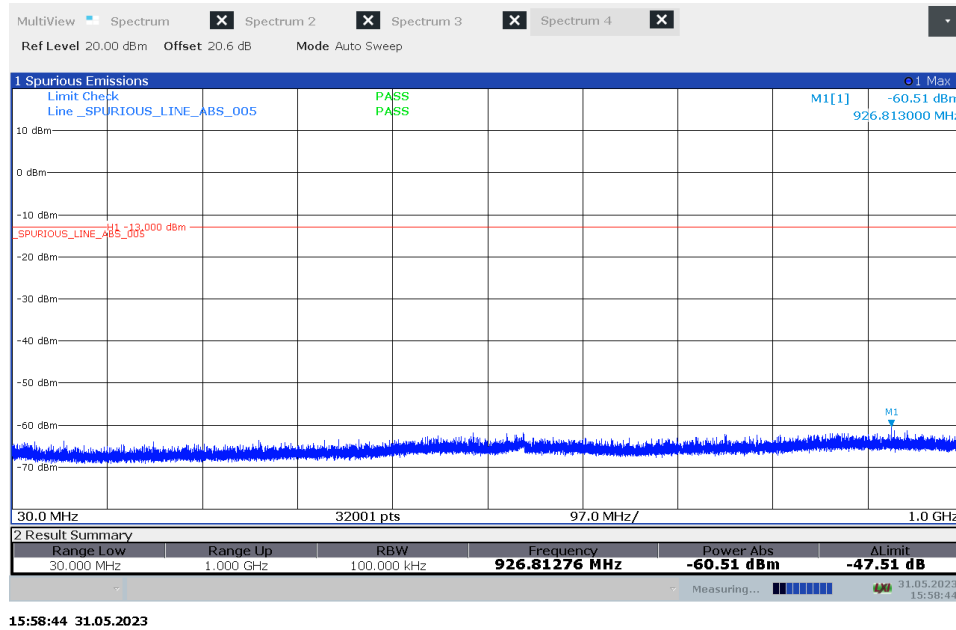


Figure 7.3-9: Conducted spurious emissions 30 – 1000 MHz (worst case)

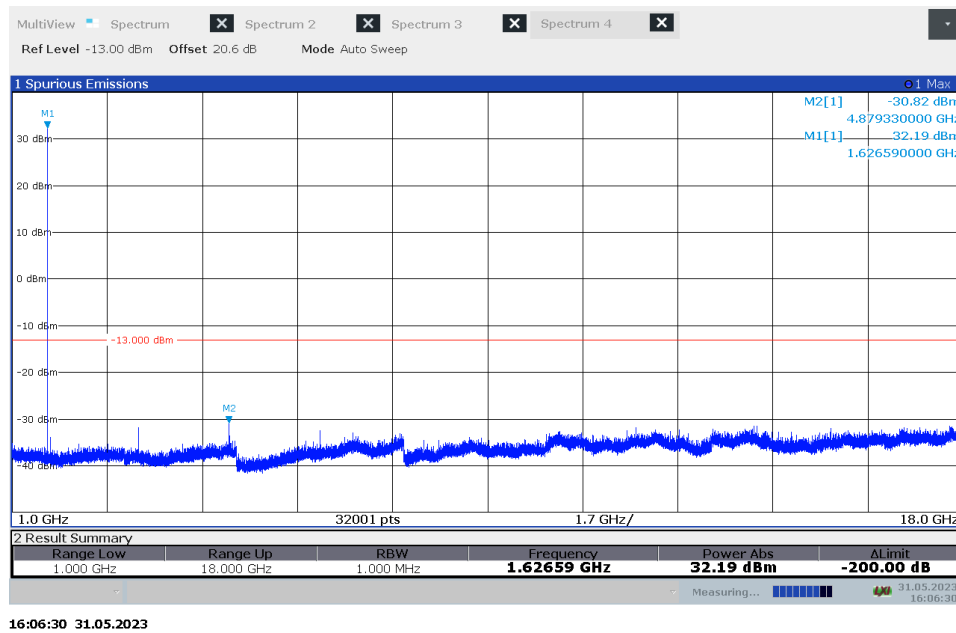


Figure 7.3-9: Conducted spurious emissions 1 – 18 GHz (worst case)

7.4 FCC 25.216 and RSS-170 5.9 Limits on emissions from mobile earth stations for protection of aeronautical radionavigation-satellite service

7.4.1 References, definitions and limits

FCC §25.216:

- (c) The e.i.r.p. density of emissions from mobile earth stations with assigned uplink frequencies between 1610 MHz and 1660.5 MHz shall not exceed -70 dBW/MHz (-40 dBm/MHz), averaged over any 2 millisecond active transmission interval, in the band 1559–1605 MHz. The e.i.r.p. of discrete emissions of less than 700 Hz bandwidth from such stations shall not exceed -80 dBW (-50 dBm), averaged over any 2 millisecond active transmission interval, in the 1559–1605 MHz band.
- (f) Mobile earth stations with assigned uplink frequencies in the 1610–1660.5 MHz band shall suppress the power density of emissions in the 1605–1610 MHz band to an extent determined by linear interpolation from -70 dBW/MHz (-40 dBm/MHz) at 1605 MHz to -10 dBW/MHz (20 dBm/MHz) at 1610 MHz.

RSS-170, Clause 5.9:

- 5.9.2 Mobile earth stations with transmitting frequencies between 1626.5 and 1660.5 MHz shall have the e.i.r.p. density of unwanted emissions in the band 1605–1610 MHz, averaged over any 2 ms active transmission interval, not exceed the following limits:
- (1) -70 dBW/MHz (-40 dBm/MHz) at 1605 MHz, linearly interpolated to -46 dBW/MHz (-16 dBm/MHz) at 1610 MHz, for broadband emissions; and
 - (2) -80 dBW/kHz (-50 dBm/kHz) at 1605 MHz, linearly interpolated to -56 dBW/kHz (-26 dBm/kHz) at 1610 MHz, for discrete emissions.

7.4.2 Test summary

Verdict	Pass		
Test date	May 31, 2023	Temperature	24 °C
Tested by	Alvin Liu	Air pressure	940 mbar
Test location	Cambridge	Relative humidity	38 %

7.4.3 Observations, settings, and special notes

Spectrum analyser settings:

Resolution bandwidth	1 MHz
Video bandwidth	3 MHz
Detector mode	RMS
Trace mode	Max-hold

7.4.4 Test data

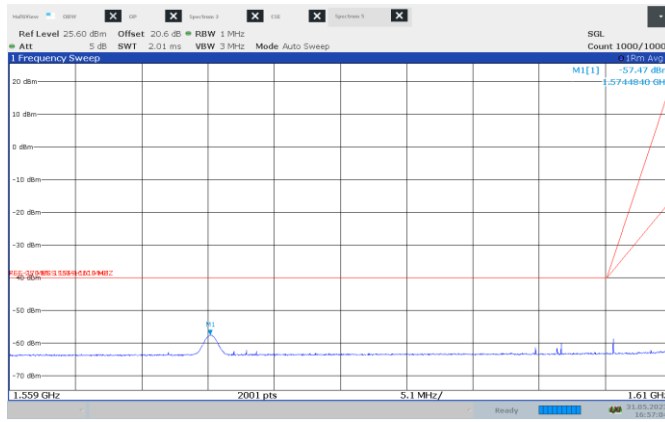


Figure 7.4-1: spurious emissions 1559–1610 MHz, Waveform R, low channel

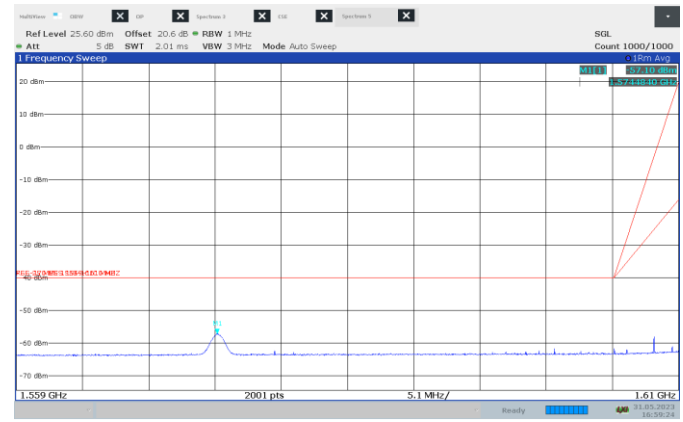


Figure 7.4-2: spurious emissions 1559–1610 MHz, Waveform S, low channel

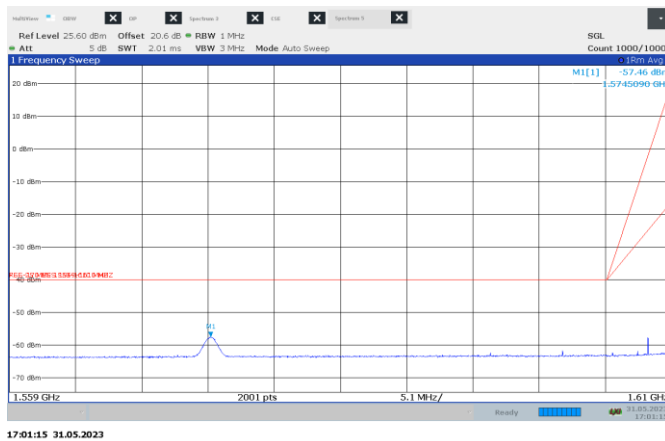


Figure 7.4-3: spurious emissions 1559–1610 MHz, Waveform X, low channel

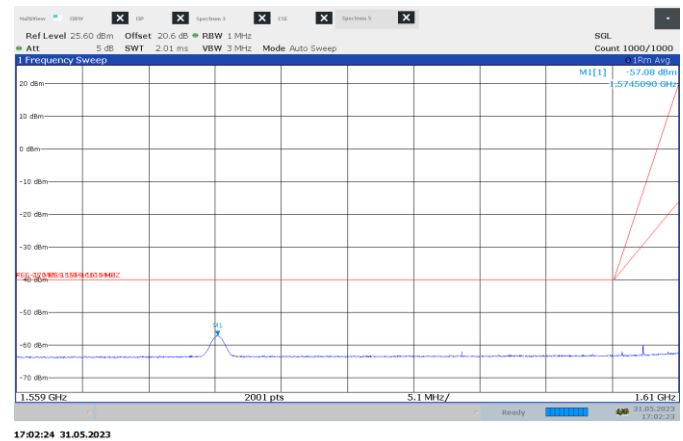


Figure 7.4-4: spurious emissions 1559–1610 MHz, Waveform Y, low channel

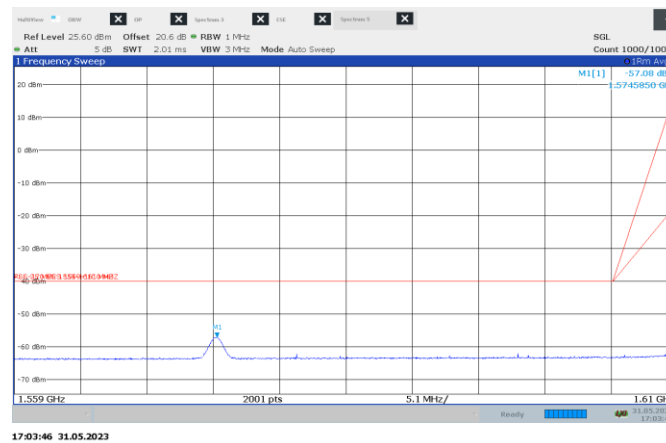
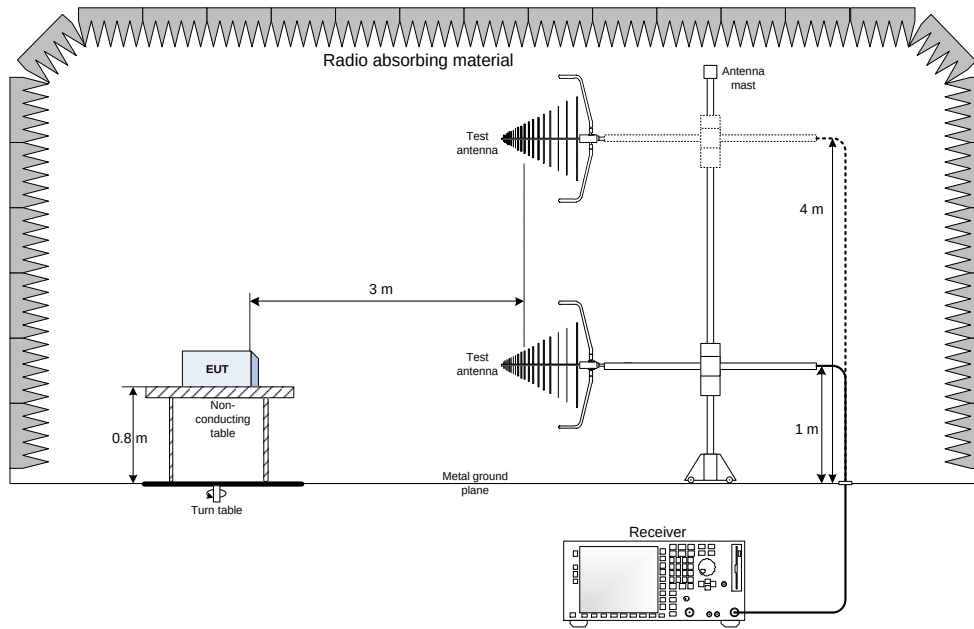


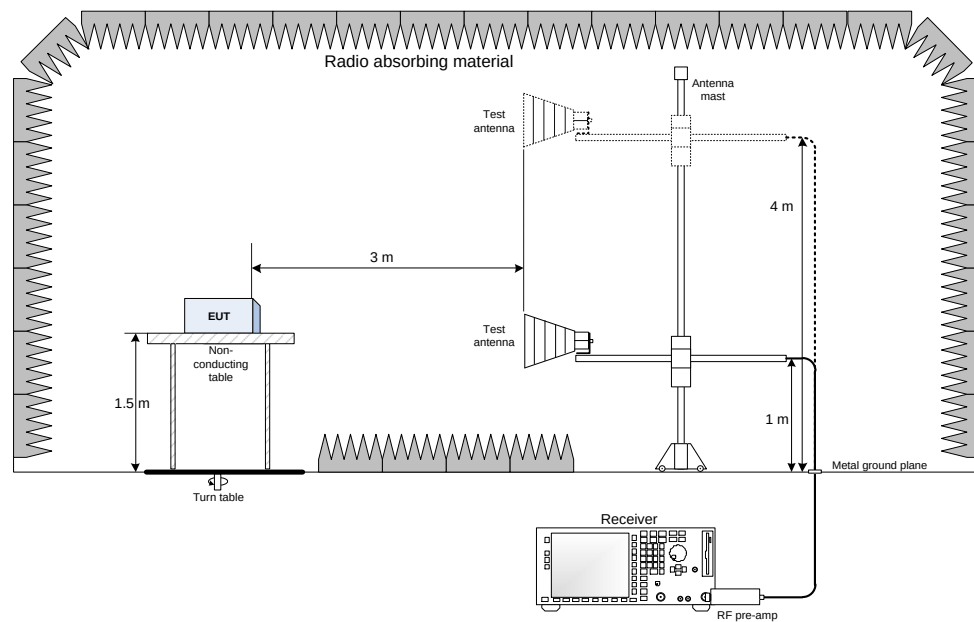
Figure 7.4-5: Radiated spurious emissions 1559–1610 MHz, Waveform Z, low channel

Section 8. Test setup diagrams

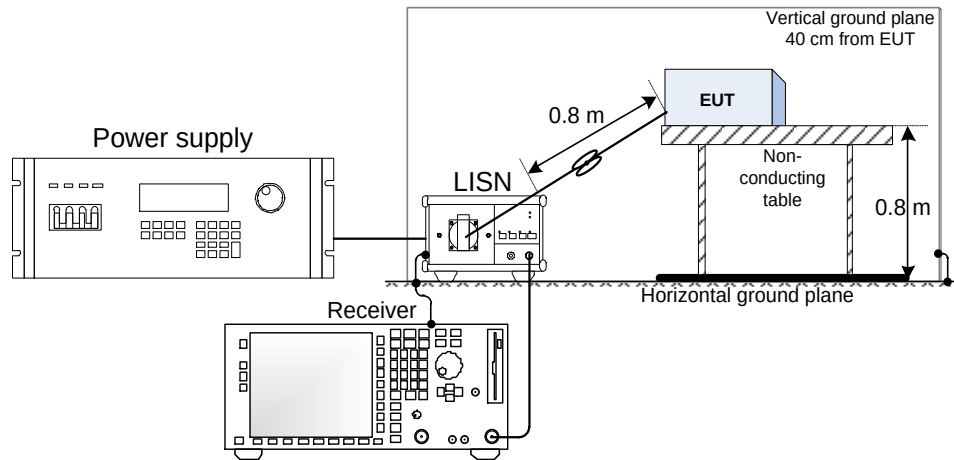
8.1 Radiated emissions set-up for frequencies below 1 GHz



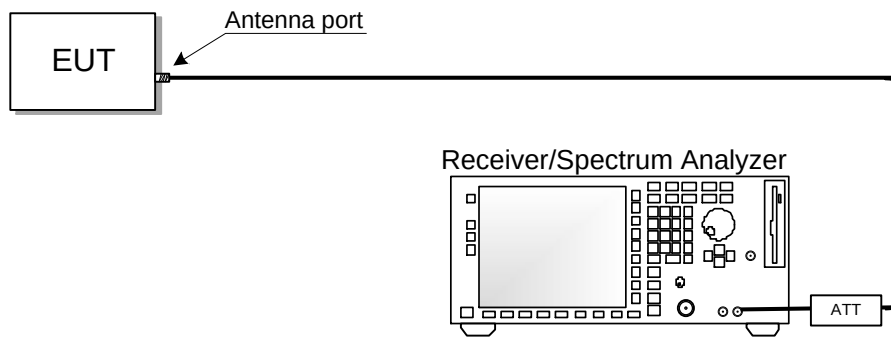
8.2 Radiated emissions set-up for frequencies above 1 GHz



8.3 AC mains conducted emissions set-up



8.4 Antenna port set-up



End of the test report