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RADIO TEST REPORT

Report ID:
REP026806

Project number:
PRJ0051009

Type of assessment:
Final product testing

Applicant:
ORBCOMM LICENCE Corp. (ORBCOMM Inc.)

Product:
SC 1000 Mobile Satellite Earth Station Terminal

Model:
SC1000

FCC identifier:
FCC ID: XGS-SC1000

ISED certification number:
IC: 11881A-SC1000

Specification:

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

Date of issue: April 2, 2024

Alvin Liu, EMC/RF Specialist
Tested by

Signature

Kevin Rose, EMC/RF Specialist
Reviewed by

Signature

Lab and test locations

Company name	Nemko Canada Inc.			
Facilities	*Ottawa site:* 303 River Road Ottawa, Ontario Canada K1V 1H2 Tel: +1 613 737 9680 Fax: +1 613 737 9691		*Montréal site:* 292 Labrosse Avenue Pointe-Claire, Québec Canada H9R 5L8 Tel: +1 514 694 2684 Fax: +1 514 694 3528	*Cambridge site:* 1-130 Saltsman Drive Cambridge, Ontario Canada N3E 0B2 Tel: +1 519 650 4811
Test site identifier	**Organization**	**Ottawa**	**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.

Copyright notification

Table of contents

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 TXReceiver 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 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.

1.4 Exclusions

None

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
REP026806	April 2, 2024	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 SC1000 has various waveform formats with different channel structure (different symbol/data rate, channel bandwidth, spectrum etc.).

For each waveform 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 TX formats are listed as below table,

Waveform	Symbol rate	CBW (Hz)	Modulation
J, N, R	800	3250	QPSK
K, S	1600	4000	QPSK
T, X	3200	6000	QPSK

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 ±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

Name	ORBCOMM LICENCE Corp. (ORBCOMM Inc.)
Address	395 W Passaic Street, Suite 325, Rochelle Park, NJ 07662 USA

4.3 EUT information

Product description	SC 1000 Mobile Satellite Earth Station Terminal
Model / HVIN	SC1000
Serial number	169 (radiated), 170 (conducted)
Part number	SC1000
Power supply requirements	Internal Battery: 3.4 – 4 V(DC), 3.6 V normal
Product description and theory of operation	The device consists of a Mobile Satellite Earth Station modem and a Bluetooth transceiver, as well as a GPS/GNSS receiver modem. The satellite modem is operating in Inmarsat's satellite network to provide two-way communication. The device is designed for industrial equipment/assets tracking and monitoring application to help customers to control and manage their assets.

4.4 Radio technical information

Frequency band	1626.5–1660.5 MHz
Frequency Min	1626.501625 MHz
Frequency Max	1660.498375 MHz
RF power Max (W), Conducted	1.368 W and (31.36 dBm)
Measured BW (kHz), 99% OBW	1.052 (Waveform R), 1.818 (Waveform S), 3.581 (Waveform X)
Type of modulation	QPSK
Emission classification (F1D, G1D, D1D)	G1D
Antenna information	Internal antenna, built-in on PCB board, F-Inverted metal assembled on to PCB, gain 5.1 dBi The EUT uses a unique antenna coupling/ non-detachable antenna to the intentional radiator.
Stated EIRP	37 dBm

4.5 EUT setup details

4.5.1 Radio exercise details

Operating conditions	EUT was controlled by TeraTerm Pro session from Laptop to transmit a radio 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
Laptop	DELL	MN: LATITUDE E6440, FA003070
DC power supply	GWINSTEK	GRP-3060D

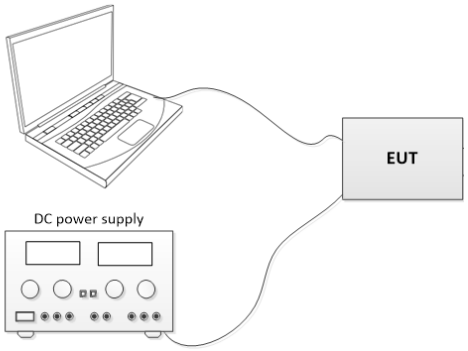


Figure 4.5-1: *Radiated testing block diagram*

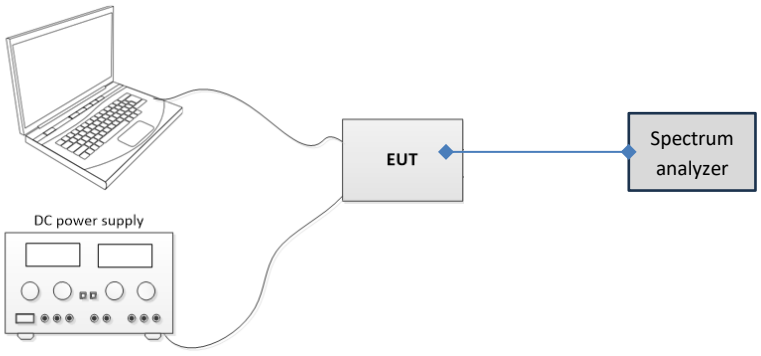


Figure 4.5-2: *Antenna port testing block diagram*

Section 5. Summary of test results

5.1 Testing period

Test start date	January 19, 2024	Test end date	January 28, 2024

5.2 Sample information

Receipt date	January 19, 2024	Nemko sample ID number(s)	PRJ00510090001, PRJ00510090002

5.3 FCC test results

Table 5.3-1: *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
25.202(d)	Frequency tolerance, earth stations	Pass
25.216	Limits for emissions from mobile earth stations for protection of aeronautical radionavigation satellite service	Pass

Notes: [1] Measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, was performed with the supply voltage varied between 85 % and 115 % of the nominal rated supply voltage. No noticeable output power variation was observed
[2] The Antennas are located within the enclosure of EUT and not user accessible.

5.4 ISED test results

Table 5.4-2: *RSS-Gen, Issue 5 test results*

Part	Test description	Verdict
6.7	Occupied bandwidth	Pass
7.3	Receiver radiated emission limits	Not applicable[1]
7.4	Receiver conducted emission limits	Not applicable[1]
8.8	AC power-line conducted emission limits	Not applicable[2]

Notes: [1] According to sections 5.2 and 5.3 of RSS-Gen, EUT does not have a stand-alone receiver neither scanner receiver, therefore exempt from receiver requirements.
[2] EUT is battery powered.

Table 5.4-3: *RSS-170, Issue 4 test results*

Part	Test description	Verdict
5.2	Frequency bands	Pass
5.3	Frequency stability	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
5.10	Carrier-off state emissions	Pass

Notes: None

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	July 14, 2024
Horn antenna (1–18 GHz)	ETS-Lindgren	3117	FA002911	1 year	May 31, 2024
Preamp (1–18 GHz)	ETS Lindgren	124334	FA002956	1 year	March 27, 2024
Signal and Spectrum Analyzer	Rhode & Schwarz	FSW43	FA002971	1 year	November 30, 2024
50 Ω coax cable	Huber + Suhner	None	FA003402	1 year	July 14, 2024
50 Ω coax cable	Huber + Suhner	None	FA003047	1 year	July 14, 2024

Notes: NCR - no calibration required

Table 6.1-2: *Automation software details*

Test description	Manufacturer of Software	Details
Radiated spurious 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	0.71
Conducted spurious emissions	0.90
Occupied Channel Bandwidth	2.43 %
Signal path calibration (Insertion loss)	0.07

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	January 28, 2024	Temperature	22 °C
Tested by	Alvin Liu	Air pressure	980 mbar
Test location	Cambridge	Relative humidity	46 %

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
1626.501625	1.052
1643.500000	1.042
1660.498375	1.051

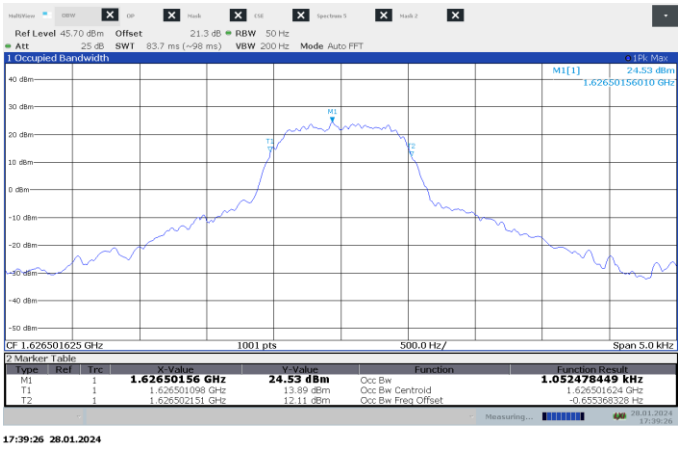


Figure 7.1-1: *99 % bandwidth on low channel – Waveform R*

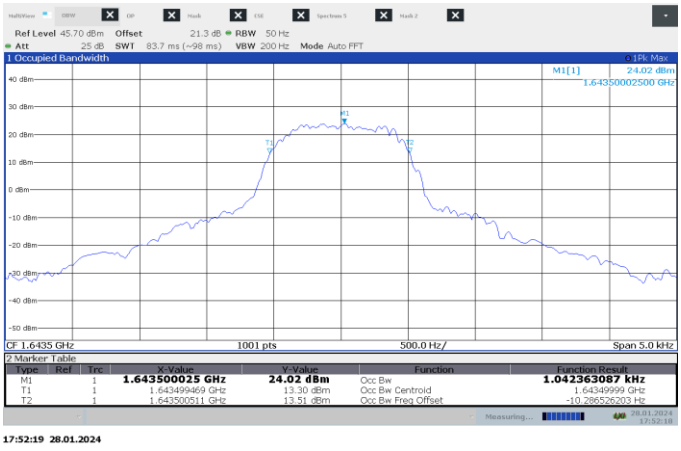


Figure 7.1-2: *99 % bandwidth on mid channel – Waveform R*

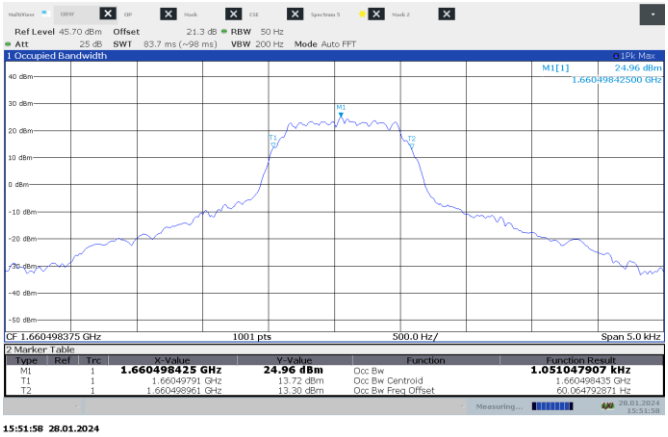


Figure 7.1-3: *99 % bandwidth on high channel – Waveform R*

Test data, continued

Table 7.1-2: *99 % occupied bandwidth results – Waveform S*

Frequency, MHz	99 % occupied bandwidth, kHz
1626.502	1.814
1643.500	1.809
1660.498	1.818

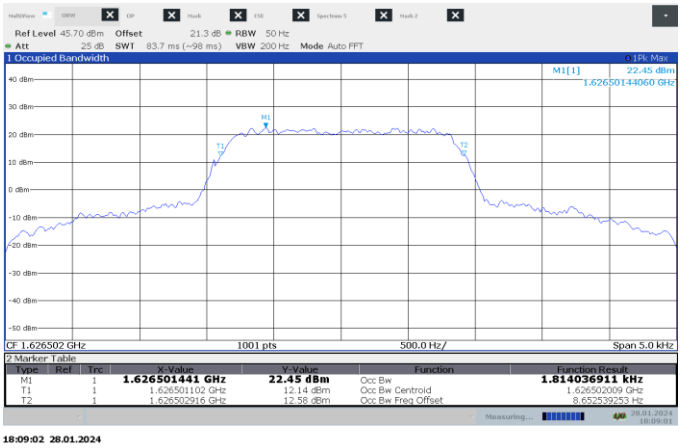


Figure 7.1-4: *99 % bandwidth on low channel – Waveform S*

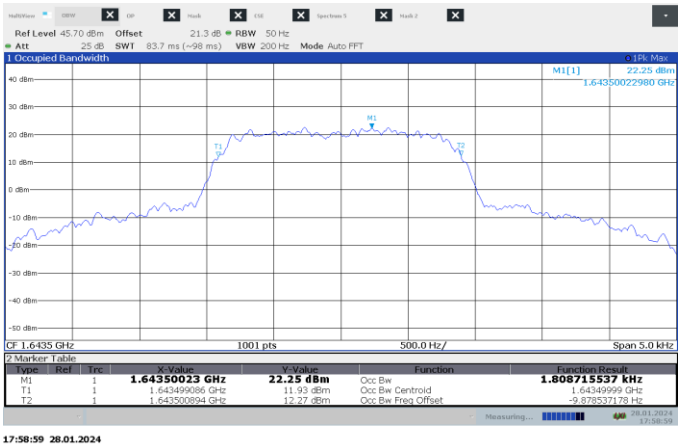


Figure 7.1-5: *99 % bandwidth on mid channel – Waveform S*

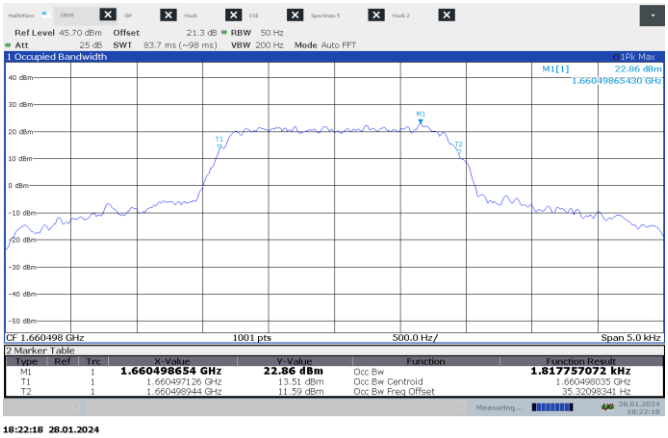


Figure 7.1-6: *99 % bandwidth on high channel – Waveform S*

Test data, continued

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

Frequency, MHz	99 % occupied bandwidth, kHz
1626.503	3.581
1643.500	3.571
1660.497	3.574

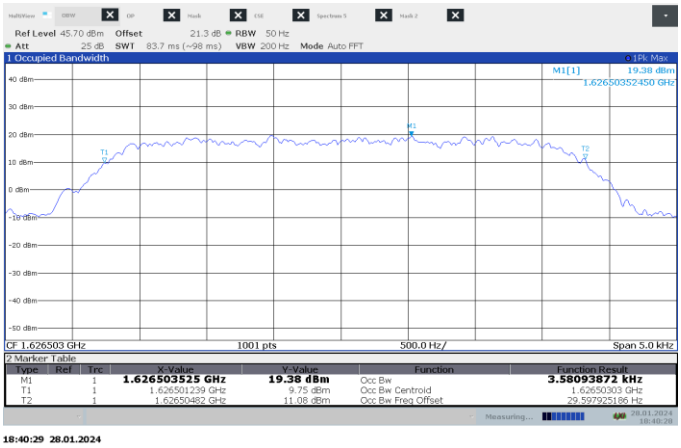


Figure 7.1-7: *99 % bandwidth on low channel – Waveform X*

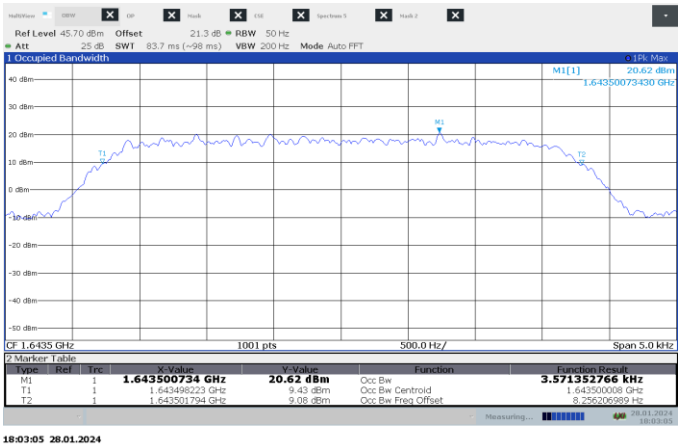


Figure 7.1-8: *99 % bandwidth on mid channel – Waveform X*

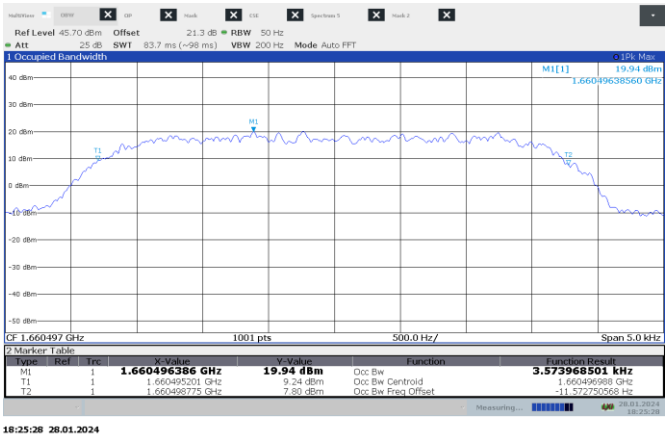


Figure 7.1-9: *99 % bandwidth on high channel – Waveform X*

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 Θ ≤ 0°
+40 + 3Θ dBW in any 4 kHz band for 0° < Θ ≤ 5°
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 Θ ≤ 0°
+64 + 3 Θ dBW in any 1 MHz band for 0° < Θ ≤ 5°
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	January 28, 2024	Temperature	22 °C
Tested by	Alvin Liu	Air pressure	980 mbar
Test location	Cambridge	Relative humidity	46 %

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 ISED – Waveform R*

Frequency, MHz	Output power, dBm	Gain, dBi	EIRP, dBm	Stated EIRP, dBm	Maximum permissible EIRP, dBm	Margin, dB
1626.501625	30.36	5.1	35.46	37.00	39.00	3.54
1643.500000	30.34	5.1	35.44	37.00	39.00	3.56
1660.498375	30.26	5.1	35.36	37.00	39.00	3.64

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
1626.501625	30.36	5.1	35.46	34.49	70.00	35.51
1643.500000	30.34	5.1	35.44	34.47	70.00	35.53
1660.498375	30.26	5.1	35.36	34.39	70.00	35.61

Note: EIRP limit [dBm/4kHz] = EIRP [dBm/5kHz] + 10×Log10(4k/5k)

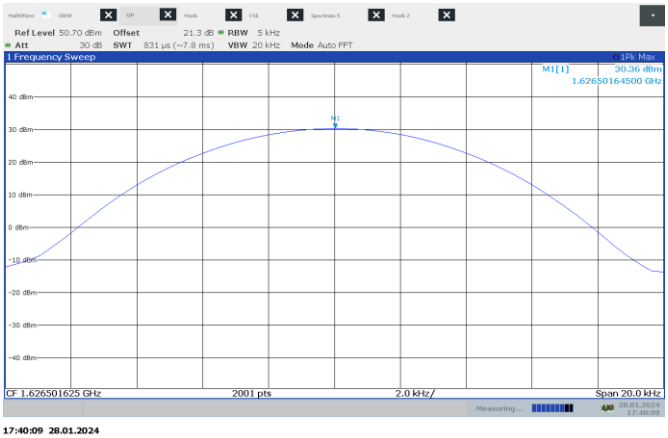


Figure 7.2-1: *Conducted peak output power on low channel – Waveform R*

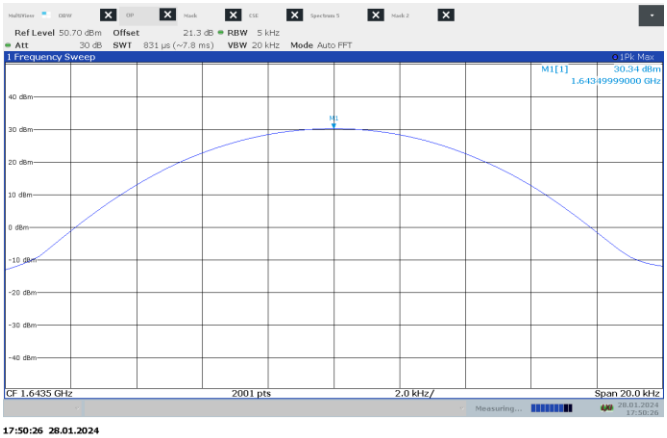


Figure 7.2-2: *Conducted peak output power on mid channel – Waveform R*

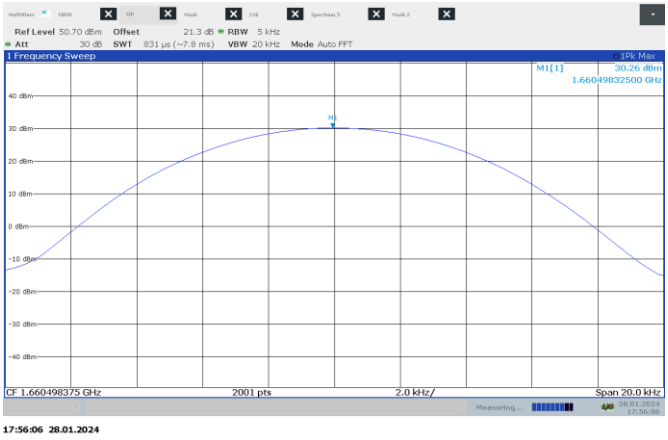


Figure 7.2-3: *Conducted peak output power on high channel – Waveform R*

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
1626.502	31.36	5.1	36.46	37.00	39.00	2.54
1643.500	30.94	5.1	36.04	37.00	39.00	2.96
1660.498	30.87	5.1	35.97	37.00	39.00	3.03

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
1626.502	31.36	5.1	36.46	35.49	70.00	34.51
1643.500	30.94	5.1	36.04	35.07	70.00	34.93
1660.498	30.87	5.1	35.97	35.00	70.00	35.00

Note: EIRP limit [dBm/4kHz] = EIRP [dBm/5kHz] + 10×Log10(4k/5k)

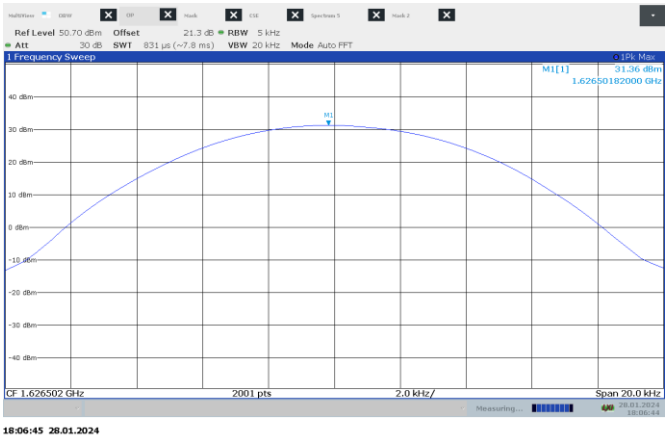


Figure 7.2-4: *Conducted peak output power on low channel – Waveform S*

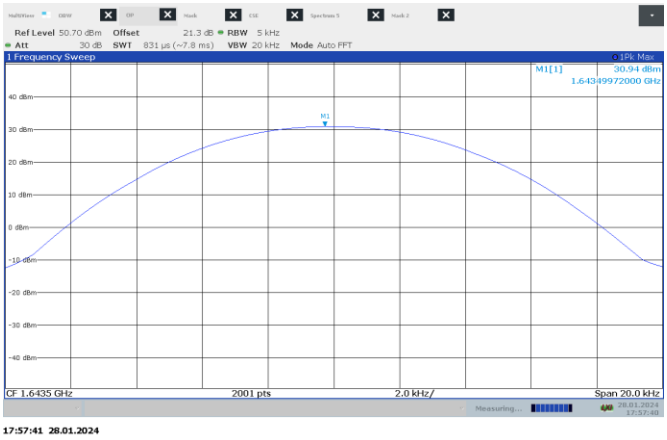


Figure 7.2-5: *Conducted peak output power on mid channel – Waveform S*

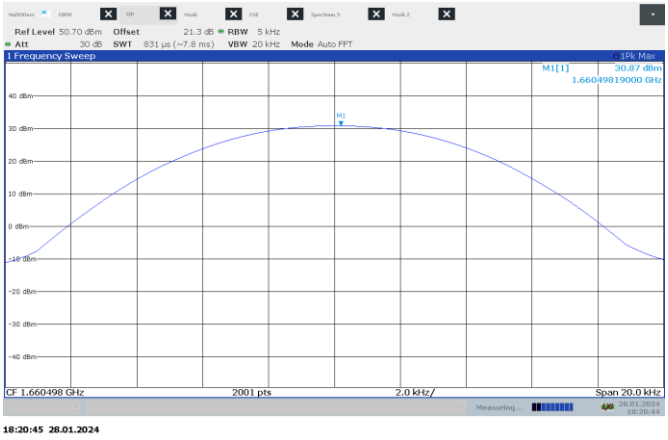


Figure 7.2-6: *Conducted peak output power on high channel – Waveform S*

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
1626.503	30.98	5.1	36.08	37.00	39.00	2.92
1643.500	30.70	5.1	35.80	37.00	39.00	3.20
1660.497	30.69	5.1	35.79	37.00	39.00	3.21

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
1626.503	30.98	5.1	36.08	35.11	70.00	34.89
1643.500	30.70	5.1	35.80	34.83	70.00	35.17
1660.497	30.69	5.1	35.79	34.82	70.00	35.18

Note: EIRP [dBm/4kHz] = EIRP [dBm/5kHz] + 10×Log10(4k/5k)

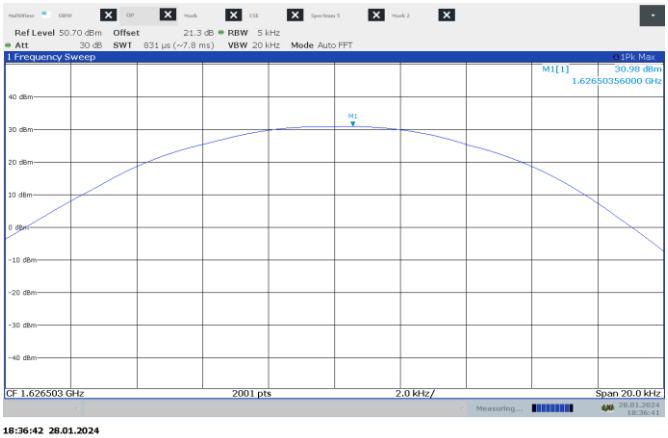


Figure 7.2-7: *Conducted peak output power on low channel – Waveform X*

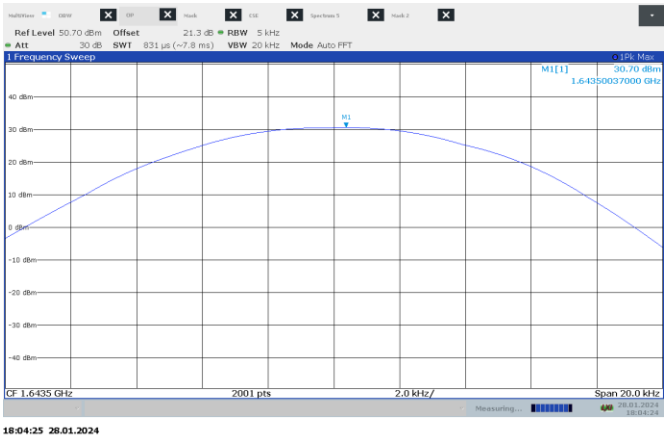


Figure 7.2-8: *Conducted peak output power on mid channel – Waveform X*

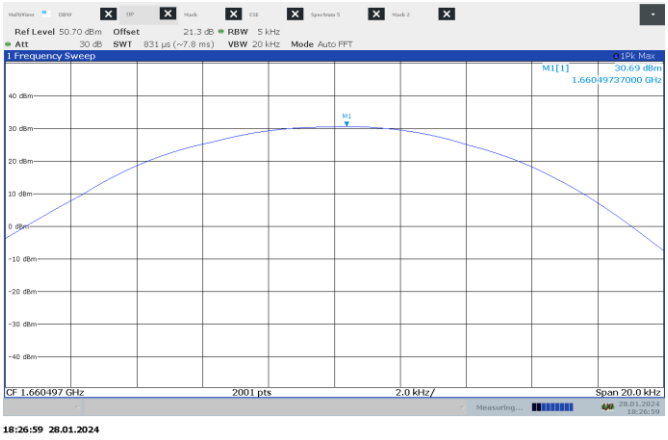


Figure 7.2-9: *Conducted peak output power on high channel – Waveform X*

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	January 19, 2028	Temperature	22 °C
Tested by	Alvin Liu	Air pressure	980 – 985 mbar
Test location	Cambridge	Relative humidity	42 – 50 %

7.3.3 Observations, settings and special notes

The spectrum was searched from 30 MHz to the 10th harmonic.
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
Radiated spurious measurements were performed while the Waveform was set at different Symbol rate. No noticeable difference of spurious emissions was observed. Only the worst-case data is presented.

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 (Reference bandwidth)/(Measurement bandwidth)

Authorized bandwidth > Occupied bandwidth, therefore, the authorized bandwidth was used to calculate spurious emission mask shifts.
For wavefor R, authorized bandwidth 3.25 kHz, 50% is 1.625 kHz shift, 100% is 3.25 kHz shift, 250% is 8.125 kHz shift.
For wavefor S, authorized bandwidth 4 kHz, 50% is 2 kHz shift, 100% is 4 kHz shift, 250% is 10 kHz shift.
For wavefor X, authorized bandwidth 6 kHz, 50% is 3 kHz shift, 100% is 6 kHz shift, 250% is 15 kHz shift.

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	≥ 1 % of OBW
Video bandwidth	≥3 × 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)	Scaled mean average power (dBm/4 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)
1626.501625	25.95	26.85	-23.35	-19.44	1.85	21.29
1660.498375	26.48	27.38	-22.72	-18.81	2.38	21.19

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)	Scaled mean average power (dBm/4 kHz)	Measured mean adjacent power 100–250% BW, (dBm/4 kHz)	Scaled mean adjacent power 100–250% BW, (dBm/4 kHz)	Limit, 100–250% (dBm/4 kHz)	Margin, (dB)
1626.501625	25.95	26.85	-26.57	-26.57	-8.15	18.42
1660.498375	26.48	27.38	-26.31	-26.31	-7.62	18.69

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

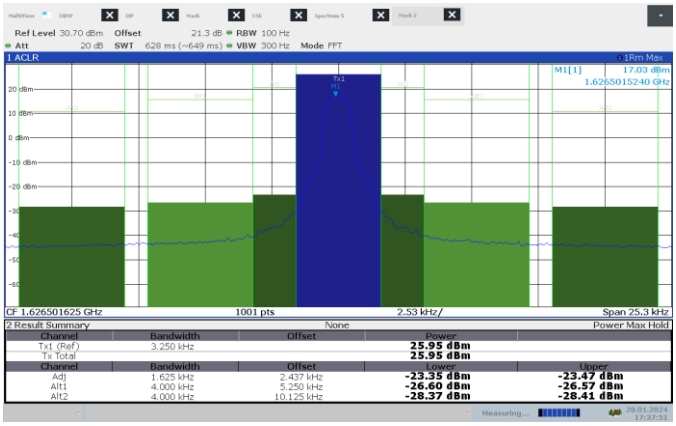


Figure 7.3-1: *Conducted band edge spurious emissions outside assigned bandwidth – Waveform R, low channel*

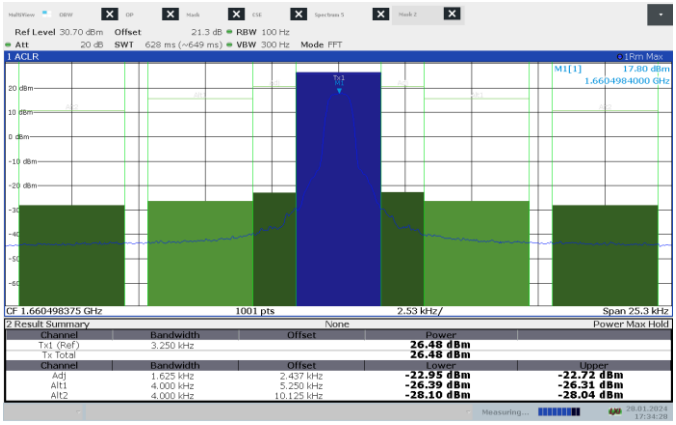


Figure 7.3-2: *Conducted band edge spurious emissions outside assigned bandwidth – Waveform R, high channel*

Test data, continued

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

Frequency, (MHz)	Measured mean output power, (dBm/4 kHz)	Scaled mean average 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)
1626.502	26.10	26.10	-13.78	-10.77	1.10	11.87
1660.498	25.72	25.72	-14.56	-11.55	0.72	12.27

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)	Scaled mean average power (dBm/4 kHz)	Measured mean adjacent power 100–250% BW, (dBm/4 kHz)	Scaled mean adjacent power 100–250% BW, (dBm/4 kHz)	Limit, 100–250% (dBm/4 kHz)	Margin, (dB)
1626.502	26.10	26.10	-27.01	-27.01	-8.90	18.11
1660.498	25.72	25.72	-27.30	-27.30	-9.28	18.02

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

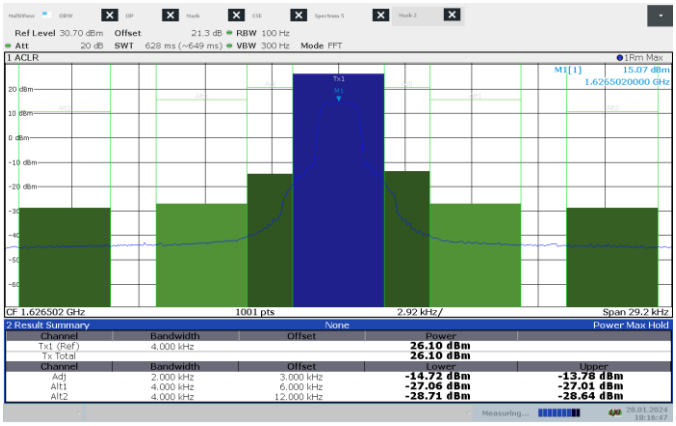


Figure 7.3-2: *Conducted band edge spurious emissions outside assigned bandwidth – Waveform S, low channel*

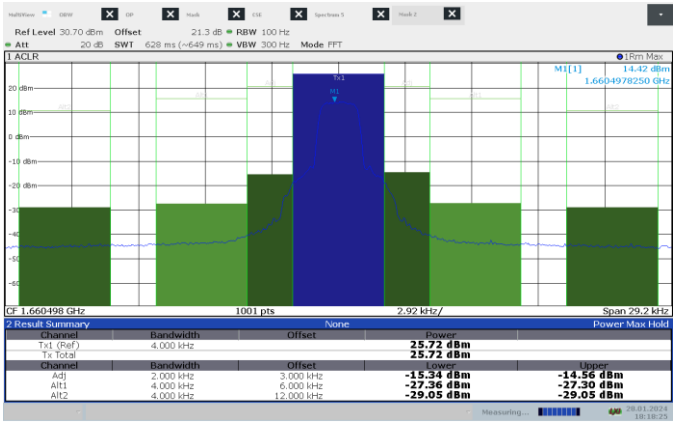


Figure 7.3-2: *Conducted band edge spurious emissions outside assigned bandwidth – Waveform S, high channel*

Test data, continued

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

Frequency, (MHz)	Measured mean output power, (dBm/4 kHz)	Scaled mean average power (dBm/4 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)
1626.503	26.08	26.08	-8.04	-6.79	1.08	7.87
1660.497	25.99	25.99	-8.44	-7.19	0.99	8.18

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 X*

Frequency, (MHz)	Measured mean output power, (dBm/4 kHz)	Scaled mean average power (dBm/4 kHz)	Measured mean adjacent power 100–250% BW, (dBm/4 kHz)	Scaled mean adjacent power 100–250% BW, (dBm/4 kHz)	Limit, 100–250% (dBm/4 kHz)	Margin, (dB)
1626.503	26.08	26.08	-25.73	-25.73	-8.92	16.81
1660.497	25.99	25.99	-26.12	-26.12	-9.01	17.11

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

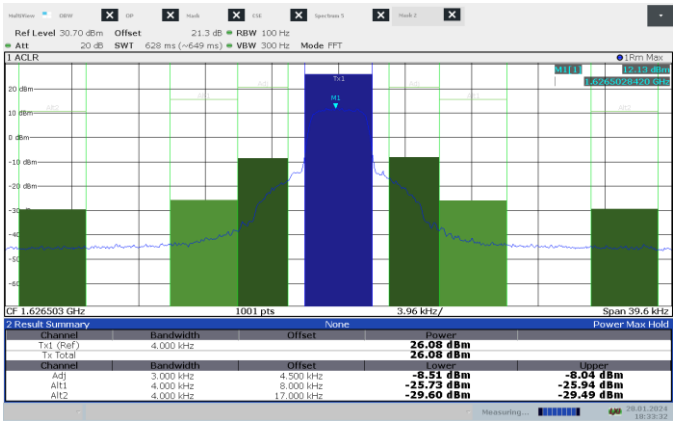


Figure 7.3-3: *Conducted band edge spurious emissions outside assigned bandwidth – Waveform X, low channel*

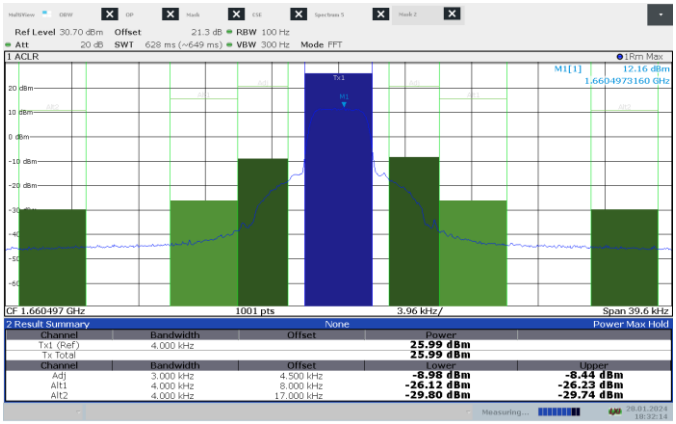


Figure 7.3-2: *Conducted band edge spurious emissions outside assigned bandwidth – Waveform X, high channel*

Test data, continued

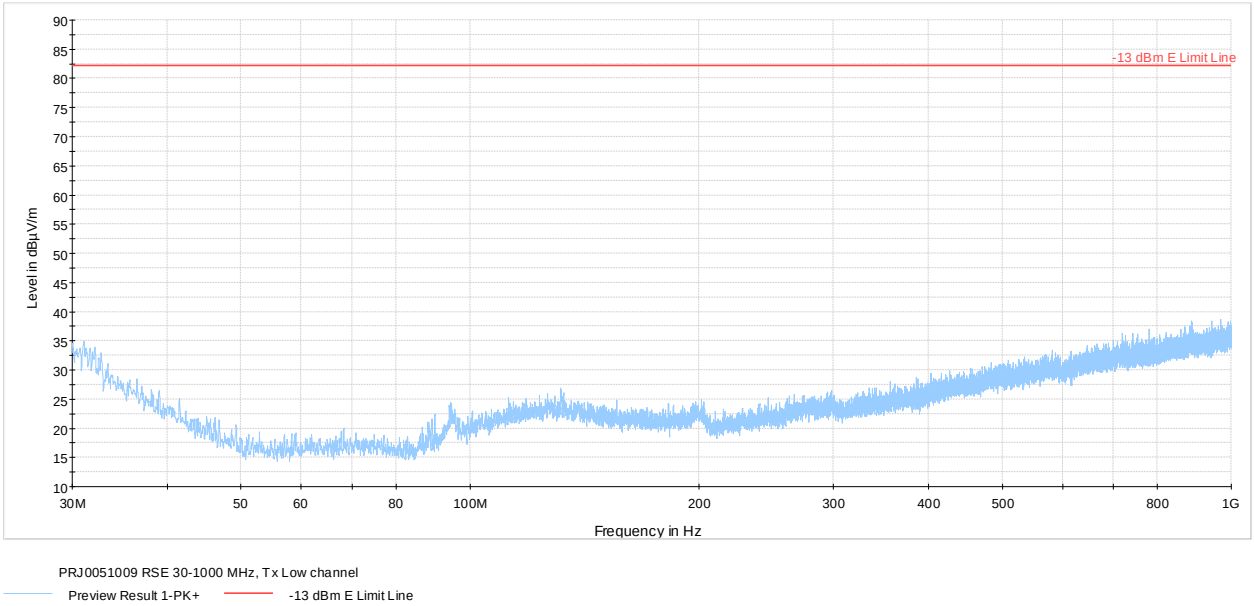


Figure 7.3-3: *Radiated Spurious emissions 30 – 1000 MHz, low channel*

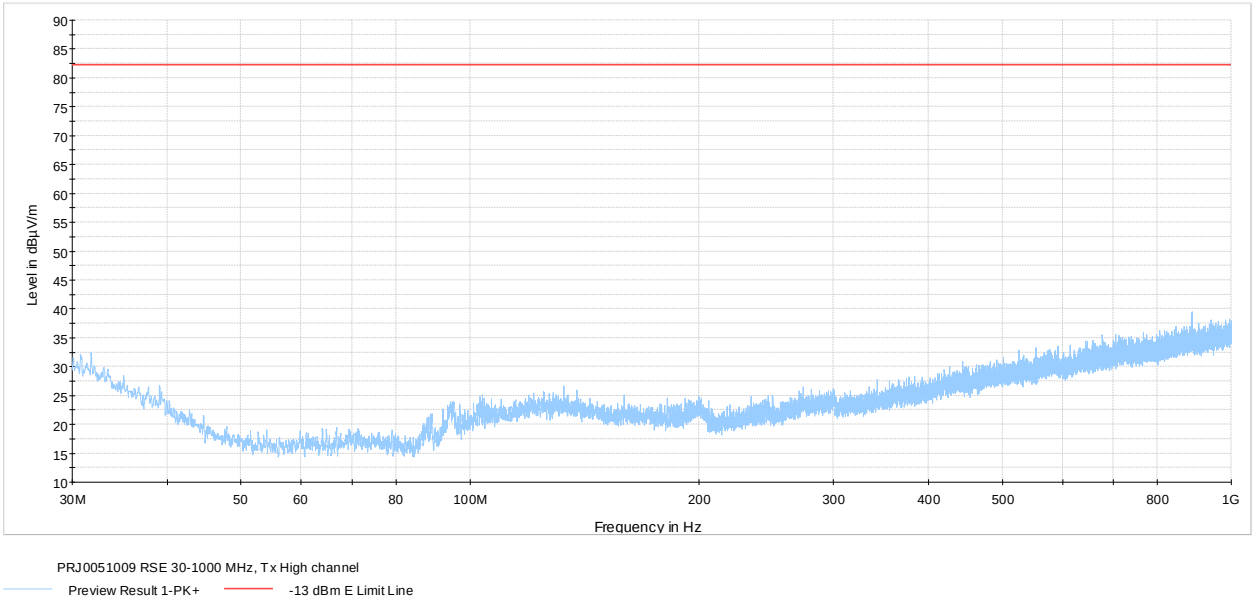


Figure 7.3-4: *Radiated Spurious emissions 30 – 1000 MHz, high channel*

Test data, continued

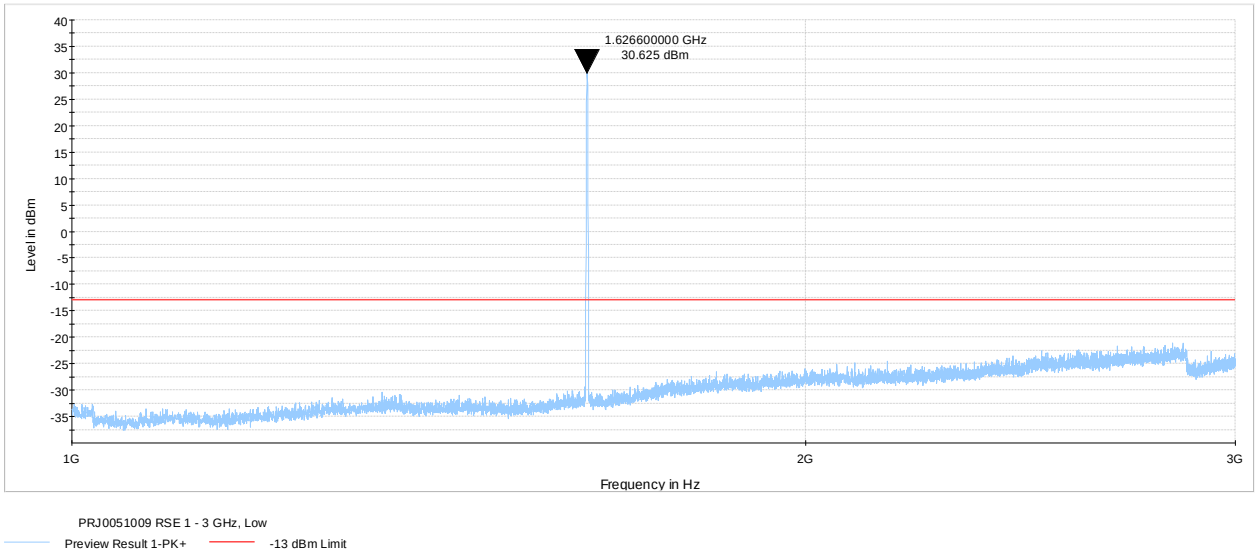


Figure 7.3-5: *Radiated Spurious emissions 1 – 3 GHz, low channel*

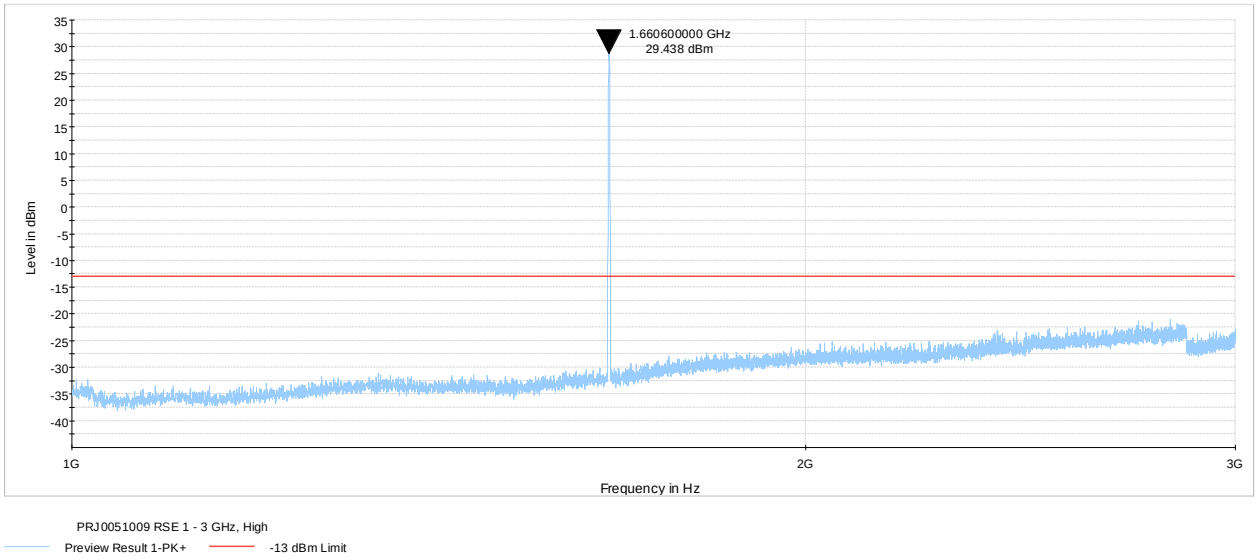


Figure 7.3-6: *Radiated Spurious emissions 1 – 3 GHz, high channel*

Test data, continued

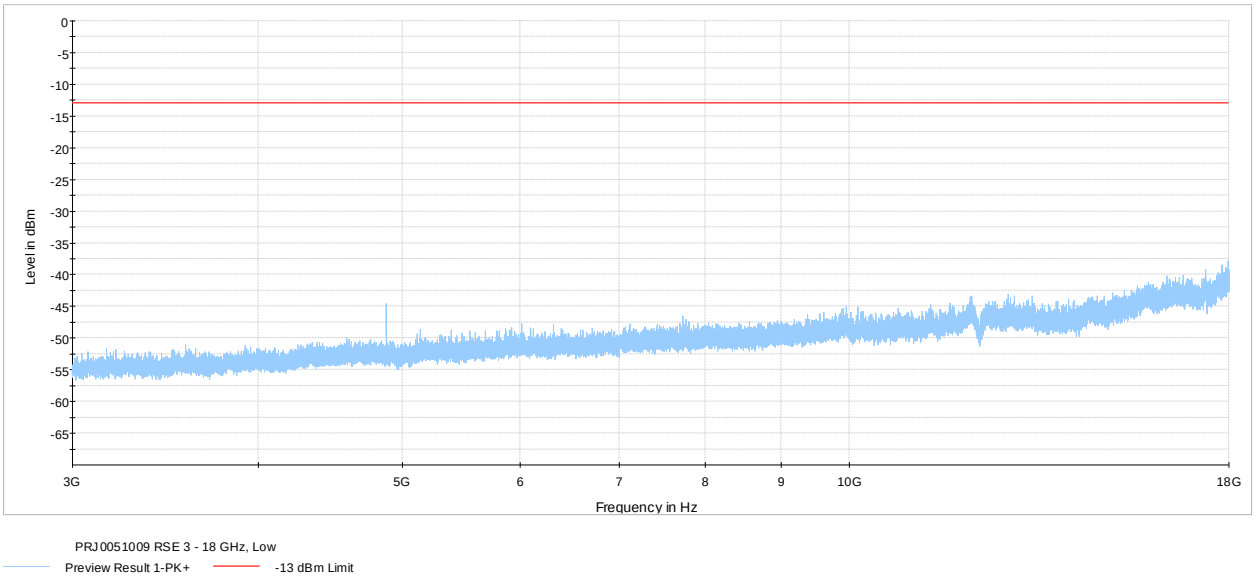


Figure 7.3-7: *Radiated Spurious emissions 3 – 18 GHz, low channel*

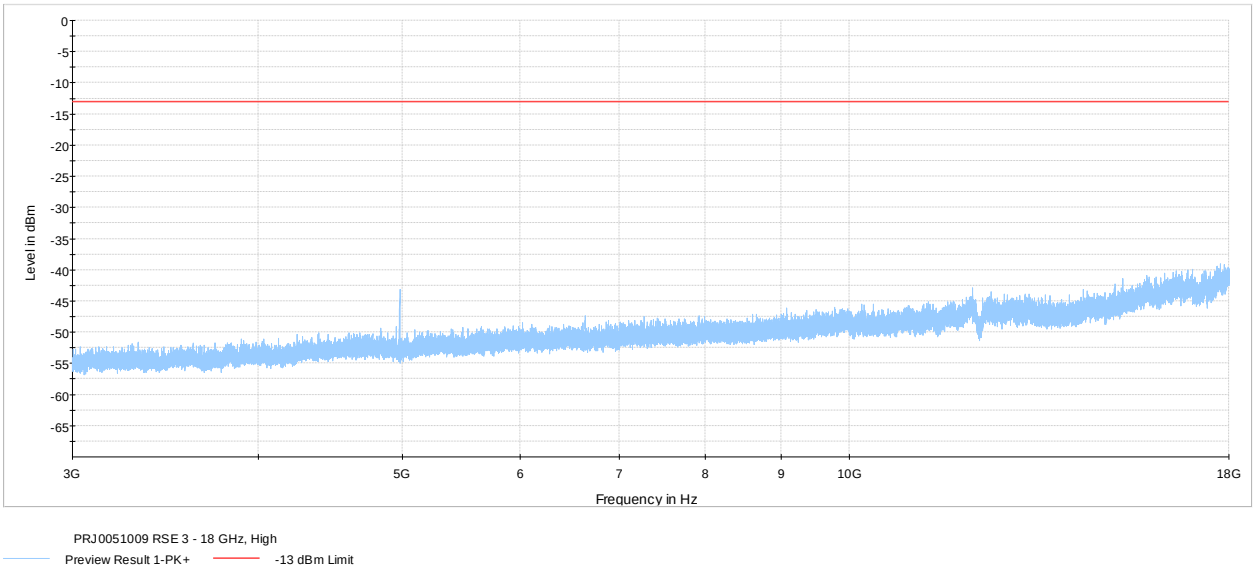


Figure 7.3-8: *Radiated Spurious emissions 3 – 18 GHz, high channel*

Test data, continued

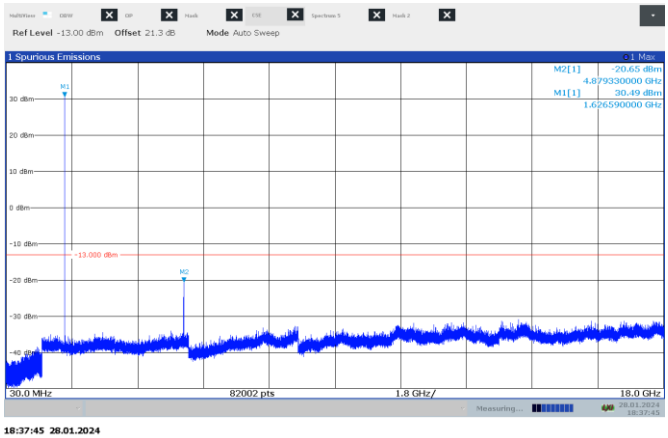


Figure 7.3-9: *Conducted spurious emissions, low channel*

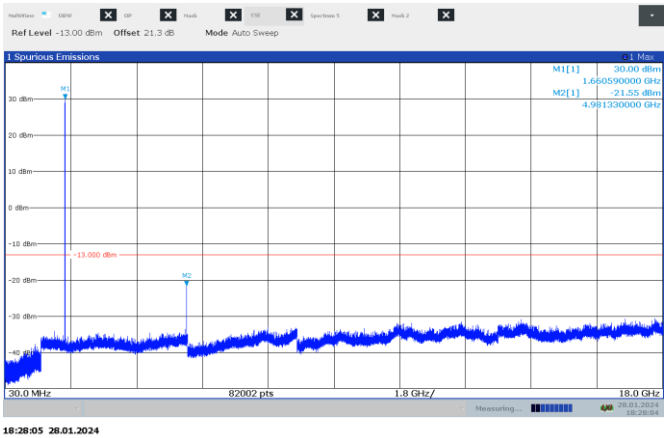


Figure 7.3-10: *Conducted spurious emissions, high channel*

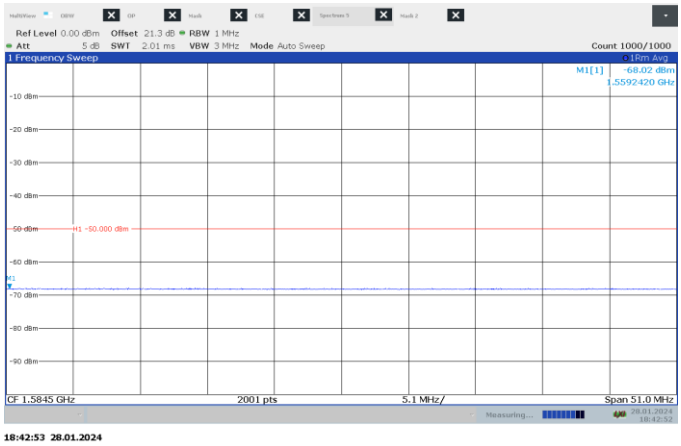


Figure 7.3-11: *Conducted emissions 1559 – 1610 MHz, Carrier-off state*

7.4 FCC 25.202(d) and RSS-170 5.3 Frequency tolerance, Earth stations

7.4.1 References, definitions and limits

FCC §25.202:

(d) **Frequency tolerance, Earth stations.**
The carrier frequency of each earth station transmitter authorized in these services shall be maintained within 0.001 percent (±10 ppm) of the reference frequency.

FCC 2.1055:

(a) The frequency stability shall be measured with variation of ambient temperature as follows:
(1) From −30°C to +50°C for all equipment except that specified in paragraphs (a)(2) and (3) of this section

(b) Frequency measurements shall be made at the extremes of the specified temperature range and at intervals of not more than 10 °C through the range.

(d) The frequency stability shall be measured with variation of primary supply voltage as follows:
(1) Vary primary supply voltage from 85 to 115 percent of the nominal value for other than hand carried battery equipment.

RSS-170, Clause 5.3:

For mobile earth station equipment, the carrier frequency shall not depart from the reference frequency by more than ±10 ppm.

7.4.2 Test summary

Verdict	Pass		
Test date	January 29, 2024	Temperature	22 °C
Tested by	Alvin Liu	Air pressure	980 mbar
Test location	Cambridge	Relative humidity	45 %

7.4.3 Observations, settings and special notes

Frequency stability measurements were performed with reference to ANSI 63.26 section 5.6.3 and section 5.6.5

EUT is only capable of operating from internal batteries and the supply voltage cannot be varied, the frequency stability tests were performed at the nominal battery voltage 3.6 V_{DC}, and the battery end point voltage 3.4 V_{DC} and 4 V_{DC} specified by the manufacturer.

Offset was calculated as per the following formula: $\frac{F_{Measured} - F_{reference}}{F_{reference}} \times 1 \cdot 10^{6}$

Spectrum analyser settings:

Resolution bandwidth:	30 Hz
Video bandwidth:	≥3 × RBW
Detector mode:	Peak
Trace mode:	Max Hold

7.4.4 Test data

Table 7.4-1: *Frequency tolerance measurement result – Waveform R, Low channel*

Test conditions	Frequency, GHz	Offset, ppm	Limit, ±ppm	Margin, ppm
+50 °C, 3.6 V_{DC}	1.626501648	0.01	10.00	9.99
+40 °C, 3.6 V_{DC}	1.626501604	-0.02	10.00	9.98
+30 °C, 3.6 V_{DC}	1.626501600	-0.02	10.00	9.98
+20 °C, 4.0 V_{DC}	1.626501641	0.00	10.00	10.00
+20 °C, 3.6 V_{DC}	**1.626501637**		**Reference**	
+20 °C, 3.4 V_{DC}	1.626501629	0.00	10.00	10.00
+10 °C, 3.6 V_{DC}	1.626501458	-0.11	10.00	9.89
0 °C, 3.6 V_{DC}	1.626501583	-0.03	10.00	9.97
−10 °C, 3.6 V_{DC}	1.626501632	0.00	10.00	10.00
−20 °C, 3.6 V_{DC}	1.626501659	0.01	10.00	9.99
−30 °C, 3.6 V_{DC}	1.626501694	0.04	10.00	9.96

Table 7.4-2: *Frequency tolerance measurement result – Waveform R, Mid channel*

Test conditions	Frequency, GHz	Offset, ppm	Limit, ±ppm	Margin, ppm
+50 °C, 3.6 V_{DC}	1.643500022	0.01	10.00	9.99
+40 °C, 3.6 V_{DC}	1.643499828	-0.11	10.00	9.89
+30 °C, 3.6 V_{DC}	1.643499974	-0.02	10.00	9.98
+20 °C, 4.0 V_{DC}	1.643500004	0.00	10.00	10.00
+20 °C, 3.6 V_{DC}	**1.643500008**		**Reference**	
+20 °C, 3.4 V_{DC}	1.643500012	0.00	10.00	10.00
+10 °C, 3.6 V_{DC}	1.643499832	-0.11	10.00	9.89
0 °C, 3.6 V_{DC}	1.643499929	-0.05	10.00	9.95
−10 °C, 3.6 V_{DC}	1.643500028	0.01	10.00	9.99
−20 °C, 3.6 V_{DC}	1.643500052	0.03	10.00	9.97
−30 °C, 3.6 V_{DC}	1.643500072	0.04	10.00	9.96

Table 7.4-3: *Frequency tolerance measurement result – Waveform R, High channel*

Test conditions	Frequency, GHz	Offset, ppm	Limit, ±ppm	Margin, ppm
+50 °C, 3.6 V_{DC}	1.660498394	0.01	10.00	9.99
+40 °C, 3.6 V_{DC}	1.660498358	-0.01	10.00	9.99
+30 °C, 3.6 V_{DC}	1.660498260	-0.07	10.00	9.93
+20 °C, 4.0 V_{DC}	1.660498375	0.00	10.00	10.00
+20 °C, 3.6 V_{DC}	**1.660498375**		**Reference**	
+20 °C, 3.4 V_{DC}	1.660498383	0.00	10.00	10.00
+10 °C, 3.6 V_{DC}	1.660498192	-0.11	10.00	9.89
0 °C, 3.6 V_{DC}	1.660498378	0.00	10.00	10.00
−10 °C, 3.6 V_{DC}	1.660498393	0.01	10.00	9.99
−20 °C, 3.6 V_{DC}	1.660498419	0.03	10.00	9.97
−30 °C, 3.6 V_{DC}	1.660498428	0.03	10.00	9.97

Test data, continued

Table 7.4-2: *Frequency tolerance measurement result – Waveform S, Low channel*

Test conditions	Frequency, GHz	Offset, ppm	Limit, ±ppm	Margin, ppm
+50 °C, 3.6 V_{DC}	1.626502024	0.00	10.00	10.00
+40 °C, 3.6 V_{DC}	1.626501986	-0.02	10.00	9.98
+30 °C, 3.6 V_{DC}	1.626501894	-0.08	10.00	9.92
+20 °C, 4.0 V_{DC}	1.626502018	0.00	10.00	10.00
+20 °C, 3.6 V_{DC}	**1.626502024**		**Reference**	
+20 °C, 3.4 V_{DC}	1.626502026	0.00	10.00	10.00
+10 °C, 3.6 V_{DC}	1.626501836	-0.12	10.00	9.88
0 °C, 3.6 V_{DC}	1.626501988	-0.02	10.00	9.98
−10 °C, 3.6 V_{DC}	1.626502028	0.00	10.00	10.00
−20 °C, 3.6 V_{DC}	1.626502053	0.02	10.00	9.98
−30 °C, 3.6 V_{DC}	1.626502070	0.03	10.00	9.97

Table 7.4-2: *Frequency tolerance measurement result – Waveform S, Mid channel*

Test conditions	Frequency, GHz	Offset, ppm	Limit, ±ppm	Margin, ppm
+50 °C, 3.6 V_{DC}	1.643500020	0.01	10.00	9.99
+40 °C, 3.6 V_{DC}	1.643499982	-0.02	10.00	9.98
+30 °C, 3.6 V_{DC}	1.643499838	-0.10	10.00	9.90
+20 °C, 4.0 V_{DC}	1.643500014	0.00	10.00	10.00
+20 °C, 3.6 V_{DC}	**1.643500008**		**Reference**	
+20 °C, 3.4 V_{DC}	1.643500004	0.00	10.00	10.00
+10 °C, 3.6 V_{DC}	1.643499824	-0.11	10.00	9.89
0 °C, 3.6 V_{DC}	1.643499988	-0.01	10.00	9.99
−10 °C, 3.6 V_{DC}	1.643500033	0.02	10.00	9.98
−20 °C, 3.6 V_{DC}	1.643500058	0.03	10.00	9.97
−30 °C, 3.6 V_{DC}	1.643500088	0.05	10.00	9.95

Table 7.4-3: *Frequency tolerance measurement result – Waveform S, High channel*

Test conditions	Frequency, GHz	Offset, ppm	Limit, ±ppm	Margin, ppm
+50 °C, 3.6 V_{DC}	1.660498014	-0.01	10.00	9.99
+40 °C, 3.6 V_{DC}	1.660497976	-0.03	10.00	9.97
+30 °C, 3.6 V_{DC}	1.660497874	-0.09	10.00	9.91
+20 °C, 4.0 V_{DC}	1.660498028	0.00	10.00	10.00
+20 °C, 3.6 V_{DC}	**1.660498026**		**Reference**	
+20 °C, 3.4 V_{DC}	1.660498026	0.00	10.00	10.00
+10 °C, 3.6 V_{DC}	1.660497814	-0.13	10.00	9.87
0 °C, 3.6 V_{DC}	1.660497993	-0.02	10.00	9.98
−10 °C, 3.6 V_{DC}	1.660498018	0.00	10.00	10.00
−20 °C, 3.6 V_{DC}	1.660498033	0.00	10.00	10.00
−30 °C, 3.6 V_{DC}	1.660498056	0.02	10.00	9.98

Test data, continued

Table 7.4-3: *Frequency tolerance measurement result – Waveform X, Low channel*

Test conditions	Frequency, GHz	Offset, ppm	Limit, ±ppm	Margin, ppm
+50 °C, 3.6 V_{DC}	1.626503024	0.00	10.00	10.00
+40 °C, 3.6 V_{DC}	1.626502980	-0.03	10.00	9.97
+30 °C, 3.6 V_{DC}	1.626502886	-0.08	10.00	9.92
+20 °C, 4.0 V_{DC}	1.626503008	-0.01	10.00	9.99
+20 °C, 3.6 V_{DC}	**1.626503024**		**Reference**	
+20 °C, 3.4 V_{DC}	1.626503000	-0.01	10.00	9.99
+10 °C, 3.6 V_{DC}	1.626502864	-0.10	10.00	9.90
0 °C, 3.6 V_{DC}	1.626502984	-0.02	10.00	9.98
−10 °C, 3.6 V_{DC}	1.626503006	-0.01	10.00	9.99
−20 °C, 3.6 V_{DC}	1.626503032	0.00	10.00	10.00
−30 °C, 3.6 V_{DC}	1.626503066	0.03	10.00	9.97

Table 7.4-2: *Frequency tolerance measurement result – Waveform X, Mid channel*

Test conditions	Frequency, GHz	Offset, ppm	Limit, ±ppm	Margin, ppm
+50 °C, 3.6 V_{DC}	1.643500022	0.00	10.00	10.00
+40 °C, 3.6 V_{DC}	1.643499984	-0.03	10.00	9.97
+30 °C, 3.6 V_{DC}	1.643499850	-0.11	10.00	9.89
+20 °C, 4.0 V_{DC}	1.643500024	0.00	10.00	10.00
+20 °C, 3.6 V_{DC}	**1.643500026**		**Reference**	
+20 °C, 3.4 V_{DC}	1.643500024	0.00	10.00	10.00
+10 °C, 3.6 V_{DC}	1.643499848	-0.11	10.00	9.89
0 °C, 3.6 V_{DC}	1.643500012	-0.01	10.00	9.99
−10 °C, 3.6 V_{DC}	1.643500033	0.00	10.00	10.00
−20 °C, 3.6 V_{DC}	1.643500035	0.01	10.00	9.99
−30 °C, 3.6 V_{DC}	1.643500042	0.01	10.00	9.99

Table 7.4-3: *Frequency tolerance measurement result – Waveform X, High channel*

Test conditions	Frequency, GHz	Offset, ppm	Limit, ±ppm	Margin, ppm
+50 °C, 3.6 V_{DC}	1.660497012	0.00	10.00	10.00
+40 °C, 3.6 V_{DC}	1.660496954	-0.04	10.00	9.96
+30 °C, 3.6 V_{DC}	1.660496858	-0.10	10.00	9.90
+20 °C, 4.0 V_{DC}	1.660497022	0.00	10.00	10.00
+20 °C, 3.6 V_{DC}	**1.660497020**		**Reference**	
+20 °C, 3.4 V_{DC}	1.660497024	0.00	10.00	10.00
+10 °C, 3.6 V_{DC}	1.660496832	-0.11	10.00	9.89
0 °C, 3.6 V_{DC}	1.660496968	-0.03	10.00	9.97
−10 °C, 3.6 V_{DC}	1.660497028	0.00	10.00	10.00
−20 °C, 3.6 V_{DC}	1.660497060	0.02	10.00	9.98
−30 °C, 3.6 V_{DC}	1.660497088	0.04	10.00	9.96

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

7.5.1 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:

5.9.1 Mobile earth stations with transmitting frequencies between 1610 and 1626.5 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 −10 dBW/MHz (20 dBm/MHz) at 1610 MHz, for broadband emissions; and
(2) −80 dBW/kHz (−50 dBm/kHz) at 1605 MHz, linearly interpolated to −20 dBW/kHz (10 dBm/kHz) at 1610 MHz, for discrete emissions.

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.

7.5.2 Test summary

Verdict	Pass		
Test date	January 24, 2024	Temperature	22 °C
Tested by	Alvin Liu	Air pressure	985 mbar
Test location	Cambridge	Relative humidity	50 %

7.5.3 Observations, settings, and special notes

The test was performed radiated at the distance of 3 m. (Direct radiated field strength method based on a pre-characterized path loss per ANSI 63.4)
EUT was tested while the Waveform was set at different Symbol rate. No noticeable difference of spurious emissions was observed. Only the worst-case data is presented.

Spectrum analyser settings:

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

7.5.4 Test data

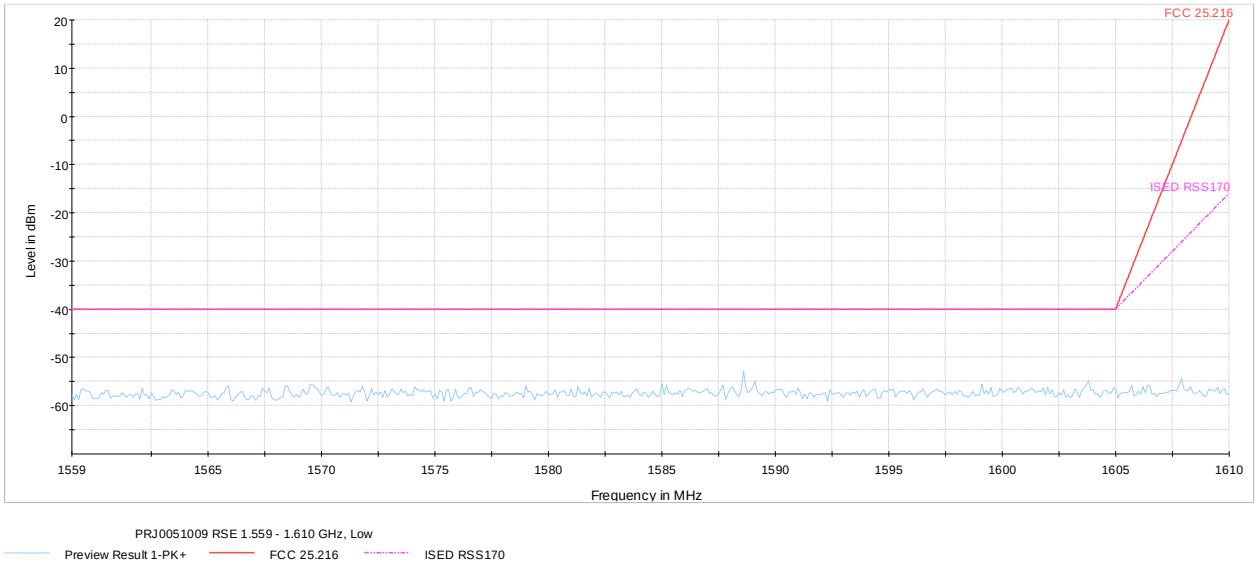


Figure 7.5-1: *Radiated spurious emissions 1559–1610 MHz, low channel*

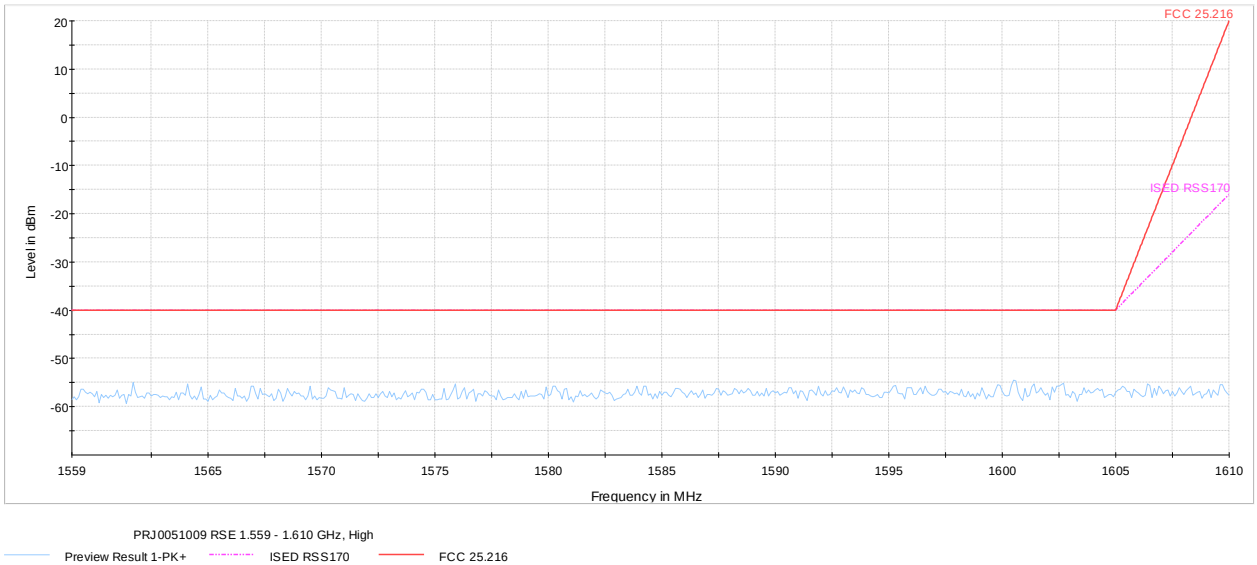
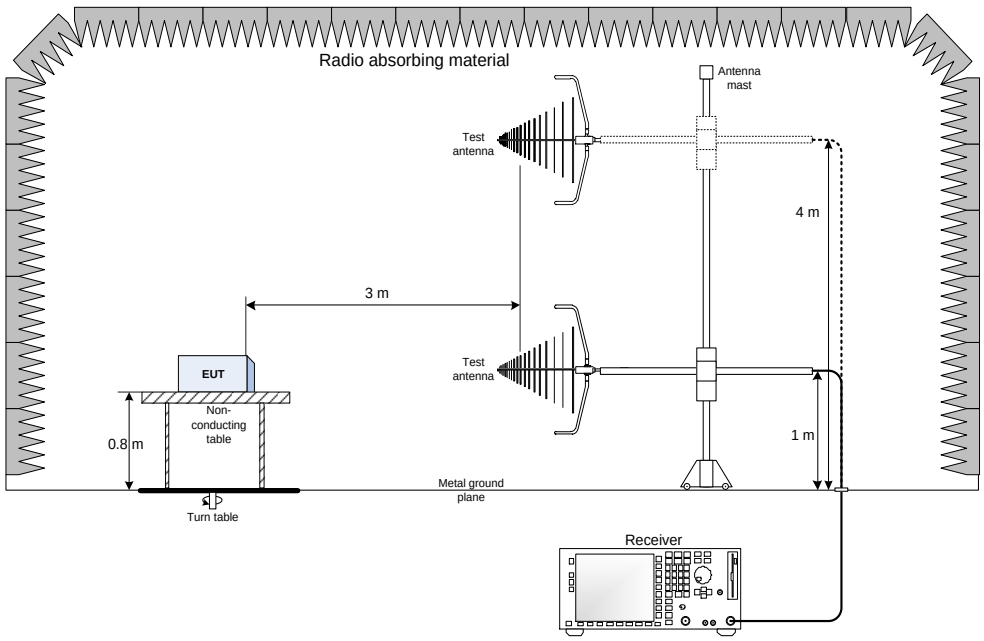


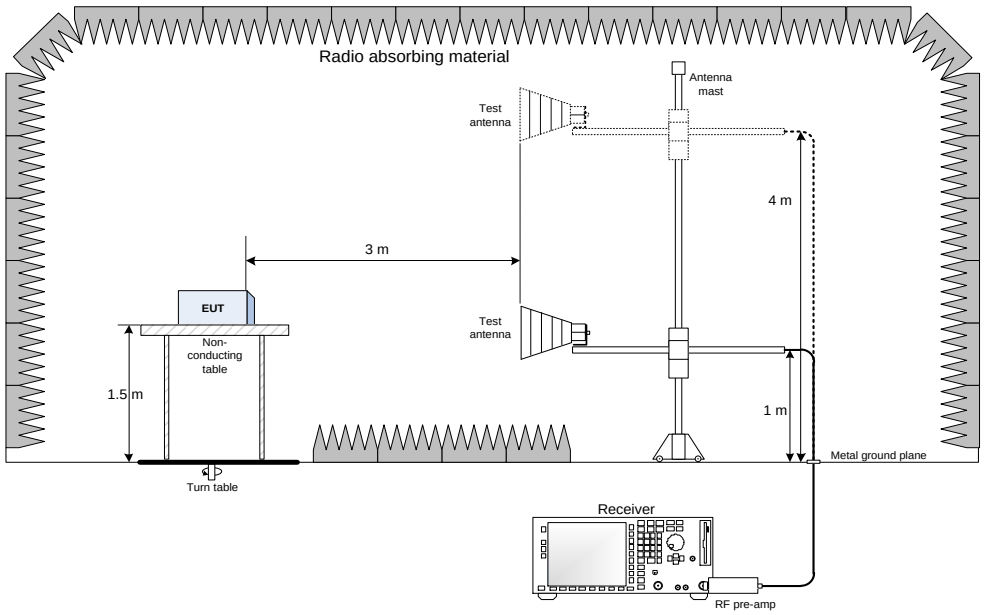
Figure 7.5-2: *Radiated spurious emissions 1559–1610 MHz, high channel*

Section 8. Test setup diagrams

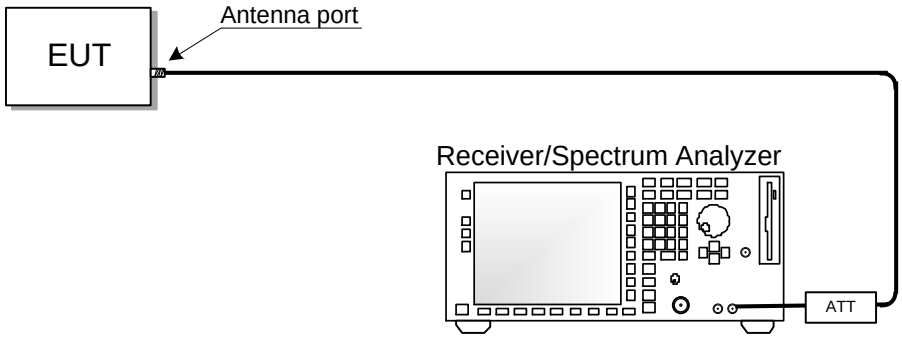
8.1 Radiated emissions set-up for frequencies below 1 GHz



8.2 Radiated emissions set-up for frequencies above 1 GHz



8.3 Antenna port set-up



End of the test report