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Wireless Test Report – 3R467183TRFWL

Applicant:

Aeryon

Product name:

Skyranger Base Station

Model:

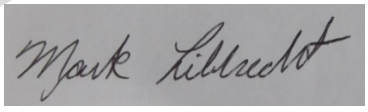
R70

Specifications:

- Article 2, paragraph 1, of Item 72
- Category RB

Date of issue: March 27, 2019

Test engineer(s): Mark Libbrecht

Signature: 

Reviewed by: Tom Tidwell

Signature: 

Lab and Test location(s)

Company name	Nemko Canada Inc. (Cambridge)
Facility	130 Saltsman Drive, Unit #1 Cambridge, ON Canada, N3E 0B2 Tel: +1 519 680 4811 Test Firm Registration Number: 332406
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 contain in this report are within Nemko Canada's ISO/IEC 17025 accreditation.

Copyright notification

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Section 1. Report summary

1.1 Applicant and manufacturer

Company name	Aeryon
Address	575 Kumpf Drive
City	Waterloo
Province/State	Ontario
Postal/Zip code	N2V 1K3
Country	Canada

1.2 Test specifications

Article 2 Paragraph 1 of item 72	Unmanned Mobile Image Transmission System

1.3 Test methods

DSP Research Inc. 2015 Test Procedure	Characteristic test method of the unmanned mobile image transmission system

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 1.5 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 Exclusions

None

1.6 Test report revision history

Revision #	Date of issue	Details of changes made to test report
TRF	February 21, 2019	Original report issued
R1	March 14, 2019	EUT Power for MIMO 2x2, Frequency Stability Pre-vibe, Site Registration Number
R2	March 18, 2019	Voltage variation +/- 20% added
R3	March 20, 2019	Spurious ch1, 99% OBW ch1 added. Antenna Gain updated
R4	March 27, 2019	Corrected MIMO antenna power tables. Added antenna patterns

Section 2. Summary of test results

2.1 General requirements test results

Table 2.1-1: *Results for Category RB Testing*

Part	Test description	Verdict
3	Temperature and Humidity test	Pass
4	Frequency Deviation	Pass
5	Occupied Bandwidth	Pass
7	Conducted Spurious Emissions	Pass
8	Antenna Power	Pass
9	Radiated Spurious Emissions	Pass

Section 3. Equipment under test (EUT) details

3.1 Sample information

Receipt date	January 2, 2019
Nemko sample ID number	1

3.2 EUT information

Product name	Skyranger Base Station
Model	R70
Serial number	BSH200052077

3.3 Technical information

All used IC test site(s) Reg. number	24676
Frequency band	2483.5 – 2494 MHz
Frequency Min (MHz)	N/A
Frequency Max (MHz)	2489
RF power Max (W), Conducted	0.873 W (29.4 dBm)
Field strength, Units @ distance	N/A
Measured BW (kHz) (99%)	4750
Type of modulation	OFDM
Emission classification (F1D, G1D, D1D)	W7W
Transmitter spurious, Units @ distance	5203.5 MHz 50.6 dBµV/m, 3 m
Power requirements	120 V_{AC} 60 Hz
Antenna information	5 dBi dipole antenna LM252. (The EUT has a non-standard antenna jack or electrical connector.)

3.4 Product description and theory of operation

Base Station connects to Aircraft using center frequency 2489 MHz

3.5 EUT exercise details

Connect Base Station to Aircraft using provided MCS software. Monitor Aircraft camera feed on client using MCS software

3.6 EUT setup diagram

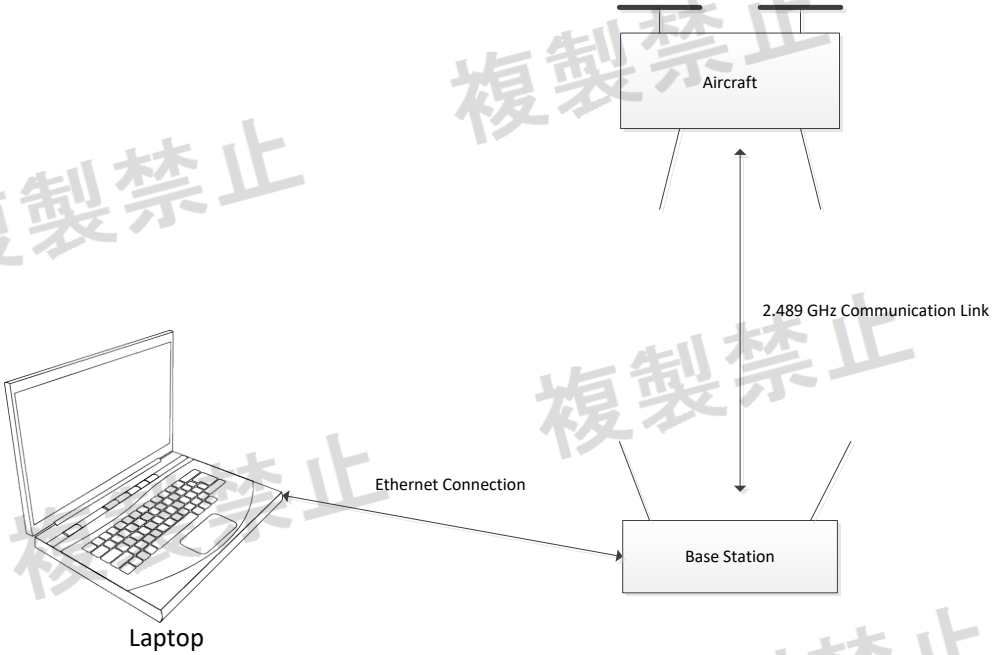


Figure 3.6-1: *Setup diagram*

3.7 EUT sub assemblies

Table 3.7-1: *EUT sub assemblies*

Description	Brand name	Model/Part number	Serial number
Laptop	Dell Latitude	E6440	6LGTG72

Section 4. Engineering considerations

4.1 Modifications incorporated in the EUT

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

4.2 Technical judgment

None

4.3 Deviations from laboratory tests procedures

No deviations were made from laboratory procedures.

Section 5. Test conditions

5.1 Atmospheric conditions

Temperature	15–30 °C
Relative humidity	20–75 %
Air pressure	860–1060 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.

5.2 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 6. Measurement uncertainty

6.1 Uncertainty of measurement

UKAS Lab 34 and TIA-603-B 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 budgets for the tests are detailed below. Measurement uncertainty calculations assume a coverage factor of K = 2 with 95% certainty.

Table 6.1-1: *Measurement uncertainty*

Test name	Measurement uncertainty, dB
All antenna port measurements	0.55
Conducted spurious emissions	1.13
Radiated spurious emissions	3.78
AC power line conducted emissions	3.55

Section 7. Test equipment

7.1 Test equipment list

Equipment	Manufacturer	Model no.	Serial no.	Asset no.	Cal./Ver. cycle	Next cal./ver.
3 m EMI test chamber	TDK	SAC-3		FA003012	1 year	Aug. 22/19
Flush mount turntable	SUNAR	FM2022		FA003006	—	NCR
Controller	SUNAR	SC110V	050118-1	FA002976	—	NCR
Antenna mast	SUNAR	TLT2	042418-5	FA003007	—	NCR
Receiver/spectrum analyzer	Rohde & Schwarz	ESR26	101367	FA002969	2 year	Mar. 2/20
Spectrum analyzer	Rohde & Schwarz	FSW43	104437	FA002971	2 year	Mar. 16/20
Horn antenna (1–18 GHz)	ETS-Lindgren	3117	00052793	FA002911	1 year	Aug. 16/19
Preamp (1–18 GHz)	ETS-Lindgren	124334	00224880	FA002956	1 year	Sept 18/19
Bilog antenna (30–2000 MHz)	SUNAR	JB1	A053018-2	FA003010	1 year	Sept. 6/19
50 Ω coax cable	Huber + Suhner	None	457630	FA003047	1 year	Nov 12/19
50 Ω coax cable	Huber + Suhner	None	457624	FA003044	1 year	Nov 12/19
Horn antenna (18–40 GHz)	EMCO	3116B	00122305	FA002948	1 year	April 18/19
Notch filter 2400–2483 MHz	Microwave Circuits	2400–2483 MHz	FA003027	—	—	VOU
50 Ω coax cable	Huber + Suhner	None	457057	FA003051	1 year	Nov 12/19
Temperature and Humidity Chamber	ESPEC	EPX-4H	0140953	N/A	1 Year	Sept. 18, 2019

Note: NCR - no calibration required, VOU - verify on use

Section 8. Testing data

8.1 Variation of power source

8.1.1 Definitions and limits

For intentional radiators, measurements of the variation of the input power or the radiated signal level of the fundamental frequency component of the emission, as appropriate, shall be performed with the supply voltage varied between 80% and 120% of the nominal rated supply voltage. For battery operated equipment, the equipment tests shall be performed using a new battery.

8.1.2 Observations, settings and special notes

a) For devices with wide range of rated supply voltage, test at 20% below the lowest and 20% above the highest declared nominal rated supply voltage.
b) For battery-operated equipment, the equipment tests shall be performed using a variable power supply.

8.1.3 Test data

EUT Power requirements:	☐ AC	☐ DC	☒ Battery
If EUT is an AC or a DC powered, was the noticeable output power variation observed?	☐ YES	☐ NO	☒ N/A
If EUT is battery operated, was the testing performed using fresh batteries?	☐ YES	☐ NO	☒ N/A
If EUT is rechargeable battery operated, was the testing performed using fully charged batteries?	☒ YES	☐ NO	☐ N/A

8.2 Test Channel Selection

Table 8.2-1: *Test channels selection*

Start of Frequency range, MHz	End of Frequency range, MHz	Frequency range bandwidth, MHz	Low channel, MHz	Mid channel, MHz	High channel, MHz
2483.5	2494	10.5	2489	2489	2489

This EUT has only one channel of operation: 2489 MHz

8.3 Antenna Requirements

Antenna Gain = 5 dBi

Must the EUT be professionally installed?	☐ YES	☒ NO	
Does the EUT have detachable antenna(s)?	☒ YES	☐ NO	
If detachable, is the antenna connector(s) non-standard?	☒ YES	☐ NO	☐ N/A

Note: reverse SMA connector

8.4 Humidity Test

8.4.1 Definitions and limits

Temperature Variation: Vary thermal chamber from -20 degrees Celsius to 50 degrees Celsius; allow EUT to soak for 1 Hour at each plateau. Vary EUT input voltage +/- 10%, and verify frequency deviation (Section 8.5)

Humidity test: Set thermal chamber at 35 degrees Celsius, 95% humidity. Allow EUT to soak for 4 hours non-operational. Verify EUT operation post humidity testing - Pass

8.4.1 Test summary

Verdict	Pass		
Test date	February 8, 2019	Temperature	23 °C
Test engineer	Mark Libbrecht	Air pressure	980 mbar
Test location	GTA	Relative humidity	32 %

8.4.2 Observations, settings and special notes

None

8.4.1 Test data

8.4.1 Test data, continued

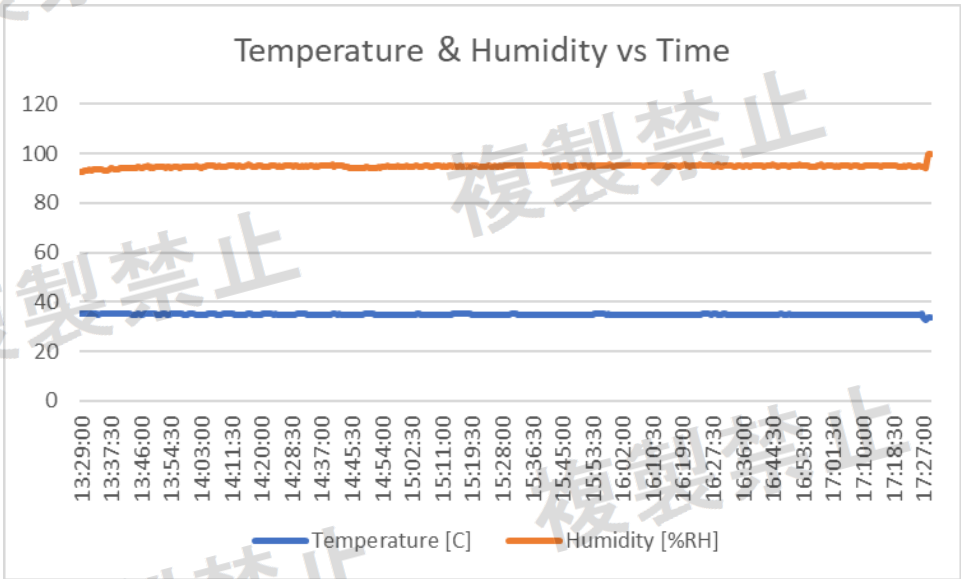


Figure 8.4-1: *Humidity Test*

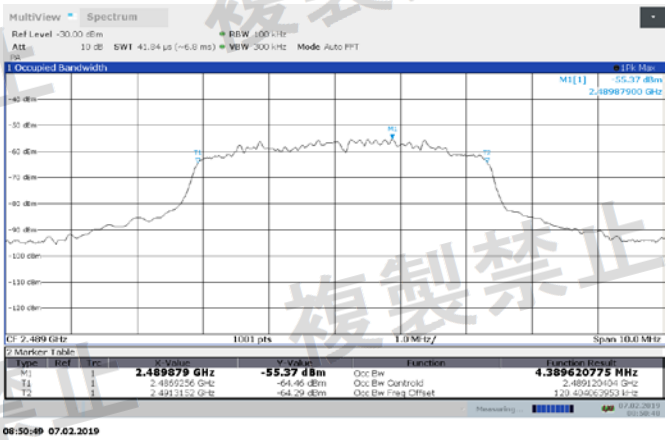


Figure 8.4-2: 2489 MHz, Pre-Humidity test

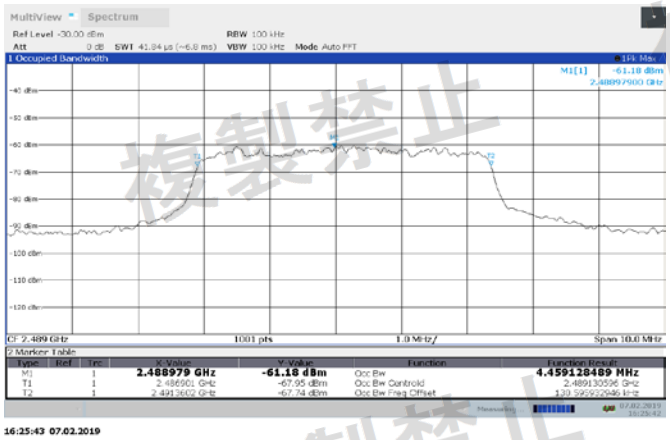


Figure 8.4-3: 2489 MHz, Post-Humidity test

8.5 Frequency Tolerance and Voltage Variation

8.5.1 Definitions and limits

Article 2 Paragraph 1 of item 72 Appendix 2 – Frequency Tolerance = 50 ppm
Voltage variation completed at +/- 20 % recommended DC input voltage

8.5.2 Test summary

Verdict	Pass		
Test date	February 7, 2019	Temperature	22 °C
Test engineer	Mark Libbrecht	Air pressure	975 mbar
Test location	GTA	Relative humidity	31 %

8.5.3 Observations, settings and special notes

None

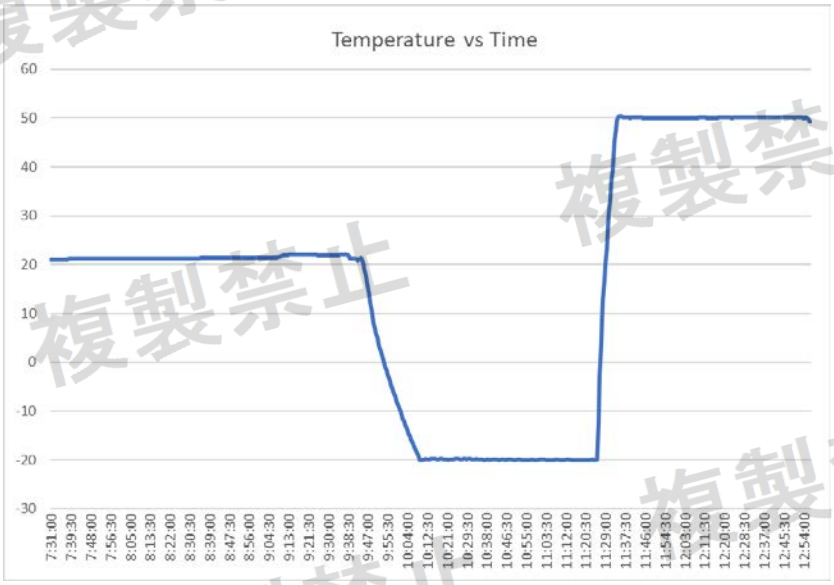


Figure 8.5-1: *Temperature Variation log*

8.5.4 Test data

Table 8.5-1: Frequency tolerance results Pre-Vibration

Voltage (V_{DC}), Temperature	Freq. F_r (Hz)	Freq. F_M (Hz)	Offset (ppm)	Limit (±ppm)	Margin (ppm)
12 VDC, 23°C	2489103327			Reference	
10.8 VDC, 23°C	2489103327	2489097032	25	50	25
13.2 VDC, 23°C	2489103327	2489106767	14	50	36
12 VDC, -20°C	2489128673			Reference	
10.8 VDC, -20°C	2489128673	2489119981	35	50	15
13.2 VDC, -20°C	2489128673	2489126139	10	50	40
12 VDC, 50°C	2489174562			Reference	
10.8 VDC, 50°C	2489174562	2489168673	24	50	26
13.2 VDC, 50°C	2489174562	2489173482	4	50	46

Notes: F_r = the reference frequency as measured under normal conditions.
F_M = the measured frequency as measured under extreme conditions.

Note: Offset calculation: $\frac{F_{Measured} - F_{reference}}{F_{reference}} \times 1 \cdot 10^6$

Table 8.5-2: Frequency tolerance results Post-Vibration

Voltage (V_{DC}), Temperature	Freq. F_r (Hz)	Freq. F_M (Hz)	Offset (ppm)	Limit (±ppm)	Margin (ppm)
12 VDC, 23°C	2489120404			Reference	
10.8 VDC, 23°C	2489120404	2489122627	9	50	41
13.2 VDC, 23°C	2489120404	2489126944	26	50	24
12 VDC, -20°C	2489169037			Reference	
10.8 VDC, -20°C	2489169037	2489175273	25	50	25
13.2 VDC, -20°C	2489169037	2489168920	1	50	49
12 VDC, 50°C	2489080506			Reference	
10.8 VDC, 50°C	2489080506	2489092335	5	50	45
13.2 VDC, 50°C	2489080506	2489085315	2	50	48

Notes: F_r = the reference frequency as measured under normal conditions.
F_M = the measured frequency as measured under extreme conditions.

Note: Offset calculation: $\frac{F_{Measured} - F_{reference}}{F_{reference}} \times 1 \cdot 10^6$

Table 8.5-3: Voltage variation results

Voltage (V_{DC}), Temperature	Freq. F_r (Hz)	Freq. F_M (Hz)	Offset (ppm)	Limit (±ppm)	Margin (ppm)
12 VDC, 23°C	2489120404			Reference	
14.4 VDC, 23°C	2489120404	2489125427	20	50	30
9.6 VDC, 23°C	2489120404	2489117298	13	50	37

Notes: F_r = the reference frequency as measured under normal conditions.
F_M = the measured frequency as measured under extreme conditions.

Note: Offset calculation: $\frac{F_{Measured} - F_{reference}}{F_{reference}} \times 1 \cdot 10^6$

8.6 Vibration

8.6.1 Observations, settings and special notes

No damage was noted post-vibration. Frequency Stability was measured within specifications post-vibration

Vibration Test A

Amplitude 3 mm

Vibration from the lowest frequency (300 CPM) to 500 CPM.

Vibration: vertical, right, left, front, and rear

Sweep frequency 1.5 CPM

Test length: 15 minutes

Vibration Test B

Amplitude 1 mm

Vibration from 500 CPM to 1800 CPM.

Vibration: vertical, right, left, front

Sweep frequency 1.5 CPM

Test length: 15 minutes

Table 8.6-1: Frequency tolerance results Post-Vibration

Voltage (V_{DC}), Temperature	Freq. F_r (Hz)	Freq. F_M (Hz)	Offset (ppm)	Limit (±ppm)	Margin (ppm)
12 VDC, 23°C	2489120404			Reference	
10.8 VDC, 23°C	2489120404	2489122627	9	50	41
13.2 VDC, 23°C	2489120404	2489126944	26	50	24
12 VDC, -20°C	2489169037			Reference	
10.8 VDC, -20°C	2489169037	2489175273	25	50	25
13.2 VDC, -20°C	2489169037	2489168920	1	50	49
12 VDC, 50°C	2489080506			Reference	
10.8 VDC, 50°C	2489080506	2489092335	5	50	45
13.2 VDC, 50°C	2489080506	2489085315	2	50	48

Notes: F_r = the reference frequency as measured under normal conditions.
F_M = the measured frequency as measured under extreme conditions.

Note: Offset calculation: $\frac{F_{Measured} - F_{reference}}{F_{reference}} \times 1 \cdot 10^6$

8.7 Occupied Bandwidth

8.7.1 Definitions and limits

Article 2 Paragraph 1 of item 72 Appendix 2 – For transmission systems 4.5 MHz < OBW < 9 MHz, Limit is 9 MHz

8.7.1 Test date

Start date	February 5, 2019

8.7.2 Test summary

Verdict	Pass		
Test date	February 5, 2019	Temperature	22 °C
Test engineer	Mark Libbrecht	Air pressure	975 mbar
Test location	GTA	Relative humidity	31 %

8.7.3 Observations, settings and special notes

Spectrum analyser settings:

Resolution bandwidth	< 3% of limit
Video bandwidth	VBW = RBW
Frequency span	2 – 3.5 x limit
Detector mode	Peak
Trace mode	Max Hold

8.7.4 Test data

Table 8.7-1: *99% occupied bandwidth results*

Channel	Frequency, MHz	99% occupied bandwidth, kHz	Limit, kHz	Margin, kHz
Ch0	2489	4750	9000	4250
Ch1	2489	4641	9000	4359

Note: there is no 99% occupied bandwidth limit in the standard's requirements, the measurement results provided for information purposes only.

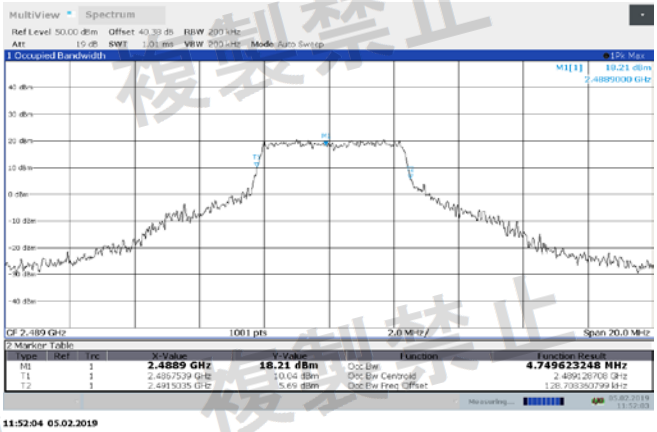


Figure 8.7-1: 99% occupied bandwidth 2489 MHz, ch0

Figure 8.7-2: 99% occupied bandwidth 2489 MHz, ch1

8.8 Antenna Power

8.8.1 Definitions and limits

Article 2 Paragraph 1 of item 72 - For Transmission Systems operating in the 2483.5–2494 MHz band, the maximum peak conducted output power shall not exceed 1 W
Isotropic Antenna Gain ≤ 6 dBi

8.8.1 Test date

Start date	February 8, 2019

8.8.1 Test summary

Verdict	Pass		
Test date	February 8, 2019	Temperature	23 °C
Test engineer	Mark Libbrecht	Air pressure	980 mbar
Test location	GTA	Relative humidity	32 %

8.8.2 Observations, settings and special notes

Spectrum analyser settings:

Resolution bandwidth	1 MHz
Video bandwidth	≥3 × RBW
Frequency span	2 x OBW
Detector mode	Peak
Trace mode	Max Hold

8.8.3 Test data

Table 8.8-1: *Output power measurements results antenna 1*

Frequency, MHz	Conducted output power, dBm		Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
	Measured	Limit					
2489	24.2	30	5.8	5.0	29.2	36	6.8

Table 8.8-2: *Output power measurements results antenna 2*

Frequency, MHz	Conducted output power, dBm		Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
	Measured	Limit					
2489	25.1	30	4.9	5.0	30.1	36	5.9

Table 8.8-3: *Output power measurements results Combined Power*

Frequency, MHz	Conducted output power, dBm				Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
	Measured ch1	Measured ch2	Combined	Limit					
2489	24.2	25.1	27.7	30	2.3	8.0	35.7	36	0.3

Combined output power for MIMO 2 × 2 application was calculated as follows: $P_{combined} = 10 \times log_{10}\left(\left(10^{P_{ch0}/10}\right) + \left(10^{P_{ch1}/10}\right)\right)$

Beamforming gain (dBi) = 5.0 dBi + 10 log(2) = 8 dBi

Rated power vs. Measured power:

Antenna port	Measured power (dBm)	Rated Power (dBm)	Deviation (%)
0	24.2	25	-16.8
1	25.1	25	+2.3
Combined	27.7	28	-6.7

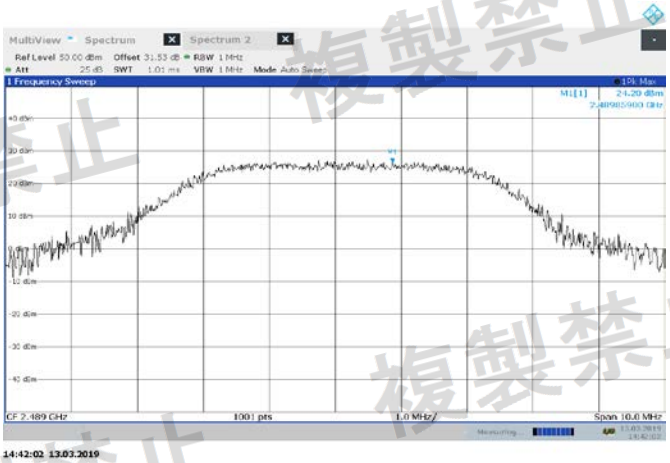


Figure 8.8-1: *Output power 2489 MHz antenna 1*

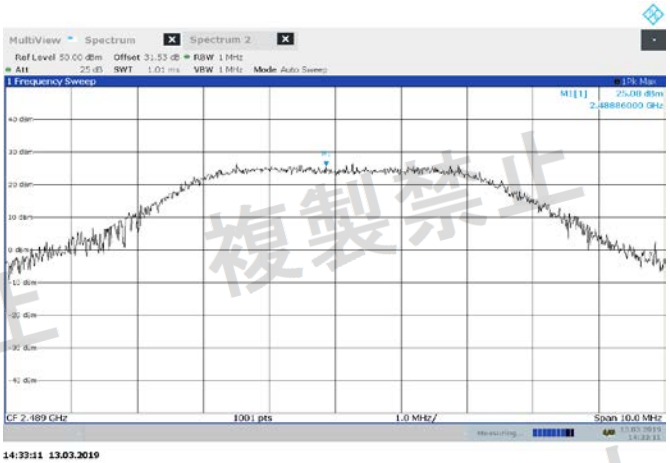


Figure 8.8-2: *Output power 2489 MHz antenna 2*

8.9 Unwanted Emission Strength

8.9.1 Definitions and limits

Article 2 Paragraph 1 of item 72 Appendix 3
Less than 2473.5 MHz: 10µW/ MHz
2473.5 – 2478.5 MHz: 150µW/ MHz
2478.5 – 2483 MHz: 1mW/ MHz
2494.5 – 2498.5 MHz: 1mw/ MHz
2498.5 – 2500 MHz: 150µW/ MHz
2500 – 2510 MHz: 10µW/ MHz
Greater than 2510 MHz: 1µW/ MHz

8.9.1 Test date

Start date	February 8, 2019

8.9.2 Test summary

Verdict	Pass		
Test date	February 8, 2019	Test date	February 8, 2019
Test engineer	Mark Libbrecht	Test engineer	Mark Libbrecht
Test location	GTA	Test location	GTA

8.9.3 Observations, settings and special notes

The spectrum was searched from 30 MHz to above the 5th harmonic.
Radiated measurements 1 – 18 GHz performed at 3 m distance
Radiated measurements 18 – 25 GHz performed at 30 cm distance
Distance conversion 3 m - 30 cm = 40 dB
Reference Level Offset 18 – 25 GHz = Antenna Factor + Cable Loss – Distance Conversion = 46.1 dB + 8.9 dB – 40 dB = 15 dB

Spectrum analyser settings for conducted spurious emissions measurements: 1 – 13 GHz

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

Spectrum analyser settings for conducted spurious emissions measurements: Band Edge

Resolution bandwidth:	30 kHz
Video bandwidth:	100 kHz
Detector mode:	Peak
Trace mode:	Max Hold

Spectrum analyser settings for radiated 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 radiated spurious emissions measurements: 1 – 25 GHz

Resolution bandwidth:	100 kHz
Video bandwidth:	300 kHz
Detector mode:	Peak
Trace mode:	Max Hold
Reference Level Offset	15 dB

8.9.4 Test data

Figure 8.9-1: *Conducted Unwanted Emission Strength 30MHz – 13 GHz, cho*

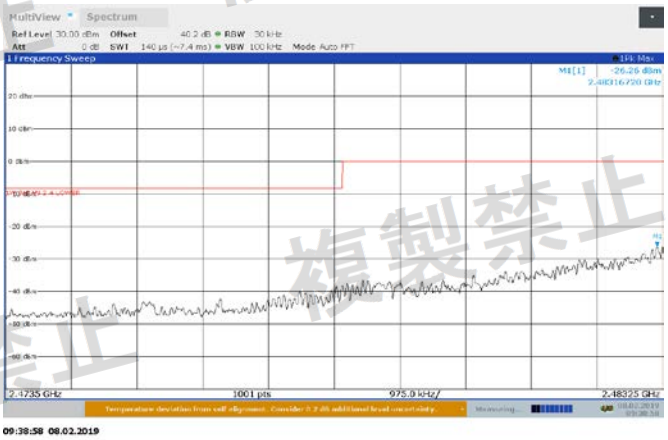


Figure 8.9-2: *Conducted Unwanted Emission Strength 2473.5 – 2483.25 MHz, cho*

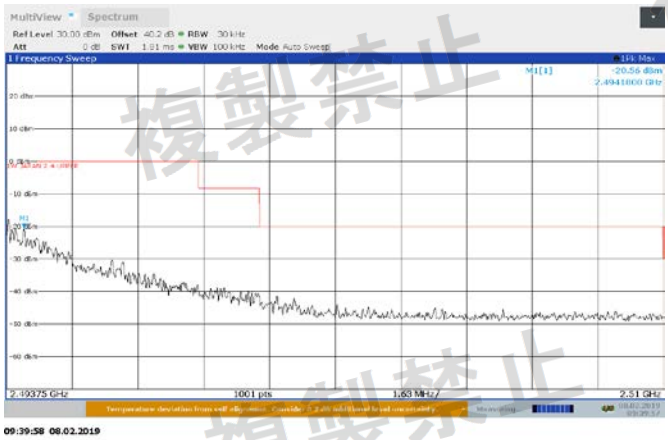


Figure 8.9-3: *Conducted Unwanted Emission Strength 2493.75 – 2510 MHz, cho*

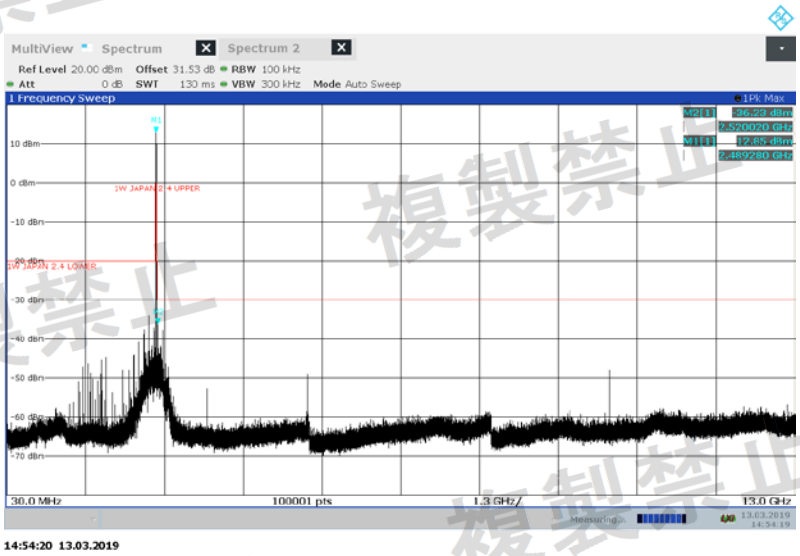


Figure 8.9-4: *Conducted Unwanted Emission Strength 30MHz – 13 GHz, ch1*

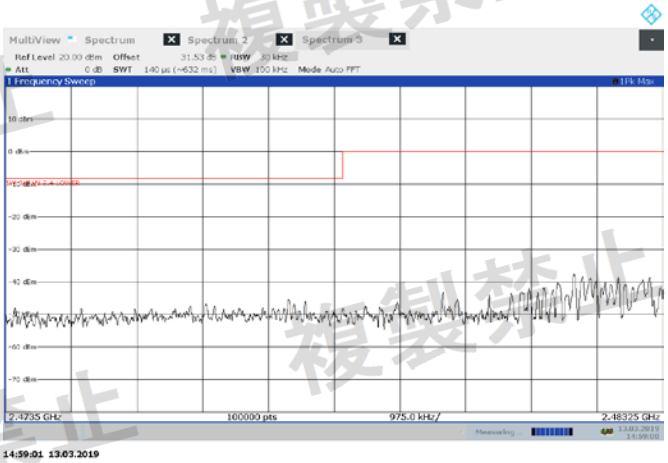


Figure 8.9-5: *Conducted Unwanted Emission Strength 2473.5 – 2483.25 MHz, ch1*

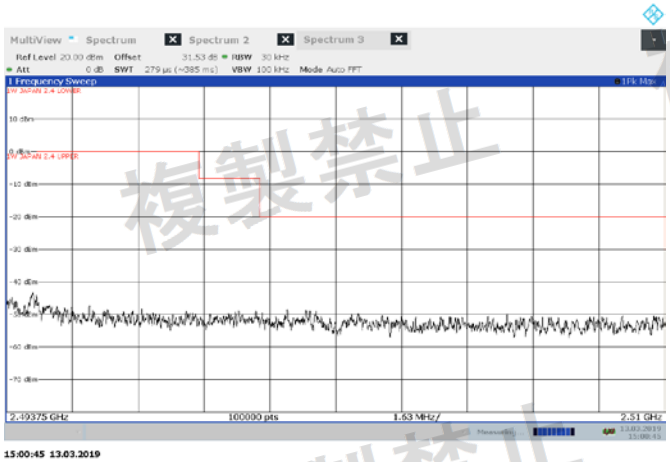


Figure 8.9-6: *Conducted Unwanted Emission Strength 2493.75 – 2510 MHz, ch1*

8.9.1 Test data, continued

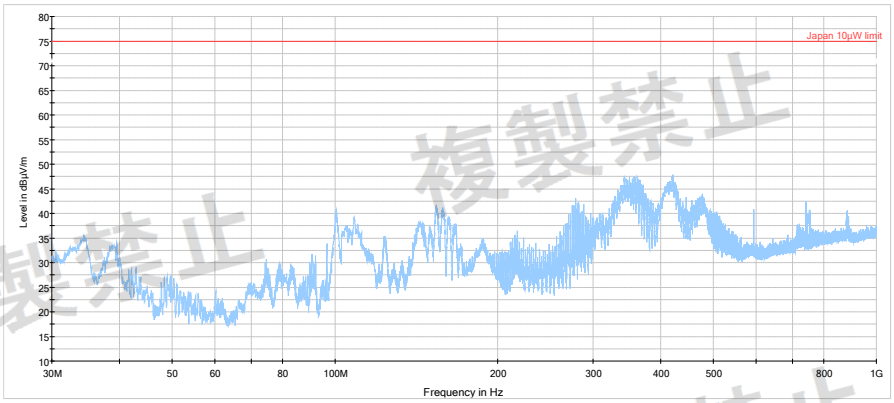


Figure 8.9-7: *Radiated Unwanted emissions strength 30 MHz – 1 GHz*

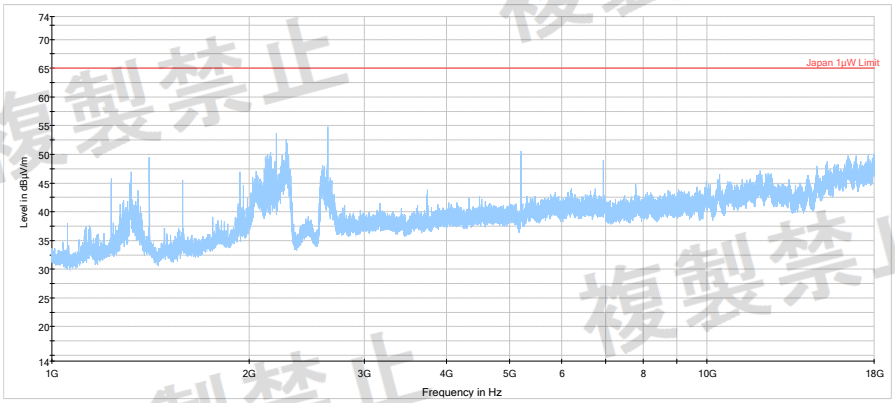


Figure 8.9-8: *Radiated Unwanted emissions strength 18 – 25 GHz*

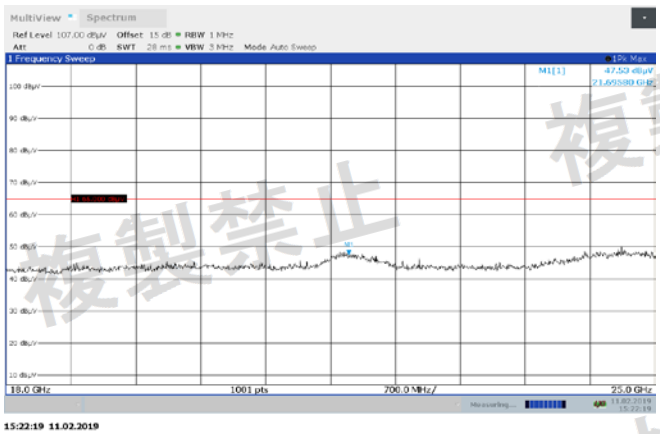


Figure 8.9-9: *Radiated Unwanted emissions strength 18 – 25 GHz*

8.10 Secondary Radiated Emission Strength

8.10.1 Definitions and limits

Article 2 Paragraph 1 of item 72

Less than 1 GHz: 4nW or less
Greater than 1 GHz: 20nW or less

8.10.2 Test date

Start date	February 11, 2019

8.10.3 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.
No spurious emissions were observed within 10 dB of limit

Spectrum analyser settings for conducted spurious emissions measurements below 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 above 1 GHz:

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

8.10.1 Test data

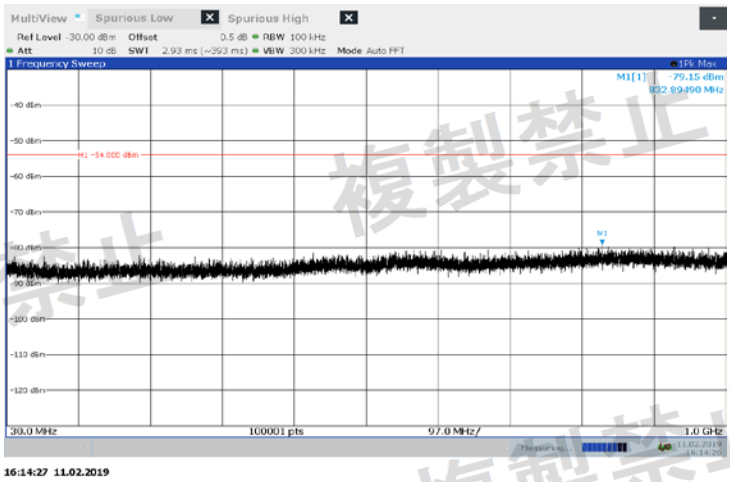


Figure 8.10-1: Conducted *Secondary Radiated Emission Strength 30MHz – 1 GHz*

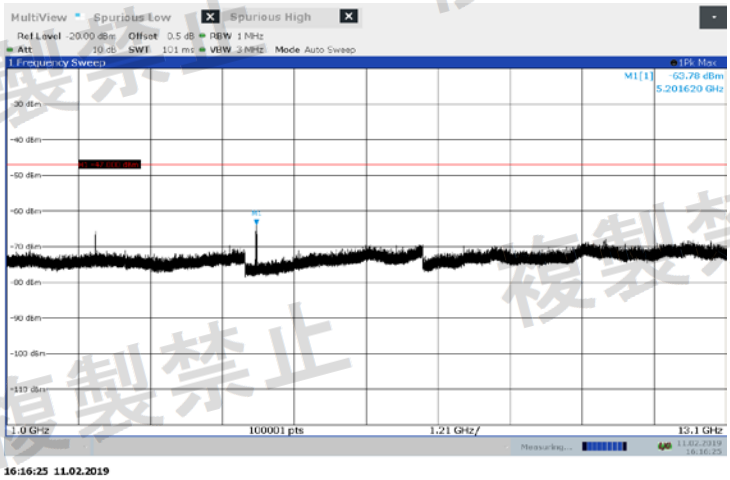
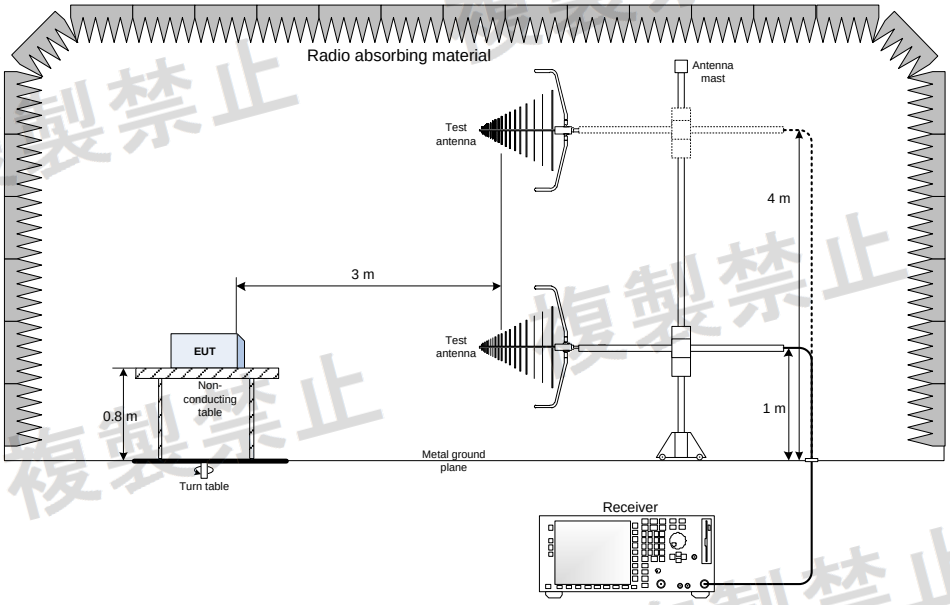


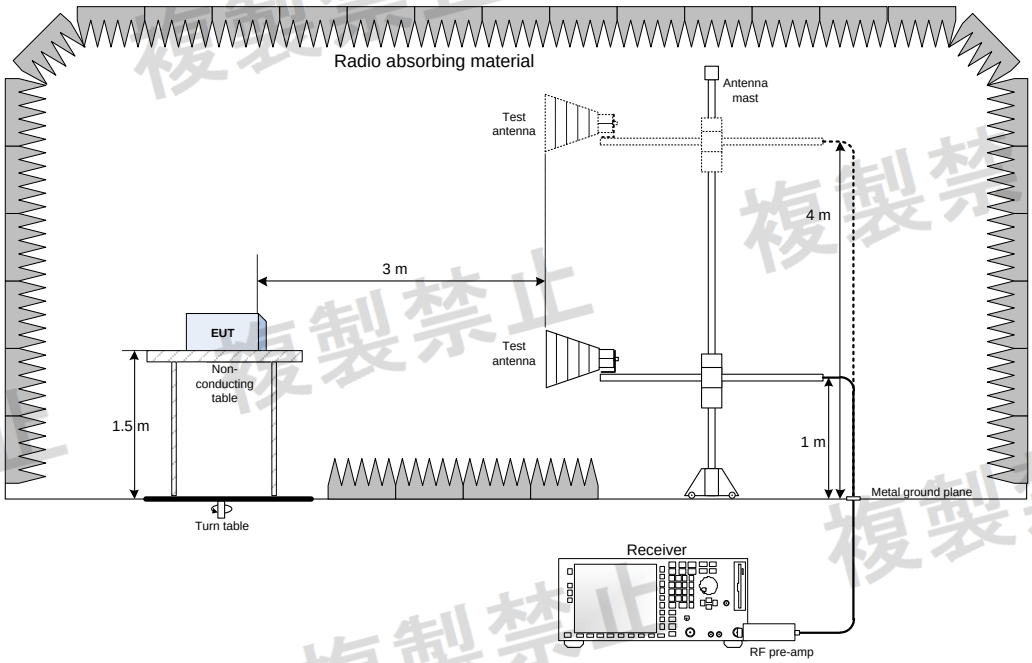
Figure 8.10-2: *Conducted* Secondary Radiated Emission Strength *1 – 13.1 GHz*

Section 9. Block diagrams of test set-ups

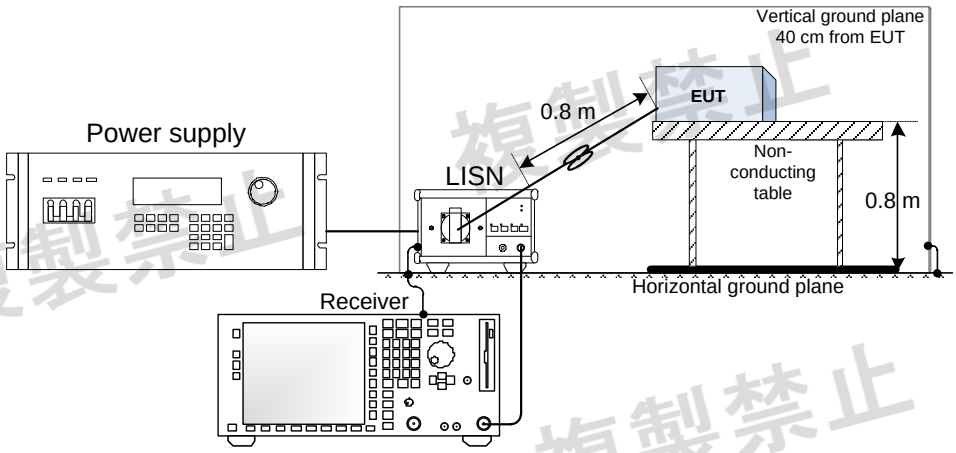
9.1 Radiated emissions set-up for frequencies below 1 GHz



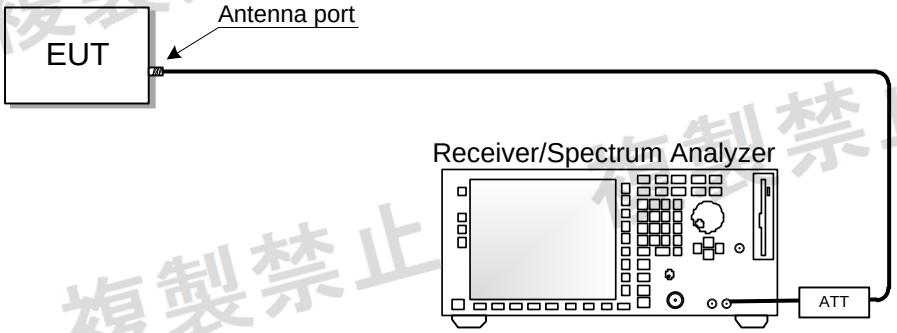
9.2 Radiated emissions set-up for frequencies above 1 GHz



9.3 Conducted emissions set-up



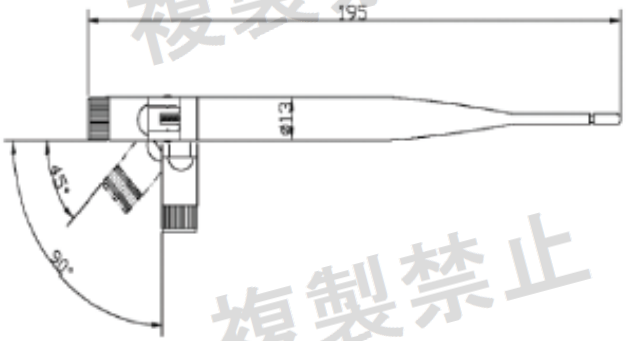
9.4 Antenna port set-up



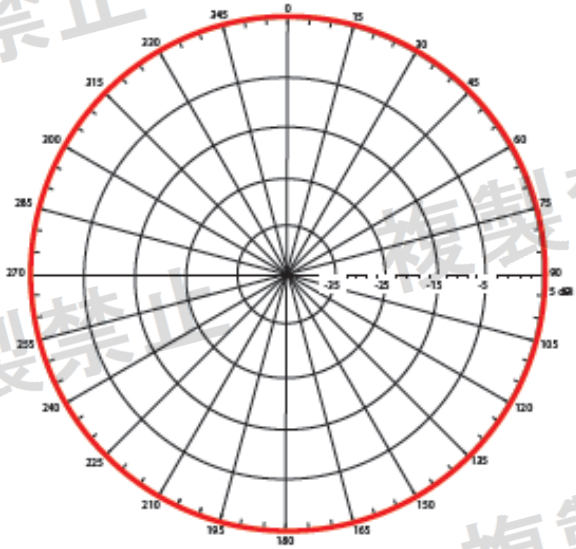
9.5 LM252 Dipole

Features

- Type: Dipole
- Frequency: 2400~2500MHz
- Gain: 5dBi
- Polarization: Linear Vertical
- SWR: <=1.5:1
- Impedance: 50Ω
- Base Connector: SMA Male Reverse Polarity
- Weight: 24.24g +/- 0.25g tolerance
- Size: H 200mm × W 13.7mm × D 13.7mm



H-PLANE



E-PLANE