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Test report

297191-1R1TRFWL

Date of issue: February 8, 2016

Applicant:

Trilliant

Product:

SecureMesh 1 Watt Radio Module

Model:

EM0069A &

EM0069B

FCC ID: TMB-EM0069

IC Registration number: 6028A-EM0069

Specifications:

- FCC 47 CFR Part 15 Subpart C, §15.247

  Operation in the 902–928 MHz, 2400–2483.5 MHz, 5725–5850 MHz

- RSS-247, Issue 1, May 2015, Section 5

  Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

Test location

Company name	Nemko Canada Inc.
Address	292 Labrosse Avenue
City	Pointe-Claire
Province	QC
Postal code	H9R 5L8
Country	Canada
Telephone	+1 514 694 2684
Facsimile	+1 514 694 3528
Toll free	+1 800 563 6336
Website	www.nemko.com
Site number	FCC: 722545; IC: 2040G-5 (3 m semi anechoic chamber)

Tested by	Yong Huang, EMC/Wireless Specialist
Reviewed by	Kevin Rose, Wireless/EMC Specialist
Review date	February 26, 2016
Reviewer signature	

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	Trilliant Network
Address	610 DU Luxembourg
City	Granby
Province/State	QC
Postal/Zip code	J2J 2V2
Country	Canada

1.2 Test specifications

FCC 47 CFR Part 15, Subpart C, Clause 15.247	Operation in 2400–2483.5 MHz
RSS-247, Issue 1, May 2015, Section 5	Digital Transmission Systems (DTSs)

1.3 Test methods

558074 D01 DTS Meas Guidance v03r02 (June 5, 2014)	Guidance for Performing Compliance Measurements on Digital Transmission Systems (DTS) Operating Under §15.247
662911 D01 Multiple Transmitter Output v02r01 (October 31, 2013)	Emissions Testing of Transmitters with Multiple Outputs in the Same Band
ANSI C63.10 v2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices

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

As per customer’s request, this report is for purpose of Class two permissive change of an additional antenna. Only radiated tests were performed, other tests were excluded from the scope of this report.

1.6 Test report revision history

Revision #	Details of changes made to test report
TRF	Original report issued
R1TRF	Report revised as per TCB’s request.

Section 2. Summary of test results

2.1 FCC Part 15 Subpart C, general requirements test results

Part	Test description	Verdict
§15.207(a)	Conducted limits	Not tested
§15.31(e)	Variation of power source	Not tested[1]
§15.203	Antenna requirement	Pass[2]

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 professional installed as per client.

2.2 FCC Part 15 Subpart C, intentional radiators test results

Part	Test description	Verdict
§15.247(a)(1)(i)	Frequency hopping systems operating in the 902–928 MHz band	Not applicable
§15.247(a)(1)(ii)	Frequency hopping systems operating in the 5725–5850 MHz band	Not applicable
§15.247(a)(1)(iii)	Frequency hopping systems operating in the 2400–2483.5 MHz band	Not applicable
§15.247(a)(2)	Minimum 6 dB bandwidth for systems using digital modulation techniques	Not tested
§15.247(b)(1)	Maximum peak output power of frequency hopping systems operating in the 2400–2483.5 MHz band and 5725–5850 MHz band	Not applicable
§15.247(b)(2)	Maximum peak output power of Frequency hopping systems operating in the 902–928 MHz band	Not applicable
§15.247(b)(3)	Maximum peak output power of systems using digital modulation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–5850 MHz bands	Not tested
§15.247(c)(1)	Fixed point-to-point operation with directional antenna gains greater than 6 dBi	Not applicable
§15.247(c)(2)	Transmitters operating in the 2400–2483.5 MHz band that emit multiple directional beams	Not applicable
§15.247(d)	Spurious emissions	Pass
§15.247(e)	Power spectral density for digitally modulated devices	Not tested
§15.247(f)	Time of occupancy for hybrid systems	Not applicable

2.3 IC RSS-GEN, Issue 4, test results

Part	Test description	Verdict
7.1.2	Receiver radiated emission limits	Not applicable[1]
7.1.3	Receiver conducted emission limits	Not applicable[1]
8.8	Power Line Conducted Emissions Limits for Licence-Exempt Radio Apparatus	Not tested

Notes: [1] According to sections 5.2 and 5.3 of RSS-Gen, Issue 4 the EUT does not have a stand-alone receiver neither scanner receiver, therefore exempt from receiver requirements

2.4 IC RSS-247, Issue 1, test results

Part	Test description	Verdict
5.1	Frequency Hopping Systems (FHSs)	
5.1 (1)	Bandwidth of a frequency hopping channel	Not applicable
5.1 (2)	Minimum channel spacing for frequency hopping systems	Not applicable
5.1 (3)	Frequency hopping systems operating in the 902–928 MHz band	Not applicable
5.1 (4)	Frequency hopping systems operating in the 2400–2483.5 MHz band	Not applicable
5.1 (5)	Frequency hopping systems operating in the 5725–5850 MHz band	Not applicable
5.2	Digital Transmission Systems (DTSs)	
5.2 (1)	Minimum 6 dB bandwidth	Not tested
5.2 (2)	Maximum power spectral density	Not tested
5.3	Hybrid Systems	
5.3 (1)	Digital modulation turned off	Not applicable
5.3 (2)	Frequency hopping turned off	Not applicable
5.4	Transmitter output power and e.i.r.p. requirements	
5.4 (1)	Frequency hopping systems operating in the 902–928 MHz band	Not applicable
5.4 (2)	Frequency hopping systems operating in the 2400–2483.5 MHz band	Not applicable
5.4 (3)	Frequency hopping systems operating in the 5725–5850 MHz	Not applicable
5.4 (4)	Systems employing digital modulation techniques	Not tested
5.4 (5)	Point-to-point systems in 2400–2483.5 MHz and 5725–5850 MHz band	Not applicable
5.4 (6)	Transmitters which operate in the 2400–2483.5 MHz band with multiple directional beams	Not applicable
5.5	Out-of-band emissions	Pass

Notes: None

Section 3. Equipment under test (EUT) details

3.1 Sample information

Receipt date	December 24, 2015
Nemko sample ID number	133-002068

3.2 EUT information

Product name	SecureMesh 1 Watt Radio Module
Model	EM0069A & EM0069B
Serial number	NDYB0006009

3.3 Technical information

Applicant IC company number	6028A
IC UPN number	EM0069
All used IC test site(s) Reg. number	2040G-5
RSS number and Issue number	RSS-247 Issue 1, May 2015
Frequency band	2400–2483.5 MHz
Frequency Min (MHz)	2405 MHz
Frequency Max (MHz)	2475 MHz
Field strength, Units @ distance	127.6 dBuV at 2440 MHz @ 3m (Peak)
Calculated BW (kHz), as per TRC-43	N/A
Type of modulation	O-QPSK
Emission classification (F1D, G1D, D1D)	Q1D
Transmitter spurious, Units @ distance	51.9 dBµV at 2483.5 MHz @ 3m
Power requirements	120 V_{AC}
Antenna information	The EUT uses a detachable antenna to the intentional radiator. As per customer, the antenna is professional installed, and the gain is 2.5 dBi.

3.4 Product description and theory of operation

In this product, there are two radios: a cellular radio using Telit LE910-NAG module and a proprietary module using Zigbee protocol to create a mesh network. A central module called the NCC links with both radios and an external Ethernet port. So, we can communicate through the Ethernet port.

3.5 EUT exercise details

When not describe in the standard, install EUT vertically, make stand if necessary.
Use the power cords connected to a 120Vac outlet, to supply the units and close doors.
Start the computer with the user and password, control the transmitter.
Remove the computer and the Ethernet cable before testing.

3.6 EUT setup diagram

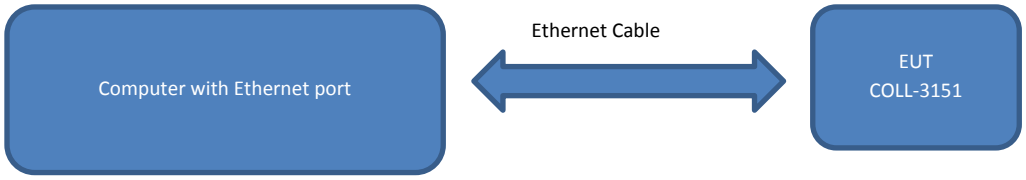


Figure 3.6-1: *Setup diagram*

3.7 EUT sub assemblies

Table 3.7-1: *EUT sub assemblies*

Description	Brand name	Model/Part number	Serial number
SecureMesh NAN node	Trilliant Network	SecureMesh NAN node	NDYB0006009
laptop	Lenovo	2904-FZU	R8-90WKZ
power adaptor for laptop	Lenovo	42T4427	11S42T4426Z1ZF3F01J152
Ethernet usb adaptor for laptop	StarTech	USB2106S	N/A

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

As per customer's request, this report is for purpose of Class two permissive change of an additional antenna. Only radiated tests were performed, other tests were deemed to be compliance as per the original approval of the RF module.

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

Measurement uncertainty budgets for the tests are detailed below. Measurement uncertainty calculations assume a coverage factor of K = 2 with 95% certainty.

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

Table 7.1-1: *Equipment list*

Equipment	Manufacturer	Model no.	Asset no.	Cal cycle	Next cal.
3 m EMI test chamber	TDK	SAC-3	FA002532	1 year	May. 25/16
Flush mount turntable	Sunol	FM2022	FA002550	—	NCR
Controller	Sunol	SC104V	FA002551	—	NCR
Antenna mast	Sunol	TLT2	FA002552	—	NCR
Power source	California Instruments	5001ix	FA002494	1 year	Jan. 22/16
Receiver/spectrum analyzer	Rohde & Schwarz	ESU 40	FA002071	1 year	April 7/16
50 Ω coax cable	C.C.A.	None	FA002603	—	VOU
50 Ω coax cable	C.C.A.	None	FA002605	—	VOU
50 Ω coax cable	C.C.A.	None	FA002607	—	VOU
Bilog antenna (20–2000 MHz)	Sunol	JB1	FA002517	1 year	Sept. 29/16
Horn antenna (1–18 GHz)	EMCO	3115	FA001452	1 year	Sept. 29/16
Horn antenna (18–40 GHz)	EMCO	3116	FA002487	2 year	July 9/16
Pre-amplifier (0.5–18 GHz)	COM-POWER	PAM-118A	FA002561	1 year	May 6/16
Pre-amplifier (18–40 GHz)	COM-POWER	PAM-840	FA002508	1 year	May 6/16
Notch Filter (2.3–2.58GHz)	Microwave Circuits	N0324413	FA002693	—	VOU
Filter (1.2–2583.5 GHz)	Microwave Circuits	H1G212G1	FA002689	—	VOU

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

Section 8. Testing data

8.1 FCC 15.247(d) and RSS-247 5.5 Spurious (out-of-band) emissions

8.1.1 Definitions and limits

FCC:
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated intentional radiator is operating, the radio frequency power that is produced by the intentional radiator shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of RMS averaging over a time interval, as permitted under paragraph (b)(3) of this section, the attenuation required under this paragraph shall be 30 dB instead of 20 dB. Attenuation below the general limits specified in §15.209(a) is not required. In addition, radiated emissions which fall in the restricted bands, as defined in §15.205(a), must also comply with the radiated emission limits specified in §15.209(a) (see §15.205(c)).

IC:
In any 100 kHz bandwidth outside the frequency band in which the spread spectrum or digitally modulated device is operating, the RF power that is produced shall be at least 20 dB below that in the 100 kHz bandwidth within the band that contains the highest level of the desired power, based on either an RF conducted or a radiated measurement, provided that the transmitter demonstrates compliance with the peak conducted power limits. If the transmitter complies with the conducted power limits based on the use of root-mean-square averaging over a time interval, as permitted under Section 5.4(4), the attenuation required shall be 30 dB instead of 20 dB. Attenuation below the general field strength limits specified in RSS-Gen is not required.

Table 8.1-1: *FCC §15.209 and RSS-Gen – Radiated emission limits*

Frequency, MHz	Field strength of emissions		Measurement distance, m
	µV/m	dBµV/m	
0.009–0.490	2400/F	$67.6 - 20 \times \log_{10}(F)$	300
0.490–1.705	24000/F	$87.6 - 20 \times \log_{10}(F)$	30
1.705–30.0	30	29.5	30
30–88	100	40.0	3
88–216	150	43.5	3
216–960	200	46.0	3
above 960	500	54.0	3

Notes: In the emission table above, the tighter limit applies at the band edges.
For frequencies above 1 GHz the limit on peak RF emissions is 20 dB above the maximum permitted average emission limit applicable to the equipment under test

Table 8.1-2: *IC restricted frequency bands*

MHz	MHz	MHz	GHz
0.090–0.110	12.51975–12.52025	399.9–410	5.35–5.46
2.1735–2.1905	12.57675–12.57725	608–614	7.25–7.75
3.020–3.026	13.36–13.41	960–1427	8.025–8.5
4.125–4.128	16.42–16.423	1435–1626.5	9.0–9.2
4.17725–4.17775	16.69475–16.69525	1645.5–1646.5	9.3–9.5
4.20725–4.20775	16.80425–16.80475	1660–1710	10.6–12.7
5.677-5.683	25.5–25.67	1718.8–1722.2	13.25–13.4
6.215–6.218	37.5–38.25	2200–2300	14.47–14.5
6.26775–6.26825	73–74.6	2310–2390	15.35–16.2
6.31175–6.31225	74.8–75.2	2655–2900	17.7–21.4
8.291–8.294	108–138	3260–3267	22.01–23.12
8.362–8.366	156.52475–156.52525	3332–3339	23.6–24.0
8.37625–8.38675	156.7–156.9	3345.8–3358	31.2–31.8
8.41425–8.41475	240–285	3500–4400	36.43–36.5
12.29–12.293	322–335.4	4500–5150	Above 38.6

Note: Certain frequency bands listed in Table 8.1-2 and above 38.6 GHz are designated for low-power licence-exempt applications. These frequency bands and the requirements that apply to the devices are set out in this Standard

Table 8.1-3: *FCC restricted frequency bands*

MHz	MHz	MHz	GHz
0.090–0.110	16.42–16.423	399.9–410	4.5–5.15
0.495–0.505	16.69475–16.69525	608–614	5.35–5.46
2.1735–2.1905	16.80425–16.80475	960–1240	7.25–7.75
4.125–4.128	25.5–25.67	1300–1427	8.025–8.5
4.17725–4.17775	37.5–38.25	1435–1626.5	9.0–9.2
4.20725–4.20775	73–74.6	1645.5–1646.5	9.3–9.5
6.215–6.218	74.8–75.2	1660–1710	10.6–12.7
6.26775–6.26825	108–121.94	1718.8–1722.2	13.25–13.4
6.31175–6.31225	123–138	2200–2300	14.47–14.5
8.291–8.294	149.9–150.05	2310–2390	15.35–16.2
8.362–8.366	156.52475–156.52525	2483.5–2500	17.7–21.4
8.37625–8.38675	156.7–156.9	2690–2900	22.01–23.12
8.41425–8.41475	162.0125–167.17	3260–3267	23.6–24.0
12.29–12.293	167.72–173.2	3332–3339	31.2–31.8
12.51975–12.52025	240–285	3345.8–3358	36.43–36.5
12.57675–12.57725	322–335.4	3600–4400	Above 38.6
13.36–13.41			

8.1.2 Test summary

Test date	January 5, 2016 and January 12, 2016	Temperature	24.6 °C
Test engineer	Yong Huang	Air pressure	1028.3 mbar
Verdict	Pass	Relative humidity	33.8 %

8.1.3 Observations, settings and special notes

The spectrum was searched from 30 MHz to the 10th harmonic.
EUT was set to transmit with 100 % duty cycle.
Radiated measurements were performed at a distance of 3 m.

Spectrum analyser settings for radiated measurements within restricted bands below 1 GHz:

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

Spectrum analyser settings for peak radiated measurements within restricted bands above 1 GHz:

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

Average radiated measurements within restricted bands were calculated with duty cycle correction factor

8.1.4 Test data

Table 8.1-4: *Radiated field strength measurement results in restricted bands*

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Margin, dB	Average Field strength, dBµV/m		Margin, dB
		Measured	Limit		Calculated	Limit	
Low	2390.0	62.5	74	11.5	42.5	54	11.5
Low	4810.0	60.8	74	13.2	40.8	54	13.2
Mid	4880.0	59.3	74	14.7	39.3	54	14.7
High	2483.5	71.9	74	2.1	51.9	54	2.1
High	4950.0	66.3	74	7.7	46.3	54	7.7

Notes: Field strength includes correction factor of antenna, cable loss, amplifier, and attenuators where applicable.

Duty cycle correction factor calculation:

According to the test report (REPORT #: 309080 TX) of original certification (Certificate #: CS04539), 'Appendix E Justifications of Average Duty Factor Calculations:

The Trilliant SecureMesh 1 Watt Radio Module will not transmit for more than 4.35ms over a 43.5ms time period. The justification is based upon the following conditions:

1) Transmit packet size 131 bytes maximum, for 4.19ms transmission duration.
2) Data rate 250kbps.
3) Each radio waits for acknowledgement prior to retransmission.
4) Acknowledgement is 5 bytes, or 0.16ms transmission duration.
5) Maximum number of hops per mesh network is 10.

Documentation is justified as below:

Example 1 – Trilliant SecureMesh Network – Source to Destination Requires Ten Hops

Typical broadcast over a large network (10 radios) includes:

A) Message is transmitted by the initiating radio (first hop). Total transmit time is 4.19ms.
B) Transmission time to the destination radio (10th hop- assuming no retries), requires anadditional 37.71ms.
C) Acknowledgement from destination radio to initiating radio requires 1.6 ms, assuming noretries.

Large network, No Retries
Transmit time: 4.19ms
Total on time: 43.5ms
Total on time per radio (Tx packet plus Ack Packet): 4.35ms
Total percentage on time per radio/best case: 10.00 per cent

Note: The Large Network, No Retries offers the highest utilization. A ten-hop mesh network will typically require retries which reduce the throughput of the system. Retries will effectively reduce the duty cycle of the radios.

Example 2 – SecureMesh Network – Source to Destination Requires 3 Hops

Typical broadcast over a network, however only 3 hops are required to get from initiating radio to destination. Timing detail includes:

A) Message is transmitted by the initiating radio. Total transmit time is 4.19ms.
B) Transmission time to the destination radio (3rd hop- assuming no retries), requires an additional 8.38ms.
C) Acknowledgement from destination radio to initiating radio requires 0.48 ms, assuming no retries.

Large network, No Retries
Transmit time: 4.19ms
Total on time: 13.5ms
Total on time per radio (Tx packet plus Ack Packet): 4.35ms

Trilliant implements limit in the application firmware so the radio does not initiate a packet within 43.5ms of the first second packet, thereby respecting the 10 percent duty cycle.

Average Factor = 20* Log10 (Worst Case EUT On-time over 100 ms time window)
The transmit packet occupies 4.35ms X 2 = 8.7 ms of time, within any 100 ms window. Therefore,
the relaxation factor allowance is calculated as:
Average Factor = 20* Log10 (8.7 / 100 ms) = -21.2 dB
A relaxation factor of allowable dB would be allowable for this product.
As worst case provided per customer, a duty cycle correction factor used for evaluation is -20 dB for average field strength.

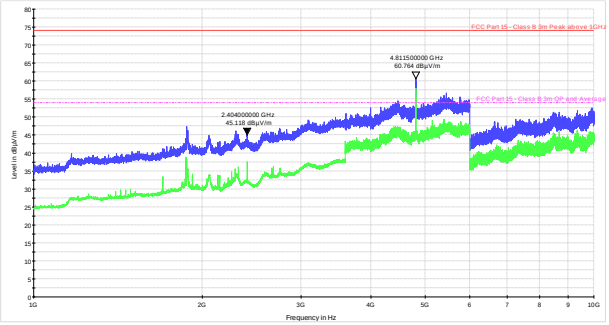


Figure 8.1-1: *Radiated spurious emissions, low channel*

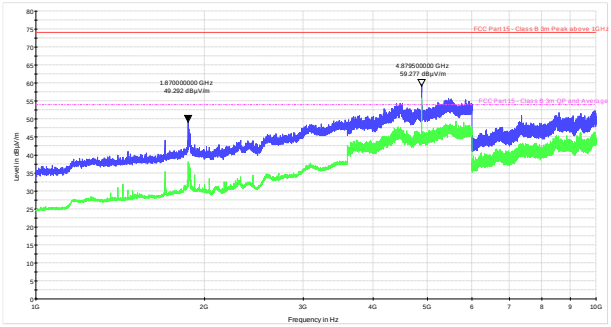


Figure 8.1-2: *Radiated spurious emissions, mid channel*

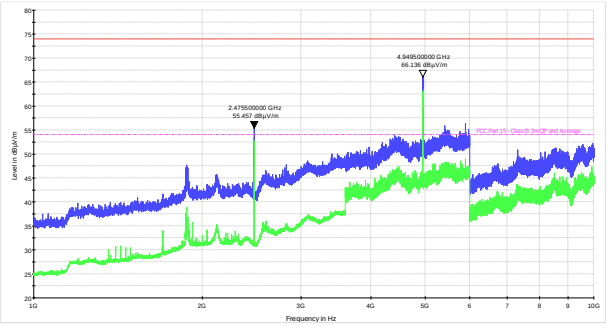
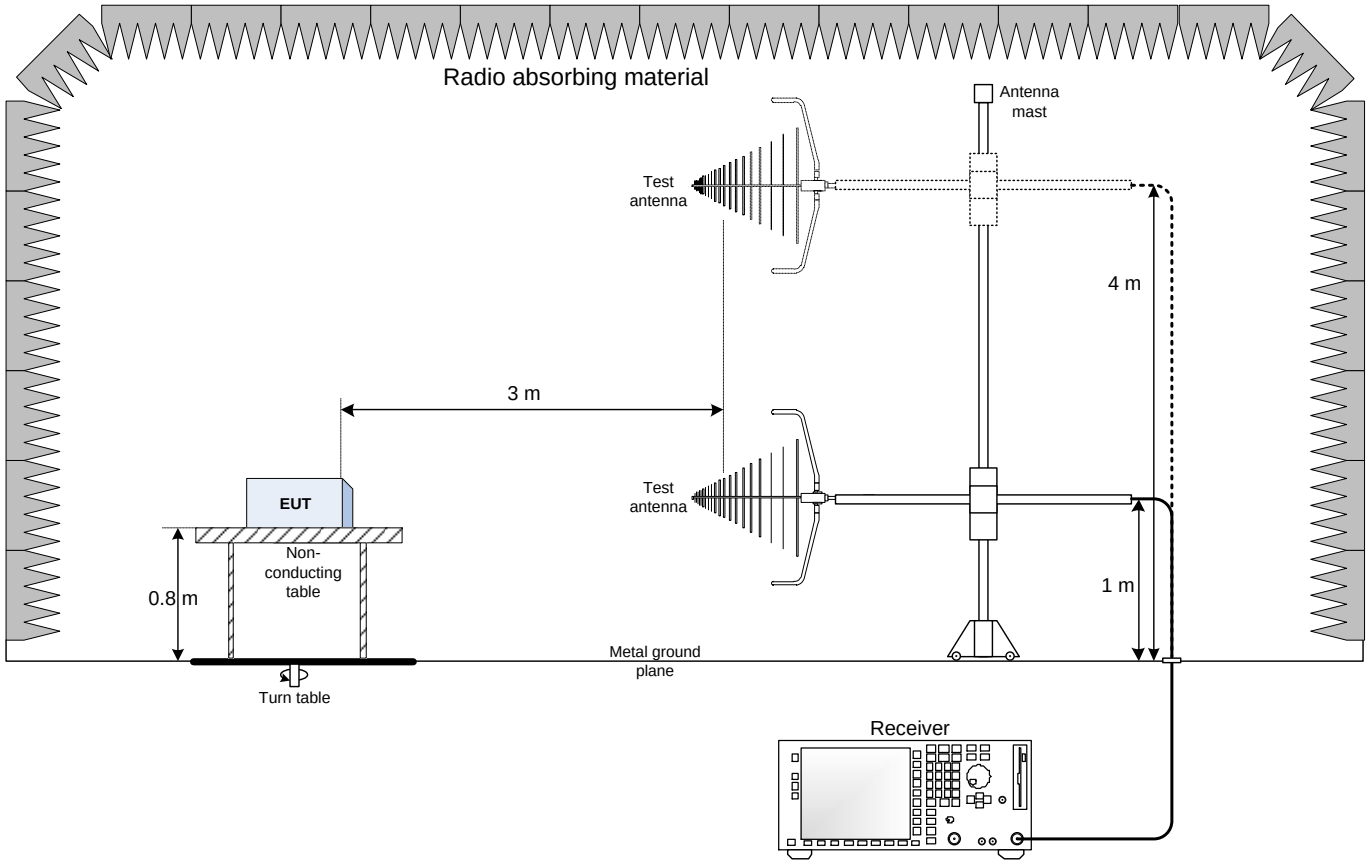


Figure 8.1-3: *Radiated spurious emissions, hi channel*

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