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Wireless test report – 369132-2TRFWL

Applicant:

Mitel Networks

Product type:

IP Conference phone

Model:

6970

FCC ID:

EHTAQUA6

IC Registration number:

173A-AQUA6

Specifications:

- FCC 47 CFR Part 15 Subpart C, §15.247

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

- RSS-247, Issue 2, Feb 2017, Section 5

  Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices, 5) Standard specifications for frequency hopping systems and digital transmission systems operating in the bands 902–928 MHz, 2400–2483.5 MHz and 5725–5850 MHz

Date of issue: April 3, 2019

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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

Table of contents

Table of contents **3**

Section 1. Report summary **4**

1.1 Applicant and manufacturer 4

1.2 Test specifications 4

1.3 Test methods 4

1.4 Statement of compliance 4

1.5 Exclusions 4

1.6 Test report revision history 4

Section 2. Summary of test results **5**

2.1 Testing period 5

2.2 FCC Part 15 Subpart C, general requirements test results 5

2.3 FCC Part 15 Subpart C, intentional radiators test results for frequency hopping spread spectrum systems 5

2.4 RSS-Gen, Issue 5, test results 6

2.5 RSS-247, Issue 2, test results for frequency hopping spread spectrum systems (FHSS) 6

Section 3. Equipment under test (EUT) details **7**

3.1 Sample information 7

3.2 EUT information 7

3.3 Technical information 7

3.4 Product description and theory of operation 7

3.5 EUT exercise details 7

3.6 EUT setup diagram 8

Section 4. Engineering considerations **9**

4.1 Modifications incorporated in the EUT for compliance 9

4.2 Technical judgment 9

4.3 Deviations from laboratory tests procedures 9

Section 5. Test conditions **10**

5.1 Atmospheric conditions 10

5.2 Power supply range 10

Section 6. Measurement uncertainty **11**

6.1 Uncertainty of measurement 11

Section 7. Test equipment **12**

7.1 Test equipment list 12

Section 8. Testing data **13**

8.1 FCC 15.31(e) Variation of power source 13

8.2 FCC 15.31(m) and RSS-Gen 6.9 Number of frequencies 14

8.3 FCC 15.203 and RSS-Gen 6.8 Antenna requirement 15

8.4 FCC 15.207(a) and RSS-Gen 8.8 AC power line conducted emissions limits 16

8.5 FCC 15.247 (a (1 (iii))) and RSS-247 5.1 (a)(b)(d) Frequency Hopping Systems requirements, 2 GHz operation 20

8.6 FCC 15.247(b (1) (4)) and RSS-247 5.4 (b) Transmitter output power and e.i.r.p. requirements for FHSS 2 GHz 27

8.7 FCC 15.247(d) and RSS-247 5.5 Spurious (out-of-band) unwanted emissions 30

Section 9. Block diagrams of test set-ups **38**

9.1 Radiated emissions set-up for frequencies below 1 GHz 38

9.2 Radiated emissions set-up for frequencies above 1 GHz 38

9.3 Conducted emissions set-up 39

9.4 Antenna port set-up 39

Section 1. Report summary

1.1 Applicant and manufacturer

Company name	Mitel Networks Corporation
Address	350 Legget Drive; Kanata; Ontario; K2K 2W7; Canada

1.2 Test specifications

FCC 47 CFR Part 15, Subpart C, Clause 15.247	Operation in the 902–928 MHz, 2400–2483.5 MHz, and 5725–585 MHz
RSS-247, Issue 2, Feb 2017, Section 5	Digital Transmission Systems (DTSs), Frequency Hopping Systems (FHSs) and Licence-Exempt Local Area Network (LE-LAN) Devices

1.3 Test methods

DA 00-705, Released March 30, 2000	Filing and Measurement Guidelines for Frequency Hopping Spread Spectrum Systems
ANSI C63.10 v2013	American National Standard of Procedures for Compliance Testing of Unlicensed Wireless Devices
RSS-Gen, Issue 5, April 2018	General Requirements for Compliance of Radio Apparatus

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

Table 1.6-1: *Test report revision history*

Revision #	Date of issue	Details of changes made to test report
TRF	April 3, 2019	Original report issued

Section 2. Summary of test results

2.1 Testing period

Test start date	February 13, 2019
Test end date	February 19, 2019

2.2 FCC Part 15 Subpart C, general requirements test results

Table 2.2-1: *FCC general requirements results*

Part	Test description	Verdict
§15.207(a)	Conducted limits	Pass[1]
§15.31(e)	Variation of power source	Pass
§15.31(m)	Number of tested frequencies	Pass
§15.203	Antenna requirement	Pass

Notes: [1] The EUT is powered via POE. The POE adapter AC mains were tested to demonstrate compliance.

2.3 FCC Part 15 Subpart C, intentional radiators test results for frequency hopping spread spectrum systems

Table 2.3-1: *FCC 15.247 results for FHSS results*

Part	Test description	Verdict
§15.247(a)(1)(i)	Requirements for operation in the 902–928 MHz band	Not applicable
§15.247(a)(1)(ii)	Requirements for operation in the 5725–5850 MHz band	Not applicable
§15.247(a)(1)(iii)	Requirements for operation in the 2400–2483.5 MHz band	Pass
§15.247(b)(1)	Maximum peak output power in the 2400–2483.5 MHz band and 5725–5850 MHz band	Pass
§15.247(b)(2)	Maximum peak output power in the 902–928 MHz band	Not applicable
§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(f)	Time of occupancy for hybrid systems	Not applicable

Notes: None

2.4 RSS-Gen, Issue 5, test results

Table 2.4-1: *RSS-Gen results*

Part	Test description	Verdict
7.3	Receiver radiated emission limits	Not applicable [1]
7.4	Receiver conducted emission limits	Not applicable [1]
6.9	Operating bands and selection of test frequencies	Pass
8.8	AC power-line conducted emissions limits	Pass

Notes: [1] According to sections 5.2 and 5.3 of RSS-Gen, Issue 5 the EUT does not have a stand-alone receiver neither scanner receiver, therefore exempt from receiver requirements.

2.5 RSS-247, Issue 2, test results for frequency hopping spread spectrum systems (FHSS)

Table 2.5-1: *RSS-247 results for FHSS results*

Part	Test description	Verdict
5.1 (a)	Bandwidth of a frequency hopping channel	Pass
5.1 (b)	Minimum channel spacing	Pass
5.1 (c)	Systems operating in the 902–928 MHz band	Not applicable
5.1 (d)	Systems operating in the 2400–2483.5 MHz band	Pass
5.1 (e)	Systems operating in the 5725–5850 MHz band	Not applicable
5.3	Hybrid Systems	
5.3 (a)	Digital modulation turned off	Not applicable
5.3 (b)	Frequency hopping turned off	Not applicable
5.4	Transmitter output power and e.i.r.p. requirements	
5.4 (a)	Systems operating in the 902–928 MHz band	Not applicable
5.4 (b)	Systems operating in the 2400–2483.5 MHz band	Pass
5.4 (c)	Systems operating in the 5725–5850 MHz	Not applicable
5.4 (e)	Point-to-point systems in 2400–2483.5 MHz and 5725–5850 MHz band	Not applicable
5.4 (f)	Transmitters which operate in the 2400–2483.5 MHz band with multiple directional beams	Not applicable
5.5	Unwanted emissions	Pass

Notes: None

Section 3. Equipment under test (EUT) details

3.1 Sample information

Receipt date	February 12, 2019
Nemko sample ID number	Item # 1 and 2

3.2 EUT information

Product name	IP Conference phone
Model	6970
Serial number	3BUFW190400DC0K

3.3 Technical information

Applicant IC company number	173A
IC UPN number	AQUA6
RSS number and Issue number	RSS-247 Issue 2, Feb 2017
Frequency band	2400–2483.5 MHz
Frequency Min (MHz)	2402
Frequency Max (MHz)	2480
RF power Min (W), Conducted	N/A
RF power Max (W), Conducted	π/4-DQPSK 2-DH5: 0.0021 (3.3 dBm) 8-DPSK 3-DH5: 0.0022 (3.5 dBm)
Field strength, Units @ distance	N/A
Measured BW (kHz) (99%)	π/4-DQPSK 2-DH5: 1215 8-DPSK 3-DH5: 1225
Calculated BW (kHz), as per TRC-43	N/A
Type of modulation	π/4-DQPSK 2-DH5 and 8-DPSK 3-DH5
Emission classification (F1D, G1D, D1D)	W7D
Transmitter spurious, Units @ distance	π/4-DQPSK 2-DH5: 51.2 dBµV/m Peak and 48.9 dBµV/m Average @ 3 m @ 2390 MHz 8-DPSK 3-DH5: 50.2 dBµV/m Peak and 47.9 dBµV/m Average @ 3 m @ 2390 MHz
Power requirements	-48 V_{DC} (Powered via external POE adapter)
Antenna information	Integral antenna 1.5 dBi gain

3.4 Product description and theory of operation

The EUT is a IP conference phone.

3.5 EUT exercise details

The EUT was setup in continuous transmit state.

3.6 EUT setup diagram

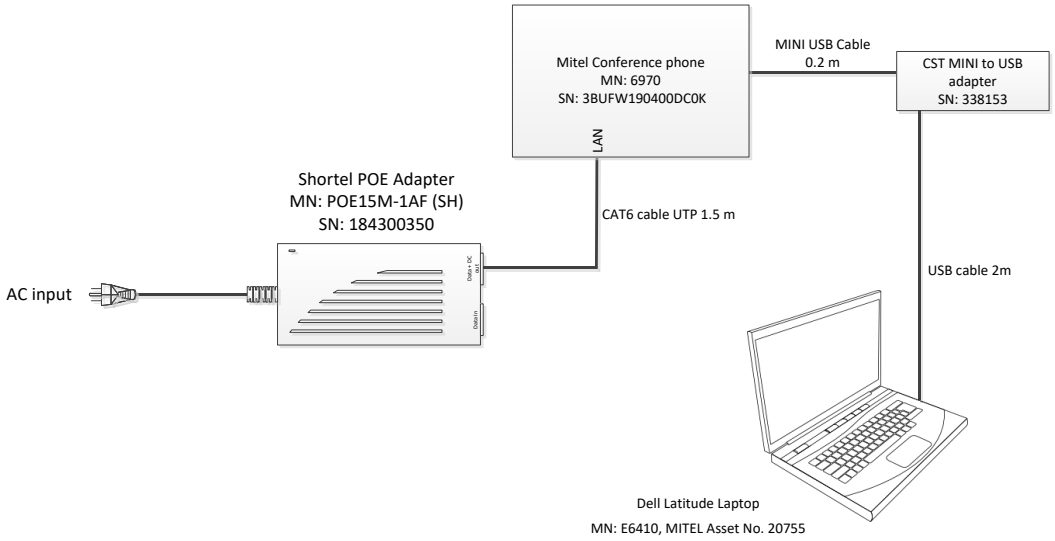


Figure 3.6-1: *Setup diagram*

Section 4. Engineering considerations

4.1 Modifications incorporated in the EUT for compliance

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	86–106 kPa

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.

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	FA002047	1 year	January 24, 2020
Receiver/spectrum analyzer	Rohde & Schwarz	ESU 26	FA002043	1 year	March 26, 2019
Spectrum analyzer	Rohde & Schwarz	FSU	FA001877	1 year	October 26, 2019
Horn (1–18 GHz)	ETS Lindgren	3117	FA002840	1 year	January 16, 2020
Horn antenna (1–18 GHz)	EMCO	3115	FA000825	1 year	October 8, 2019
Preamp (1–18 GHz)	ETS Lindgren	124334	FA002873	1 year	November 4, 2019
Bilog antenna (20–3000 MHz)	Sunol	JB3	FA002108	1 year	January 3, 2020
Horn antenna (18–40 GHz)	EMCO	3116	FA001847	1 year	October 9, 2019
Pre-amplifier (18–26 GHz)	Narda	BBS-1826N612	FA001550	—	VOU
Notch filter 2400–2483 MHz	Microwave Circuits	2400–2483 MHz	FA001940	—	VOU
61505 AC source	Chroma	61509	FA003036	—	VOU
LISN	Rohde & Schwarz	ENV216	FA002023	1 year	August 13, 2019

Notes: VOU - verify on use

Section 8. Testing data

8.1 FCC 15.31(e) Variation of power source

8.1.1 Definitions and limits

FCC §15.31:

(e) 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 85% and 115% of the nominal rated supply voltage. For battery operated equipment, the equipment tests shall be performed using a new battery.

8.1.2 Test date

Start date	February 13, 2019

8.1.3 Observations, settings and special notes

The testing was performed as per ANSI C63.10 Section 5.13.

a) Where the device is intended to be powered from an external power adapter, the voltage variations shall be applied to the input of the adapter provided with the device at the time of sale. If the device is not marketed or sold with a specific adapter, then a typical power adapter shall be used.
b) For devices where operating at a supply voltage deviating ±15% from the nominal rated value may cause damages or loss of intended function, test to minimum and maximum allowable voltage per manufacturer's specification and document in the report.
c) For devices with wide range of rated supply voltage, test at 15% below the lowest and 15% above the highest declared nominal rated supply voltage.
d) For devices obtaining power from an input/output (I/O) port (USB, firewire, etc.), a test jig is necessary to apply voltage variation to the device from a support power supply, while maintaining the functionalities of the device.

For battery-operated equipment, the equipment tests shall be performed using a variable power supply.

8.1.4 Test data

The EUT is powered via POE. The client provided a POE adapter for testing. The AC input of the POE adapter was varied.
The supply voltage was varied between 85% and 115% of the nominal rated supply voltage. No change to transmitter performance was observed.

8.2 FCC 15.31(m) and RSS-Gen 6.9 Number of frequencies

8.2.1 Definitions and limits

FCC §15.31:

(m) Measurements on intentional radiators or receivers, other than TV broadcast receivers, shall be performed and, if required, reported for each band in which the device can be operated with the device operating at the number of frequencies in each band specified in the following table:

RSS-Gen Section 6.9:

Except where otherwise specified, measurements shall be performed for each frequency band of operation for which the radio apparatus is to be certified, with the device operating at the frequencies in each band of operation shown in table below. The frequencies selected for measurements shall be reported in the test report.

Table 8.2-1: *Frequency Range of Operation*

Frequency range over which the device operates (in each band)	Number of test frequencies required	Location of measurement frequency inside the operating frequency range
1 MHz or less	1	Center (middle of the band)
1–10 MHz	2	1 near high end, 1 near low end
Greater than 10 MHz	3	1 near high end, 1 near center and 1 near low end

Notes: "near" means as close as possible to or at the centre / low end / high end of the frequency range over which the device operates.

8.2.2 Test date

Start date	February 13, 2019

8.2.3 Observations, settings and special notes

Per ANSI C63.10 Subclause 5.6.2.1:

The number of channels tested can be reduced by measuring the center channel bandwidth first and then applying the following relaxations as appropriate:

a) For each operating mode, if the measured channel bandwidth on the middle channel is at least 150% of the minimum permitted bandwidth, then it is not necessary to measure the bandwidth on the high and low channels.
b) For multiple-input multiple-output (MIMO) systems, if the measured channel bandwidth on testing the middle channel exceeds the minimum permitted bandwidth by more than 50% on one transmit chain, then it is not necessary to repeat testing on the other chains.
c) If the measured channel bandwidth on the middle channel is less than 50% of the maximum permitted bandwidth, then it is not necessary to measure the bandwidth on the high and low channels.

Per ANSI C63.10 Subclause 5.6.2.2:

For devices with multiple operating modes, measurements on the middle channel can be used to determine the worst-case mode(s). The worst-case modes are as follows:

a) Band edge requirements—Measurements on the mode with the widest bandwidth can be used to cover the same channel (center frequency) on modes with narrower bandwidth that have the same or lower output power for each modulation family (e.g., OFDM and direct sequence spread spectrum).
b) Spurious emissions—Measure the mode with the highest output power and the mode with the highest output power spectral density for each modulation family (e.g., OFDM and direct sequence spread spectrum).
c) In-band PSD—Measurements on the mode with the narrowest bandwidth can be used to cover all modes within the same modulation family of an equal or lower output power provided the result is less than 50% of the limit.

8.2.4 Test data

Table 8.2-2: *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
2400	2483.5	83.5	2402	2441	2480

8.3 FCC 15.203 and RSS-Gen 6.8 Antenna requirement

8.3.1 Definitions and limits

FCC §15.203:

An intentional radiator shall be designed to ensure that no antenna other than that furnished by the responsible party shall be used with the device. The use of a permanently attached antenna or of an antenna that uses a unique coupling to the intentional radiator shall be considered sufficient to comply with the provisions of this section. The manufacturer may design the unit so that a broken antenna can be replaced by the user, but the use of a standard antenna jack or electrical connector is prohibited. This requirement does not apply to intentional radiators that must be professionally installed, such as perimeter protection systems and some field disturbance sensors, or to other intentional radiators which, in accordance with §15.31(d), must be measured at the installation site. However, the installer shall be responsible for ensuring that the proper antenna is employed so that the limits in this part are not exceeded.

RSS-Gen Section 6.8:

The applicant for equipment certification shall provide a list of all antenna types that may be used with the transmitter, where applicable (i.e. for transmitters with detachable antenna), indicating the maximum permissible antenna gain (in dBi) and the required impedance for each antenna. The test report shall demonstrate the compliance of the transmitter with the limit for maximum equivalent isotropically radiated power (e.i.r.p.) specified in the applicable RSS, when the transmitter is equipped with any antenna type, selected from this list.

For expediting the testing, measurements may be performed using only the antenna with highest gain of each combination of transmitter and antenna type, with the transmitter output power set at the maximum level. However, the transmitter shall comply with the applicable requirements under all operational conditions and when in combination with any type of antenna from the list provided in the test report.

8.3.2 Test date

Start date	February 13, 2019

8.3.3 Observations, settings and special notes

None

8.3.4 Test data

The EUT has an internal integrated antenna, non-detachable. The EUT is not professionally installed.

8.4 FCC 15.207(a) and RSS-Gen 8.8 AC power line conducted emissions limits

8.4.1 Definitions and limits

FCC §15.207:

a) Except as shown in paragraphs (b) and (c) of this section, for an intentional radiator that is designed to be connected to the public utility (AC) power line, the radio frequency voltage that is conducted back onto the AC power line on any frequency or frequencies, within the band 150 kHz to 30 MHz, shall not exceed the limits in the following table, as measured using a 50 µH/50 Ω line impedance stabilization network (LISN). Compliance with the provisions of this paragraph shall be based on the measurement of the radio frequency voltage between each power line and ground at the power terminal. The lower limit applies at the boundary between the frequency ranges.

ANSI: C63.10 subclause 6.2
If the EUT normally receives power from another device that in turn connects to the public utility ac power lines, measurements shall be made on that device with the EUT in operation to demonstrate that the device continues to comply with the appropriate limits while providing the EUT with power. If the EUT is
operated only from internal or dedicated batteries, with no provisions for connection to the public utility ac power lines (600 VAC or less) to operate the EUT (such as an adapter), then ac power-line conducted measurements are not required.
For direct current (dc) powered devices where the ac power adapter is not supplied with the device, an "off-the-shelf" unmodified ac power adapter shall be used. If the device is supposed to be installed in a host (e.g., the device is a module or PC card), then it is tested in a typical compliant host.

RSS-GEN Section 8.8:

A radio apparatus that is designed to be connected to the public utility (AC) power line shall ensure that the radio frequency voltage, which is conducted back onto the AC power line on any frequency or frequencies within the band 150 kHz to 30 MHz, shall not exceed the limits in table below.

Unless the requirements applicable to a given device state otherwise, for any radio apparatus equipped to operate from the public utility AC power supply either directly or indirectly (such as with a battery charger), the radio frequency voltage of emissions conducted back onto the AC power lines in the frequency range of 0.15 MHz to 30 MHz shall not exceed the limits shown in table below. The more stringent limit applies at the frequency range boundaries.

Table 8.4-1: *AC power line conducted emissions limit*

Frequency of emission, MHz	Conducted limit, dBµV	
	Quasi-peak	Average**
0.15–0.5	66 to 56*	56 to 46*
0.5–5	56	46
5–30	60	50

Notes: * - The level decreases linearly with the logarithm of the frequency.
** - A linear average detector is required.

8.4.2 Test date

Start date	February 19, 2019

8.4.3 Observations, settings and special notes

Port under test – Coupling device	AC Input of POE – Artificial Mains Network (AMN)
EUT power input during test	120 V_{AC} 60 Hz
EUT setup configuration	Table top
Measurement details	A preview measurement was generated with the receiver in continuous scan mode. Emissions detected within 10 dB or above the limit were re-measured with the appropriate detector against the correlating limit and recorded as the final measurement.
	The spectral plots have been corrected with transducer factors. (i.e. cable loss, LISN factors, and attenuators)

Receiver settings:

Resolution bandwidth	9 kHz
Video bandwidth	30 kHz
Detector mode	Peak and Average (Preview measurement), Quasi-peak and CAverage (Final measurement)
Trace mode	Max Hold
Measurement time	– 100 ms (Peak and Average preview measurement) – 100 ms (Quasi-peak final measurement) – 160 ms (CAverage final measurement)

8.4.4 Test data

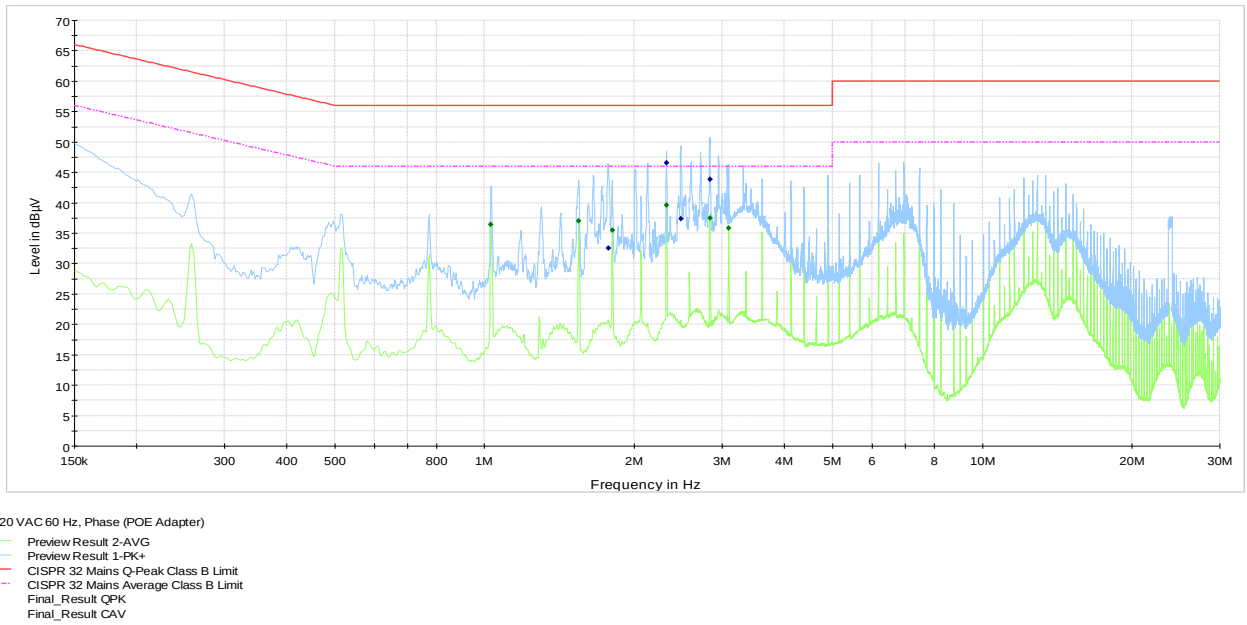


Figure 8.4-1: *AC power line conducted emissions – spectral plot on phase line*

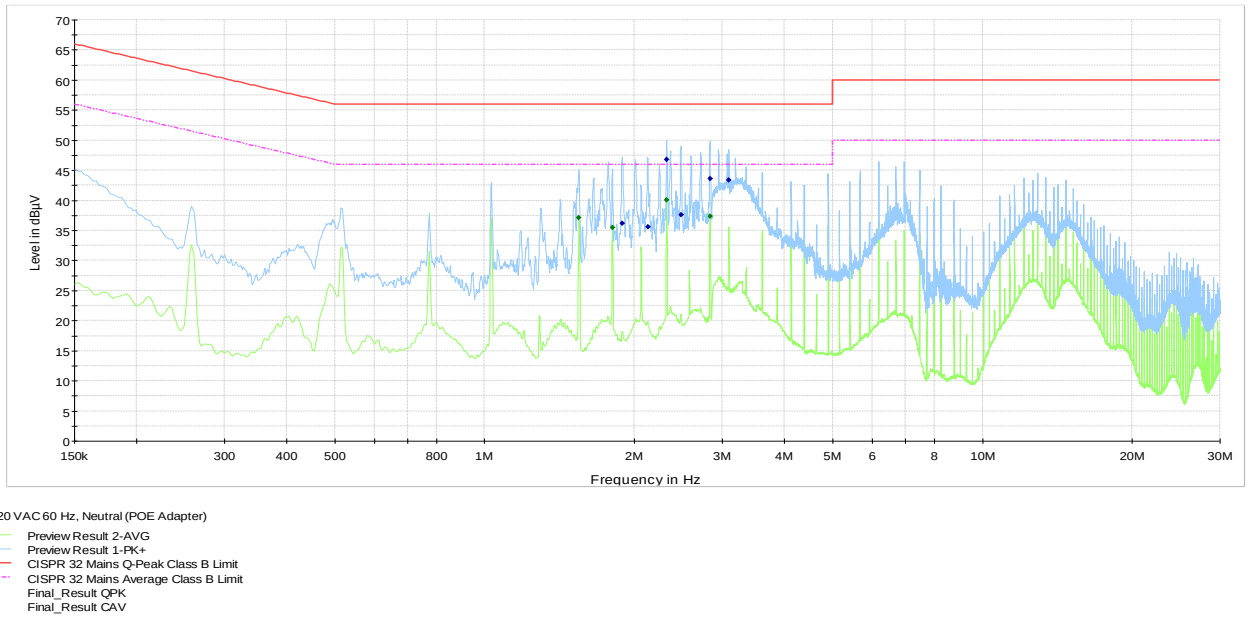


Figure 8.4-2: *AC power line conducted emissions – spectral plot on neutral line*

8.4.4 Test data, continued

Table 8.4-2: *AC power line conducted emissions results*

Frequency (MHz)	Quasi-Peak result[1] [and 3] (dBµV)	Quasi-Peak limit (dBµV)	Margin (dB)	Measurement time (ms)	Bandwidth (kHz)	Conductor	Filter	Correction factor[2] (dB)
1.77225	32.5	56.0	23.5	100	9	L1	ON	9.7
2.31900	46.5	56.0	9.5	100	9	L1	ON	9.7
2.47875	37.3	56.0	18.7	100	9	L1	ON	9.7
2.83425	43.9	56.0	12.1	100	9	L1	ON	9.7
1.889250	36.2	56.0	19.8	100	9	N	ON	9.7
2.125500	35.6	56.0	20.4	100	9	N	ON	9.7
2.321250	46.7	56.0	9.3	100	9	N	ON	9.7
2.481000	37.6	56.0	18.4	100	9	N	ON	9.7
2.834250	43.6	56.0	12.4	100	9	N	ON	9.7
3.095250	43.4	56.0	12.6	100	9	N	ON	9.7

Frequency (MHz)	CAverage result[1] [and 3] (dBµV)	CAverage limit (dBµV)	Margin (dB)	Measurement time (ms)	Bandwidth (kHz)	Conductor	Filter	Correction factor[2] (dB)
1.02975	36.4	46.0	9.6	160	9	L1	ON	9.7
1.54725	37.0	46.0	9.0	160	9	L1	ON	9.7
1.80375	35.4	46.0	10.6	160	9	L1	ON	9.7
2.31900	39.6	46.0	6.4	160	9	L1	ON	9.7
2.83650	37.4	46.0	8.6	160	9	L1	ON	9.7
3.09300	35.8	46.0	10.2	160	9	L1	ON	9.7
1.54725	37.2	46.0	8.8	160	9	N	ON	9.7
1.80600	35.5	46.0	10.5	160	9	N	ON	9.7
2.32125	40.1	46.0	5.9	160	9	N	ON	9.7
2.83650	37.4	46.0	8.6	160	9	N	ON	9.7

Notes:
[1] Result (dBµV) = receiver/spectrum analyzer value (dBµV) + correction factor (dB)
[2] Correction factor (dB) = LISN factor IL (dB) + cable loss (dB) + attenuator (dB)
[3] Emissions that were continuously present for a minimum of 1 second and occurred more than once for every 15 seconds observation period were considered valid emissions. The maximum value of valid emissions has been recorded.

Sample calculation: 39.6 dBµV (result) = 26.9 dBµV (receiver reading) + 9.7 dB (Correction factor)

8.5 FCC 15.247 (a (1 (iii))) and RSS-247 5.1 (a)(b)(d) Frequency Hopping Systems requirements, 2 GHz operation

8.5.1 Definitions and limits

FCC §15.247:

(a) Operation under the provisions of this Section is limited to frequency hopping and digitally modulated intentional radiators that comply with the following provisions:

(1) Frequency hopping systems shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, frequency hopping systems operating in the 2400–2483.5 MHz band may have hopping channel carrier frequencies that are separated by 25 kHz or two-thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided the systems operate with an output power no greater than 125 mW. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. Each frequency must be used equally on the average by each transmitter. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

(iii) Frequency hopping systems in the 2400–2483.5 MHz band shall use at least 15 channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds multiplied by the number of hopping channels employed. Frequency hopping systems may avoid or suppress transmissions on a particular hopping frequency provided that a minimum of 15 channels are used.

RSS-247 Part 5.1:

a. The bandwidth of a frequency hopping channel is the 20 dB emission bandwidth, measured with the hopping stopped. The system's radio frequency (RF) bandwidth is equal to the channel bandwidth multiplied by the number of channels in the hopset. The system shall hop to channel frequencies that are selected at the system hopping rate from a pseudo randomly ordered list of hopping frequencies. The system receivers shall have input bandwidths that match the hopping channel bandwidths of their corresponding transmitters and shall shift frequencies in synchronization with the transmitted signals.

b. FHSs shall have hopping channel carrier frequencies separated by a minimum of 25 kHz or the 20 dB bandwidth of the hopping channel, whichever is greater. Alternatively, FHSs operating in the band 2400-2483.5 MHz may have hopping channel carrier frequencies that are separated by 25 kHz or two thirds of the 20 dB bandwidth of the hopping channel, whichever is greater, provided that the systems operate with an output power no greater than 0.125 W.

d. FHSs operating in the band 2400-2483.5 MHz shall use at least 15 hopping channels. The average time of occupancy on any channel shall not be greater than 0.4 seconds within a period of 0.4 seconds, multiplied by the number of hopping channels employed. Transmissions on particular hopping frequencies may be avoided or suppressed provided that at least 15 hopping channels are used.

8.5.2 Test date

Start date	February 14, 2019

8.5.3 Observations, settings and special notes

Carrier frequency separation was tested per ANSI C63.10 subclause 7.8.2. Spectrum analyser settings:

Resolution bandwidth	Start with the RBW set to approximately 30% of the channel spacing; adjust as necessary to best identify the center of each individual channel.
Video bandwidth	≥ RBW
Frequency span	Wide enough to capture the peaks of two adjacent channels
Detector mode	Peak
Trace mode	Max Hold

Number of hopping frequencies was tested per ANSI C63.10 subclause 7.8.3. Spectrum analyser settings:

Resolution bandwidth	To identify clearly the individual channels, set the RBW to less than 30% of the channel spacing or the 20 dB bandwidth, whichever is smaller.
Video bandwidth	≥ RBW
Frequency span	The frequency band of operation. Depending on the number of channels the device supports, it may be necessary to divide the frequency range of operation across multiple spans, to allow the individual channels to be clearly seen.
Detector mode	Peak
Trace mode	Max Hold

Time of occupancy (dwell time) was tested per ANSI C63.10 subclause 7.8.4. Spectrum analyser settings:

Resolution bandwidth	shall be ≤ channel spacing and where possible RBW should be set >> 1 / T, where T is the expected dwell time per channel.
Video bandwidth	≥ RBW
Frequency span	Zero span, centered on a hopping channel.
Detector mode	Peak
Trace mode	Max Hold

20 dB bandwidth was tested per ANSI C63.10 subclause 6.9.2. Spectrum analyser settings:

Resolution bandwidth	≥ 1–5% of the 20 dB bandwidth
Video bandwidth	≥ RBW
Frequency span	approximately 2 to 5 times the 20 dB bandwidth, centered on a hopping channel
Detector mode	Peak
Trace mode	Max Hold

8.5.4 Test data

Table 8.5-1: *20 dB bandwidth results*

Modulation type	Frequency, MHz	20 dB bandwidth, kHz
π/4-DQPSK 2-DH5	2402	1315.0
π/4-DQPSK 2-DH5	2441	1385.0
π/4-DQPSK 2-DH5	2480	1380.0
8-DPSK 3-DH5	2402	1340.0
8-DPSK 3-DH5	2441	1325.0
8-DPSK 3-DH5	2480	1305.0

Table 8.5-2: *99% occupied bandwidth results*

Modulation type	Frequency, MHz	99% occupied bandwidth, kHz
π/4-DQPSK 2-DH5	2402	1215.0
π/4-DQPSK 2-DH5	2441	1195.0
π/4-DQPSK 2-DH5	2480	1195.0
8-DPSK 3-DH5	2402	1195.0
8-DPSK 3-DH5	2441	1200.0
8-DPSK 3-DH5	2480	1225.0

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

Table 8.5-3: *Carrier frequency separation results*

Modulation type	Carrier frequency separation, kHz	Two thirds of the 20 dB bandwidth limit, kHz	Margin, kHz
π/4-DQPSK 2-DH5	1004	911	93
8-DPSK 3-DH5	1004	918	86

Notes: FHSs operating in the band 2400-2483.5 MHz may have hopping channel carrier frequencies that are separated by two thirds of the 20 dB bandwidth of the hopping channel, provided that the systems operate with an output power no greater than 0.125 W

Table 8.5-4: *Number of hopping frequencies results*

Number of hopping frequencies	Minimum limit	Margin
79	15	64

Table 8.5-5: *Average time of occupancy results*

Modulation type	Dwell time of each pulse, ms	Number of pulses within period [1]	Total dwell time within period, ms	Limit, ms	Margin, ms
π/4-DQPSK 2-DH5	2.9	106	307.4	400.0	92.6
8-DPSK 3-DH5	2.9	106	307.4	400.0	92.6

Notes: [1]Measurement period =-31.6 s (0.4 seconds, multiplied by the number of hopping channels employed)

- Separation time between re-transmission at each channel = 296.3 ms.
- Within 31.6 s the number of pulses =106 (31600 /296.3)

8.5.4 Test data, continued

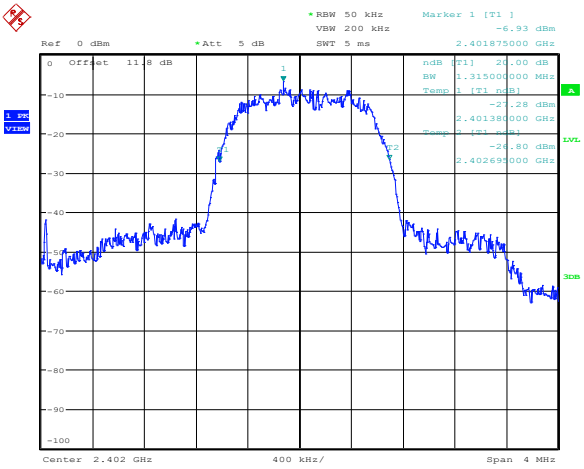


Figure 8.5-1: *20 dB bandwidth π/4-DQPSK 2-DH5 – sample plot*

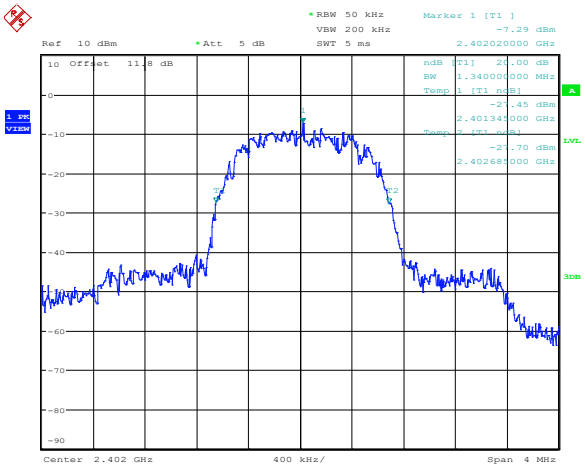


Figure 8.5-2: *20 dB bandwidth 8-DPSK 3-DH5 – sample plot*

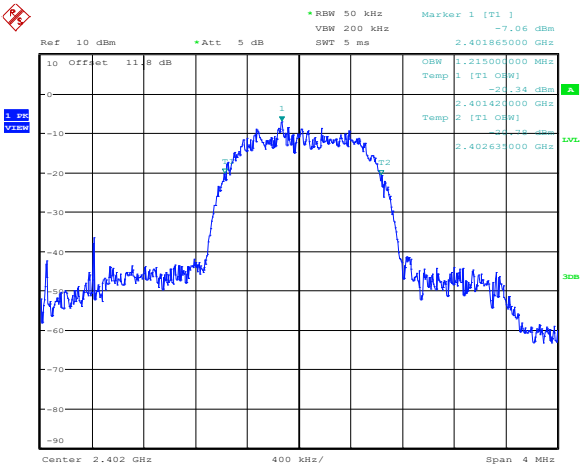


Figure 8.5-3: *99% occupied bandwidth π/4-DQPSK 2-DH5 – sample plot*

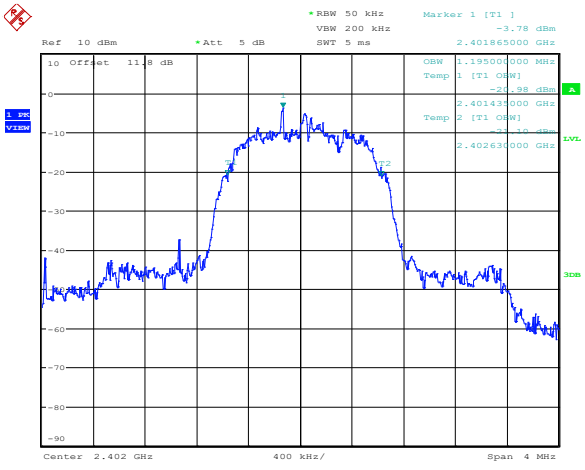


Figure 8.5-4: *99% occupied bandwidth 8-DPSK 3-DH5 – sample plot*

8.5.4 Test data, continued

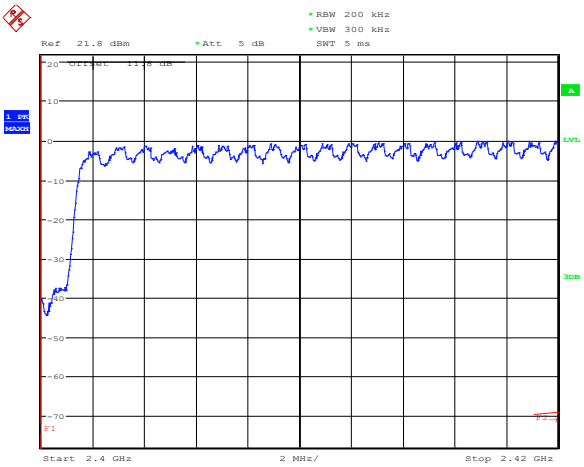


Figure 8.5-5: *Number of hopping channels, 2.4 to 2.42 GHz = 19*

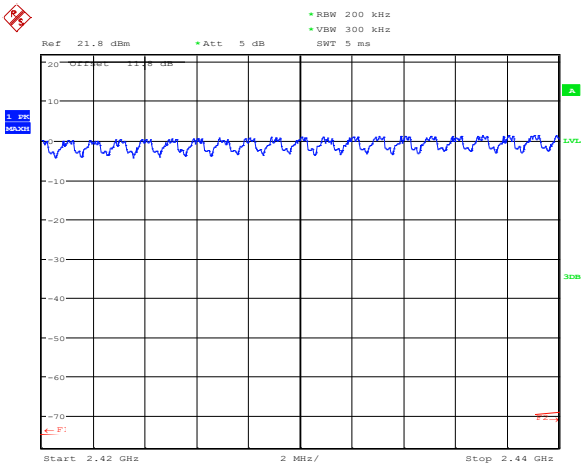


Figure 8.5-6: *Number of hopping channels, 2.42 to 2.44 GHz = 20*

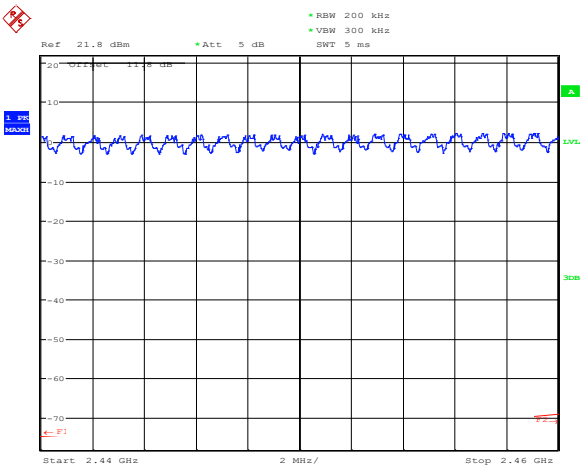


Figure 8.5-7: *Number of hopping channels, 2.44 to 2.46 GHz = 20*

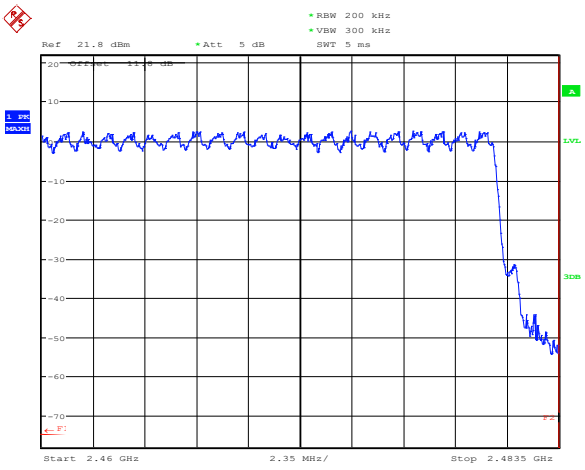


Figure 8.5-8: *Number of hopping channels, 2.46 to 2.483.5 GHz = 20*

8.5.4 Test data, continued

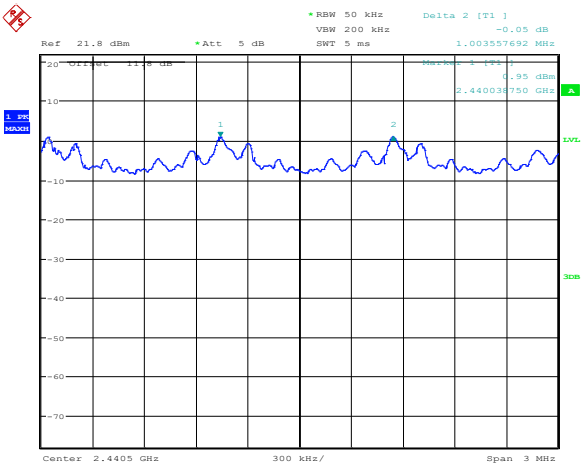


Figure 8.5-9: *Carrier frequency separation – π/4-DQPSK 2-DH5*

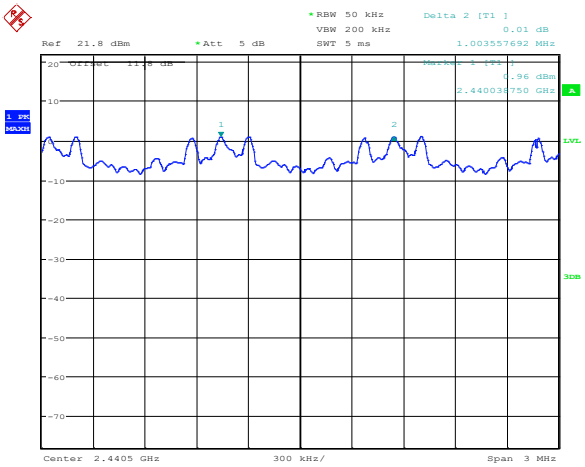


Figure 8.5-10: *Carrier frequency separation – 8-DPSK 3-DH5*

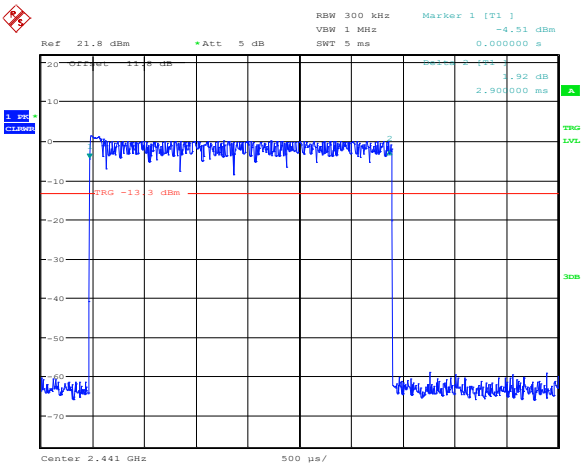


Figure 8.5-11: *Average time of occupancy pulse – π/4-DQPSK 2-DH5*

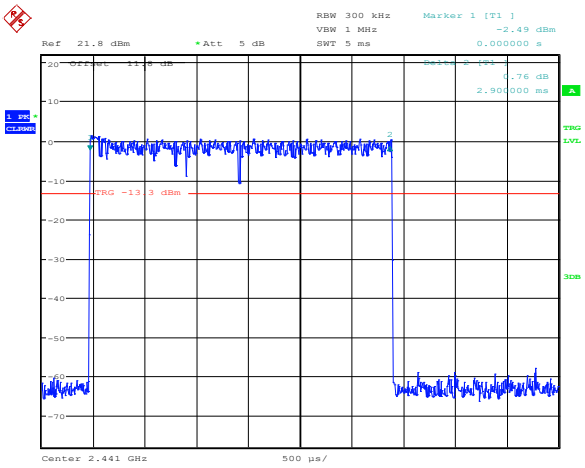


Figure 8.5-12: *Average time of occupancy pulse – 8-DPSK 3-DH5*

8.5.4 Test data, continued

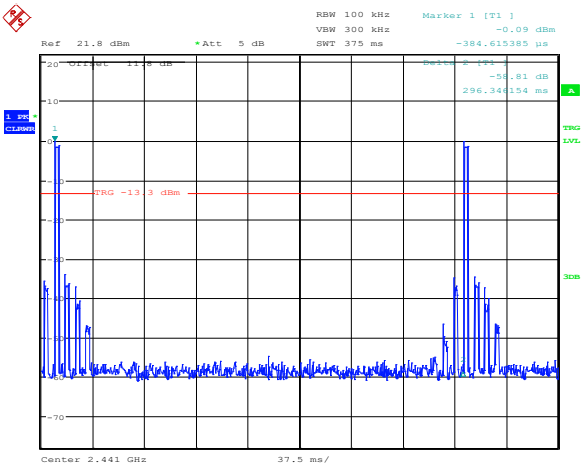


Figure 8.5-13: *Time of occupancy – Pulse separation*

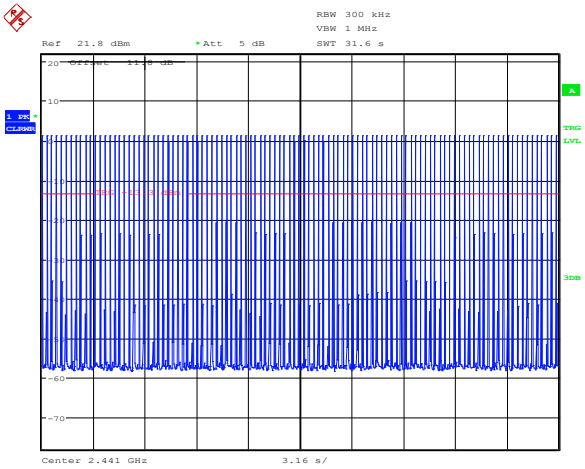


Figure 8.5-14: *Time of occupancy over 31.6 seconds*

8.6 FCC 15.247(b (1) (4)) and RSS-247 5.4 (b) Transmitter output power and e.i.r.p. requirements for FHSS 2 GHz

8.6.1 Definitions and limits

FCC §15.247:

(b) The maximum peak conducted output power of the intentional radiator shall not exceed the following:

(1) For frequency hopping systems operating in the 2400–2483.5 MHz band employing at least 75 non-overlapping hopping channels, and all frequency hopping systems in the 5725–5850 MHz band: 1 watt. For all other frequency hopping systems in the 2400–2483.5 MHz band: 0.125 watts.

(4) The conducted output power limit specified in paragraph (b) of this section is based on the use of antennas with directional gains that do not exceed 6 dBi. Except as shown in paragraph (c) of this section, if transmitting antennas of directional gain greater than 6 dBi are used, the conducted output power from the intentional radiator shall be reduced below the stated values in paragraphs (b)(1), (b)(2), and (b)(3) of this section, as appropriate, by the amount in dB that the directional gain of the antenna exceeds 6 dBi.

IC RSS-247 Part 5.4:

b. For FHSs operating in the band 2400–2483.5 MHz, the maximum peak conducted output power shall not exceed 1.0 W if the hopset uses 75 or more hopping channels; the maximum peak conducted output power shall not exceed 0.125 W if the hopset uses less than 75 hopping channels. The e.i.r.p. shall not exceed 4 W, except as provided in section 5.4(e).

8.6.2 Test date

Start date	February 14, 2019

8.6.3 Observations, settings and special notes

Conducted output power was tested per ANSI C63.10 subclause 7.8.5. The hopping shall be disabled for this test. Spectrum analyser settings:

Resolution bandwidth	> 20 dB bandwidth of the emission being measured
Video bandwidth	≥ RBW
Frequency span	approximately 5 times the 20 dB bandwidth, centered on a hopping channel
Detector mode	Peak
Trace mode	Max Hold

8.6.4 Test data

Table 8.6-1: *Output power and EIRP results*

Frequency, MHz	Output power, dBm	Output power limit, dBm	Margin, dB	Antenna gain, dBi	EIRP, dBm	EIRP limit, dBm	EIRP margin, dB
π/4-DQPSK 2-DH5							
2402	-1.5	30.0	31.5	1.5	0.0	36.0	36.0
2441	2.5	30.0	27.5	1.5	4.0	36.0	32.0
2480	3.3	30.0	26.7	1.5	4.8	36.0	31.2
8-DPSK 3-DH5							
2402	-1.2	30.0	31.2	1.5	0.3	36.0	35.7
2441	2.8	30.0	27.2	1.5	4.3	36.0	31.7
2480	3.5	30.0	26.5	1.5	5.0	36.0	31.0

Notes: EIRP = Output power + Antenna gain

8.6.4 Test data, continued

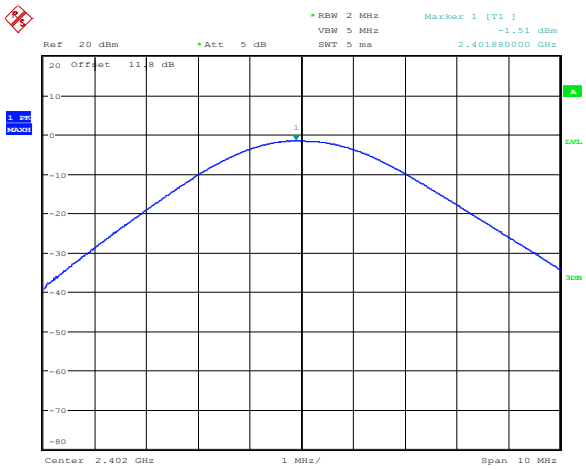


Figure 8.6-1: *Output power on low channel – π/4-DQPSK 2-DH5*

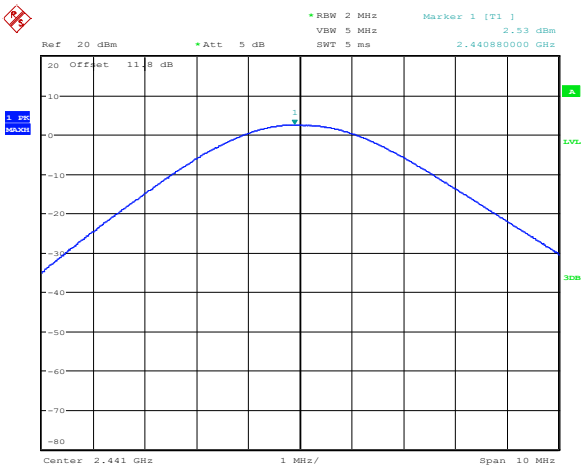


Figure 8.6-2: *Output power on mid channel – π/4-DQPSK 2-DH5*

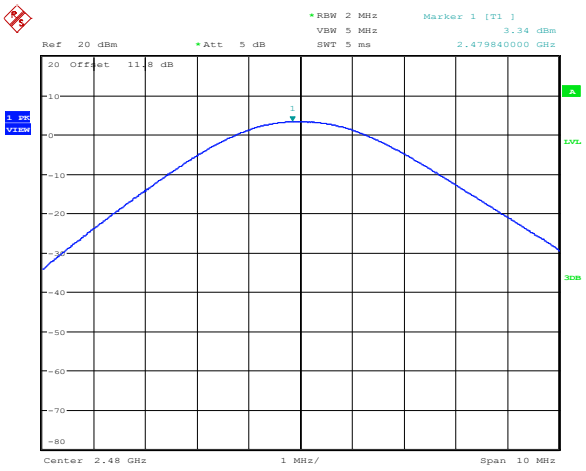


Figure 8.6-3: *Output power on high channel– π/4-DQPSK 2-DH5*

8.6.4 Test data, continued

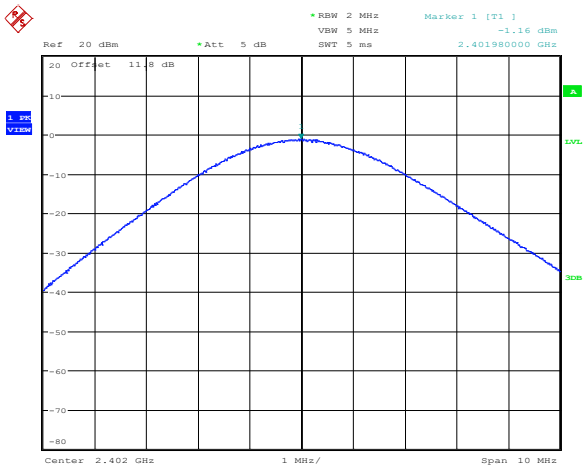


Figure 8.6-4: *Output power on low channel – 8-DPSK 3-DH5*

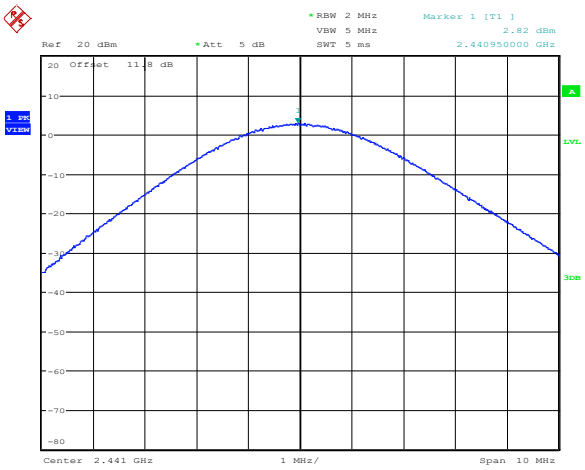


Figure 8.6-5: *Output power on mid channel – 8-DPSK 3-DH5*

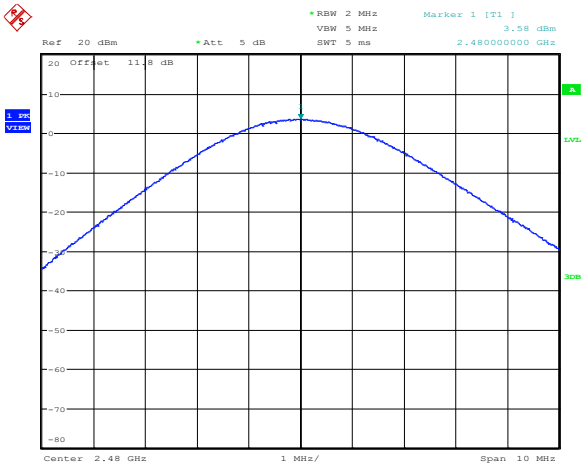


Figure 8.6-6: *Output power on high channel – 8-DPSK 3-DH5*

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

8.7.1 Definitions and limits

FCC §15.207 (d):

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)).

RSS-247 Section 5.5:

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(d), 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 8.7-1: *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 8.7-2: *ISED restricted frequency bands*

MHz	MHz	MHz	GHz
0.090–0.110	12.57675–12.57725	399.9–410	7.25–7.75
0.495–0.505	13.36–13.41	608–614	8.025–8.5
2.1735–2.1905	16.42–16.423	960–1427	9.0–9.2
3.020–3.026	16.69475–16.69525	1435–1626.5	9.3–9.5
4.125–4.128	16.80425–16.80475	1645.5–1646.5	10.6–12.7
4.17725–4.17775	25.5–25.67	1660–1710	13.25–13.4
4.20725–4.20775	37.5–38.25	1718.8–1722.2	14.47–14.5
5.677–5.683	73–74.6	2200–2300	15.35–16.2
6.215–6.218	74.8–75.2	2310–2390	17.7–21.4
6.26775–6.26825	108–138	2483.5–2500	22.01–23.12
6.31175–6.31225	149.9–150.05	2655–2900	23.6–24.0
8.291–8.294	156.52475–156.52525	3260–3267	31.2–31.8
8.362–8.366	156.7–156.9	3332–3339	36.43–36.5
8.37625–8.38675	162.0125–167.17	3345.8–3358	Above 38.6
8.41425–8.41475	167.72–173.2	3500–4400	
12.29–12.293	240–285	4500–5150	
12.51975–12.52025	322–335.4	5350–5460	

Notes: Certain frequency bands listed in this table and above 38.6 GHz are designated for low-power licence-exempt applications. These frequency bands and the requirements that apply to related devices are set out in the 200 and 300 series of RSSs

8.7.1 Definitions and limits, continued

Table 8.7-3: *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			

Notes: None

8.7.2 Test date

Start date	February 14, 2019

8.7.3 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
- DTS emissions in non-restricted frequency bands test was performed as per KDB 558074, section 8.5 with reference to ANSI C63.10 subclause 11.11.
- Since fundamental power was tested using the maximum peak conducted output power procedure to demonstrate compliance, the spurious emissions limit is −20 dBc/100 kHz.
- DTS emissions in restricted frequency bands test was performed as per KDB 558074, section 8.6 with reference to ANSI C63.10 subclause 11.12.
- DTS band-edge emission measurements test was performed as per KDB 558074, section 8.7 with reference to ANSI C63.10 subclause 11.13.

Spectrum analyser settings for conducted spurious emissions measurements:

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

Spectrum analyser settings for radiated measurements within restricted bands:

Resolution bandwidth:	Frequencies below 1 GHz: 100 kHz, Frequencies above 1 GHz: 1 MHz
Video bandwidth:	Frequencies below 1 GHz: 300 kHz, Frequencies above 1 GHz: 3 MHz
Detector mode:	Peak
Trace mode:	Max Hold

8.7.4 Test data

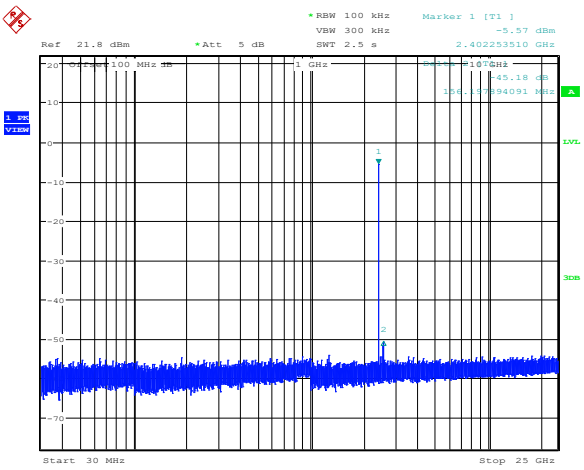


Figure 8.7-1: *Conducted spurious (out-of-band) emissions, low channel – π/4-DQPSK 2-DH5*

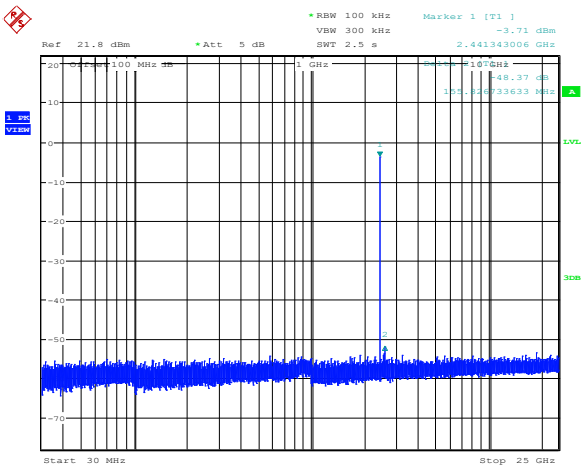


Figure 8.7-2: *Conducted spurious (out-of-band) emissions, mid channel – π/4-DQPSK 2-DH5*

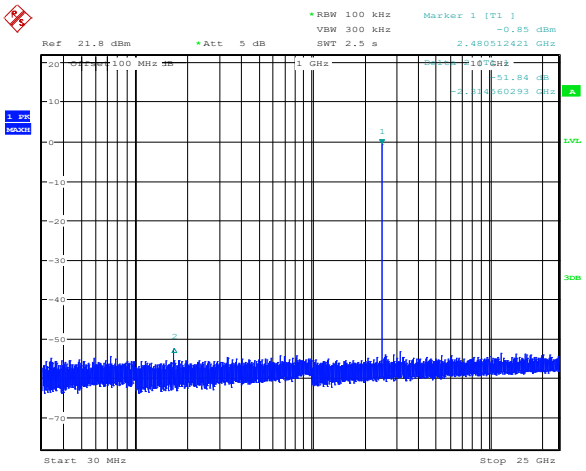


Figure 8.7-3: *Conducted spurious (out-of-band) emissions, high channel – π/4-DQPSK 2-DH5*

8.7.4 Test data, continued

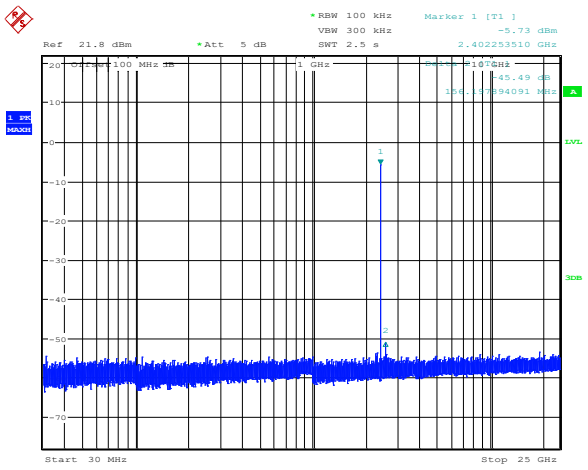


Figure 8.7-4: *Conducted spurious (out-of-band) emissions, low channel – 8-DPSK 3-DH5*

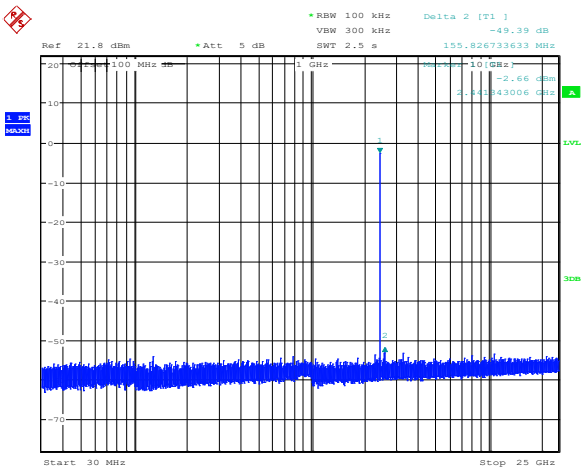


Figure 8.7-5: *Conducted spurious (out-of-band) emissions, mid channel – 8-DPSK 3-DH5*

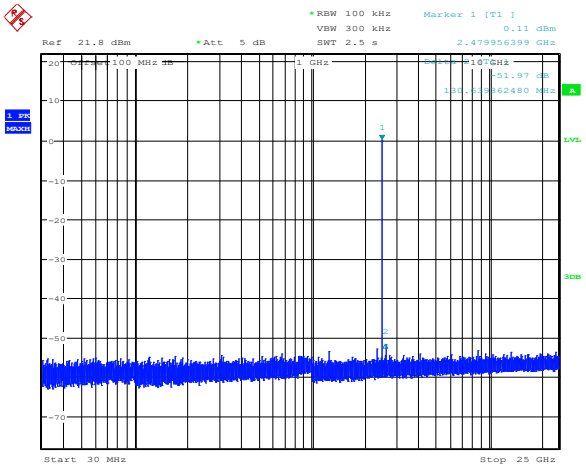


Figure 8.7-6: *Conducted spurious (out-of-band) emissions, high channel – 8-DPSK 3-DH5*

8.7.4 Test data, continued

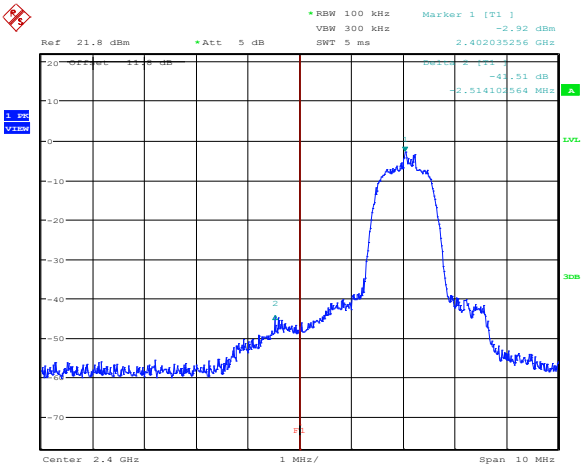


Figure 8.7-7: *Conducted spurious (out-of-band) emissions, low channel, low band edge – π/4-DQPSK 2-DH5*

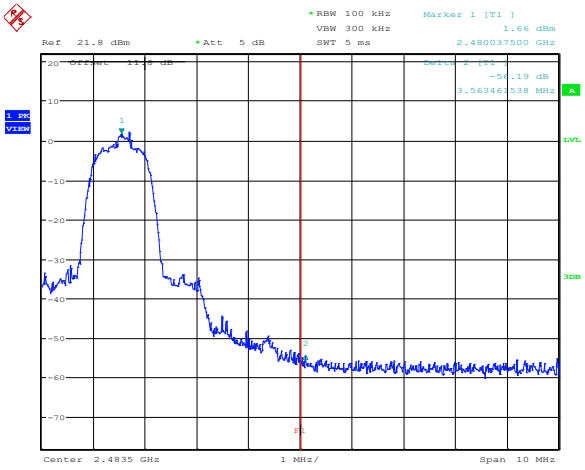


Figure 8.7-8: *Conducted spurious (out-of-band) emissions, high channel, high band edge – π/4-DQPSK 2-DH5*

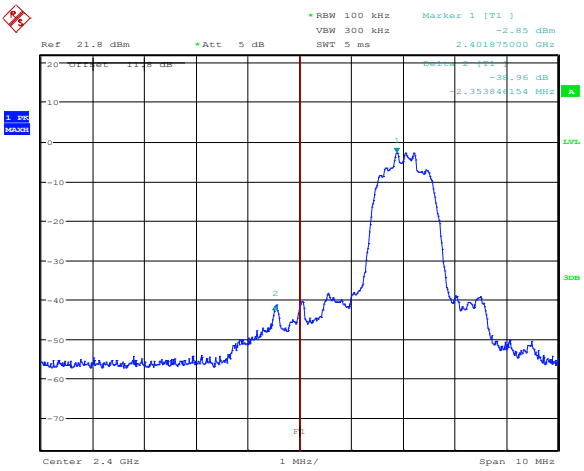


Figure 8.7-9: *Conducted spurious (out-of-band) emissions, low channel, low band edge – 8-DPSK 3-DH5*

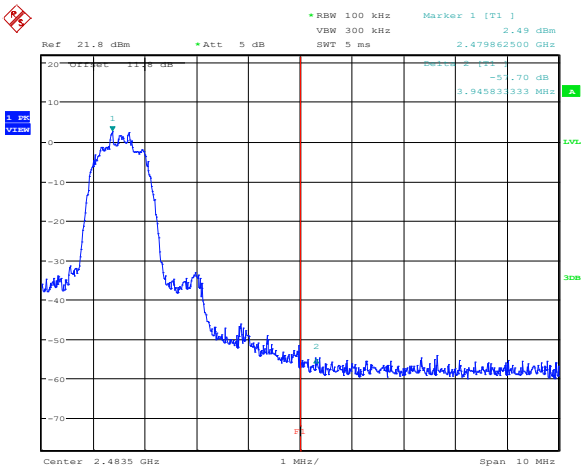


Figure 8.7-10: *Conducted spurious (out-of-band) emissions, high channel, high band edge – 8-DPSK 3-DH5*

8.7.5 Test data, continued

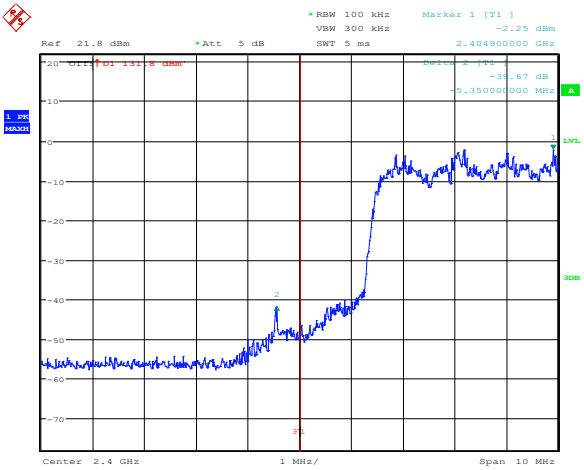


Figure 8.7-11: *Conducted spurious (out-of-band) emissions, Tx hopping, low band edge – π/4-DQPSK 2-DH5*

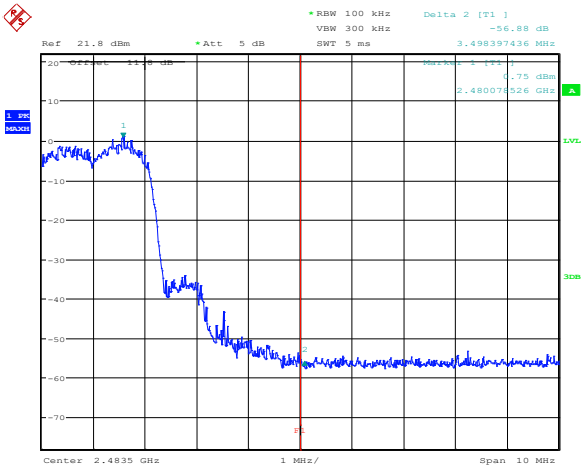


Figure 8.7-12: *Conducted spurious (out-of-band) emissions, Tx hopping, high band edge – π/4-DQPSK 2-DH5*

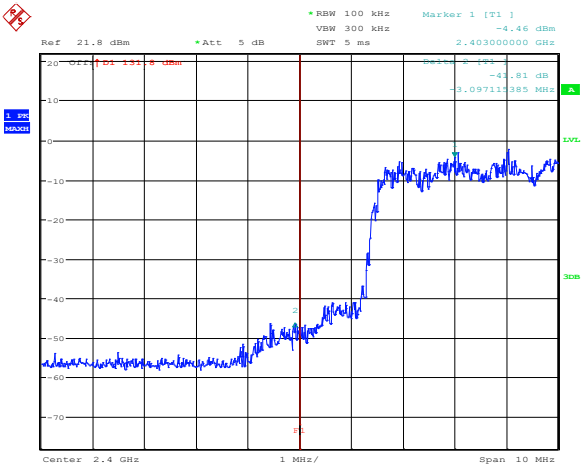


Figure 8.7-13: *Conducted spurious (out-of-band) emissions, Tx hopping, low band edge – 8-DPSK 3-DH5*

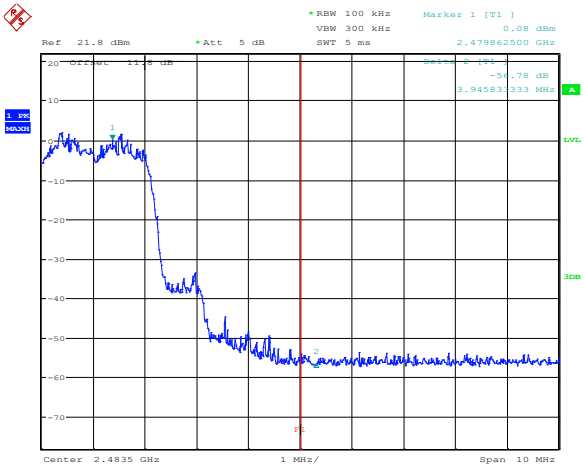


Figure 8.7-14: *Conducted spurious (out-of-band) emissions, Tx hopping, high band edge – 8-DPSK 3-DH5*

8.7.4 Test data, continued

Duty cycle/average factor calculations

§15.35(c) When the radiated emission limits are expressed in terms of the average value of the emission, and pulsed operation is employed; the measurement field strength shall be determined by averaging over one complete pulse train, including blanking intervals, as long as the pulse train does not exceed 0.1 seconds.

$$Duty\ cycle\ or\ average\ factor = 20 \times \log_{10}\left(\frac{Tx_{on}}{Tx_{Period}}\right)$$

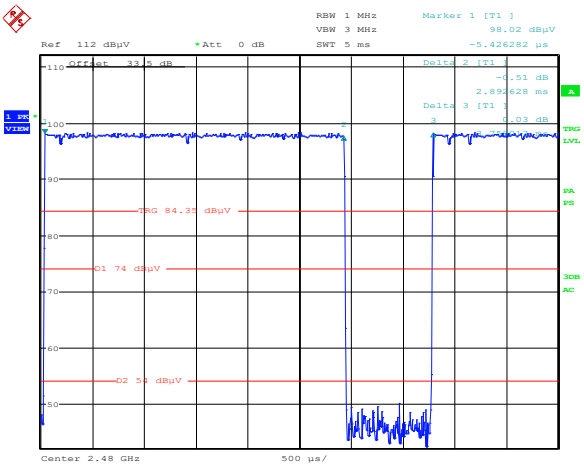


Figure 8.7-15: *Transmission duration plot – π/4-DQPSK 2-DH5*

$$Duty\ cycle\ or\ average\ factor = 20 \times \log_{10}\left(\frac{2.89}{3.76}\right) = -2.3\ dB$$

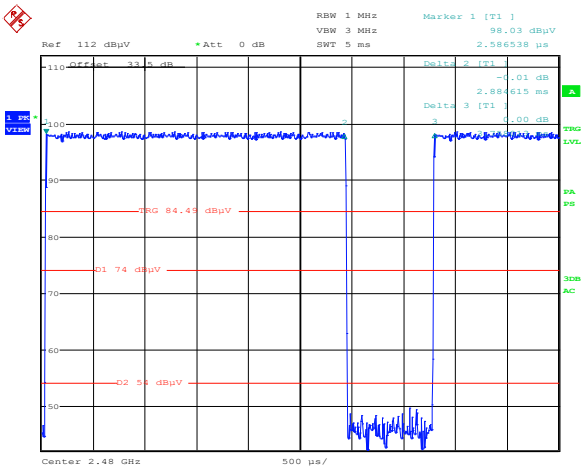


Figure 8.7-16: *Transmission duration plot – 8-DPSK 3-DH5*

$$Duty\ cycle\ or\ average\ factor = 20 \times \log_{10}\left(\frac{2.89}{3.76}\right) = -2.3\ dB$$

8.7.4 Test data, continued

Table 8.7-4: *Radiated Spurious (out-of-band) unwanted emissions within restricted bands – π/4-DQPSK 2-DH5 results*

Channel	Frequency, MHz	Peak Field strength, dBµV/m		Peak margin, dB	Average Field strength, dBµV/m			Margin, dB
		Measured	Limit		DCCF	Calculated	Limit	
Low	2390	51.2	74.0	22.8	-2.3	48.9	54.0	5.1
Low	4804	49.2	74.0	24.8	-2.3	46.9	54.0	7.1
Mid	4882	47.1	74.0	26.9	-2.3	44.8	54.0	9.2
High	2483.5	48.9	74.0	25.1	-2.3	46.6	54.0	7.4
High	4960	49.6	74.0	24.4	-2.3	47.3	54.0	6.7

Notes: Field strength (dBµV/m) = Spectrum analyzer value (dBµV) + transducer factors (dB)
Transducer factors (i.e. antenna factors, cable loss, amplifier gains, and attenuators.
Average field strength calculation was performed using the following formula:
Average Field strength = Peak Field strength + Duty cycle correction factor (DCCF) for BT

DCCF = -2.3 dB
All other emissions were greater than 20 dB below the limit.

Table 8.7-5: *Radiated Spurious (out-of-band) unwanted emissions within restricted bands – 8-DPSK 3-DH5 results*

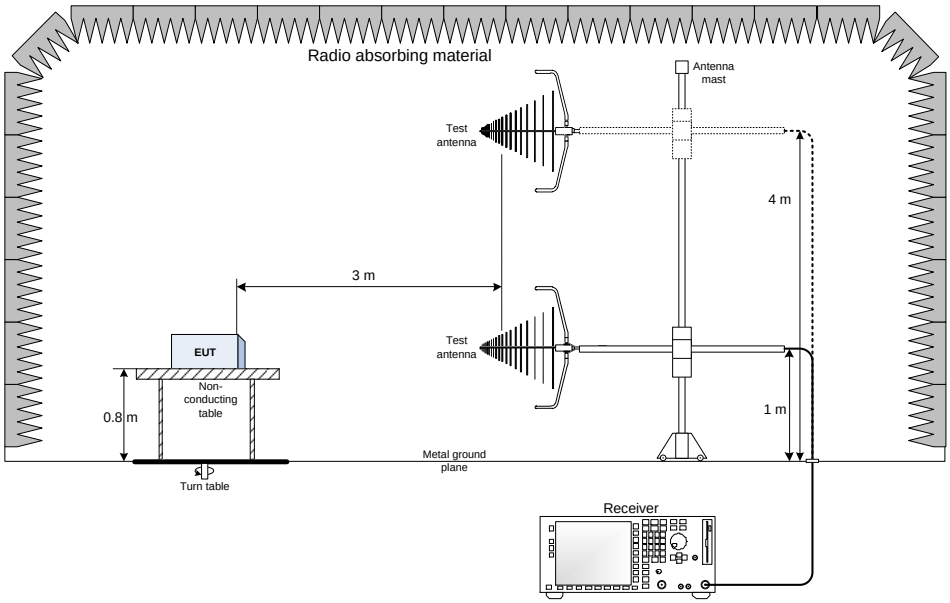
Channel	Frequency, MHz	Peak Field strength, dBµV/m		Peak margin, dB	Average Field strength, dBµV/m			Margin, dB
		Measured	Limit		DCCF	Calculated	Limit	
Low	2390	50.2	74.0	23.8	-2.3	47.9	54.0	6.1
Low	4804	49.9	74.0	24.1	-2.3	47.6	54.0	6.4
Mid	4882	47.3	74.0	26.7	-2.3	45	54.0	9.0
High	2483.5	47.9	74.0	26.1	-2.3	45.6	54.0	8.4
High	4960	49.7	74.0	24.3	-2.3	47.4	54.0	6.6

Notes: Field strength (dBµV/m) = Spectrum analyzer value (dBµV) + transducer factors (dB)
Transducer factors (i.e. antenna factors, cable loss, amplifier gains, and attenuators.
Average field strength calculation was performed using the following formula:
Average Field strength = Peak Field strength + Duty cycle correction factor (DCCF) for BT

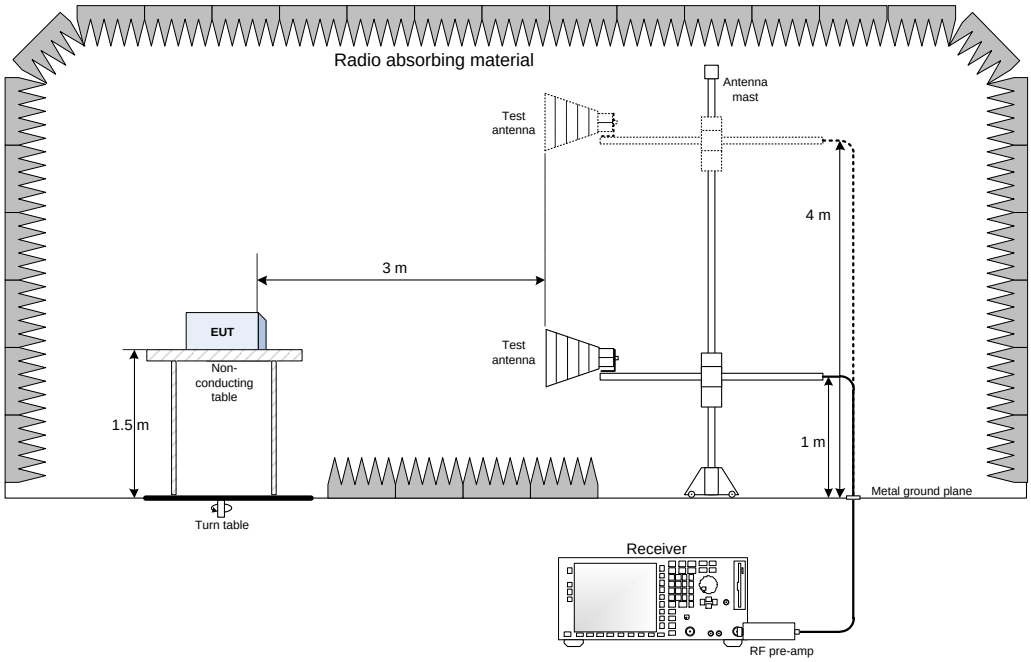
DCCF = -2.3 dB
All other emissions were greater than 20 dB below the limit.

Section 9. Block diagrams of test set-ups

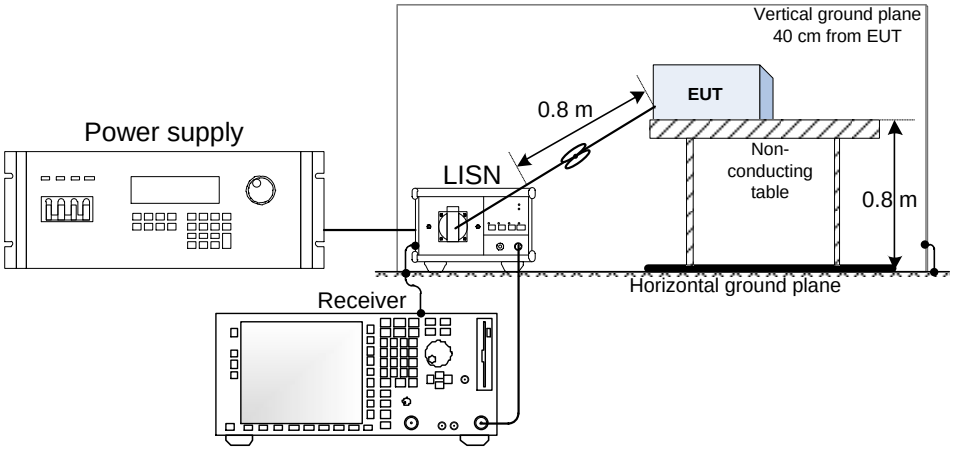
9.1 Radiated emissions set-up for frequencies below 1 GHz



9.2 Radiated emissions set-up for frequencies above 1 GHz



9.3 Conducted emissions set-up



9.4 Antenna port set-up