AN12798

K32W RF System Evaluation Report for Bluetooth LE and IEEE 802.15.4

Rev. 3 — 28 August 2023 Application note

Document Information

Information	Content
Keywords	AN12798, Bluetooth LE, TX, RX
Abstract	This document provides the RF evaluation test results of the K32W for Bluetooth Low Energy (LE) applications on Two Frequency Shift Keying (2FSK) modulation.

1 Introduction

This document provides the RF evaluation test results of the K32W for the following:

- Bluetooth Low Energy (Bluetooth LE) applications on Two Frequency Shift Keying (2FSK) modulation
- IEEE 802.15.4 applications (OQPSK modulation)

It includes the test setup description and the tools used to perform the tests. To get the K32W radio parameters, see the K32W data sheet.

2 Bluetooth LE applications

This section lists the RF evaluation test results of the K32W for Bluetooth LE applications on 2FSK modulation.

2.1 Test presentation

This section includes the list of tests, software, and equipment for Bluetooth LE applications on 2FSK modulation.

2.1.1 List of tests

Conducted tests on K32W:

- TX tests
  - Bench setup
  - Frequency accuracy
  - Phase noise
  - TX power
  - TX power in band
  - TX spurious (H2 to H5, ETSI, and FCC)
  - Upper band edge
  - Modulation characteristics
  - Carrier frequency offset and drift
- RX tests
  - Bench setup
  - Sensitivity
  - Receiver maximum input level
  - RX spurious (from 30 MHz to 12.5 GHz)
  - Receiver interference rejection performances
    - C/I and receiver selective performances
    - Receiver blocking
    - Blocking interferers
- Intermodulation
- Return loss (S11)
  - RX
  - TX

2.1.2 Software

Before the measurements, load a binary code (connectivity software) in the flash memory of the board. The Connectivity tool supports the receiver and transmitter functions of the device.

The version of the software is 1.0.2 (bin filename is `K32W_Certi_Tools.bin`). The radio driver version is 2069.

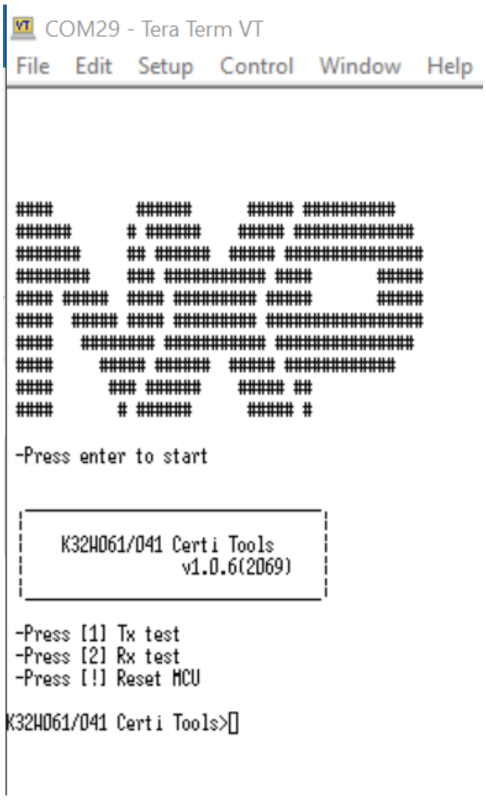


Figure 1. Certi_tool evaluation software

2.1.3 List of equipment

The list of equipment used for the RX and TX measurements are as follows:

- DK6 board and a K32W module with SMA connector (same design as modules with an M10 printed antenna)
- R&S SMBV100A signal generator
- R&S FSV spectrum analyzer; 13 GHz for harmonic measurements up to H5
- R&S ZND vector network analyzer for S11 measurements
- R&S RF shielded box to avoid interferences
- PC equipped with a GPIB card

2.2 Test summary

RF PHY Bluetooth test specification: RF-PHY.TS.4.2.0 (2014-12-09)

The list of measurements is given in Table 1 for Europe and Table 2 for the US:

Table 1. List of tests for Europe

Name	Measurements	Reference	Limit	Status
Transmission	TX maximum power	Bluetooth LE 4.2, BV-01-C	-20 dBm ≤ PAVG ≤ +10 dBm EIRP	PASS
		Bluetooth LE 5.0	20 dBm ≤ PAVG ≤ +20 dBm EIRP	

Table 1. List of tests for Europe...*continued*

Name	Measurements	Reference	Limit	Status
	TX power in band	Bluetooth LE 4.2, BV-03-C	P_{TX} <= -20 dBm for (f_{TX} +/- 2 MHz) P_{TX} <= -20 dBm for (f_{RX} +/-4 MHz and +/-5 MHz)	PASS
		Bluetooth LE 5.0	P_{TX} <= -30 dBm for (f_{TX} +/- [3 + n] MHz]) P_{TX} <= -30 dBm for (f_{RX} +/- [6+n] MHz)	
	Modulation characteristics	Bluetooth LE 4.2, BV-05-C	225 kHz <= delta $f1_{avg}$ <= 275 kHz	PASS
		Bluetooth LE 5.0	450 kHz <= delta $f1_{avg}$ <= 550 kHz	
	Carrier frequency offset and drift	Bluetooth LE 4.2, BV-06-C	f_{TX} -150 kHz <= f_n <= f_{TX} +150 kHz where f_{TX} is the nominal transmit frequency and n=0,1,2,3…k |f0 – fn| <= 50 kHz where n=2,3,4…k	PASS
		Bluetooth LE 5.0		
	Spurious 30 MHz - 1 GHz	ETSI EN 300 328	-36 dBm or -54 dBm (depends on frequency) (100 kHz BW)	PASS
	Spurious 1 GHz - 12.5 GHz	ETSI EN 300 328	-30 dBm (1 MHz BW)	PASS
	EIRP TX spectral density	ETSI EN 300 328	10 dBm/MHz	PASS
	Phase noise (unspread)	NA	NA	For information
Reception	RX sensitivity	Bluetooth LE 4.2, BV-01-C	Packet Error Rate (PER) 30.8 % with a minimum of 1500 packets	PASS
		Bluetooth LE 5.0		
	Co-channel	Bluetooth LE 4.2, BV-03-C	> 21 dB	PASS
		Bluetooth LE 5.0		
	Adjacent channel interference rejection (N+/-1,2,3+MHz)	Bluetooth LE 4.2, BV-03-C	> 15 dB, -17 dB, -27 dB	PASS
		Bluetooth LE 5.0		
	Blocking interferers	Bluetooth LE 4.2, BV-04-C	-30 dBm / -35 dBm	PASS[1]
		Bluetooth LE 5.0		
	Intermodulation performance	Bluetooth LE 4.2, BV-05-C	PER 30.8 % with a minimum of 1500 packets	PASS
		Bluetooth LE 5.0		
	RX maximum input level	Bluetooth LE 4.2, BV-06-C	PER 30.8 % with a minimum of 1500 packets	PASS
		Bluetooth LE 5.0		
	RX emissions 30 MHz - 1 GHz	ETSI EN 300 328	-57 dBm (100 kHz)	PASS
	RX emissions 1 GHz - 12.5 GHz	ETSI EN 300 328	-47 dBm (1 MHz)	PASS
Miscellaneous	Return loss (S11)	Return loss in TX mode	For information	
		Return loss in RX mode		

[1] Blockers below 2399 GHz and above 2484 GHz are not measured in this report.

Table 2. List of tests for the US

Name	Measurements	Reference	Limit	Status
Transmission	TX maximum power	FCC part 15.247	PAVG ≤ 100 mW +20 dBm EIRP	PASS
	Spurious 1 GHz - 12.5 GHz	FCC part 15.249	Field strength < 50 mV/m @ 3 m	PASS
			-41.12 dBm (1 MHz BW)	

2.3 TX conducted tests

This section includes TX conducted tests.

2.3.1 TX test setup

Figure 2 and Figure 3 show the TX test setup.

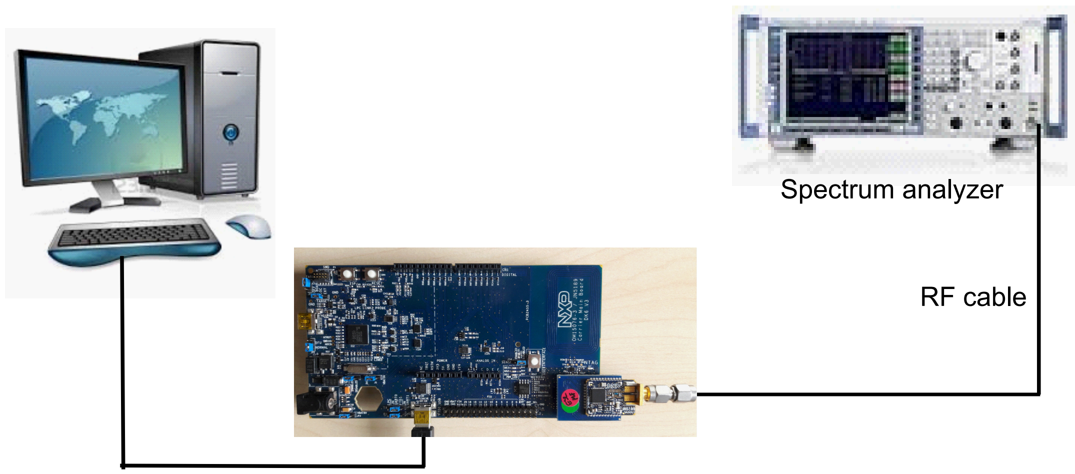


Figure 2. Conducted TX test setup

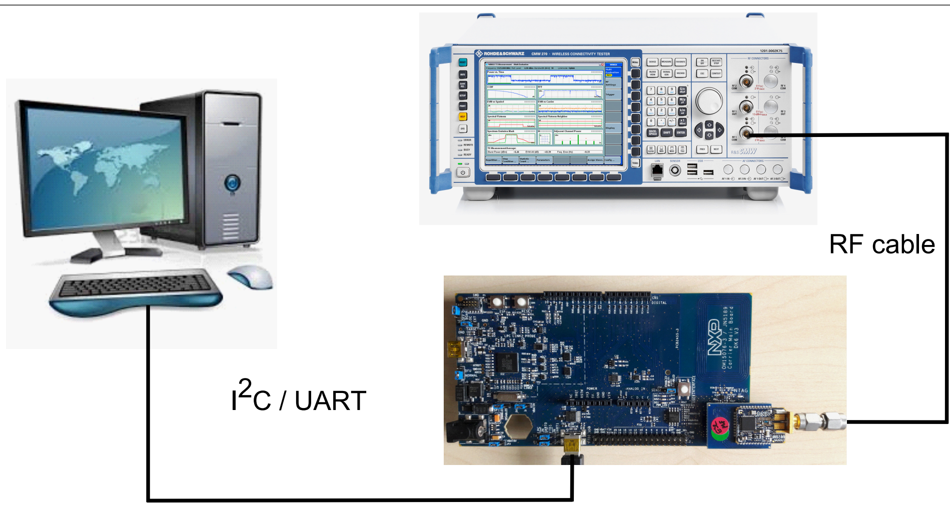


Figure 3. Specific conducted TX test setup

2.3.2 Test results

The test results for the TX conducted tests are provided in further sections.

2.3.2.1 Frequency accuracy

Test method:

- Set the radio to:
  - TX mode
  - CW
  - Continuous mode
  - Frequency: Channel 19
- Set the analyzer to:
  - Center frequency = 2.44 GHz
  - Span = 1 MHz
  - Ref amp = 20 dBm
  - RBW = 10 kHz
  - VBW = 100 kHz
- Measure the CW frequency with the marker of the spectrum analyzer.

Result for 1 MB/s:

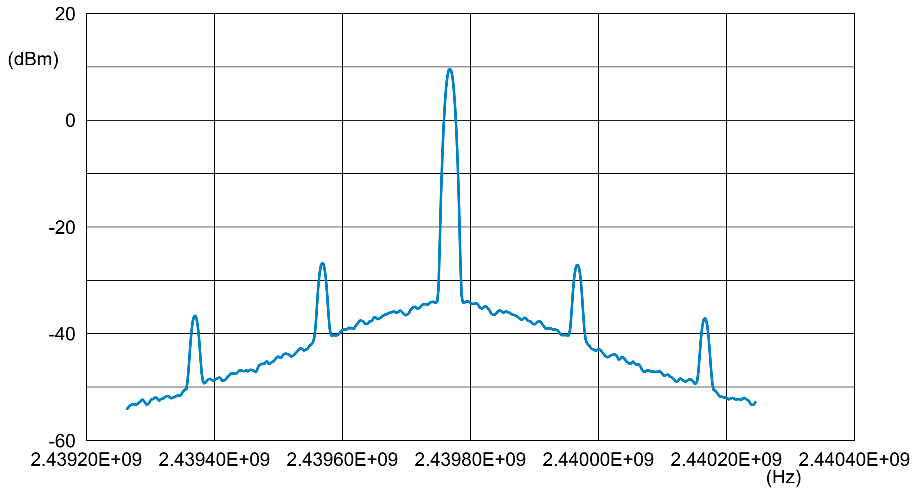


Figure 4. TX frequency accuracy for 1 MB/s

- Measured frequency = 2.4397635 GHz
- ppm value = (243976350 - 24397500) / 24397500 = +5.5 ppm

Table 3. Frequency accuracy

Result	Target
+5.5 ppm	+/-25 ppm

Result for 2 MB/s:

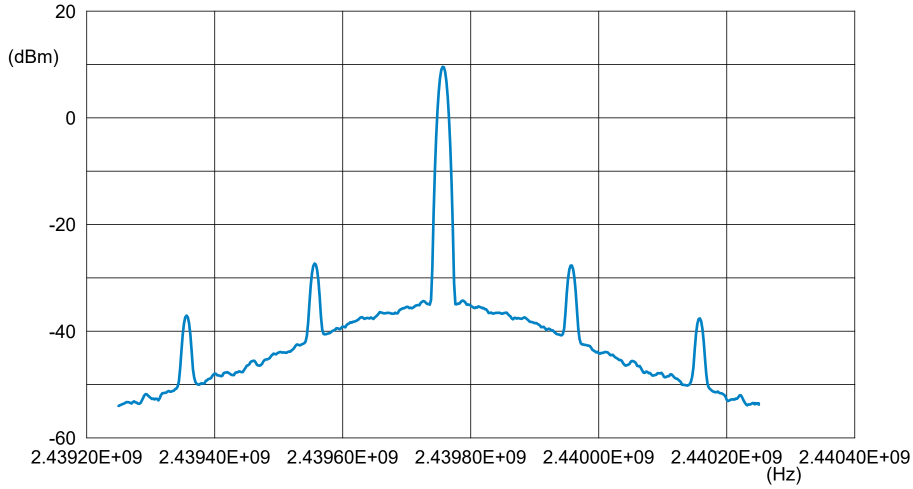


Figure 5. TX frequency accuracy for 2 MB/s

- Measured frequency = 2.43951 GHz
- ppm value = (243951000 - 24395000) / 24395000 = +4.1 ppm

Table 4. Frequency accuracy

Result	Target
+4.1 ppm	+/-25 ppm

Note: *The frequency accuracy depends on the XTAL model.*

Conclusion:

- The frequency accuracy complies with the data sheet.

2.3.2.2 Phase noise

Test method:

- Set the radio to:
  - TX mode
  - CW
  - Continuous mode
  - Frequency: Channel 19
- Set the analyzer to:
  - Center frequency = 2.44 GHz
  - Span = 1 MHz
  - Ref amp = 20 dBm
  - RBW = 10 kHz
  - VBW = 100 kHz
- Measure the phase noise at the 100 kHz offset frequency:
  - RBW (spectrum analyzer) = 10 kHz (20 log (10 kHz) = 40 dBc)

Result:

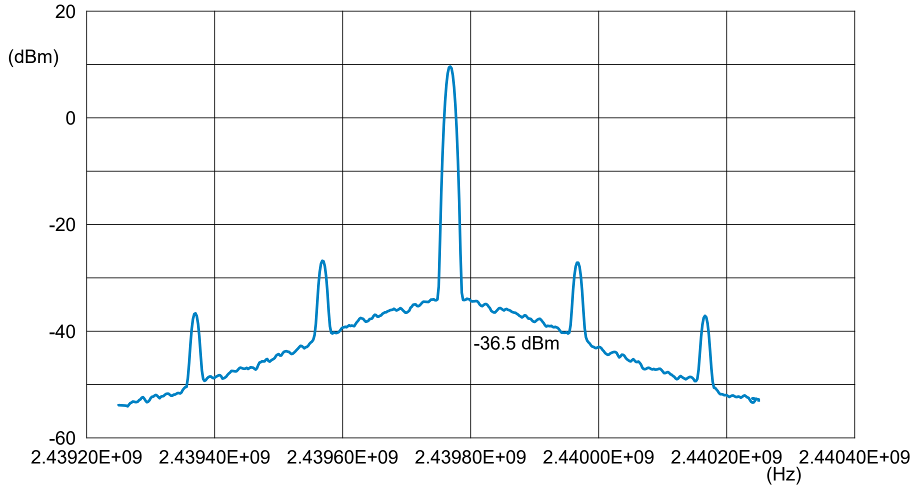


Figure 6. Conducted phase noise for 1 MB/s

- Marker value (delta) = -46.1 dBm / 100 kHz = -86.1 dBc/Hz

Note: *The phase noise is just for informational purposes. No specific issue on this parameter.*

Conclusion:

- The result is the same for 2 MB/s data rate.

2.3.2.3 TX power (fundamental)

Test method:

- Set the radio to:
  - TX mode 1 M
  - Unmodulated
  - Continuous mode (00)
- Set the analyzer to:
  - Start frequency = 2.4 GHz
  - Stop frequency = 2.5 GHz
  - Ref amp = 20 dBm
  - Sweep time = 11.3 µs
  - RBW = 3 MHz
  - VBW = 3 MHz
  - Maximum Hold mode
  - Detector = RMS
- Sweep all the channels from channel 0 to channel 39

Result:

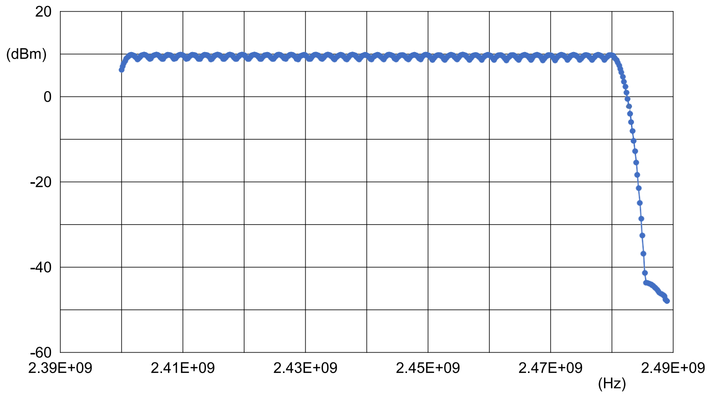


Figure 7. TX power for 1 MB/s

- Maximum power is on channel 10: 9.74 dBm
- Minimum power is on channel 20: 9.67 dBm
- Tilt over frequencies is: 0.07 dB

The same test is performed when setting 2 MB/s. Figure 8 shows the result:

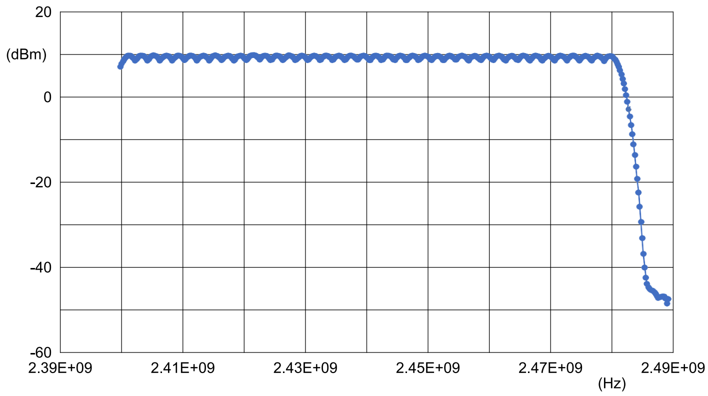


Figure 8. TX power for 2 MB/s

- Maximum power is on channel 10: 9.74 dBm
- Minimum power is on channel 11: 9.66 dBm
- Tilt over frequencies is: 0.07 dB

Conclusion:

- The default TX power is in line with the expected results.
- The power is flat over frequencies.

2.3.2.4 TX power in band

Test method:

- Set the radio to:
  - TX mode
  - Modulated
  - Continuous mode
- Set the analyzer to:
  - Start frequency = 2.35 GHz

- Stop frequency = 2.5 GHz
- Ref amp = 10 dBm
- Sweep time = 100 ms
- RBW = 100 kHz
- VBW = 300 kHz
- Maximum Hold mode
- Detector = RMS
- Number of sweeps = 10

• Sweep on channel 2, channel 19, and channel 37

Result:

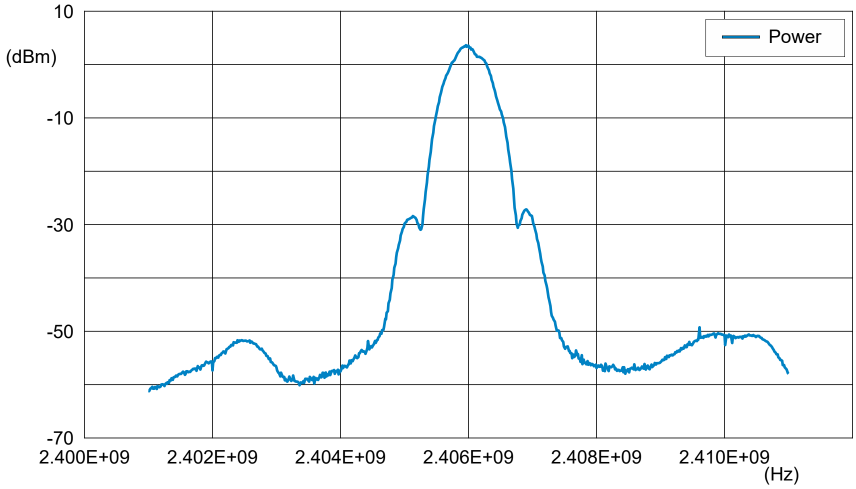


Figure 9. TX power in band, channel 2 for 1 MB/s

Table 5 shows the statistics on 1 MHz bandwidth using CMW270 equipment measurement:

Table 5. For 1 MB/s

Bandwidth	Specification	Measurement (dBm)
Max peak level <= -2 MHz	-20	-33.9
Max peak level >= +2 MHz	-20	-33.3
Max peak level <= -3 MHz	-30	-45.2
Max peak level >= +3 MHz	-30	-43.8

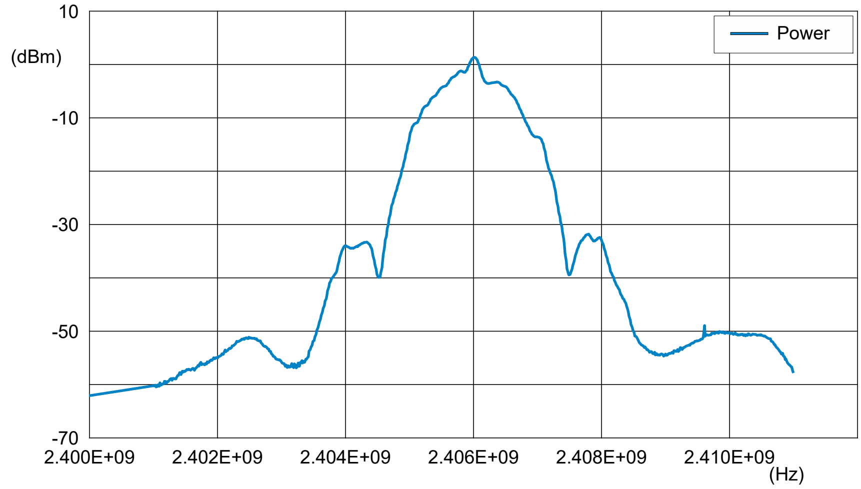


Figure 10. TX power in band, channel 2 for 2 MB/s

Table 6 shows the statistics on 1 MHz bandwidth using CMW270 equipment measurement.

Table 6. For 2 MB/s

Bandwidth	Specification	Measurement (dBm)
Max peak level <= -4 MHz	-20	-49.8
Max peak level >= +4 MHz	-20	-47.4
Max peak level <= -6 MHz	-	-
Max peak level >= +6 MHz	-30	-54.4

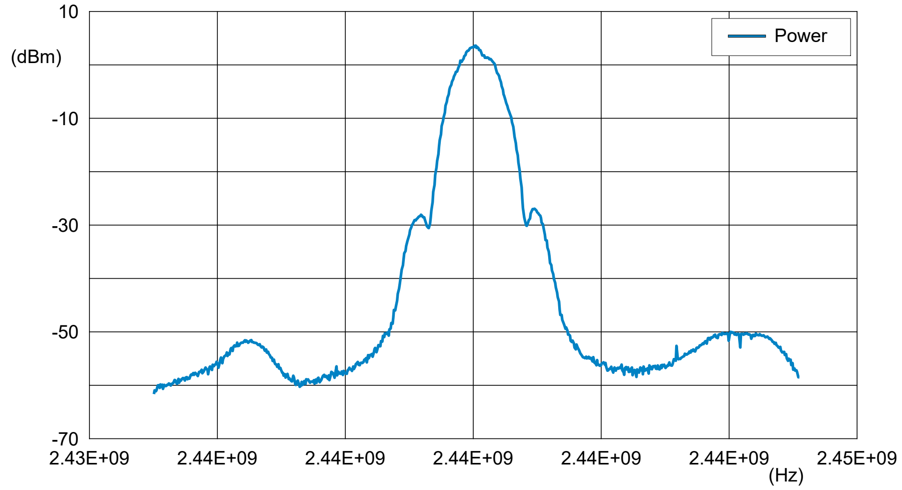


Figure 11. TX power in band, channel 19 for 1 MB/s

Table 7 shows the statistics on 1 MHz bandwidth using CMW270 equipment measurement.

Table 7. For 1 MB/s

Bandwidth	Specification	Measurement (dBm)
Max peak level <= -2 MHz	-20	-45.3
Max peak level >= +2 MHz	-20	-45.6
Max peak level <= -3 MHz	-30	-49.6

Table 7. For 1 MB/s*...continued*

Bandwidth	Specification	Measurement (dBm)
Max peak level >= +3 MHz	-30	-48.8

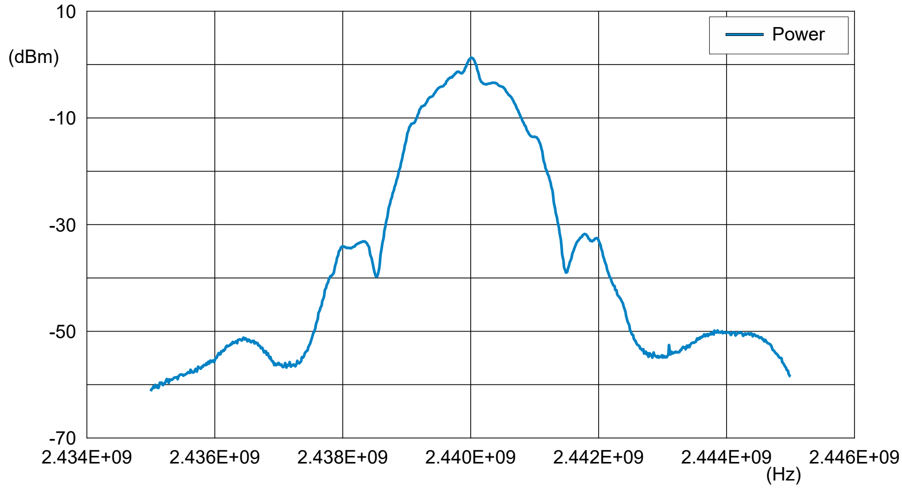


Figure 12. TX power in band, channel 19 for 2 MB/s

Table 8 shows the statistics on 1 MHz bandwidth using CMW270 equipment measurement.

Table 8. For 2 MB/s

Bandwidth	Specification	Measurement (dBm)
Max peak level <= -4 MHz	-20	-49.6
Max peak level >= +4 MHz	-20	-47.3
Max peak level <= -6 MHz	-30	-54.2
Max peak level >= +6 MHz	-30	-54.2

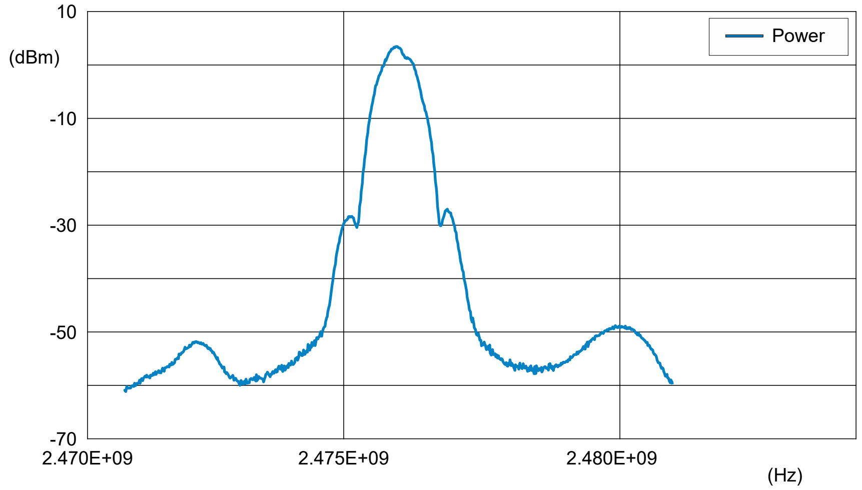


Figure 13. TX power in band, channel 37 for 1 MB/s

Table 9 shows the statistics on 1 MHz bandwidth using CMW270 equipment measurement.

Table 9. For 1 MB/s

Bandwidth	Specification	Measurement (dBm)
Max peak level <= -2 MHz	-20	-45.0
Max peak level >= +2 MHz	-20	-45.2
Max peak level <= -3 MHz	-30	-49.6
Max peak level >= +3 MHz	-30	-48.6

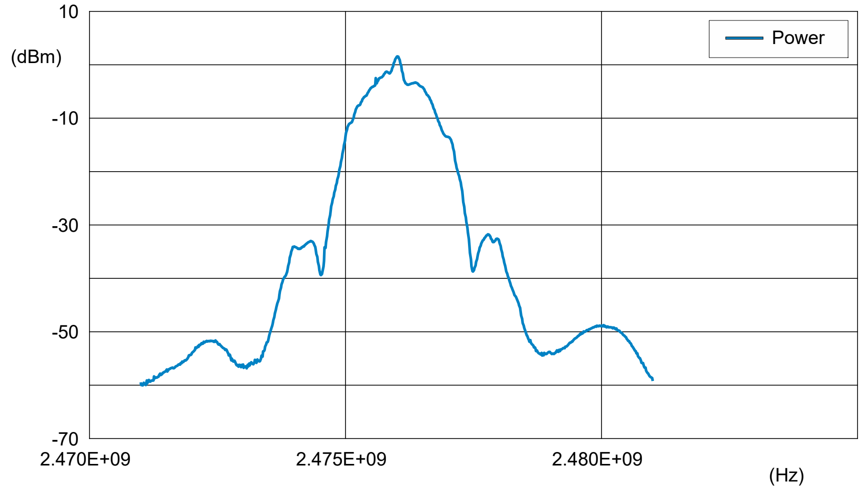


Figure 14. TX power in band, channel 37 for 2 MB/s

Table 10 shows the statistics on 1 MHz bandwidth using CMW270 equipment measurement.

Table 10. For 2 MB/s

Bandwidth	Specification	Measurement (dBm)
Max peak level <= -4 MHz	-20	-46.3
Max peak level >= +4 MHz	-20	-44.9
Max peak level <= -6 MHz	-30	-48.8
Max peak level >= +6 MHz	-	-

Conclusion:

- These results are compliant with Bluetooth LE 4.2 and Bluetooth LE 5.0.

2.3.2.5 TX spurious

This section includes the overview of TX spurious tests.

2.3.2.5.1 30 MHz to 12.5 GHz

A spurious overview of the full band from 30 MHz to 12.5 GHz when the device is in the transmission mode is as follows:

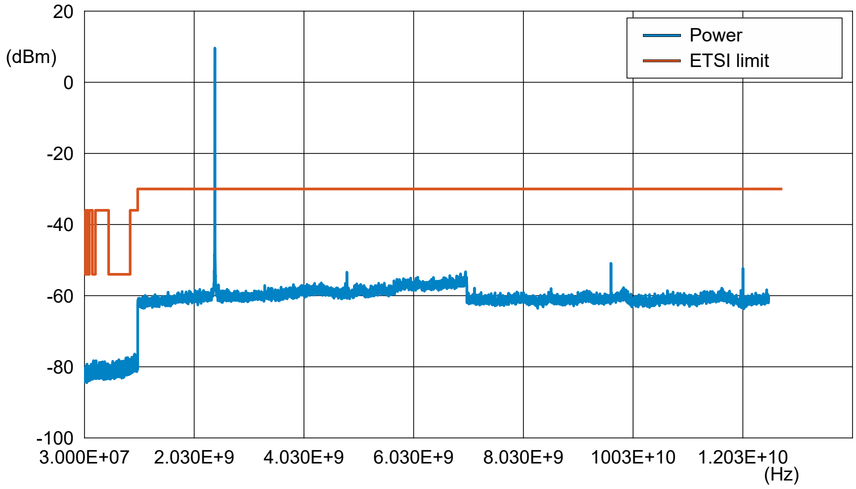


Figure 15. Conducted TX spurious 1 MB/s (30 MHz to 1 GHz)

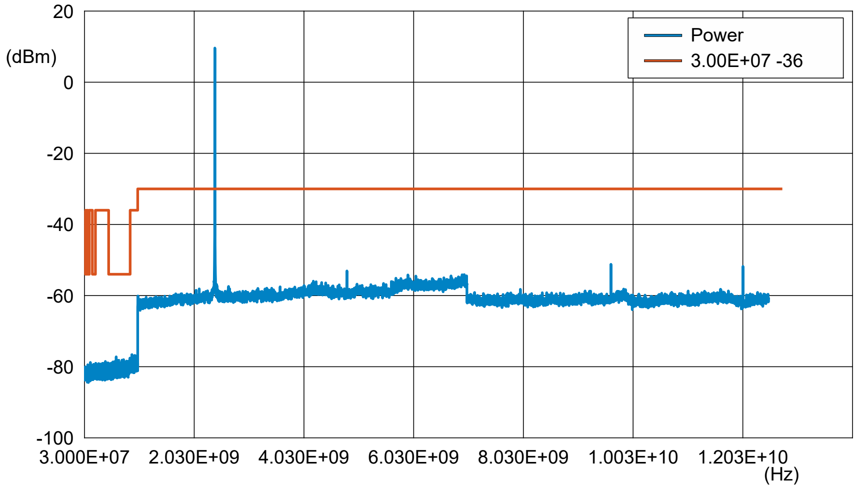


Figure 16. Conducted TX spurious for 2 MB/s (30 MHz to 12.5 GHz)

Conclusion:

- There are no TX spurs above the EN 300 328 limit (more than 15 dB margin).
- Harmonics are measured in the following sections.

2.3.2.5.2 H2 (ETSI test conditions, peak measurement)

Test method:

- Set the radio to:
  - TX mode
  - Modulated
  - Continuous mode
- Set the analyzer to:
  - Start frequency = 4.7 GHz
  - Stop frequency = 5 GHz
  - Ref amp = -20 dBm
  - Sweep time = 100 ms

- RBW = 1 MHz
- VBW = 3 MHz
- Maximum Hold mode
- Detector = Peak
- Sweep all the channels from channel 0 to channel 39

Result:

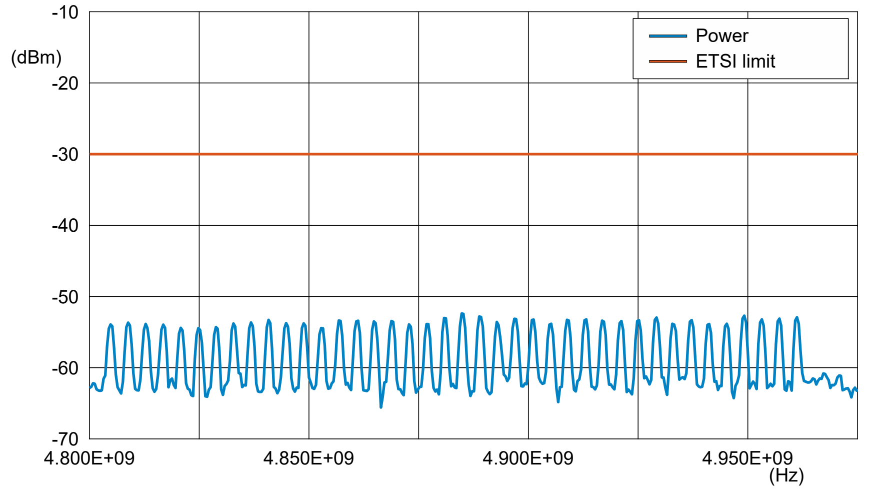


Figure 17. Conducted H2 spurious

- Maximum power is at channel 21: -52.4 dBm

Conclusion:

- There is a 22.4 dB margin to the ETSI limit.

2.3.2.5.3 H3 (ETSI test conditions, peak measurement)

The test method is the same as for the H2, except the spectrum analyzer frequency start/stop is set to 7.0 GHz and 7.5 GHz.

Result:

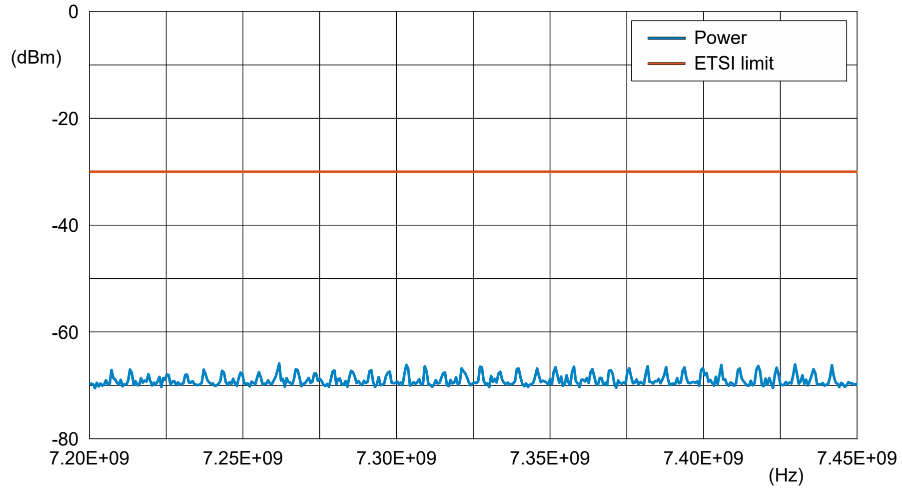


Figure 18. Conducted H3 spurious

- H3 Maximum power is at channel 17: -66.9 dBm

Conclusion:

- There is a 36.9 dB margin to the ETSI limit.

2.3.2.5.4 H4 (ETSI test conditions, peak measurement)

The test method is the same as for the H2, except that the spectrum analyzer frequency span is set from 9.4 GHz to 10.0 GHz.

Result:

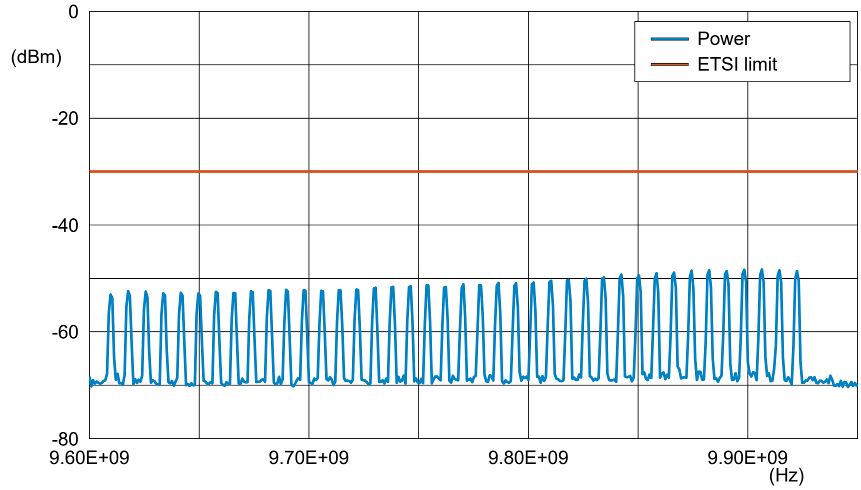


Figure 19. Conducted H4 spurious

- Maximum power is at channel 37: -48.4 dBm

Conclusion:

- There is a 18.4 dB margin to the ETSI limit.

2.3.2.5.5 H5 (ETSI test conditions, peak measurement)

The test method is similar as for the H2, except that the spectrum analyzer frequency span is set from 11.7 GHz to 12.5 GHz.

Result:

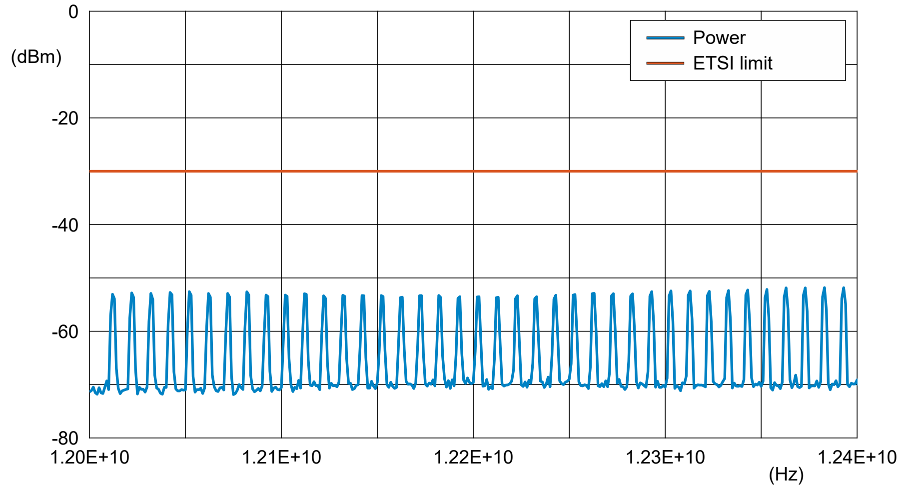


Figure 20. Conducted H5 spurious

- Maximum power is at channel 37: -47.95 dBm

Conclusion:

- There is a 17.95 dB margin to the ETSI limit.

2.3.2.5.6 H2 (FCC test conditions, average measurements)

Test method:

- Set the radio to:
  - TX mode
  - Modulated
  - Continuous mode
- Set the analyzer to:
  - Start frequency = 4.7 GHz
  - Stop frequency = 5 GHz
  - Ref amp = -20 dBm
  - Sweep time = 100 ms
  - RBW = 1 MHz
  - VBW = 3 MHz
  - Trace = Maximum Hold mode
  - Detector = RMS
- Sweep all the channels from channel 0 to channel 39

  Note: *For this case and further sections, only 4 is represented.*

  I

Result:

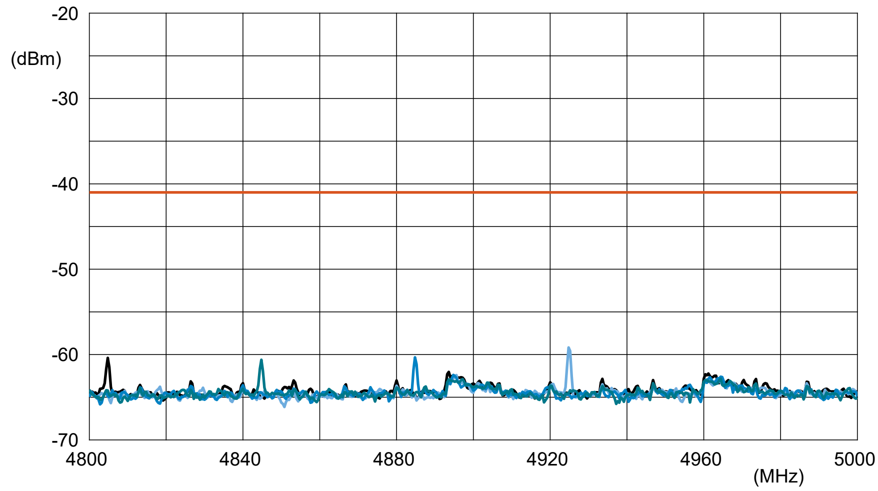


Figure 21. Conducted H2 FCC spurious

Conclusion:

- There is around 20 dB margin to the FCC limit.

2.3.2.5.7 H3 (FCC test conditions, average measurements)

The test method is similar as for the H2, except that the spectrum analyzer frequency span is set from 7.0 GHz to 7.5 GHz.

Result:

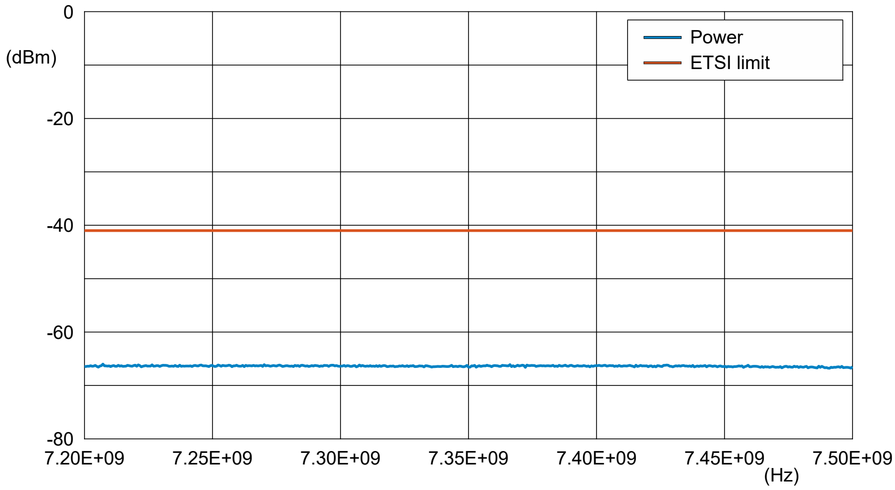


Figure 22. Conducted H3 FCC spurious

- Power is -66 dBm below the noise floor of this measurement.

Conclusion:

- There is a 25 dB margin to the FCC limit.

2.3.2.5.8 H4 (FCC test conditions, average measurements)

The test method is the same as for the H2, except that the spectrum analyzer frequency span is set from 9.4 GHz to 10 GHz.

Result:

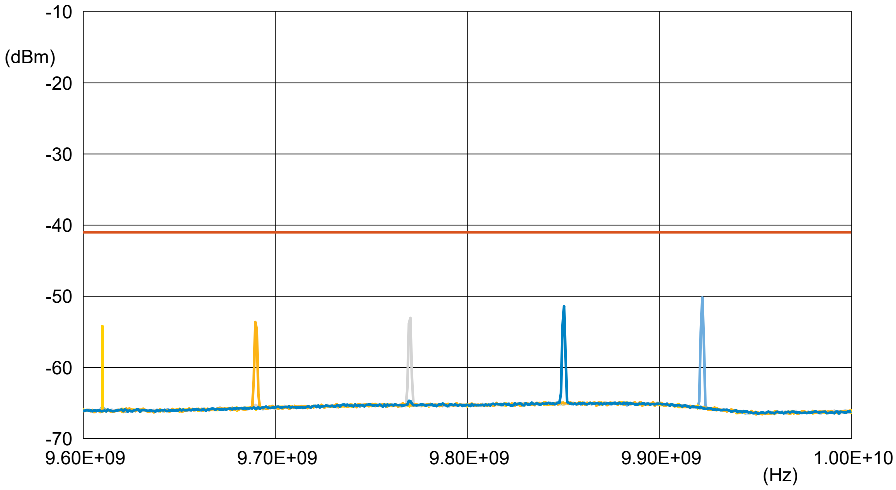


Figure 23. Conducted H4 FCC spurious

Conclusion:

- There is around 9 dB margin to the FCC limit.

2.3.2.5.9 H5 (FCC test conditions, average measurements)

The test method is the same as for the H2, except that the spectrum analyzer frequency span is set from 11.7 GHz to 12.5 GHz.

Result:

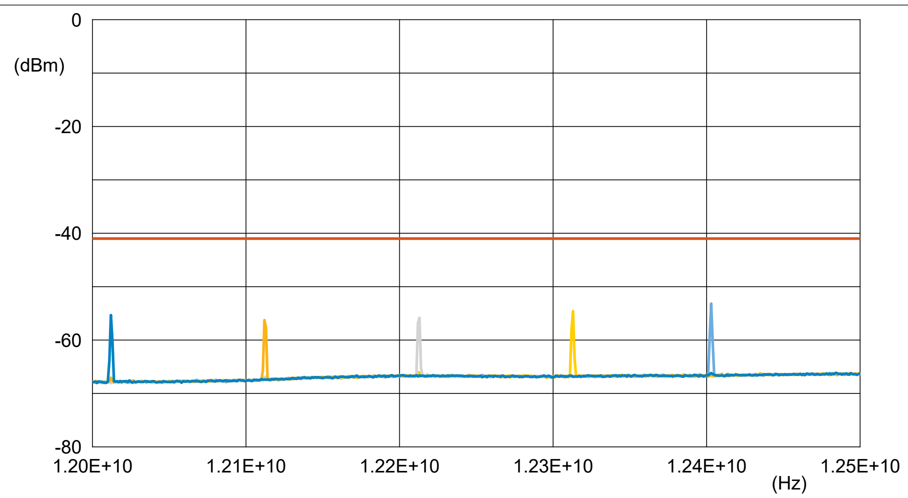


Figure 24. Conducted H5 FCC spurious

Conclusion:

- There is around 12 dB margin to the FCC limit.

2.3.2.6 Upper band edge

Test method:

- Set the radio to:
  - TX mode
  - Modulated
  - Continuous mode
- Set the analyzer to:
  - Start frequency = 2.475 GHz
  - Stop frequency = 2.485 GHz
  - Ref amp = -20 dBm
  - Sweep time = 100 ms
  - RBW = 1 MHz
  - VBW = 3 MHz
  - Detector = Average
  - Average mode = Power
  - Number of Sweeps = 100
  - Set the channel 39 (2.48 GHz)

Results:

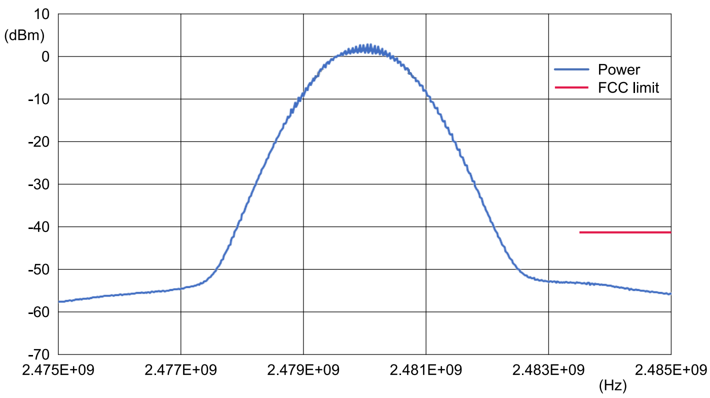


Figure 25. Upper band edge for 1 MB/s, channel 39

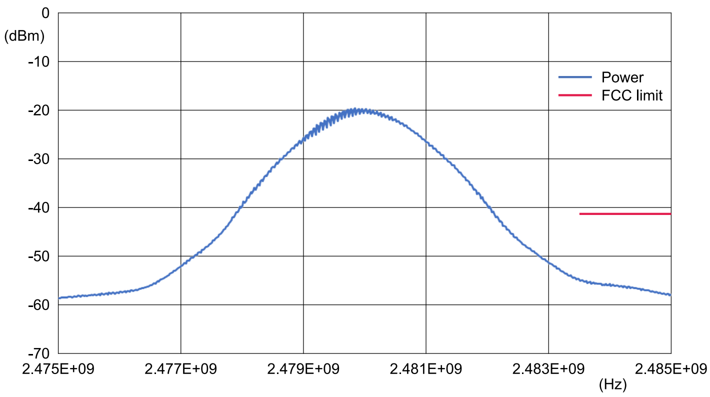


Figure 26. Upper band edge for 2 MB/s, channel 39

Conclusion:

- The upper band edge test passes the FCC certification.
- There is a 12.7 dB margin for 1 MB/s and 13.5 dB margin for 2 MB/s to the FCC limit.

2.3.2.7 Modulation characteristics

A CMW equipment is used to measure the frequency deviation df1 and df2. A specific binary is flashed from the SDK: `hci_blackbox_bm.bin`. The version 2.11 is used here.

Test method:

- Generator for the desired signal: CMW R&S
- Criterion: PER < 30.8 % with 1500 packets
- Channels under test: 0, 2, 12, 19, 37, and 39

Result:

Table 11. Modulation characteristics at 1 MB/s

Frequency deviation	Channel number						Specification	
	0	2	12	19	37	39	min	max
Frequency deviation df1 Average (kHz)	250.54	248.77	250.11	250.47	249.72	250.65	225	275
Frequency deviation df2 99.9 % (kHz)	204.14	204.84	201.35	204.84	209.44	206.34	185	-

Table 11. Modulation characteristics at 1 MB/s*...continued*

Frequency deviation	Channel number						Specification	
	0	2	12	19	37	39	min	max
Frequency deviation df2 Average / df1 Average	0.904	0.918	0.899	0.916	0.908	0.9	0.8	-

Table 12. Modulation characteristics at 2 MB/s

Frequency deviation	Channel number						Specification	
	0	2	12	19	37	39	min	max
Frequency deviation df1 Average (kHz)	509.94	502.86	508.01	509.61	508.37	510.28	450	550
Frequency deviation df2 99.9 % (kHz)	421.28	423.67	416.28	427.87	424.67	422.27	370	-
Frequency deviation df2 Average / df1 Average	0.874	0.89	0.871	0.884	0.878	0.872	0.8	-

Conclusion:

- The margins are good and in line with the expected results.

2.3.2.8 Carrier frequency offset and drift

A CMW equipment is used to measure the frequency deviation df1 and df2. A specific binary is flashed from the SDK: `hci_blackbox_bm.bin`. The version 2.11 is used here.

Test method:

- Generator for the desired signal: CMW270 R&S
- Criterion: PER < 30.8 % with 1500 packets
- Channels under test: 0, 2 ,12, 19, 37, and 39

Result:

Table 13. Carrier frequency offset and drift at 1 MB/s

Frequency offset and drift	Channel number						Specification	
	0	2	12	19	37	39	min	max
Frequency drift (kHz)	-5.14	-5.65	-3.87	0.03	2.25	2.49	-50	50
Max drift rate (kHz/50 µs)	-0.14	-0.41	0.17	0.7	0.07	0.12	-20	20
Frequency offset (kHz)	9.39	9.8	8.13	7.86	7.72	7.93	-150	150
Initial frequency drift (kHz)	-3.15	-2.95	-1.43	0.39	1.05	1.58	-23	23

Table 14. Carrier frequency offset and drift at 2 MB/s

Frequency offset and drift	Channel number						Specification	
	0	2	12	19	37	39	min	max
Frequency drift (kHz)	-4.97	-4.34	-1.87	1.53	4.73	3.35	-50	50

Table 14. Carrier frequency offset and drift at 2 MB/s*...continued*

Frequency offset and drift	Channel number						Specification	
	0	2	12	19	37	39	min	max
Max drift rate (kHz/50 µs)	-1.82	-3.09	-2.11	-1.55	-1.63	-1.89	-20	20
Frequency offset (kHz)	9.42	9.4	8.54	8.35	7.89	8.05	-150	150
Initial frequency drift (kHz)	-1.76	-0.74	-0.45	2.43	4.39	3.13	-23	23

Conclusion:

- Good margins, in line with the expected results.

For the receiver measurements below, the software used is the connectivity tool 1.0.2.

2.4 RX tests

This section describes the setup and results for RX tests.

2.4.1 Test setup

The module and DK6 board must be placed into an RF shielded box.

The conducted RX test setups are shown in Figure 27 to Figure 30.

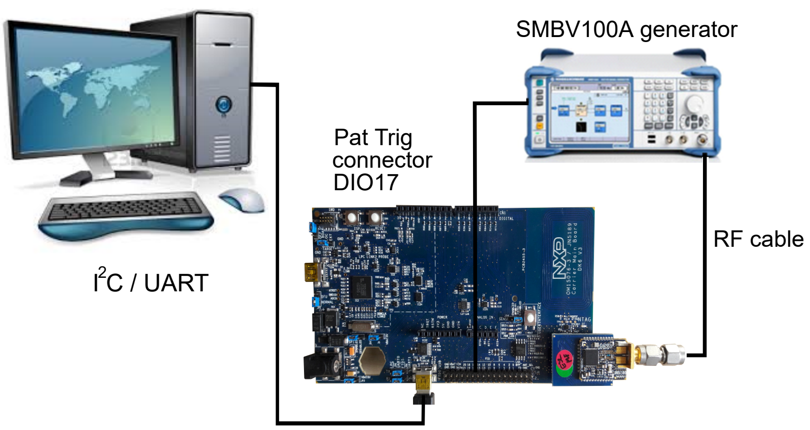


Figure 27. Conducted RX test setup for sensitivity with RF generator and faraday box

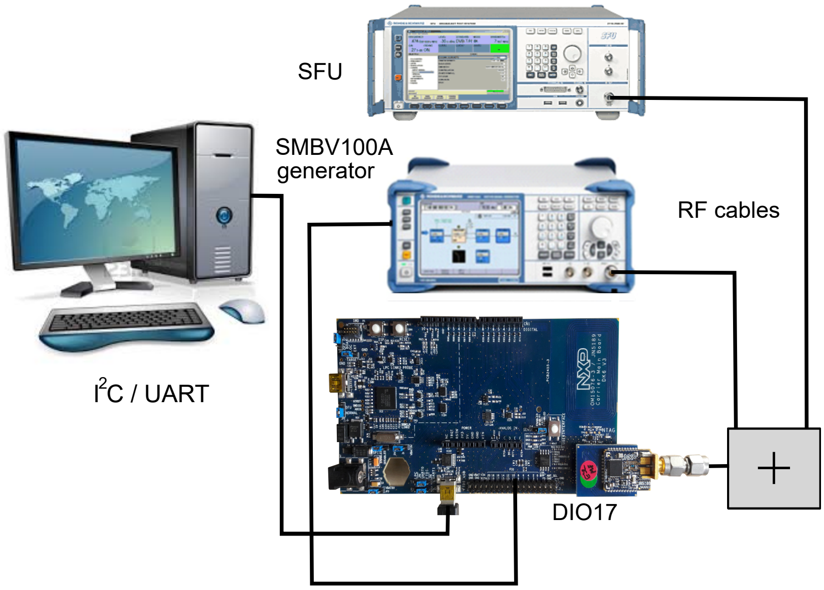


Figure 28. Conducted RX test setup for interference rejection

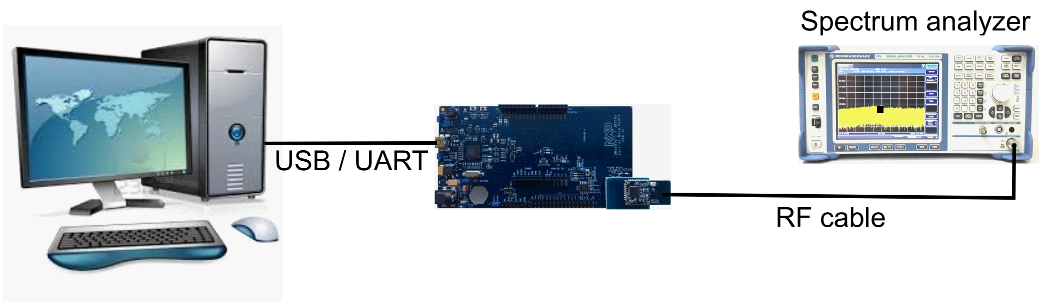


Figure 29. Conducted RX test setup for spurious

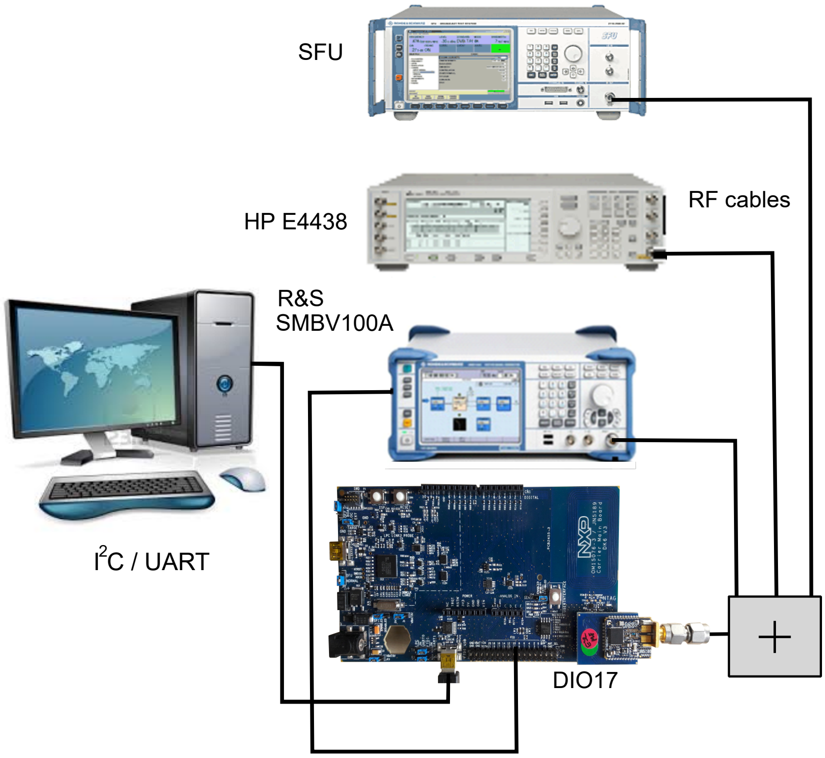


Figure 30. Conducted RX test setup for intermodulation performances

2.4.2 RX sensitivity

Test method:

To remain immune to the external parasitic signals, the DK6 board is placed in an RF shielded box.

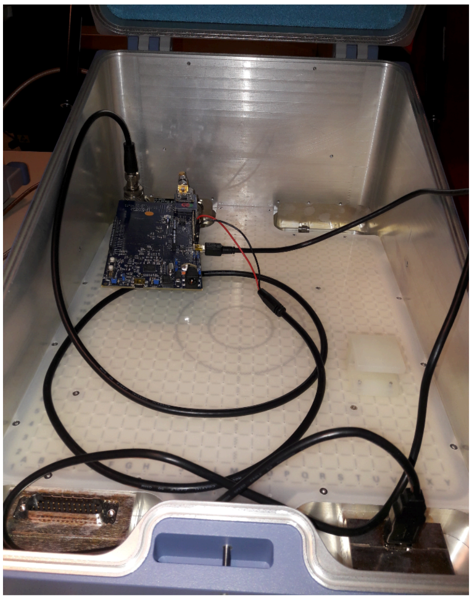


Figure 31. Sensitivity test

The generator, SMBV100A, is used in the ARB mode to generate a pattern of 1500 packets (DIO17 of DK6 connected to signal generator Trig in). The Tera Term window is used to control the module.

The test method is as follows:

- Set it to channel 0
- The connection is automatically established and the Packet Error Rate (PER) is measured
- Decrease the level of the SMBV at the RF input of the module until PER = 30.8 %
- Repeat it up to channel 39

The results of the few channels measured manually are as follows.

Results for 1 MB/s data rate:

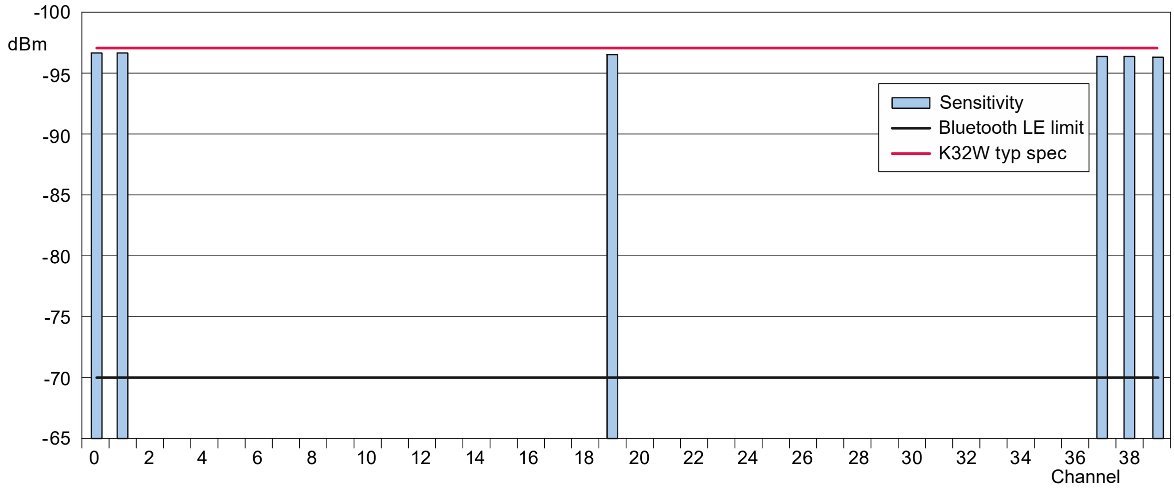


Figure 32. 1 MB/s sensitivity result

- The best sensitivity is on channel 1: -96.7 dBm
- The lowest sensitivity is: -96.3 dB
- Delta over channels: 0.4 dB

Results for 2 MB/s data rate:

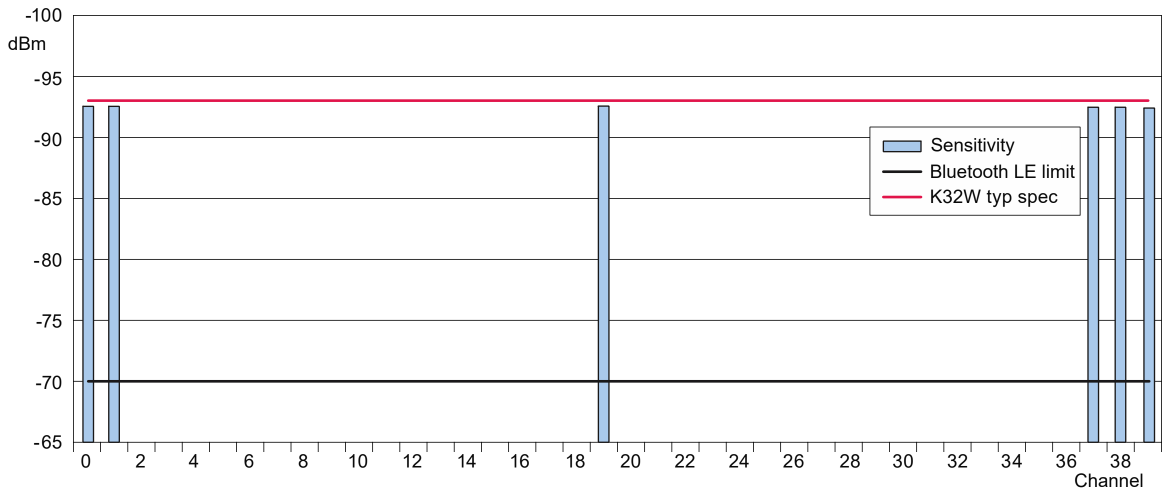


Figure 33. 2 MB/s sensitivity result

- The best sensitivity is on channel 0, 1, 19: -92.7 dBm

- The lowest sensitivity is: -92.6 dB
- Delta over channels: 0.1 dB

Conclusion:

- The average value for sensitivity is -96.5 dBm for 1 MB/s and -92.7 dBm for 2 MB/s. These results are in line with characterization results.

2.4.3 Receiver maximum input level

Test method:

- The test setup is the same as for the sensitivity test.
- The signal level is increased up to the PER = 30.8 % with 1500 packets.

Results at 1 MB/s:

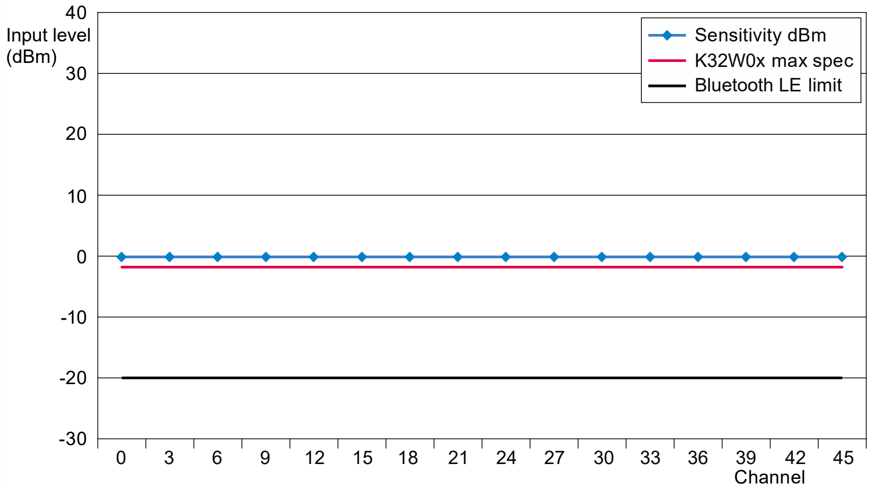


Figure 34. Maximum input power for 1 MB/s

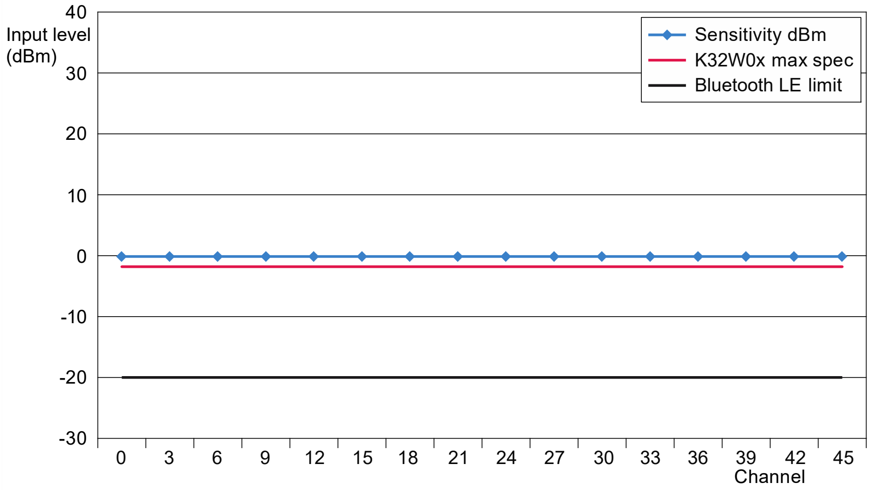


Figure 35. Maximum input power for 2 MB/s

Conclusion:

- The value specified by the data sheet is only for the information purpose.

- According to the test results from above, there is a margin to increase the input power level up to 20 dBm. Therefore, from a system perspective, these results are consistent with the expected values.

2.4.4 RX spurious

Test method:

- Set the radio to:
  - Receiver mode
  - Frequency: Channel 18
- Set the analyzer to:
  - Ref amp = - 20 dBm
  - Trace = Max hold
  - Detector = Max peak
  - Start/stop frequency = 30 MHz/1 GHz
    - RBW = 100 kHz, VBW = 300 kHz
  - Then set the start/stop frequency = 1 GHz/12.5 GHz
    - RBW = 1 MHz, VBW = 3 MHz

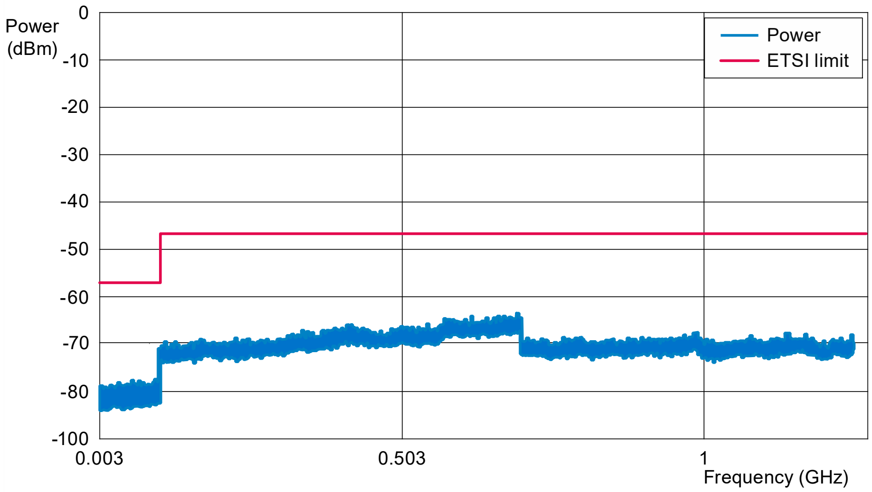


Figure 36. Conducted RX spurious 30 MHz - 12.5 GHz

Conclusion:

- There are no spurs above the spectrum analyzer noise floor.
- More than 13 dB margin.

2.4.5 Receiver interference rejection performances

2.4.5.1 Adjacent, alternate, and co-channel rejection

The interferers are at the adjacent channel (+/-1 MHz, +/-2 MHz, +/-3 MHz) or co-channel. The test is performed with only one interfering unmodulated signal at a time.

Test method:

- Generator for the desired signal: SMBV100A.
- Generator for interferers: R&S SFU.
- Criterion: PER < 30.8 % with 1500 packets.

- The desired signal is set to -67 dBm; the interferer is increased until the PER threshold is reached.
- Channel under test = 2.

Results for 1 MB/s:

	ch2			
	2406			
	N-2 MHz	**N-1 MHz**	**N+1 MHz**	**N+2 MHz**
	2404	2405	2407	2408
Interferer Read value	-27.4	-26.9	-27.7	-13.9
Interferer level (dBm)	-32.4	-31.9	-32.7	-18.9
Interferer level (C/I dB)	-34.6	-35.1	-34.3	-48.1
Bluetooth LE 4.2 limit (C/I dB)	-17	15	15	-17
Margin (dB)	17.6	50.1	49.3	31.1

	ch2		Co-channel ch2
	2406		2406
	N-3 MHz	**N+3 MHz**	**N**
	2403	2409	2406
Interferer Read value	-13.7	-7.5	-63
Interferer level (dBm)	-18.7	-12.5	-68.0
Interferer level (C/I dB)	**-48.3**	**-54.5**	**1.0**
Bluetooth LE 4.2 limit (C/I dB)	-27	-27	21
Margin (dB)	21.3	27.5	20.0

Figure 37. Adjacent, alternate, and co-channel rejection

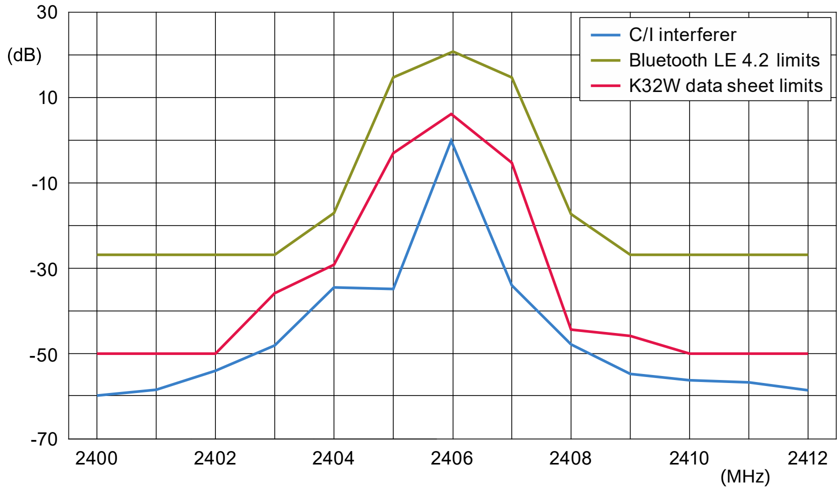


Figure 38. Adjacent, alternate, and co-channel rejection @ channel2

Results for 2 MB/s:

	ch2			
	2406			
	N-4 MHz	**N-2 MHz**	**N+2 MHz**	**N+4 MHz**
	2402	2404	2408	2410
Interferer Read value	-32.0	-26.9	-22	-13.4
Interferer level (dBm)	-37.0	-31.9	-27.0	-18.4
Interferer level (C/I dB)	-30.0	-35.1	-40.0	-48.6
Bluetooth LE 5.0 limit (C/I dB)	-17	15	15	-17
Margin (dB)	13.0	50.1	55.0	31.6

	ch2		Co-channel ch2
	2406		2406
	N-6 MHz	**N+6 MHz**	**N**
	2400	2412	2406
Interferer Read value	-13.7	-11.5	-65.1
Interferer level (dBm)	-18.7	-16.5	-70.1
Interferer level (C/I dB)	**-48.3**	**-50.5**	**3.1**
Bluetooth LE 5.0 limit (C/I dB)	-27	-27	21
Margin (dB)	21.3	23.5	17.9

Figure 39. Adjacent, alternate, and co-channel rejection

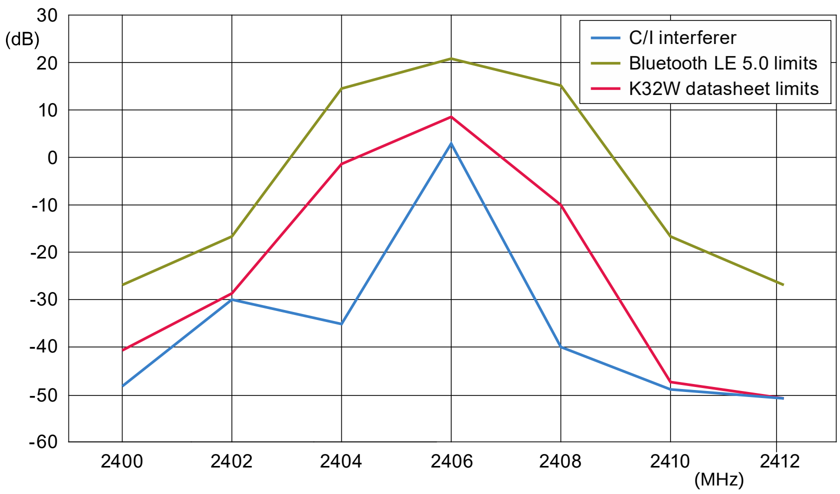


Figure 40. Adjacent, alternate, and co-channel rejection @channel2

Conclusion:

- The shape of the curve is due to the CW interferer.
- The results are compliant with the K32W specification and Bluetooth LE limits.

2.4.5.2 Receiver blocking

The blocking interferers are at the out of band channels depending on the receiver category.

2.4.5.2.1 Receiver category 2

The test is performed with only one interfering signal at a time. For more details, see the *ETSI 300.328 2.1.1 chapter 4.3.1.12.4.3*.

Test method:

- Generator for the desired signal: R&S SMBV100A
- Generator for interferers: R&S SFU
- Criterion: PER < 10 % (sensitivity at 10 % PER must be measured before)
- The desired signal is set to Pmin at 10 % PER + 6 dB; the interferer is increased until the PER threshold is reached.
- Channels under test: 0 and 39
- The test is performed for 1 MB/s first and then for 2 MB/s.

Result for 1 MB/s:

	1 MB/s			
	ch0	**ch0**	**ch39**	**ch39**
	2402	2402	2480	2480
	Low	**Low**	**High**	**High**
	2380	2503.5	2380	2503.5
Interferer level (dBm)	**-22.6**	**-16.7**	**-18.4**	**-19.7**
Interferer level (dBc)	67.4	73.3	71.6	70.3
EN 300 328 V2.1.1 limit (dBm)	-57	-57	-57	-57
Margin (dB)	34.4	40.3	38.6	37.3

	1 MB/s			
	ch0	**ch0**	**ch39**	**ch39**
	2402	2402	2480	2480
	Low	**Low**	**High**	**High**
	2300	2583.5	2300	2583.5
Interferer level (dBm)	**-18.4**	**-15.7**	**-18.1**	**-15.9**
Interferer level (dBc)	71.6	74.3	71.9	74.1
EN 300 328 V2.1.1 limit (dBm)	-47	-47	-47	-47
Margin (dB)	28.6	31.3	28.9	31.1

Figure 41. Receiver blocking (out of band) rejection for 1 MB/s (Pmin @ 10 % PER + 6 dB = -90.0 dBm)

Result for 2 MB/s:

	2 MB/s			
	ch0	**ch0**	**ch39**	**ch39**
	2402	2402	2480	2480
	Low	**Low**	**High**	**High**
	2380	2503.5	2380	2503.5
Interferer level (dBm)	**-23.0**	**-16.7**	**-18.3**	**-20.4**
Interferer level (dBc)	67.0	73.3	71.7	69.6
EN 300 328 V2.1.1 limit (dBm)	-57	-57	-57	-57
Margin (dB)	34.0	40.3	38.7	36.6

	2 MB/s			
	ch0	**ch0**	**ch39**	**ch39**
	2402	2402	2480	2480
	Low	**Low**	**High**	**High**
	2300	2583.5	2300	2583.5
Interferer level (dBm)	**-18.4**	**-15.8**	**-18.4**	**-15.9**
Interferer level (dBc)	71.6	74.2	71.6	74.1
EN 300 328 V2.1.1 limit (dBm)	-47	-47	-47	-47
Margin (dB)	28.6	31.2	28.6	31.1

Figure 42. Receiver blocking (out of band) rejection for 2 MB/s (Pmin @ 10 % PER + 6 dB = -86.3 dBm)

Conclusion:

- There is a good margin to the ETSI specification for blockers category 2.

2.4.5.3 Intermodulation

This test verifies that the receiver intermodulation performance is adequate. Two interferers are used with the desired signal. One interferer is a sinusoid non-modulated signal and the second interferer is a modulated signal with PRSB15 data.

Test method:

- Generator for the desired signal: R&S SMBV100A
- Generator for the first interferer (CW): Agilent E4438
- Generator for the second interferer (PRBS15): R&S SFU
- Criterion: PER < 30.8 % with 1500 packets
- The desired signal is set to -64 dBm
- Channels under test: 0, 19, and 39

Results for 1 MB/s:

	ch0	ch0	ch0	ch0	ch0	ch0
	2402	2402	2402	2402	2402	2402
	Low	Low	Low	Low	Low	Low
Interferer 1 (CW) (MHz)	-5	-4	-3	3	4	5
Interferer 2 (Mod) (MHz)	-10	-8	-6	6	8	10
Interferer level (dBm)	**-29.7**	**-28.7**	**-29.0**	**-22.3**	**-26.9**	**-28.9**
Interferer level (dBc)	34.3	35.3	35.0	41.7	37.1	35.1
Data sheet limit (dBm)	-30	-29	-27	-27	-29	-30
Margin (dB)	9.5	9.5	7.2	13.9	11.3	10.3

	ch19	ch19	ch19	ch19	ch19	ch19
	2440	2440	2440	2440	2440	2440
	Mid	Mid	Mid	Mid	Mid	Mid
Interferer 1 (CW) (MHz)	-5	-4	-3	3	4	5
Interferer 2 (Mod) (MHz)	-10	-8	-6	6	8	10
Interferer level (dBm)	**-30.0**	**-29.0**	**-29.3**	**-22.4**	**-27.2**	**-29.0**
Interferer level (dBc)	34.0	35.0	34.7	41.6	36.8	35.0
Data sheet limit (dBm)	-30	-29	-27	-27	-29	-30
Margin (dB)	9.2	9.2	6.9	13.8	11.0	10.2

	ch39	ch39	ch39	ch39	ch39	ch39
	2480	2480	2480	2480	2480	2480
	High	High	High	High	High	High
Interferer 1 (CW) (MHz)	-5	-4	-3	3	4	5
Interferer 2 (Mod) (MHz)	-10	-8	-6	6	8	10
Interferer level (dBm)	**-29.7**	**-28.7**	**-29.0**	**-22.2**	**-27.8**	**-28.8**
Interferer level (dBc)	34.3	35.3	35.0	41.8	36.2	35.2
Data sheet limit (dBm)	-30	-29	-27	-27	-29	-30
Margin (dB)	9.5	9.5	7.2	14.0	10.4	10.4

Figure 43. Intermodulation results for 1 MB/s

Results for 2 MB/s:

	ch0	ch0	ch0	ch0	ch0	ch0
	2402	2402	2402	2402	2402	2402
	Low	Low	Low	Low	Low	Low
Interferer 1 (CW) (MHz)	-10	-8	-6	6	8	10
Interferer 2 (Mod) (MHz)	-20	-16	-12	12	16	20
Interferer level (dBm)	**-29.2**	**-31.3**	**-31.2**	**-30.7**	**-30.7**	**-30.2**
Interferer level (dBc)	34.8	32.7	32.8	33.3	33.3	33.8
Data sheet limit (dBm)	-30.5	-32.5	-32	-32	-32.5	-30.5
Margin (dB)	10.5	10.4	10.0	10.5	11.0	9.5

	ch19	ch19	ch19	ch19	ch19	ch19
	2440	2440	2440	2440	2440	2440
	Mid	Mid	Mid	Mid	Mid	Mid
Interferer 1 (CW) (MHz)	-10	-8	-6	6	8	10
Interferer 2 (Mod) (MHz)	-20	-16	-12	12	16	20
Interferer level (dBm)	**-29.2**	**-31.3**	**-31.4**	**-30.9**	**-30.5**	**-30.3**
Interferer level (dBc)	34.8	32.7	32.6	33.1	33.5	33.7
Data sheet limit (dBm)	-30.5	-32.5	-32	-32	-32.5	-30.5
Margin (dB)	10.5	10.4	9.8	10.3	11.2	9.4

	ch39	ch39	ch39	ch39	ch39	ch39
	2480	2480	2480	2480	2480	2480
	High	High	High	High	High	High
Interferer 1 (CW) (MHz)	-10	-8	-6	6	8	10
Interferer 2 (Mod) (MHz)	-20	-16	-12	12	16	20
Interferer level (dBm)	**-29.0**	**-31.0**	**-31.0**	**-30.6**	**-30.5**	**-29.9**
Interferer level (dBc)	35.0	33.0	33.0	33.4	33.5	34.1
Data sheet limit (dBm)	-30.5	-32.5	-32	-32	-32.5	-30.5
Margin (dB)	10.7	10.7	10.2	10.6	11.2	9.8

Figure 44. Intermodulation results for 2 MB/s

Conclusion:

- The results are compliant with the specified values from the data sheet.

2.5 Return loss

The SMA connector is used for the measurements.

2.5.1 RX return loss

In the RX mode, the return loss measurement is performed by setting the LNA gain of K32W to the maximum.

Hardware: DK6 board

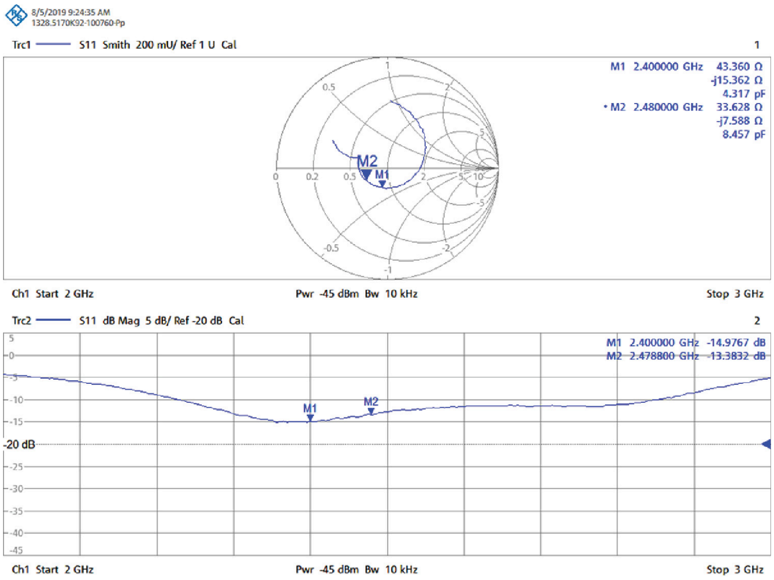


Figure 45. S11 diagram (RX mode)

Results:

- Return loss: -15.0 dB (2.4 GHz) < S11 < -13.3 dB (2.48 GHz)

Note: *There is no specification for the return loss.*

Conclusion:

- The return loss (S11) is lower than -10 dB.

2.5.2 TX return loss

In the TX mode, the return loss measurement is performed by setting the K32W RF output power to the minimum.

Hardware: DK6 board

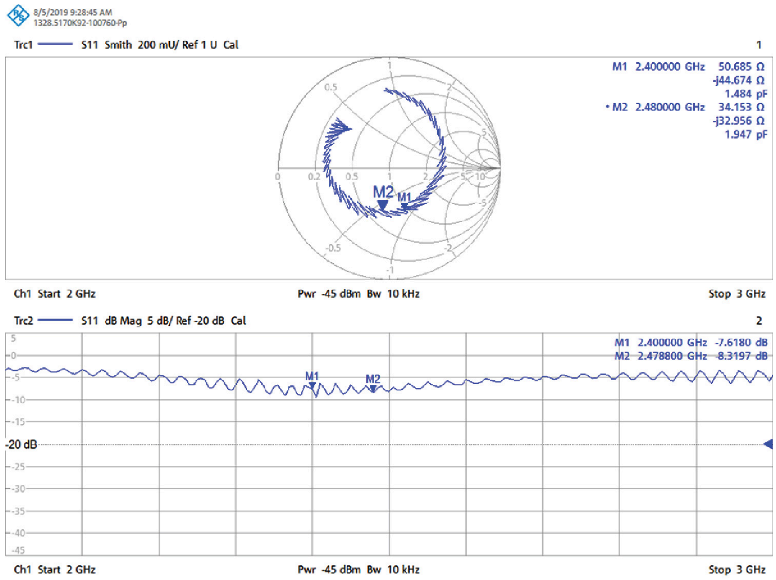


Figure 46. S11 diagram (TX mode)

Results:

- Return loss: -8.3 dBm (2.48 GHz) < S11 < -7.6 dB (2.4 GHz)

Note: *There is no specification for the return loss.*

Conclusion:

- The return loss (S11) is lower than -7 dB.

2.6 Conclusion

The preliminary results are compliant with the specification and Bluetooth LE standard.

3 802.15.4 applications

This section lists the RF evaluation test results of the K32W for 802.15.4 applications on 2FSK modulation.

3.1 Test presentation

This section includes the list of tests, software, and equipment for 802.15.4 applications on 2FSK modulation.

3.1.1 List of tests

Conducted tests on K32W:

- TX tests:
  - Frequency accuracy
  - Phase noise
  - TX power
  - TX spurious
  - Harmonics
  - EVM and offset EVM

  - Upper band edge
- RX tests:
  - Sensitivity
  - Maximum input level
  - RX spurious
  - LO leakage
  - Interferers (as per IEEE 802.15.4 requirements)
  - Co-channel
  - Receiver blocking (as per ETSI 300 328 requirements)
- Return loss:
  - RX

3.1.2 Software

Before the measurements, load a binary code (connectivity software) in the flash memory of the board using the Flash Programmer application JN-SW-4407.

The binary code used for the following tests is the Customer Module Evaluation Tool (CMET) version 2038 compiled on February 28, 2020.

```
*********************************************
*    Customer Module Evaluation Tool        *
*    Version 2038                           *
*    Compiled Feb 28 2020 10:23:14          *
*    Radio Test version 2041                *
*    Radio Driver version 2085              *
*    Chip ID 000e2117                       *
*********************************************
```

Figure 47. CMET evaluation software version

The Tera Term terminal emulator is used to communicate with the K32W UART0. Two USB ports are available on the DK6 board to control the K32W with CMET: LPC Link2 and FTDI

Section 5 provides the selected options to perform the following tests.

3.1.3 Test equipment

Table 15 shows test equipment required for 802.15.4 applications.

Table 15. Test equipment

Spectrum analyzer	Generators
R&S FSP	R&S SFU
R&S FSU	R&S SMBV100A

3.2 Test summary

This section synthetizes in Table 16 and Table 17 the main tests performed on the K32W modules. Most of the test results and setup details are described in this document. For further information, contact your NXP local contact.

Table 16. List of tests for Europe

Name	Measurements	Reference	Limit	Status
Transmission	TX maximum power	ETSI EN 300 328	20 dBm, 100 mW (radiated)	PASS

Table 16. List of tests for Europe*...continued*

Name	Measurements	Reference	Limit	Status
	Eirp TX spectral density	ETSI EN 300 328	10 dBm/MHz	PASS
	TX spectral density	IEEE 802.15.4_2011	-20 dBc or -30 dBm (100 kHz, f-fc > 3.5 MHz)	PASS
	Spurious 30 MHz - 1 GHz	ETSI EN 300 328	-36 dBm or -54 dBm (depends on frequency) (100 kHz BW)	PASS
	Spurious 1 GHz - 12.5 GHz	ETSI EN 300 328	-30 dBm (1 MHz BW)	PASS
	EVM	IEEE 802.15.4_2011	35 %	PASS
	TX frequency tolerance	IEEE 802.15.4_2011	+/- 40 ppm	PASS
Reception	Reachable low limit of maximum power	IEEE 802.15.4_2011	-3 dBm	PASS
	Phase noise (unspread)	IEEE 802.15.4_2003	NA	For information
	RX emissions 30 MHz - 1 GHz	ETSI EN 300 328	-57 dBm (100 kHz)	PASS
	RX emissions 1 GHz - 12.5 GHz	ETSI EN 300 328	-47 dBm (1 MHz)	PASS
	RX sensitivity	IEEE 802.15.4	-85 dBm	PASS
	Adjacent channel interference rejection N +/-1	IEEE 802.15.4_2011	0 dB	PASS
	Alternate channel interference rejection N +/-2	IEEE 802.15.4_2011	30 dB	PASS
	Receiver blocking	ETSI EN 300 328	-57 dBm/-47 dBm	PASS
	RX maximum input level	IEEE 802.15.4_2011	-20 dBm	PASS
Miscellaneous	Return loss (S11)	Return loss in TX mode Return loss in RX mode	For information	

Table 17. List of tests for US

Name	Measurements	Reference	Limit	Status
Transmission	Spurious 1 GHz - 12.5 GHz	FCC part 15	-41 dBm (1 MHz BW)	PASS

3.3 TX conducted tests

This section lists the 802.15.4 application TX conducted tests.

3.3.1 TX modes

Three different modulation modes exist in K32W transmission as follows:

- Regular
- Proprietary 1
- Proprietary 2

In Regular mode, the entire OQPSK spectrum is transmitted without any filtering. In Proprietary mode 1, the spectrum is less digitally filtered and in Proprietary mode 2, the spectrum is more heavily filtered. Filtering the spectrum is useful to pass the FCC upper band-edge test without reducing the TX power on channel 26. Filtering the TX spectrum also benefits the receiver from its full selective performance. For details, refer Section 4.

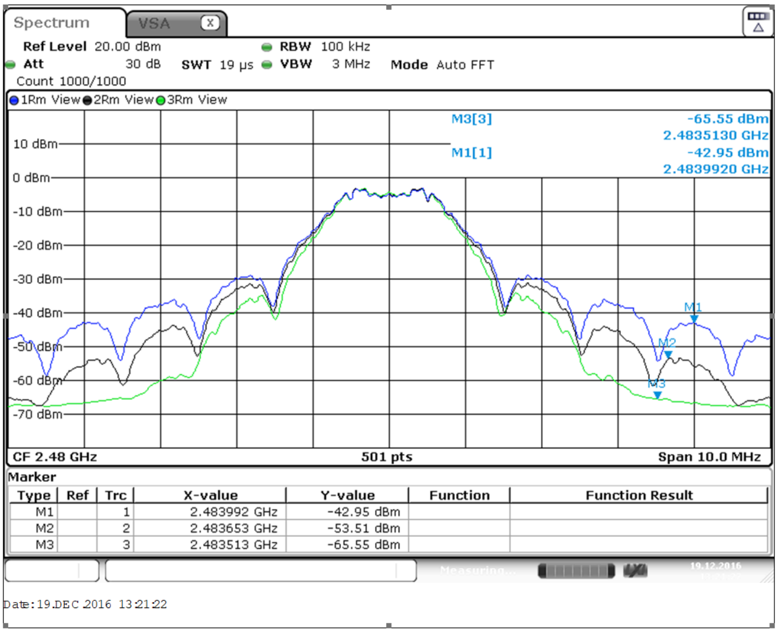


Figure 48. K32W TX spectrum

- Blue graph: Regular mode
- Black graph: Proprietary mode 1
- Green graph: Proprietary mode 2

Note: *The measurements included in this document are done in the Regular mode otherwise specified.*

3.3.2 Test setup

The TX power of the K32W is set to +10 dBm. Connect the RF port of the module to the spectrum analyzer.

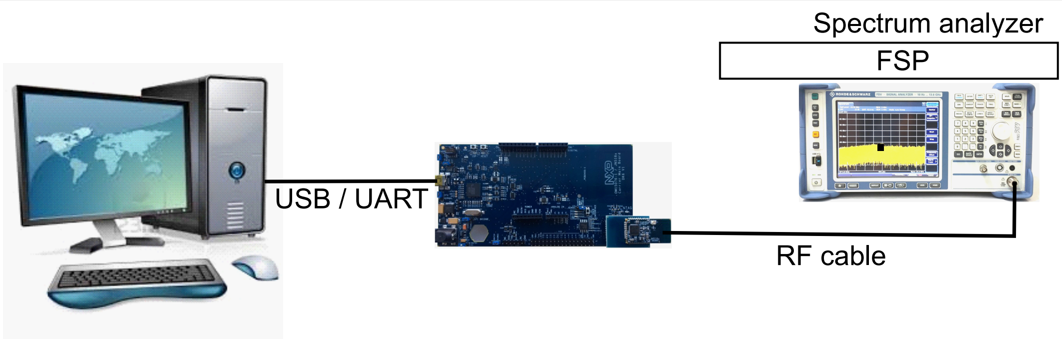


Figure 49. Conducted TX test setup

3.3.3 Test results

The test results are as follows:

3.3.3.1 Frequency accuracy

Test method:

- Set the radio in:
  - TX mode
  - CW
  - Continuous mode
  - Frequency: Channel 18
- Set the analyzer to:
  - Center frequency = 2.44 GHz
  - Span = 1 MHz
  - Ref amp = 20 dBm
  - RBW = 10 kHz
- Measure the CW frequency with the marker of the spectrum analyzer

Result:

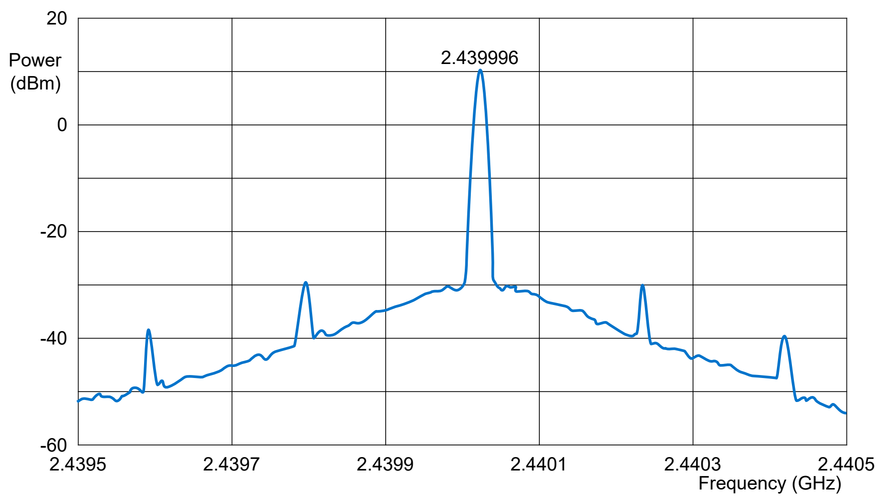


Figure 50. Frequency accuracy

- Measured frequency = 2.439996 GHz
- ppm value = -1.3 ppm

Result	Target	IEEE 802.15.4 limit
-1.3 ppm	+/- 25 ppm	+/- 40 ppm

Note: *The frequency accuracy depends on the XTAL model. The model used on the OM15070 is NX2016SA EXS00A-CS11213-6pF from NDK.*

Conclusion:

- The channel frequency is correctly centered and therefore, is fully compliant with the IEEE 802.15.4 specifications.

3.3.3.2 Phase noise at 100 kHz offset

Test method:

- Set the radio in:
  - TX mode
  - CW continuous mode
  - Frequency: Channel 18
- Set the analyzer to:
  - Center frequency = 2.44 GHz
  - Span = 1 MHz
  - Ref amp = 20 dBm
- Measure the phase noise at 100 kHz offset frequency:
  - RBW = 10 kHz (40 dBc)

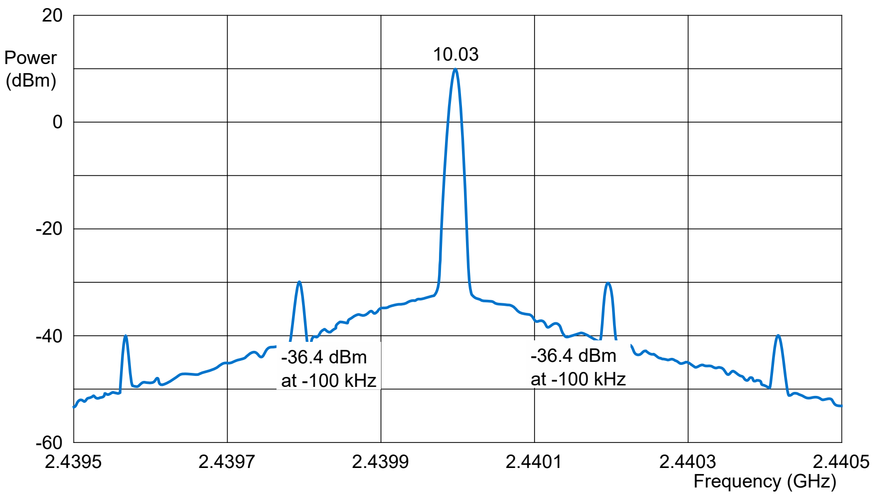


Figure 51. Phase noise

Results:

- Marker value = -36.4 dBm within 10 kHz RBW
  - Marker delta = 10.0 - (-36.4) = 46.4 dB
  - Phase noise at 100 kHz offset = -46.4 -10 log (10 kHz) = -86.4 dBc/Hz

Note: *Phase noise is for information purposes only.*

3.3.3.3 TX power (fundamental)

Test method:

- Set the radio in:
  - TX mode
  - Modulated
  - Continuous mode
- Set the analyzer to:
  - Start frequency = 2.4 GHz
  - Stop frequency = 2.5 GHz
  - Ref amp = 20 dBm
  - Sweep time = 100 ms
  - RBW = 3 MHz
- Max Hold mode

- Detector: Peak
- Sweep all the channels from ch11 to ch26

Result:

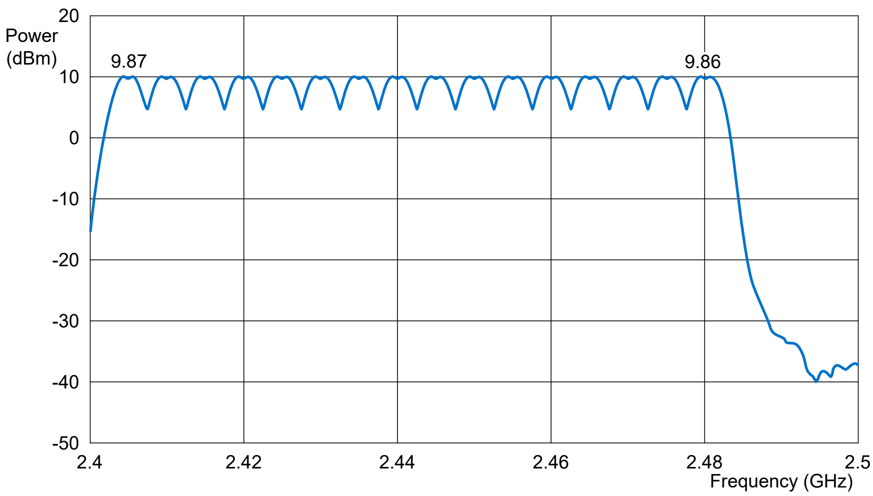


Figure 52. TX maximum power

- Maximum power is on channel 17: +9.92 dBm
- Minimum power is on channel 20: +9.76 dBm
- Tilt over frequency is 0.16 dB

Conclusion:

- The default TX power is in line with the expected results.
- The power is flat over frequency.

3.3.3.4 TX spurious

This section describes TX spurious for different test conditions.

3.3.3.4.1 Global view from 0.3 GHz to 12.5 GHz (desired = channel 18)

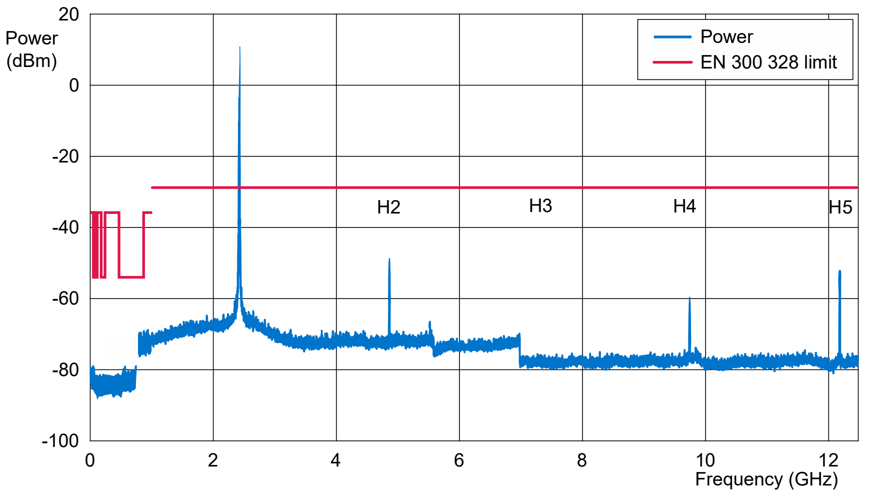


Figure 53. Conducted TX spurious

Conclusion:

- There are no TX spurs above the EN 300 328 limit.
- Harmonics are measured in the following paragraphs.

3.3.3.4.2 H2 (ETSI test conditions)

Test method:

- Set the radio in:
  - TX mode
  - Modulated
  - Continuous mode
- Set the analyzer to:
  - Start frequency = 4.8 GHz
  - Stop frequency = 5 GHz
  - Ref amp = -20 dBm
  - Sweep time = 100 ms
  - RBW = 1 MHz
- Max Hold mode
- Detector: Peak
- Sweep all the channels from ch11 to ch26

Results:

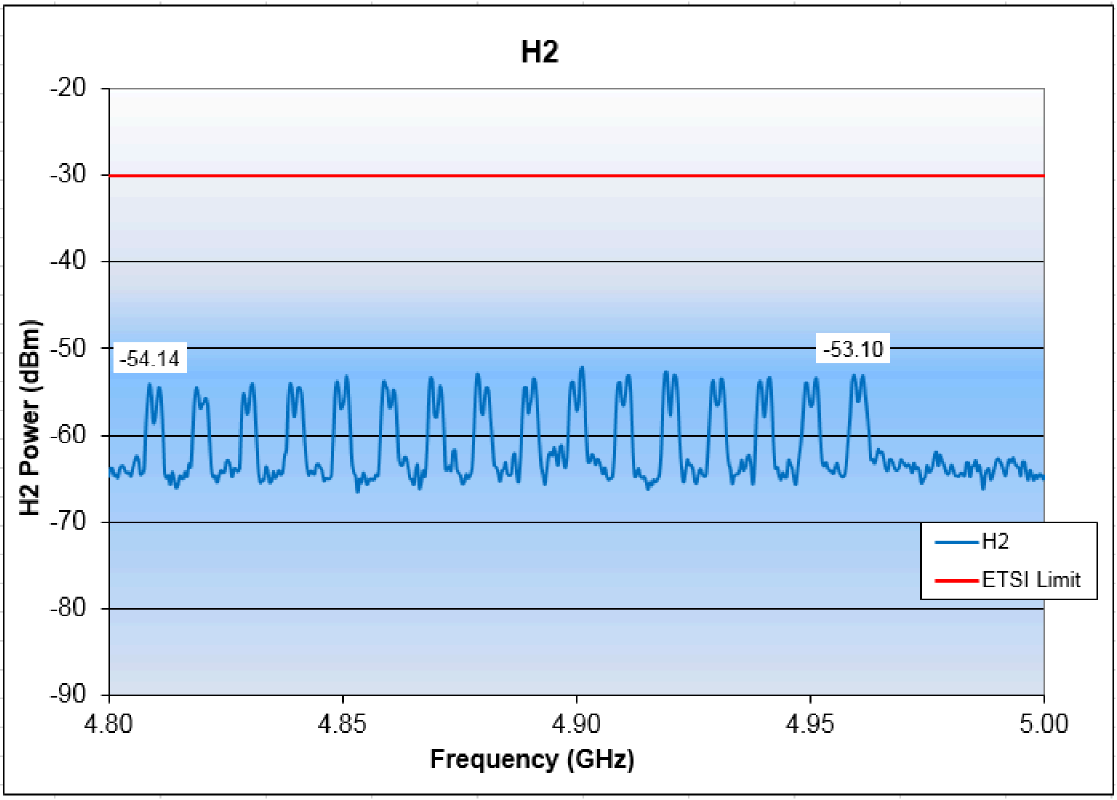


Figure 54. Conducted H2 spurious

- Maximum power is on channel 20: -52.2 dBm

Conclusion:

- There is a 22.2 dB margin to the ETSI limit.

3.3.3.4.3 H3 (ETSI test conditions)

The test method is the same as for the H2, except the spectrum analyzer frequency start/stop is set to 7.2 GHz and 7.5 GHz.

Results:

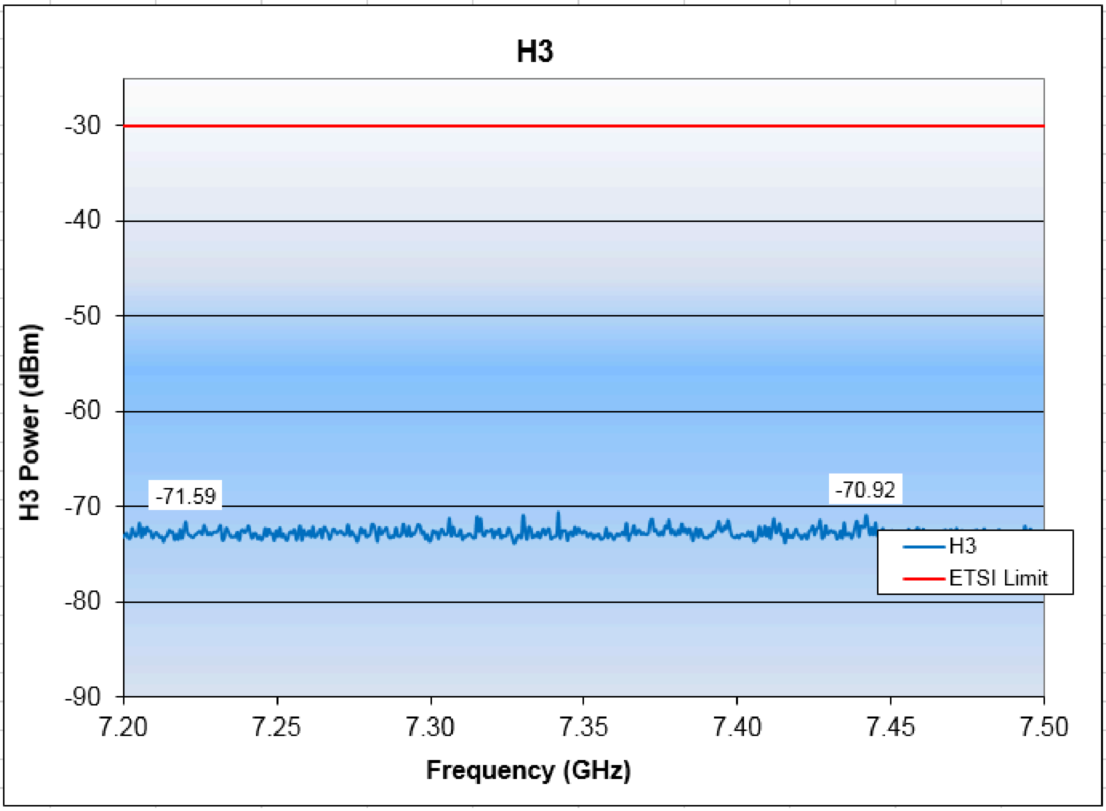


Figure 55. Conducted H3 spurious

- Maximum power is on channel 19: -70.6 dBm

Conclusion:

- There is a 40.6 dB margin to the ETSI limit.

3.3.3.4.4 H4 (ETSI test conditions)

The test method is the same as for the H2, except the spectrum analyzer frequency span is set from 9.6 GHz to 10.0 GHz.

Result:

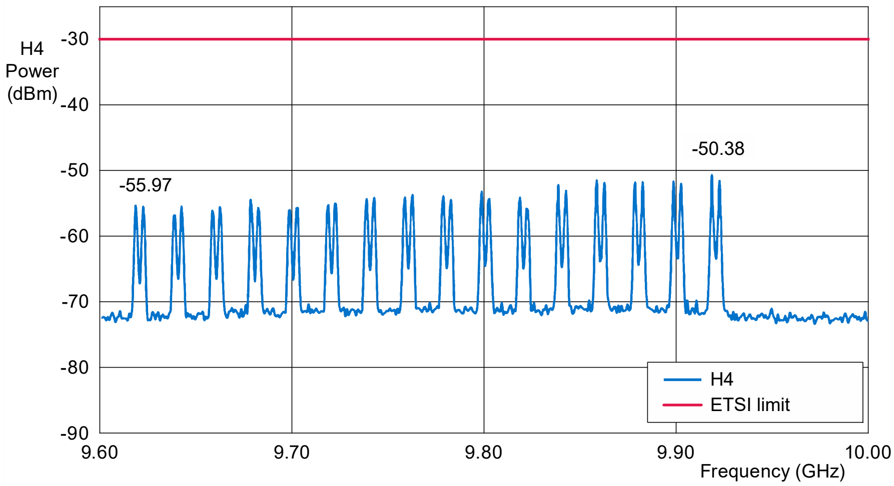


Figure 56. Conducted H4 spurious

- Maximum power is on channel 26: -50.3 dBm

Conclusion:

- There is a 20.3 dB margin to the ETSI limit.

3.3.3.4.5 H5 (ETSI test conditions)

The test method is the same as for the H2, except the spectrum analyzer frequency span is set from 12.0 GHz to 12.5 GHz.

Result:

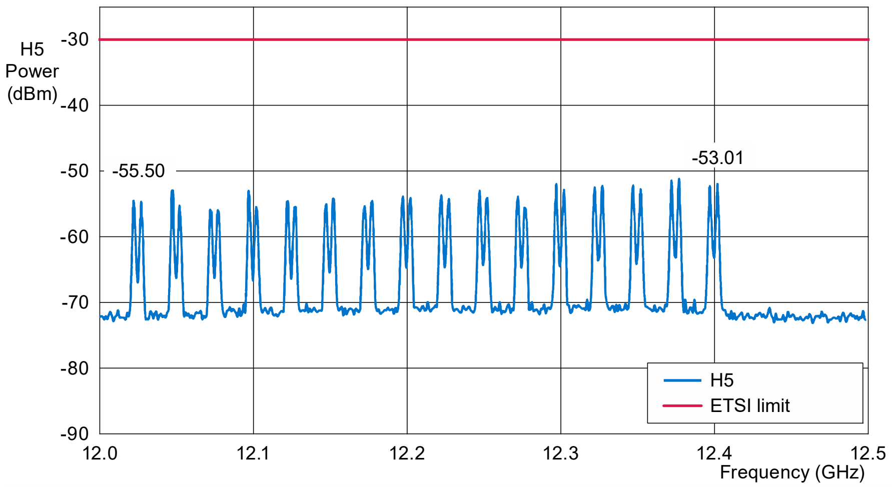


Figure 57. Conducted H5 spurious

- Maximum power is on channel 26: -53.0 dBm

Conclusion:

- There is a 23.0 dB margin to the ETSI limit.

3.3.3.4.6 H6 (ETSI test conditions)

The test method is the same as for the H2, except the spectrum analyzer frequency span is set from 14.4 GHz to 15.0 GHz.

Result:

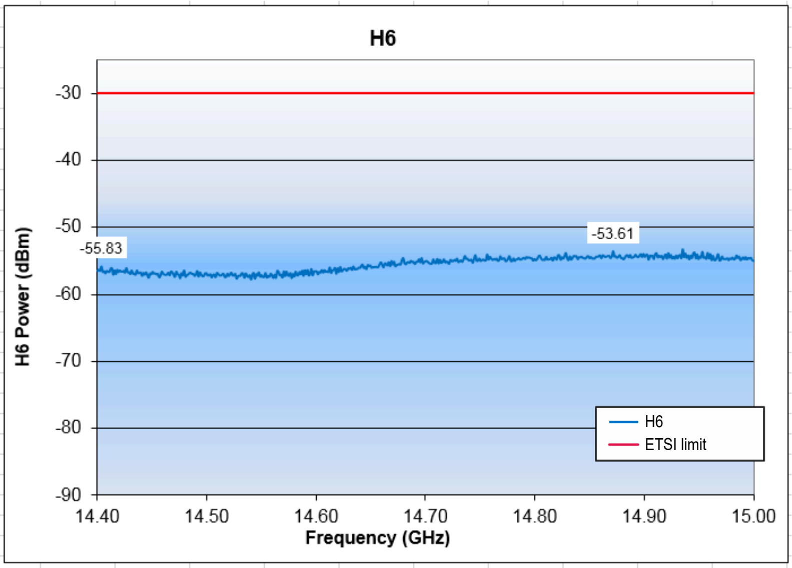


Figure 58. Conducted H6 spurious

- Maximum power is on channel 26: -53.6 dBm

Conclusion:

- There is a 23.6 dB margin to the ETSI limit.

3.3.3.4.7 H7 (ETSI test conditions)

The test method is the same as for the H2, except the spectrum analyzer frequency span is set from 16.8 GHz to 17.5 GHz.

Result:

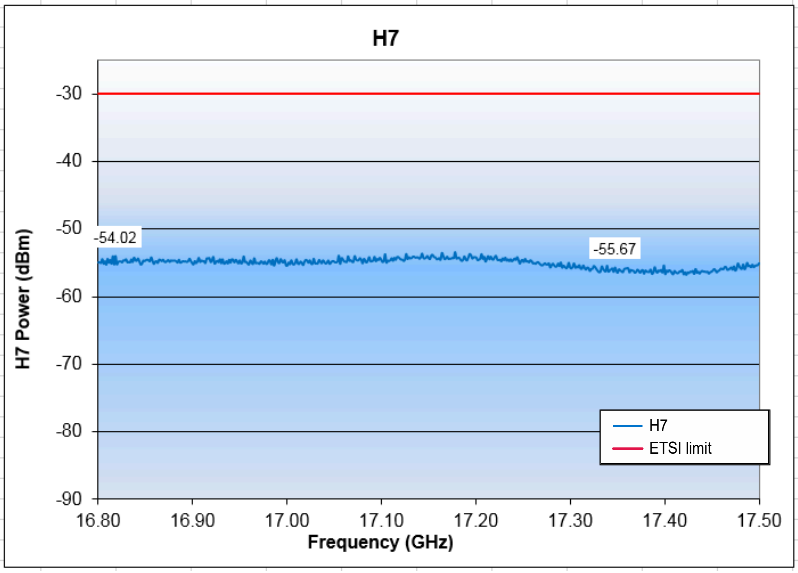


Figure 59. Conducted H7 spurious

- Maximum power is on channel 21: -53.5 dBm

Conclusion:

- There is a 23.5 dB margin to the ETSI limit.

3.3.3.4.8 H8 (ETSI test conditions)

The test method is the same as for the H2, except the spectrum analyzer frequency span is set from 19.2 GHz to 20.0 GHz.

Result:

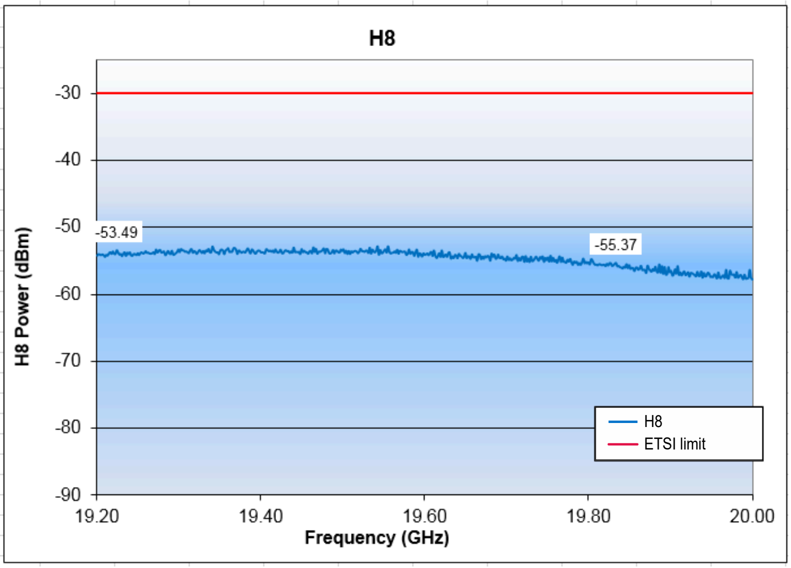


Figure 60. Conducted H8 spurious

- Maximum power is on channel 19: -52.9 dBm

Conclusion:

- There is a 22.9 dB margin to the ETSI limit.

3.3.3.4.9 H9 (ETSI test conditions)

The test method is the same as for the H2, except the spectrum analyzer frequency span is set from 21.6 GHz to 22.5 GHz.

Result:

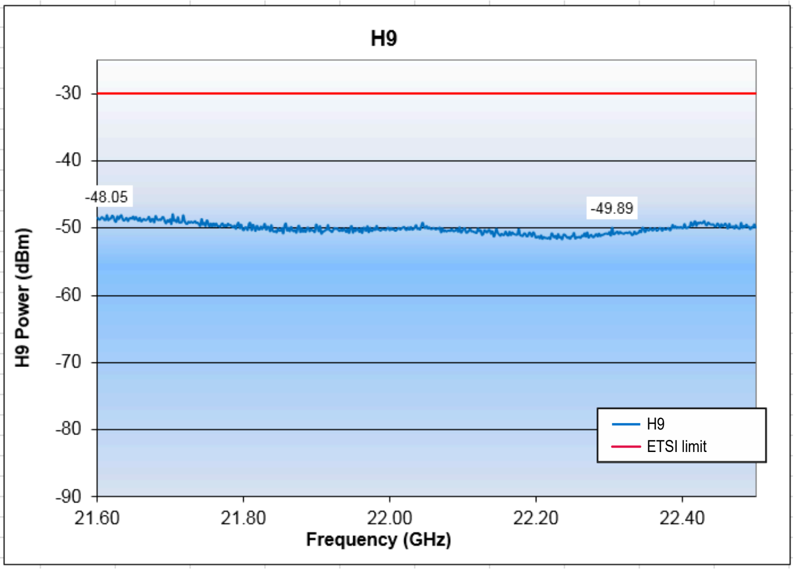


Figure 61. Conducted H9 spurious

- Maximum power is on channel 12: -47.9 dBm

Conclusion:

- There is a 17.9 dB margin to the ETSI limit.

3.3.3.4.10 H10 (ETSI test conditions)

The test method is the same as for the H2, except the spectrum analyzer frequency span is set from 24 GHz to 25 GHz.

Result:

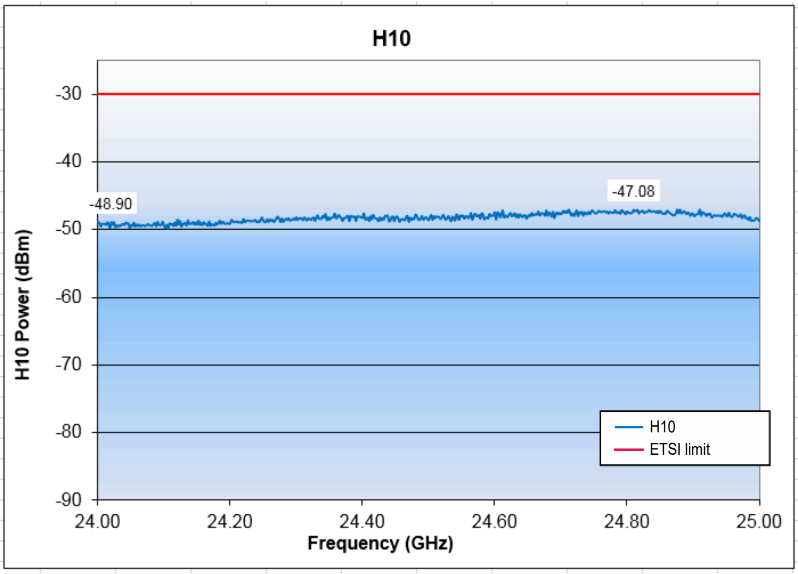


Figure 62. Conducted H10 spurious

- Maximum power is on channel 12: -47.9 dBm

Conclusion:

- There is a 17.9 dB margin to the ETSI limit.

3.3.3.4.11 H2 (FCC test conditions)

Test method:

- Set the radio in:
  - TX mode
  - Modulated
  - Continuous mode
- Set the analyzer to:
  - Start frequency= 4.8 GHz
  - Stop frequency = 5 GHz
  - Ref amp = -20 dBm
  - RF attenuation = Sweep time = 100 ms
  - RBW = 1 MHz
- Trace mode: Average
- Detector: RMS
- Sweep all the channels from ch11 to ch26

Result:

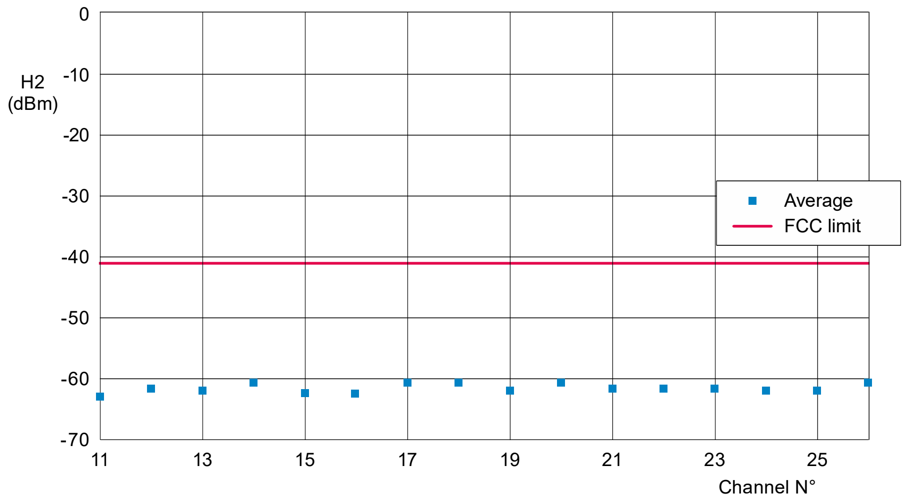


Figure 63. Conducted H2 spurious

- Maximum power is: -61.0 dBm

Conclusion:

- There is a 20 dB margin to the FCC limit.

3.3.3.4.12 H3 (FCC test conditions)

The test method is similar as for the H2, except the spectrum analyzer frequency start/stop are set to 7.2 GHz and 7.5 GHz.

Result:

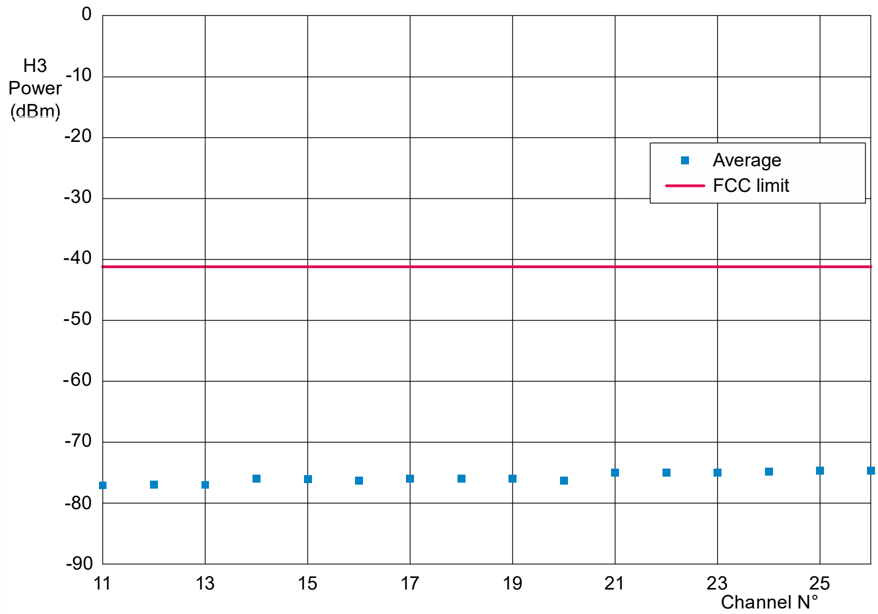


Figure 64. Conducted H3 spurious

- Maximum power is on channels 21 to 26: -75 dBm

Conclusion:

- There is a 34 dB margin to the ETSI limit.

3.3.3.4.13 H4 (FCC test conditions)

The test method is the same as for the H2, except the spectrum analyzer frequency span is set from 9.6 GHz to 10.0 GHz.

Result:

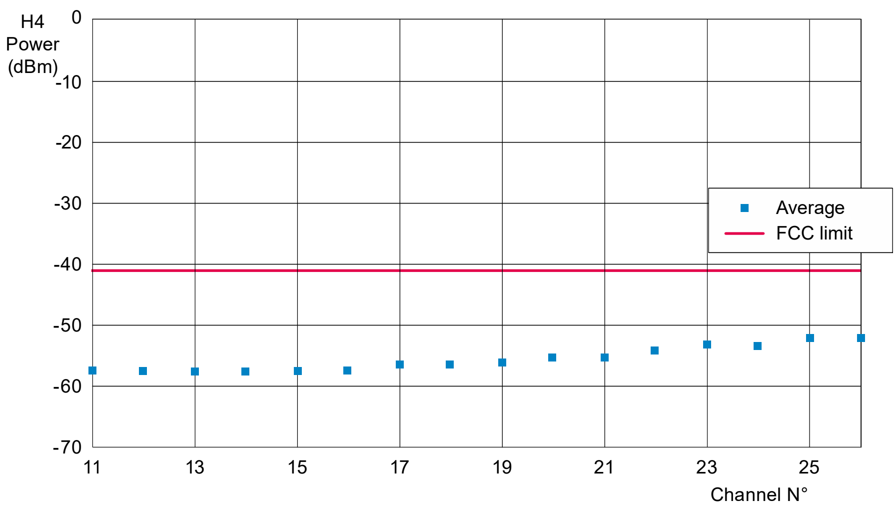


Figure 65. Conducted H4 spurious

- Maximum power is on channels 25 and 26: -53 dBm

Conclusion:

- There is a 12 dB margin to the FCC limit.

3.3.3.4.14 H5 (FCC test conditions)

The test method is the same as for the H2, except the spectrum analyzer frequency span is set from 12 GHz to 12.5 GHz.

Result:

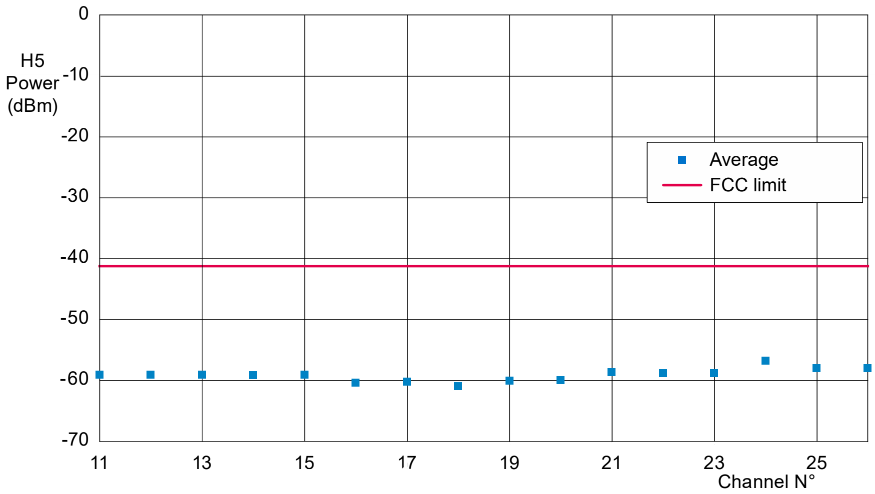


Figure 66. Conducted H5 spurious

- Maximum power is on channel 13: -57 dBm

Conclusion:

- There is a 16 dB margin to the FCC limit.

3.3.3.4.15 H6 (FCC test conditions)

The test method is the same as for the H2, except the spectrum analyzer frequency span is set from 14.4 GHz to 15.0 GHz.

Result:

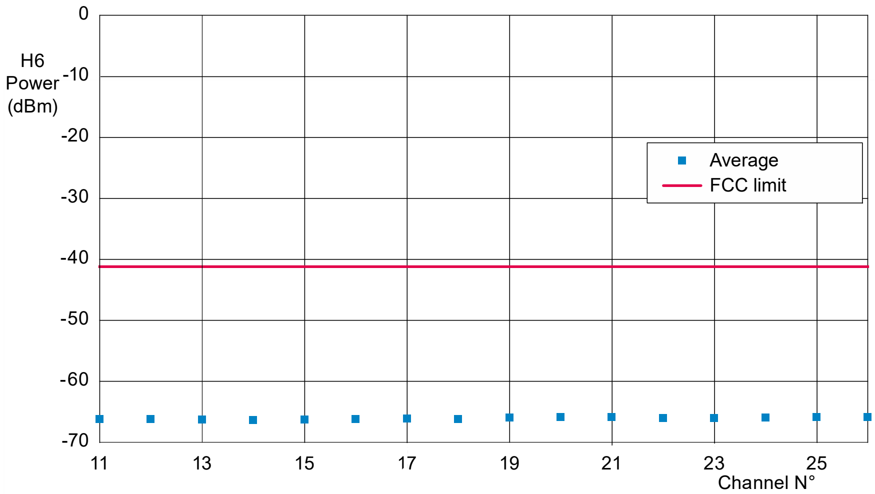


Figure 67. Conducted H6 spurious

- Maximum power is on all channels: -66 dBm

Conclusion:

- There is a 25 dB margin to the FCC limit.

3.3.3.4.16 H7 (FCC test conditions)

The test method is the same as for the H2, except the spectrum analyzer frequency span is set from 16.8 GHz to 17.5 GHz.

Result:

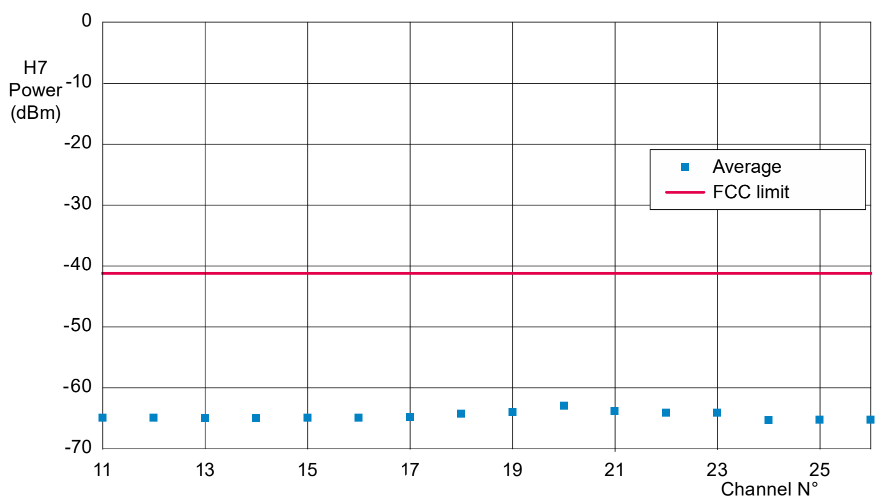


Figure 68. Conducted H7 spurious

- Maximum power is on all channels: -63 dBm

Conclusion:

- There is a 22 dB margin to the FCC limit.

3.3.3.4.17 H8 (FCC test conditions)

The test method is the same as for the H2, except the spectrum analyzer frequency span is set from 19.2 GHz to 20.0 GHz.

Result:

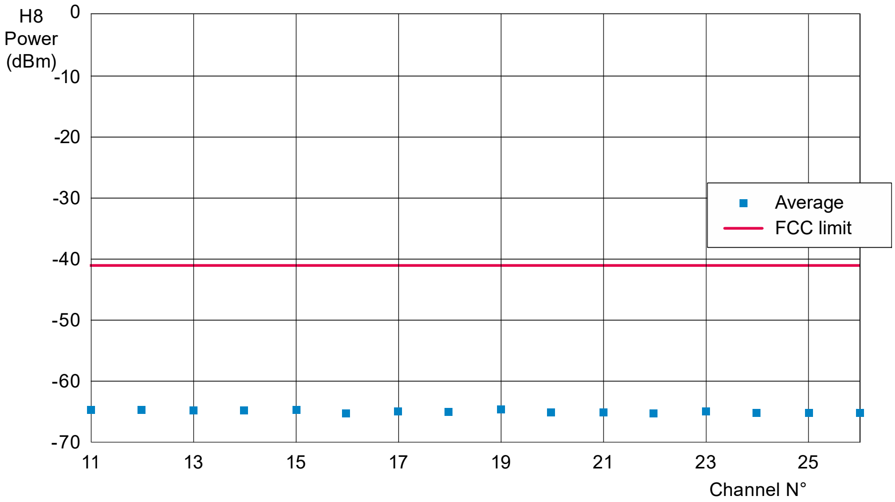


Figure 69. Conducted H8 spurious

- Maximum power is on all channels: -65 dBm

Conclusion:

- There is a 24 dB margin to the FCC limit.

3.3.3.4.18 H9 (FCC test conditions)

The test method is the same as for the H2, except the spectrum analyzer frequency span is set from 21.6 GHz to 22.5 GHz.

Result:

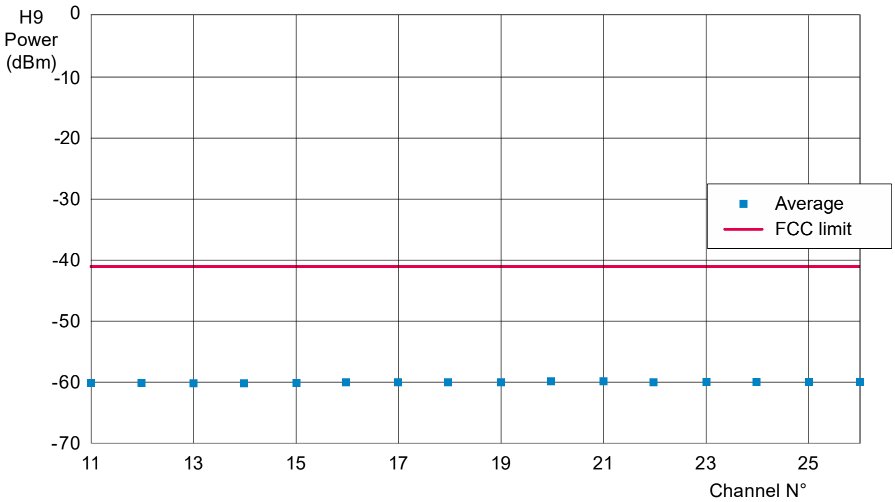


Figure 70. Conducted H9 spurious

- Maximum power is on all channels: -60 dBm

Conclusion:

- There is a 19 dB margin to the FCC limit.

3.3.3.4.19 H10 (FCC test conditions)

The test method is the same as for the H2, except the spectrum analyzer frequency span is set from 24 GHz to 25 GHz.

Result:

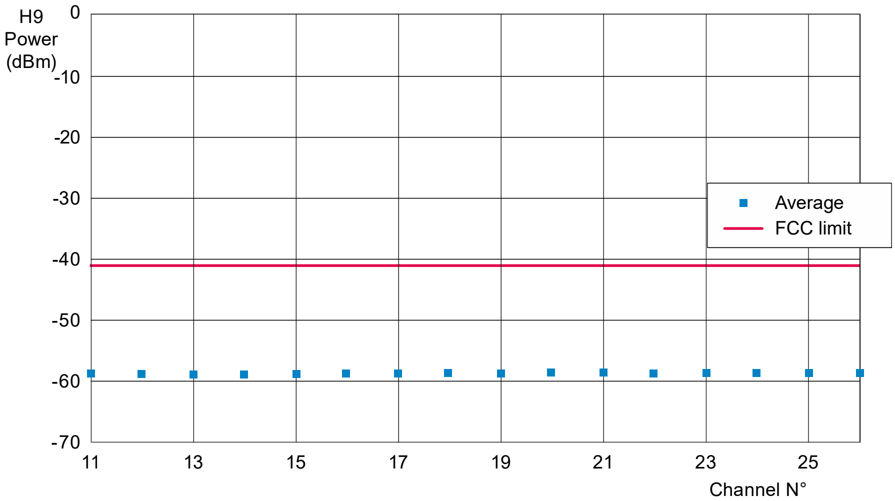


Figure 71. Conducted H10 spurious

- Maximum power is on all channels: -59 dBm

Conclusion:

- There is an 18 dB margin to the FCC limit.

3.3.3.5 TX modulation

3.3.3.5.1 EVM

Test method:

- Connect the RF port of the module to the R&S FSV30 spectrum analyzer. To do the EVM measurement, use the specific menu of the SA.
- Set the K32W in continuous Modulated mode.
- Set the TX frequency to channel 11.
- Measure the offset EVM value.
- Repeat the test for each channel.

Filtering the spectrum with Proprietary mode 1 or Proprietary mode 2 affects the EVM and offset EVM.

Figure 72 and Figure 73 show the EVM value for both the Proprietary mode 2 and the Regular mode.

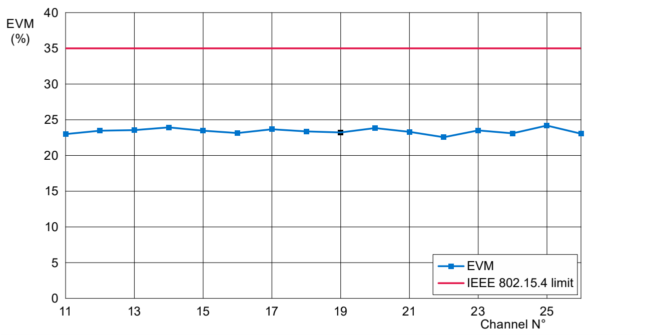


Figure 72. EVM in Proprietary mode 2

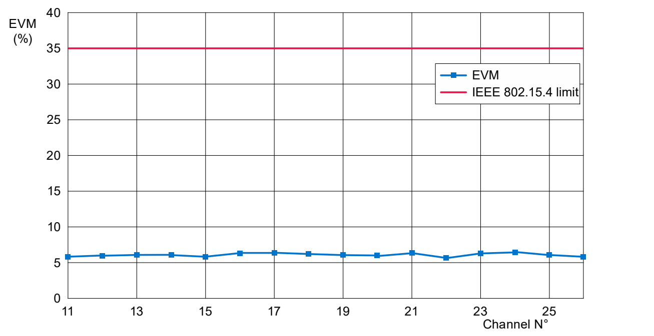


Figure 73. EVM in Regular mode

Result:

- Proprietary mode 2 maximum value on channel 25 = 24.2 %
- Regular mode maximum value on channel 26 = 6.4 %

Conclusion:

- Good margin vs IEEE 802.15.4 limit in Regular mode.
  Note: *Although the EVM is degraded in Proprietary mode 2, there is still a good margin to the IEEE 802.15.4 limit.*

3.3.3.5.2 Offset EVM

Test method:

- The test method is the same as for the EVM measurement described in Section 3.3.3.5.1.
  Figure 74 and Figure 75 show the offset EVM value for both the Proprietary mode 2 and the Regular mode.

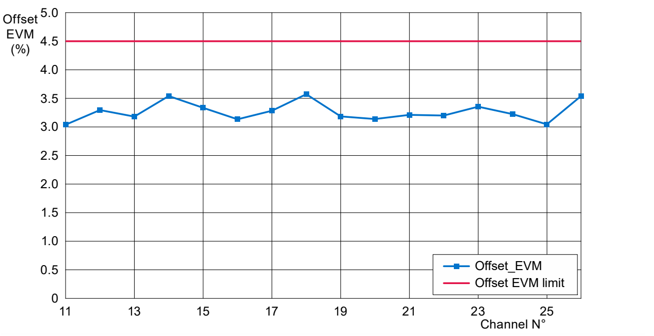


Figure 74. Offset EVM in Proprietary mode 2

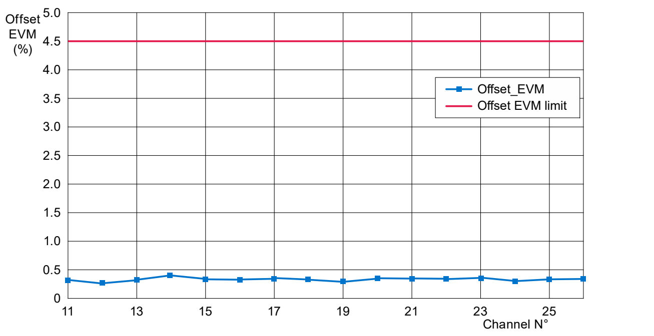


Figure 75. Offset EVM in Regular mode

Result:

- Proprietary mode 2 maximum value on channel 18 = 3.57 %
- Regular mode maximum value on channel 23 = 0.37 %

Conclusion:

- Good margin vs K32W specification in Regular mode.

Note: *Although the offset EVM is degraded in Proprietary mode 2, there is still a good margin to the K32W specification.*

3.3.3.6 Upper band edge

Test method:

- Set the radio to:
  - TX mode
  - Modulated
  - Continuous mode
- Set the analyzer to:
  - Start frequency = 2.475 GHz
  - Stop frequency = 2.485 GHz
  - Ref amp=-20 dBm
  - Sweep time=100 ms
  - RBW = 1 MHz
  - VBW = 3 MHz
  - Detector = Average
  - Average mode: Power
  - Number of sweeps = 100
  - Set the channel 26 (2.48 GHz)

Result:

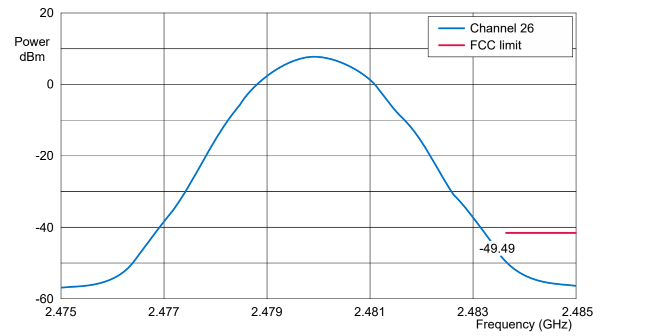


Figure 76. Upper band edge in Proprietary mode 2

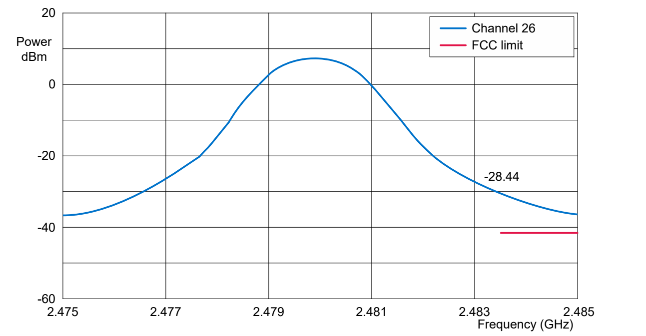


Figure 77. Upper band edge in Regular mode

Conclusion:

- The upper band edge test passes the ETSI certification in the Proprietary mode 2.

3.4 RX tests

This section lists the RX tests of the K32W for 802.15.4 applications.

3.4.1 Test setup

The conducted RX test setups are shown in Figure 78 to Figure 80.

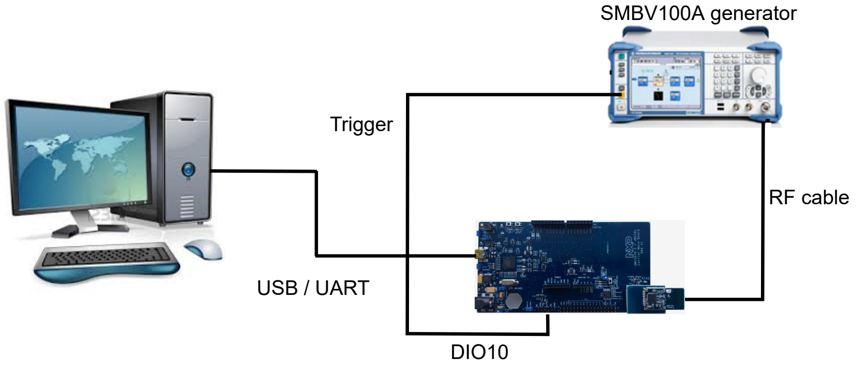


Figure 78. Conducted RX test setup for sensitivity and receiver maximum input level

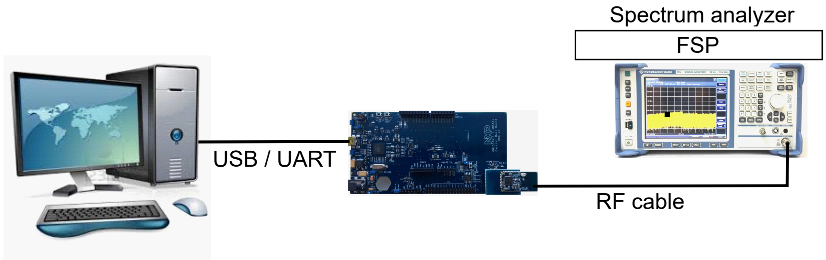


Figure 79. Conducted RX test setup for spurious

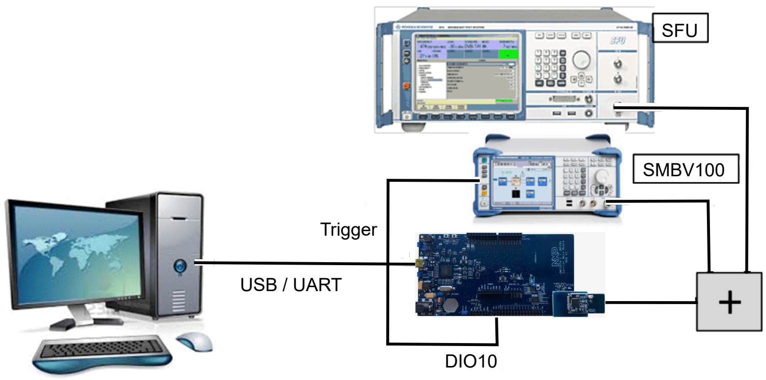


Figure 80. Conducted RX test setup for interference rejection

3.4.2 RX sensitivity

Test method:

The carrier board and K32W module are placed in an RF shield box to avoid any interference.

Generator: R&S SMBV100

The generator is used in ARB mode. It generates a pattern of 1000 packets of 20 octets. The DIO10 of the K32W is connected to the trigger input of the generator. A TeraTerm window is used to control the module.

- Set the receive frequency to channel 11.
- Set the module in the trigger packet test.
- The connection is automatically established and the Packet Error Rate (PER) is measured.
- Decrease the level of the generator at the RF input of the module until PER = 1 %.

Result:

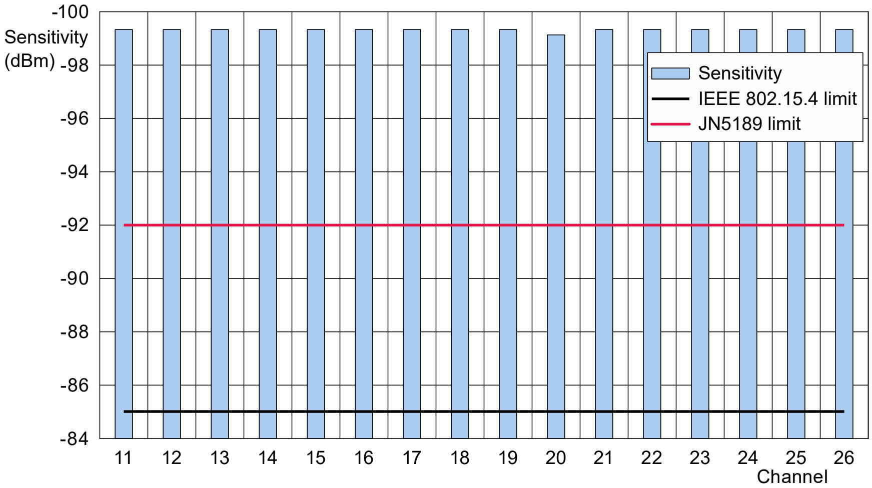


Figure 81. Receiver sensitivity

Conclusion:

- Minimum value: -100.2 dBm on channel 16
- Maximum value: -99.6 dBm on channel 23

Note: *K32W041 (without NTAG) and K32W061 (with NTAG) have the same sensitivity. The addition of the NTAG does not affect the sensitivity of the K32W chip.*

3.4.3 Receiver maximum input level

Test method:

Generator: R&S SMBV100

The generator is used in ARB mode. It generates a pattern of 1000 packets of 20 octets. The DIO10 of the K32W is connected to the trigger input of the generator. A TeraTerm window is used to control the module.

- Set the receive frequency to channel 11.
- Set the module in the trigger packet test.
- The connection is automatically established and the PER is measured.
- Increase the level of the generator at the RF input of the module until PER = 1 %.
- Do the same for the other channels.

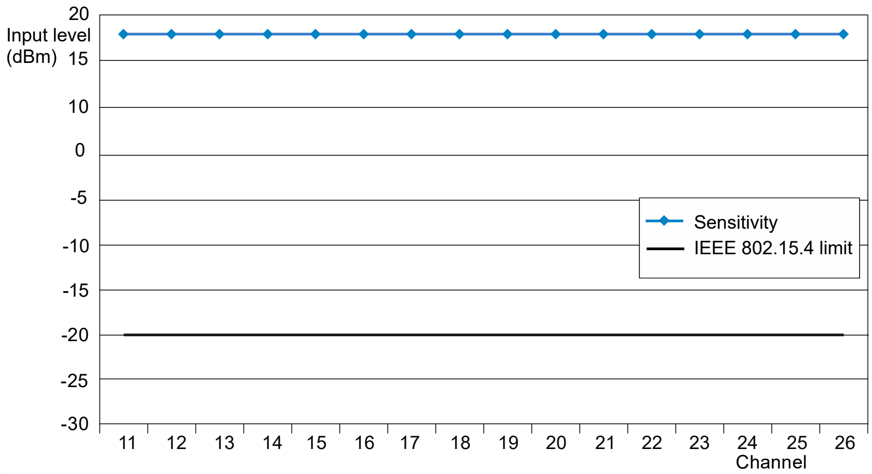


Figure 82. Maximum input power

Conclusion:

- The actual maximum input level cannot be measured with the test environment. The maximum level that can be delivered to the K32W is limited by the maximum output power of the generator and the cable losses.
- The maximum input level of K32W is higher than 17.8 dBm on all channels.

3.4.4 RX spurious

3.4.4.1 Wide band

Test method:

- Set the radio in:
  - Receiver mode
  - Frequency: Channel 18
- Set the analyzer to:
  - Ref amp = -20 dBm
  - Trace = Max Hold
  - Detector = Max Peak
  - Start/stop frequency: 30 MHz/1 GHz, RBW = 100 kHz
  - Start/stop frequency: 1 GHz/12.75 GHz, RBW = 1 MHz

Result:

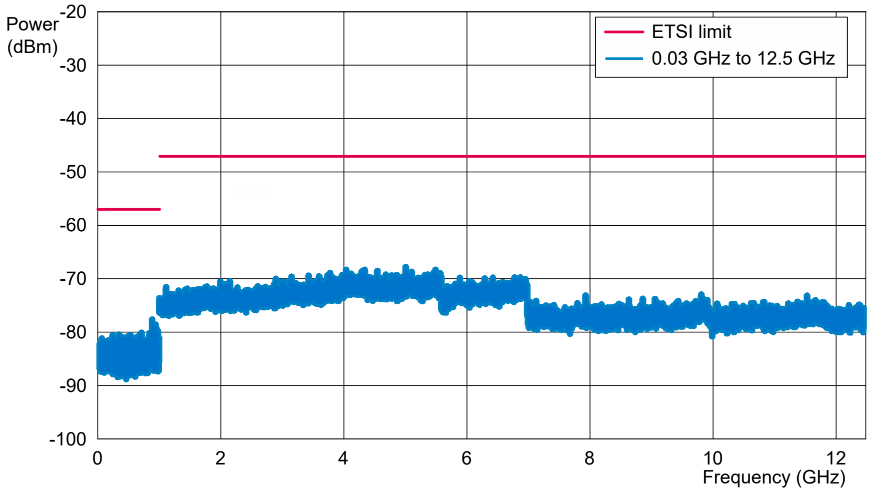


Figure 83. Conducted RX spurious (0.03 GHz to 12.5 GHz)

Note: *No spur has been detected.*

3.4.4.2 LO leakage

Test frequency: 2440 MHz (channel 18)

Results:

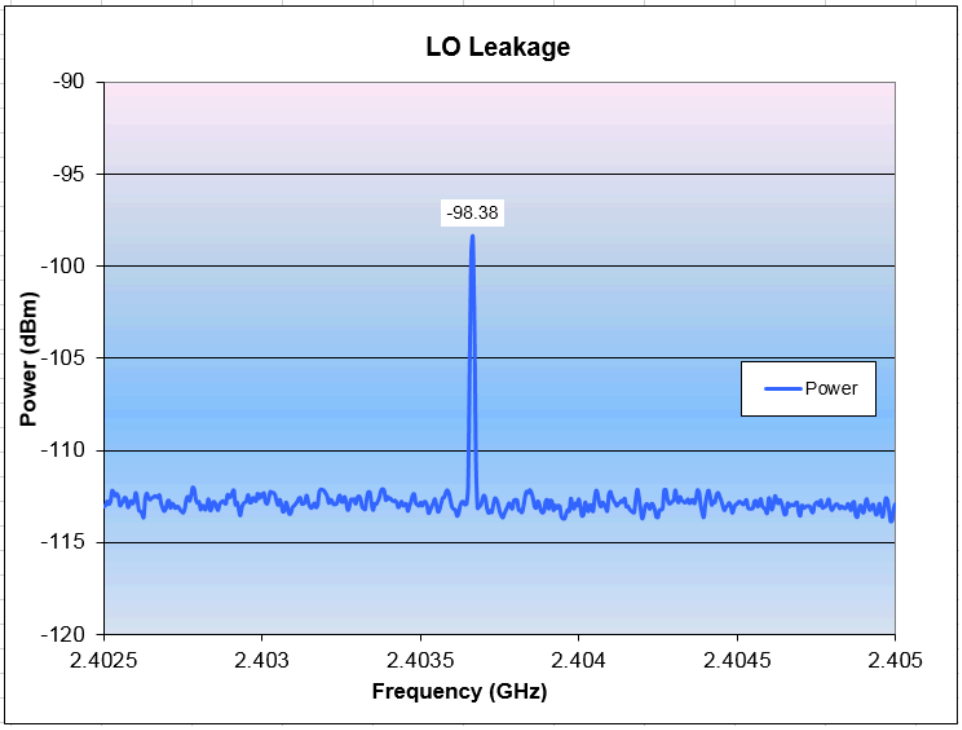


Figure 84. LO leakage

- - 98.4 dBm

Conclusion:

- 51.4 dB margin to ETSI limit

3.4.5 Receiver interference rejection

3.4.5.1 Adjacent and alternate channels with standard interferers

Interferers are located in the adjacent channel (n-1 and n+1) or alternate channels (n-2 and n+2).

The test is performed with only one interfering signal at a time.

Test method:

- Generator for the desired signal: Rohde & Schwarz SMBV100A generator (modulated)
- Generator for interferers: R&S SFU (modulated)
- Criterion: PER < 1 %
- The desired signal is set to - 82 dBm; the interferer is increased until the PER threshold has been reached
- Channels under test: 11, 18 and 26 (although n-1, n-2 are not system relevant for channel 11 and n+, n+2 are not system relevant for channel 26)

Results:

	ch11				**ch18**				**ch26**			
	2405				2440				2480			
	n-2	**n-1**	**n+1**	**n+2**	**n-2**	**n-1**	**n+1**	**n+2**	**n-2**	**n-1**	**n+1**	**n+2**
	2395	2400	2410	2415	2430	2435	2445	2450	2470	2475	2485	2490
Interferer level (dBm)	-35.6	-46.5	-45.7	-35.4	-35.6	-46.5	-45.7	-35.2	-35.6	-46.5	-45.5	-35.2
Interferer level (dBc)	46.4	35.5	36.3	46.6	46.4	35.5	36.3	46.8	46.4	35.5	36.5	46.8
IEEE 802.15.4 limit (dB)	30	0	0	30	30	0	0	30	30	0	0	30
Margin (dB)	16.4	35.5	36.3	16.6	16.4	35.5	36.3	16.8	16.4	35.5	36.5	16.8

Figure 85. Adjacent and alternate rejection

Conclusion:

- Good margin, in line with the expected results.

3.4.5.2 N-3 and N+3 channels with standard interferers

Test method:

Similar as for the adjacent and alternate channels but the interferer is set at +/- 15 MHz offset from the desired channel.

Results:

	ch11		**ch18**		**ch26**	
	2405		2440		2480	
	n-3	**n+3**	**n-3**	**n+3**	**n-3**	**n+3**
	2390	2420	2425	2455	2465	2495
Interferer level (dBm)	-30.3	-30.3	-30.3	-30.3	-30.3	-30.3
Interferer level (dBc)	**51.7**	**51.7**	**51.7**	**51.7**	**51.7**	**51.7**
Datasheet typical value (dB)	48	48	48	48	48	48
Margin (dB)	3.7	3.7	3.7	3.7	3.7	3.7

Figure 86. N-3 and N+3 band rejection

Conclusion:

- In line with the expected values.

3.4.5.3 Co-channel

	ch11	ch18	ch26
	2405	2440	2480
	co-ch	co-ch	co-ch
	2405	2440	2480
Interferer level (dBm)	-84.5	-84.5	-84.2
Interferer level (dBc)	**-2.5**	**-2.5**	**-2.2**
Datasheet typical value (dB)	48	48	48
Margin (dB)	-50.5	-50.5	-50.2

Figure 87. Co-channel

Conclusion:

- In line with the expected values.

3.4.5.4 Adjacent and alternate channels with filtered interferers

This section describes adjacent and alternate channels with filtered interferers as generated by a K32W in Proprietary mode 2.

Interferers are located in the adjacent channel (n-1 and n+1) or alternate channels (n-2 and n+2). The test is performed with only one interfering signal at a time.

Test method:

- Generator for the desired signal: Rohde & Schwarz SMBV100A generator (modulated)
- Generator for interferers: R&S SFU (modulated and filtered frame)
- Criterion: PER < 1 %
- The desired signal is set to - 82 dBm; the interferer is increased until the PER threshold has been reached
- Channels under test: 11, 18 and 26 (although n-1, n-2 are not system relevant for channel 11 and n+, n+2 are not system relevant for channel 26)

Results:

	ch11				ch18				ch26			
	2405				2440				2480			
	n-2	n-1	n+1	n+2	n-2	n-1	n+1	n+2	n-2	n-1	n+1	n+2
	2395	2400	2410	2415	2430	2435	2445	2450	2470	2475	2485	2490
Interferer level (dBc)	62.2	58.2	59.7	62.2	62.2	58.2	59.2	62.2	62.7	58.2	59.7	63.2
IEEE 802.15.4 limit (dBm)	30	0	0	30	30	0	0	30	30	0	0	30
Margin (dB)	32.2	58.2	59.7	32.2	32.2	58.2	59.2	32.2	32.7	58.2	59.7	33.2

Figure 88. Adjacent and alternate rejection

Conclusion:

When creating a network with K32W that transmits in Proprietary mode 2, the immunity can be improved as follows:

- The user can improve the immunity to adjacent interferers by 23 dB.
- The user can improve the immunity to alternate interferers by more than 15 dB.

3.4.5.5 N-3 and N+3 channels with filtered interferers

Test method:

Similar as for the adjacent and alternate channels but the interferer is set at +/- 15 MHz offset from the desired channel.

Results:

	ch11		ch18		ch26	
	2405		2440		2480	
	n-3	n+3	n-3	n+3	n-3	n+3
	2390	2420	2425	2455	2465	2495
Interferer level (dBc)	**56.7**	**58.2**	**56.7**	**59.2**	**57.2**	**59.2**

Figure 89. N-3 and N+3 band rejection

Conclusion:

- When creating a network with K32W that transmits in Proprietary mode 2 immunity can be improved to N-3 or N+3 interferers by more than 16 dB.

3.4.5.6 Co-channel with a filtered interferer

	ch11	ch18	ch26
	2405	2440	2480
	co-ch	co-ch	co-ch
	2405	2440	2480
Interferer level (dBc)	**-2.6**	**-2.6**	**-2.6**

Figure 90. Co-channel

Conclusion:

- There is no significant difference in Co-channel when using a standard interferer or a filtered interferer.
- Results are as expected.

3.4.6 Receiver blocking

The K32W is the equipment of category 1 as defined by the ETSI 300 328 (TX signal is higher than 10 dBm). Tests and limits are used according to category 1. The interferer is a CW signal.

3.4.6.1 Test 1

Figure 91 shows test 1 for receiver blocking.

	ch11	ch11	ch26	ch26
	2405	2405	2480	2480
	Low	High	Low	High
	2380	2503.5	2380	2503.5
Interferer level (dBm)	**-22.7**	**-20.6**	**-20.6**	**-23.1**
Interferer level (dBc)	71.3	73.4	73.4	70.9
IEEE 802.15.4 limit (dBm)	-53	-53	-53	-53
Margin (dB)	30.3	32.4	32.4	29.9

Figure 91. Receiver blocking test 1

Conclusion:

- Good margin

3.4.6.2 Test 2

Figure 92 shows test 2 for receiver blocking.

	ch11	ch11	ch11	ch26	ch26	ch26
	2405	2405	2405	2480	2480	2480
	Low	Low	Low	Low	Low	Low
	2300	2330	2360	2300	2330	2360
Interferer level (dBm)	-19.3	-20.1	-21.6	-19.6	-19.9	-20.5
Interferer level (dBc)	74.7	73.9	72.4	74.4	74.1	73.5
IEEE 802.15.4 limit (dBm)	-53	-53	-53	-53	-53	-53
Margin (dB)	33.7	32.9	31.4	33.4	33.1	32.5

Figure 92. Receiver blocking test 2

Conclusion:

- Good margin

3.4.6.3 Test 3

Figure 93 shows test 3 for receiver blocking.

	ch11	ch11	ch11	ch11	ch11	ch11
	2405	2405	2405	2405	2405	2405
	High	High	High	High	High	High
	2523.5	2553.5	2583.5	2613.5	2643.5	2673.5
Interferer level (dBm)	-20.1	-20.4	-20.1	-20.1	-19.8	-19.9
Interferer level (dBc)	73.9	73.6	73.9	73.9	74.2	74.1
IEEE 802.15.4 limit (dBm)	-53	-53	-53	-53	-53	-53
Margin (dB)	32.9	32.6	32.9	32.9	33.2	33.1

	ch26	ch26	ch26	ch26	ch26	ch26
	2480	2480	2480	2480	2480	2480
	High	High	High	High	High	High
	2523.5	2553.5	2583.5	2613.5	2643.5	2673.5
Interferer level (dBm)	-21.5	-21.0	-20.6	-20.2	-19.8	-19.9
Interferer level (dBc)	72.5	73.0	73.4	73.8	74.2	74.1
IEEE 802.15.4 limit (dBm)	-53	-53	-53	-53	-53	-53
Margin (dB)	31.5	32.0	32.4	32.8	33.2	33.1

Figure 93. Receiver blocking test 3

Conclusion:

- Good margin

3.4.7 Packet Error Rate versus RX input power

PER value is picked up when input power is decreased.

Test method:

Generator for the desired signal: Rohde & Schwarz SMBV100A generator

Results:

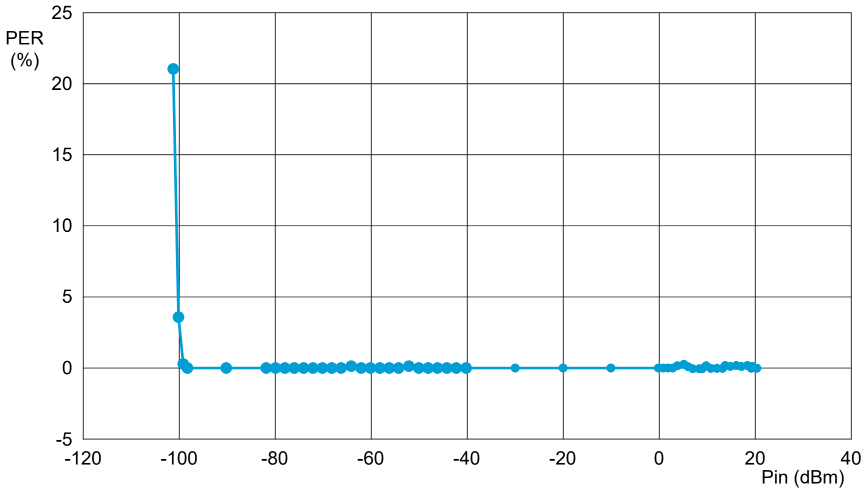


Figure 94. PER versus RX input power

3.5 Return loss

This section includes TX and RX return losses.

3.5.1 RX return loss

Figure 95 shows S11 RX results.

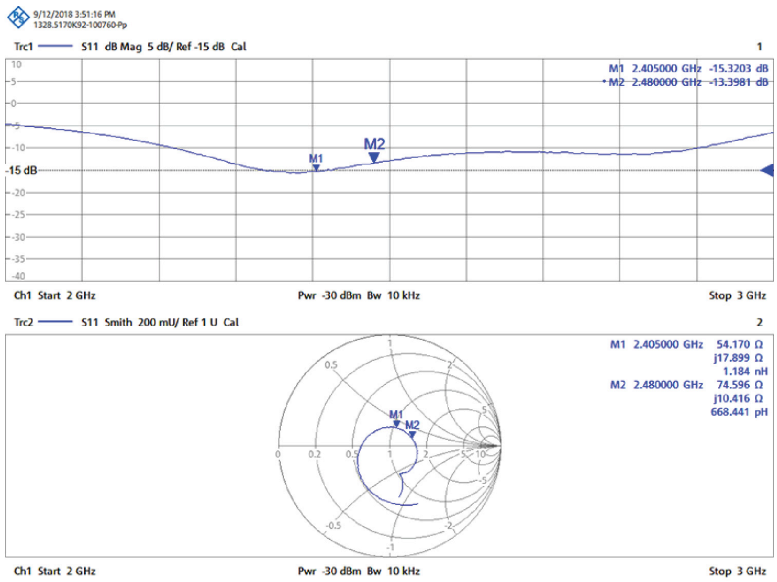


Figure 95. S11 RX

Results:

- Return loss: S11 < -12 dB at 2.405 GHz to 2.480 GHz

3.5.2 TX return loss

Figure 96 shows the S11 TX results.

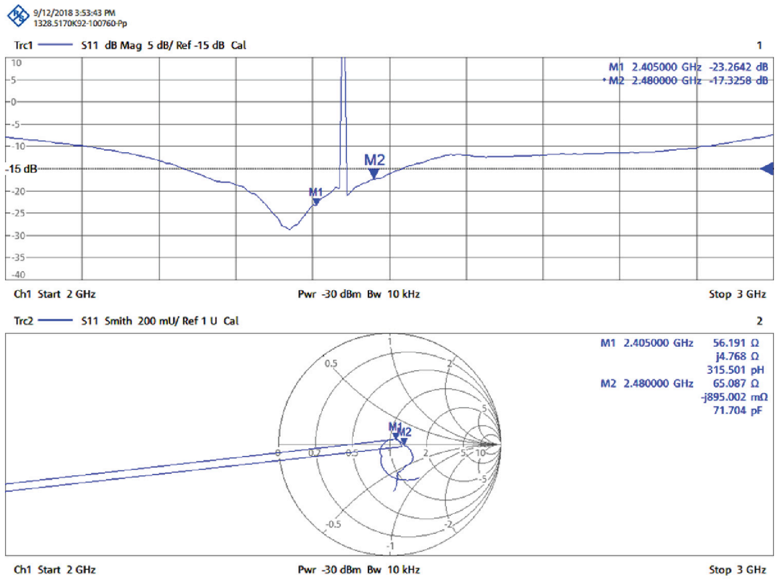


Figure 96. S11 TX

Results:

- Return loss: S11 < -17 dB at 2.405 GHz to 2.480 GHz

Conclusion:

- The S11 TX and RX are better than the NXP -10 dB target.

Note: *There is no specification for the return loss.*

On a module with a SMA connector instead of a µFl connector, the return loss is improved by 1 dB in the same network.

3.6 Conclusion

Beyond RED, 802.15.4, and FCC compliance, these radio tests prove the good RF performance of the K32W.

4 Proprietary mode benefit

This section explains the benefit of using a Proprietary mode in a Zigbee network.

Consider a K32W configured in ZigBee RX mode, while a second K32W generates the desired channel when configured in ZigBee TX mode. Consider that a third K32W is configured in Transmit mode and generates an interferer ZigBee in a near-by channel.

In this case, the side lobes of the ZigBee modulation limit the interferer immunity of the K32W receiver if the interferer signal is generated without any filtering.

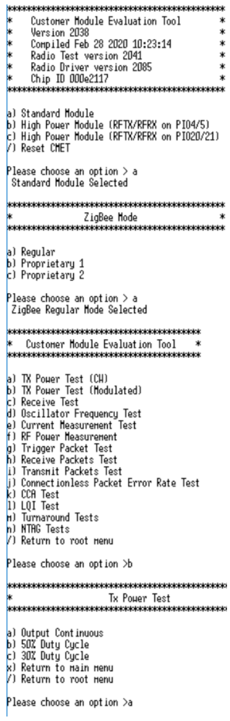
The K32W radio performs better in terms of interferers immunity compared to the side-lobes limitation of the ZigBee modulation. Therefore, using the Proprietary mode for the transmitter that generates the interferer improves the interferer immunity of the K32W, which is configured in RX mode.

Alternatively, when the K32W interferer uses the Proprietary mode as compared to the Regular mode, the level of the interferer can be higher relative to the desired channel.

5 CMET settings

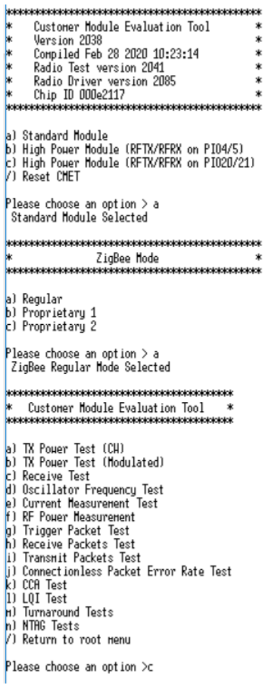
This section includes CMET settings for the tests presented in this application note.

1. For tests in Transmit mode:

Section	CMET selection	CMET evaluation software
Frequency accuracy	a) a) a)	
Phase noise	a) a) a)	
TX power (fundamental)	a) a) a) +/-	
TX spurious	a) a) b) a)	
TX modulation	a) a) b) a)	
EVM	a) a) b) a) +/-	
Offset EVM	a) a) b) a) +/-	
Upper band edge	a) a) b) a) Ch26	
TX return loss	a) a) b) a)	

```
********************************************
*    Customer Module Evaluation Tool       *
*    Version 2038                          *
*    Compiled Feb 28 2020 10:23:14         *
*    Radio Test version 2041               *
*    Radio Driver version 2085             *
*    Chip ID 000e2117                      *
********************************************

a) Standard Module
b) High Power Module (RFTX/RFRX on PIO4/5)
c) High Power Module (RFTX/RFRX on PIO20/21)
/) Reset CMET

Please choose an option > a
 Standard Module Selected

********************************************
*               ZigBee Mode                *
********************************************

a) Regular
b) Proprietary 1
c) Proprietary 2

Please choose an option > a
 ZigBee Regular Mode Selected

****************************************
*   Customer Module Evaluation Tool    *
****************************************

a) TX Power Test (CW)
b) TX Power Test (Modulated)
c) Receive Test
d) Oscillator Frequency Test
e) Current Measurement Test
f) RF Power Measurement
g) Trigger Packet Test
h) Receive Packets Test
i) Transmit Packets Test
j) Connectionless Packet Error Rate Test
k) CCA Test
l) LQI Test
m) Turnaround Tests
n) NTAG Tests
/) Return to root menu

Please choose an option >b

********************************************
*                     Tx Power Test
********************************************

a) Output Continuous
b) 50% Duty Cycle
c) 30% Duty Cycle
x) Return to main menu
/) Return to root menu

Please choose an option >a
```

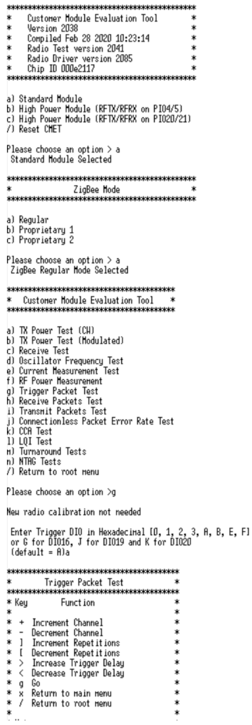
2. For tests in Receive mode:

Section	CMET selection	CMET evaluation software
RX return loss	a) a) h)	

```
***********************************************
*    Customer Module Evaluation Tool          *
*    Version 2038                             *
*    Compiled Feb 28 2020 10:23:14            *
*    Radio Test version 2041                  *
*    Radio Driver version 2085                *
*    Chip ID 000e2117                         *
***********************************************

a) Standard Module
b) High Power Module (RFTX/RFRX on PIO4/5)
c) High Power Module (RFTX/RFRX on PIO20/21)
/) Reset CMET

Please choose an option > a
 Standard Module Selected

***********************************************
*               ZigBee Mode                   *
***********************************************

a) Regular
b) Proprietary 1
c) Proprietary 2

Please choose an option > a
 ZigBee Regular Mode Selected

*****************************************
*   Customer Module Evaluation Tool     *
*****************************************

a) TX Power Test (CW)
b) TX Power Test (Modulated)
c) Receive Test
d) Oscillator Frequency Test
e) Current Measurement Test
f) RF Power Measurement
g) Trigger Packet Test
h) Receive Packets Test
i) Transmit Packets Test
j) Connectionless Packet Error Rate Test
k) CCA Test
l) LQI Test
m) Turnaround Tests
n) NTAG Tests
/) Return to root menu

Please choose an option >c
```

3. For PER test:

Table 18. Adjacent and alternate channels with standard interferers

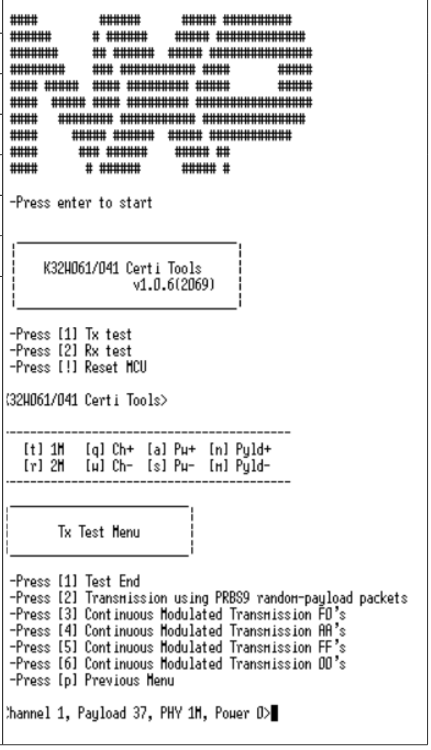
Section	CMET selection	CMET evaluation software
RX senstivity	a) a) g) 'A' 'g' +/-	
Receiver maximum input level	a) a) c)	
RX spuriouz Wide band Adjacent and alternate channels with standard interferers N-3 & n+3 channels with filtered interferers (as generated by a K32W in proprietary mode 2) Co-channel with a filtered interferer Adjacent and alternate channels with filtered interferers (as generated by a K32W in proprietary mode 2) N-3 & n+3 channels with filtered interferers (as generated by a K32W in proprietary mode 2) Co-channel with a filtered interferer Receiver blocking	a) a) c)	

```
*******************************************
*   Customer Module Evaluation Tool       *
*   Version 2038                          *
*   Compiled Feb 28 2020 10:23:14         *
*   Radio Test version 2041               *
*   Radio Driver version 2085             *
*   Chip ID 000e2117                      *
*******************************************

a) Standard Module
b) High Power Module (RFTX/RFRX on PIO4/5)
c) High Power Module (RFTX/RFRX on PIO20/21)
/) Reset CMET

Please choose an option > a
 Standard Module Selected

*******************************************
*              ZigBee Mode                *
*******************************************

a) Regular
b) Proprietary 1
c) Proprietary 2

Please choose an option > a
 ZigBee Regular Mode Selected

***************************************
*  Customer Module Evaluation Tool    *
***************************************

a) TX Power Test (CW)
b) TX Power Test (Modulated)
c) Receive Test
d) Oscillator Frequency Test
e) Current Measurement Test
f) RF Power Measurement
g) Trigger Packet Test
h) Receive Packets Test
i) Transmit Packets Test
j) Connectionless Packet Error Rate Test
k) CCA Test
l) LQI Test
m) Turnaround Tests
n) NTAG Tests
/) Return to root menu

Please choose an option >g

New radio calibration not needed

 Enter Trigger DIO in Hexadecimal [0, 1, 2, 3, A, B, E, F]
 or G for DIO16, J for DIO19 and K for DIO20
 (default = A)a

****************************************
*        Trigger Packet Test           *
****************************************
* Key       Function                   *
*                                      *
*  +  Increment Channel                *
*  -  Decrement Channel                *
*  ]  Increment Repetitions            *
*  [  Decrement Repetitions            *
*  >  Increase Trigger Delay           *
*  <  Decrease Trigger Delay           *
*  g  Go                               *
*  x  Return to main menu              *
*  /  Return to root menu              *
*                                      *
```

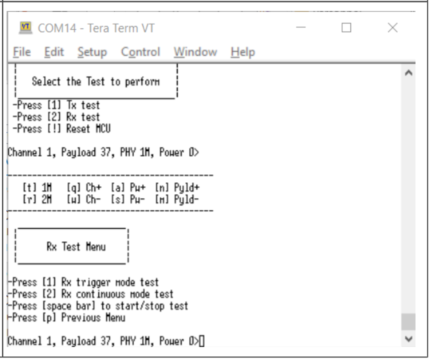
6 K32W certi tool settings

This section includes K32W_certi_tool settings for the tests presented in this application note.

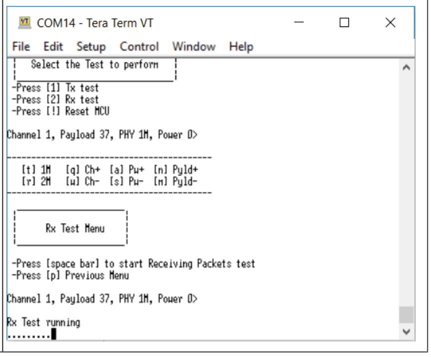
1. For tests in Transmit mode:

Section	K32W_certi_tool selection	Certi_tool evaluation software
Frequency accuracy	[1], [5] or [6]	
Phase noise	[1], [5] or [6]	
TX power (fundamental)	[1], [5] or [6],then [q] or [w]	
TX power in band	[1], [2], [t] or [r]	
TX spurious	[1], [2], [t] or [r]	
Upper band edge	[1], [2], [t] or [r], [q] up to channel 39	
Modulation characteristics	On CMW equipment	
Carrier frequency offset and drift	On CMW equipment	

2. For tests in Receive mode:

Section	K32W_certi_tool selection	Certi_tool evaluation software
RX return loss	[2], [2]	

3. For PER test:

Section	K32W_certi_tool selection	Certi_tool evaluation software
RX sensitivity Receiver maximum input level RX spurious • Section 2.4.5.1 • Receiver blocking • Intermodulation	[2], [q] or [w], [t] or [r], Space bar	

A signal generator sends the packets to the K32W device. Then, the packets received by the K32W device are counted for 15 seconds and the ratio of **packets received** to **sent packets** is calculated and displayed. If no packets are received, PER is 100 %, as shown in Figure 97.

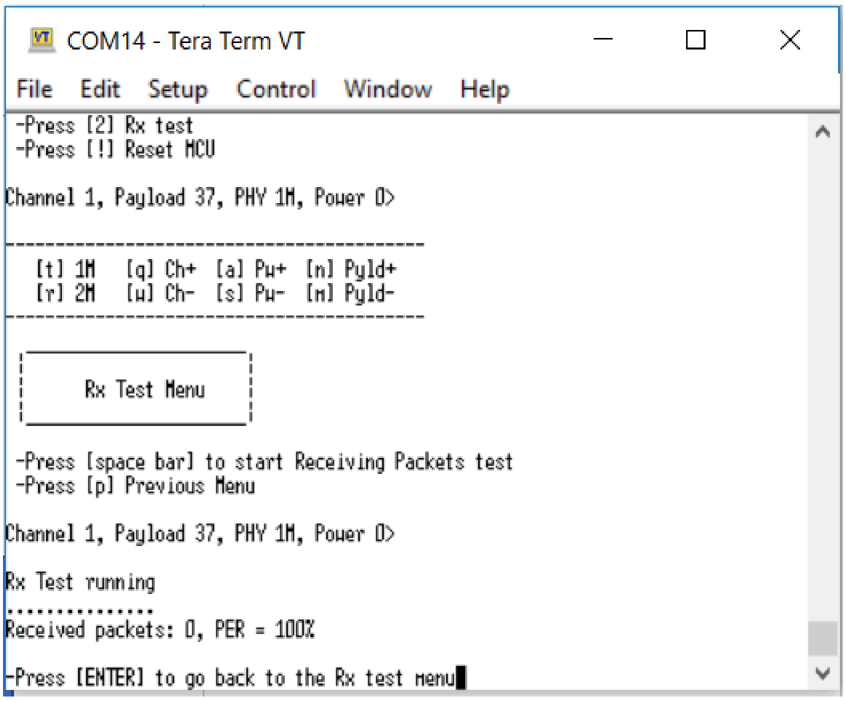


Figure 97. Certi_tool evaluation software

7 References

The references used to supplement this application note are as follows:

- **FCC**: 47 CFR Part 15C
- **RED**: The European Radio Equipment Directive applied from June 2016
- **R&TTE**: The radio and Telecommunications Terminal Equipment Directive (R&TTED) (1999/5/EC) has been stopped in June 2016.
- **ETSI EN 300 328:** European telecommunication standard - Radio Equipment and Systems (RES) wideband data transmission systems, technical characteristics, and test conditions for data transmission equipment operating in the 2.4 GHz ISM band, using spread spectrum modulation techniques.

- **IEEE 802.15.4**: IEEE standard for Information Technology – Telecommunications and information exchange between systems – Local and metropolitan area networks – Specific requirements – Part 15.4: Wireless Medium Access Control (MAC) and Physical Layer (PHY) Specifications for Low Rate Wireless Personnel Area Networks (LR-WPANs).
- **RF-PHY TS 4.2.0/5.0**: Bluetooth Test Specification. This document defines test structures and procedures for qualification testing of Bluetooth implementations of the Bluetooth Low Energy RF PHY.
- **FCC Part 15**: Operation to FCC Part 15 is subject to two conditions. First, the device cannot cause harmful interference and, second, the device must accept any interference received, including interference that can cause undesired operation. Therefore, there is no guaranteed quality of service when operating a Part 15 device.

8 Revision history

Table 19 summarizes the revisions to this document.

Table 19. Revision history

Revision number	Release date	Description
3	28 August 2023	• Updated with latest NXP style sheet. • Figures are updated through the entire document to svg format. • Content is updated throughout the entire document. • Updated Figure 32, Figure 33, Figure 34, and Figure 35.
2	September 2020	Latest NXP template
1	April 2020	Initial public release

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