AN12154

JN5189T SMA Module Radio Evaluation

Rev. 0 — 11/2020 Application Note

Contents

1 Introduction

This document provides the results of the RF evaluation tests of the JN5189T MCU in the ZigBee standard.

The JN5189T is mounted on the OM15070 module. The access to the RF signal is made via the SMA connector.

The module is soldered to the mezzanine board OM15077 that allows to plug it to the OM15076 mother board, also called “Carrier Board DK6”.

All the measurements have been done in the conducted mode on a JN5189 from STR n° = C8017.

Figure 1. OM15070 module and OM15076 carrier board

1.1 Matching network

The RF matching network has been optimized in February 2018. The modification consists in changing the capacitor C24 = 1.2 pF and L2 = 3.3 nH.

Figure 2 shows the new matching network. The related BOM version is v2.0.

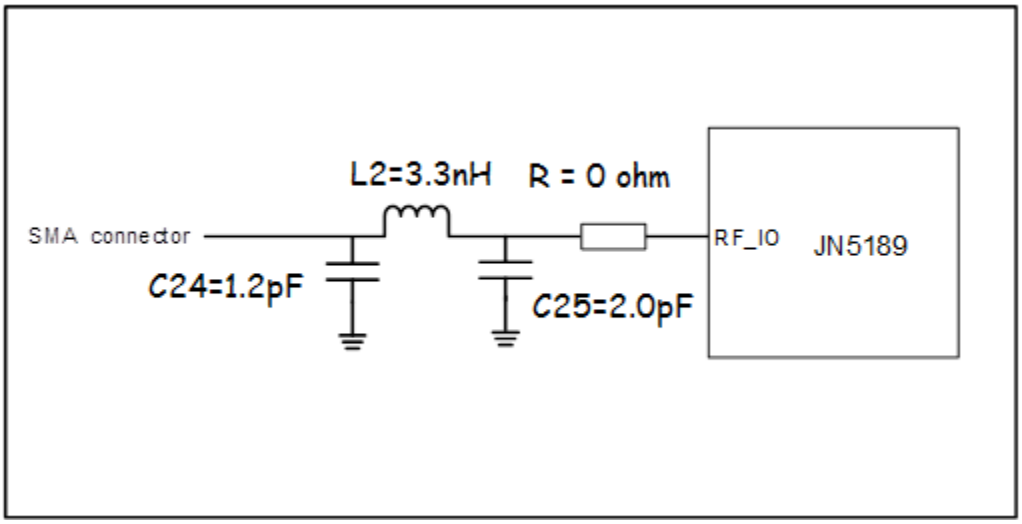

Figure 2. JN5189T module front-end matching and filtering network

Modifications have also been made in the CMET according to this new matching network. Be sure to use revision 2036 of the CMET (or above) with the boards that are populated with this latest matching network.

1.2 List of tests

1. Conducted tests
    a. Tx tests
        i. Frequency accuracy
        ii. Phase noise
        iii. Tx power
        iv. TX spurious
        v. Harmonics
        vi. EVM and offset EVM
        vii. Upper band edge
    b. Rx tests
        i. Sensitivity
        ii. Maximum input level
        iii. Rx spurious
        iv. LO leakage
        v. Interferers (as per 802.15.4 requirements)
        vi. Co-channel
        vii. Receiver blocking (as per ETSI 300 328 requirements)
2. Return loss
    a. Rx
    b. Tx

1.3 Software

Before the measurement, a binary code must be loaded into the flash memory of the board using the Flash Programmer application JN-SW-4407.

The binary code used for the following tests is the CMET (Customer Module Evaluation Tool) version 2036 compiled on April 3, 2019.

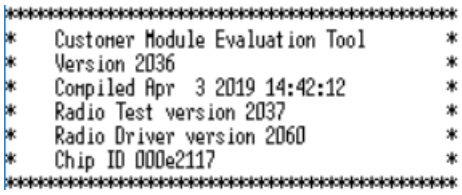

Figure 3. CMET

The TeraTerm terminal emulator is used to communicate with the JN5189 UART0.

Two USB ports are available on the DK6 board to control the JN5189 with CMET: LPC Link2 and FTDI.

Annex B presents the selected options to perform the tests below.

1.4 Test equipment

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

2 Test summary

This section summarizes the main tests performed on the JN5189T modules in one tab. Most of the tests' results details and setup are described in this document. To get further explanation, contact your local NXP contact.

Table 1. List of tests (Europe)

		EUROPE		
		reference	*limit*	*Status*
Transmission	TX Maximum Power	ETSI EN 300 328	20 dBm, 100 mW (radiated)	PASS
	Eirp Tx spectral density	ETSI EN 300 328	10 dBm/MHz	PASS
	TX spectral density	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	PASS

Table continues on the next page...

Table 1. List of tests (Europe) (continued)

		EUROPE		
			-54 dBm (depends on frequency)	
			(100 KHz BW)	
	Spurious 1GHz - 12.5 GHz	ETSI EN 300 328	-30 dBm	PASS
			(1 MHz BW)	
	EVM	802.15.4_2011	35 %	PASS
	TX Frequency Tolerance	802.15.4_2011	+/- 40 ppm	PASS
	Reachable Low limit of max power	802.15.4_2011	-3 dBm	PASS
	Phase noise (unspread)	802.15.4_2003	NA	For information
		reference	*limit*	*Status*
Reception	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	802.15.4	-85 dBm	PASS
	Adjacent channel interference rejection N+/-1	802.15.4_2011	0 dB	PASS
	Alternate channel interference rejection N+/-2	802.15.4_2011	30 dB	PASS
	Receiver blocking	ETSI EN 300 328	-57 dBm / -47 dBm	PASS
	RX Maximum input level	802.15.4_2011	-20 dBm	PASS
Misc.	Return loss (S11)	Return loss in Tx mode	For information	
		Return loss in Rx mode	For information	

Table 2. List of tests (US)

		US		
		reference	*limit*	*Status*

Table continues on the next page...

Table 2. List of tests (US) (continued)

Transmission	Spurious 1 GHz - 12.5 GHz	FCC part15	-41 dBm (1 MHz BW)	PASS

3 Conducted tests

3.1 TX modes

The following three different modulation modes exist in the JN5189 transmission:

- Regular
- Proprietary 1
- Proprietary 2

In the regular mode, the whole OQPSK spectrum is transmitted without filtering. In proprietary mode 1, the spectrum is slightly digitally filtered. In proprietary mode 2, the spectrum is more heavily filtered.

Filtering the spectrum can be useful to pass the FCC upper band-edge test without reducing the TX power on channel 26.

Filtering the TX spectrum also allows the receiver to benefit from its full selectivity performances (see Appendix A for details).

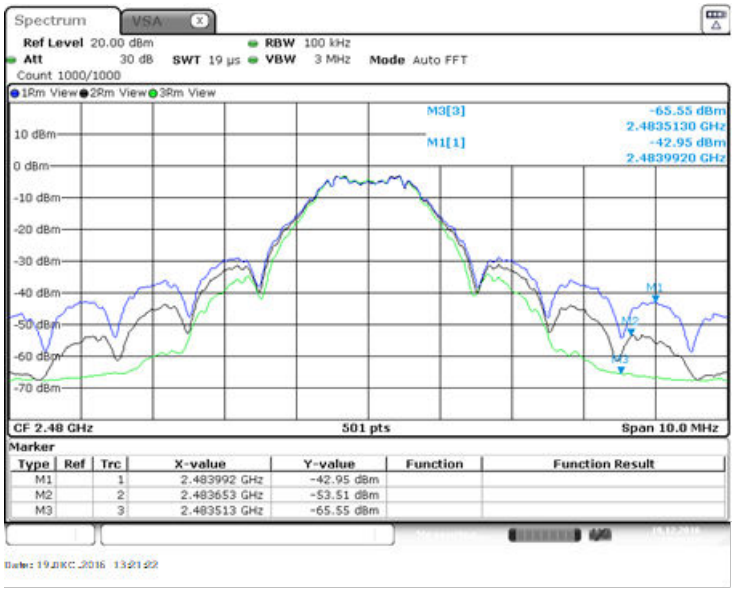

Figure 4. JN5189T TX spectrum

In Figure 4, the legend is as follows:

- Blue graph: regular mode
- Black graph: proprietary mode 1
- Green graph: proprietary mode 2

The measurements included in this document were done in the regular mode, unless specified otherwise.

3.2 TX tests

The TX power of the JN5189T is set to **+10 dBm.**

3.2.1 Test setup

Connect the RF port of the module to the spectrum analyzer.

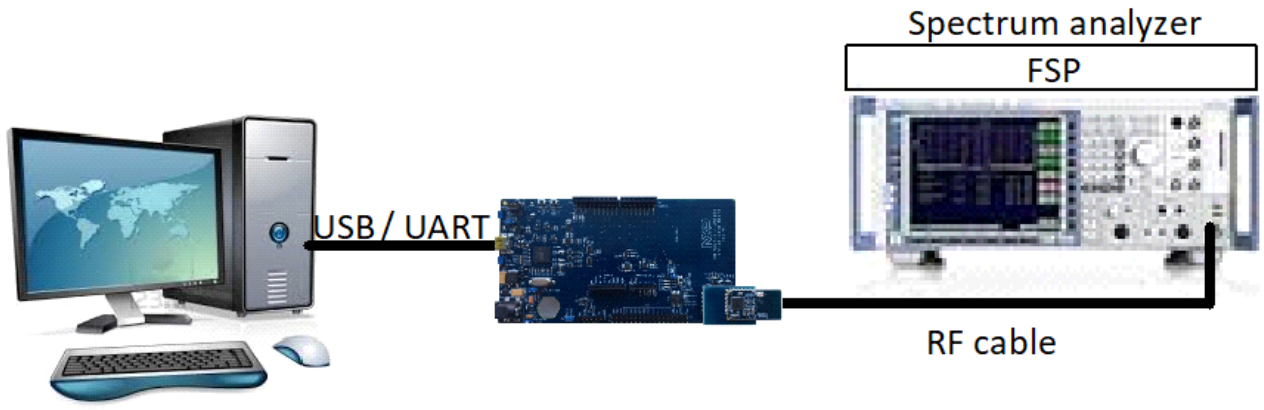

Figure 5. Conducted TX test setup

3.2.2 Frequency accuracy

Test method:

- Set the radio to:
  - 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:

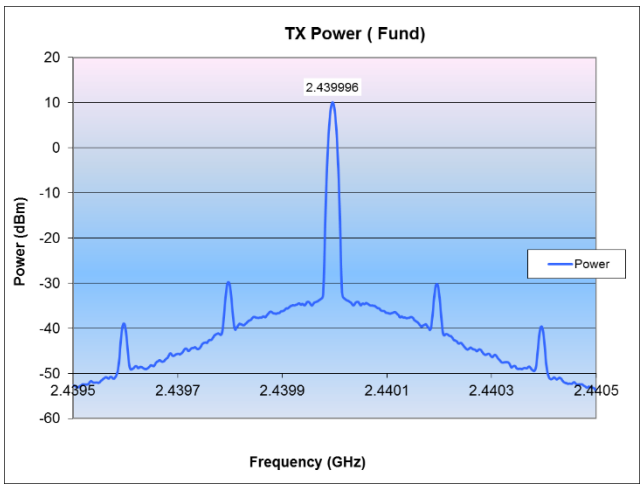

Figure 6. Frequency accuracy

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

Result	Target	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 fully compliant with the 802.15.4 specifications.

3.2.3 Phase noise @ 100 KHz offset

Test method:

- Set the radio to:
  - 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 the 100 KHz offset frequency.
  - RBW = 10 KHz (40 dBc)

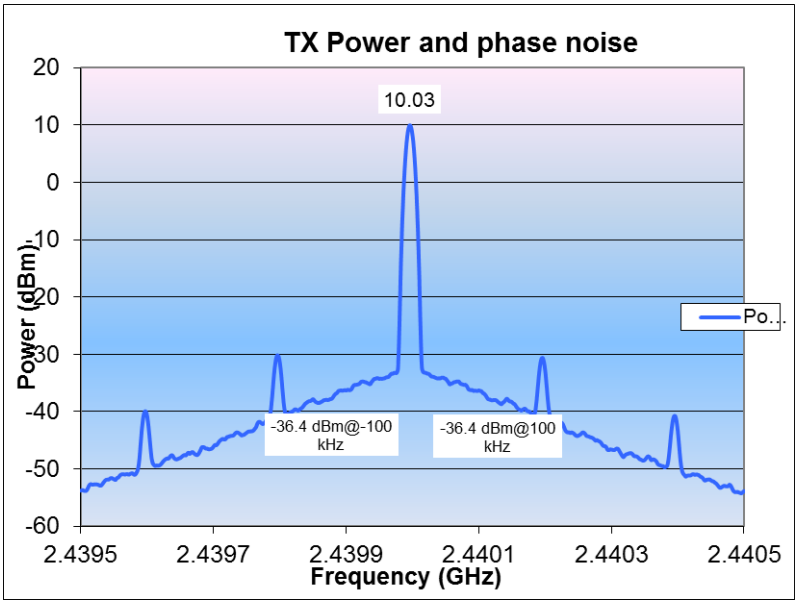

Figure 7. Phase noise

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.

3.2.4 TX power (fundamental)

Test method:

- Set the radio to:
  - 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.

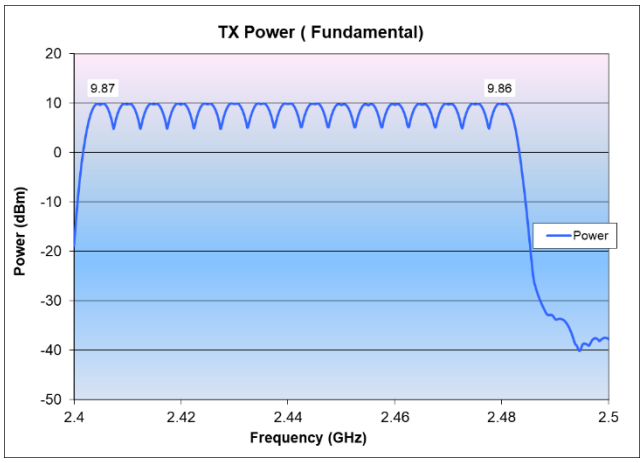

Figure 8. TX max power

Result:

The maximum power is on channel 17: +**9.92 dBm.**

The minimum power is on channel 20: **+ 9.76 dBm.**

The tilt over frequencies is **0.16 dB.**

Conclusion:

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

3.2.5 TX spurious

3.2.5.1 Global view from 0.3 GHz to 12.5 GHz (wanted = channel 18)

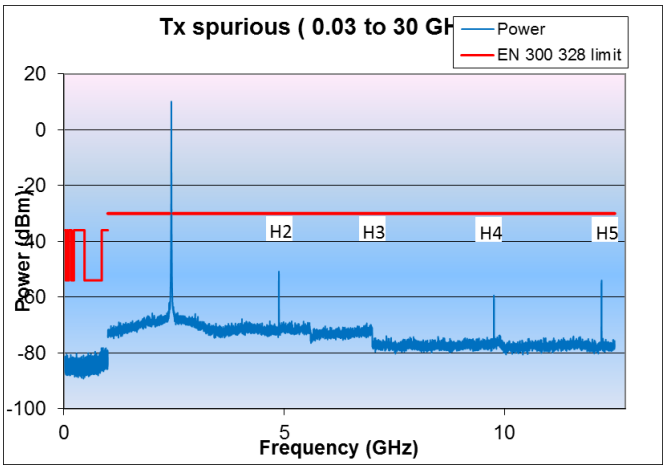

Figure 9. Conducted TX spurious

Conclusion:

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

3.2.5.2 H2 (ETSI test conditions)

Test method:

- Set the radio to:
  - 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.

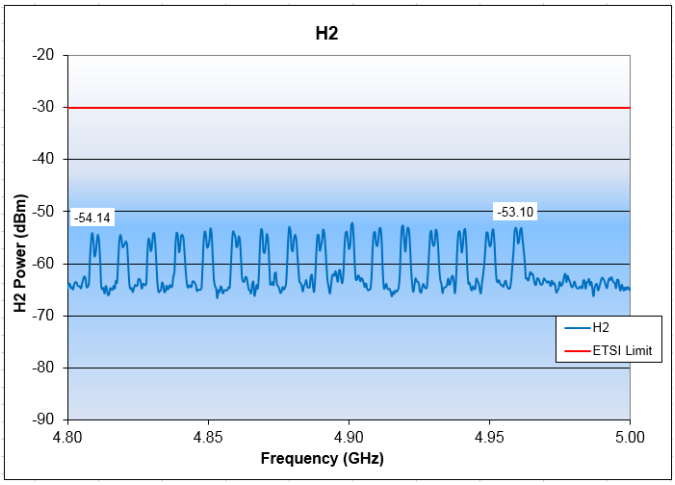

Figure 10. Conducted H2 spurious

Results:

The maximum power is on channel 20: **- 52.2 dBm.**

Conclusion:

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

3.2.5.3 H3 (ETSI test conditions)

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

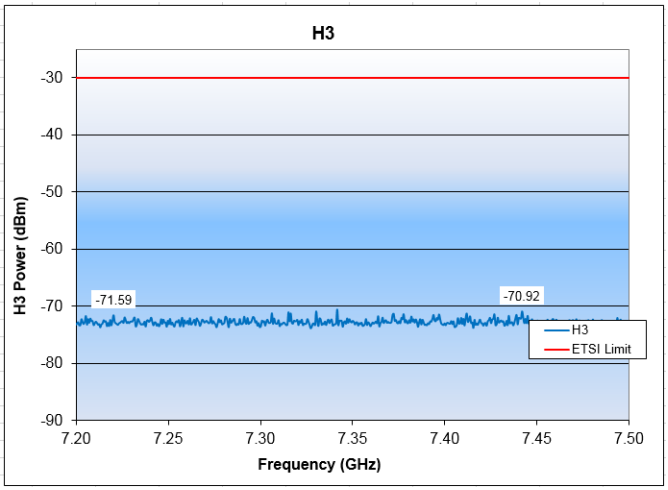

Figure 11. Conducted H3 spurious

Results:

The maximum power is on channel 19: **- 70.6 dBm.**

Conclusion:

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

3.2.5.4 H4 (ETSI test conditions)

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

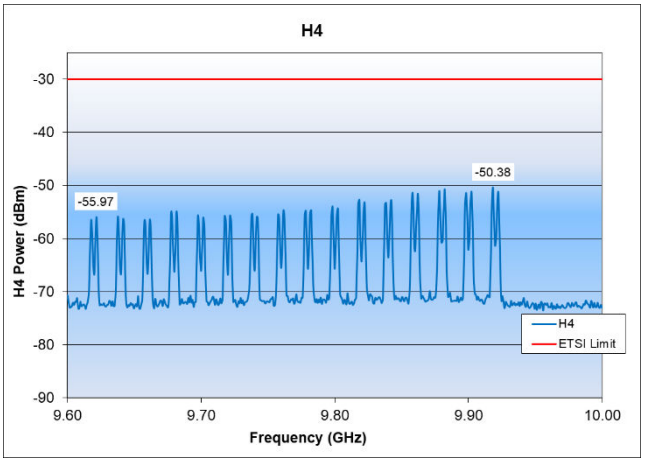

Figure 12. Conducted H4 spurious

Results:

The maximum power is on channel 26: **- 50.3 dBm.**

Conclusion:

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

3.2.5.5 H5 (ETSI test conditions)

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

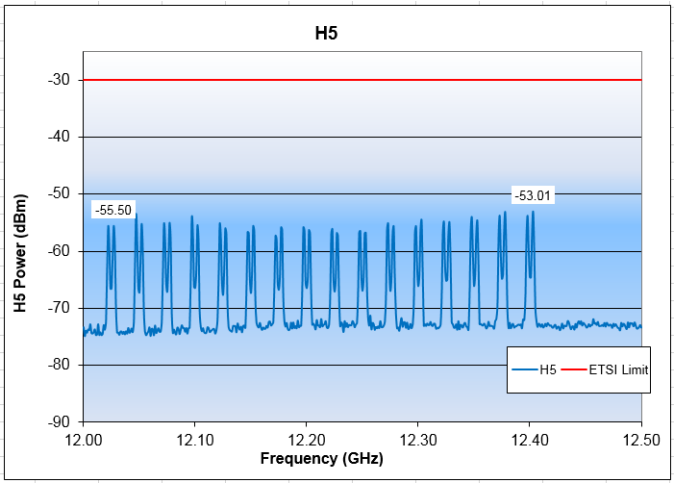

Figure 13. Conducted H5 spurious

Results:

The maximum power is on channel 26: **-53.0 dBm.**

Conclusion:

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

3.2.5.6 H6 (ETSI test conditions)

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

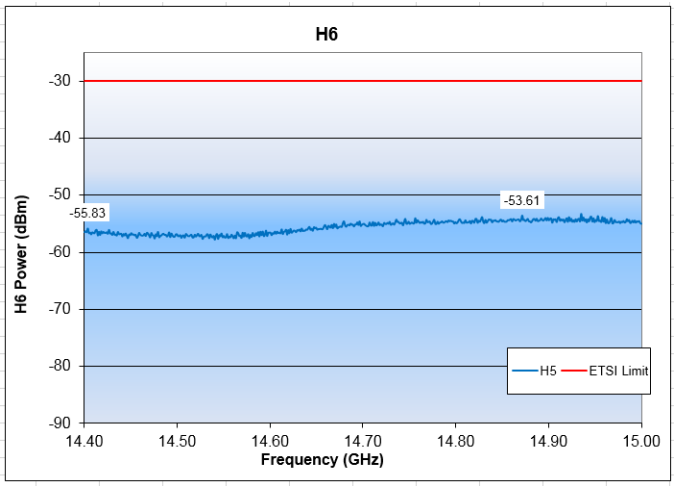

Figure 14. Conducted H6 spurious

Results:

The maximum power is on channel 26: **-53.6 dBm.**

Conclusion:

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

3.2.5.7 H7 (ETSI test conditions)

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

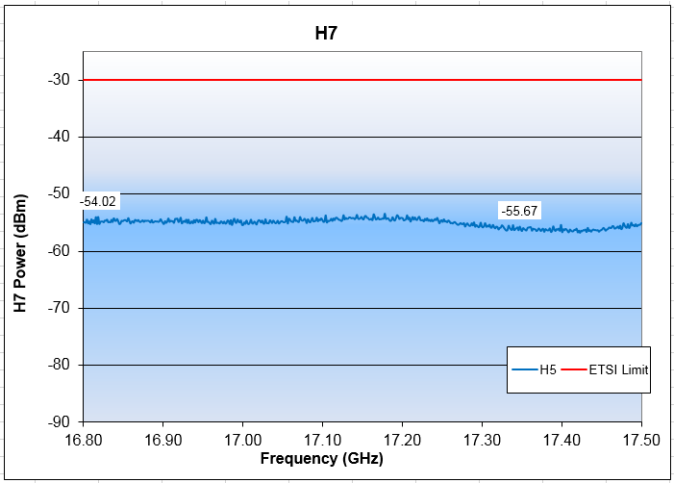

Figure 15. Conducted H7 spurious

Results:

The maximum power is on channel 21: **-53.5 dBm.**

Conclusion:

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

3.2.5.8 H8 (ETSI test conditions)

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

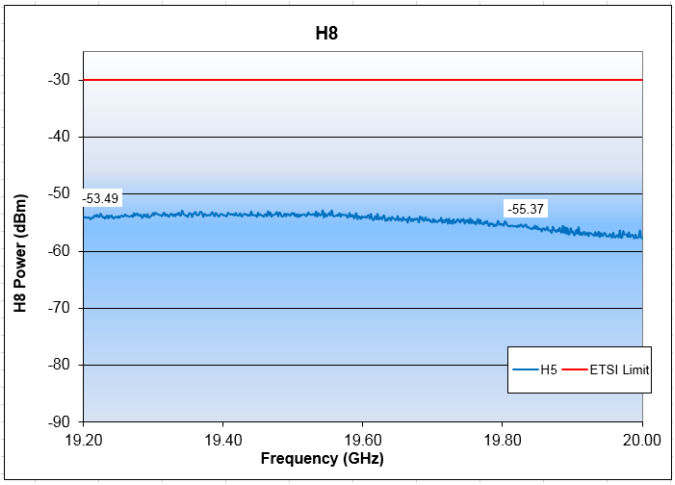

Figure 16. Conducted H8 spurious

Results:

The maximum power is on channel 19: **-52.9 dBm.**

Conclusion:

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

3.2.5.9 H9 (ETSI test conditions)

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

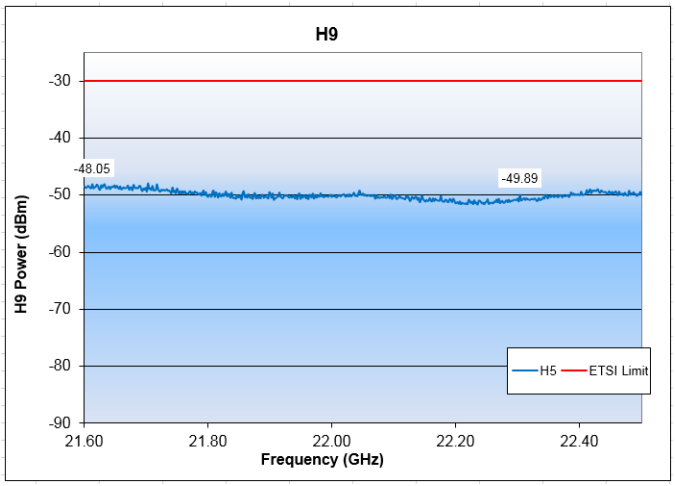

Figure 17. Conducted H9 spurious

Results:

The maximum power is on channel 12: **-47.9 dBm.**

Conclusion:

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

3.2.5.10 H10 (ETSI test conditions)

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

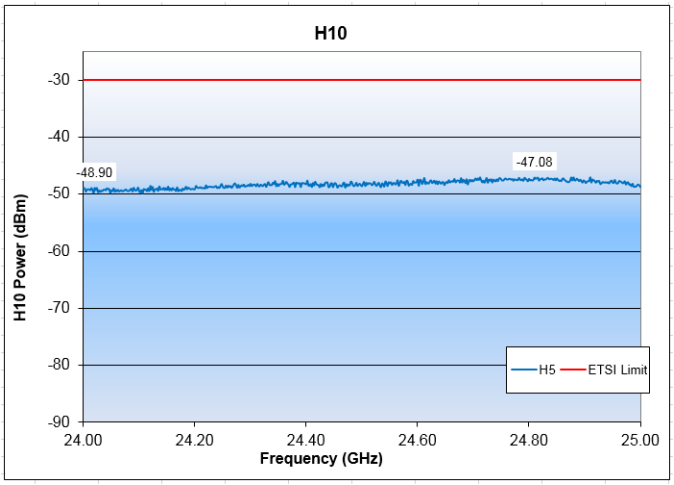

Figure 18. Conducted H10 spurious

Results:

The maximum power is on channel 24: **-47.1 dBm.**

Conclusion:

- There is a 17.1 dB margin to the ETSI limit.

3.2.5.11 H2 (FCC test conditions)

Test method:

- Set the radio to:
  - 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.

Results:

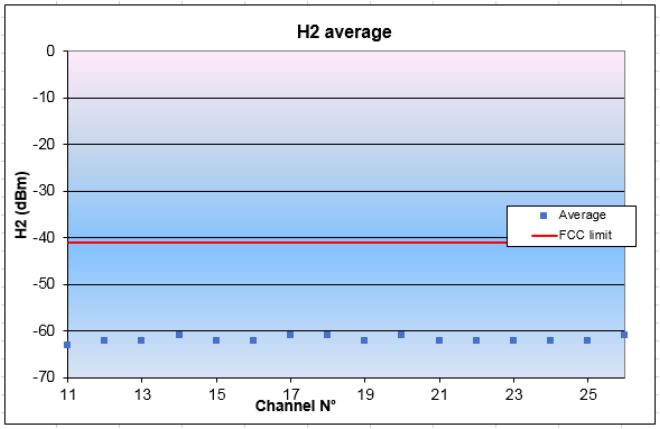

Figure 19. Conducted H2 spurious

The maximum power is: **-61.0dBm.**

Conclusion:

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

3.2.5.12 H3 (FCC test conditions)

The same method as H2 except that the spectrum analyzer frequency start/stop are set to 7.2 and 7.5 GHz.

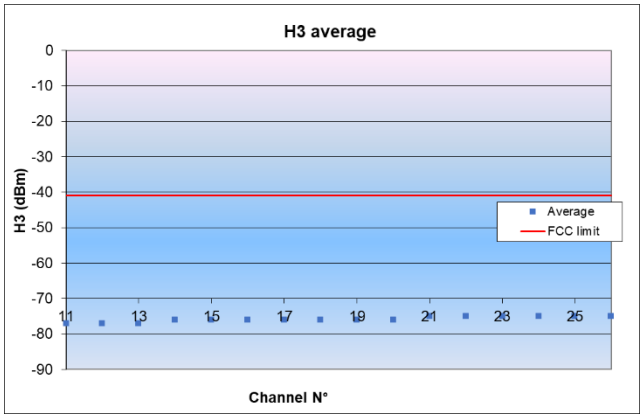

Figure 20. Conducted H3 spurious

Results:

The maximum power is on channels 21 to 26: **-75 dBm.**

Conclusion:

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

3.2.5.13 H4 (FCC test conditions)

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

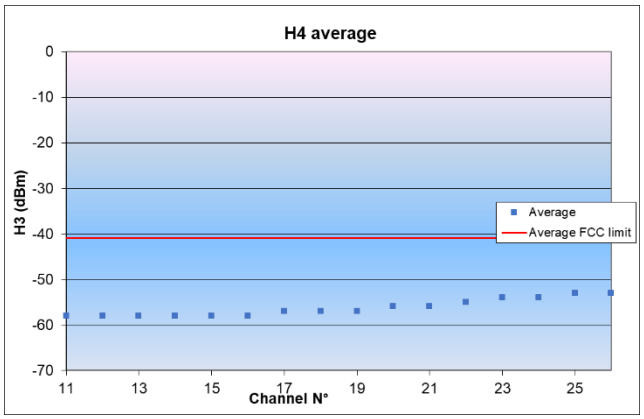

Figure 21. Conducted H4 spurious

Results: The maximum power is on channel 25 and 26: -**53 dBm.**

Conclusion:

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

3.2.5.14 H5 (FCC test conditions)

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

Result:

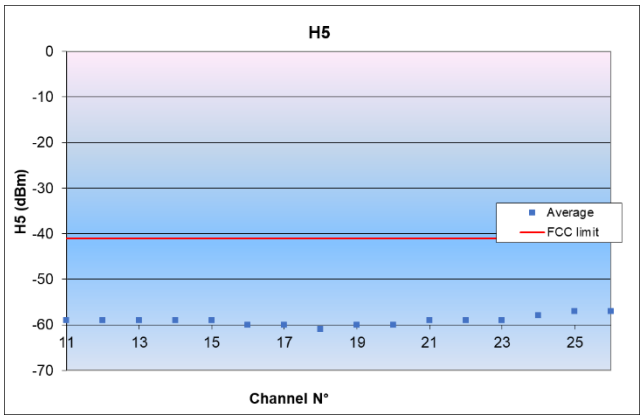

Figure 22. Conducted H5 spurious

The maximum power is on channel 13: -**57 dBm.**

Conclusion:

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

3.2.5.15 H6 (FCC test conditions)

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

Result:

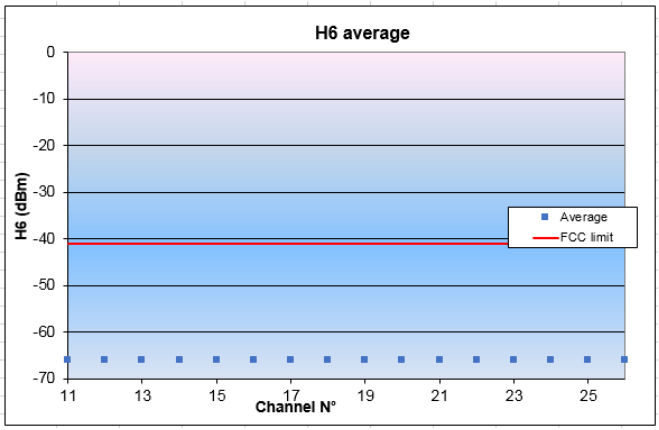

Figure 23. Conducted H6 spurious

The maximum power is: -66 **dBm.**

Conclusion:

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

3.2.5.16 H7 (FCC test conditions)

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

Result:

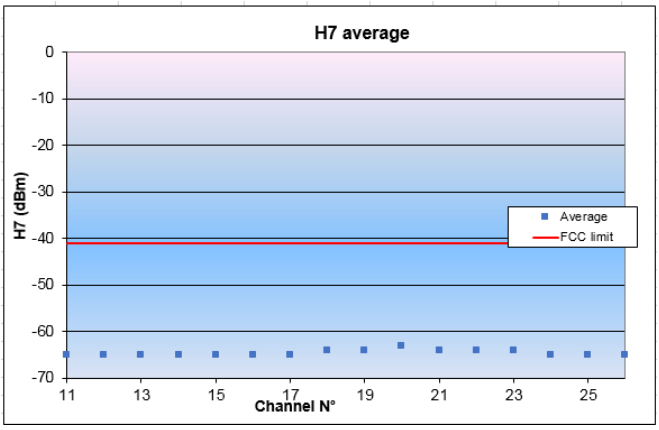

Figure 24. Conducted H7 spurious

The maximum power is: -63 **dBm.**

Conclusion:

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

3.2.5.17 H8 (FCC test conditions)

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

Result:

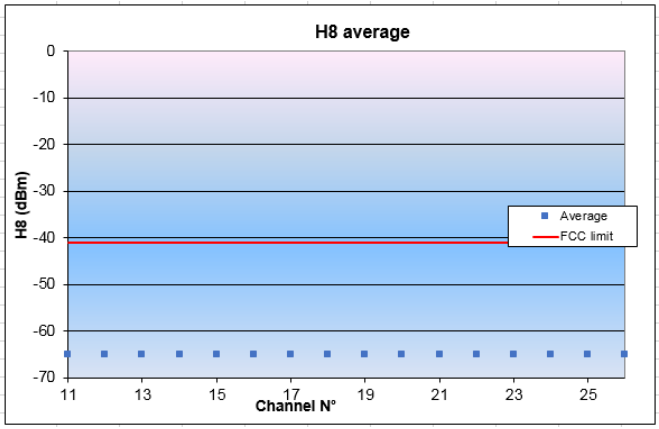

Figure 25. Conducted H8 spurious

The maximum power is: -65 **dBm.**

Conclusion:

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

3.2.5.18 H9 (FCC test conditions)

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

Result:

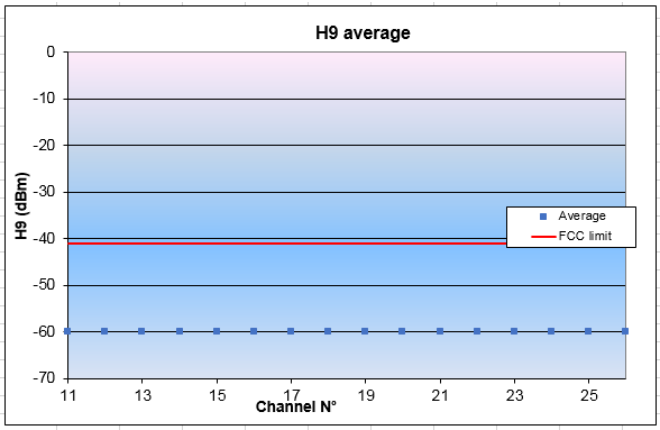

Figure 26. Conducted H9 spurious

The maximum power is on channel: -60 **dBm.**

Conclusion:

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

3.2.5.19 H10 (FCC test conditions)

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

Result:

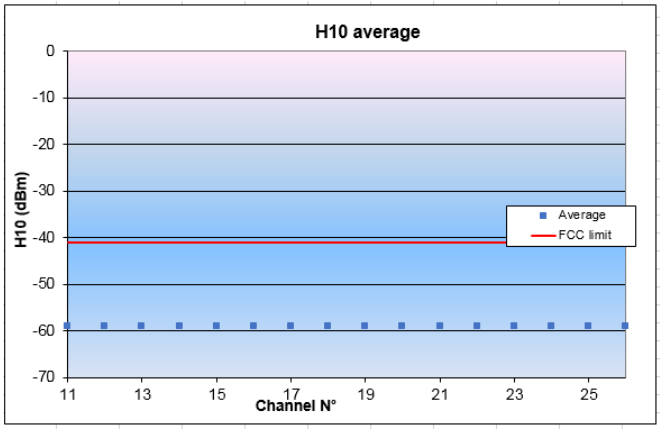

Figure 27. Conducted H10 spurious

The maximum power is: -59 **dBm.**

Conclusion:

- There is a **18** dB margin to the FCC limit.

3.2.6 TX modulation

3.2.6.1 EVM

Test method:

- Connect the RF port of the module to the R&S FSV30 spectrum analyzer. Use the specific menu of the SA to do the EVM measurement.
- Set the JN5189T to 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

The graphs below show the EVM value for both the proprietary mode 2 and the regular mode.

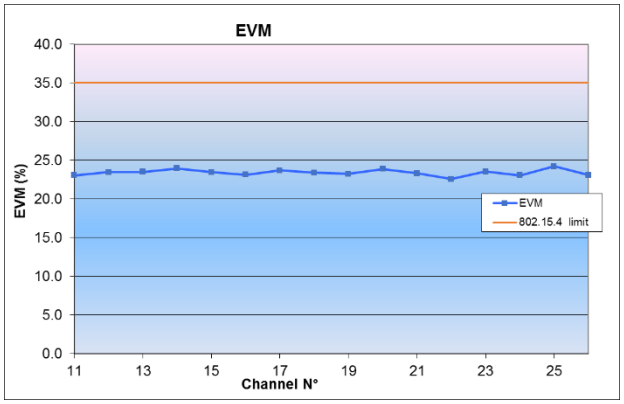

Figure 28. EVM in proprietary mode 2

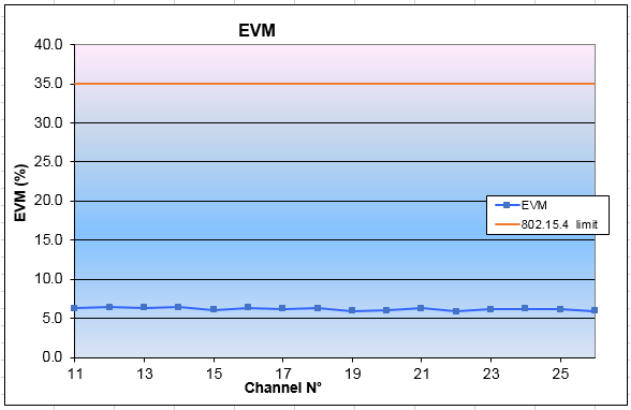

Figure 29. EVM in regular mode

Result:

Proprietary mode 2 maximum value on ch25 = **24.2 %.**

Regular mode maximum value on ch26 = **6.4 %.**

Conclusion:

- Very good margin to the 802.15.4 limit in the regular mode.
- Although the EVM is degraded in proprietary mode 2, there is still a good margin to the 802.15.4 limit.

3.2.6.2 Offset EVM

Test method:

- The same method as the EVM measurement.

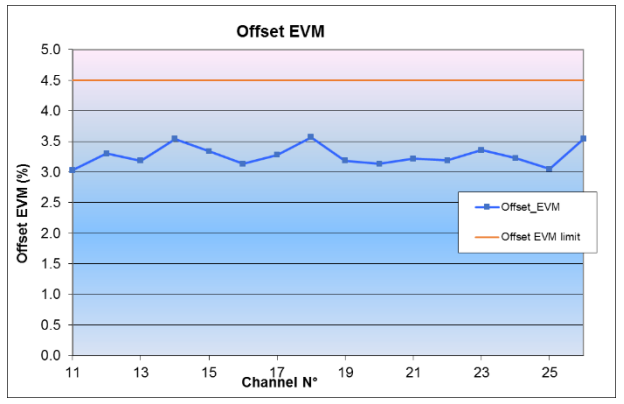

Figure 30. Offset EVM in proprietary mode 2

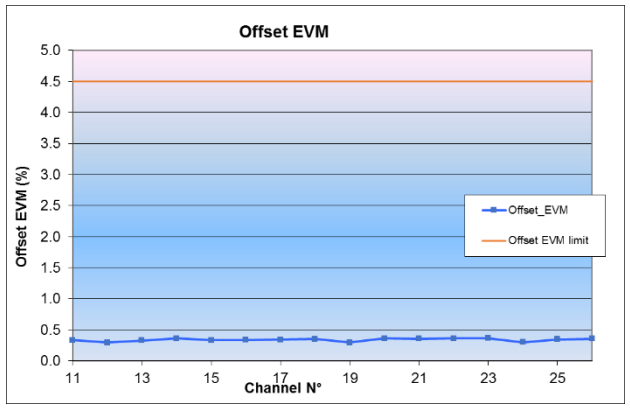

Figure 31. Offset EVM in regular mode

Result:

Proprietary mode 2 maximum value on ch18 = **3.57 %.**

Regular mode maximum value on ch23 = **0.37 %.**

Conclusion:

- Very good margin to the JN5189T specification in the regular mode.

Although the offset EVM is degraded in proprietary mode 2, there is still a good margin to the JN5189T specification.

3.2.7 Upper band edge

Test method:

- Set the radio to:
  - TX mode, modulated, continuous mode
- Set the analyzer to:
  - Start freq = 2.475 GHz, Stop freq=2.485 GHz, Ref amp=-20 dBm, sweep time=100 ms
  - RBW = 1 MHz, Video BW = 3 MHz
  - Detector = average
  - Average mode : power
  - Number of sweeps = 100
  - Set the channel 26 (2.48 GHz)

Result:

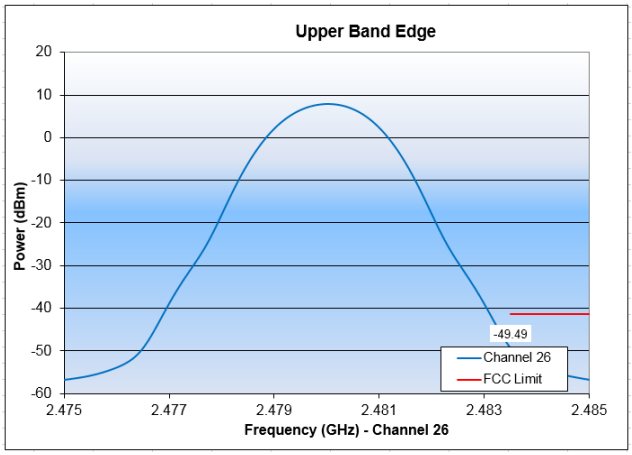

Figure 32. Upper band edge in proprietary mode 2

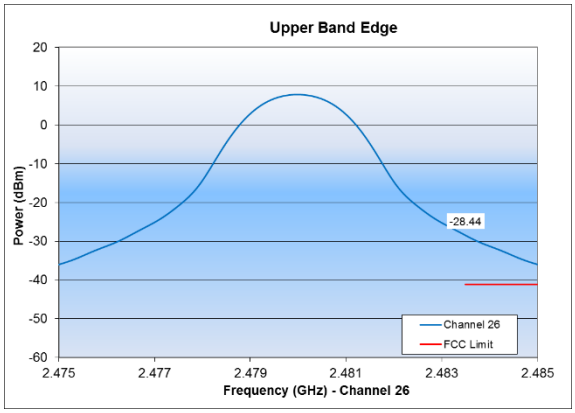

Figure 33. Upper band edge in regular mode

Conclusion:

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

3.3 RX tests

3.3.1 Test setup

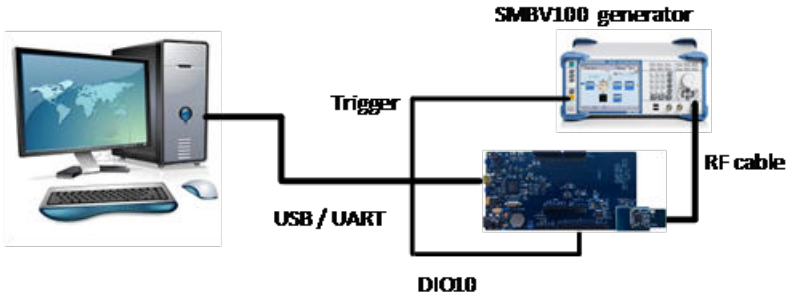

Figure 34. Conducted Rx test setup for sensitivity and receiver maximum input level

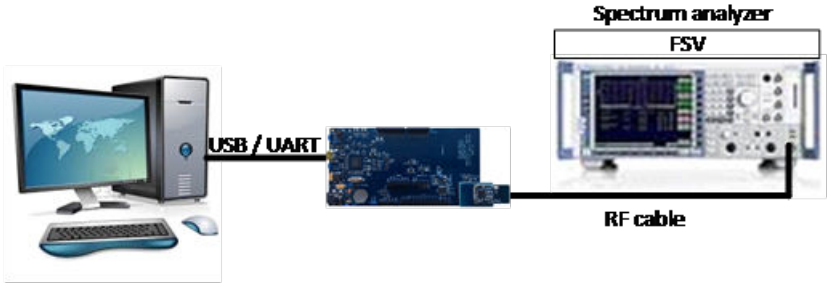

Figure 35. Conducted Rx test setup for spurious

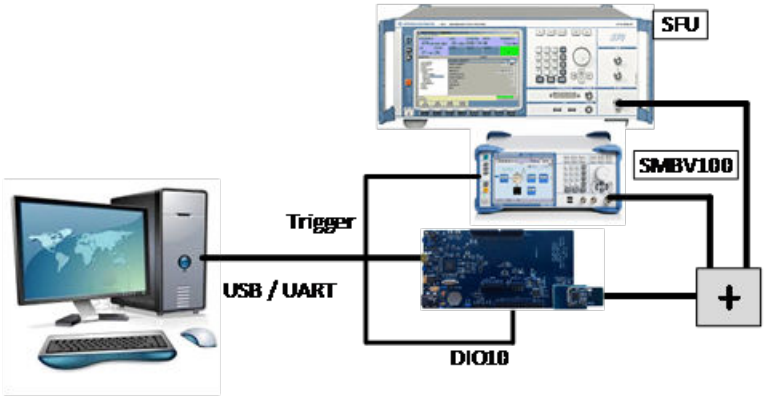

Figure 36. Conducted Rx test setup for interference rejection

3.3.2 Sensitivity

Test method:

The carrier board and the JN5189 module are placed in a RF shield box to avoid any interference.

Generator: R&S SMBV100

The generator is used in the ARB mode. It generates a pattern of 1000 packets of 20 octets. The DIO10 of the JN5189 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 to the “trigger packet test”.

- The connection is automatically established and the PER (Packet Error Rate) is measured.
- Decrease the level of the generator at the RF input of the module until PER = 1 %.

Result:

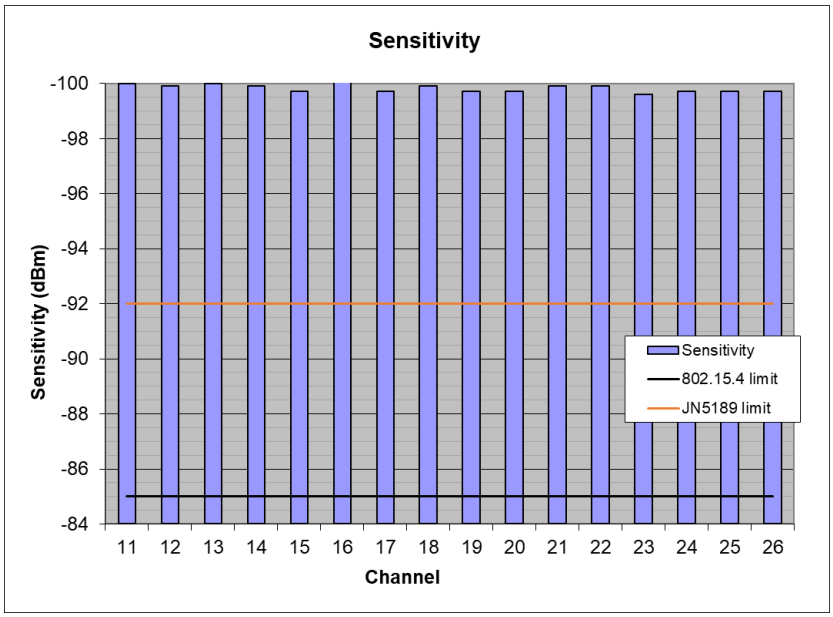

Figure 37. Sensitivity

Conclusion:

Minimum value: **- 100.2 dBm on channel 16.**

Max value: **-99.6 dBm on channels 23.**

JN5189 (without NTAG) and JN5189T (with NTAG) have the same sensitivity. The addition of the NTAG does not affect the sensitivity of the JN5189 chip.

3.3.3 Receiver maximum input level

Test method:

Generator: R&S SMBV100

The generator is used in the ARB mode. It generates a pattern of 1000 packets of 20 octets. The DIO10 of the JN5189 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 to the “trigger packet test”.
- The connection is automatically established and the PER (Packet Error Rate) is measured.
- Increase the level of the generator at the RF input of the module until PER = 1 %.
- Do the same for other channels.

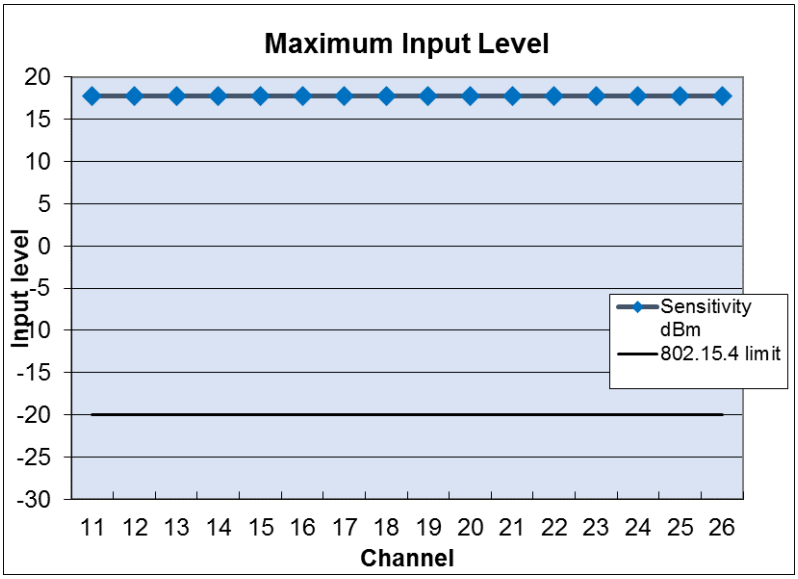

Figure 38. Maximum input power

Conclusion:

The actual maximum input level could not be measured in the test environment. The maximum level that can be delivered to the JN5189 is limited by the maximum output power of the generator and the cable losses.

The maximum input level of JN5189 is higher than **17.8 dBm** on all channels.

3.3.4 RX spurious

3.3.4.1 Wide band

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 / 1GHz

      RBW = 100 KHz,
    - Then Start/Stop frequency: 1 GHz / 12.75 GHz

      RBW = 1 MHz,

Results:

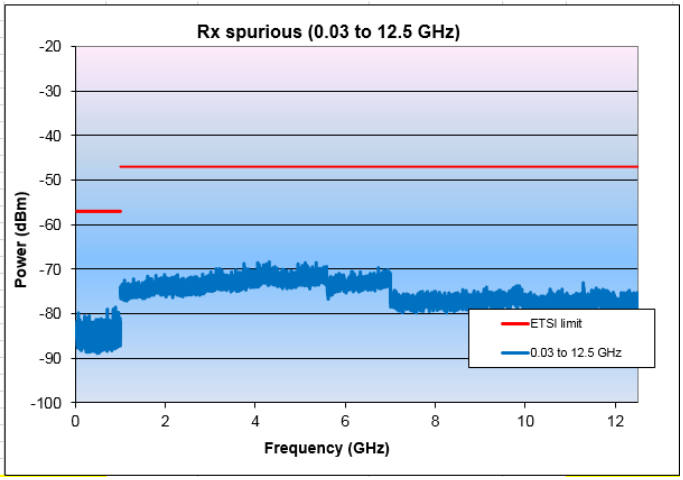

Figure 39. Conducted Rx spurious

Note: No spur was detected.

3.3.4.2 LO leakage

Test frequency: 2440 MHz (channel 18).

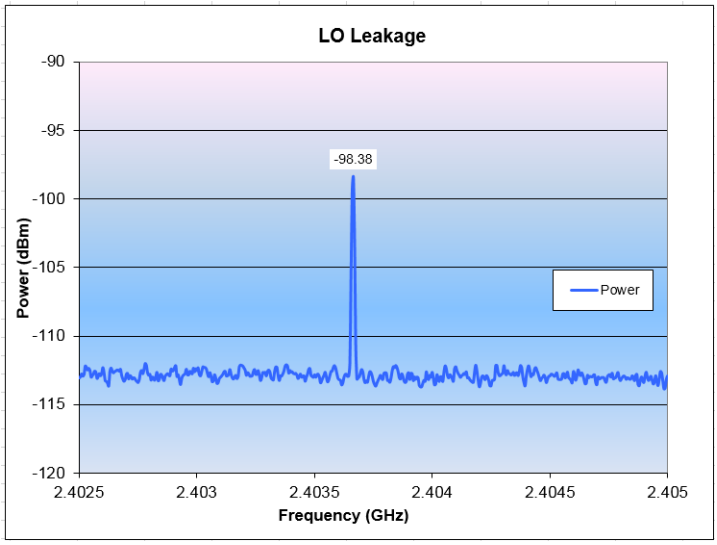

Figure 40. LO leakage

Results:

- **- 98.4** dBm

Conclusion:

- **51.4 dB** margin to the ETSI limit

3.3.5 Receiver interference rejection

3.3.5.1 Adjacent and alternate channels with standard interferers

The 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: R&S SMBV100A generator (modulated)

Generator for interferers: R&S SFU (modulated)

Criterion: PER < 1 %

The wanted signal is set to - 82 dBm. The interferer is increased until the PER threshold is 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			
	2405			
	n-2	n-1	n+1	n+2
	2395	2400	2410	2415
Interferer level (dBm)	-35.6	-46.5	-45.7	-35.4
Interferer level (dBc)	46.4	35.5	36.3	46.6
802.15.4 limit (dB)	30	0	0	30
Margin (dB)	16.4	35.5	36.3	16.6

ch18			
2440			
n-2	n-1	n+1	n+2
2430	2435	2445	2450
-35.6	-46.5	-45.7	-35.2
46.4	35.5	36.3	46.8
30	0	0	30
16.4	35.5	36.3	16.8

ch26			
2480			
n-2	n-1	n+1	n+2
2470	2475	2485	2490
-35.6	-46.5	-45.5	-35.2
46.4	35.5	36.5	46.8
30	0	0	30
16.4	35.5	36.5	16.8

Figure 41. Adjacent and alternate rejection

Conclusion: Good margin, in line with the expected results.

3.3.5.2 N-3 and n+3 channels with standard interferers

Test method:

The same as adjacent and alternate channels but the interferer is set to +/- 15 MHz offset from the desired channel.

Results:

	ch11	
	2405	
	n-3	n+3
	2390	2420
Interferer level (dBm)	-30.3	-30.3
Interferer level (dBc)	**51.7**	**51.7**
Datasheet typical value (dB)	48	48
Margin (dB)	3.7	3.7

ch18	
2440	
n-3	n+3
2425	2455
-30.3	-30.3
51.7	**51.7**
48	48
3.7	3.7

ch26	
2480	
n-3	n+3
2465	2495
-30.3	-30.3
51.7	**51.7**
48	48
3.7	3.7

Figure 42. N-/+3 band rejection

Conclusion:

In line with the expected values

3.3.5.3 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 43. co-channel

Conclusion:

In line with the expected values

3.3.5.4 Adjacent and alternate channels with filtered interferers (as generated by a JN5189T 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: R&S SMBV100A generator (modulated)

Generator for the interferers: R&S SFU (modulated and filtered frame)

Criterion: PER < 1 %

The wanted signal is set to - 82 dBm. The interferer is increased until the PER threshold is reached.

Channels under the test: 11, 18, and 26 (although n-1 and n-2 are not system-relevant for channel 11 and n+ and 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
802.15.4 limit (dB)	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 44. Adjacent and alternate rejection

Conclusion:

When making a network with a JN5189T that transmits in proprietary mode 2, you can improve the immunity to adjacent interferers by **23 dB** and the immunity to alternate interferers by more than **15** dB.

3.3.5.5 n-3 and n+3 channels with filtered interferers (as generated by a JN5189T in proprietary mode 2)

Test method:

The same as the adjacent and alternate channels but the interferer is set to a +/- 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 45. N-/+3 band rejection

Conclusion:

When making a network with a JN5189T that transmits in proprietary mode 2, you can improve the immunity to N-3 or N+3 interferers by more than **16** dB.

3.3.5.6 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 46. Co-channel

Conclusion:

There is no significant difference in the co-channel when using a standard interferer or a filtered interferer (as expected).

3.3.6 Receiver blocking

The JN5189T is an equipment of category 1, as defined by the ETSI 300 328 (TX signal higher than 10 dBm).

Tests and limits are used according to category 1.

The interferer is a CW signal.

3.3.6.1 Test 1

	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**
Interfere level (dBc)	71.3	73.4	73.4	70.9
802.15.4 limit (dBm)	-53	-53	-53	-53
Margin (dB)	30.3	32.4	32.4	29.9

Figure 47. Receiver blocking test 1

Conclusion: very good margin

3.3.6.2 Test 2

	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
Interfere level (dBc)	74.7	73.9	72.4	74.4	74.1	73.5
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 48. Receiver blocking test 2

Conclusion: very good margin

3.3.6.3 Test 3

	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
Interfere level (dBc)	73.9	73.6	73.9	73.9	74.2	74.1
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
Interfere level (dBc)	72.5	73.0	73.4	73.8	74.2	74.1
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 49. Receiver blocking test 3

Conclusion: very good margin

3.3.7 PER versus RX input power

The PER value is picked up when the input power is decreased.

Test method:

Generator for the desired signal: R&S SMBV100A generator

Results:

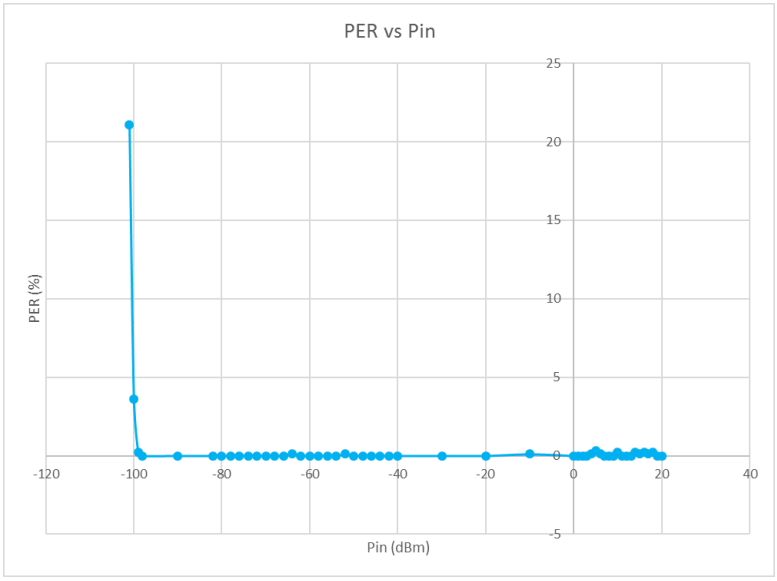

Figure 50. PER versus RX input power

3.4 Return loss

3.4.1 RX return loss

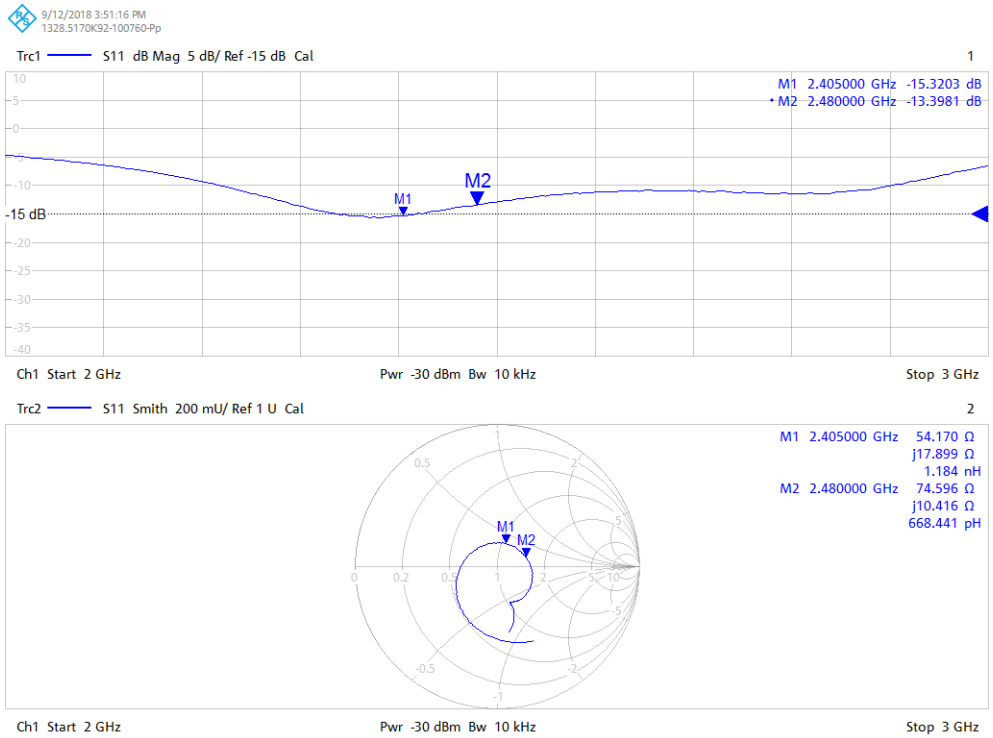

Figure 51. S11 Rx

S11 < -12 dB @ 2.405 – 2.480 GHz

3.5 TX return loss

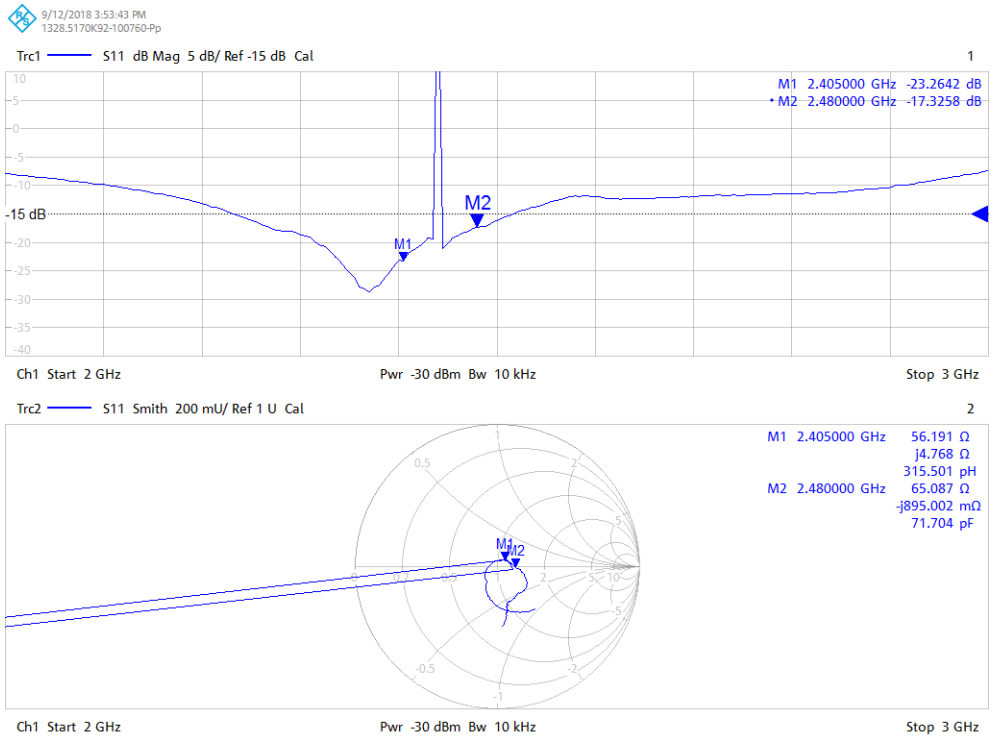

Figure 52. S11 Tx

S11 < -17 dB @ 2.405 – 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 with the same matching network.

4 Conclusion

Beyond the RED, 802.15.4, and FCC compliances, these radio tests prove a good RF performance of the JN5189T.

5 References

FCC: 47 CFR Part 15C

RED: European Radio Equipment Directive applied from June 2016

R&TTE: Radio & Telecommunications Terminal Equipment Directive (R&TTED) (1999/5/EC) was stopped on 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 and 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)

6 Appendix A

The benefit of using a proprietary mode in a ZigBee network:

Consider a JN5189T configured in the Rx mode ZigBee while another JN5189T is configured in the Tx mode ZigBee and generates the wanted channel.

Consider that a third JN5189T is configured in the transmit mode and generates an interferer ZigBee in a nearby channel.

In this case, if the interferer signal is generated without any filtering, then the interferer immunity of the JN5189T receiver is severely limited by the side lobes of the ZigBee modulation.

Because the JN5189T radio has a much better performance in terms of interferers immunity compared to the side lobes limitation of the ZigBee modulation, then using the proprietary mode for the transmitter that generates the interferer improves the interferer immunity of the JN5189T which is configured in the Rx mode.

In other words, the level of the interferer can be higher in relation to the wanted channel when the JN5189T interferer uses the proprietary mode compared to the regular mode.

7 Appendix B

The following are the CMET settings for the tests presented in this application note:

For tests in the transmit modes:

Table 3. Transmit modes

Chapter	CMET selection
Frequency Accuracy	a)a)a)
Phase Noise @ 100 kHz offset	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)

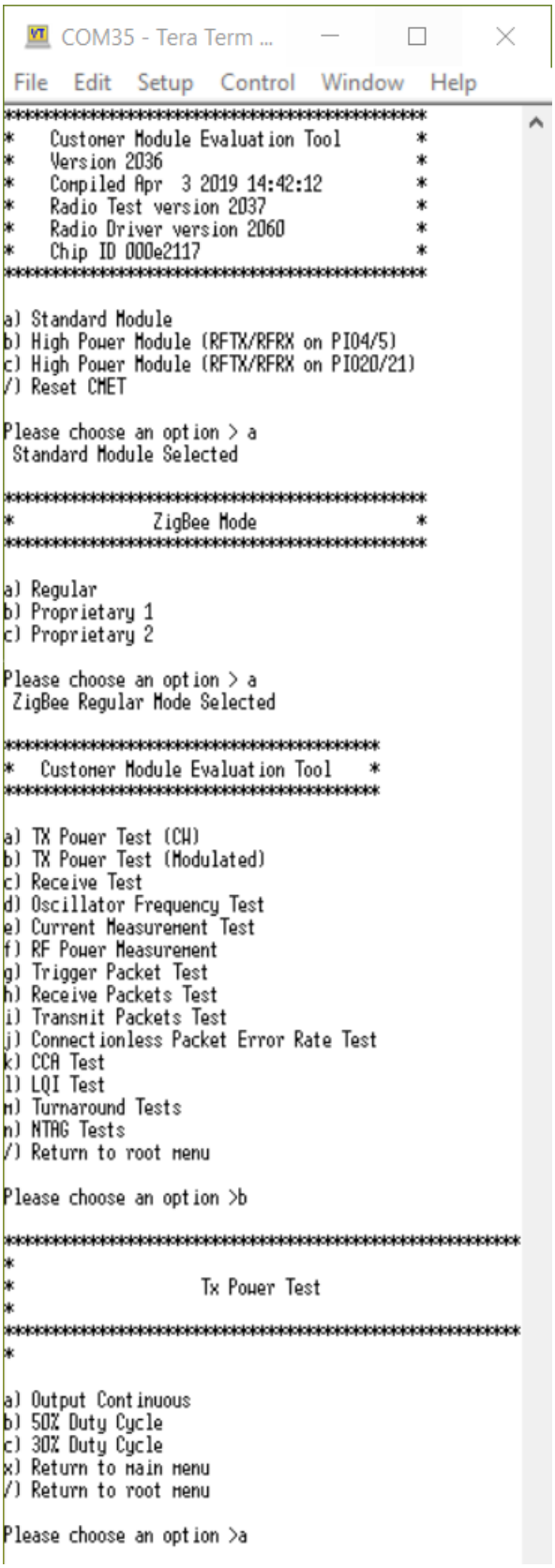

Figure 53. Transmit modes

For tests in the receive modes:

Table 4. Receive modes

Chapter §	CMET selection
Receiver Maximum Input Level	a)a)c)
RX spurious Wide Band Adjacent and alternate channels with standard interferers N-3 & n+3 channels with standard interferers Co-channel Adjacent and alternate channels with filtered interferers (as generated by a JN5189T in proprietary mode 2) n-3 & n+3 channels with filtered interferers (as generated by a JN5189T in proprietary mode 2) Co-channel with a filtered interferer Receiver Blocking	a)a)c)
RX return loss	a)a)h)

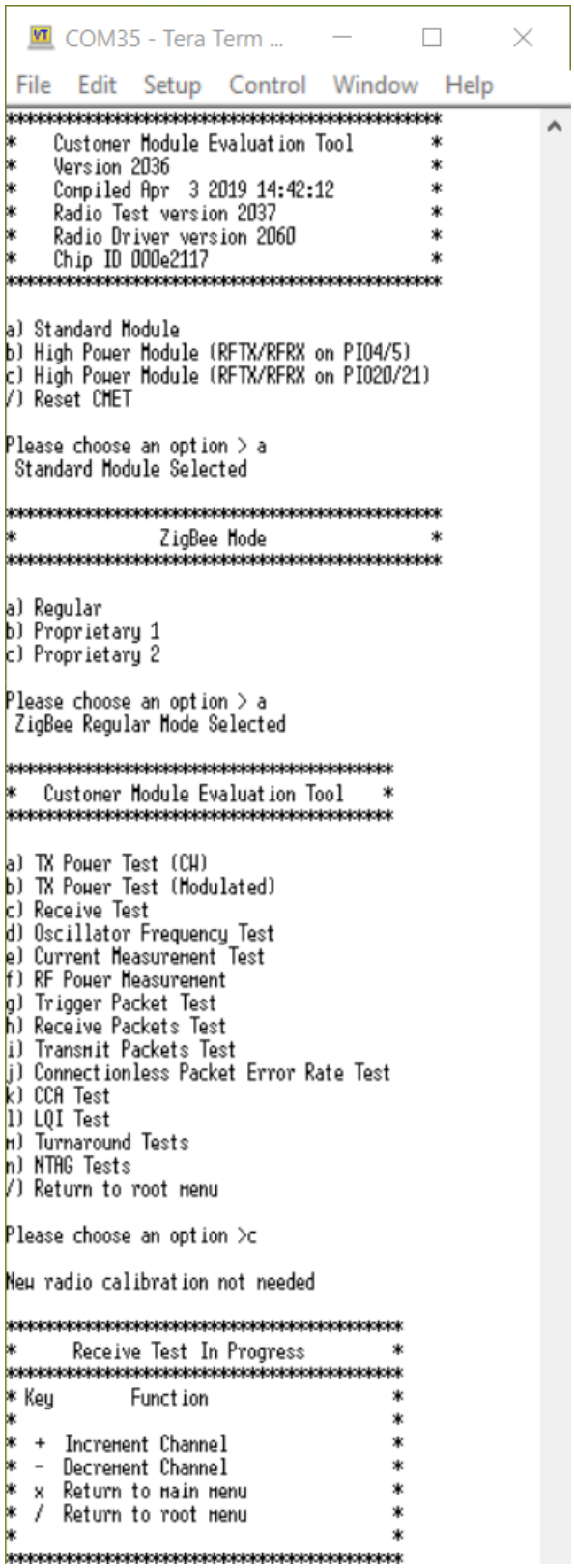

Figure 54. Receive modes

For the PER test:

Table 5. PER test

Chapter ¤§	CMET selection
Sensitivity	a)a)g)'A' 'g' +/-
Packet Error Rate versus RX Input power	a)a)g)'A' 'g'

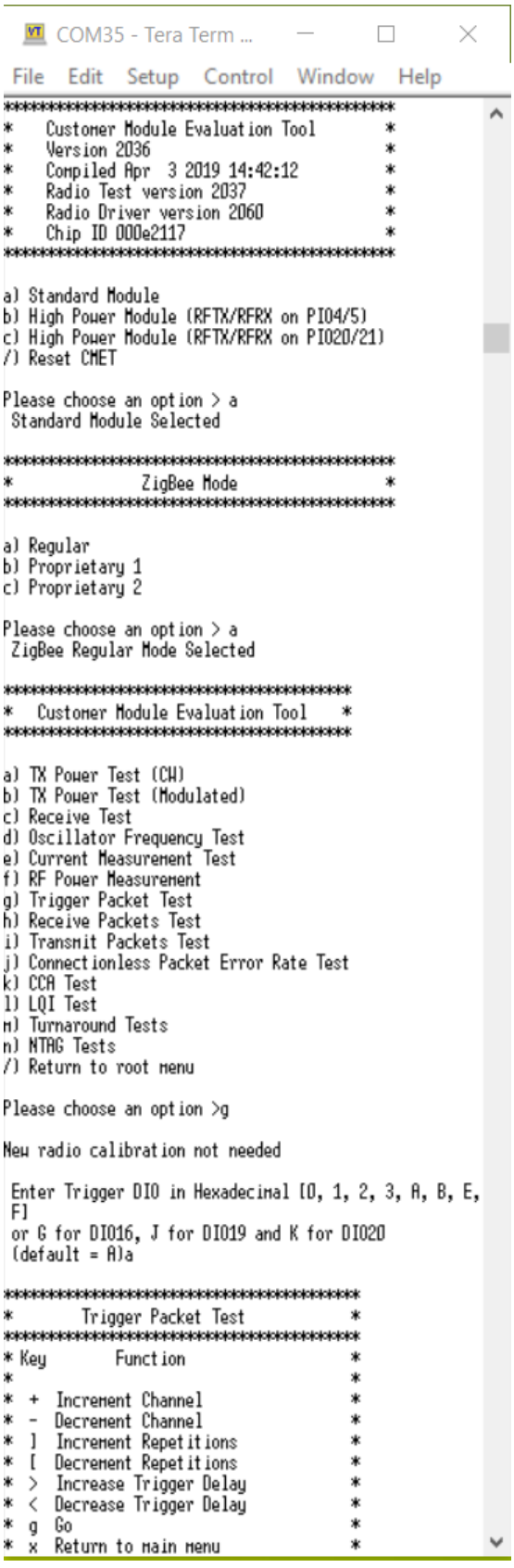

Figure 55. PER test

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