AN_11659

JN5169/001 RF System Tests Report

Rev. 2.0 — 2015 March 15 Application note

Document information

Info	Content
Keywords	Zigbee, JN5169, SMA, system
Abstract	JN5169 RF tests

Revision history

Rev	Date	Description
1.0	2014/03/12	Creation
2.0	2015/03/15	JN5169 ES2 official samples update

Contact information

For more information, please visit: http://www.nxp.com

1. Introduction

This paper provides the RF evaluation test results of the DR1185_JN5169 SMA module.

The version of the module is DR1185_1V1_version C

On this module the RF port of the JN5169 is connected to a SMA connector.

The module is plugged to a mother board called “Carrier Board” (DR1174_1V4)

All the measurements have been done in conducted mode.

Module under test: n° 50

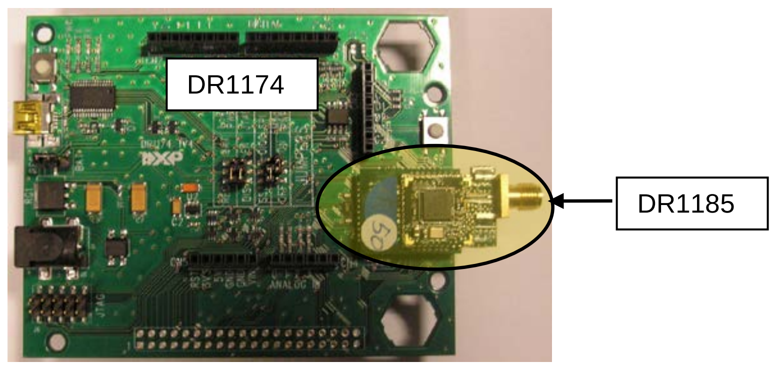

Fig 1. DR1185 module and DR1174 carrier board (mother board)

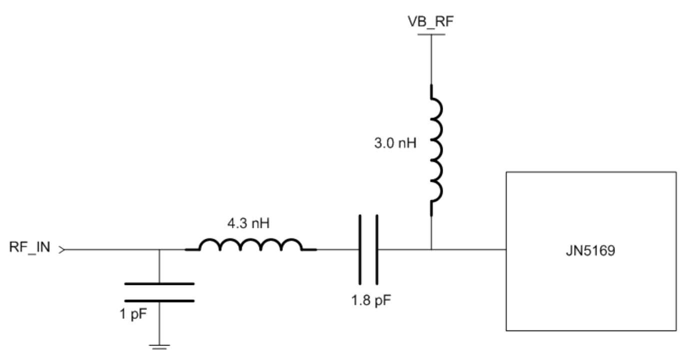

Fig 2. DR1185 front-end matching network

All the tests have been done with the test boards being supplied by the USB port.

1.1 List of Tests

Test standards	Results
ETSI EN 300 328 V1.8.1	PASS
IEEE 802.15.4 2011	PASS

A- Conducted tests
- a. Tx tests
  - i. Frequency accuracy
  - ii. Phase noise
  - iii. Tx power
  - iv. TX harmonics
  - v. 32MHz spurious
  - vi. Other TX spurious
  - vii. EVM & Offset EVM
- b. Rx tests
  - i. Sensitivity
  - ii. Rx spurious
  - iii. LO leakage
  - iv. Interference rejection
  - v. 3G immunity
  - vi. LTE immunity

B- Return loss
- a. Tx
- b. Rx

1.2 SW

Prior to the measurements a binary code must be loaded into the Flash memory of the board.

The user Guide JN-UG-3099 describes how to use the Flash Programmer application for loading the code.

The binary code that has been used for the following tests is the CMET (Customer Module Evaluation Tool) version 4.00 compiled on 2015 March 5th.

```
*********************************************
*    Customer Module Evaluation Tool        *
*    Version  4.00                          *
*    Compiled Mar  5 2015 18:12:40          *
*    Production Test API Version 0x00010040 *
*    Chip ID 0x6000b686                     *
*********************************************

*********************************************
*    Customer Module Evaluation Tool        *
*    Radio Params 0x00010000                *
*    Wifi Mode 0xff                         *
*********************************************
```

The TERATERM terminal emulator is used to communicate with the chip.

2. Tests Summary

Transmission		EUROPE			
		reference	*Section*	*limit*	Status
	TX Maximum Power	ETSI EN 300 328	4.3.2.1	20 dBm	PASS
	TX Spurious 30 MHz - 1GHz	ETSI EN 300 328	4.3.2.8.2	-36 or -54 dBm (depends on frequency) (100 kHz BW)	PASS
	TX Spurious 1GHz - 12.5 GHz	ETSI EN 300 328	4.3.2.8.2	-30 dBm (1MHz BW)	PASS
	EVM	802.15.4	10.3.8	35%	PASS
	TX Frequency Tolerance	802.15.4	10.3.9	+/- 40 ppm	PASS
	min of max power	802.15.4	10.3.10	-3 dBm	PASS
	Phase noise (unspread)	No reference			For information

		EUROPE			
		reference	*Section*	*limit*	Status
Reception	RX spurious 30 MHz - 1GHz	ETSI EN 300 328	4.3.2.9.2	-57 dBm (100 KHz)	PASS
	RX spurious 1GHz - 12.5 GHz	ETSI EN 300 328	4.3.2.9.2	-47 dBm (1 MHz)	PASS
	RX Sensitivity	802.15.4	10.3.4	-85 dBm	PASS
	Interference rejection N+/-1 (adjacent)	802.15.4	10.3.5	0 dB	PASS
	Interference rejection N+/-2 (alternate)	802.15.4	10.3.5	30 dB	PASS
	RX Max input	802.15.4_2011	10.3.11	-20 dBm	Not tested
Miscellaneous	Return loss (S11)	Return loss in Tx mode			For information
		Return loss in Rx mode			For information

3. Conducted Tests

3.1 TX tests

The TX power of the JN5169 can be adjusted by 3 ways:

- Coarse adjustments are achieved with the PAPx modes (6 modes from PAP0 to PAP5)
- 3 fine tuning steps allow to increase the TX Default power by 0.8 dB, 1.2 dB or 1.6 dB by adding 0.4, 0.8 or 1.2 mA extra biasing current in the TX block of the chip.
- A switchable attenuator allows to attenuate the power by 2.5 dB

All these TX power modes can be combined in order to give a high flexibility on the TX power.

In this document we will make reference only to four TX power configurations:

- ➢ "TX default power" : PAP5 + default biasing current + attenuator OFF
- ➢ "TX default power + 0.8 dB" : PAP5 + 0.4 mA extra biasing current + attenuator OFF
- ➢ "TX default power + 1.2 dB" : PAP5 + 0.8 mA extra biasing current + attenuator OFF
- ➢ "TX default power + 1.6 dB" : PAP5 + 1.2 mA extra biasing current + attenuator OFF

3.1.1 TX Test Set-Up

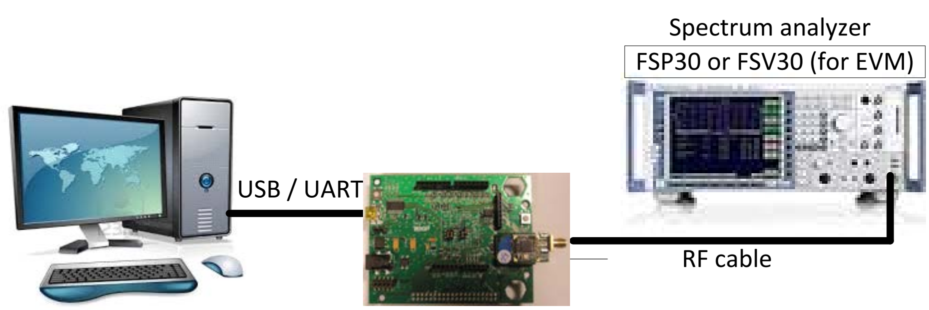

Fig 3. Conducted Tx test set up

3.1.2 Frequency Accuracy

Test method:

- Set the radio in :
  - o TX mode, CW, continuous mode, frequency : channel 18
- Set analyzer to :
  - o 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:

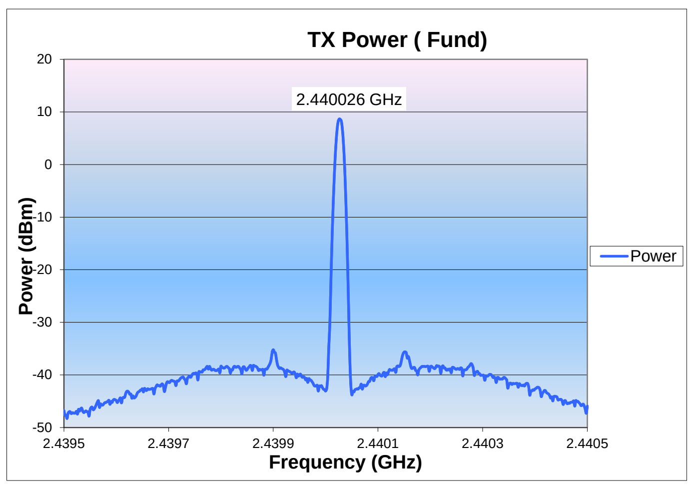

Fig 4. Frequency accuracy

- Measured frequency : 2.440026 GHz
- ppm value = (2440026 - 2440000) / 2.440 = **+ 10.7** ppm

Result	Target	802.15.4 limit
+ 10.7 ppm	+/- 25 ppm	+/- 40 ppm

Note: the frequency accuracy depends on the XTAL model. The model used on the DR1185 is **AELX32M000000S039A**.

3.1.3 Phase Noise

Test method:

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

3.1.3.1 "TX Default Power" mode

Result:

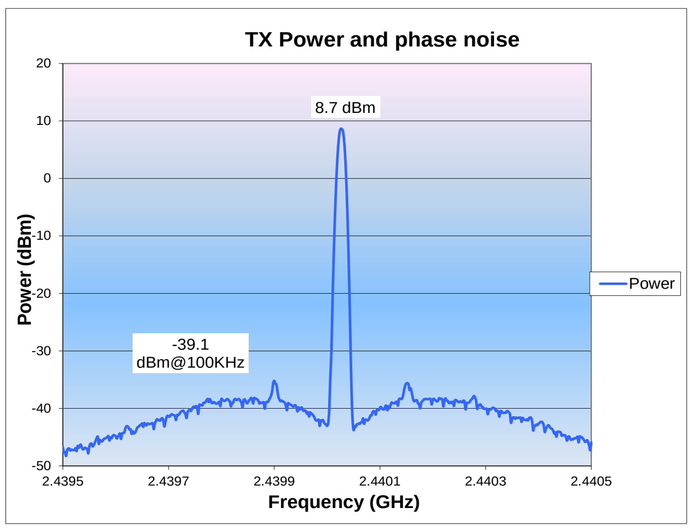

Fig 5. Conducted Phase noise with "TX default power" mode

- Marker value = -39.1dBm/10kHz ➔
  - o Marker delta = 8.7 - (- 39.1) = 47.8 dB
  - o Phase noise = -47.8 -10 Log (10kHz) = -87.8 dBc/Hz

Note:

- Phase noise is only for information.
- There is no issue on this parameter.

3.1.3.2 "TX Default power + 1.6 dB" mode

Result:

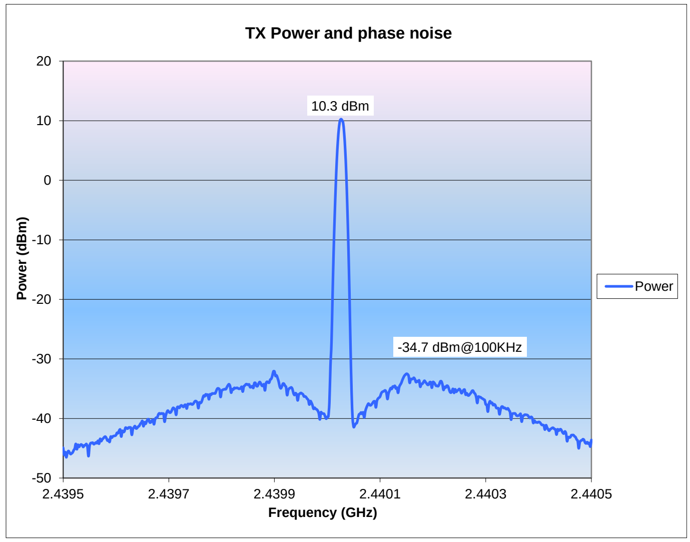

Fig 6. Conducted Phase noise with "TX default power + 1.6 dB" mode

- Marker value = -34.7 dBm/10kHz ➔
  - Marker delta = 10.3 - (- 34.7) = 45 dB
  - Phase noise = - 45 -10 Log (10kHz) = -85 dBc/Hz

Note:

- Phase noise is only for information.
- There is no issue on this parameter.

3.1.4 TX Power (fundamental)

Test method:

- Set the radio in :
  - o TX mode, modulated, continuous mode
- Set analyzer to :
  - o Start freq = 2.4 GHz , Stop freq = 2.5 GHz , Ref amp = 20 dBm , sweep time = 100 ms , RBW = 3 MHz
  - o Max Hold mode
- Sweep all the channels from ch11 to ch26

3.1.4.1 “TX default Power” mode

Result:

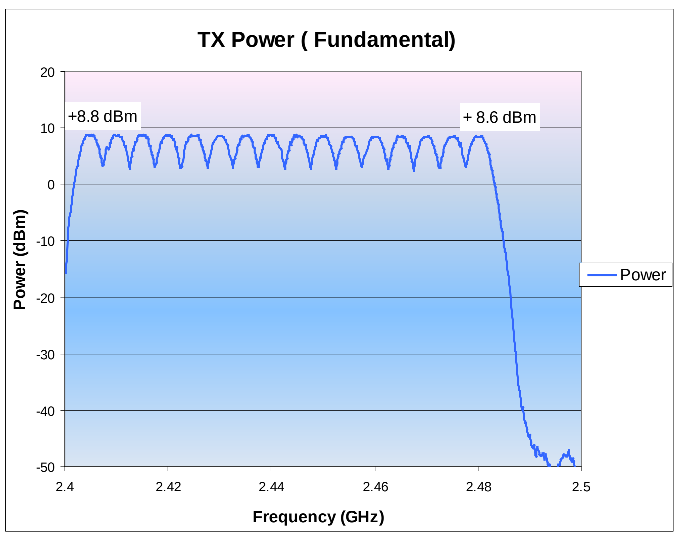

Fig 7. TX max power with “TX default power” mode

Maximum power is on channel 11: **+ 8.8 dBm**

Minimum power is on channel 26**:+ 8.6 dBm**

Tilt over frequencies is**: 0.2 dB**

3.1.4.2 “TX Default power + 0.8 dB” mode

Result:

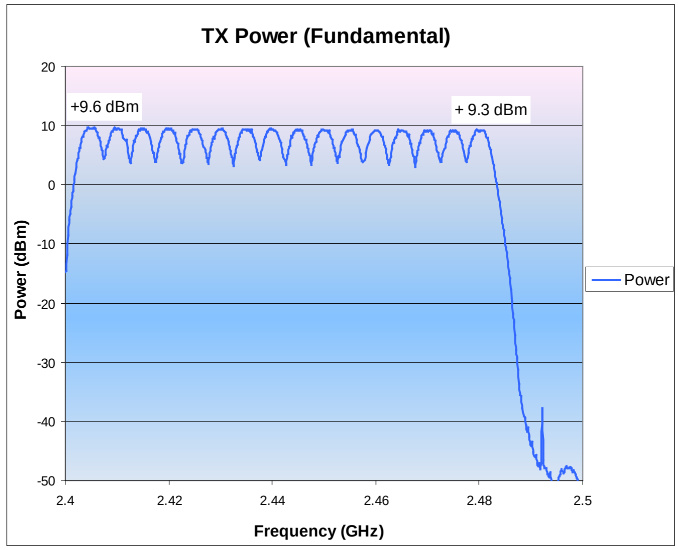

Fig 8. TX max power with “TX default power + 0.8 dB” mode

Maximum power is on channel 11: **+ 9.6 dBm**

Minimum power is on channel 26**:+ 9.3 dBm**

Tilt over frequencies is**: 0.3 dB**

3.1.4.3 “TX Default power +1.2 dB” mode

Result:

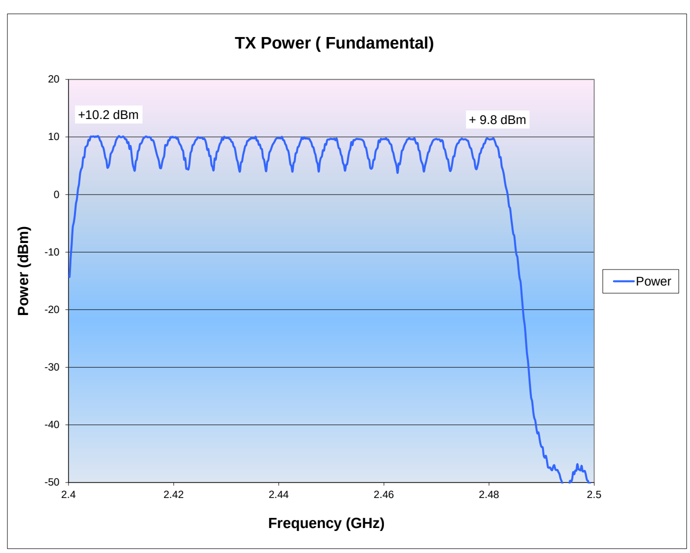

Fig 9. TX max power with “TX default power + 1.2 dB” mode

Maximum power is on channel 11: **+ 10.2 dBm**

Minimum power is on channel 26**:+ 9.8 dBm**

Tilt over frequencies is**: 0.4 dB**

3.1.4.4 “TX Default power + 1.6 dB” mode

Result:

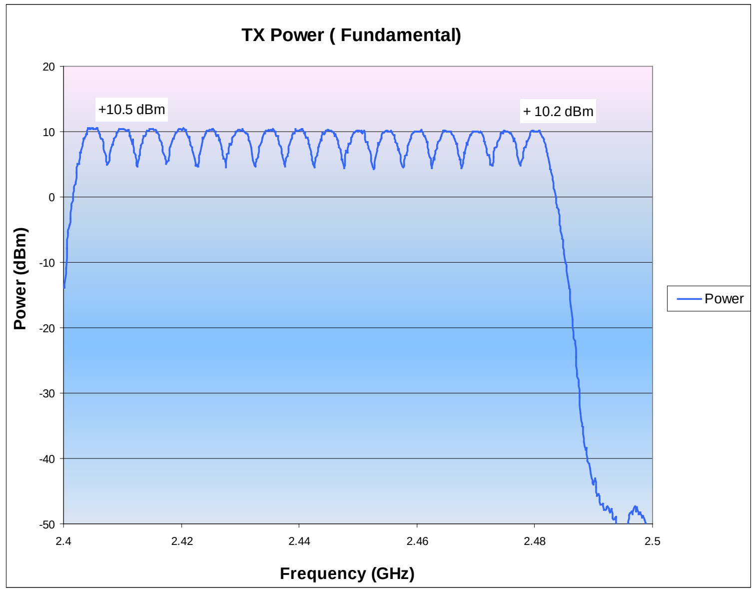

Fig 10. TX max power with “TX default power + 1.6 dB” mode

Maximum power is on channel 11: **10.5 dBm**

Minimum power is on channel 26: **10.2 dBm**

Tilt over frequencies is**: 0.3 dB**

3.1.5 TX spurious

3.1.5.1 Global view from 0.3GHz to 12.5 GHz

Frequency : channel 18

a. With “TX Default Power” mode

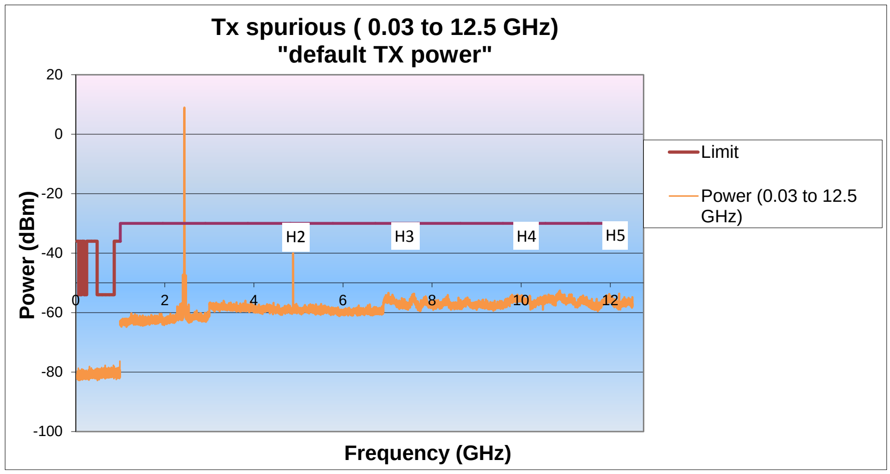

Fig 11. Conducted Tx spurious with “TX default power” mode

b. With “TX Default power + 1.6 dB” mode

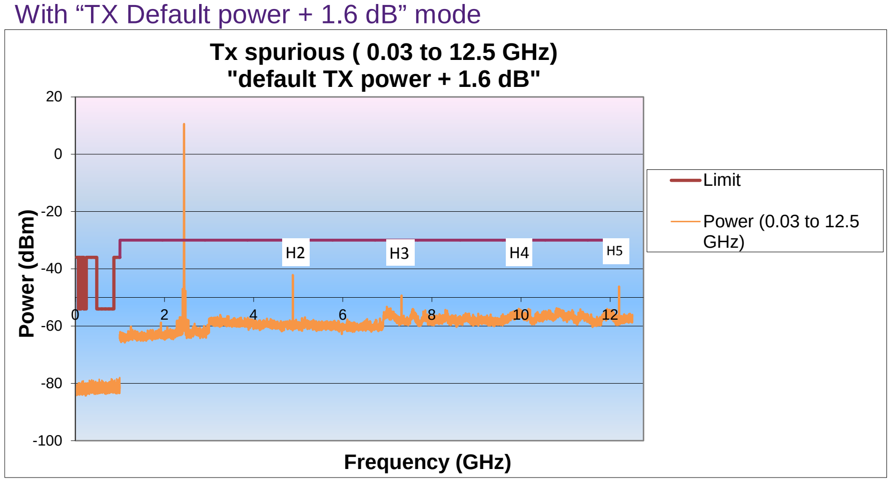

Fig 12. Conducted Tx spurious with “TX default power + 1.6 dB” mode

Conclusion:

- There are no TX spurs above the EN 300 328 limit
- The harmonics of the wanted signal can be detected with good margin to the limit. See detailed measurements in the following paragraphs.
- The spurs at +/- 32 MHz offset cannot be seen on this graph. They are below the limit with good margin. See detailed measurements in the following paragraphs.

3.1.5.2 H2

Test method:

- Set the radio in:
  - o TX mode, modulated, continuous mode
- Set analyzer to:
  - o Start frequency = 4.8 GHz , Stop frequency = 5 GHz , Ref amp = -20 dBm , sweep time = 100 ms , RBW = 1 MHz
  - o Max Hold mode
- Sweep all the channels from ch11 to ch26

a) With “TX Default Power” mode

Result:

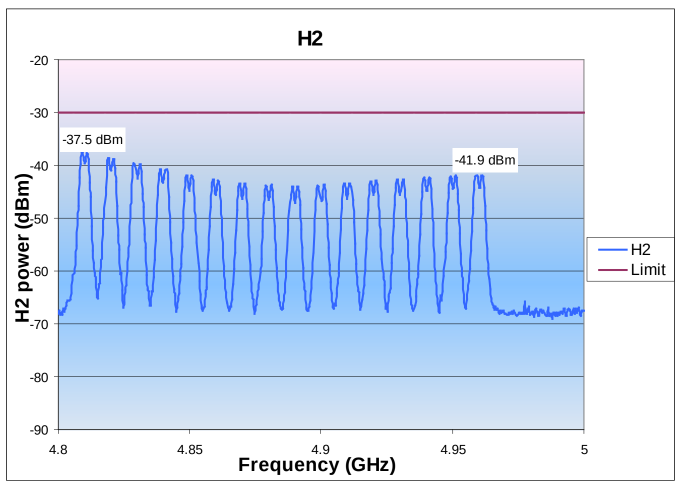

Fig 13. Conducted H2 spurious with “TX default power” mode

Maximum power is on channel 11: -37.5 dBm

Power at channel 26: -41.9 dBm

Conclusion: Good margin (7.5 dB)

b) With “TX Default Power + 1.6 dB” mode

Result:

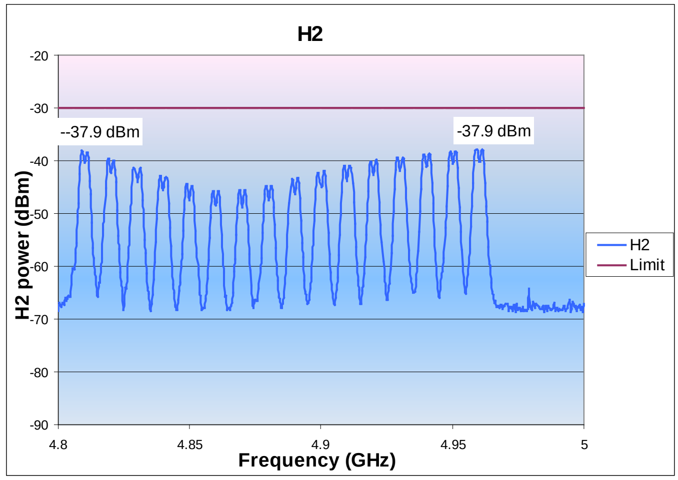

Fig 14. Conducted H2 spurious with “TX default power + 1.6 dB” mode

Maximum power is on channels 11 & 26: -37.9 dBm

Conclusion: Good margin (7.9 dB)

3.1.5.3 H3

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

a) With "TX Default Power" mode

Result:

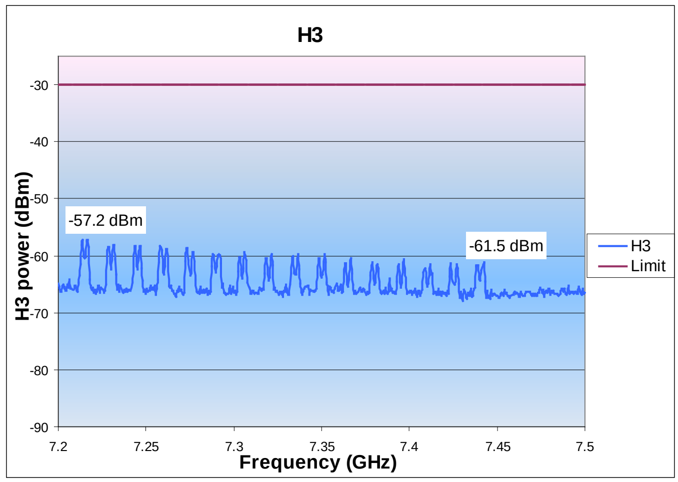

Fig 15. Conducted H3 spurious with "TX default power" mode

Maximum power is on channel 11: - 57.2 dBm

Power on channel 26: - 61.5 dBm

Conclusion: Good margin (27.2 dB)

b) With TX Default Power + 1.6 dB

Result:

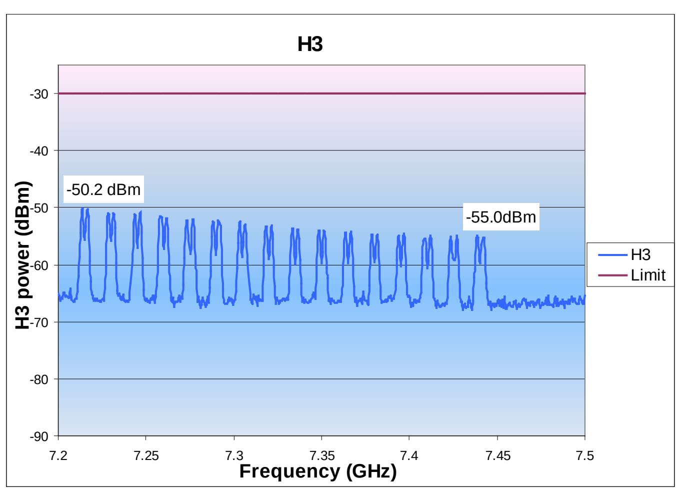

Fig 16. Conducted H3 spurious with "TX default power + 1.6 dB" mode

Maximum power is on channel 11: - 50.2 dBm

Power on channel 26: - 55.0 dBm

Conclusion: Good margin (20.2dB)

3.1.5.4 H4

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

a) With “TX Default Power” mode

Result

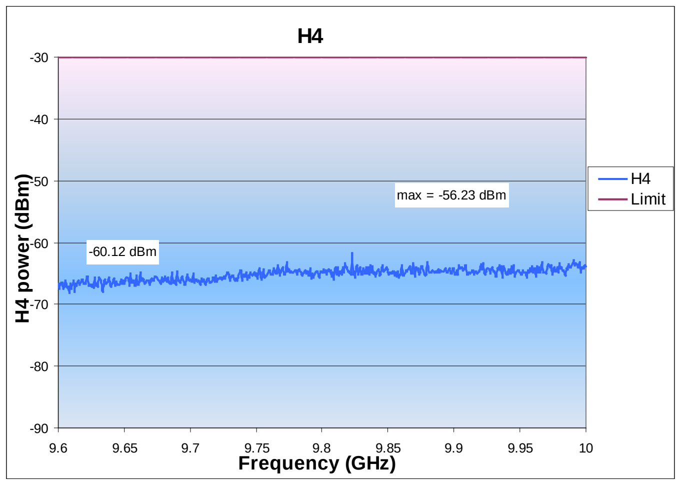

Fig 17. Conducted H4 spurious with “TX default power” mode

Conclusion: H4 harmonics cannot be detected.

b) With “TX Default Power + 1.6 dB” mode

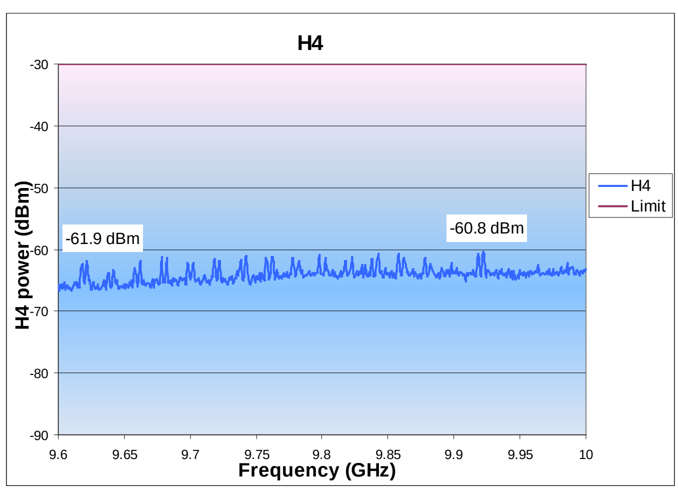

Fig 18. Conducted H4 spurious with “TX default power + 1.6 dB” mode

Power on channel 11: - 61.9 dBm

Maximum power is on channel 26: - 60.8 dBm

Conclusion: Good margin (30.8dB)

3.1.5.5 H5

Same method as H2 except the spectrum analyzer frequency span is set from 12 GHz to 12.5 GHz

Result:

The fifth harmonics are below the noise floor of the spectrum analyzer.

3.1.6 32 MHz spurious

Test method:

- Set the radio in TX, modulated, continuous mode
    - o TX mode, CW, continuous mode, frequency : channel 18
- Set analyzer to :
    - o Center frequency = 2.44 GHz , span = 100 MHz, Ref amp = 20 dBm
- Measure the spurs level at +/- 32 MHz frequency offset from the carrier frequency with the marker.

3.1.6.1 With “TX default power” mode

Result:

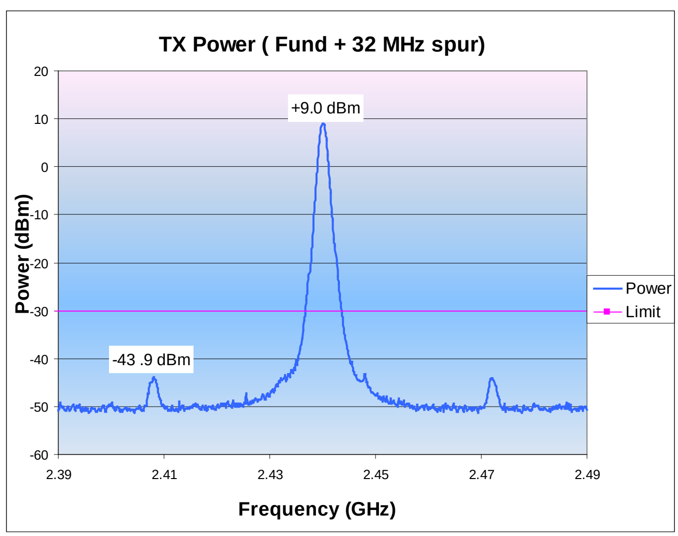

Fig 19. Conducted 32MHz spurious with “TX default power” mode

Fundamental peak level: 9.0 dBm

Left quartz (32MHz) spur peak level: -43.9 dBm

Right quartz (32MHz) spur peak level: -44.1 dBm

Conclusion: Good margin: **13.9 dB**

3.1.6.2 With “TX default power + 1.6 dB” mode

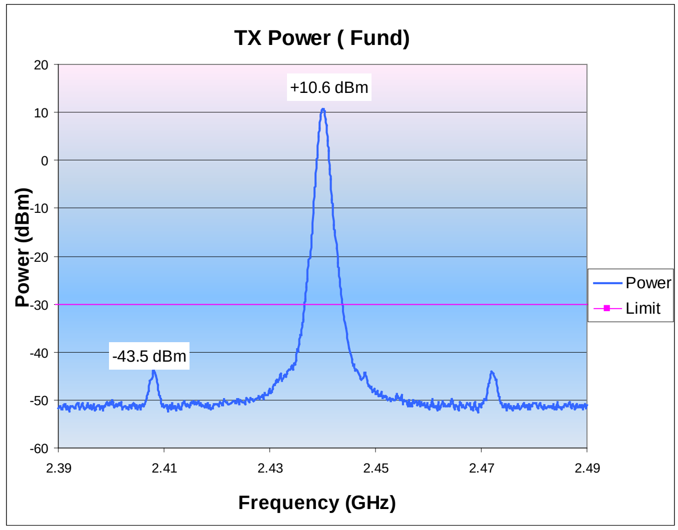

Fig 20. Conducted 32MHz spurious with “TX default power + 1.6 dB” mode

Fundamental peak level: 10.6 dBm

Left quartz (32MHz) spur peak level: -43.5 dBm

Right quartz (32MHz) spur peak level: -44.0 dBm

<u>Conclusion</u>: Good margin: 13.5 dB

3.1.7 TX Modulation quality

3.1.7.1 Overview

<u>Test conditions:</u>

- Channel 18
- TX default power

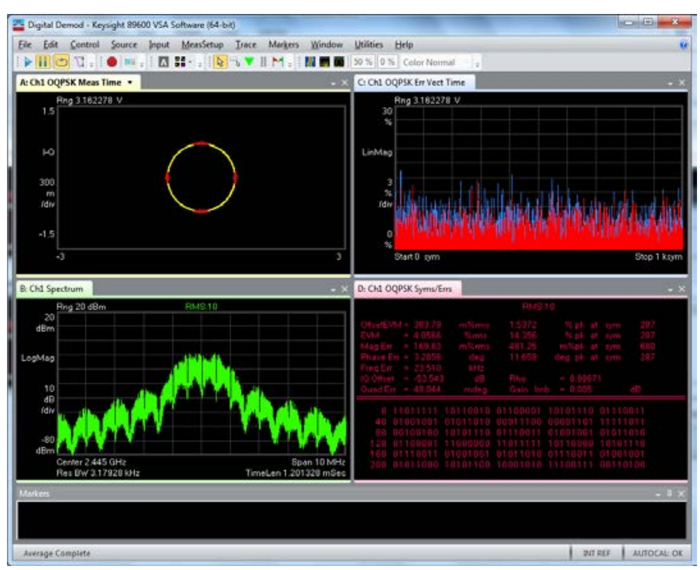

Fig 21. OQPSK modulation quality

3.1.7.2 EVM

Test method:

- Connect the RF port of the module to the R&S FSV30 Spectrum Analyzer. Use the specific menu of the Spectrum Analyzer to do the EVM measurement
- Set the JN5169 in “Tx default power” mode
- Set the TX frequency to channel 11
- Measure the EVM value.
- Repeat the test for each channel

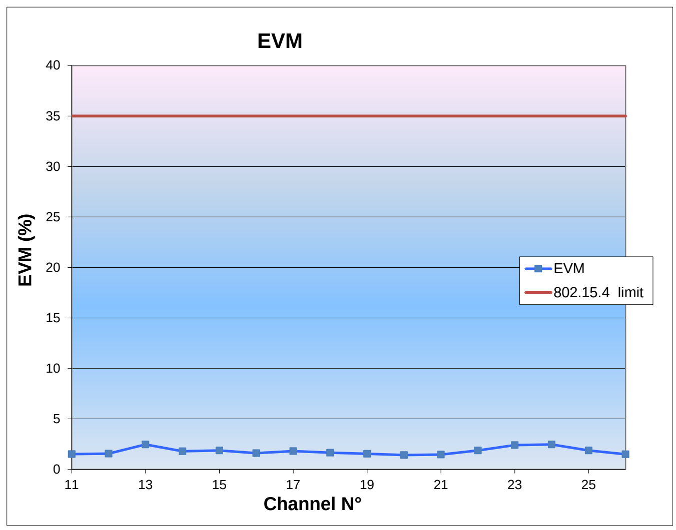

Fig 22. EVM

3.1.7.3 Offset EVM

Test method: same as EVM measurement. The same menu is used for EVM and Offset EVM measurements.

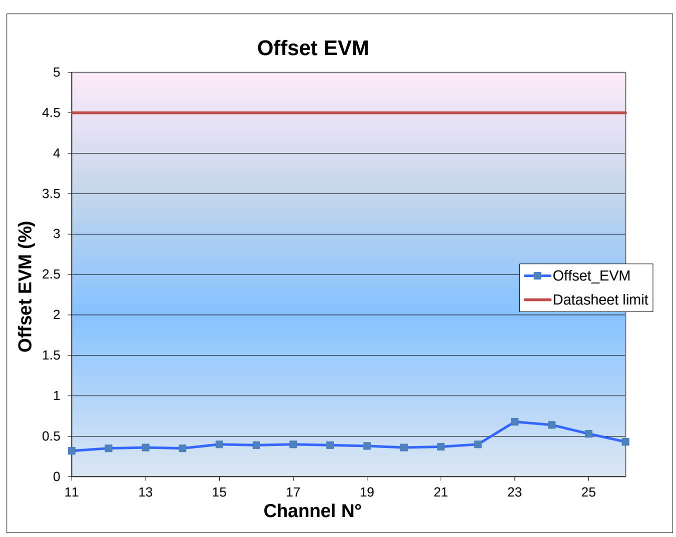

Fig 23. Offset EVM

Conclusion: both the EVM and Offset EVM are stable over frequency

3.2 RX tests

3.2.1 Test Set-Up

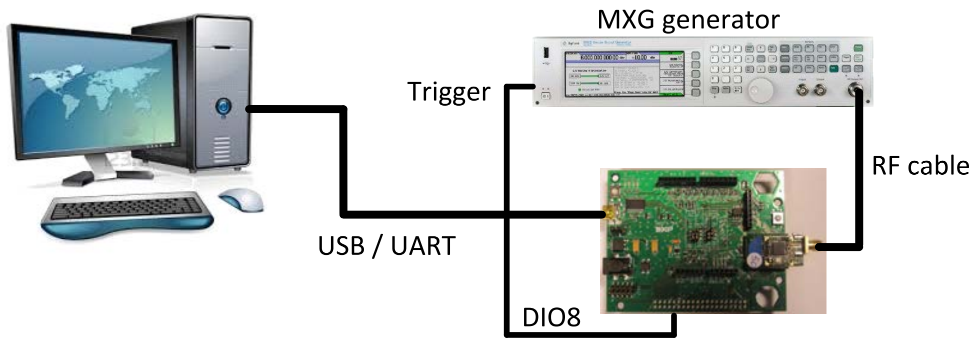

Fig 24. Conducted Rx test set up for sensitivity and receiver maximum input level

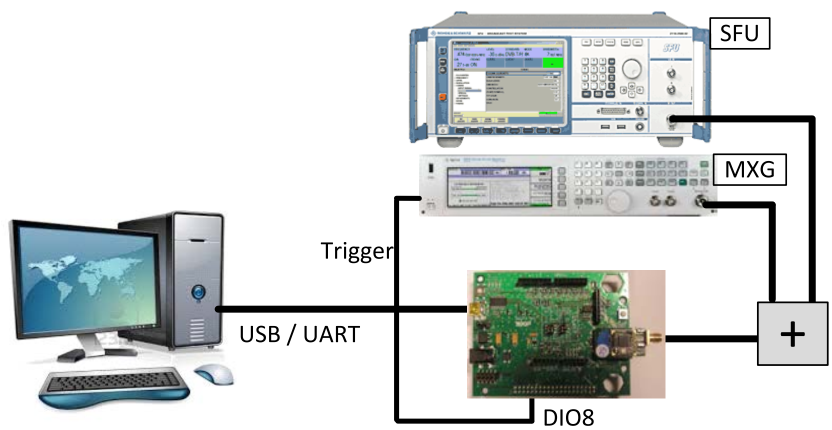

Fig 25. Conducted Rx test set up for interference rejection

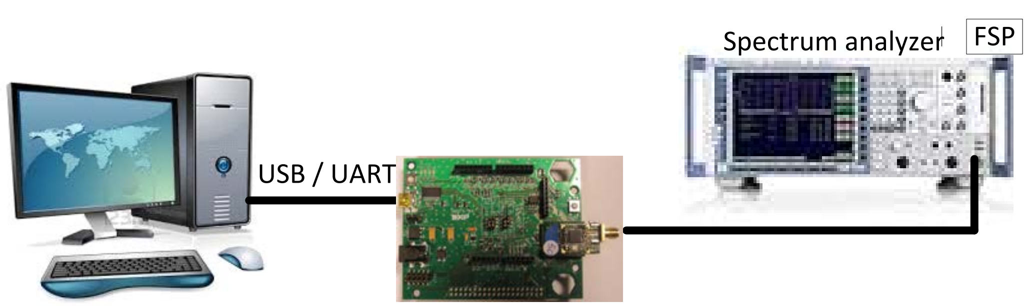

Fig 26. Conducted Rx test set up for spurious

3.2.2 Sensitivity

Test method:

The sensitivity tests were done in a Faraday cage.

Generator: Agilent NX5181 (MXG)

The generator is used in ARB mode to generate a pattern of 1000 packets of 20 octets. The DIO8 of the JN5169 is connected to the trigger input of the generator.

A TERATERM window is used to control the module.

- Set the receiver frequency to channel 11
- Set the module in “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%.
- Repeat the test for each channel.

Result:

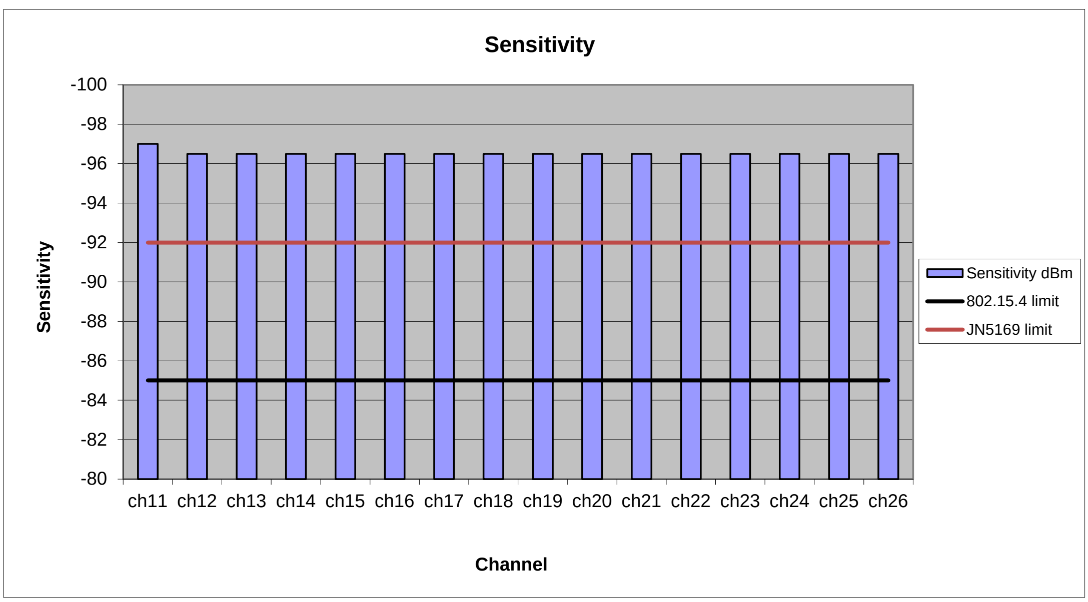

Fig 27. Sensitivity

Average value = -96.5 dBm.

3.2.3 Receiver maximum input level

Test method:

- The same test set-up as the sensitivity test is used.
- The “Trigger packet test” is used in the same way as the sensitivity test
- The measurement is done on channel 17 only.
- The signal level is increased up to the PER = 1%

Result:

The maximum power that can be delivered by the MXG generator is + 17 dBm. With this input level the PER = 0.

Conclusion:

The receiver maximum input level is higher than **17 dBm.**

3.2.4 RX spurious

3.2.4.1 Wide Band

Test method:

- Set the radio in :
  - o Receiver mode, frequency : channel 18
- Set the analyzer to :
  - o 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 MHz
      - ✓ RBW = 1 MHz

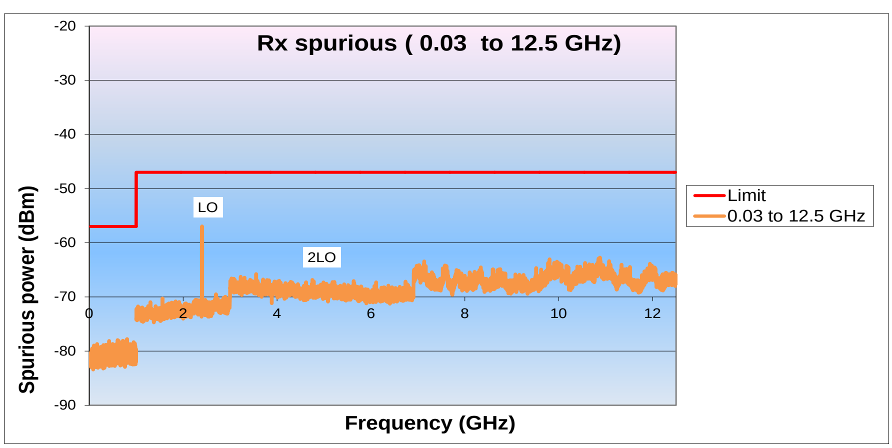

Fig 28. Conducted Rx spurious

Note: There are no spurs. Only LO leakage is detected. Detailed LO leakage measurement is described in the following paragraph.

3.2.4.2 LO leakage

Channel Frequency: 2405 MHz (channel 11)

LO frequency = channel frequency – 1.3125 MHz

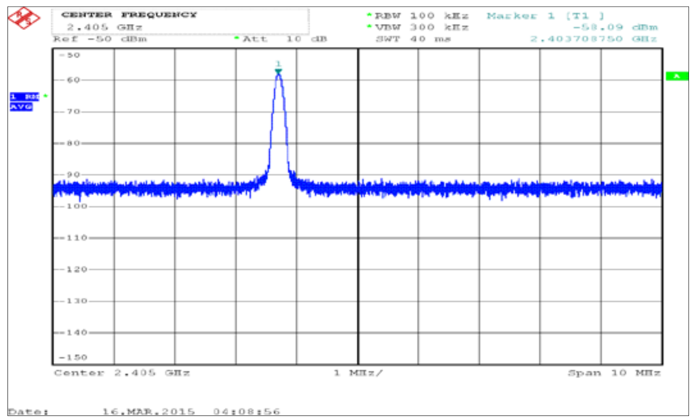

Fig 29. LO leakage

LO leakage = -58.1 dBm

3.2.5 Receiver Interference Rejection

3.2.5.1 Adjacent and alternate channels

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

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

Test method:

Generator for desired signal: Agilent NX5181 (MXG)

Generator for interferers: R&S SFU

Criterion: PER < 1 %

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

Channels under test: 11, 18 and 26

Result:

	ch18				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)	39.2	18.2	33.2	42.7	39.2	18.2	33.2	42.2	38.2	18.2	32.7	42.2
802.15.4 limit (dB)	30	0	0	30	30	0	0	30	30	0	0	30
Margin (dB)	9.2	18.2	33.2	12.7	9.2	18.2	33.2	12.2	8.2	18.2	32.7	12.2

Fig 30. Adjacent and alternate rejection

Conclusion: 8.2 dB margin, worst case.

3.2.5.2 N-3 and n+3 channels

Test method:

Same as Adjacent and alternate channels but the interferer is set at 15 MHz offset from the desired channel.

Result:

	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)	**44.2**	**47.7**	**44.7**	**46.7**	**44.7**	**46.7**

Fig 31. Other In Band rejection

Note: This test is for information. There are no specifications for it.

3.2.5.3 3G blocker

A CW is used as a 3 G interferer. It is set at 2100 MHz.

Test method:

Generator for desired signal: Agilent NX5181 (MXG)

Generator for 3G blocker: R&S SFU

Criterion: PER < 1 %

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

Channels under test: 11.

Result:

	ch11
	2405
	3G
	2100
Interferer level (dBm)	**-6.3**

Fig 32. 3G immunity

Note: This test is for information. There are no specifications for it.

3.2.5.4 LTE blocker (2500 MHz band)

A CW is used as a LTE interferer. It is set at 2500 MHz.

Test method:

Generator for desired signal: Agilent NX5181 (MXG)

Generator for LTE blocker: R&S SFU

Criterion: PER < 1 %

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

Channels under test: 26.

Result:

	ch26
	2480
	3G
	2500
Interferer level (dBm)	**-18.8**

Fig 33. LTE immunity

Note: This test is for information. There are no specifications for it.

4. Return loss

4.1 TX

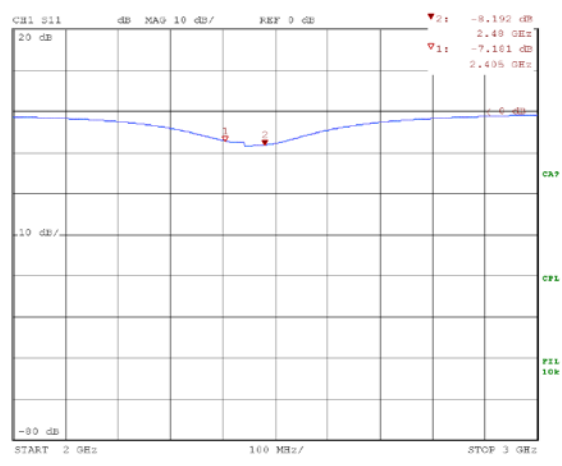

Fig 34. S11 Tx

-8.2 dB (2.48 GHz) <S11< -7.2 dB (2.405GHz)

4.2 RX

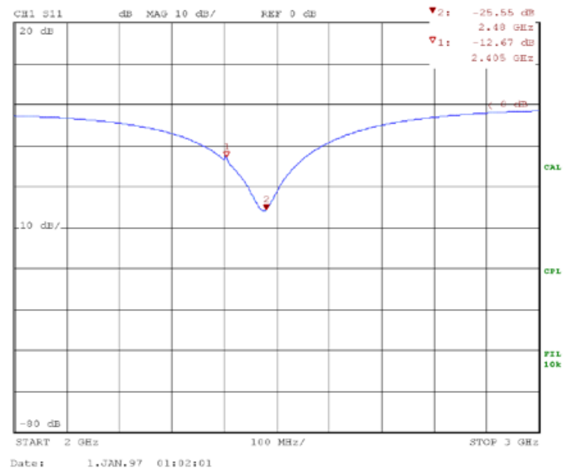

Fig 35. S11 Rx

-25.5.6dB (2.48 GHz) <S11< -12.7 dB (2.405 GHz)

Note: These tests are for information. There are no specifications for them.

5. Conclusion

Beyond the R&TTE and 812.15.4 compliances, these radio tests prove the good performances of the JN5169 wireless Zigbee microcontroller.

6. References

ETS 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 2.4GHz 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)

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