

Test Report

INTENTIONAL RADIATOR TESTS ACCORDING TO ARIB STD-T66 REQUIREMENTS

Equipment Under Test: Bluetooth Low Energy Module

Model: BGM121A
BGM121N
BGM123A
BGM123N

Brand: Silicon Laboratories Finland Oy

Manufacturer: Silicon Laboratories Finland Oy
Bertel Jungin aukio 2
FI-02600 Espoo
FINLAND

Customer: Silicon Laboratories Finland Oy
Bertel Jungin aukio 2
FI-02600 Espoo
FINLAND

Date: 8 November 2016

Issued by:



Rauno Repo
Test Engineer

Date: 8 November 2016

Checked by:



Jari Merikari
Technical Manager

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Equipment Under Test (EUT)

Bluetooth Low Energy module	
Brand:	Silicon Laboratories Finland Oy
Model:	BGM121A, BGM121N, BGM123A, BGM123N
Type:	-
Serial no:	-
HW version:	-
SW version:	-

Description of the EUT

BGM121A and BGM121N are Bluetooth Low Energy modules. Model A has an internal antenna and model N has an external antenna. The difference between BGM121 and BGM123 is that BGM123 has it's transmit power limited to 3 dBm nominal. Antenna port measurements were made using the model BGM121N since power setting of A and N variants are the same and BGM123 has lower transmit power.

Modifications Incorporated in the EUT

No modifications were applied to the EUT during testing

Ratings and declarations

Operating Frequency Range (OFR):	2402 – 2480 MHz
Channels:	39
Channel separation:	2 MHz
Conducted power:	8.22 mW
Modulation:	GFSK
Antenna gain:	1.0 dBi integral antenna with BGM121A 2.14 dBi external antenna with BGM121N

Power Supply

BGM12x is powered by a single, nominally 3.3V supply. The module is designed to operate with supply voltages between 2.2 and 3.6V, although if the ADC or DAC are used, the supply voltage should exceed 2.4V.

According to the customers declaration the internal supply voltages of the EUT are regulated. Therefore tests were performed using only the nominal input voltage level.

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SUMMARY OF TESTING

Description of Test	Result
Antenna power, tolerances for antenna power	PASS
Frequency tolerance	PASS
Occupied Bandwidth (99%)	PASS
Transmission spurious emissions	PASS
Receiver spurious emissions	PASS

EUT Test Conditions during Testing

The EUT was in continuous transmit or receiving mode during all the tests.

The hopping was stopped and the EUT was configured into the wanted channel. Normal modulation and duty cycle was applied in all tests except for frequency tolerance measurement that was performed with unmodulated signal.

According to the customers declaration the internal supply voltages of the EUT are regulated. Therefore tests were performed using only the nominal input voltage level.

Following channels were used during the tests when the hopping was stopped:

Channel LOW = 2402 MHz

Channel MID = 2442 MHz

Channel HIGH = 2480 MHz

The EUT was controlled by using software supplied by the customer.

Test Facility

<input type="checkbox"/> Testing Location / address: FCC registration number: 90598	SGS Fimko Ltd Särkiniementie 3 FI-00210, HELSINKI FINLAND
<input checked="" type="checkbox"/> Testing Location / address: FCC registration number: 178986 Industry Canada registration number: 8708A-2	SGS Fimko Ltd Karakaarenkuja 4 FI-02610, ESPOO FINLAND

Antenna Power and Tolerances

Limit:	ARIB-T66	
Tested by:	RRE	
Date:	6 September 2016	
Temperature:	22 °C	
Humidity:	34 % RH	
Measurement uncertainty	± 0.49 dB	Level of confidence 95 % (k = 2)
Limits:	10 mW or less; 2 400 – 2483.5 MHz	
	Antenna POWER TOLERANCE: -80% to +20%	

Test procedure

Antenna power was measured using spectrum analyzer. First the maximum peak power frequency was searched for channel under measurement. This frequency was used as a center frequency for zero span measurements to measure the Average Burst Power (True RMS) (= Antenna Power (W)).

The Average Burst Power level was measured in continuous modulated mode.

Test Results

Table 1. Measured antenna power

Channel	Reading (dBm)	Result (mW)	Limit (mW)	Margin (mW)	Result
Low	9.15	8.22	10	1.78	PASS
Mid	8.88	7.73	10	2.27	PASS
High	8.67	7.36	10	2.64	PASS

Table 2. Tolerances of antenna power

Channel	Declared antenna power (mW)	-80% limit	+20% limit	Maximum measured power (mW)	Deviation (%)	Result
Low	7.8	1.56	9.36	8.22	5.385	PASS
Mid	7.8	1.56	9.36	7.73	-0.897	PASS
High	7.8	1.56	9.36	7.36	-5.641	PASS

Power tolerance is calculated by using the following formula:

$$\text{Power tolerance} = \{[(\text{Measured power}) - (\text{Rated Cond. P})] / (\text{Rated Cond. P})\} \times 100$$

Table 3. EIRP evaluation

Antenna Power (dBm)	Antenna Gain (dBi)	EIRP (dBm)	EIRP= Antenna Power (dBm) + Antenna Gain (dBi)
9.15	2.14	11.29	

Antenna gain and beamwidth measurements are not required because the EIRP power is less than 12.14 dBm.

Frequency Tolerance

Limit:	ARIB-T66	
Tested by:	RRE	
Date:	6 September 2016	
Temperature:	22 °C	
Humidity:	34% RH	
Measurement uncertainty	$\pm 4.758 \times 10^{-8}$	Level of confidence 95 % (k = 2)
Limit:	± 50 ppm	

Test procedure

Frequency tolerance was measured by using frequency counter function of the spectrum analyzer.

Test Results

Table 4. Test Results for Frequency Tolerance

Channel	Low	Mid	High
Channel Frequency [MHz]	2402	2442	2480
Reading Frequency [MHz]	2401.9893111	2441.9878683	2479.9865815
Frequency error [kHz]	-10.6889	-12.1317	-13.4185
Frequency error [ppm]	-4.45	-4.97	-5.41
Margin [ppm]	45.55	45.03	44.59
Result	PASS	PASS	PASS

99% Occupied Bandwidth

Limit: ARIB-T66
Tested by: RRE
Date: 6 September 2016
Temperature: 22 °C
Humidity: 34 % RH
Measurement uncertainty ± 1.78 dB Level of confidence 95 % (k = 2)

99% Occupied bandwidth test procedure

99% Occupied Bandwidth was measured with the occupied bandwidth function of the test receiver.
 The limit for 99% occupied bandwidth is ≤ 26 MHz.

Test Results

Table 5. Test results for 99% Occupied Bandwidth

Channel	Limit [MHz]	99% BW [MHz]	Result
Low	≤ 26	1.108840349	PASS
Mid	≤ 26	1.102371801	PASS
High	≤ 26	1.107902878	PASS

Transmission Spurious Emissions

Limit:	ARIB-T66
Tested by:	RRE
Date:	22 June 2015
Temperature:	21 °C
Measurement uncertainty	± 2.96 dB Level of confidence 95 % (k = 2)
Limits:	-26.02 dBm (< 2387 MHz)
	-16.02 dBm (2387 MHz – 2400 MHz)
	-16.02 dBm (2483.5 MHz – 2496.5 MHz)
	-26.02 dBm (> 2496.5 MHz)

Unwanted spurious emissions are measured in the frequency range of 30 MHz – 12.5 GHz. The resolution bandwidth is 1 MHz for all measurements.

Test Result

Table 6. Channel low

Frequency [MHz]	Detector	Level [dBm]	Limit [dBm]	Margin [dBm]	Result
2377.6575	Peak	-45.67	-26.02	19.65	PASS
2872.5260	Peak	-41.53	-26.02	15.51	PASS
6939.9400	Peak	-36.59	-26.02	10.57	PASS

Table 7. Channel mid

Frequency [MHz]	Detector	Level [dBm]	Limit [dBm]	Margin [dBm]	Result
2513.9779	Peak	-43.46	-26.02	17.44	PASS
2996.6120	Peak	-41.09	-26.02	15.07	PASS
6977.4200	Peak	-36.17	-26.02	10.15	PASS

Table 8. Channel high

Frequency [MHz]	Detector	Level [dBm]	Limit [dBm]	Margin [dBm]	Result
2386.0188	Peak	-43.25	-26.02	17.23	PASS
2974.0600	Peak	-41.49	-26.02	15.47	PASS
6990.8200	Peak	-38.20	-26.02	12.18	PASS

Limitation of Collateral Emission of Receiver

Limit:	ARIB-T66	
Tested by:	RRE	
Date:	6 September 2016	
Temperature:	22 °C	
Measurement uncertainty	± 2.96 dB	Level of confidence 95 % (k = 2)
Limits:	-53.98 dBm (<1000 MHz)	
	-46.99 dBm (>1 GHz)	

Unwanted spurious emissions are measured in the frequency range of 30 MHz – 12.5 GHz. The resolution bandwidth for measurements is 1 MHz.

Test Results

With low, mid and high channels activated peak margins are more than 10 dB.

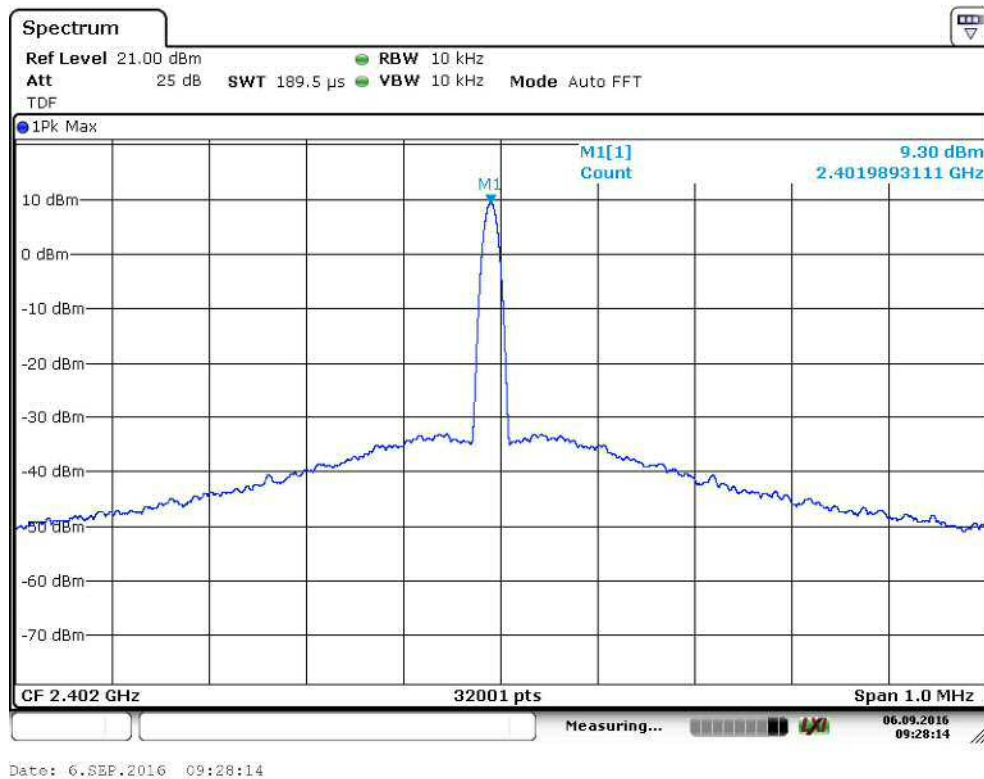
LIST OF TEST EQUIPMENT

Type	Manufacturer	Model	Serial No.	Calibrated	Next calibration
Attenuator 10dB	Palsternack	DC to 40 GHz	-	June 2016	June 2017
Spectrum analyzer	Rohde&Schwarz	FSV40	101068	2016-06-10	2017-06-10
Frequency standard	Pendulum	GPS-88	SM 968615	-	-

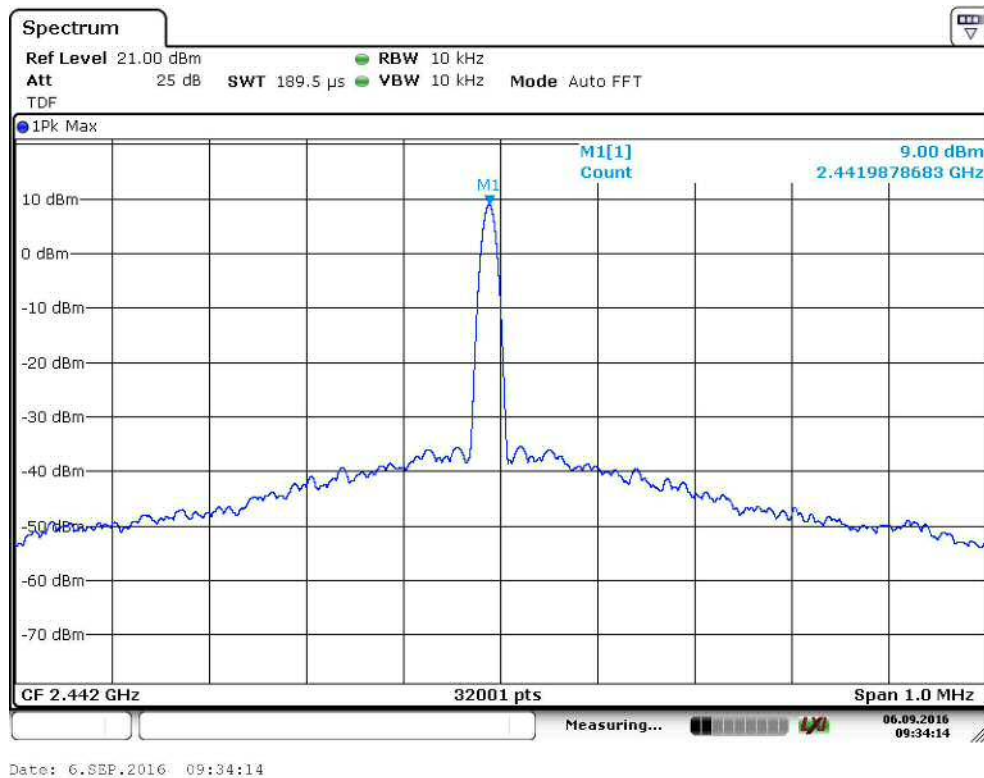
ANNEX A

Graphical data

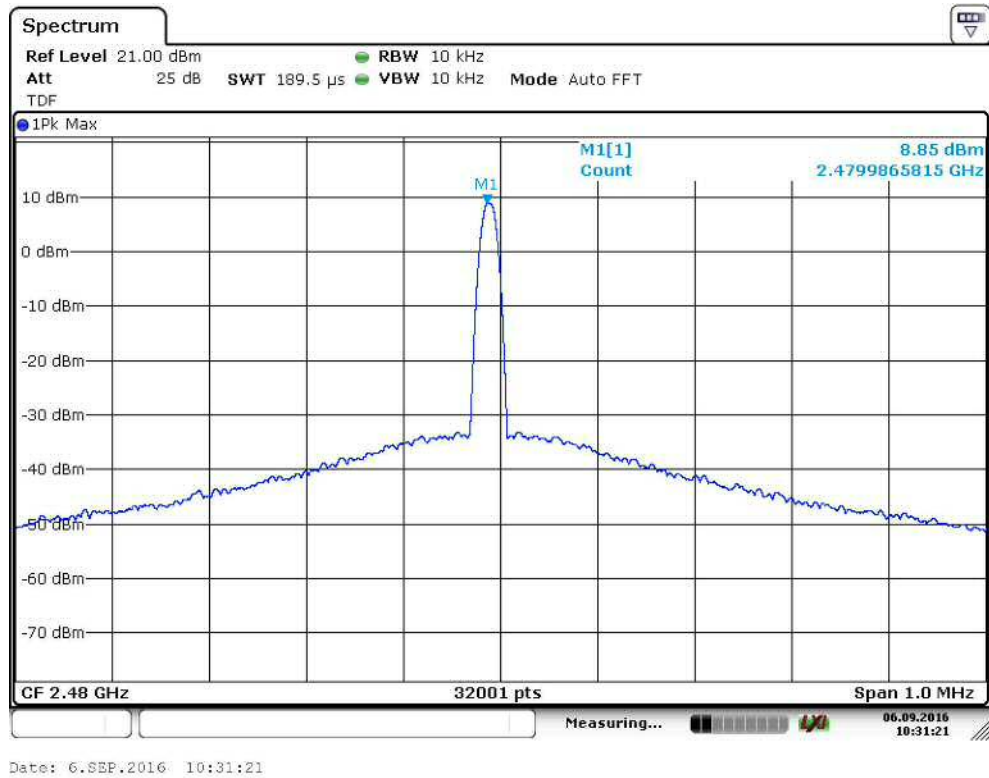
This annex contains the graphical data recorded during the tests.



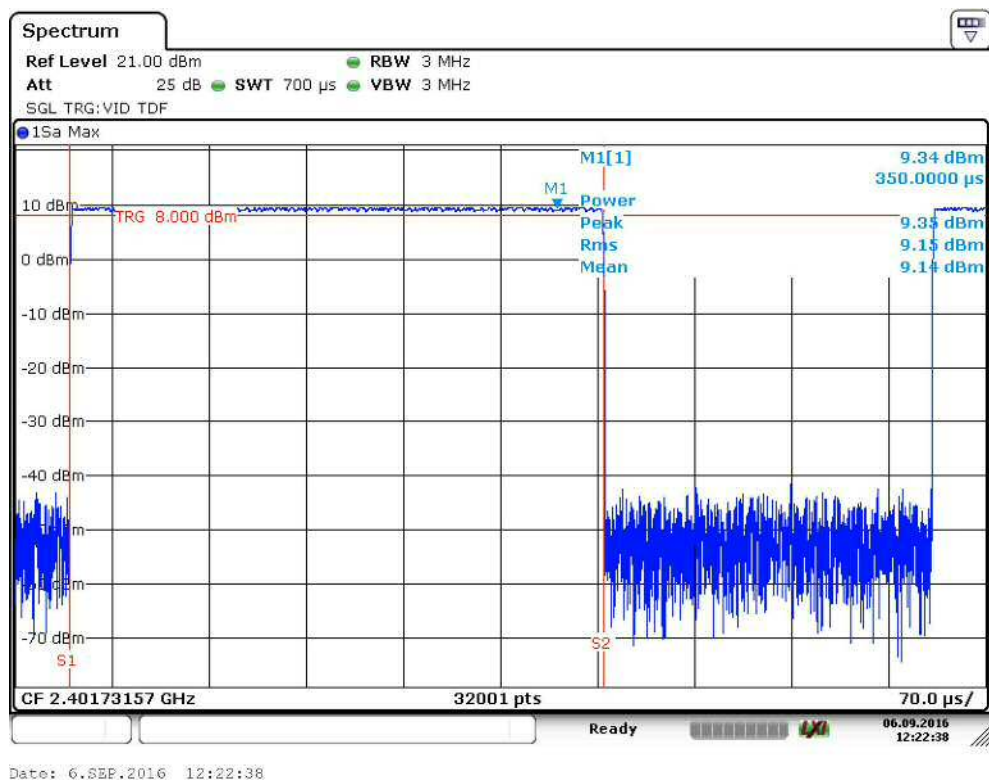
Graph 1. Frequency Tolerance Channel Low.



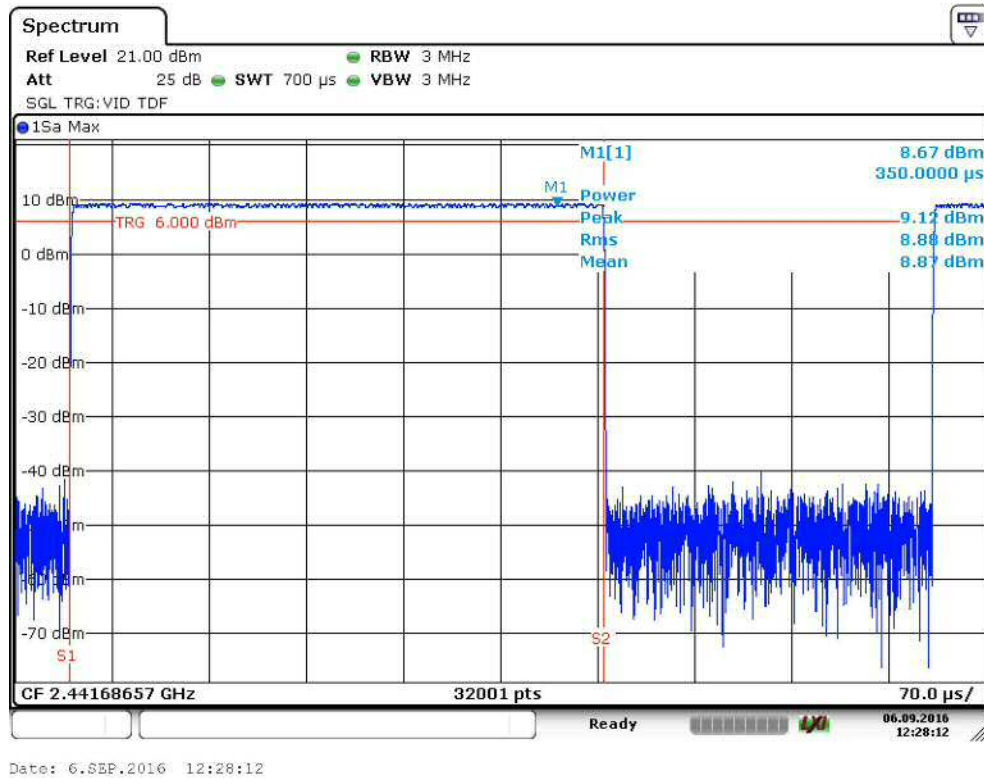
Graph 2. Frequency Tolerance Channel Mid.



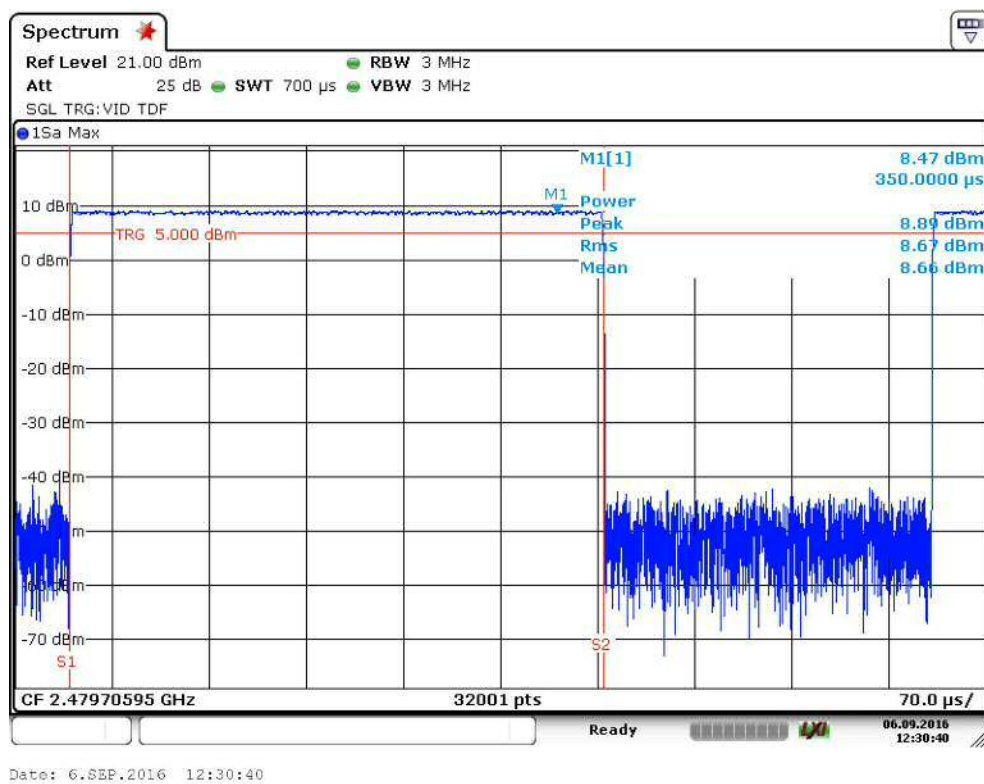
Graph 3. Frequency Tolerance Channel High.



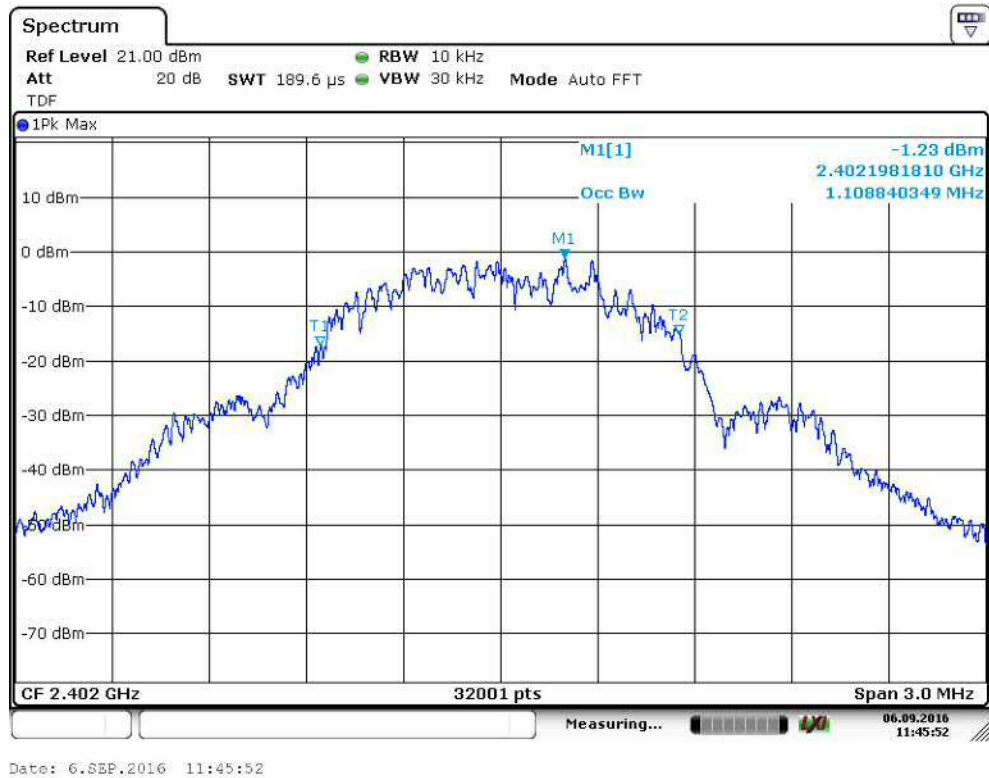
Graph 4. Antenna Power Channel Low.



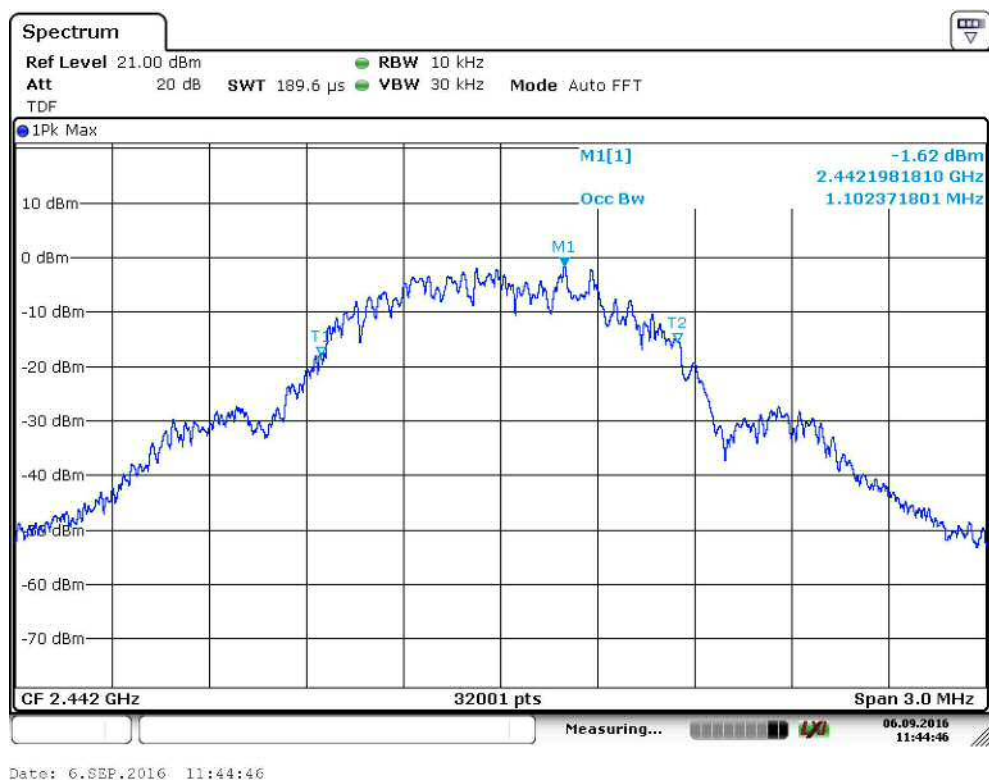
Graph 5. Antenna Power Channel Mid.



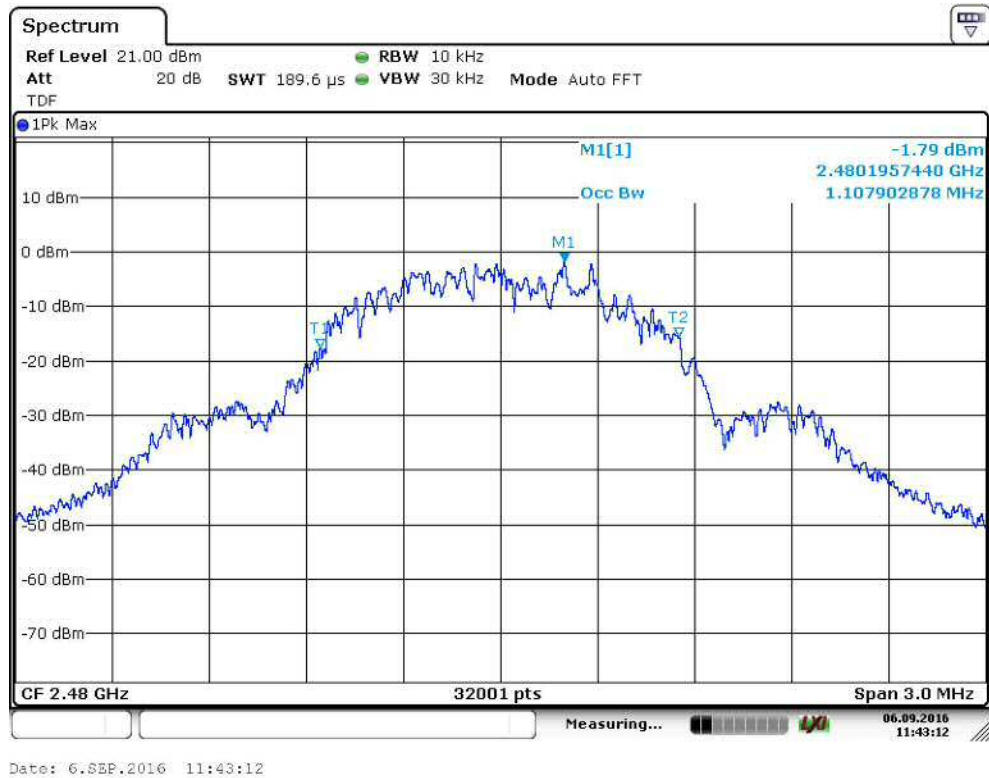
Graph 6. Antenna Power Channel High.



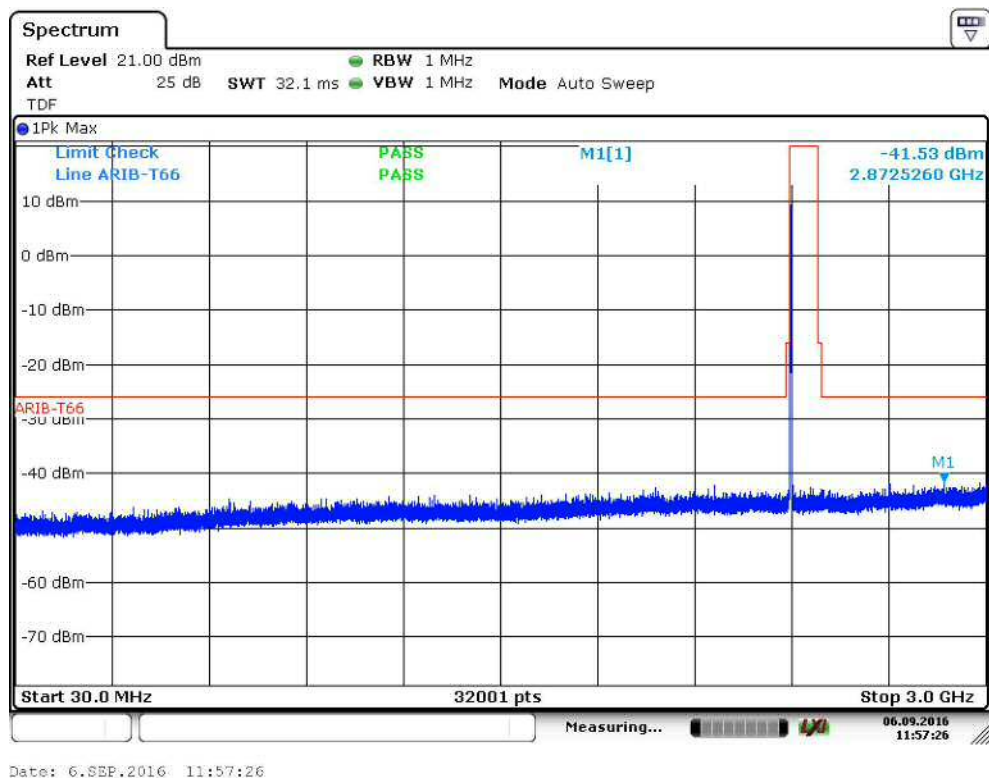
Graph 7. 99% Occupied Bandwidth Channel Low.



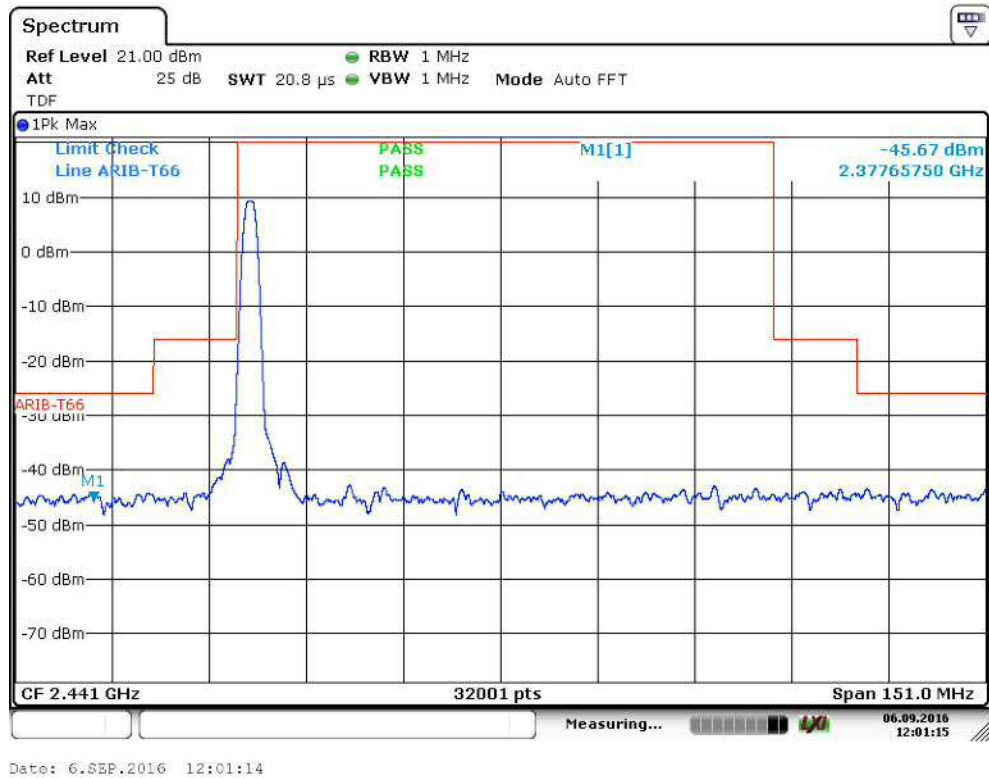
Graph 8. 99% Occupied Bandwidth Channel Mid.



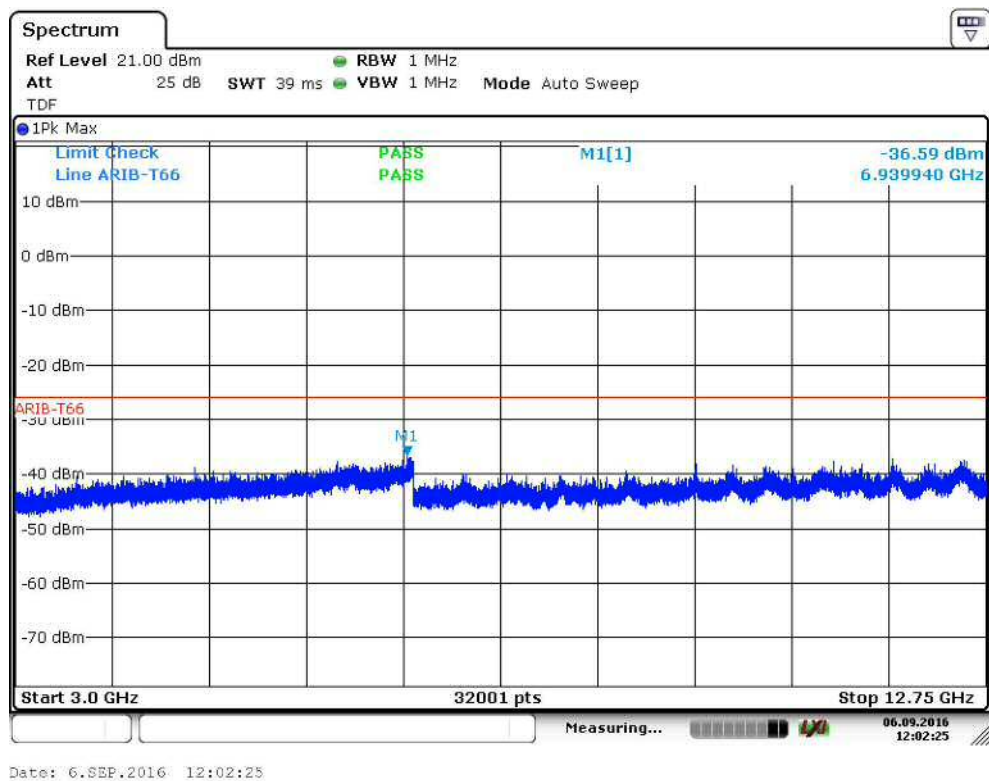
Graph 9. 99% Occupied Bandwidth Channel High.



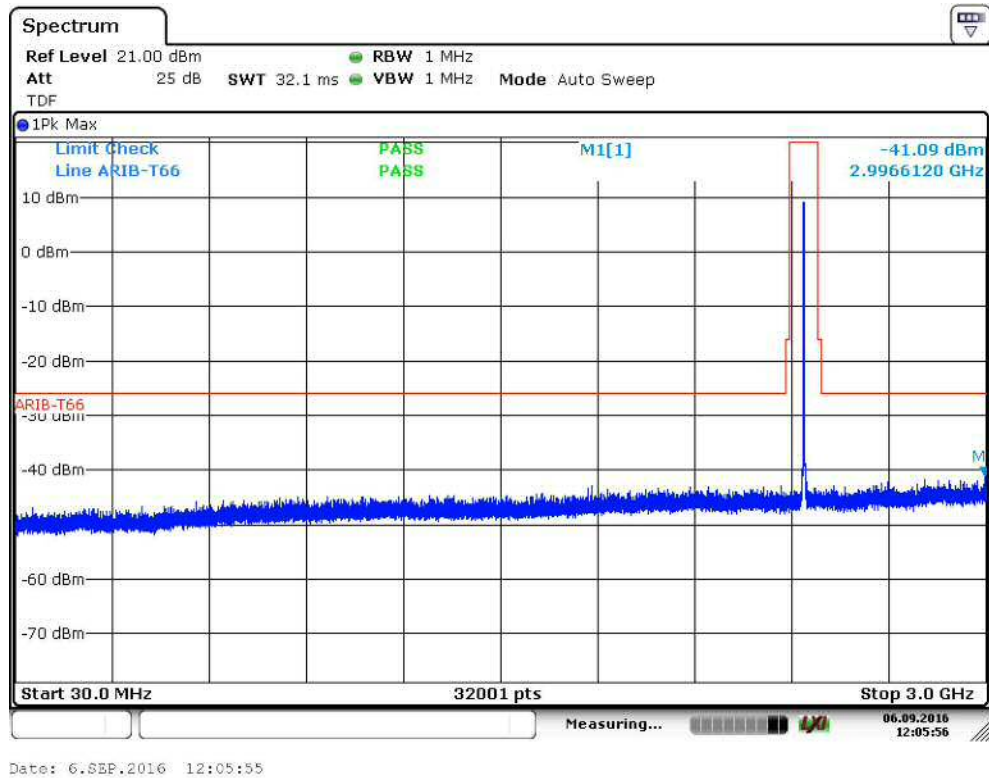
Graph 10. Tx Spurious Emissions Channel Low 30 – 3000 MHz.



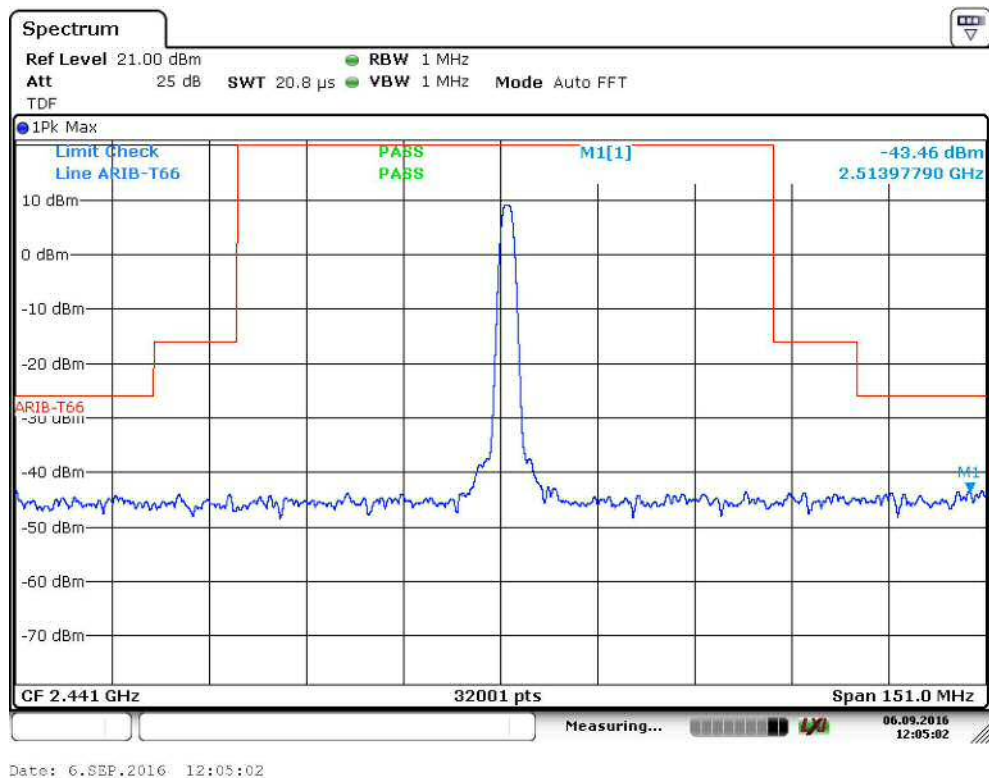
Graph 11. Tx spurious Emissions Channel Low 2.4 GHz.



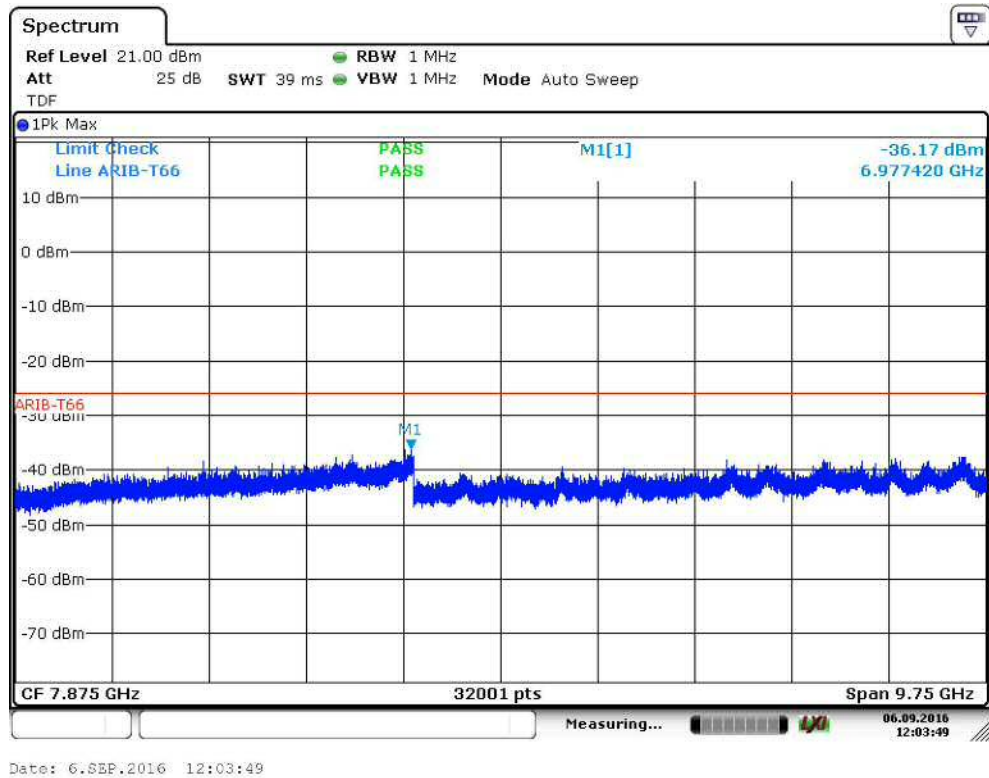
Graph 12. Tx Spurious Emissions Channel Low 3.0 – 12.75 GHz.



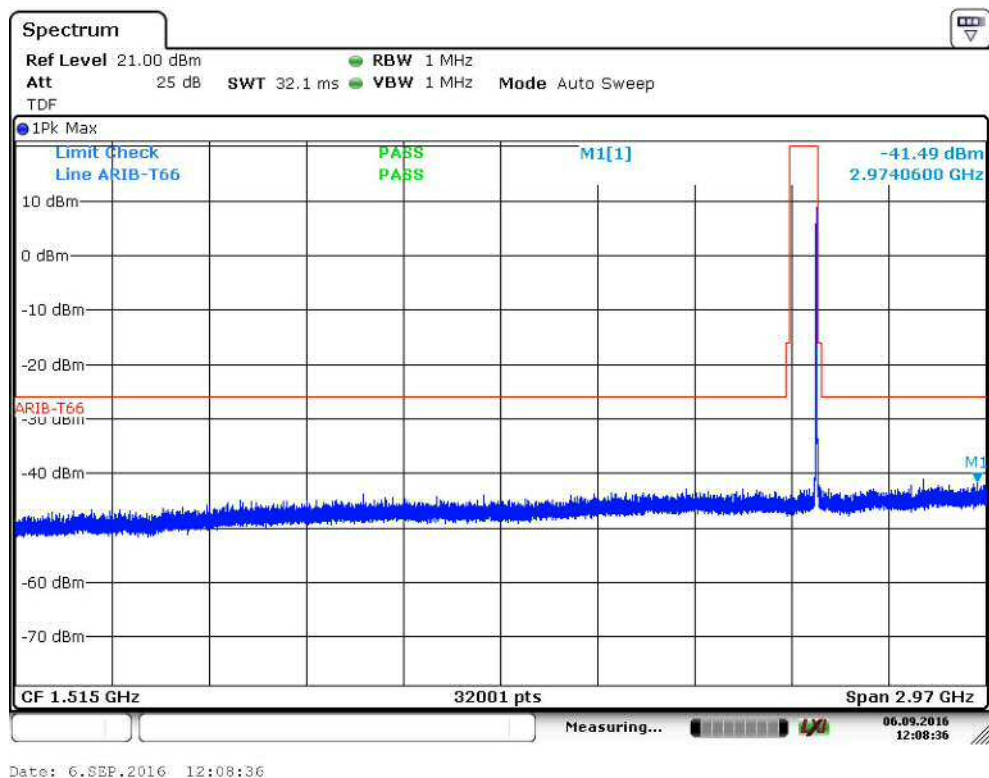
Graph 13. Tx Spurious Emissions Channel Mid 30 – 3000 MHz.



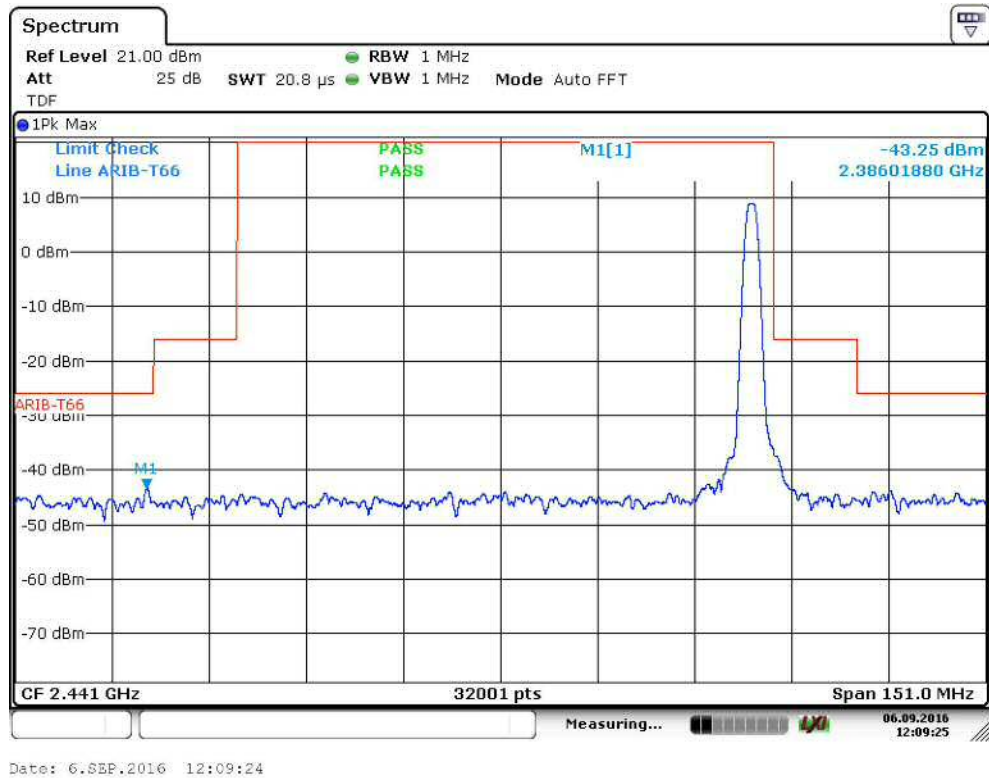
Graph 14. Tx spurious Emissions Channel Mid 2.4 GHz.



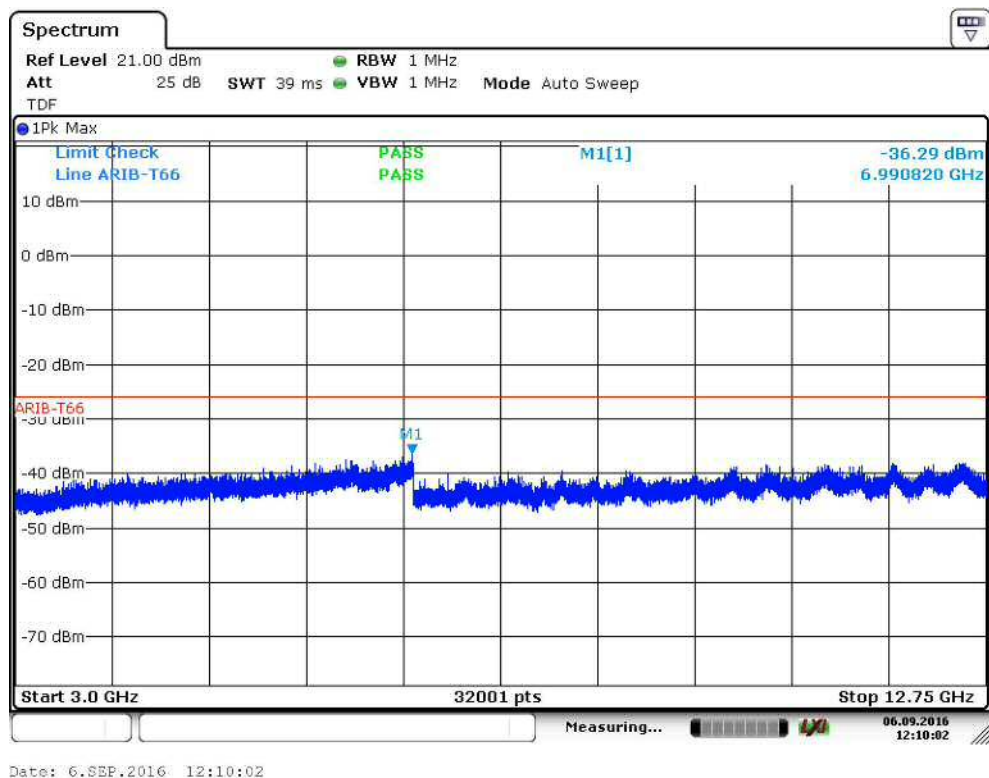
Graph 15. Tx Spurious Emissions Channel Mid 3 – 12.75 GHz



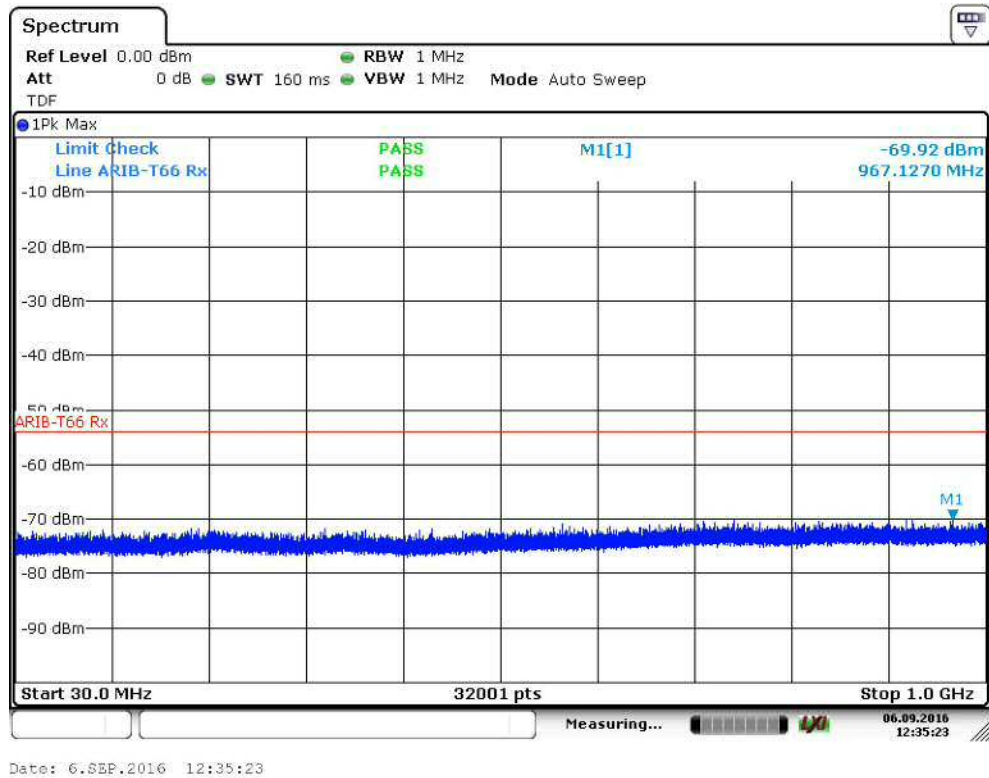
Graph 16. Tx Spurious Emissions Channel High 30 MHz – 3000 MHz.



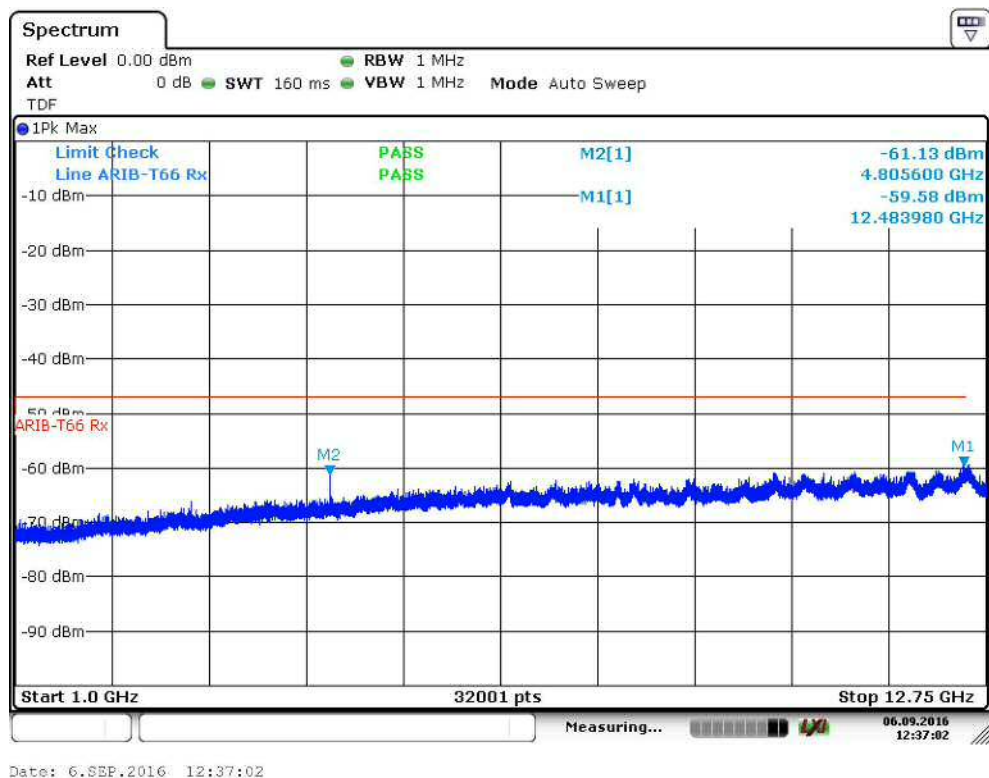
Graph 17. Tx Spurious Emissions Channel High 2.4 GHz.



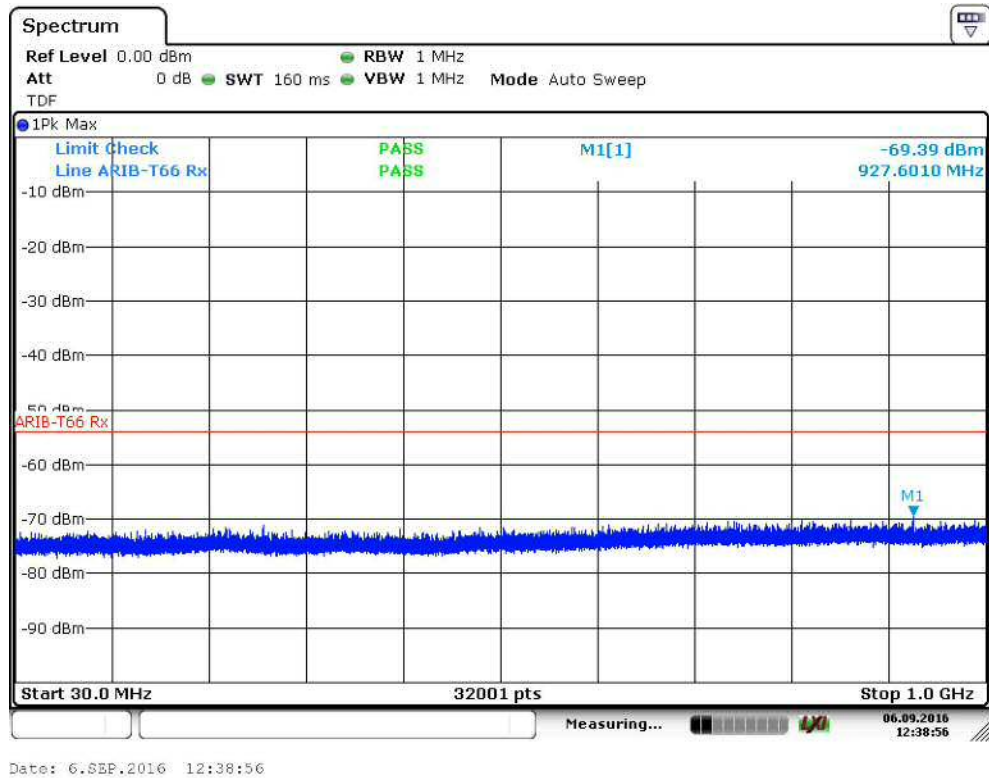
Graph 18. Tx Spurious Emissions Channel High 3 – 12.75 GHz.



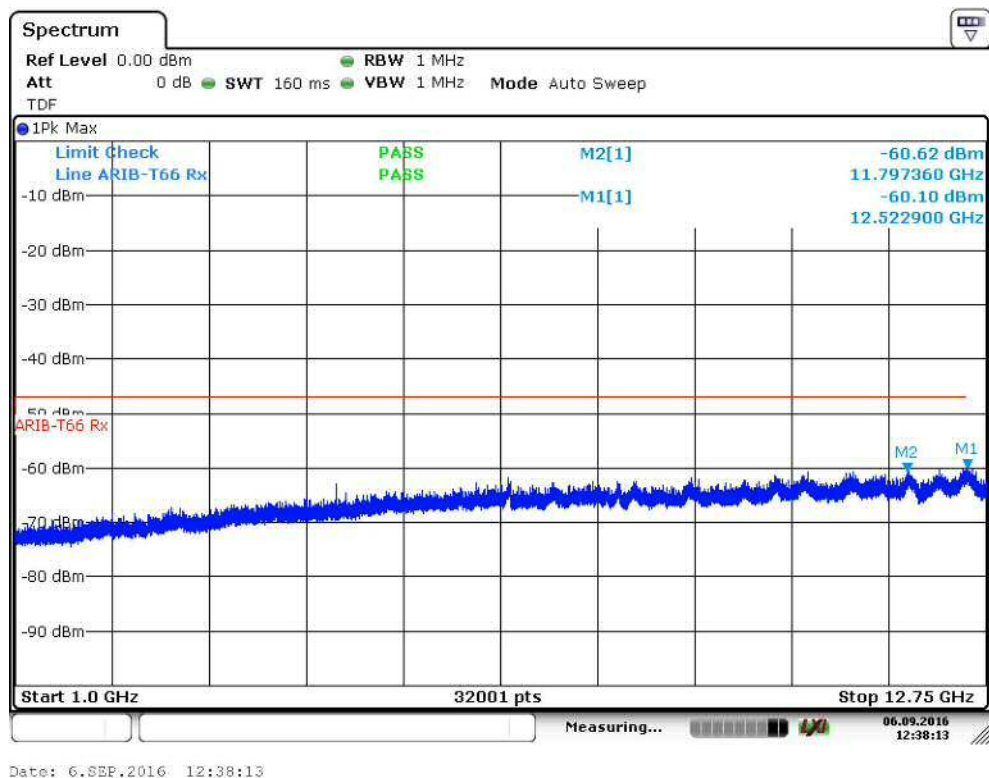
Graph 19. Rx Spurious Emissions Channel Low 30 MHz – 1.0 GHz.



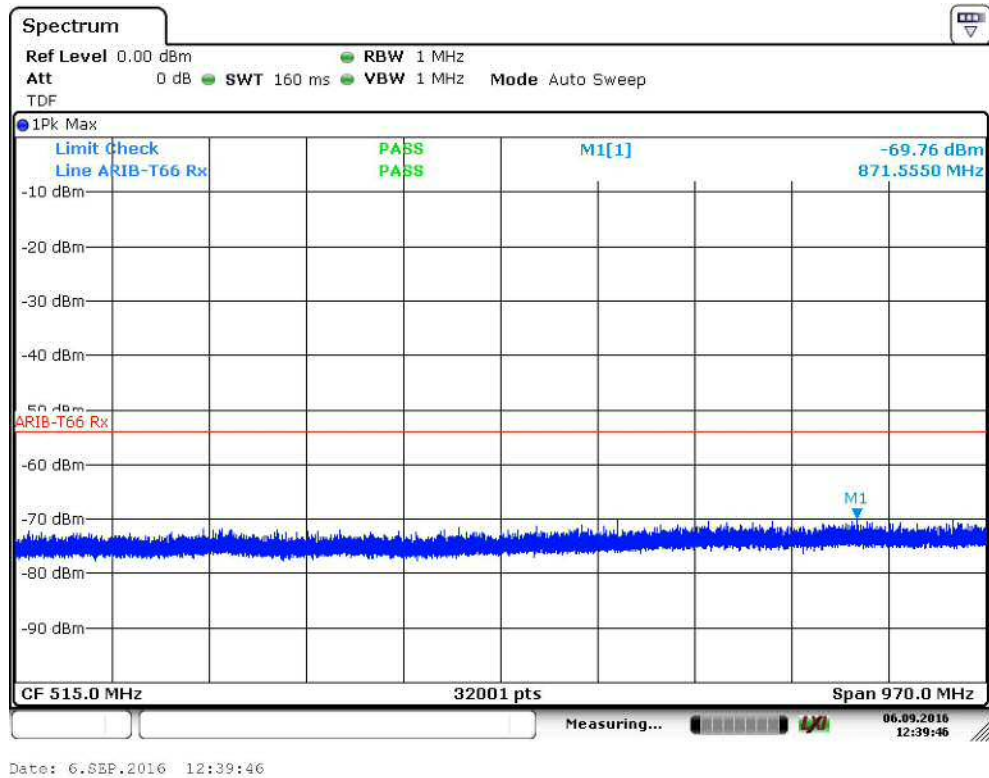
Graph 20. Rx Spurious Emissions Channel Low 1.0 GHz – 12.75 GHz.



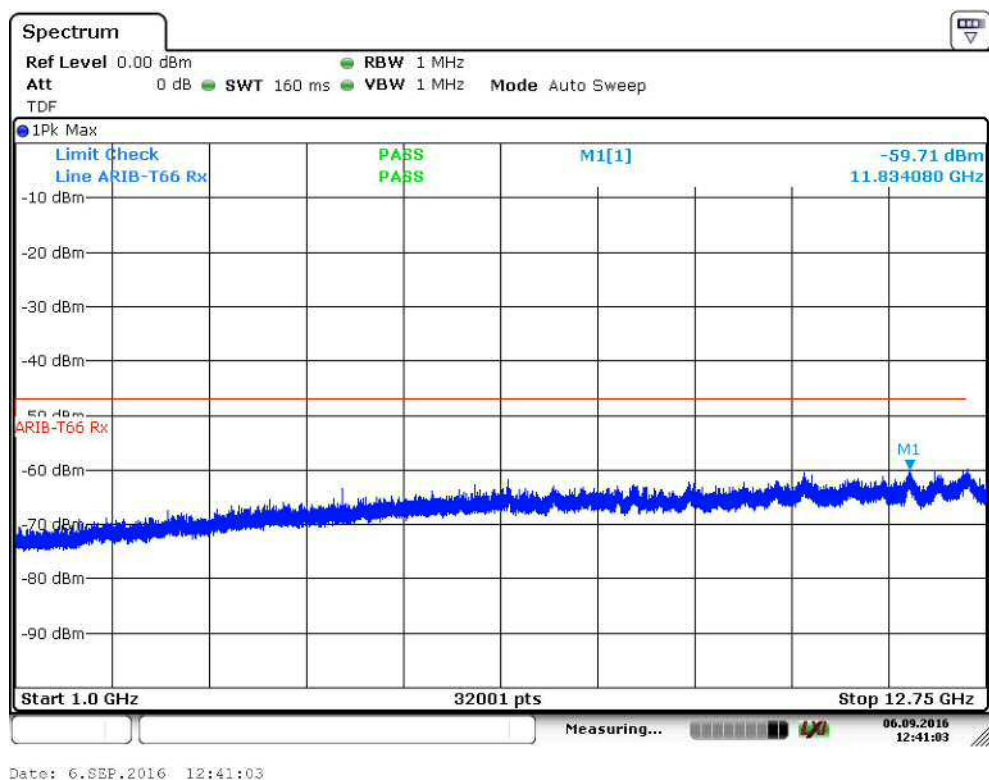
Graph 21. Rx Spurious Emissions Channel Mid 30 MHz – 1.0 GHz.



Graph 22. Rx Spurious Emissions Channel Mid 1.0 GHz – 12.75 GHz.



Graph 23. Rx Spurious Emissions Channel High 30 MHz – 1.0 GHz.

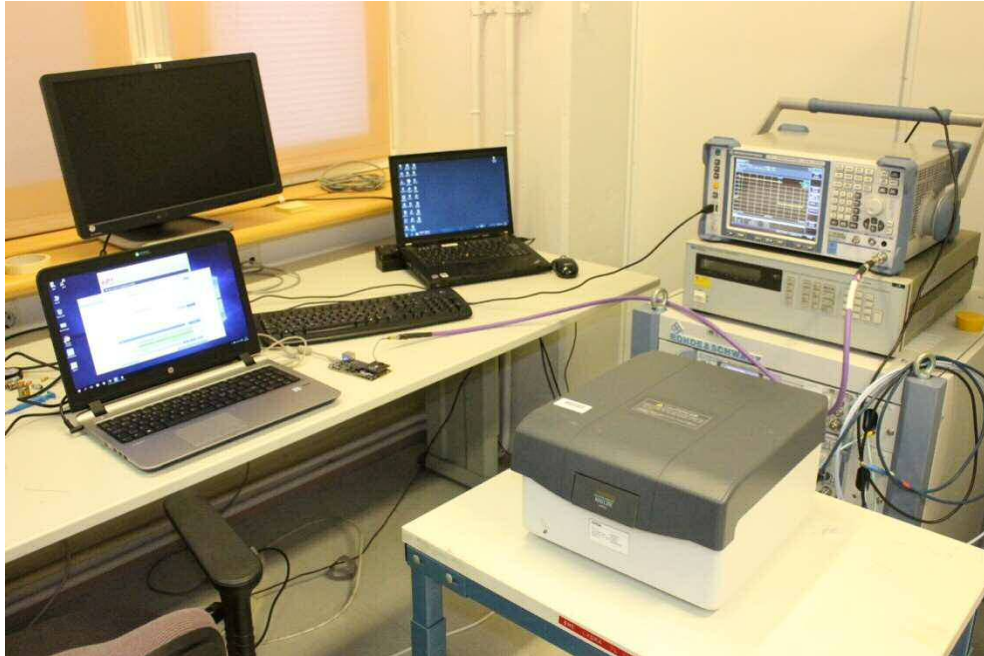


Graph 24. Rx Spurious Emissions Channel High 1 GHz – 12.75 GHz.

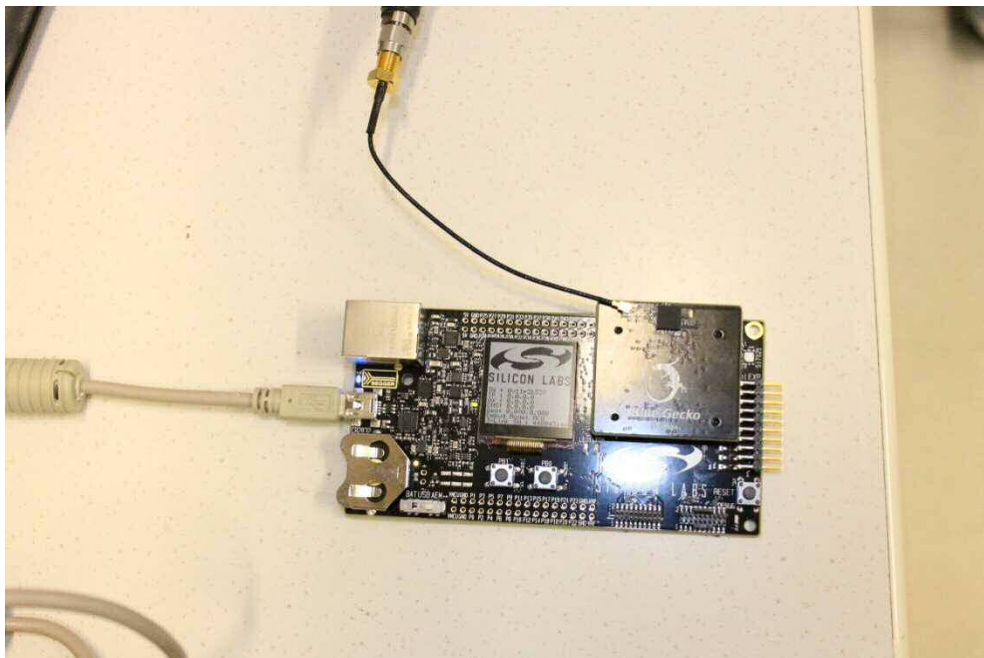
ANNEX B

Photographs

This annex contains the photographs of the EUT and test setup.



Photograph 1. Test setup.



Photograph 2. The EUT attached to the evaluation board.



Photograph 3. The EUT.