TEXAS INSTRUMENTS

Application Report
SWRA536–February 2016

ETSI EN 300 328 RX Blocking Test for Bluetooth® Low Energy

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ABSTRACT

This application report describes the setup and procedure used to measure the new ETSI EN receiver (RX) blocking test added to version v2.1.1 of the ETSI EN 300 328 harmonized standard.

Project collateral discussed in this application report can be downloaded from the following URL: http://www.ti.com/lit/zip/swra536.

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Trademarks

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Wi-Fi is a registered trademark of Wi-Fi Alliance.
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1 Introduction

ETSI EN 300 328 is a European harmonized standard that specifies the regulatory requirement for data transmission equipment operating in the 2.4 GHz ISM band and using wide band modulation techniques in Europe. This standard covers technology such as Wi-Fi®, Bluetooth and ZigBee® but also other proprietary transmission systems that use the 2.4 GHz ISM band.

In the current version of V2.1.1, which was released in November, 2016 under the European Radio Equipment Directive 2014/53/EU (RED), a new requirement regarding receiver blocking performance was added and this application report shows how it can be measured for a Bluetooth low energy system using a Rohde & Schwartz vector signal generator. The same method can be applied for most other transmission systems or signal generator vendors.

2 ETSI EN 300 328 V2.1.1 Requirement

The ETSI specification divides receivers into three different categories: category 1 to category 3. The categorization can be found in the *Categorization* section in the ETSI specification (V2.1.1, 2016, p.15). Bluetooth low energy devices fall in either category 2 or category 3 based on Medium Utilization (MU), a product of TX duty cycle and output power. Category 2 covers devices with output power between 0 and 10 dBm assuming 100% duty cycle, and has stricter requirements than category 3. As the CC2640 easily fulfills the requirements for category 2, we will only focus on these requirements throughout this document.

The blocking requirements for receiver category 2 is found in the *Receiver Category 2* section in the ETSI specification (V2.1.1, 2016, p. 38).

Table 1. Receiver Blocking Parameters Receiver Category 2 Equipment

Wanted Signal Mean Power From Companion Device (dBm)	Blocking Signal Frequency (MHz)	Blocking SIgnal Power (dBm) (see [(1)])	Type of Blocking Signal
P_{min} + 6 dB (see [(2)])	2380 2503.5	-57	CW
P_{min} + 6 dB (see [(2)])	2300 2583.5	-47	CW

(1) The levels specified are levels in front of the UUT antenna. In case of conducted measurements, the levels have to be corrected by the actual antenna assembly gain.

(2) P_{min} is the minimum level of the wanted signal (in dBm) required to meet the minimum performance criteria as defined in the clause in the *Performance Criteria* section of ETSI EN 300 328 V2.1.1 in the absence of any blocking signal.

Tests should be performed at both lowest and highest operating frequency according to the *Test Conditions* section in the ETSI specification (V2.1.1, 2016, p. 72).

3 Test Setup

This example shows how to setup the measurement of a Bluetooth low energy blocking test. The test is performed at the lowest and highest channels (2402 MHz and 2480 MHz) according to the ETSI EN 300 328 (V2.1.1, 2016). The Bluetooth low energy specification specifies a PER limit at 30.8% (1038 OK packages out of 1500 packages).

Setup is for conducted measurements.

3.1 Test Equipment

- DUT. For this document a CC2650EM-7ID with SmartRF06EB was used.
- SMBV100A (or other newer R&S signal generators)
- CW generator (R&S SMU or similar)
- Spectrum analyzer (R&S FSQ or similar)

3.2 R&S Waveform

The waveform, R&S_IQ_BLE_1Mbps_1pkt_70ms_guard.ww, is a binary file containing I/Q samples that can be used through a baseband generator with ARB to create a 1 Mbps BLE modulated test data package. This waveform is compatible with all new Rohde and Schwarz signal generators like SMW200A, SMU200A, SMJ100A, SMATE200A, AMU200A, SMBV100A, AFQ100B, SMA100A, SMB100A or SMC100A.

The waveform contains a 37 byte large 1 Mbps BLE modulated package with an access address of 0x71764129.

There is a 1 ms guard time added at the beginning of the waveform and a 69 ms guard time at the end of the waveform. This leads to a 70 ms time between each package when the waveform is looped repeatedly back to back. The reason for adding the guard bands is so that each packet can be received reliably without any packages getting lost due to the limited bandwidth between the DUT and the PC running SmartRF™ Studio.

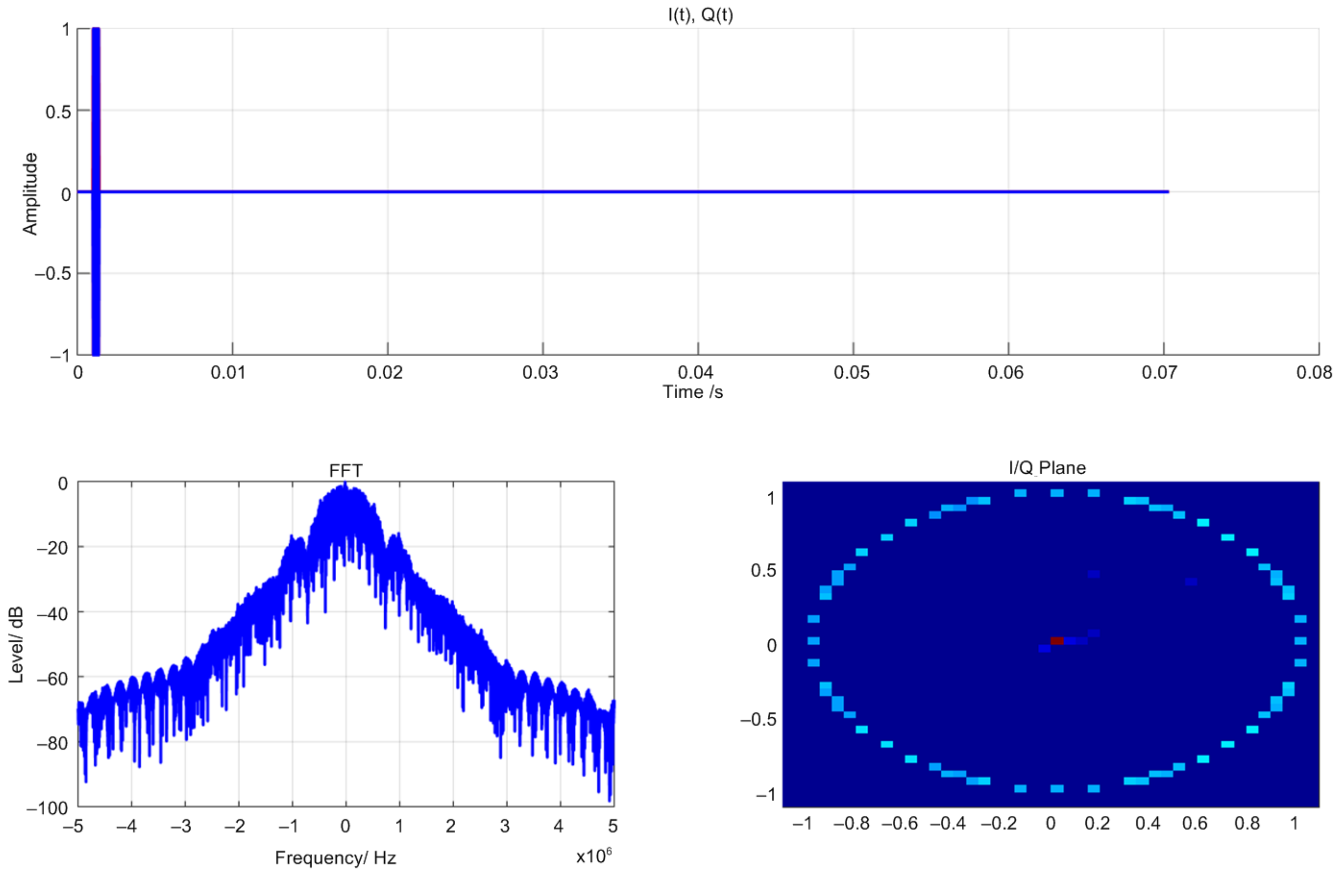

Figure 1. I/Q Traces vs Time, FFT Spectrum and Density Plot for Waveform

3.3 Connection

Figure 2 shows the connection for the test setup. The directional coupler and spectrum analyzer is optional but is good to have when the loss in the test system are going to be measured.

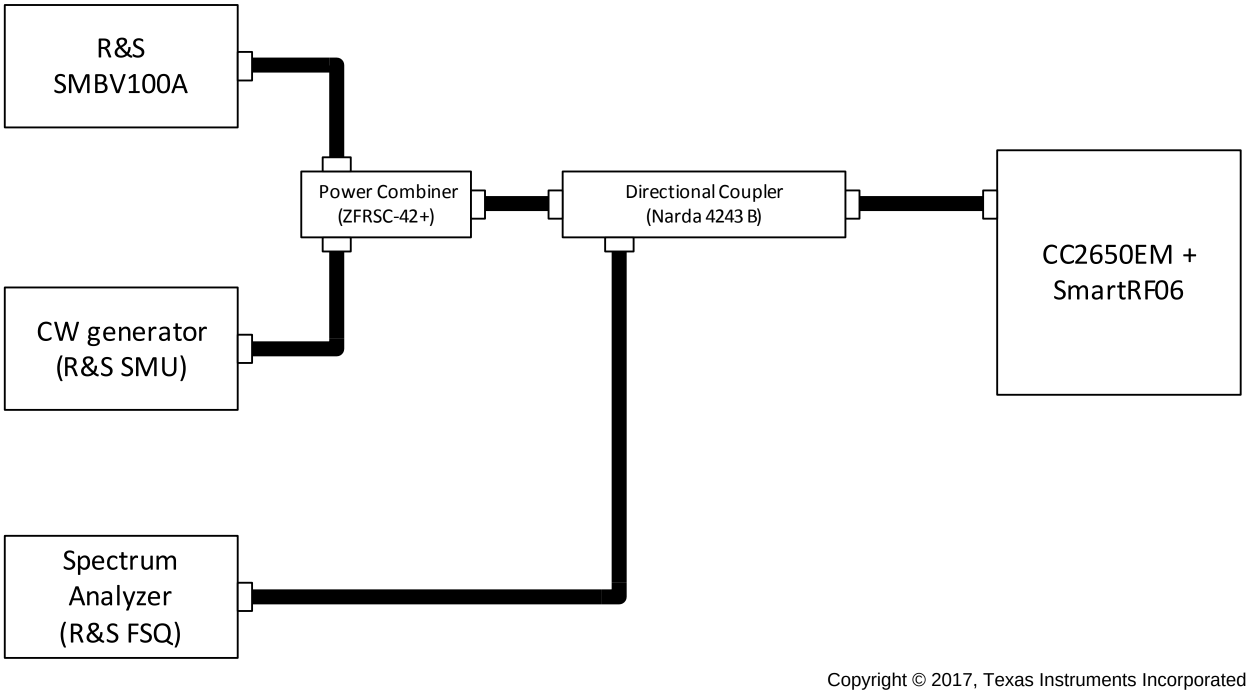

Figure 2. Test Setup Connection

3.4 TX Setup

This is the setup for a R&S SMBV100A signal generator.

1. Upload IQ waveform, R&S_IQ_BLE_1Mbps_1pkt_70ms_guard.wv, to SMBV100A using R&S_ARB_toolbox or a USB flash drive.
2. Set the wanted frequency and level on the modulated signal.

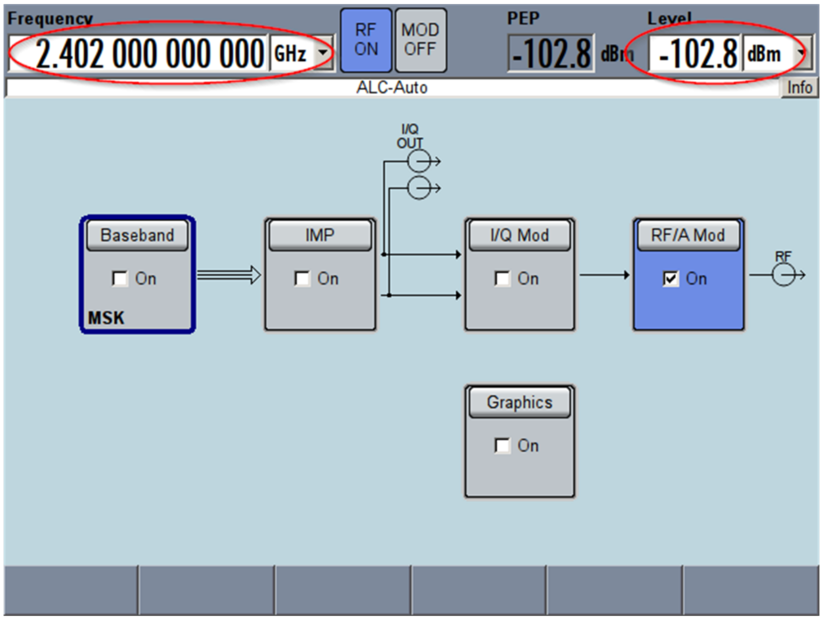

Figure 3. Setting the Frequency and Level

3. Select "BaseBand" and "ARB" on the signal generator

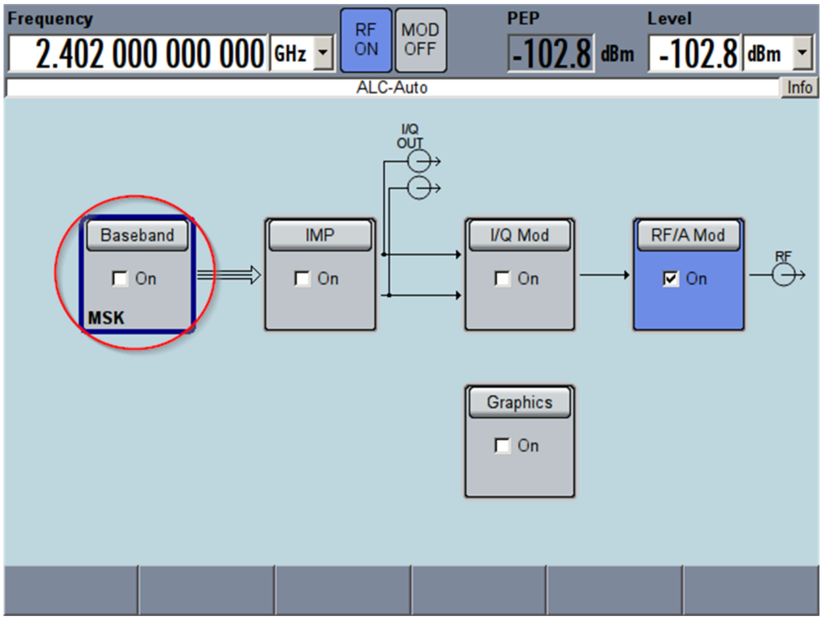

Figure 4. Baseband and ARB

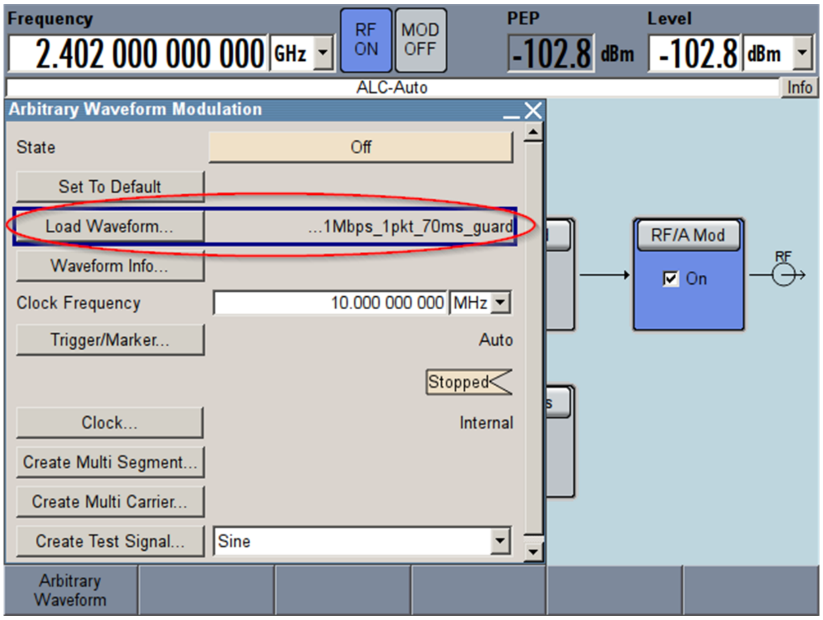

Figure 5. Waveform Modulation

4. Select “Load Waveform” and load R&S_IQ_BLE_1Mbps_1pkt_70ms_guard.vw.

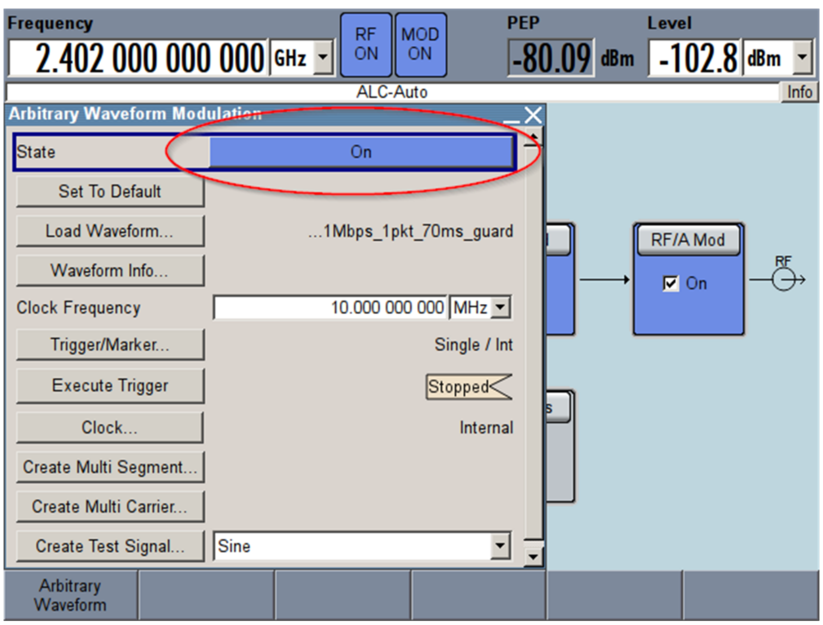

Figure 6. Load Waveform

5. Turn on modulation.

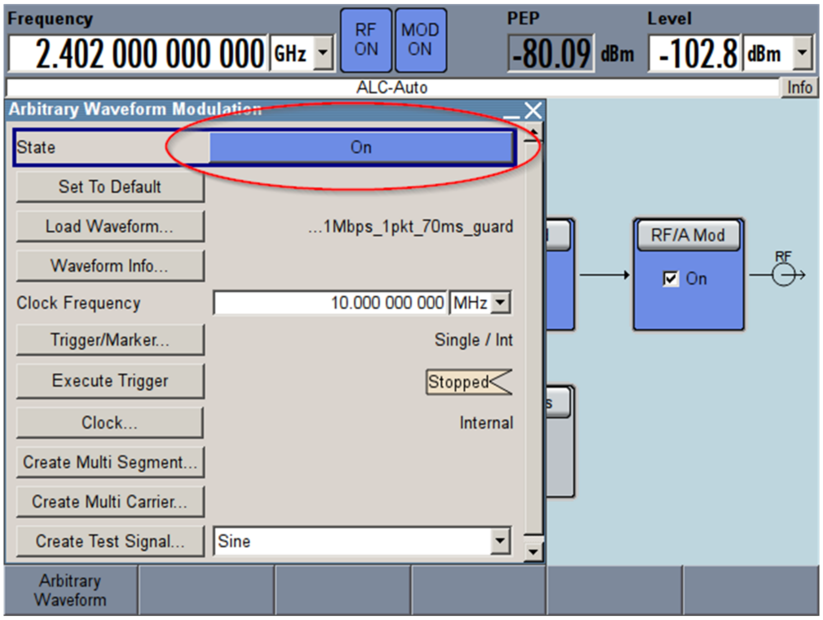

Figure 7. Turn On Moduation

6. Select “Trigger/Marker”.

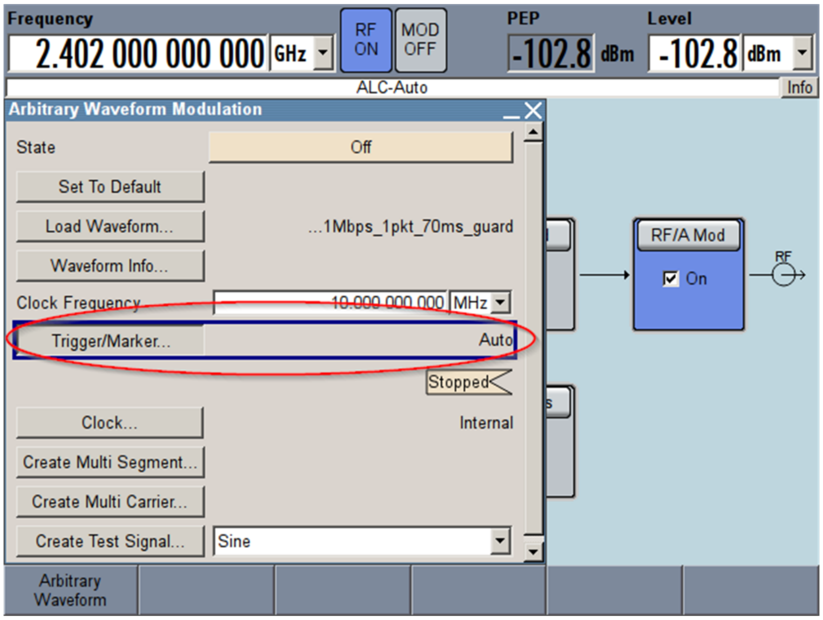

Figure 8. Trigger/Marker

7. Select Mode “Single” and 1500 Signal Duration (number of packages to send per trigger).

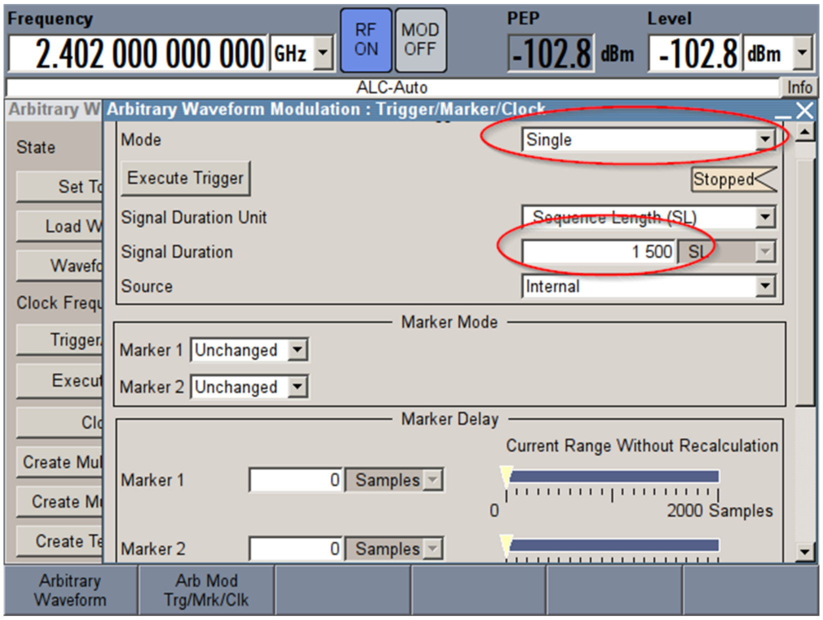

Figure 9. Mode “Single” and 1500 Signal Duration

8. Press “Execute Trigger” to start a transmission of 1500 packages

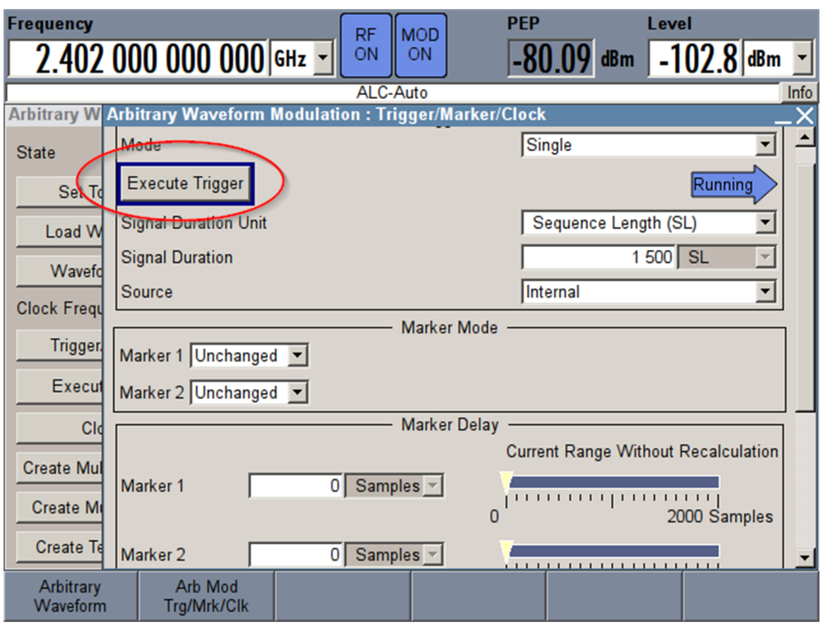

Figure 10. Execute Trigger

3.5 RX Setup

SmartRF Studio is used to setup the DUT to receive Bluetooth low energy packages.

1. Download and install SmartRF Studio from www.ti.com (http://www.ti.com/tool/SMARTRFTM-STUDIO)
2. Start SmartRF Studio and select CC2650 BLE mode
3. Device Control Panel configuration:
    1. Set Expected Packet Count (1500)
    2. Select Frequency
        1. 2402 MHz (BLE Channel 37)
        2. 2480 MHz (BLE Channel 39)
    3. Uncheck “Whitening”
    4. Uncheck “Seq. Number included in Payload”
    5. Set Access Addr to 0x71764129

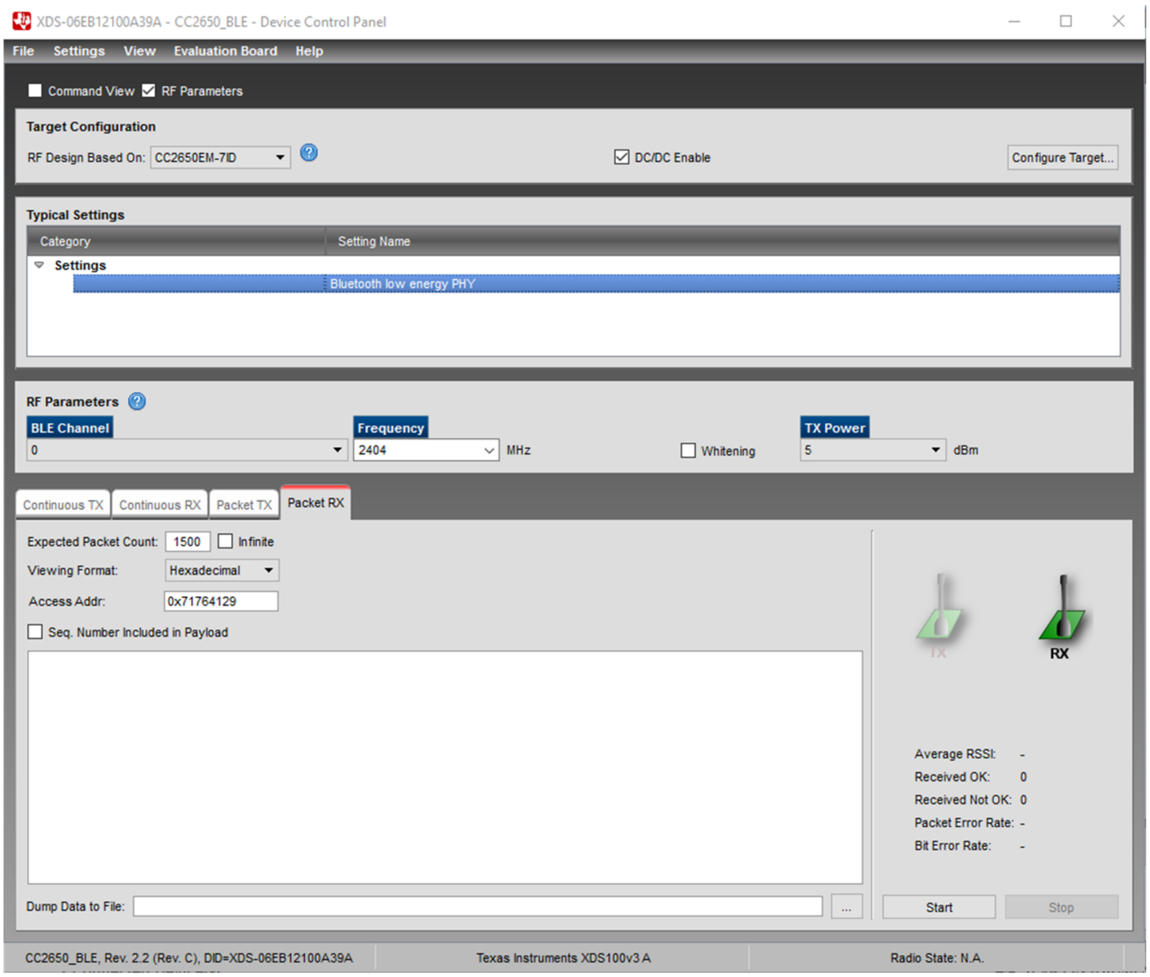

Figure 11. RX Setup

4. Press “Start” to configure and start receiving packages.

4 Measurement Data

The measurement of the receiver blocking performance is divided into three steps. The first step (see Section 4.1) is to measure the loss in the test setup, the second step (see Section 4.2 and Section 4.3) is to measure the sensitivity for the Device Under Test (DUT) and, finally, the third step (see Section 4.4) is where the actual receiver blocking performance is measured.

4.1 TX CW Blocker Setup

Loss for the TX CW blocker through cables, splitter and coupler from the signal generator in the test setup needs to be measured and compensated to get the correct measurement results.

The cable connected to the DUT is connected to the spectrum analyzer and the power level of the TX CW is measured at the different TX CW test frequencies. The difference between the TX CW source output power and the power applied to the DUT is calculated and used to compensate the measurement result presented in Section 4.4.

Table 2. TX CW Blocker Loss

	2380.0 MHz	2503.5 MHz	2300.0 MHz	2583.5 MHz
Blocker output [dBm]	-30.0	-30.0	-30.0	-30.0
@ Coupler [dBm]	-47.8	-47.2	-47.5	-48.1
@ DUT [dBm]	-39.9	-39.8	-39.8	-40.5
Loss in test setup [dB]	-9.9	-9.8	-9.8	-10.5

4.2 Low Channel Sensitivity (2402 MHz)

Table 3. BLE PEP vs PER at 2402 MHz

Level	PEP	Ok pkt	PER[%]
-105.0	-82.29	150	0.00 %
-106.0	-83.29	148	1.33 %
-107.0	-84.29	145	3.33 %
-108.0	-85.29	127	15.33 %
-108.5	-85.79	110	26.67 %
-109.0	-86.29	97	35.33 %
-110.0	-87.29	38	74.67 %

Measured sensitivity at 2402 MHz was found to be -86.05 dBm Peak Envelope Power (PEP). Wanted signal should, according to the *Receiver Blocking Parameters Receiver Category 2 Equipment* table in ETSI EN 300 328 V2.1.1, be set 6 dB above the sensitivity limits. With a measured sensitivity at -86.05 dBm that will lead to that the level on the wanted signal should be -80.09 dBm PEP (level = -102.8 dBm).

Note that there is a loss in the test setup at almost 10dB (see Section 4.1) so actual RX sensitivity level is around 96dBm.

4.3 High Channel Sensitivity (2480 MHz)

Table 4. BLE PEP vs PER at 2480 MHz

Level	PEP	Ok Pkt	PER[%]
-105.0	-82.29	148	1.33 %
-106.0	-83.29	141	6.00 %
-107.0	-84.29	132	12.00 %
-108.0	-85.29	117	22.00 %
-108.6	-85.89	104	30.67 %
-109.0	-86.29	94	37.33 %
-110.0	-87.29	45	70.00 %

Measured sensitivity at 2480 MHz was found to be -85.89 dBm PEP. The wanted signal should, according to the *Receiver Blocking Parameters Receiver Category 2 Equipment* table in ETSI EN 300 328 V2.1.1, be set 6 dB above the sensitivity limits. With a measured sensitivity of -85.89 dBm this leads to that the level on the wanted signal being -79.89 dBm PEP (level = -102.2 dBm).

Note that there is a loss in the test setup of almost 10 dB (see Section 4.1) so actual sensitivity level is around -96 dBm.

4.4 BLE PER vs Blocking Requirement (ETSI EN 300 328 V2.1.1)

Test steps:

1. Wanted signal level is set 6 dB above the sensitivity level for the selected operating frequency (2402 MHz and 2480 MHz) according to the result from Section 4.2 and Section 4.3.
2. Apply a TX CW interferer at 2300.0 MHz to the DUT with increasing power level until PER goes above the specified 30.8% level for BLE.
3. Repeat step 2 for 2380.0 MHz, 2503.5 MHz and 2583.5 MHz

As can be seen in Table 5, Figure 12 and Figure 13, the CC2650 are well inside the requirements specified in ETSI EN 300 328 V2.1.1 when using Bluetooth low energy.

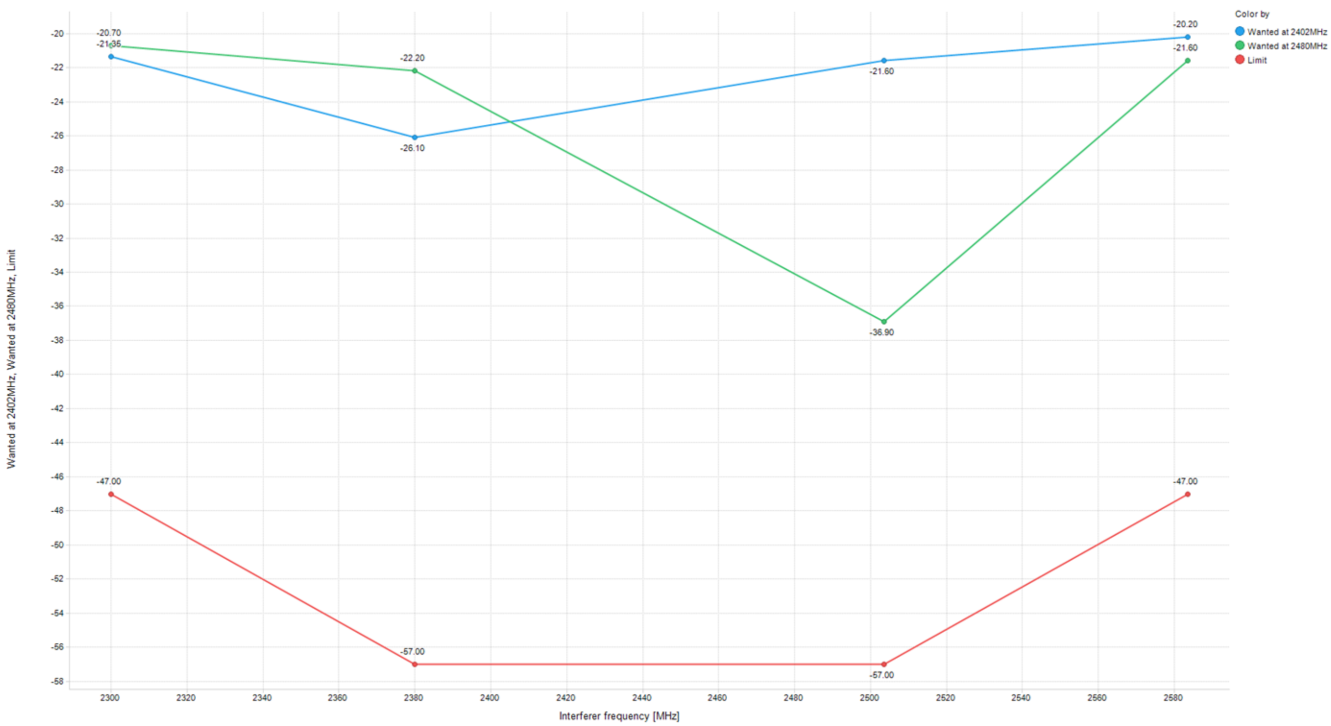

Figure 12. RX Blocking Measurement Results

Table 5. Brief Table

Interferer Frequency [MHz]	Limit [dBm]	Wanted at 2402 MHz [dBm]	Wanted at 2480 MHz [dBm]
2300.00	-47	-21.35	-20.70
2380.00	-57	-26.10	-22.20
2503.50	-57	-21.60	-36.90
2583.50	-47	-20.20	-21.60

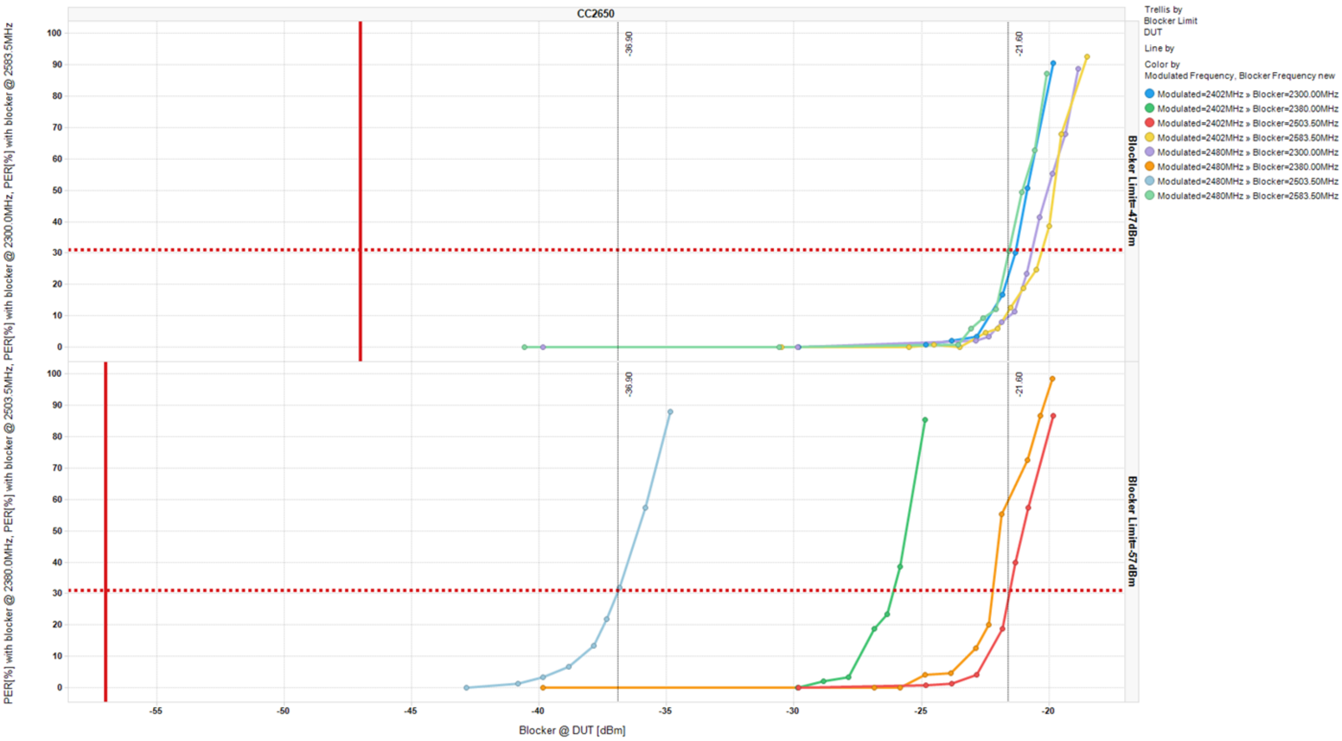

Figure 13. Detailed Plot

5 References

- TI. (2016, December 09). TI.com. Retrieved January 3, 2017, from SmartRF Studio: http://www.ti.com/tool/SMARTRFTM-STUDIO
- V2.1.1, E. E. (2016, November 15). ETSI EN 300 328 V2.1.1. Retrieved January 3, 2017, from ETSI.org: http://www.etsi.org/deliver/etsi_en/300300_300399/300328/02.01.01_60/en_300328v020101p.pdf