

# Bit error rate testing of the MC12311 development board using the Rhode and Schwartz SMIQ signal generator

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## 1 Introduction

The MC12311 is a sub-1GHz communications integrated circuit incorporating a transceiver and 8-bit microcontroller. The highly-integrated RF transceiver operates over a wide frequency range including 300 MHz, 450 MHz and 900 MHz frequency bands with FSK, GFSK, MSK, or OOK modulation.

This applications note describes the steps to perform a Bit Error Rate (BER) test of the MC12311 mounted on its MRB development board using the Rhode & Schwartz SMIQ signal generator.

## 2 Signal generator with BER test feature

The Rhode & Schwartz SMIQ is a family of signal generators available with numerous options. Among the options was Bit Error Rate Testing, BERT, options B20 & B21. [note: The R&S representative reports this option is no longer available to purchase.]

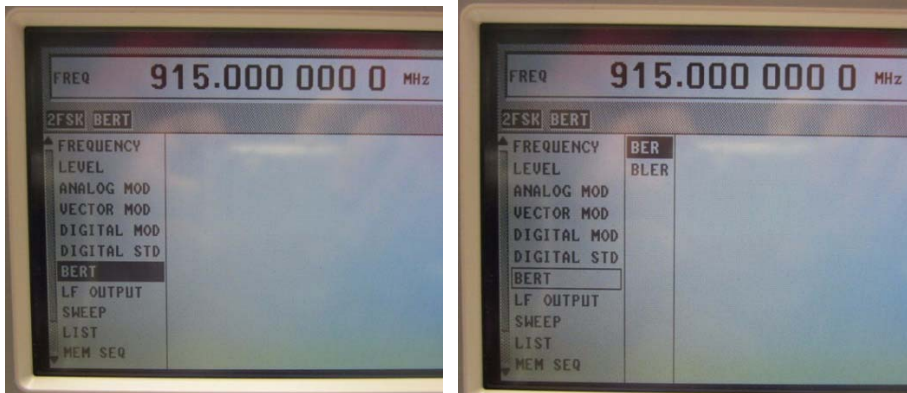
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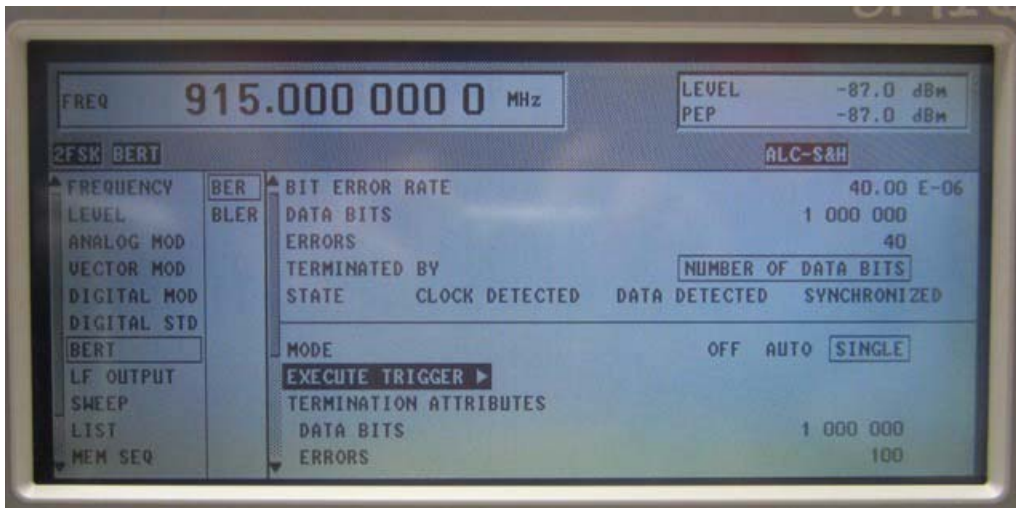
## Signal generator with BER test feature

The BER test function operates by modulating a pseudorandom number (PN) pattern onto its RF output signal. The UUT receives and demodulates that signal and feeds a clock and data on its baseband output. This baseband signal is fed into the back panel of the SMIQ which then compares the transmitted pattern with the pattern from the UUT.

To find and select the BER option on the SMIQ, using the knob, scroll down the selections menu on the left of the window. If BERT is not on the list, the option is not installed on that particular SMIQ. Select BERT with the select button then select BER.



This brings up the BER window:



### 3 Set up SMIQ

#### DIGITAL MOD

- Modulation: 2FSK/50.00 kHz, or some other modulation format, such as: GFSK / GMSK for 802.15.4g MR-FSK
- Symbol rate: 25 000 sm/s (or as needed)
- Filter Rectangular: (FSK) / Gaussian with BT = 0.5
- Source: PBR5 15

#### BERT

- Select Bit Error Rate (BER) (not Block Error Rate (BLER))
- MODE off auto single (using SINGLE in this example)
- Data bits 1 000 000
- Termination attributes: (The BER test terminates at the below number of bits or errors.)
  - Data bits 1 000 000
  - Errors: 10000

#### NOTE

- Mode can be set to AUTO for running pure BER measurements and set to SINGLE for BER / PER correlation.
- Terminating after a smaller number of data bits, such as 100 000, will make the test faster.
- Keep error count for termination to about 1% of the data bit number to ensure accurate reading of BER greater than  $1e-3$ . Terminating with a much smaller number of errors will make the test go faster but not give accurate readings for higher BER.

#### Level:

- Start at a fairly high level, such as  $-40$  dBm, later step the level down to  $-90$  or  $-100$  dBm at the SMA of the MC12311 MRB (consider splitter/cable loss) to find the sensitivity level where BER = 0.1% or whatever the target BER for sensitivity is. The RSSI window on the GUI reads approximately the signal level during this test.

#### Frequency:

- 915.000 000 (or any frequency the test is to be performed at).

## 4 12311-MRB

The 12311-MRB is the development board for the MC12311 sub-1 GHz transceiver. See Freescale document 12311DHRM for detail and operation of the MRB.



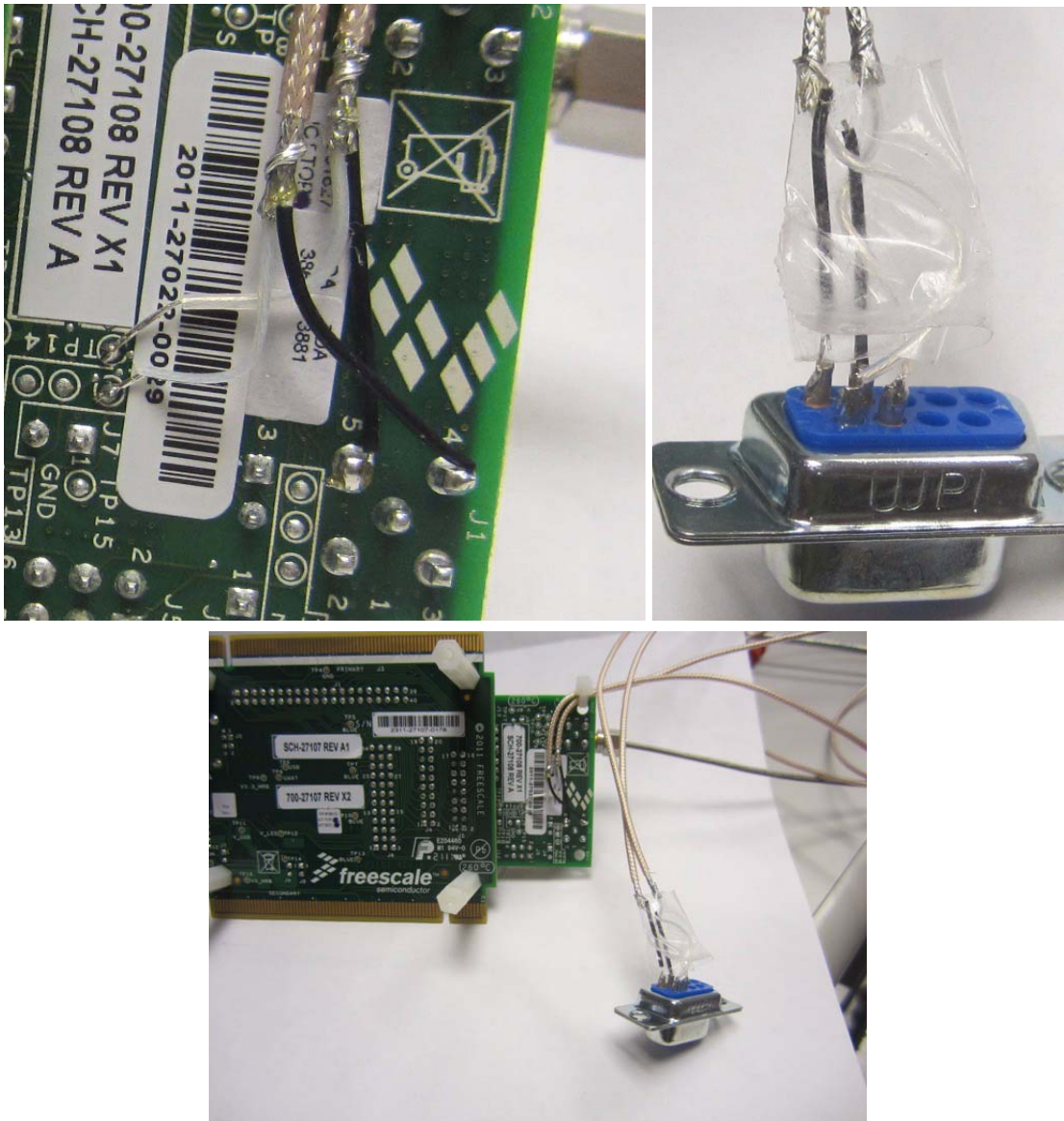
Typically the 12311-MRB mounts on TWR-RF for power and control, partially visible in photos below.

## 5 Cabling the SMIQ to the 12311-MRB

A cable was created with two shielded cables.

The rear panel of the SMIQ accepts a female 9-pin D-connector.

- Wire Signal DIO1 CLK from MRB TP14 to pin 6 of the D connector
- Wire Signal DIO2 DATA from MRB TP13 to pin 7 of D-connector
- The shields are soldered to the conveniently close ground pins of an SMA on the MRB board and to pins 1 & 2 on the D-connector

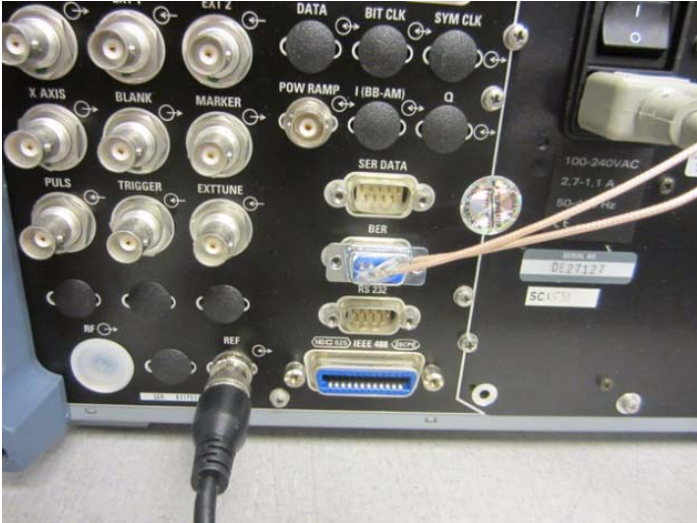


Alternately, pins can be added to the MRB to allow quick attach/disconnect of the BER cables assembled with a mating header:

Cabling the SMIQ to the 12311-MRB



Plug the D connector in the back panel BER input of the SMIQ:



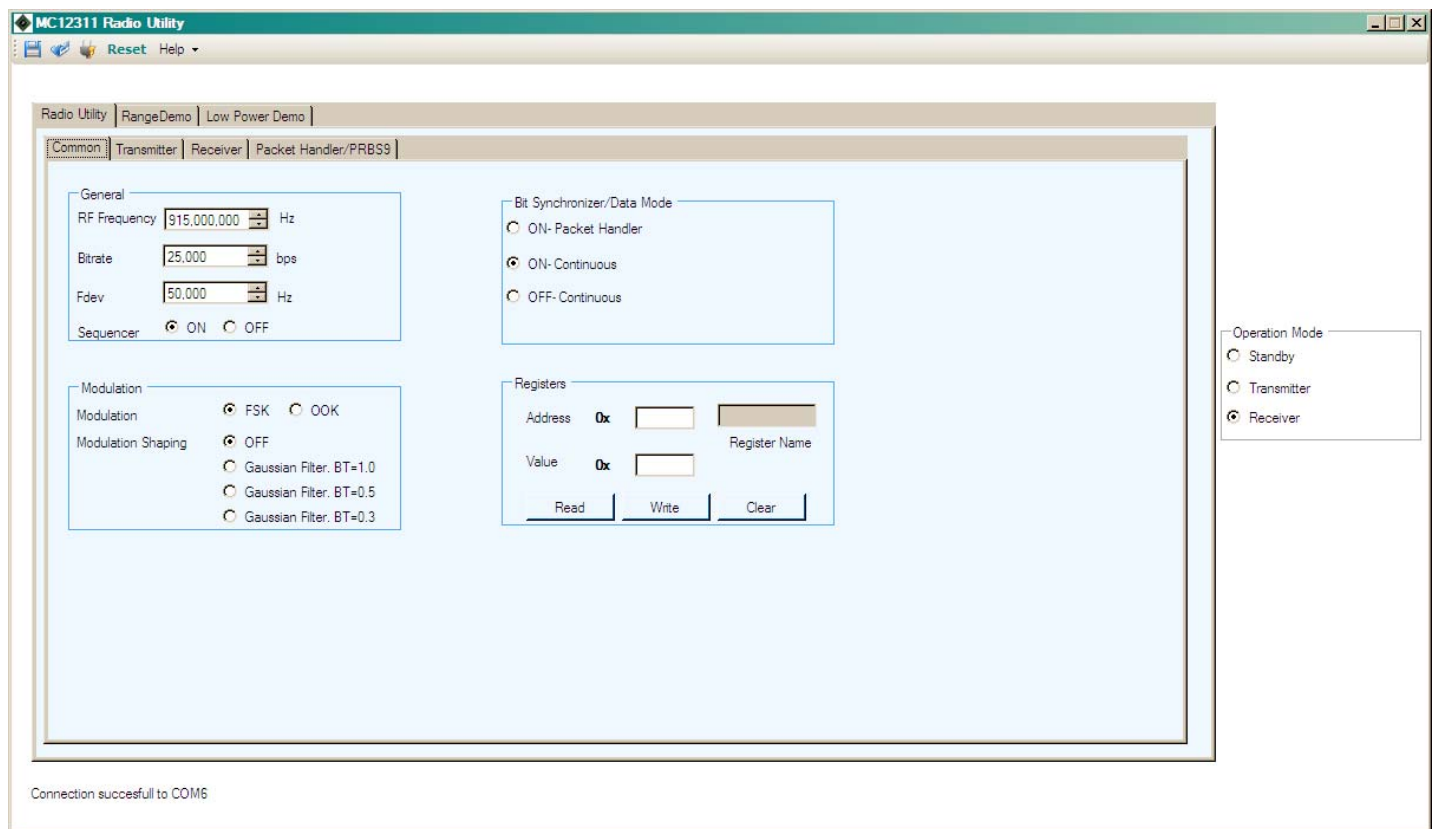
## 6 MC12311

The MC12311 is controlled via a Radio Utility GUI.

Set up the MC12311 as follows:

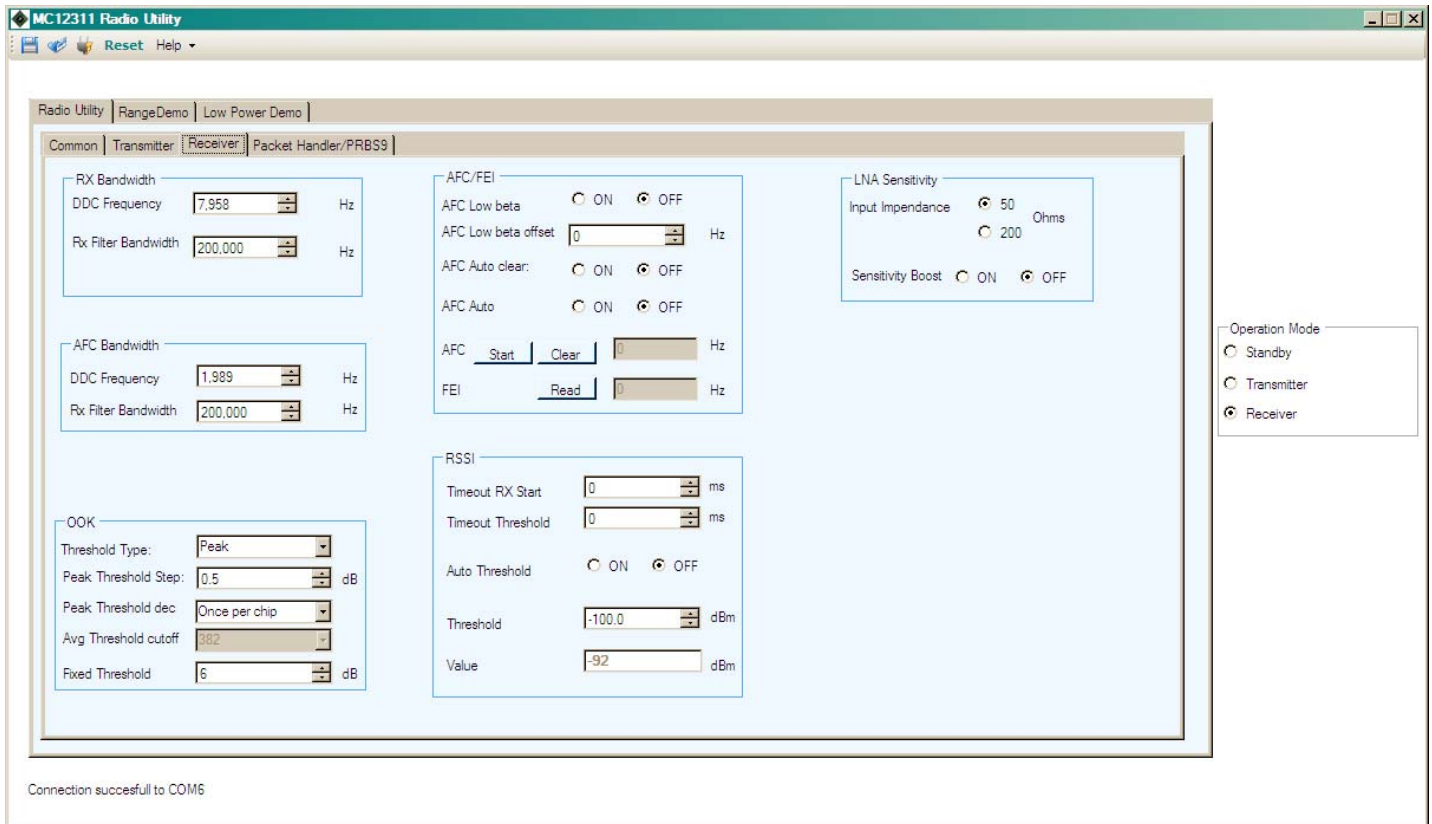
Common Window:

- RF frequency: 915 000 000 (or chosen test frequency)
- Bitrate: 25 000 (or chosen test modulation)
- F dev: 50 000 (or chosen test modulation)
- Sequencer: ON
- Modulation: FSK, Filter off
- Bit synch/data: ON-continuous



Receiver Window:

- RX BW: 200 000 (or a bandwidth appropriate to the chosen modulation)
- (DDC set to 7958 automatically)
- AFC BW: 200 000
- (DDC set to 1989 automatically)
- LNA sensitivity: Input Impedance = 50 ohms
- Sensitivity boost: OFF
- RSSI threshold: -100



AFC is not typically needed if the frequency error of the MRB is much less than the receiver bandwidth. AFC functionality is discussed elsewhere.

With the Operation Mode set to Receiver, the MC12311 MRB will output a clock and any data on the DIO1 CLK and DIO2 DATA lines fed to the SMIQ.

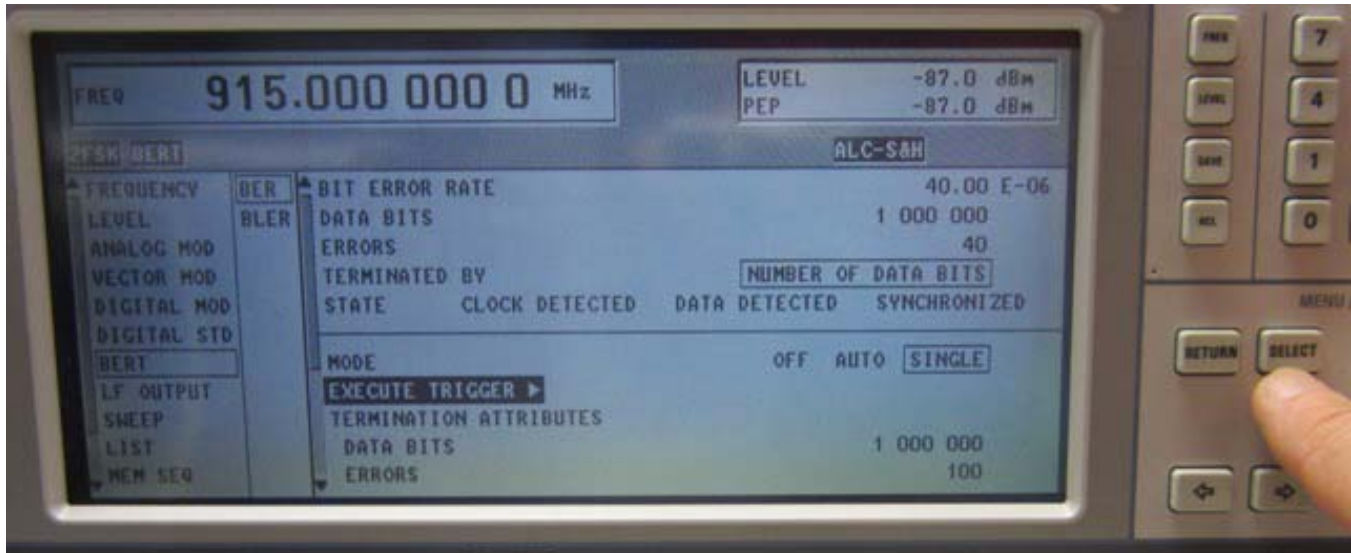


## 7 Performing the test

Once set up, the signal generator transmits a continuously modulated signal, and automatically detects the CLK and DATA on its rear panel BER port.

Set the MC12311 GUI from standby to receive. (RSSI should exceed threshold for function).

With the cursor on the EXECUTE TRIGGER Press the “select” button.



The signal generator will detect the clock, data and then synchronize the patterns and begin a test. It will show in the upper half of the window the number of bits sent and errors detected and the calculated Bit Error Rate until the termination attribute is met.

A longer bit stream takes longer than a shorter one but effectively averages the BER of the equivalent number of short bit streams. Finding the transition from no bit errors to bit errors occurring can more quickly be performed using a shorter string of data bits for the test. For a given set of conditions, a longer bit stream will give a more accurate reading.

The image above shows a 1 000 000 bit test that found 40 errors for a BER of 40 e-6.

### NOTE

During the test especially with GFSK modulation with  $MI = 1.0$  or GMSK modulation, jitter on the clock of the MRB can cause the SMIQ clock to lose sync – this can be especially noticeable close to nominal sensitivity level where the sequence length is long.

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